# Cost-Effective Sediment Remediation at Port of Richmond on San Francisco Bay

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## INTRODUCTION

This paper presents a case study of a cost effective sediment remediation project that occurred in 2005/2006 at Operable Unit No. 2 (OU2) (Figure 1) within the Point Potrero Marine Terminal (PPMT) at the Port of Richmond (the Port). The Port employed an innovative capping strategy for containing contaminated sediments in a marsh area. The paper discusses aspects of the cap design, complexities involved with environmental permitting, and contractor means and methods employed during construction. This paper concludes with a summary of consulting and construction contracting methods and cost. The project was completed by the Port with consulting assistance from Weiss Associates, ANWest Engineering, and Fugro West. Dutra Marine Construction performed construction activities.

## SITE HISTORY AND PROJECT OVERVIEW

The site was formerly a tidal mudflat. In 1942, the U.S. Government appropriated PPMT for wartime shipbuilding and the area was developed into a shipyard by Henry Kaiser in 1941 and 1942 to build Ocean, Liberty, Cargo, C4 Transports, Frigates and Victory ships. Shipyard No. 3 was one of the four Richmond shipyards which together constituted the largest World War II shipyard in the USA, where 747 ships were built between 1942 and 1947.

The United States Maritime Commission (USMC) retained control of PPMT from the end of the war until 1962. During this period, the site was used for ship receiving, recycling, salvaging and scrapping decommissioned ships and other metal recycling activities (Figure 2). The City of Richmond purchased the site from the USMC in 1968. In 1968, an inlet was dug into the fill material along the shoreline to facilitate ship graving. Ships were pulled into the inlet by a winch and the area was then dammed and dewatered and the ships were dismantled. Significant environmental contamination occurred in the inlet area, which is referred to as OU2.

Environmental site investigation began in 1984, when the California EPA, Department of Toxic Substance Control (DTSC) required a site cleanup. A Remedial Action Plan was prepared in 1996 which divided PPMT into three separate remediation sub-areas, referred to as operable units. Sediment remediation at OU2 is the focus of this paper. OU2 includes 1.6-acres upland shoreline and 1.2-acres of marsh. The Port prepared a Feasibility Study Remedial Action Plan (FSRAP) that recommended construction of a containment cap over the contaminated area to prevent migration of contaminants and infiltration of rainwater. Mercury, lead, zinc, and total PCBs were identified as the sediment constituents of concern. The Effects Range – Medium sediment quality criteria, developed by the National Oceanic and

Atmospheric Administration (NOAA), were used as the basis for sediment cleanup goals.

The Port prepared a Remedial Design and Implementation Plan (RDIP) for construction of three containment caps across the OU2. A 2.5-foot thick clean bay mud cap was selected for the marsh area. Engineered fill and riprap section was recommended for the shoreline area. An asphalt concrete section was selected for the upland area.

Dutra Marine Construction (Dutra) commenced construction on July 8, 2005 and finished on May 14, 2006. 6,700 cubic yards of contaminated sediment and 100 metric tons of scrap metal were removed from the marsh and 1,400 feet of adjacent shoreline. Sediments were removed via a combination land-based dragline dredge and water-based derrick barge with clamshell bucket. Contaminated dredge spoils were stabilized onsite and used as sub-base material for the asphalt concrete parking lot. Contaminated sediments remaining in place were capped with clean bay mud dredged from the City of Martinez. The salt marsh area was revegetated and the shoreline was repaired and armored.

## SUBAQUEOUS CAP DESIGN

The OU2 remedial action objective was to protect human health and the environment by preventing human and benthic exposure to contaminants. The inlet area was suspected to contain vast amounts of scrap metal, an asphalt deck, and other subsurface obstructions. Drilling was refused at depths of approximately 4 to 5 feet during environmental geotechnical investigations. Chemical concentrations at these depths exceeded site cleanup goals and the vertical extent of contamination could not be determined. The Port participated in a remediation project at a site directly adjacent to OU2 where a conventional "dig and chase" approach was employed. The volume of waste generated by this project was orders of magnitude greater than estimates. The material was placed on a 5-acre 30-foot impoundment at the adjacent site and was a frequent topic in the local media and government. The Port was reluctant to excavate with an unknown depth of contamination.

The Army Corps developed a numerical model for determining the design thickness of a cap to prevent migration of impacted material into benthic environments. The numerical model, *Model for Chemical Containment by a Cap*, is contained in Appendix B of the publication Guidance for Subaqueous Dredged Material Capping, June 1998 (Figure 3) and was developed by University of Louisiana for the U.S. Environmental Protection Agency and the Army Corps. The model was utilized at the Port to estimate the minimum cap thickness in the marsh area that would prevent sediment concentrations at the water/sediment interface from exceeding OU2 cleanup goals within a 100 year cap life.

Pore water is the significant driving force for mass transfer in sediments. Tidal flux affects most of OU2. The interaction of pore water and sediments is described in the model by the chemical-specific partitioning coefficient, Kd. A supplemental data-gathering program was undertaken to evaluate sediment characteristics necessary to determine a site-specific Kd value for each of chemicals of concern. Cores were collected in four-inch aluminum core barrel with stainless steel cutter-head and catcher. The core interval at three to four-feet was isolated and homogenized. Pore water was isolated in a centrifuge. Samples were then analyzed for zinc, lead, mercury and total PCBs. Chemical concentrations in the pore water and sediment were then equated to determine the Kd for each chemical of concern.

A cap thickness of 1.5 feet was predicted to prevent chemical concentrations at the cap/water interface from exceeding site cleanup goals over the 100 year design life. A design cap thickness of 2.5 feet was selected to allow a sufficient safety factor to account for variations in chemical concentration, cap consolidation, and variation in cap permeability.

The Port hoped to develop a performance specification that the cap material would be (1) approved for unconfined aquatic disposal in the San Francisco Bay and (2) that the material would meet the necessary physical and chemical criteria. The borrow source would not have been specified—allowing the dredging contractors flexibility to obtain the material. Instead, permitting agencies required identification of borrow material before environmental permits were issued; so the Port identified sought and specified cap material available to all bidders. The San Francisco Bay Dredge Material Management Office (DMMO) is an interagency task force that reviews dredging and fill projects in the San Francisco Bay. The DMMO suggested options for borrow sources, which were screened for applicability. The Martinez Marina is a recreational marina located 25 miles northeast of Richmond. The mud was dried in two large containment cells. A workplan was submitted to the DMMO outlining the borrow source location and proposed testing. Samples were collected and analyzed and a report was submitted to the DMMO. Samples were collected from the mud and were analyzed for a full range of environmental contaminants. The samples were combined into one composite sample and tested for priority metals according to EPA Method 6010B, mercury according to EPA 7471A, PCBs according to EPA Method 8082, PAHs according to EPA Method 8270C, and pesticides according to EPA Method 8081. Chemical analysis results for the composite samples were compared to values for Wetland Surface Material presented in the *Draft Staff Report, Beneficial Reuse of Dredge Materials, Sediment Screening and Testing Guidelines* prepared by San Francisco Bay Regional Water Quality Control Board in May 2000. The samples were also analyzed for physical characteristics (grain size, total organic carbon and specific gravity). DMMO approved the dredging and found the Martinez Marina dredge material to be suitable for unconfined aquatic disposal (subaqeous cap) at OU2.

The City of Martinez and the Port negotiated a price and resolved the coordination and permitting issues. The construction contractor documents specified the material location and quantity, the City of Martinez administrative requirements, the truck haul routes and the transportation mitigation. The cost to purchase the material from the City of Martinez, permitting fees, excavation costs, transportation costs and placement costs were combined into a single line item in the contract's cost estimate The Dutra unit cost to excavate, transport and place 4,800 cubic yards of mud was $85 per cubic foot.

## PERMITTING CHALLENGES

Environmental permits were obtained from the United States Army Corps of Engineers (the Army Corps), the San Francisco Bay Conservation and Development (BCDC), San Francisco Regional Water Quality Control Board (RWQCB). The following resource agencies were consulted: the United States Department of Fish and Wildlife Service (FWS), the National Oceanographic and Atmospheric Administration Fisheries Division (NOAA), the San Francisco Bay Dredge Material Management Office (DMMO), and the California Department of Fish and Game.

Permit challenges included offsite mitigation requirements for dredging a salt marsh, demonstrating no significant impacts to Salt Marsh Harvest Mouse (the Mouse) and eel grass colonies, and obtaining a BCDC development permit.

A Joint Aquatic Resource Permit Application (JARPA) was submitted to permitting agencies. Submittal of the JARPA was the first step in permitting the project The JARPA enables permit applicants to prepare one permit application. JARPA is a useful tool that streamlines the submittal of the initial permit application; still providing for each permitting agencies' resource-specific comments. .

The Army Corps authorization was required under Section 404 of the Clean Water Act for dredging, sub aqueous cap placement and shoreline improvements. The Army Corps used a Nationwide Permit 38—Cleanup of Hazard and Toxic Waste Site (NWP 38). The project involved excavation of a jurisdictional wetland regulated under the Rivers and Harbors Act and the Clean Water Act, an activity that can enact offsite mitigation under both these statutes. The project was undertaken to remove and contain impacted sediments. During the permit process, the Port and its consultants demonstrated that the project would be a temporary disturbance but, would improve overall aquatic habitat. The habitat value of the area was limited by contamination, small size, and relative marsh isolation. The Port agreed to mitigation measures to protect the aquatic environment during construction and a revegetation and monitoring plan was prepared to encourage, wetland vegetation, which included monitoring and removing invasive species. The Army Corps agreed that the project would improve onsite habitat and did not require offsite mitigation. The Army Corps consulted FWS to seek their concurrence on the Army Corps "Not likely to adversely affect" (NLAA) determination for regulated species. FWS concurred with the NLAA for all species except the Mouse, a state and federally protected species, as the project area comprised a small salt marsh habitat, and the presence of the Mouse could not discounted FWS presented two options: saturation trapping of the project area to discover the or assume the Mouse is present and request a formal Biological Opinion by FWS and provide suitable offsite compensation for the loss of Mouse habitat. Either of these options would have caused a minimum project delay, due to the timing of the dredging work window of one year. The Port contracted a biologist licensed to trap the Mouse with specific expertise in salt marsh habitat and associated species, to review the project area. The biologist prepared a brief report to supplement the habitat assessment contained in the JARPA, which was submitted to FWS. It concluded that the inlet is not expected to support the Mouse because: (1) the inlet is artificial and not a remnant of a larger salt marsh supporting a relict Mouse population; (2) the existing salt marsh vegetation is too sparse to support the Mouse; (3) there is no suitable habitat occupied by the Mouse near the site; and (4) intense predation and limited cover would prevent establishment of a viable population of the Mouse should they make their way to the inlet. The report enabled FWS to concur with the Army Corps NLAA determination.

The Army Corps consulted NOAA Fisheries at the same time. NOAA expressed concern that the project was adjacent to a significant population of eel grass and that dredging and filling of the small patches of eel grass in the project area could reduce that habitat or negatively impact the adjacent larger eel grass colony. A NOAA biologist visited the site days after informal consultation was initiated, and suggested options for mitigation measures to limit impacts and to encourage redevelopment of the eel grass colony. NOAA suggestions were considered in the cap borrow source screening. The physical characteristic of the bay mud in the project area (total organic carbon, density, and grain size distribution) were compared against the physical characteristics of the potential boring source clean mud that would be used to form the subaqueous cap. NOAA concluded that the project would improve the habitat conditions in the project area and the project was not likely to impact Essential Fish Habitats.

The BCDC regulates activities in the waters of the San Francisco Bay, and upland areas extending 100-feet perpendicular to the mean high water line (or five feet mean sea level for wetlands.) A nonmaterial amendment to an existing administrative permit was obtained from BCDC. The preferred alternative selected in the FSRAP was to drive a sheet pile wall at the mouth of the inlet and fill the area to match surrounding elevations. This alternative would have permanently filled the inlet, allowing the Port to reclaim 2.5 acres of usable marine terminal while placing only 0.9 acres fill. The concept was taken to 50% design so that a permit application could be submitted. BCDC, responded, indicating their Commission could not approve the project due to nonconformance with Bay fill policies. BCDC policy is set forth in the San Francisco Bay Plan (“Bay Plan”), which includes the San Francisco Seaport Plan (“Seaport Plan”). The Seaport Plan designates port priority and marine terminal use areas, including estimates of bay filling required to maintain sufficient terminal space for regional cargo capacity. The Seaport Plan proposes a change in cargo type at the Port from neo bulk to container and allots 33 acres of fill for this conversion. The Port sought permission from BCDC to fill 0.9 acres, as the first fill request of the 33 acres proposed in the Seaport Plan. Since the Seaport Plan was written, the Port of Oakland had established capacity to meet container cargo demand. BCDC indicated that they could not approve the fill as the area would not be used for container cargo. BCDC suggested that the Port request and fund an amendment of the Seaport Plan to reflect the area’s current and future use as a neo bulk cargo terminal. Amending the Seaport Plan would have delayed the environmental remediation project at least one year. BCDC suggested that the Port consider a no-net-fill subaqueous cap whereby the project could proceed on schedule, the marsh would be restored, and the Port would not gain additional land. The Port then designed a cap where final site elevations matched original site elevations, thus resulting in no fill to the Bay.

## REMEDIATION CONSTRUCTION SUMMARY

This section summarizes construction means and methods. Site preparation include contractor mobilization, clearing/grubbing, debris removal, and construction of the dredge material containment area. Graded areas were cleared of all grass, brush, roots, rubbish, and debris. 105 tons of metal debris from clearing and dredging activities were removed and recycled (Figure 4). Dutra constructed a dredged material containment area by grading two bermed containment cells to facilitate unloading of dredge material and processing the material with lime, while preventing discharge of any decant water. The containment area was constructed on the peninsula and covered the area except for throughway to permit crane and equipment access.

A slow-cycle dredge process was employed to remove free water. The minimum time between lifting the laden clamshell bucket and its deposition in the containment area was 90 seconds. A turbidity barrier was placed around the project area during dredging and cap placement. The purpose was to limit the migration of suspended sediments through the use of a semi-permeable barrier around the construction zone. An American Boom and Barrier Corp., Model Mark II High velocity Floating Turbidity Barrier was used. Background turbidity levels were measured once every 24 hours at three locations along the perimeter of the dredging area, outside the turbidity barrier. All turbidity monitoring indicated that turbidity levels never exceed 50 nephelometric turbidity units.

Two containment cells were utilized to process the dredge material. Both cells were graded such that water was contained on all sides by earthen berms. Wet dredge material was unloaded into the first cell. The dredge material was then pushed to the second cell with blades and loaders, where it was mixed with a fast acting lime dewatering agent. The cells could contain approximately 1,000 cubic yards of wet mud.

Two dredging methods were employed at the site: water based for the Bay side and land-based for the inlet side. The Bay side is at the mouth of the inlet where it opens to the Richmond Harbor and is beyond the reach of land based equipment. Bay side dredging was performed with a DB3-type clamshell dredge ("the Beaver"). The Beaver (Figure 5) employed a five cubic yard cable arm environmental bucket to minimize turbidity, mounted on a 1,000-ton flat deck derrick barge. A Trojan type tending tugboat was used to position the Beaver, and a survey boat assisted with dredge tracking. A total of 2.5 feet of contaminated sediment were removed from an approximately 16,500 square foot area. Approximately 1,550 cubic yards of contaminated sediments were removed with the Beaver and placed into the containment cells for treatment.

Dredging of the inlet side was accomplished using a Bucyrus Erie 65D Dragline Crane with environmental clamshell bucket ("the 65D"). The 65D was a track-mounted crane, equipped with a three cubic yard cable arm bucket. The 65D was positioned at different locations around the perimeter of the inlet. A 2.5 foot cut was dredged across an 89,855 square foot area. Approximately 3,450 cubic yards of contaminated sediment were placed directly in the containment cells. Excavation of the revetment area was performed with the 65D and conventional earthmoving equipment. A 2.5 foot cut was made across a 19,345 square foot area. Approximately 1,750 cubic yards of contained sediment were removed from the revetment and placed in the dredge material containment area.

The sub aqueous cap was formed by placing a 2.5-foot layer of clean bay mud across all areas of OU2 inlet, extending from the revetment to the limit of dredging. Approximately 4,715 cubic yards of clean bay mud was placed. The clean bay mud was excavated from the City of Martinez dredge cells using typical earthmoving equipment and was transported to OU2 in 15-cubic yard dump trucks. The clean bay mud was placed in a similar sequence by which the dredging occurred. Most clean bay mud was placed using the 65D. The Beaver was used to place bay mud in the Bay side of the Site that could not be accessed from land.

Approximately 1,400 feet of OU2 revetment were treated with riprap. The revetment area was excavated to enable riprap placement while enacting no-net-fill. After excavation, a revetment section was placed consisting of a half-foot of clean bay mud, a one-foot of aggregate base, a geotextile, a half foot of rock backing and a 18 to 24 inch layer of riprap.

Dredge material was processed to engineered fill by the addition of a lime dewatering agent and the removal of large stones or debris and placed in the upland areas to form a subgrade. Fill was placed in layers of eight inches or less in loose thickness and compacted with a sheepsfoot roller. The engineered fill was moisture-conditioned to between optimum and two percent above optimum moisture content and compacted to at least 90 percent relative compaction in accordance with American Society for Testing Materials (ASTM) D1557. The top six inches of engineered fill below the aggregate base layer was compacted to at least 95 percent relative compaction. Field density tests were performed by an independent Port Geotechnical Engineer to verify that moisture content, dry density, relative compaction, and maximum density of the material conformed to the specifications.

Earthwork and grading activities were substantially complete prior to the 2005/2006 rainy season. Erosion and stormwater controls were used for the duration of the 2005/2006 rainy season. A layer of aggregate base rock was placed over the subgrade at the north side of the OU2 before rain started to contain dredge spoils. A layer of clean bay mud was placed and compacted over the peninsula area before the onset of the rainy season. Stormwater controls at the Site consisted of silt fences and straw waddles placed along the top of the shoreline around the perimeter of the Site (Figure 6). Shorelines were protected using a geotextile and geogrid to prevent erosion. Silt fences and straw waddles were placed around catch basins.

The upland cap comprises three functional layers: treated bay mud subgrade, aggregate base, and asphalt concrete. Once the grading and the subgrade treatment were accomplished, a layer of crushed rock conforming to the California Department of Transportation (CalTrans) standards for Class 2 aggregate base was placed in a nine-inch layer across the Site. The aggregate base was spread and compacted to a density of not less than 95 percent relative compaction. It is estimated that approximately 2,995 tons of aggregate base rock was placed. Finally, a two-inch layer of asphalt concrete conforming to CalTrans specifications for Type B asphalt concrete were placed across the entire OU2 area. The asphalt concrete was compacted to a density of not less than 95 percent relative compaction. It is estimated that a total of 782 tons of asphalt concrete were placed.

The inlet salt marsh was re-vegetated (Figure 7) with a native seed mix consisting of Pickle weed (Salicornia virginia), Alkali heath (Frankenia salina), Marsh rosemary (Limionium californica), Alkali barley (Hordeum depressum), Fat hen (Atriplex patula) and Alkali rush (Scriptus maritimus).

## CONTRACTING AND COST

The Port executed two contracts to complete the project: a remedial design contract and construction contract. Weiss Associates was engaged on a time and materials / not to exceed basis. All specialty consultants were contracted through Weiss Associates. Dutra Marine Construction was engaged in a lump sum contract in accordance with CalTrans Standard Specifications. There was no re-measurement of materials once work began. The total project costs are summarized below.

**Table 1. Total Project Costs**

| Item | Cost | Percent of Total |
|---|---|---|
| Investigation | $188,200 | 9% |
| Engineering Design | $181,400 | 9% |
| Environmental Permitting | $56,800 | 3% |
| Construction | $1,535,000 | 75% |
| Oversight and Documentation | $79,900 | 4% |

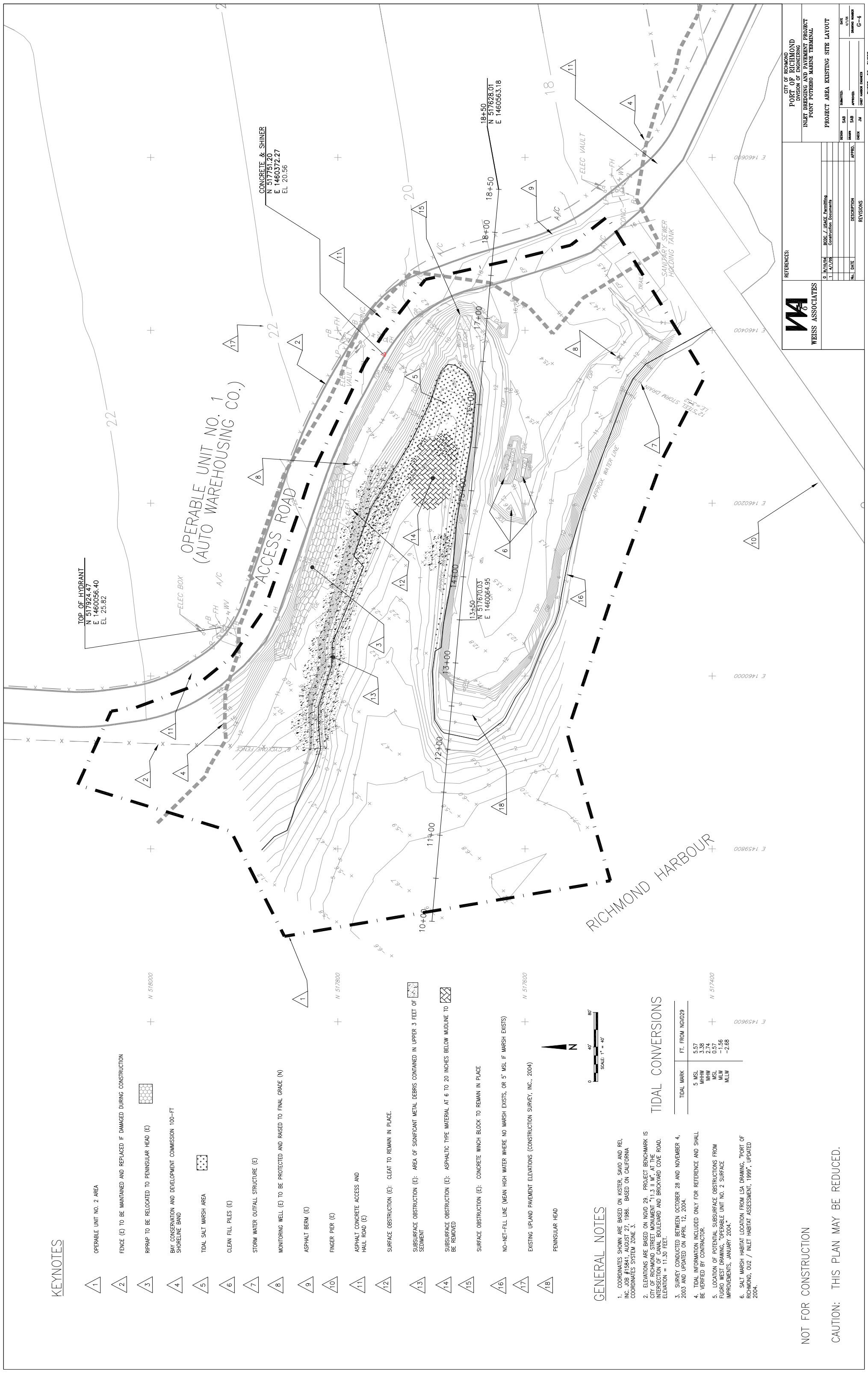


Figure 1. Site Layout, Operable Number 2, Sediment Remediation Area, Port of Richmond

Figure 2. Photograph of Former Shipyard No. 3 Scrap Area (OU2 at top left).

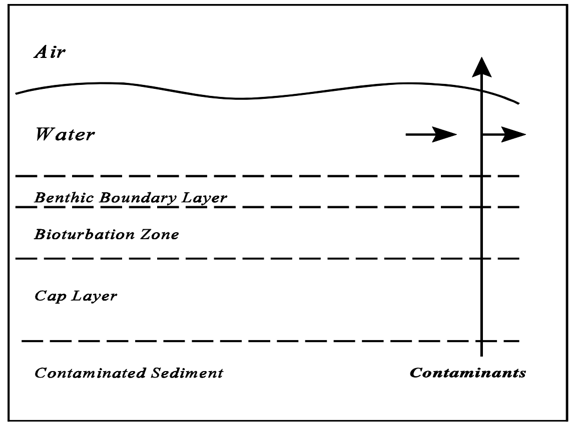


Figure 3. Conceptual Contaminant Transport through Capping Layers

Figure 4. Removal of Ship Hull During Dredging Activities.

Figure 5. Positioning of Derrick Crane and Barge. Temporary Turbidity Barrier in Foreground

Figure 6. View of Inlet During High Tide. Preliminary Erosion Controls Evident.

Figure 7. Development of Wetland Vegetation