COMPARISON OF CLAMSHELL/SCOW AND HOPPER DREDGE DISPOSAL AT THE ALCATRAZ DISPOSAL SITE

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disposal on six loads during each phase that were the subject of plume tracking studies at the disposal site.

42. At the Alcatraz Disposal Site, samples were obtained, using the DPPD, at locations immediately north of the disposal buoy and 25 meters north, east, south and west of that position (Figure 2-5). The DPPD was set to obtain measurements at depths of .5, 1 and 1.5 meters. Instrument problems with the density probe and damage to the DPPD caused by extreme currents during Phase I of the study required that some samples be obtained using a grab and analyzed in the laboratory. However, these problems were corrected by Phase II and a complete suite of in-situ density measurements were made with the Nuclear Density Probe. In order to provide statistical verification of the measurements, three (3) replicate one minute counts were taken at all stations and at all penetration depths.

Piston Cores

43. All of the parameters described in the previous sections were measured through remote electronic or photographic techniques. In order to provide verification of those parameters associated with the dredged material deposit, piston cores were taken at the same locations as the density measurements (Figure 2-5). The piston core was provided by the University of Southern California and consisted of an adjustable (2500 lb maximum) weight stand and standard 2.5" inside diameter galvanized core pipe in ten foot long sections. Butyrate core liners with 2 1/4" outside diameter were used to provide ease of extrusion and handling aboard ship. After sampling, the cores liners were immediately extruded, capped and stored in a vertical orientation until the ship returned to the dock. On shore the cores were cut into one meter sections, recapped and stored at 4 C until analysis.

Plume Tracking

44. During the disposal period, measurements of the disposal plume were made to assess the amount and fate of material in suspension during and after the Convective Descent Phase. Such measurements provide information on the descent rate of the material, the direction of transport and dispersion of disposed sediments and an indication as to potential increase in the suspended sediment load as a result of the disposal operation.

45. The Datasonics DFS-2100 Dual Frequency Sub-bottom Profiler described in Section 2.5 was also used for this portion of the program through implementation of the high frequency (200 kHz) channel. The DFT-210 transceiver provides a capability for quantifying the output and return levels of the acoustic signal so that measurement of the acoustic backscatter from the suspended sediment plume can be made. The signal was monitored on an oscilloscope and recorded on the EPC-3200 graphic recorder and a Mitsubishi DT-2 analog tape recorder. Navigation control was provided by the SAIC INDAS with a Del Norte Trisponder and Loran-C interfaced to the system.

46. During each Phase of the program, plume tracking observations were conducted on six disposal operations spaced at different stages of the tide to evaluate the effects of current on the dispersion of sediment. Measurements were made at high and low slack water, at maximum ebb and flood current, and at times of moderate ebb and flood current. To conduct the measurements, the scow or hopper dredge approached the disposal point on a downstream approach. The survey vessel maneuvered close to the bow of the disposal vessel, and once the tape recorder was initialized, the INDAS was set to record position fixes, and all acoustic systems were operational, the scow or dredge was instructed by radio to open the hopper doors. The time of disposal was recorded and the survey vessel remained stationary until the disposal plume was observed on the graphic recorder and oscilloscope. Following disposal the dredge would back upstream from the disposal point to reduce the effect of propeller wash on the measurements.

47. Once the plume was detected, the survey vessel crossed the plume several times, generally in a north-south direction until the acoustic backscatter returned to ambient levels. The limits of the plume were defined by recording a position fix each time the margin from high acoustic return to ambient conditions was observed. At least twice during each operation a water sample was obtained in the plume. The graphic recorder was marked at the time of sampling, and a time and position fix was recorded so that the acoustic signal could be calibrated relative to the suspended sediment concentration in the water sample.

2316, with the exception that samples were dried at 70°C to avoid volatilizing any organic material. Wet Density was determined by measuring the wet weight and volume of the sub-sample which was then dried to determine the water content. Dry density was determined by dividing the wet density by the water content plus 1.0.

64. Grain size analyses were conducted using US standard sieves and hydrometer measurements according to ASTM Procedure D 421 and D 422. Settling rates were determined by weighing partial settling rates according to the results of the grain size analysis. For coarse-grained material the partial settling rates were calculated based on Stoke's Law. For finer particles, the hydrometer test results were used.

65. Atterberg limits were determined using ASTM Procedure D 4318. Organic contents were determined either through ignition, where all calcareous material is included in the value obtained and the modified Walkley Black procedure, which measures only the organic matter that is readily oxidized. Cation exchange capacity was measured by saturating the sediment with barium, washing the sample with a dilute 7×10^{-4}N BaC$_{12}$ solution and then measuring the remaining barium in the sediment using atomic absorption spectroscopy

Plume Tracking Analysis

66. Analysis of Plume Tracking data is a complicated procedure requiring the synchronization in time of four separate sets of data:

a. position data recorded by the SAIC INDAS to determine the location of the measurement,

b. acoustic reverberation data recorded on the graphic recorder, which indicates the presence of the disposal plume,

c. acoustic reverberation data recorded on tape, which provides quantitative measurement of the backscatter caused by the disposal plume, and

d. suspended sediment concentration data obtained from water samples taken in the plume to provide a relationship between measured backscatter and sediment concentration.

67. In order to determine the transport and dispersion of the plume, the location of each crossing of the plume margin as shown on the graphic recorder, was plotted and tabulated, and the range and bearing from each location back to

the disposal point were calculated. Using these data it was then possible to determine both the velocity of transport and the rate of lateral dispersion of the disposal plume.

68. The concentration of the suspended sediment in the plume at any given time was calculated from measurements of the backscatter reverberation. Proni et al (1976) have demonstrated that acoustic backscatter has a direct linear relationship to the concentration of suspended particulate matter, such that

$$I = \alpha N \qquad \text{Eq. III-3}$$

where:

I = Acoustic reverberation intensity
N = Number of particles per unit volume (concentration)
α = Function which depends on particle shape, size, density, compressibility and acoustic frequency

69. In this study, I was determined by measuring the reverberation level from the Datasonics DFS-2100 system, and α by simultaneous measurement of the suspended sediment concentration from a water sample. In practice the measurement of reverberation level is accomplished by recording the receiver voltage on an analog tape recorder and playing the tape back into a storage oscilloscope. The storage scope permits averaging of several signals and then stores the display for later analysis. Reverberation levels are obtained by measuring the amplitude of the outgoing pulse and subsequent acoustic returns as a function of time. One series of acoustic measurements are made at the time of the water sampling, and the amplitude at the sampling depth is accurately measured to provide a calibration point for intensity as a function of sediment concentration. Measurements of concentration as a function of time and depth are then made to determine the dispersal of the plume.

content. As a result, the liquid limit of the sediment was rarely exceeded and the entire deposit can be expected to behave as a cohesive sediment that would be resistant to erosion.

127. Examination of the geotechnical parameters of the Phase II cores indicated that prior to disposal of the Richmond Channel sediment, the deposit in the vicinity of the disposal point was predominantly a fine sand and silt deposit on the margin of the disposal mound. The grain size distribution ranged from predominantly silt to sand layers, very little coarse sand or gravel was present. The density of the sediment was relatively high averaging 1.60 g/cm^3, and the water content averaged approximately 60%. However, since the material was predominantly sand, the Atterberg limits were low; this indicates that the material would act as a fluid deposit. Following disposal of the Richmond Channel sediment, the grain size of the material at the site was predominantly silt. The percentage of sand in the deposit did increase to some extent during the one and three month post disposal surveys. This would indicate that the fluidized muds evident in the REMOTS images were gradually removed from the deposit.

Plume Tracking

128. The disposal of dredged material in the marine environment occurs through three major phases which affect the behavior of the material in the water column and the nature of the deposit on the bottom. These are:

a. The **Convective Descent Phase** during which the majority of the dredged material is transported to the bottom under the influence of gravity as a concentrated cloud of material,

b. The **Dynamic Collapse Phase** following impact of the bottom where the vertical momentum present during the Convective Descent Phase is transferred to horizontal spreading of the material, and

c. The **Passive Dispersion Phase** following loss of momentum from the disposal operation, when ambient currents and turbulence determine the transport and spread of material.

129. During the Convective Descent Phase of the disposal process, water is entrained with the disposal cloud resulting in a gradual decrease in the concentration and density of the discharged material. This entrainment of water and the residual dispersal of sediment washing out of the disposal vessel will result in some portion of the dredged material remaining in suspension

throughout the water column after disposal. Since these suspended sediments are not transported as part of the Convective Descent Plume, the ultimate fate of this material depends primarily on its settling rate and the ambient currents in the area. Since the currents in the vicinity of the Alcatraz Disposal Site are relatively strong, it can be expected that the material remaining in suspension can be transported significant distances before it is deposited. It is important to note that the contribution of this suspended dredged material to the overall suspended sediment load of the site is minuscule. Assuming a 4000 m^3 disposal load, with a sediment density of 1.3 g/cm^3; if 10% of the sediment remains in suspension following the Convective Descent Phase, and is dispersed over a 1 km^2 area 25 m deep, then the increase in sediment concentration for that volume of water would be .02 mg/l. Since the ambient sediment concentration levels in this portion of the bay are on the order of 14 mg/l, it is obvious that the plume can be expected to drop to background levels in a fairly short time, considering the turbulent current velocities and the high suspended sediment load.

130. The objectives of the plume tracking operations conducted during this study were to evaluate the transport of the suspended dredged material, to assess the amount of material remaining in suspension and to determine its dispersion. To accomplish these objectives, six scows and hopper dredge disposal operations were studied, one each at slack high and low water, and two each during ebb and flood tidal flow.

131. The transport and dispersion of the suspended sediments were studied by tracking the plume with the SAIC INDAS system using the Datasonics DSF 2100 to sense the presence of the plume. The track charts generated during this operation were simplified during reconstruction so that only those portions of the track within the plume were examined. In this manner, both the lateral transport and the dispersion of the plume could be readily determined, and the velocity of transport estimated.

132. In all cases, the disposal operation took place immediately north of the disposal buoy while the survey vessel stood by close to the disposal scow or hopper dredge. When the signal to open the hopper doors was given, the time from disposal to first detection of the plume was measured. Knowing the distance from the disposal point to the survey vessel, this provided an estimate of the rate of convective descent and dynamic collapse. This

measurement resulted in an average descent velocity of 3.8 ft/sec (1.1 m/sec) which was identical to that observed by Bokuniewicz et al. (1978). Following this initial measurement the survey vessel passed in and out of the plume to delineate the margins while observing the concentrations levels through accurate measurement of the acoustic return. Representative plume tracks from both the Phase I and Phase II disposal operations are discussed below.

133. During the Phase I operation, plume #3 (Figure 4-23) occurred during a flood tide and showed an immediate transport toward the east at a rate of 75 cm/sec. The plume spread slightly also in a northwest-southeast orientation and dispersed in a period of less than 20 minutes.

134. Plume #4 of the Phase I study (Figure 4-24), took place during a maximum ebb tide, and showed a tendency to elongate in the westerly direction without much spread to the north or south. The rate of advance of the plume was approximately 140 cm/sec. This rapid transport caused the plume to dissipate rather quickly and the material could not be detected after a period of less than ten minutes.

135. Overall, the Phase I plume studies showed that the initial concentrations immediately following disposal ranged from a maximum of 165 mg/l in the near bottom portion of Plume #4 to relatively low values of 44 mg/l in Scow #3. Scow #5, which conducted disposal operations during maximum flood, was loaded to the largest capacity possible considering the shallow waters at the San Rafael Creek Channel and the plume resulting from that operation had consistently higher sediment concentrations; nearly double those of the other plumes. The dispersion of Plume #5 was tracked for more than 20 minutes, at which time the concentration levels were still approximately 80 mg/l, four times the normal levels. Apparently, the high current velocities combined with the large sediment load of this scow maintained the material in suspension for a longer period of time. All other scows had concentration levels less than 30 mg/l within approximately 15 minutes of disposal. In summary, the behavior of the disposal plumes was very much controlled by the currents occurring at the time of disposal. The plumes were very short lived, rarely lasting more than 15 - 20 minutes even when there were low currents and turbulent diffusion was not a factor. The disposal of larger volumes of material might play a factor in spreading the material over a larger area, as the plume from scow #5 was more persistent than all of the smaller disposal operations. The result of

plumes acting in this manner would be the concentration of most of the high water content material in a region spreading east and west of the disposal point, since the material tends to settle to the bottom before significant transport can occur. This is in agreement with the observations of the side scan sonar survey, which showed a broad cover of fine grained sediment surrounding the disposal point.

136. In the Phase II study, plume #3 took place at slack high water (Figure 4-25). No transport and very little dispersion was noticed during this operation. Sediment concentrations were initially high, but returned to background values within ten minutes of disposal.

137. Plume #4 (Figure 4-26) took place on a strong ebb tide and migrated to the west at a rate of nearly 90 cm/sec during the period it was tracked. The concentration of this plume reached a maximum of 90 mg/l immediately after disposal and dispersed rapidly reaching values on the order of 25-30 mg/l within eight minutes of disposal.

138. In summary, the disposal plumes from the hopper dredge behaved very similar to the plumes from the clamshell/scow operations. The plumes did not persist beyond 10-15 minutes and did not disperse significantly in a north-south direction. Transport of sediment was relatively rapid, frequently reaching values approaching 100 cm/sec. Therefore, the expected deposit would be one of a tight configuration of dense material surrounded by an apron of finer, less dense sediment that should be readily resuspended. There did not appear to be significant transport of material off of the disposal site during the actual disposal operation.

PART V: CONCLUSIONS

139. The observations made at the Alcatraz Disposal Site in this study have provided valuable insights into the processes affecting the disposal of dredged material at that site. Specifically, the effects of two dredging techniques (clamshell/scow and hopper dredging) on the dispersal of disposed sediments from the site have been assessed. This comparison has pointed to those factors which influence the behavior of the dredged materials both during and after disposal. An understanding of these factors is essential to the effective management of the site (i.e. prolonging its useful life as a disposal area).

140. The estimated volumes of the disposal mounds formed during the Phase I and Phase II studies indicate that much less material accumulates at the site when a hopper dredge is used. During the clamshell/scow operation (Phase I), the change in volume at the disposal site resulting from the accumulation of dredged material, as measured by bathymetric surveys, amounted to 28% of the volume of sediment dredged. The Phase I sub-bottom profiles suggest that a somewhat higher percentage of this volume (43%) remained at the site. However, the consolidation of existing pre-disposal deposits resulting from the accumulation of new material resulted in an absolute volume change that is approximately one third of the material dredged. In contrast, the deposit resulting from hopper dredge disposal, as estimated by both bathymetric and sub-bottom surveys, was approximately 15% of the volume of sediment dredged. Because equivalent volumes of material were dredged in each phase of the study, this indicates that the volume of the hopper dredged material which remained at the disposal site was approximately one half of the volume of the clamshell material.

141. The plume tracking operations did not reveal any significant difference between the hopper and scow disposal operations. Based on the plume tracking data, it is apparent that, in both dredging techniques, most of the sediment deposited at the site reaches the bottom during the Convective Descent Phase and is not dispersed as a large, disposal plume. In both Phase I and Phase II, the velocity of the convective descent was identical to that measured at other disposal sites, and the plume remaining in suspension immediately after disposal contained only a small percentage of the material dumped.

Furthermore, this plume was dispersed rapidly and was generally undetectable within 10 to 15 minutes after disposal.

142. Density stratification of the sediments in the hopper dredge relative to the scows may be an important factor in the fate of material being disposed. The density in the hopper was stratified with significantly greater density observed near the bottom of the bin. This distinct density stratification evident in the hopper dredge, and not in the scows, indicates that the sediment is in a much more fluid state following hopper dredging and is likely more readily dispersed once it reaches the bottom.

143. The material reaching the bottom did behave differently depending on the dredging/disposal technique employed. In the clamshell/scow operation, the deposit formed in the vicinity of the disposal buoy consisted of a concentration of relatively cohesive, high density material, surrounded by soft, low density high water content material that was highly mobile and soon lost to the deposit. This soft material results from a combination of the Dynamic Collapse Phase spreading material radially from the disposal point and the settling of material from the disposal plume during the few minutes immediately following disposal. The soft deposit was observed as an east-west spread of a fine grained, low reflectance deposit in the side scan sonar records and as an acoustically transparent layer in the sub-bottom profiler records immediately after disposal. In REMOTS photographs, the material was apparent as fluid muds interspersed between mud clasts in a very loosely bound matrix. This material was extremely susceptible to erosion and was most likely removed from the site within a matter of hours or days following disposal. It was not present in REMOTS photographs at the one month post disposal survey, and the sub-bottom records became increasingly opaque with time. It is important to note, however, that although the REMOTS and sub-bottom profile data documented the loss of fluid muds prior to the one month post disposal survey, this did little to change the overall volume of material in the deposit, and no significant volume changes were observed following the initial post disposal survey. This indicates that this fluid deposited represented a relatively small percentage of the total deposit.

144. Conversely, a notably larger proportion of the hopper dredged material appeared to be susceptible to erosion due to the high percentage of fluidized mud. REMOTS photographs taken immediately following disposal

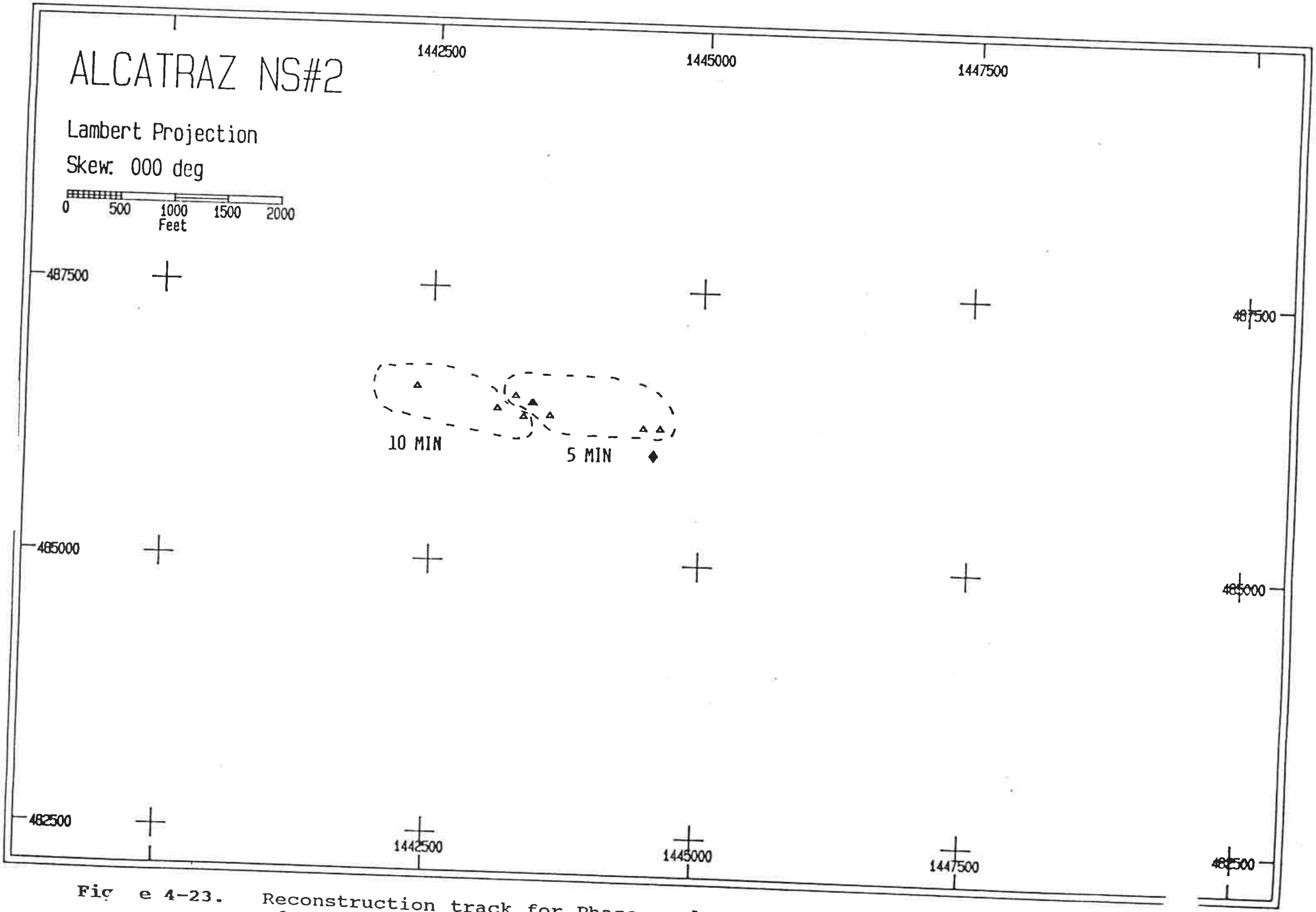


Fig e 4-23. Reconstruction track for Phase plume #4. Dashed lines represent boundary of observed plume.

track for Phase I plume #4. Dashed lines represent boundary of observed plume.

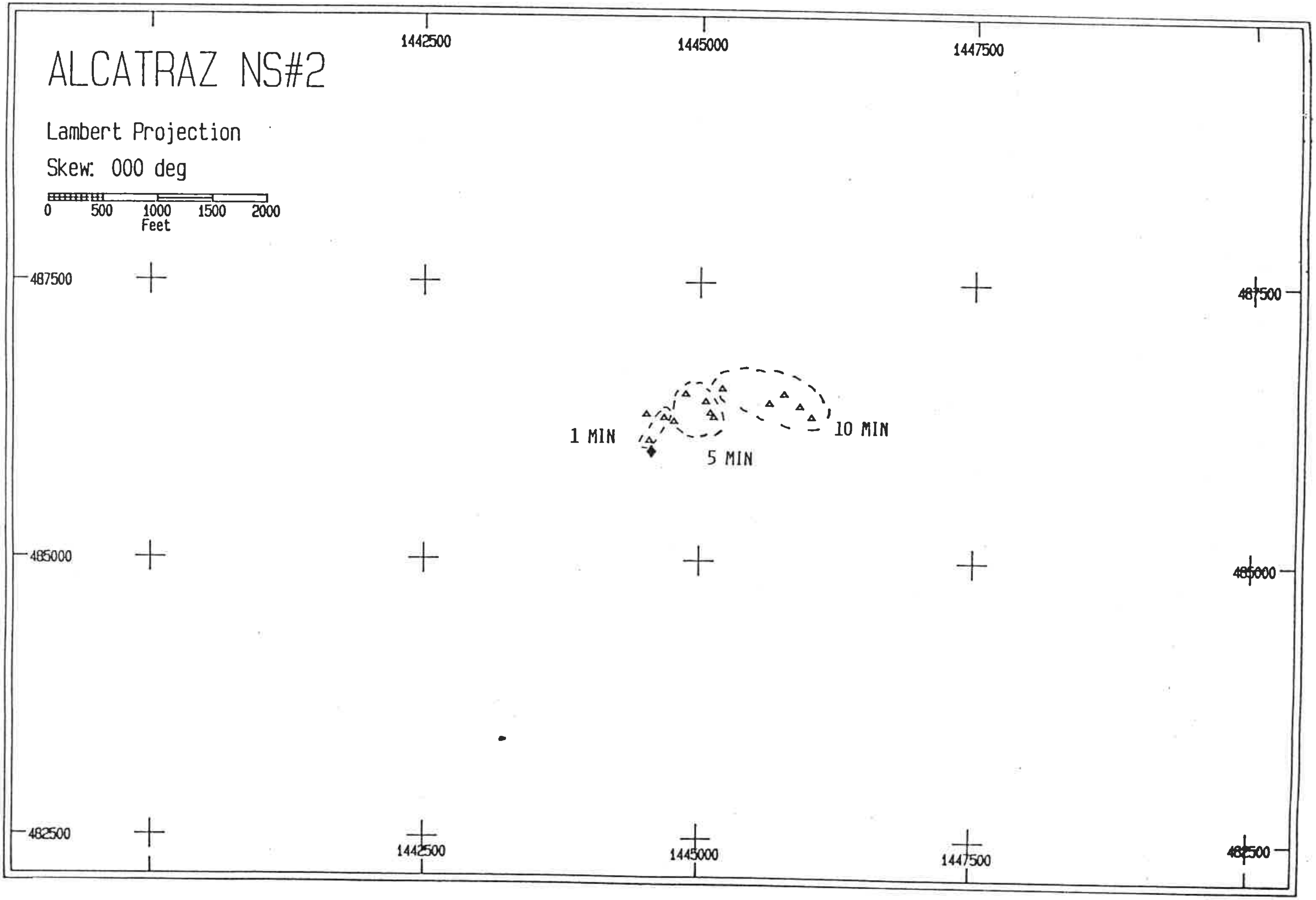


Figure 4-24. Reconstruction track for Phase - plume #3. Dashed lines represent boun y of observed plume.

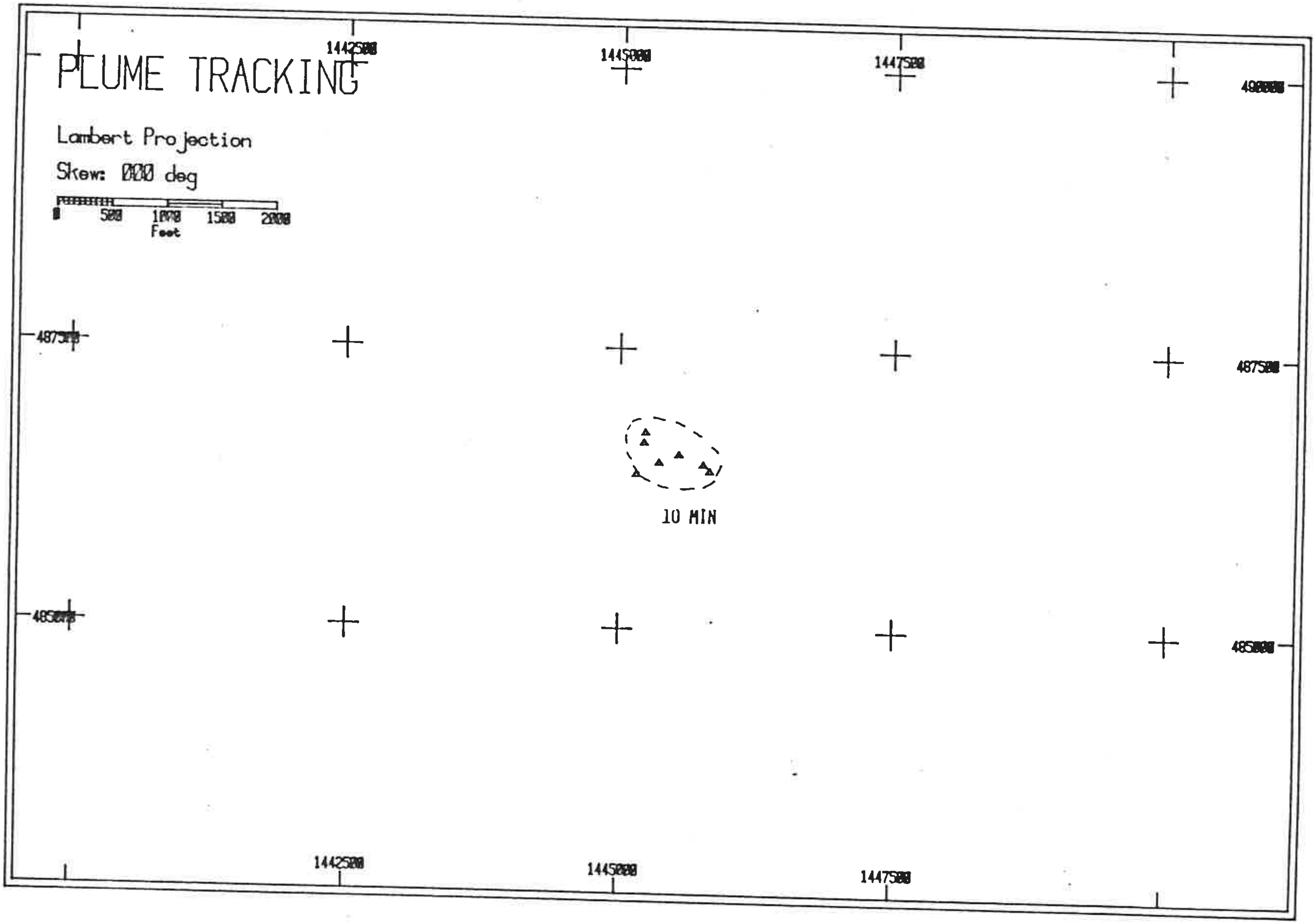


Figure 4-25. Reconstruction track for Phase II plume #3. Dashed lines represent boundary of observed plume.

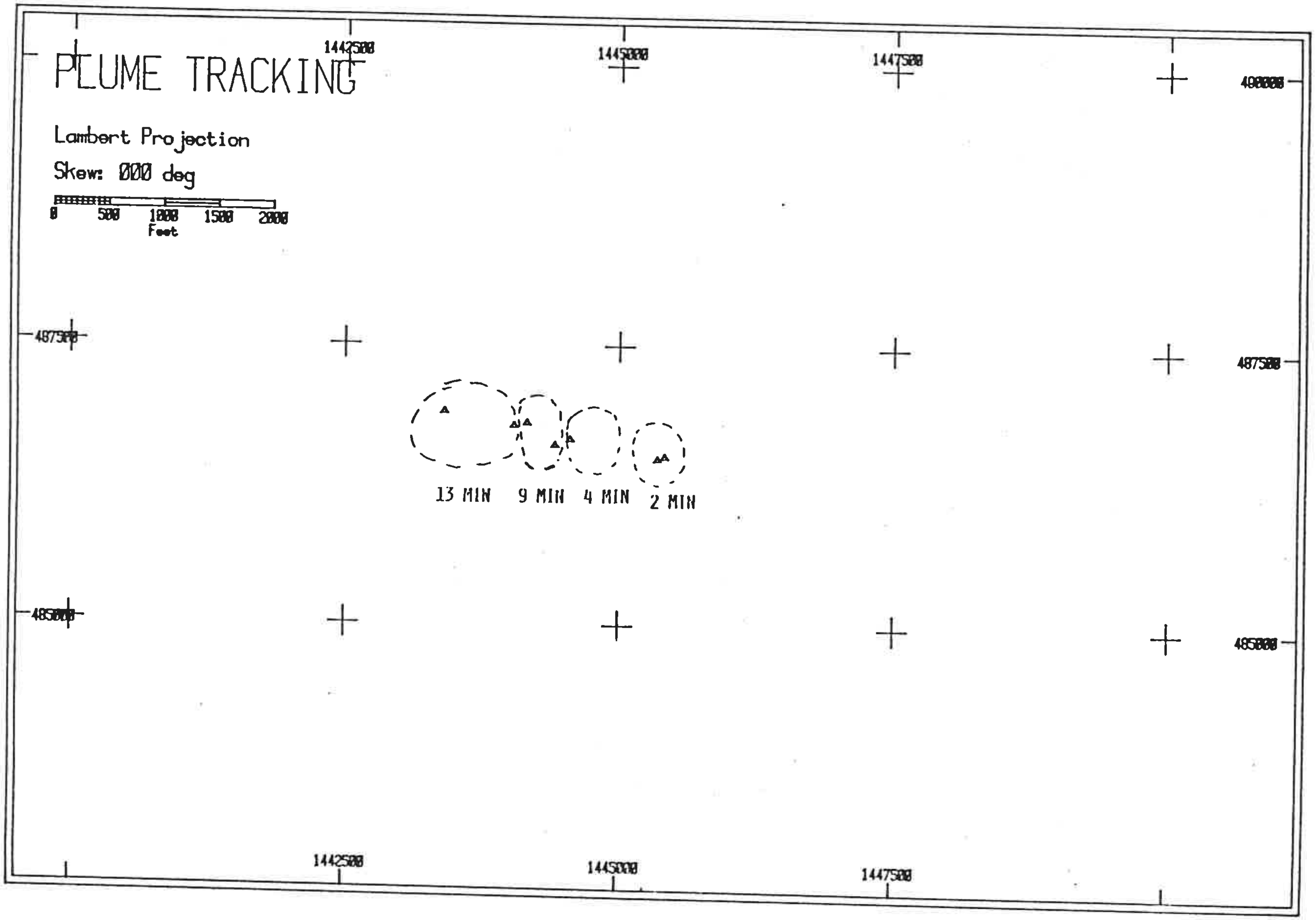


Figure 4-26. Reconstruction track for Phase II plume #4. Dashed lines represent boundary of observed plume.

US ARMY CORPS
OF ENGINEERS
SAN FRANCISCO DISTRICT

OAKLAND HARBOR

DEEP-DRAFT NAVIGATION IMPROVEMENTS
DESIGN MEMORANDUM NUMBER 1, GENERAL DESIGN

AND

FINAL SUPPLEMENT I TO THE ENVIRONMENTAL IMPACT STATEMENT

ALAMEDA COUNTY
CALIFORNIA
MARCH 1988

UNITED STATES ARMY CORPS OF ENGINEERS
SAN FRANCISCO DISTRICT
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105-1905

The South Bay has little freshwater inflow and a estuarine circulation cell is not present. Mixing in this portion of the system is dependent on extreme freshet conditions or local wind conditions. The South Bay water column exhibits little or no salinity stratification in the summer when the prevailing northwest winds are strongest. Surface transport in the general direction of the prevailing winds, to the southeast, generates a compensating near bottom flow to the northwest. Drifter studies have estimated these currents at 1 to 2 cm/s.

Mixing and circulation of bay water affects the transport of sediments, nutrients and other organic and inorganic substances brought into the estuary by both tides and freshwater runoff. Tidal and wind-induced currents together with the Delta inflow are one of the primary reasons why San Francisco Bay is naturally turbid year-round with visibility confined only to a meter (probably less than a meter for the most part).

The currents and wind-wave action tend to keep the material suspended throughout the water column but it eventually settles out either in the ocean or in the shallows of the estuary. Sedimentation normally occurs where low salinity water meets high salinity water, and the material differentially settles onto the intertidal flats and channels. The fine material that settles on the tide flats is often resuspended and redistributed by wind-generated currents and waves whereas sedimentation of coarser material in the deep channel is more or less permanent and often compacted to several meters deep. Many of these deep channels are periodically dredged for use as shipping lanes, and as a result are out of equilibrium with their environment.

Another important process of mixing in an estuary is that it creates a unique physico-chemical environment so different from fresh or saline water alone. Sediments in an estuary adsorb or chelate many chemicals and thereby play an important role in trapping and releasing nutrients and trace metals. These chemicals can range from a simple metal ion to a complex hydrocarbon molecule (such as pesticides, plastics, oil, etc.). Trapping and releasing of these chemicals could thus have a profound effect on the estuarine biota.

All of these estuarine processes - tides, freshwater inputs, sediment transport, turbidity, transparency and their interaction - which result from mixing of the sea and river are the reasons why a very rich and diverse ecosystem is so characteristic of an estuary - different from that of the original waters. The San Francisco Bay estuary is no exception.

3.3.3 Sediment Transport. An estuary such as San Francisco Bay is both a sink and a holding area for fluvial sediment in transit to the ocean from soil erosion in the Bay's extensive drainage system. Sediment entering the Bay system is either temporarily or permanently held in residence, depending on the dynamic conditions in the estuary. Surficial bottom sediments quickly respond to changes in the distributing forces from wind-wave action and currents. The nature and energy of the forces responsible for development of a profile of equilibrium fluctuate 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.

Inflowing sediment 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, circulated, and redeposited elsewhere. The net effect of this process is that some portion of these sediments are always being progressively transported toward the mouth of the estuary as suspended load and bedload. Most new sediment enters the Bay system during the months of maximum runoff (November to March). When the sediment laden water mixes with the saltwater, aggregation and settling occur. The broad expanses of the shallow bays, 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 accumulation of sediments. In the spring and summer months, daily onshore breezes generate waves over the shallow areas, resuspending sediments and maintaining them in suspension, while tidal and wind-generated currents circulate them throughout the bay. The suspended sediments are 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 margins of these channels, tidal currents become the primary transporting mechanism. Like the shallow areas in equilibrium with the depth of effective wave action, the depth of the natural flow channel is in equilibrium with the flow volume and current velocity in the channel. When suspended sediments from the shallows are transported into natural channels, the sediment has a tendency to be transported along the channel in the direction of net flow. 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, or moved back into the fresh-saltwater mixing zone in Carquinez Strait with net water movement upstream near the bottom and mixed upward with flows moving into the Bay.

Some sediment is permanently retained in the Bay system. This sediment is deposited and accumulated in low energy areas where wind-wave action and water velocities are not sufficient 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 structures and dredged channels. Marshes trap sediments by decreasing flow velocities and wind-wave action to the extent that a portion of the sediments may no longer be flushed out. Inlets and sloughs provide sheltered areas with very low current velocities.

Figure 3.5 presents a schematic depiction of sediment movement in the San Francisco Bay system. As displayed in the figure, sediment transport is a large scale phenomena in the estuary with millions of cubic meters being conveyed into and out of the system annually. The estimated average annual sediment inflow to San Francisco Bay is approximately 6 to 8 million m^3 (8 to 10.5 million yd^3). Hydrographic surveys of San Francisco Bay taken between 1897 and 1950 show an annual increase in sediment accumulation from Suisun Bay to North San Francisco Bay of 4.2 million m^3 (5.5 million yd^3). South San Francisco Bay actually shows a net loss of 0.7 million m^3 (0.9 million yd^3) per year (Krone, 1979).

Sediment outflow through the Golden Gate is generally estimated to be between two and three million cubic meters. Taking a median value of 2.5 million cubic meters (3.3 million yd^3), approximately 4.5 million cubic meters (5.8 million yd^3) of material is added to the sediment regime of San Francisco Bay annually. Within the sediment regime of the Bay, the major source of suspended sediments is resuspension of previously deposited material by tidally dominated currents and, especially in the shallower areas of the Bay, by waves. These waves can be induced by prevailing westerly winds in the summer or strong Pacific storms in the winter. The quantity of sediment that is annually resuspended in the shallow areas by wind waves and wind driven currents has been estimated by Krone (1966) to be 120 to 130 million cubic meters (160 to 170 million yd^3).

Dredged navigation channels are out of equilibrium with the overall Bay sediment regime in that the channels must be maintained to a depth greater than the natural depth. Maintenance of dredged channels is required since the channels, with few exceptions, will tend to regain the equilibrium depth of their surroundings. Flow velocities in these dredged channels are usually not great enough to maintain required depths. For this reason, sediment that accumulates in maintained channels will remain there until the channels are dredged.

Shoaled sediment may be derived directly from sediment inflow to the Bay or it may be derived from some part of the resuspension-circulation-redeposition cycle. Shoaling rates in the dredged channels are not constant but vary from year to year, depending on the variable sediment inflow volume, wind-wave action and current 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. The same process occurs in the shallow areas where the depths of accumulation will be greater than normal reducing local water depths. In the spring-summer season, shoaling in the dredged channels is due to the redistribution of sediment accumulated in the shallow areas during winter.

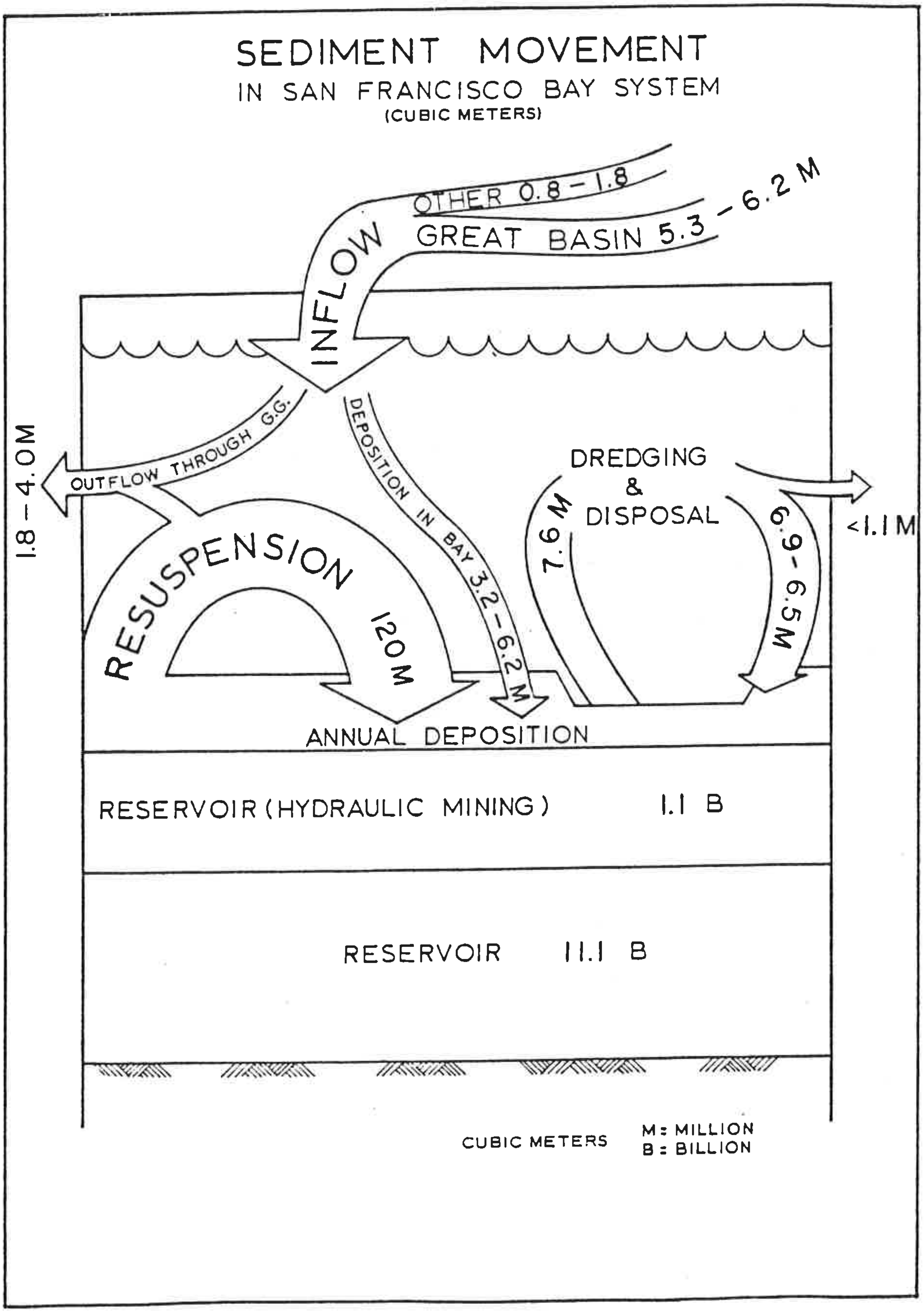

SEDIMENT MOVEMENT
IN SAN FRANCISCO BAY SYSTEM
(CUBIC METERS)
OTHER 0.8 – 1.8
GREAT BASIN 5.3 – 6.2 M
INFLOW
OUTFLOW THROUGH G.G.
1.8 – 4.0M
DEPOSITION IN BAY 3.2 – 6.2 M
DREDGING & DISPOSAL
7.6 M
6.9 – 6.5M
<1.1 M
RESUSPENSION
120M
ANNUAL DEPOSITION
RESERVOIR (HYDRAULIC MINING) 1.1 B
RESERVOIR 11.1 B
CUBIC METERS
M = MILLION
B = BILLION

FIGURE 3.5

Disposal of dredged sediments in the Bay brings back into circulation material that would otherwise remain out of circulation (retained in the channel). Upon disposal, the dredged sediment will reenter the deposition-resuspension-redeposition cycle, eventually being permanently placed in low energy areas or carried to the ocean. Since dredged channels are out of equilibrium, some of the disposed dredged sediment will likely reenter the same or other dredged channels (USACE, 1977, Appendix E).

The major transportation mechanism of the dredged sediments in the natural channels is by tidal currents and occurs at depths greater than the depth of effective wave action. Just as the water has a tendency to remain in the natural channels, as evidenced by the high current velocities, dredged sediments also have a tendency to remain within the confines of the natural channels for at least a short period of time. The natural channel network in the Bay leading to the ocean is not continuous, causing the dredged sediments, like the natural sediments, to leave the boundaries of the natural channels and move onto the shallows to become part of the resuspension-circulation-redeposition cycle.

Discharged dredged material can be highly mobile. Based on tagging studies (USACE, 1977, Appendix E), the dispersion of dredged sediments after disposal at the Carquinez disposal site was found to be very rapid. During the dredging operation, however, dredged sediments make up a large percent of the total sediment in and around the disposal site. In March 1974, while dredging of Mare Island Strait was still continuing, large quantities of dredged sediments were found in the sampled 80 square kilometer area around the disposal site, including dredged sediments that re-entered the dredged channel. After the completion of dredging operations at Mare Island Strait dredged sediments were found dispersed in April 1974 over a 260 square kilometer area including San Pablo Bay, Carquinez Strait and Suisun Bay. Localized areas were found in San Pablo Bay that had higher percentages of dredged sediments. By August 1974, five months after dredging had been completed, very little evidence of dredged sediments was present in the first 23 centimeters of sediment over the 260 square kilometer study area.

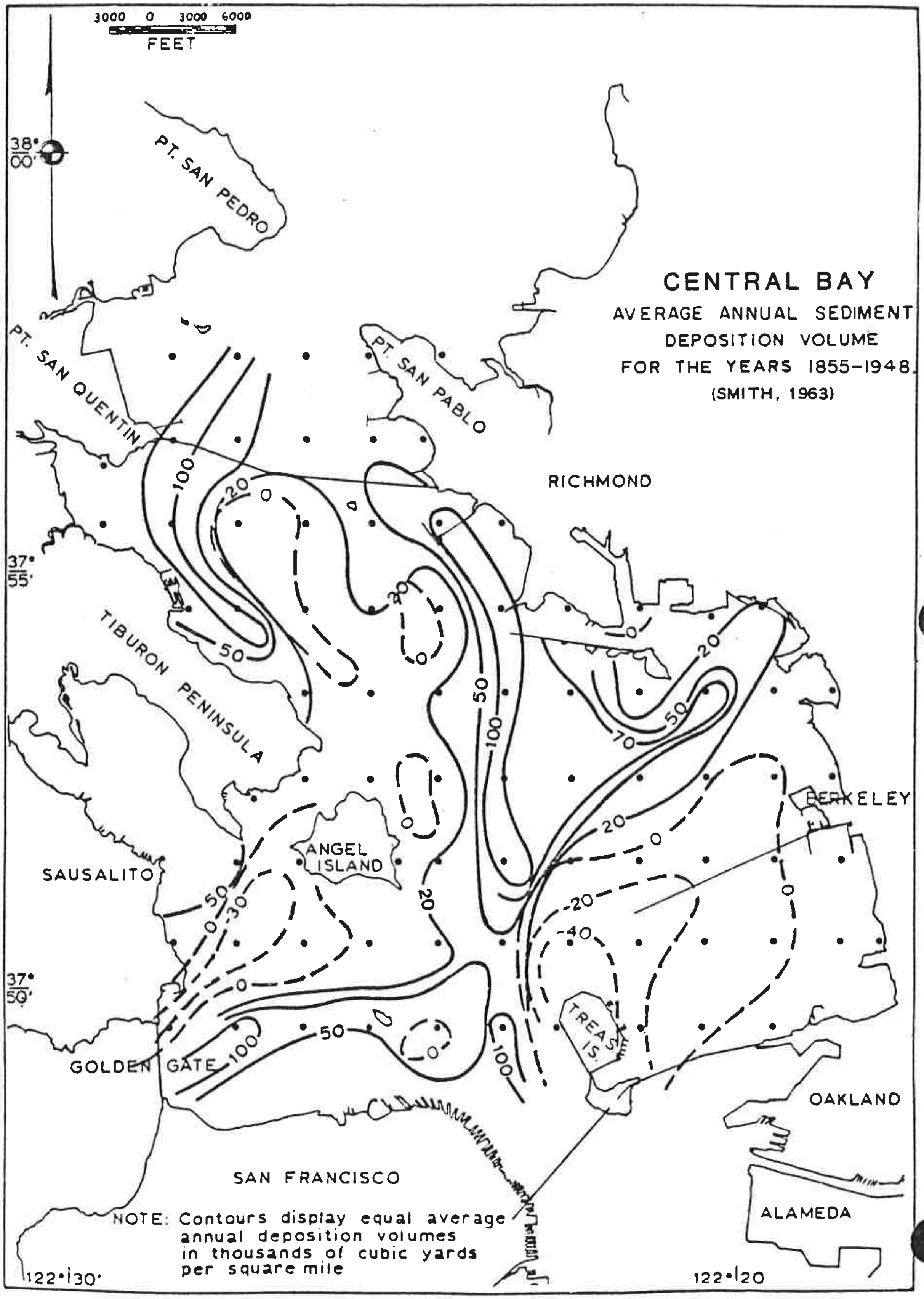
In September-October 1974, large quantities of dredged sediments were found in the upper 23 centimeters of sediment. The increase was due to the redredging of sediments in Mare Island Strait and the wind-wave recirculation of sediments on the shallows of San Pablo Bay. A large portion of the dredged sediments in October was located in the natural channel leading to San Pablo Strait and Central Bay. By December 1974, most of the dredged sediments were again absent from the study area. Analysis of samples obtained from Mare Island Strait and the hopper during dredging and previous studies of the area indicated that about 10 percent of the dredged sediments returned to the dredged channel in Mare Island Strait.

At the Alcatraz disposal site, following the initial deposition of sediments suspended during material discharge, a portion of the material is again resuspended and carried from the site by tidal currents. Dredged material retained at the site, based on monthly bathymetric surveys and logs of disposal quantities, is calculated to be 20 percent within 305 m (1000 ft) of site center and 30 percent within a 610 m (2000 ft) radius of site center. An additional 5 to 10 percent (7.5% is used for subsequent calculations) is estimated to have been deposited in the bathymetric depression on the east and south perimeter of the site. This material accumulated through gravity induced flow of the fluid mud fraction of material deposited during the passive transport phase.

It follows that slightly more than half (52.5%) of the total material discharged at the site is resuspended and transported from the vicinity after initial deposition by the strong currents. The erosional capacity of the site for the high water content, fluid material (1.3 g/cc or less) is much higher than the amount of material deposited (Teeter, 1987). Thus, combined with the ten percent lost to the water column during the convective descent phase, approximately five-eighths (62.5%) of the material discharged at the site is dispersed and transported from the site. In light of the above, it is estimated that annually five-eighths (62.5%) of the 3.8 million m^3 (5.0 million yd^3) of dredged material discharged at the site, or 2.4 million m^3 (3.1 million yd^3) is added to the Bay's suspended and surficial sediment regime.

The ultimate fate of this eroded material must be estimated from circumstantial evidence because quantitative data are lacking. Useful information is available from previously conducted field work looking at Central Bay water quality and geomorphic conditions. First, all suspended sediment plumes tracked during recent field investigations (SAIC, 1987a and 1987b) at Alcatraz moved in an east-west direction. The suspended material did not disperse significantly in a north-south direction. Second, geomorphic evidence that is useful includes an investigation of erosion and accretion patterns gleamed from historic surveys (Smith, 1963) and studies of the movement of bedforms in Central Bay (Rubin and McCulloch, 1979).

Smith (1963) developed estimates of historic sedimentation patterns for the years 1855-1948. Figure 3.6 presents his data in graphical format for the Central Bay locale (taken from USACE, 1979, Appendix B). In this figure areas of erosion are depicted by dashed lines, and areas of accretion are depicted using solid lines. As shown in the figure, Smith's data indicate that the highest shoaling rates have occurred along the flanks of the deep water channels in water depths of 3 to 9 m (10 to 30 ft). These areas are located along the fringes of Berkeley Flats on the east side of Central Bay and along the fringes of San Rafael and Corte Madera Flats on the western side. Intermediate shoal areas are adjacent the high shoaling areas in water depths of 1.2 to 3 m (4 to 10 ft). Large intermediate shoal areas are located in northern Berkeley Flats, San Rafael and Corte



CENTRAL BAY
AVERAGE ANNUAL SEDIMENT
DEPOSITION VOLUME
FOR THE YEARS 1855-1948
(SMITH, 1963)

NOTE: Contours display equal average annual deposition volumes in thousands of cubic yards per square mile

FIGURE 3.6

Madera Flats, Richardson Bay and along the San Francisco waterfront. The deep water channels of Central Bay including Richmond and West Richmond Channels, Raccoon Strait and the Golden Gate have shown little or no shoaling. The southern portion of Berkeley Flats has experienced moderate to high scouring.

The channel margins in Central Bay have experienced the highest rates of shoaling as a result of diminishing current and wave action. These deposition zones are too far away from the channel axis to be affected by current generated erosion and too deep to be affected by wave generated erosion. The deep water channels of Central Bay appear to be in approximate dynamic equilibrium as a result of scouring action of currents. The shallow sub-tidal flats such as Berkeley Flats also appear to be in approximate dynamic equilibrium as a result of scouring by wind-wave action.

Rubin and McCulloch (1979) investigated bedform movement in Central Bay. They found that many of the bedforms are very active under normal tidal conditions. Bedforms asymmetry was used to deduce the net direction of bottom sediment transport. In general, the transport of bed material was determined to parallel with the circulation and velocity characteristics of tidal flows. The narrow stricture at the Golden Gate produces ebb and flood jets as tidal flow accelerates to pass through the opening. These jets tend to move sediment away from the Golden Gate portal. Lower velocity flows occurring between the jets and shore were ebb dominant within the Bay and flood dominant outside. These flows tend to move sediment toward the Gate. There are boundaries between these mobile zones that form ridge lines, and one of these lines is in the area of Alcatraz Island. The asymmetrical sand waves at that location indicate that the bed is moving east to the north of the island and to the west on the south side of the island (Rubin and McColloch, 1979, Figure 10).

Extrapolating from the findings of these three studies, it appears that the dominant direction of sediment transport, whether suspended or surficial load, under normal tidal circulation is in an east-west alignment in Central Bay. Of course, under extreme events, such as high freshet conditions or coastal storm episodes, tidal circulation patterns may not dominate in determining predominate accretion and erosion patterns. However, during normal periods, sediment transport in the northern part of Central Bay appears to be oriented to the east and transport in the southern part oriented towards the west. This conclusion is supported by the reported accretion and erosion patterns of San Pablo Bay and South Bay. Movement of sediment at the bed appears to occur under conditions of flood predominance into San Pablo Bay and upstream (Conomos et al., 1979). Movement of sediment out of South Bay has been suggested by Krone (1979) and Conomos et al.(1979).

Thus, returning to the fate of material discharge at Alcatraz, the ten percent in the water column is probably about equally divided between being carried out the Gate and farther into the Bay. The portion moving into the Bay probably settles in an accretion zone near one of the channel margins. The material that is subsequential eroded from the settled deposit at the Alcatraz site and in the depression to the southeast probably moves toward the Gate with a portion shunted back into the Bay as it approaches the Gate. Using the San Francisco Bay-Delta hydraulic model studies of dredged material disposal (Schutz, 1965) to estimate movement of this transient material, those studies indicate about 47 percent of the material discharged at Alcatraz moves out the Gate and about 53 percent moves back into the Bay. The portion that moved into the Bay was distributed with 2 percent moving into San Pablo Bay, 28 percent remaining in Central Bay, 22 percent into upper South Bay and one percent into lower South Bay. The 47 percent actually equates to 24.7 percent of the initial deposit that moved from the site, and the 53 percent equates to 27.8 percent of transient deposit.

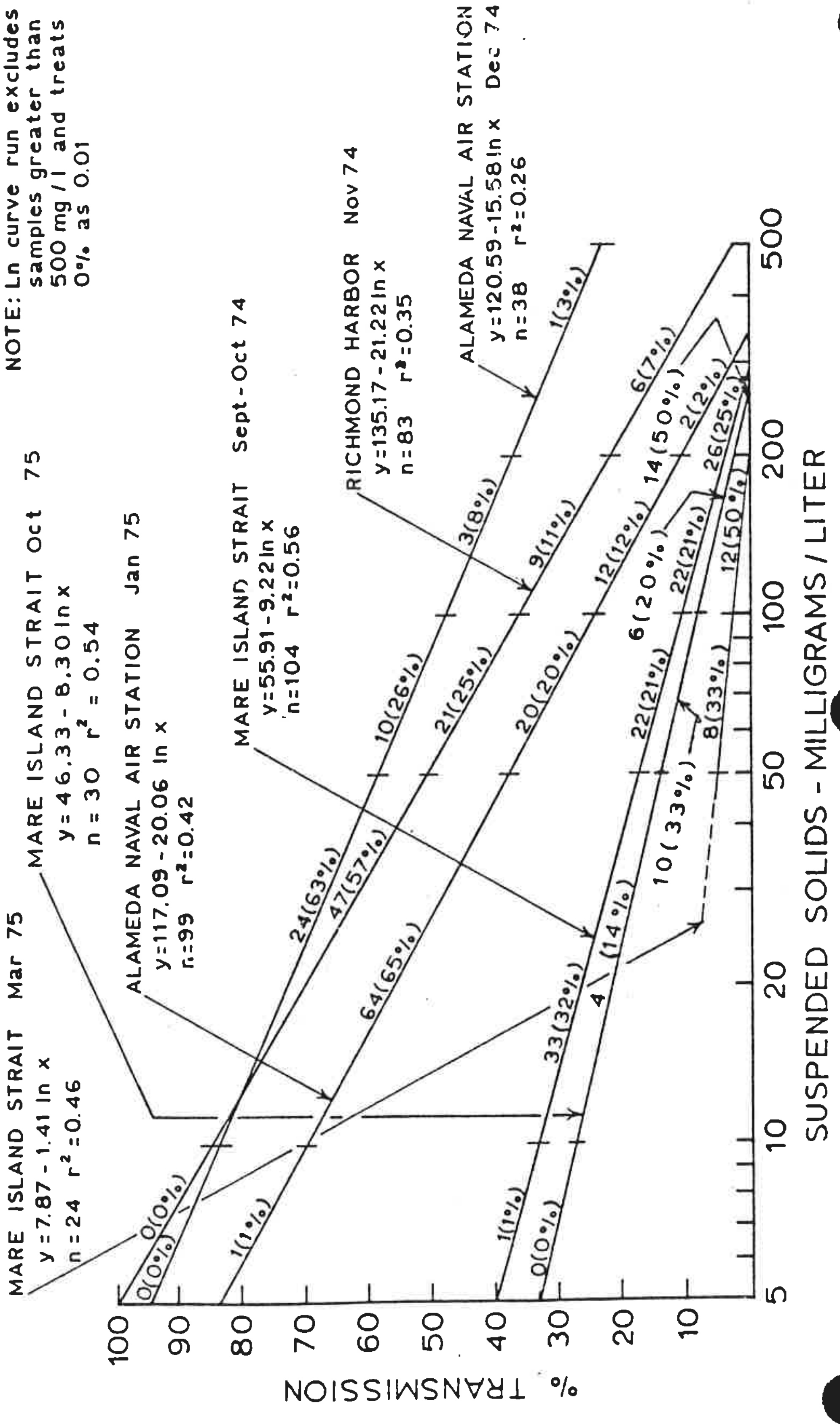
In summary, the percentage of discharged material that is retained in Central Bay is approximately 50 percent -- 37.5 percent retained at Alcatraz and 12.8 percent (7.8% from the bed and 5% in the water column) being widely distributed over the Bay. Upper South Bay (the area encompassing the Port of Oakland, Alameda and south to the San Mateo Bridge) receives approximately 6.1 percent of the transient deposit and possibly some small percentage (less than 1%) of material suspended in the water column. The amount of material that is lost from the Bay environment to the ocean is approximately 30 percent (24.7% from the transient deposit and 5% in the water column).

3.3.4 <u>Turbidity and Suspended Sediment</u>. Because it has been and continues to be a source of semantic error and confusion, it should be noted that the terms turbidity and suspended sediment are not synonymous. Turbidity is the measure of the amount of light that will pass through a liquid and describes the degree of light attenuation produced by colored dissolved materials along with particulate matter suspended in the liquid (LaSalle, 1986) The particulate matter in the liquid is often referred to as suspended solids or suspended sediments. Again, it is not quite correct to use the terms interchangeably. Suspended solids consists of both lithogenous and biogenous particles. The biogenous particles may be either living (phytoplankton, zooplankton, or bacteria) or nonliving (organic detritus)[Conomos, 1979]. Suspended sediment refers only to the bottom material (both lithogenous and biogenous) that has been physically disturbed and mixed into the water column. Planktonic matter (phytoplankton and zooplankton) may constitute a substantial potion of the suspended particles in estuarine environments and is not part of the sediment regime. Organic acids and dissolved solids can change the color and may effect the amount of light that will pass through Bay water.

Similarly, turbidity in San Francisco Bay and the level of suspended sediment within the Bay are not synonymous. High levels of solute organic acids and other substances that can inhibit light transmission are found in Bay water. Particulate matter is contributed by rivers, the ocean, sewage effluent, the atmosphere, resuspended from the substrate, and produced in situ by biological processes. The total quantity of material in solution and the amount of particulate matter in suspension at any given time is highly variable and is greatly influenced by the dynamics of San Francisco Bay. Because many factors can affect turbidity, measurements of turbidity in San Francisco Bay do not accurately define the level of suspended sediment present in Bay waters. Correlation between suspended particulate or suspended sediments and light transmission can be established for a specific location for a limited time period by calibrating simultaneous measurements of both and extrapolating relationship curves.

Measurement of light transmission and suspended solids was undertaken as part of the Dredge Disposal Study, San Francisco Bay and Estuary by the U.S. Army Corps of Engineers (USACE), San Francisco District (USACE, 1976). Transmission measurements and suspended solids measurements of water samples collected in situ were correlated to enable curve generation. Results are shown in Figure 3-7. The interdependence of turbidity and suspended solids was highly variable over time and location within the Bay. Examination of the generated curves clearly establishes the inefficacy of measuring turbidity or light transmission and drawing conclusions regarding suspended particulate levels in San Francisco Bay. Conclusions concerning suspended sediment loading based on turbidity are even less sound as suspended sediments are a subset of suspended solids. To assess turbidity and suspended sediment levels in San Francisco Bay it is essential to understand the ocean, waste, and surface runoff waters entering the Bay and the water properties, circulation, and mixing of the diverse components. An overview of circulation and mixing in San Francisco Bay is presented in Conomos, 1977. A brief description of tides and currents in San Francisco Bay is presented in section 3.3.2. Suspended particulate and suspended sediment loading of Bay waters are presented below:

Riverine inflow, mostly from the Sacramento-San Joaquin River Delta contributes 8.3 million m^3 (10.5 million yd^3) of largely lithogenous suspended sediments to the Bay annually, mostly in the winter and spring. An estimated 130 million m^3 (170 million yd^3) of sediments are resuspended annually from the shallow areas of the Bay by wind generated waves. Wind generated resuspension of sediments is most prevalent during prolonged periods of strong northwest winds in summer. Riverine inflow also carries large quantities of biogenous matter, particularly plant fragments (detritus) and freshwater phytoplankton. Warmer temperatures, increased insolation, and heightened mixing in summer months induce huge increases in the planktonic population. Late summer concentrations of phytoplankton and zooplankton in the turbidity maximum range up to 30 percent of suspended particulate matter, up from typical winter concentrations of 3 percent (Conomos and Peterson, 1973). Ocean waters that mix with the Bay waters can also contribute suspended particulate matter. An estimated 5 percent of Bay water is replaced by "new" ocean water in an average tidal cycle during the summer and over 15 percent of Bay water can be replaced in



% TRANSMISSION Vs SUSPENDED SOLIDS

FIGURE 3.7

winter months (Parker, 1972). From March to as late as September, northerly winds along the California coast generate periods of upwelling that produce episodic blooms of netplankton (Malone, 1971). Maxima of planktonic diatoms in the Central Bay often result from these offshore blooms during the upwelling period (Cloern, 1979).

As shown above, suspended sediments in San Francisco Bay contribute to the suspended particulate loading of the Bay and the suspended particles augment turbidity in San Francisco Bay. Dredged sediment disposal, in turn, is a small addition to the total suspended sediment regime of the Bay. The total annual quantity of dredged material disposed at aquatic sites within the Bay is a distant third in quantity behind natural resuspension of sediments by wind generated waves and riverine sediment inflow and is quite small in comparison (Table 3.D). Further, only part of the dredged material disposed at aquatic sites is dispersed and contributes to the Bay's suspended sediment regime. Determining the amount of sediments suspended and recirculated in the Bay from dredged material disposal at the Alcatraz site requires an understanding of the physical discharge and descent of dredged material and the mixing characteristics of the site.

Fall of dredged material through the water column and distribution on the Bay floor occurs in three distinct phases: convective descent, dynamic collapse, and passive transport. Density differential between released dredged material and the water at the receiving site enables convective descent of the dredge material to the Bay floor. Average descent velocity at the site has been measured at 1.2 m/s (3.8 ft/s). The mass of material moving downward conveys lighter particles to the bottom simultaneously. The dynamic collapse phase begins when the mass of material impacts the bottom and vertical momentum is translated to horizontal spreading. Examination of the area immediately after impact and initial settling of typical Bay mud reveals a central deposit of relatively cohesive, high density sediments surrounded by soft, low density, high water content material that behaves like a viscous fluid (SAIC, 1987c). The passive transport phase begins when erosion, gravity induced flow, or a combination of both, act to remove the material from the site.

Release of dredged material from a hopper dredge in October 1986 was monitored to determine the movement and persistence of turbidity or suspended material (SAIC, 1987a, SAIC, 1987b). The longest period of time that an elevated suspended sediment level was detectable above background levels in the vicinity of the site extended up to fifteen minutes. The maximum suspended sediment load of six monitored plumes (two coincident with strong ebb currents, two during periods of strong flood currents, and two simultaneous with slack water), reached about 60 mg/l near the surface and 120 mg/l near the bottom. Suspended sediment levels dropped to less than 40 mg/l very rapidly.

Table 3.D: ESTIMATED SUSPENDED PARTICULATE LOADING TO SAN FRANCISCO BAY WATERS[a]

Volume (m^3)[b]	Source
130,000,000	wind/wave resuspension
8,000,000	riverine inflow
unknown	netplankton[c]
2,800,000	dispersion from Alcatraz dredged material disposal site
2,010,000	Bay basin surface runoff[d]
994,000	dispersion from San Pablo Bay dredged material disposal sites
443,000	net erosion from South Bay[e]
174,000	point sources[f]
157,000	aerial[g]

---

a) annual figures irrespective of residence time.
b) volumes calculated with specific gravity value of 2.65 and saturated density of 1.3 g/cc.
c) 3% to 30% of suspended matter in turbidity maximum is living or detrital biogenous matter (Conomos and Peterson, 1977)
d) (Russel, 1982)
e) (Conomos, 1977)
f) Municipal and industrial wastewater discharges (Russel, 1982; Miller, 1986.)
g) inputs directly to surface of Bay, includes precipitation and dustfall (Russel, 1982; Miller 1986)

All plumes tracked east-west and material did not disperse significantly in a north-south direction. Calculations based on volume and suspended solids concentration measurements of the respective plumes, indicate that about ten percent of the material disperses in the water column during the convective descent and dynamic collapse phases. It is important to note that that the contribution of this suspended dredged material to the overall suspended sediment load of the water column at the site is minuscule. Assuming a 4000 m^3 disposal load, with an average sediment density of 1300 g/l, and the ten percent dispersed over an area of 1 km^2 25 m deep, the increase in suspended sediment for that volume is 0.02 mg/l. Ambient concentrations at the site can be as low as 12 to 15 mg/l near the end of a flood tide in summer when the site is dominated by relatively clear coastal waters, or up to 30 to 50 mg/l at the end of an ebb tide when the site is dominated by the sediment laden waters of San Pablo and Suisun Bays.

Dredged material retained at the site, based on monthly bathymetric surveys and logs of disposal quantities, is calculated to be 20 percent within 305 m (1000 ft) of site center and 30 percent within a 610 m (2000 ft) radius of site center. An additional 5-10 percent (7.5% is used for subsequent calculations) is estimated to have been deposited in the bathymetric depression on the east and south perimeter of the site, through gravity induced flow of the fluid fraction of material deposited during the dynamic collapse phase. The distribution of the viscous fluid mud in the vicinity of the disposal site is presented in SAIC, 1987a and SAIC, 1987b.

It follows that slightly more than half (52.5%) of the total material discharged at the site is resuspended and transported from the vicinity after initial deposition by the strong currents. The erosional capacity of the site for the high water content, fluid material (1.3 g/cc or less) is much higher than the amount of material deposited (Teeter, 1987). Combined with the ten percent lost to the water column during the convective descent phase, approximately five-eighths (62.5%) of the material discharged at the site is dispersed and transported from the site. In light of the above, it can be estimated that for an average year, five-eighths (62.5%) of the 3.8 million m^3 (5.0 million yd^3) of dredged material discharged at the site, or 2.8 million m^3 (3.7 million yd^3) is added to the Bay's suspended sediment regime by disposal of dredged material at the Alcatraz site (see Table 3.D).

The turbidity attributable to the additional sediments resuspended by dredged material disposal at Alcatraz is minor. The overall concentration of suspended sediments measured between July 1986 and February 1987 in the vicinity of the Alcatraz Disposal Site was dependent on the stage of the tide. Greatest concentrations occurred after slack low water and the lowest concentrations were observed immediately after slack high water. The influence of tidal circulation in the Bay, transporting sediment laden waters from the shallow areas of the Bay and Delta, and relatively clear waters from the Golden Gate and beyond, back and forth across the disposal site, as overwhelmingly the most important factor affecting suspended sediment load. If resuspension of sediments from the substrate was a major contributing factor to the sediment load and turbidity in the vicinity of the disposal site, then the amount of suspended sediment would be relative to tidal velocity and not tidal stage.

The oscillating flow of sediment laden waters from upstream in the Bay system and the less turbid waters from beyond the Golden Gate across the Central Bay has been widely observed (Carlson and McCulloch, 1974; Winzler and Kelly, 1985; SAIC, 1987c). A significant portion of the estimated 130 million m^3 (170 million yd^3) of sediments resuspended annually by wind generated waves can be transported miles to the ocean or miles upstream during a typical tidal excursion. In the summer months, when riverine inflow is the low and prevailing winds from the west or northwest are augmented by daily pressure gradient induced movement of air due to solar heating of air masses in the interior valley, the interface between sediment laden waters and the relative clean ocean waters is readily visible at the Bay's surface. The migration of the interface back and forth through the Central Bay can be observed from boats and planes, from elevated topographic locations around the Central Bay, and from bridges or even offices buildings in San Francisco.

Historically, most Corps of Engineers dredging in San Francisco Bay has been undertaken with hopper dredges which produce a slurried disposal material. The substitution of clamshell dredging with barge transport for a significant portion of hopper dredging in San Francisco Bay and the evolution of larger clamshell equipment have resulted in denser, more consolidated material being discharged at the site and larger loads of dredged material per discharge event. Increased density and increased volume of material per discharge event both contribute to material retention at the site and will hasten eventual filling of the site to its capacity. To reduce dredged material retention at the site, the San Francisco District of the Corps of Engineers proposed a slurry requirement on dredging in 1986. The slurry requirement was not effectively applied until mid-1987 and never became truly operational. Clamshell dredging equipment could not produce a slurry without extensive modification of plant equipment and/or methods of operation. It has been alleged that this partially implemented requirement to slurry dredged material has contributed significantly to turbidity levels in San Francisco Bay during 1986 and 1987 and that high turbidity levels adversely affected selected fisheries in the Bay during the same period.

The first comments related to increased turbidity levels in San Francisco Bay attributed to dredged material disposal practices were advanced by representatives of clamshell dredging industry in July and August 1987 (Dredged Material Management Advisory Steering Committee Meetings #3 and #4, July 29, 1987 and August 18, 1987). Representatives of the charter boat sportsfishing industry followed with charges of unexpected "muddy water" and the sudden disappearance of Striped bass from the Central Bay in September, 1987 (Dredged

Material Management Advisory Steering Committee Meeting #5, September 11, 1987). California Department of Fish and Game (CDFG) accessed Secchi disc data from three Central Bay stations for a seven year period from 1980 through October, 1987 and "partyboat" catch log data for the same years (CDFG, unpublished data, 1987). At first glance, these data may lend to the plausibility of the charges advanced by the clamshell dredgers and sportsfishermen However, any objective examination of the data clearly shows that the charges are not credible.

First, there is no correlation between level of dredged material disposal at the Alcatraz site and turbidity in the Central Bay as measured by the Secchi discs. In fact, the May-October period with the highest turbidity coincided with the lowest level of dredged material disposal activity of several years. The highest annual turbidity was present in 1983, a fact not reported by CDFG, and dredging activity was below the seven year average. Dredged material disposal in 1987 was highest of several years, yet turbidity levels measured by Secchi disc were third highest of the seven year period, below turbidity levels in 1983 and 1986. In perspective, turbidity and suspended solids monitoring at the Alcatraz site during dredged material disposal, has shown that turbidity levels at the site are influenced more by tidal oscillation of waters of varying sediment load from beyond the site than the perturbations due to dredged material disposal.

Secondly, the correlation between the Secchi disc turbidity data and sportfishing catch reports is tenuous at best. Sportfishing log reports indicated above-average fishing in 1983, yet the highest levels of turbidity were indicated by the Secchi disc data for the same time period. Reports of the worst sportfishing in the seven year period occurred in 1987, but again, turbidity levels were only the third highest of the seven year period. Fishing success was better in 1986 than 1987, but turbidity was higher in 1986 versus 1987. Sportfishing boats leaving Central Bay in September, 1987, due to poor Striped bass fishing (alleged to be caused by elevated turbidity in Central Bay) moved to the more turbid waters of San Pablo Bay and Suisun Bay and were reported locally as catching the legal limits on numerous occasions. No mention of the typical variation in distribution of fish or presence and availability of food source as a result of salinity or temperature is furnished by CDFG, although these inconspicuous factors could contribute to "poor fishing conditions" in a particular geographic area. If Striped bass were being caught in more turbid waters, it is illogical to charge that too much turbidity was the driving influence in their migrating from the Central Bay. A historical, but much less exiguous, data set for California Department of Fish and Game block 488, North San Francisco Bay (section of Bay north of the San Francisco-Oakland Bay Bridge, south of the Richmond-San Rafael Bridge, and east of the Golden Gate) summarizes party boats logs collected over a twenty year period and summarizes the block as follows:

> "The North Bay (Block 488) has been good on occasion but is highly variable. In 1944 this block accounted for 23 percent of all party boat days, in 1948 a mere one percent...Fishing is best during the summer months and almost at a standstill from September through April..."(Skinner, 1962).

It is misleading to attribute alleged September 1987 declines in the Striped bass fishery in the Central Bay to purported high turbidity in light of the above twenty years of data and events of 1987. It is even less valid to link the reputed declines in selected fisheries to dredged material disposal because of the poor correlation between turbidity measurements and disposal activity. Finally, it is highly questionable that an analysis of turbidity levels can be based on an exiguous set of Secchi disc data. The Secchi disc is a white, circular disc that is lowered into the water until it just disappears from sight. The measurement of Secchi depth is very subjective, and due to a number of extraneous influences (surface waves, atmospheric variations such as haze and clouds, and visual acuity of the observer), is little more than a qualitative estimate of water clarity (Stern and Stickle, 1978). Additionally, Secchi depth readings taken monthly, cannot gauge temporal changes such as turbidity from tidal oscillation or wind wave resuspension and limited geographic data sets cannot detect systemic changes.

There is no scientific data that supports the recent allegations of turbidity induced reduction in fisheries or of the dredged material disposal connection with purported high Central Bay turbidities. Alternately, there has been a study of disposal operations that demonstrates the short duration, limited extent increase of suspended sediments and turbidity in the immediate vicinity of the Alcatraz disposal site attributable to dredged material disposal, and that documents the back and forth, oscillation of sediment laden waters from the shallow areas of the Bay and relatively clean waters from the near ocean, across the disposal site that dominates turbidity and suspended sediment levels at the site.

3.3.5 <u>Water Quality</u>. The water quality in the Central Bay region is dominated by oceanic conditions. Semi-diurnal tidal exchange through the Golden Gate causes mixing of Bay and Pacific Ocean water twice daily. This oceanic modulation is illustrated by the stability of Central Bay water characteristics. Comparison of water parameter data including salinity, temperature, pH, dissolved oxygen, suspended solids and transparency between 1960-1964 and 1970-1970 for Central Bay indicate little change in its chemical and physical makeup (USACE, 1976, Appendix C).

Observations in the field and laboratory indicate that upon addition of organic-sulfide rich dredged material to the water column, the dissolved oxygen immediately drops to a lower level, more so than with sandy sediments (USACE, 1976, Appendix C; Chen <u>et al</u>. 1976). This reduction in the dissolved oxygen concentrations is a function of the level of oxygen-consuming materials in the sediments. The levels in navigation channel sediments are not typically sufficient

To: J. Farless@CO,T. Keesling@CO,T. Bruch@CO,H. Cheong@CO
D. Smith@CO,J. Azeveda@CO,R. Chisholm,T. Wakeman
Cc: G. Yanagihara@DE,J. Soper@DE,W. Coffey@DE,J. Harari@DE
B. Angeloni,A. Rakstins
Bcc:
From: B. Opton@PE@SPN
Subject: WATER QUALITY MONITORING OF ALCATRAZ, FY 88 O&M
Date: Monday, December 12, 1988 at 6:03:50 am PST
Attach:
Certify: N
Forwarded by:

---

1. WATER QUALITY MONITORING OF OUR MAINTENANCE DREDGING DISPOSAL OPERATIONS AT ALCATRAZ HAS BEEN REQUIRED BY THE RWQCB SINCE EARLY IN CALENDAR YEAR 1988. THE PRIMARY PARAMETERS BEING TESTED FOR ARE TURBIDITY, DISSOLVED OXYGEN, AND AMMONIA. DATA IS ALSO REQUIRED FOR EACH SAMPLE ON SALINITY, TEMPERATURE, AND PH. I HAVE IDENTIFIED FOUR FIXED SAMPLING LOCATIONS, ONE IN THE CENTER OF THE ALCATRAZ DISPOSAL SITE AND THREE AROUND THE OUTSIDE OF THE CIRCLE. AT EACH LOCATION, A SAMPLE IS TAKEN ONE FOOT BELOW THE SURFACE, ANOTHER SAMPLE AT MID-DEPTH, AND ANOTHER ONE FOOT ABOVE THE BOTTOM. FOR EACH LOCATION, THE THREE DEPTHS ARE COMPOSITED WITH THE TESTS RUN ON THE COMPOSITED SAMPLES. SAMPLING AND TESTING IS REQUIRED BEFORE, DURING, AND AFTER EACH DISPOSAL OPERATION.

2. THE FINAL FY88 SAMPLING (RICHMOND 'AFTER') WAS PERFORMED ON DECEMBER 7. WITH ALL OTHER TEST RESULTS IN EXCEPT DECEMBER 7, THE DISPOSAL OPERATIONS HAVE NOT SHOWN ANY ADVERSE IMPACT IN TERMS OF THE PARAMETERS WE ARE TESTING FOR.

3. TURBIDITY LEVELS HAVE NOT BEEN UNUSUALLY HIGH, EVEN IMMEDIATELY AFTER A DISPOSAL OPERATION. THERE IS ALSO NO EVIDENT TREND SHOWING AN INCREASE IN TURBIDITY LEVELS OVER THE LAST YEAR. D.O. LEVELS HAVE REMAINED RELATIVELY CONSTANT, WITH LITTLE OR NO IMPACT RESULTING FROM THE DISPOSAL OPERATIONS.

4. EVEN IF THERE WAS A TREND FOR THE "DURING" OR "AFTER" TESTS, THE DATA COULD NOT BE CONSIDERED HIGHLY RELIABLE SINCE THE DISPOSAL SITE IS ALMOST ALWAYS IN USE BY SOMEBODY, AND OUR "AFTER" TESTS ARE QUITE OFTEN SOMEBODY ELSES "DURING". THE RWQCB IS AWARE OF THIS. TO SET UP A MORE SOPHISTICATED SAMPLING PROGRAM, YOU WOULD ALMOST HAVE TO STATION A VESSEL AT THE DISPOSAL SITE FOR A LONG PERIOD OF TIME. THIS WOULD BE QUITE COSTLY AND IS NOT BEING REQUIRED BY THE RWQCB.

5. I AM NOW IN THE PROCESS OF SETING UP THE FY 89 TESTING PROGRAM.

BARNEY O.

[redacted]

Oakland
before

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April 14, 1988

1-2-3

DEPARTMENT OF THE ARMY
San Francisco District, Corps of Engineers
211 Main Street
San Francisco, CA 94105-1905

ATTN: Barney Opton, CESPN-PE-R
SUBJ: DACW07-88-D-0011 WO# 0001
Sampling Results for April 6, 1988

The following table lists the results for the surface water samples collected in and around the Alcatraz Disposal Site on the morning of April 6, 1988.

Site # Location	1 Center of Disposal Site	2 200′ to N.W. of Boundary	3 200′ to S.W. of Boundary	4 200′ to S.E. of Boundary
Lambert X	1,444,568	1,443,718	1,443,718	1,445,368
Lambert Y	486,827	487,627	485,977	485,977
pH	8.30	8.25	8.06	8.27
Turbidity NTU	8.2	12.0	13.0	7.9
Ammonia mg/L	0.13	0.09	0.13	0.21
D.O. mg/L	6.2	9.8	9.1	6.8

A map indicating the sampling locations is enclosed.

If you have any questions regarding this information, please call John Vlastelicia or myself.

Sincerely,

Karl Krcma

Karl V. Krcma, P.E.
OGDEN BEEMAN & ASSOCIATES, INC.

Enclosure

ENCL 1

Ogden Beeman & Associates, Inc.

Consulting in the development of ports, waterways, and marine facilities

522 S.W. 5th Avenue
Portland, Oregon 97204
Tel. (503) 223-8254

May 5, 1988

Oakland odm
During
1-2-5 ✓

DEPARTMENT OF THE ARMY
San Francisco District, Corps of Engineers
211 Main Street
San Francisco, CA   94105-1905

ATTN: Barney Opton, CESPN-PE-R
SUBJ: DACW07-88-D-0011 WO# 0001
Sampling Results for April 28, 1988

The following table lists the results for the surface water samples collected in and around the Alcatraz Disposal Site on the morning of April 28, 1988.

Site #	1	2	3	4
Location	Center of Disposal Site	200′ to N.W. of Boundary	200′ to S.W. of Boundary	200′ to S.E. of Boundary
Lambert X	1,444,568	1,443,718	1,443,718	1,445,368
Lambert Y	486,827	487,627	485,977	485,977
pH	7.81	7.54	7.67	7.80
Turbidity NTU	15.0	5.6	4.6	5.5
Ammonia mg/L	<0.10*	0.11	<0.10*	0.10
D.O. mg/L	8.2	7.7	7.7	8.0

* Results less than detection limit of 0.10 mg/L

A map indicating the sampling locations is enclosed.

If you have any questions regarding this information, please call John Vlastelicia or myself.

Sincerely,

Karl V. Krcma

Karl V. Krcma, P.E.
OGDEN BEEMAN & ASSOCIATES, INC.

Enclosure

Ogden Beeman & Associates, Inc.

Consulting in the development of ports, waterways,
and marine facilities

522 S.W. 5th Avenue
Portland, Oregon 97204
Tel. (503) 223-8254

Oakland OdM af.
1-2-3 ✓

June 9, 1988

DEPARTMENT OF THE ARMY
San Francisco District, Corps of Engineers
211 Main Street
San Francisco, CA 94105-1905

ATTN: Barney Opton, CESPN-PE-R
SUBJ: DACW07-88-D-0011 WO# 0001
Sampling Results for June 1, 1988

The following table lists the results for the surface water samples collected in and around the Alcatraz Disposal Site on the morning of June 1, 1988.

Site #	1	2	3	4
Location	Center of Disposal Site	200' to N.W. of Boundary	200' to S.W. of Boundary	200' to S.E. of Boundary
Lambert X	1,444,568	1,443,718	1,443,718	1,445,368
Lambert Y	486,827	487,627	485,977	485,977
pH	7.49	7.24	7.27	7.38
Turbidity NTU	16.0	13.0	13.0	14.0
Ammonia mg/L	<0.10*	0.10	0.10	<0.10*
D.O. mg/L	8.5	8.7	8.5	8.4

* Results less than detection limit of 0.10 mg/L

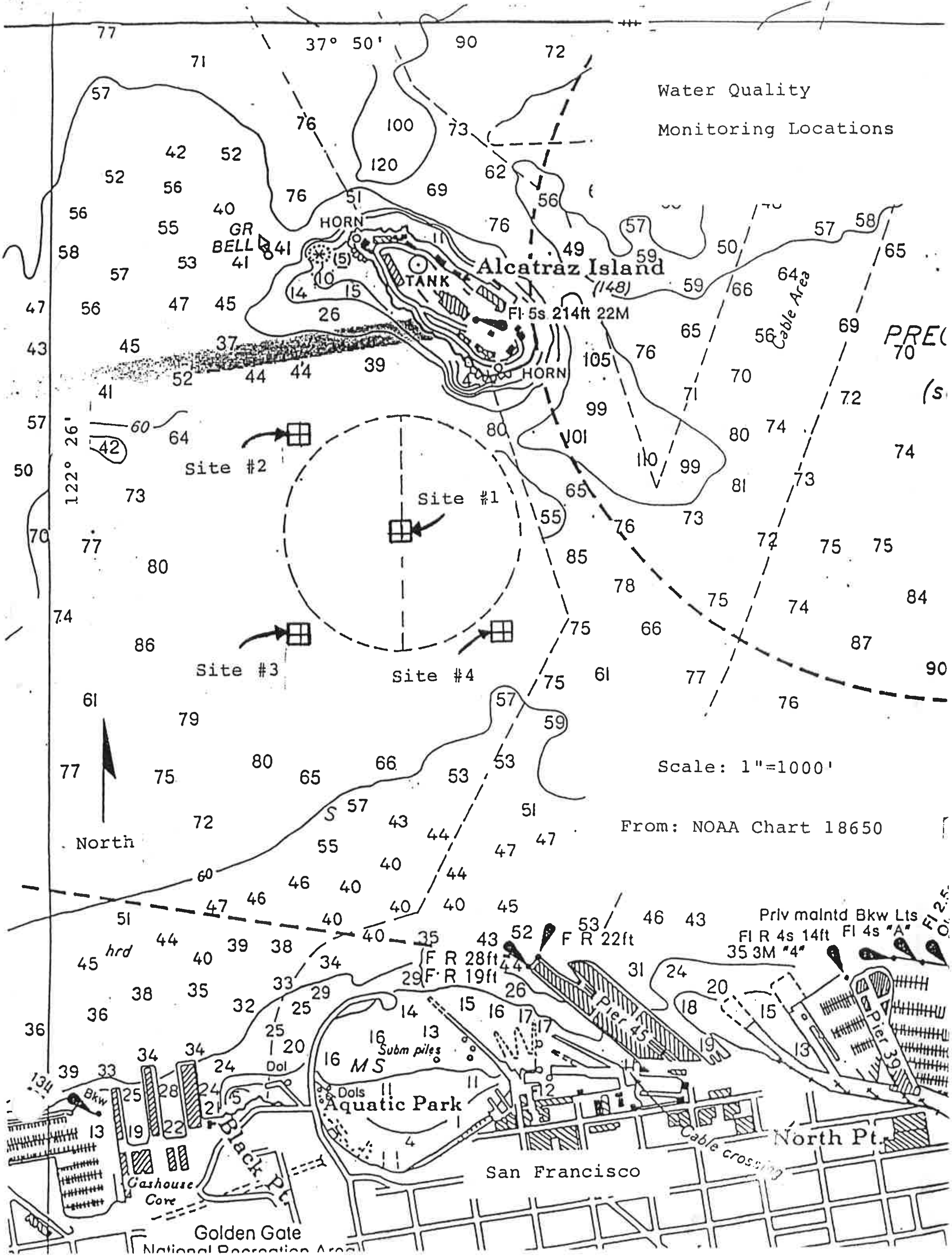
A map indicating the sampling locations is enclosed.

If you have any questions regarding this information, please call John Vlastelicia or myself.

Sincerely,

Karl V. Krcma, P.E.
OGDEN BEEMAN & ASSOCIATES, INC.

Enclosure


Water Quality
Monitoring Locations
37° 50'
122° 26'
Alcatraz Island
(148)
TANK
HORN
HORN
GR
BELL
Fl 5s 214ft 22M
Cable Area
PREC
Site #1
Site #2
Site #3
Site #4
Scale: 1"=1000'
From: NOAA Chart 18650
North
hrd
F R 28ft
F R 19ft
F R 22ft
Prlv maintd Bkw Lts
Fl R 4s 14ft
35 3M "4"
Fl 4s "A"
Pier 45
Pier 39
Subm piles
MS
Dols
Dol
Aquatic Park
Bkw
Gashouse
Cove
Black Pt
Cable crossing
North Pt
San Francisco
Golden Gate
National Recreation Area

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105 - 1905

COPY

10 August 1989

ATTN. MIKE CARLIN
REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION, OAKLAND

MIKE,

ATTACHED ARE THE RICHMOND HARBOR O&M WATER QUALITY MONITORING TEST RESULTS FOR "DURING" AND "AFTER".

Barney O.
BARNEY OPTON

INCL:

15 June 89
20 July 89

Ogden Beeman & Associates, Inc.

Consulting in the development of ports, waterways, and marine facilities

310 S.W. 4th Avenue
Portland, Oregon 97204
Tel (503) 223-8254 Fax (503) 222-0657

June 28, 1989

DEPARTMENT OF THE ARMY
San Francisco District, Corps of Engineers
211 Main Street
San Francisco, CA 94105-1905

RICHMOND O&M
"DURING"

ATTN: Barney Opton, CESPN-PE-R
SUBJ: DACW07-88-D-0011 WO# 0007
Sampling Results for June 15, 1989

The following table lists the results the water samples collected in and around the Alcatraz Disposal Site on the morning of June 15, 1989. Three samples were collected at each site: 1) One foot below the surface, 2) Mid-point, and 3) One foot from the bottom. Dissolved oxygen was tested on the bottom (+1') sample. The samples were composited and analyzed for turbidity and un-ionized ammonia.

Site #	1	2	3	4
Location	Center of Disposal Site	200' to N.W. of Boundary	200' to S.W. of Boundary	200' to S.E. of Boundary
Lambert X	1,444,568	1,443,718	1,443,718	1,445,368
Lambert Y	486,827	487,627	485,977	485,977
Time	9:55	9:00	9:15	9:30
Turbidity NTU	94.0	9.8	8.8	7.6
Un-ionized Ammonia mg/L	<0.01*	<0.01*	<0.01*	<0.01*
D.O. mg/L	6.2	7.4	7.2	7.4

* Results less than detection limit of 0.01 mg/L

A map indicating the sampling locations is enclosed.

Please note that a dump scow deposited a load of material in the vicinity of the center of the site at approximately 9:50. Sample Number 1 was taken from the center of the site immediately afterward.

If you have any questions regarding this information, please call John Vlastelicia or myself.

Sincerely,

Karl V. Krcma, P.E.
OGDEN BEEMAN & ASSOCIATES, INC.

Enclosure