PORT HUENEME CONFINED AQUATIC DISPOSAL CELL DESIGN AND CONSTRUCTION
PORT HUENEME, CALIFORNIA

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ABSTRACT

Located approximately 60 miles northwest of Los Angeles, the Port of Hueneme is the only deep-water port between Los Angeles and the San Francisco Bay area and is the United States. Port of Entry for California's central coast region. The Port of Hueneme Harbor consists of berths owned by the Oxnard Harbor District (OHD) and U.S. Navy and a Federal Channel portion that is maintained by the U.S. Army Corps of Engineers (USACE). The OHD and U.S. Navy wharves were last dredged more than 10 years ago and have since accumulated between 1 and 3 meters of contaminated sediment along these wharf faces. Several open-water areas within the USACE Federal Channel also contain contaminated sediments. These sediments were chemically characterized and found to be unsuitable for open-ocean or beach disposal, due in most cases to elevated concentrations of metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethane (DDT) and its breakdown products, and organotins, such as tributyltin. Collectively, the contaminated sediments from the OHD, U.S. Navy, and USACE areas of Port of Hueneme Harbor total approximately 240,000 cubic meters.

In 2007, the OHD, U.S. Navy, and USACE began a collaborative effort to design and obtain regulatory approval for the construction of a Confined Aquatic Disposal (CAD) facility as a mechanism for managing the contaminated sediments within Port of Hueneme Harbor. Material excavated to create the CAD facility was used for nourishment on a beach located immediately outside the harbor, and clean cap material will come from uncontaminated areas within Port of Hueneme Harbor. This paper describes the major engineering and regulatory tasks associated with the CAD facility, focusing on the engineering design aspects of the project as well as a reporting on the current progress to date. Project construction began in December of 2008 and will be concluded in June of 2009.

INTRODUCTION

Port of Hueneme Harbor is located approximately 60 miles northwest of Los Angeles along the California coastline (Figure 1). The Oxnard Harbor District (OHD), U.S. Navy, and U.S. Army Corps of Engineers (USACE) are all responsible for maintaining authorized navigation depths in different parts of Port of Hueneme Harbor. The current dredging project is required as a maintenance action to restore authorized navigation depths within the USACE Federal Channel and areas adjacent to the OHD and U.S. Navy wharves (Figure 2).

The overall goal for this project was to remove contaminated sediments from navigation areas and dispose of them in a cost-effective, yet environmentally protective, manner. Because the contaminated sediments are not suitable for beach or open-ocean disposal, the only available and permitted off-site disposal location is an upland landfill; however, the costs of dredging, offloading, dewatering, rehandling, transporting, and disposing of the dredged material at an upland landfill was deemed prohibitive. As a result, on-site management options were evaluated and the construction of a CAD facility was selected as the best available alternative.

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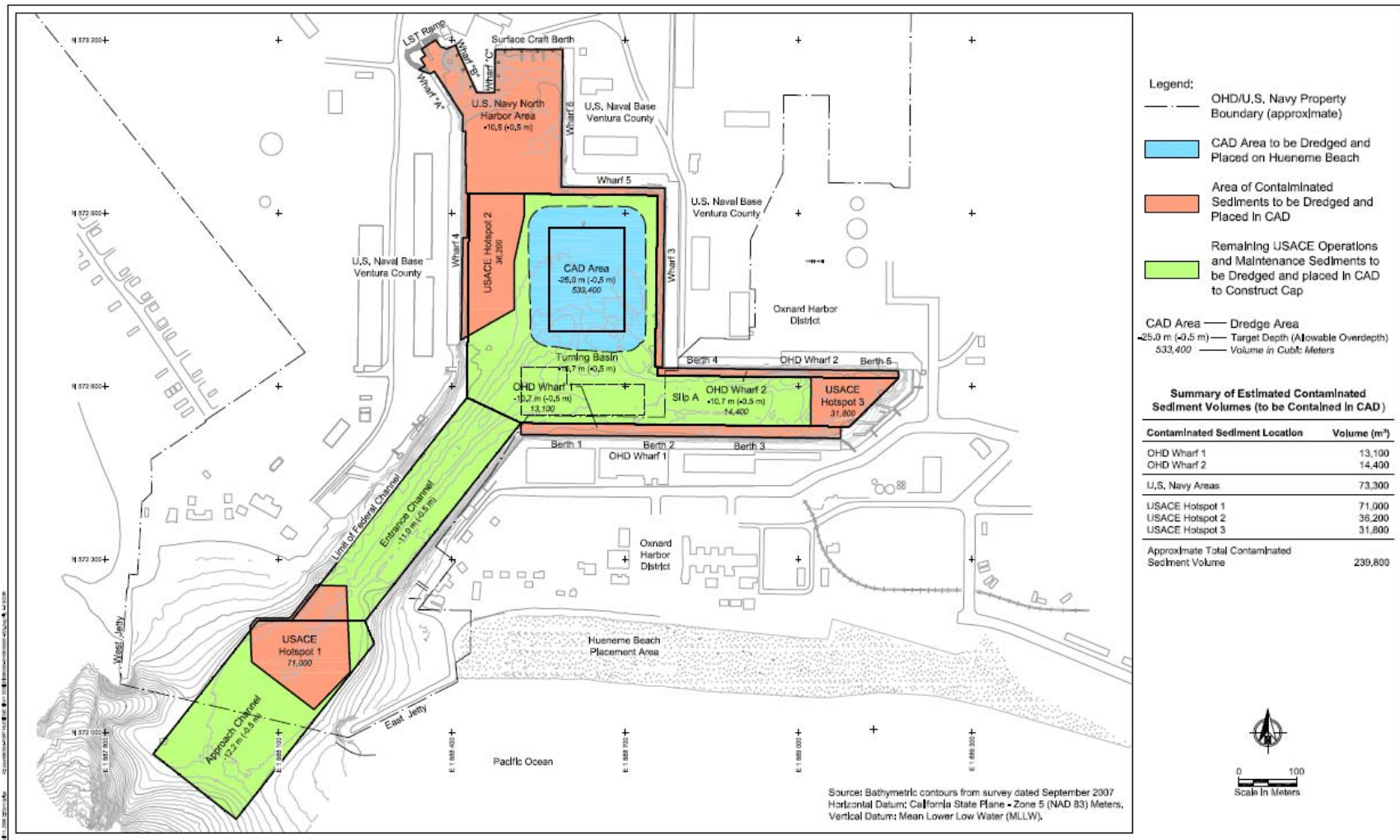
Figure 1. Site location map.

Figure 2. Project area site plan including key structures.

This paper describes the engineering development of this CAD facility—a unique and innovative solution to a regional problem in which the resources of the OHD, U.S. Navy, and USACE were combined into a single project. The on-site CAD facility is a highly cost-effective solution for all parties involved, as it entails minimal transportation costs, no tipping fees, and no need for sediment rehandling. In general, the project consisted of three main components:

- Hydraulic excavation of the CAD cell with placement of the excavated clean sand on an adjacent beach, which had been severely eroded and in need of nourishment

- Mechanical dredging of contaminated sediment from the OHD and U.S. Navy wharves and USACE open-water areas along with barge placement of the sediments into the CAD cell

- Capping and armoring of the CAD cell, which consists of dredging clean operations and maintenance (O&M) areas from within the USACE Federal Channel and placing this material in the CAD cell to form a clean cap and importing rock to form an armor layer

A summary of the major design and permitting tasks are presented herein, including CAD design and construction, water quality analyses, cap stability analyses, cap chemical isolation analyses, and environmental and regulatory approvals, followed by a brief status report on work completed to date. Additional project details can be found in the final design report for the project (Anchor 2008).

CAD DESIGN AND CONSTRUCTION

Starting in December of 2008, approximately 530,000 cubic meters (meters^3) of sand was hydraulically excavated from the prescribed area of the Turning Basin (Figure 2) in order to create the CAD facility. The required size of the CAD facility was determined by calculating the amount of contaminated dredged material expected to be generated from the OHD, U.S. Navy, and USACE areas, while leaving sufficient space for clean capping material (i.e., USACE O&M dredging material) and armor rock. Additionally, the design for the CAD facility incorporates a final surface elevation of the cap that accounts for the possible future deepening of Port of Hueneme Harbor by an additional 1.5 meters beyond the current authorization.

The following constraints controlled the dimensions of the CAD facility:
- CAD cell side slopes were set at a ratio of 2.5 horizontal to 1 vertical (2.5H:1V).
- CAD cell excavation should reach no deeper than -26 meters mean lower low water (MLLW) in order to stay well above underlying aquifer zones.
- North and east side slopes should daylight no closer than 30 meters from the adjacent U.S. Navy wharves to maintain their structural stability.
- West side slope should not overlap the adjoining USACE Hotspot 2, because the hotspot material needs to be disposed of within the CAD cell and cannot be placed on the beach.
- The cap was set at 3-meters thick to provide: (a) an inherent degree of conservatism with the regulatory agencies and (b) the ability to deepen the harbor at some future date without affecting the fill material.
- A 1-meter-thick protective layer of coarse ("armor") stone will be added atop a portion of the cap to resist erosive forces.

Because it is feasible that the Turning Basin could be deepened from its current authorized depth of -10.7 meters MLLW to an elevation of -12.2 meters MLLW (plus 0.5 meter of allowable over dredge), it was desirable to maintain the top elevation of the armor stone sufficiently below this elevation to avoid having the armor stone inadvertently dredged should the USACE conduct this deepening project in the future. Therefore, the armor material will be restricted to an elevation no higher than -13.2 meter MLLW, which provides an extra 0.5 meter of clearance below the allowable overdredge limit.

A geometric analysis of a trapezoidal-shaped CAD cell developed a base footprint of 125 meters by 175 meters, 2.5H:1V side slopes, and excavated base elevation of -26 meters MLLW will have approximately 240,000 meters^3 of capacity below elevation -17.2 meters MLLW, which is sufficient to contain the required volume of sediment, incorporating a 5 percent contingency volume factor.

The overall structure stability of the adjacent U.S. Navy Wharves 3 and 5 was investigated with regard to the proximity of the CAD cell side slopes to these structures. Situating the CAD cell excavation too close to the wharves could decrease necessary passive horizontal pressure against the pilings and lessen their stability.

The computer slope stability software SLIDE 5.0 (developed by Rocscience, Inc.), was therefore used to analyze the effects of various possible side slopes and CAD cell offset distances. The intention of this analysis was to select a reasonable offset distance for the CAD cell, which would allow the full volume capacity to be obtained while not adversely impacting the overall stability of the piles and slopes that support the wharves.

Different combinations of failure surfaces, soil properties, CAD cell locations, CAD cell slopes, and surface loadings were investigated in this study to indicate the critical factor of safety for each scenario. The software used both circular and wedge-type failure surfaces to find the lowest factor of safety in each model. Based on this analysis, the top of the excavated CAD cell side slopes was set back from the wharves' edges by a distance of 30 meters.

Certain segments along the U.S. Navy wharves were identified as dredging restriction areas, and dredging operations were restricted to 25- to 15-meter-long segments to maintain stability and prevent undermining of the structures. Individually dredged segments were required to be backfilled within 36 hours of dredging to maintain stability.

In addition to volumetric and infrastructure concerns, possible effects to groundwater were analyzed. Using chemical diffusion modeling assumptions developed for the CAD cell's overlying cap layer and assuming a downward flow gradient through the underlying Semi-perched Aquifer instead of the more realistic neutral one, it was concluded that more than 16,000 years would be needed for chemicals to diffuse downward from the CAD cell and through to the confining clay layer. In actuality, the time span to reach the Oxnard Aquifer would be much longer because groundwater would have to pass through the low-permeability materials that comprise the Clay Cap Aquitard, which ranges in thickness between 15 and 30 meters.

CAP CHEMICAL ISOLATION ANALYSES

The steady-state model of Reible et al. (2004), was used to estimate chemical concentrations in the biologically available near-surface layer of the cap (i.e., the bioturbation layer) once steady-state (i.e., long-term equilibrium) conditions are achieved after capping of contaminated sediments within the CAD cell.

As the dissolved contaminants move upward through the cap, they are predicted to undergo biodegradation while simultaneously partitioning onto the cap material, while bioturbation mixes the surface layer and further reducing concentrations. The model predicts steady-state concentrations of sediment or porewater in the surface layer by applying developed formulas to represent these various processes. The chemical isolation performance of the cap can then be evaluated by comparing the model-predicted steady-state surficial concentrations to toxicity guidelines or criteria.

The chemical concentrations for sediment underlying the cap were obtained from four sediment sampling events conducted in 2001, 2002, 2006, and 2007. Based on evaluation of the data, the Chemicals of Potential Concern (COPCs) for chemical isolation were determined to be organic chemicals. Thus, the concentrations were normalized for the organic carbon content of the sediment (using the average total organic carbon [TOC] calculated from all data sets) to obtain concentrations in milligrams per kilogram of organic carbon (mg/kg OC). Where values were undetected for a particular COPC, a concentration equal to half the detection limit was assumed and then organic carbon normalized.

The 95 percent upper confidence levels (UCLs) of all available data were calculated for each COPC. These values were then converted into porewater concentrations assuming equilibrium partitioning conditions and using the organic carbon water partitioning coefficients from the Risk Assessment Information System (RAIS) database (DOE 2007). The resulting porewater concentrations were input into the model as C_{bio} values (as summarized in Table 1).

The model was run using a seepage scenario representing neutral flow conditions (i.e., zero upward seepage velocity) within the Semi-perched Aquifer, reflecting long-term groundwater data from the region (Anchor 2008).

Table 1. Summary of chemical isolation layer modeling results under nominal seepage velocity scenario.

Seepage Velocity	Chemical	Porewater Concentration (C_{bio}) at Steady State (mg/L)	Sediment Concentration (W_{bio}) at Steady State (mg/kg)	Hazard Quotients Porewater HQ	ERM Sediment HQ[b]	ERL Sediment HQ[b]	Time to Steady State (years)
0 cm per year	Tributyltin	3.87E-10	1.45E-07	0.000001	N/A[a]	N/A[a]	8,400
	Benzo(a)anthracene	5.42E-08	1.86E-04	0.001	0.0001	0.001	49,000
	Benzo(a)pyrene	1.20E-09	1.41E-05	0.00002	0.00001	0.00003	168,000
	Benzo(b)fluoranthene	4.98E-10	5.95E-06	0.00001	N/A[a]	N/A[a]	277,000
	Chrysene	3.56E-08	1.25E-04	0.001	0.00004	0.0003	73,000
	Heptachlor Epoxide	6.67E-08	5.23E-06	0.61	N/A[a]	N/A[a]	2,400
	Total DDT	3.15E-09	1.03E-05	0.01	0.0002	0.01	85,000
	Total PCBs	2.48E-07	1.66E-04	0.01	0.001	0.01	10,700

Notes:

a – Sediment guidelines are not available for TBT
b – ERM and ERL are from Buchman 1999
cm = centimeter
DDT = dichloro-diphenyl-trichloroethane
ERL = effects range low
ERM = effects range medium
HQ = Hazard Quotient
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
N/A – not applicable

Table 1 shows that predicted Hazard Quotients (HQs) are below 1 for all parameters. The estimated time to steady-state conditions ranges from approximately 2,400 to 277,000 years. Keeping in mind that these results assume a cap thickness of 1 meter when in reality the actual cap will be at least 3-meters thick, which is a better estimate of breakthrough potential is closer to 8,000 years for the most mobile of contaminants present at the site (i.e., heptachlor epoxide). The implications of these results are that the cap is predicted to be effective in isolating all contaminants for many thousands of years.

WATER QUALITY ANALYSES

The potential for water quality impacts from contaminated sediment dredging and disposal has been estimated for this project using quantified sediment characteristics as well as documented placement techniques. Known chemical concentrations in site sediments were evaluated to estimate the potential for suspended sediments to contribute dissolved contaminants to the surrounding water column. In addition, the computer model DREDGE (developed by the USACE) was used to predict short-term water quality impacts at the point of dredging, and the computer model Short-term Fate of Dredged Material Disposal in Open Water Models (STFATE; also developed by USACE; Version 5.01; Johnson et al. 1994) was used to predict water quality impacts at the CAD fill site during sediment disposal by split-hull dump scows.

The STFATE model suggests that the plume of suspended sediments, which forms after the sediment is released, is wider and more extensive at depth than it is at the surface. At shallow depth (1 meter below the water surface), maximum total suspended solid (TSS) concentrations ranged from 2.6 to 6.8 milligrams per liter (mg/L). At mid-depth (5.5 meters below the water surface), maximum TSS concentrations ranged from 8.3 to 22 mg/L. At the greatest depth modeled (11 meters below the water surface), the maximum TSS concentrations were predicted to range from 46 to 185 mg/L.

The predicted turbidity plume was predicted to extend a maximum distance of approximately 80 meters horizontally from the disposal point (i.e., the turbidity plume was predicted to be not more than 160 meters across). This condition was predicted for a depth of 11 meters during the disposal of sediment from USACE Hotspot 1. The

highest predicted TSS concentration was 185 mg/L, for disposal of sediments dredged from OHD Wharves 1 and 2 and USACE Hotspot 3 area, again at bottom depth (11 meters).

Under conditions modeled for four disposal scenarios, after 20 minutes following the disposal event, predicted TSS concentrations were expected to reach zero at distances of no more than approximately 80 meters from the disposal point. When compared to documented thresholds for acute and sub-lethal impacts from TSS (Anchor 2003), these predicted TSS concentrations were predicted to have negligible impacts to the aquatic environment, except for brief periods near the bottom surface in the immediate vicinity of the dump event.

After dredging to the required elevations, confirmatory sediment samples were collected to verify whether contaminated sediments were fully removed. Areas containing sediments with elevated chemical concentrations were bounded using field data and targeted for re-dredging with typical cuts ranging from 1 to 1.5 meters (plus 0.5 meters for over allowable dredging).

CAP STABILITY ANALYSES

The waves at the CAD site are expected to be small due to its location within a protected harbor; therefore, the focus of the hydrodynamic analysis was on the propeller-induced currents at the project site.

A propeller wash model based on the equations developed by Blaauw and van de Kaa (1978), Blaauw et al. (1984), and Verhey (1983) and calibrated with field measurements at San Diego Bay (Everest 2003) was used for this study to evaluate the propeller-generated currents at the CAD location. The model predicted the velocity field behind a propeller jet based on the momentum theory by assuming that the propeller thrust equals the change of the fluid momentum caused by the propeller. It also predicted the laws of free jet turbulence for submerged jets by assuming that flow is steady, uniform, and frictionless.

The propeller wash model requires information about specific vessels to predict the propeller jet velocities. This information was obtained by interviewing the appropriate parties, and it was determined that the vessels that would most affect the CAD location include tugboats, automobile vessels, and U.S. Navy Destroyers.

The propeller wash model was used to predict the vessel-generated velocities on the surface of the proposed CAD cell, assumed for the purposes of this modeling to be at an elevation of -12.7 meters MLLW. The predicted maximum bottom velocities generated by the tugboat are between 0.73 and 0.88 meters per second (m/s), occurring at about 37 to 49 meters behind the boat. As expected, the highest velocity occurs at the shallowest water level (i.e., at lowest recorded water [LRW]). The automobile vessel can generate maximum bottom velocity between 1.7 to 2.3 m/s, while the U.S. Navy Destroyer can generate maximum bottom velocity between 2.8 and 3.8 m/s.

The scouring analyses indicate that propeller wash currents created by the U.S. Navy Destroyer has the potential to generate deep scour holes in the proposed capping material of 0.2 millimeters. Hence, cobbles with D_{50} of approximately 100 to 125 millimeters will be used to protect part of the CAD. By using capping material of this size, the potential maximum scour depths will be approximately 0.3 meter or less due to the propeller wash currents generated by the automobile vessels. For the U.S. Navy Destroyer, during the vast majority of the time, the maximum scour depth will be less than 1 meter. Only under the rare occasion when the U.S. Navy Destroyer is leaving the harbor at a time when the tide is at the lowest recorded level, the scour depth will be 1 meter. To protect the cap from these propeller wash forces, approximately 33,900 tons of armor rock will be placed at a thickness of 1 meter over the southwest portion of the CAD cell.

Even when this predicted scour does occur, because of its short duration, it is expected that the individual, relatively heavy stones composing the cobble layer will move only a short distance before resettling. The CAD design also includes an additional degree of safety, as the top of the armor rock will be restricted to elevations below -13.2 meters MLLW, which is up to 0.5 meter deeper than the cap elevation of -12.7 meters MLLW that was used for the analysis described above. This cap elevation will have the effect of further reducing the predicted velocities experienced at the top of the CAD armor layer and, therefore, decrease the potential temporary scouring depth.

ENVIRONMENTAL AND REGULATORY APPROVALS

Dredging of the OHD and U.S. Navy wharves and the USACE Federal Channel and construction of the CAD facility are subject to both California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) review. The OHD acted as the lead CEQA agency, while the U.S. Navy acted as the lead NEPA agency. As the lead federal agency, the U.S. Navy coordinated with resource agencies such as the National Marine Fisheries Service (NMFS) and California Department of Fish and Game (CDFG) to ensure compliance with requirements of the Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act. In addition, the U.S. Navy assumed the lead role in addressing cultural and historic resource issues, including requirements of Section 106 of the National Historic Properties Act.

The environmental analysis was carried out as a joint document combining the CEQA Initial Study and Mitigated Negative Declaration with the NEPA Environmental Assessment. Because no significant impacts were identified in the environmental analyses, the OHD completed the CEQA process by adopting the Mitigated Negative Declaration, while the U.S. Navy completed the NEPA process by issuing a Finding of No Significant Impact (FONSI) to accompany a final Environmental Assessment. The USACE is also responsible for NEPA compliance for their O&M dredging component of the overall project and prepared a supplement to their existing Environmental Assessment.

The project also required permits from a number of state and federal agencies. The U.S. Navy and USACE acted as co-applicants in obtaining a federal consistency determination from the California Coastal Commission for the entire project, which satisfies requirements of the Coastal Zone Management Act. The OHD and U.S. Navy acted as co-applicants for the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) permits from the USACE and Clean Water Act (Section 401) water quality certification from the Regional Water Quality Control Board.

CONCLUSIONS AND CURRENT STATUS

The multi-user CAD facility at Port of Hueneme Harbor demonstrates an innovative approach of combining the resources of the OHD, U.S. Navy, and USACE to create a single, complete solution to their sediment management needs while conserving federal and municipal funds. This solution combines the efficiency and environmental protection of isolating the contaminated sediment within the harbor with the use of clean sand to nourish Hueneme Beach. Construction and implementation of the CAD facility will also avoid significant, adverse effects to air quality and transportation (both traffic and infrastructure) by eliminating the need to transport the contaminated sediment to an upland disposal facility.

As of the date of this manuscript (May 1, 2009), the project is about 90 percent complete. Manson Construction was retained to complete all the dredging and capping work, and Connolly Pacific was retained to deliver the rock and construct the armor layer. Anchor QEA assisted the sponsors with construction management and conducted all water quality and sediment monitoring activities.

The CAD cell was excavated between December of 2008 and January of 2009, all the contaminated material was been placed within the disposal cell between February of 2009 and April of 2009, and capping commenced in May of 2009. Cap placement should be completed no later than June 1, 2009, and the armor layer will require an additional 2 to 3 weeks to complete. All project activities should be completed by the end of June 2009. No unforeseen challenges were encountered. Construction downtime was limited to less than 1 week for combined mechanical- and weather-related issues and the project will be completed nearly 1 month ahead of schedule.

ACKNOWLEDGEMENTS

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