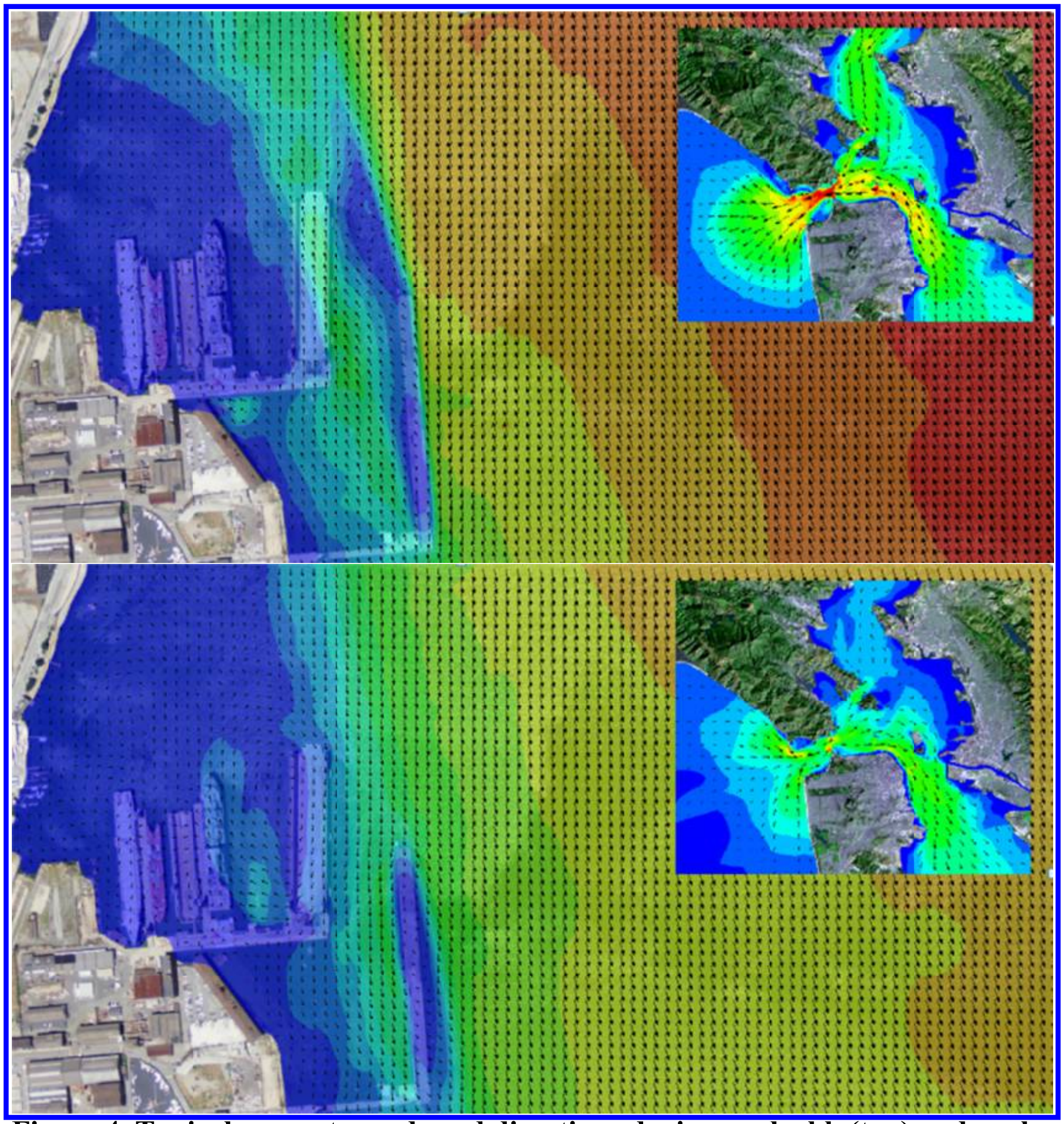

Figure 4. Typical current speeds and directions during peak ebb (top) and peak flood (bottom) currents around Central Basin.

SEDIMENTATION MODEL CALIBRATION

The sediment transport/morphology model was calibrated using a one-month simulation of tidal currents, and simply allowing the Bay-wide model to pick up sediment on its own from the Bay floor and transport it into Central Basin. Sediment transport was modeled using a cohesive sediment excess shear formulation which computes erosion and deposition based on an erosion rate parameter and critical shear values for erosion and deposition. The critical shear stresses of erosion and deposition were adjusted to match the observed sedimentation rate in the Central Basin. It was determined that the calibration required was fairly minimal and calibration parameters remained within a relatively small range.

Model calibration results show an overall excellent match in terms of volumes of sediment deposited into the various zones in Central Basin. Figure 5 shows the model predicted annual sedimentation rate (one month results scaled linearly to one year). Overall, the predicted sedimentation rates from the calibration exercise are slightly higher than the measured rates. The calibration resulted in a reliable tool for evaluation of sedimentation in the area following the removal of Wharf 8 and other activities.

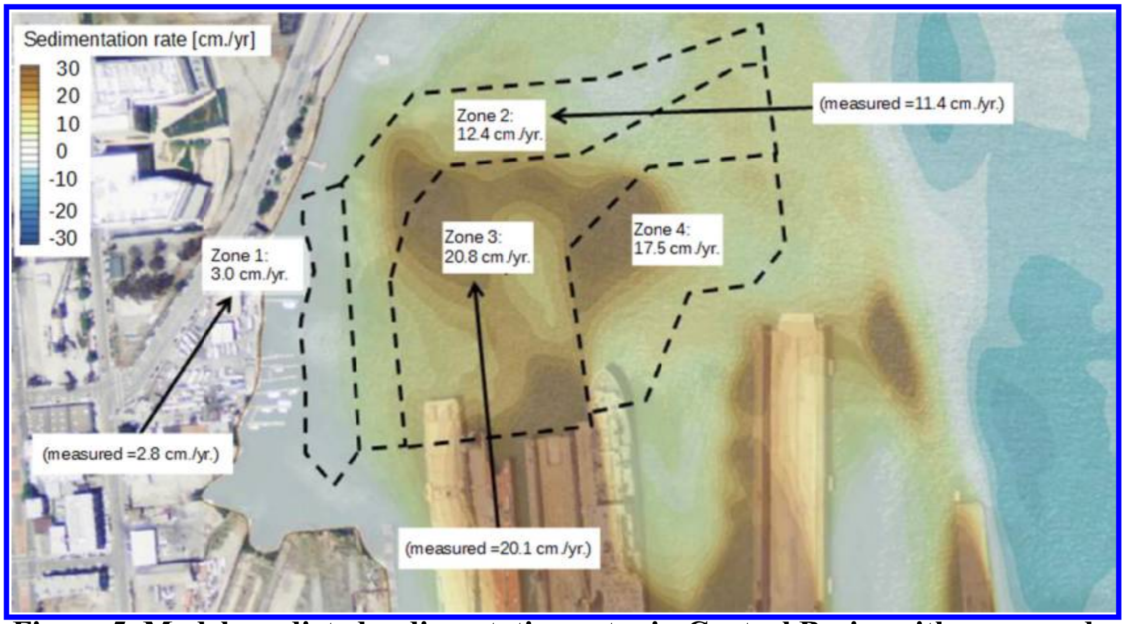

Figure 5. Model predicted sedimentation rates in Central Basin, with measured rates noted in surrounding boxes.

IMPACT ANALYSIS FOR WHARF 8 REMOVAL

Wharf 8 is a 1,300-ft long, 82-ft wide pile-supported pier running in the roughly north-south direction that is connected to land by a perpendicular 700-ft section of pier. The wharf has been out of use for many years. The north-south span is supported by rows of circular steel pile (3 wide) which are spanned by 3-ft steel girders running along the length of the pier. The pile field has some effect on tidal currents as noted in the modeling, and at high tide, the bottom of the girders could provide some attenuation of storm waves. A 300-ft section of the wharf also has a vertical timber screen which could offer additional protection. Photos of the Wharf 8 structure and timber screen are shown in Figure 6.

Figure 6. View from north end of Wharf 8 looking south (left) and timber screen on Wharf 8 (right), looking west.

Some changes in sedimentation patterns and rates should be expected if the wharf were removed as proposed. The calibrated sedimentation model was used to simulate the sedimentation pattern after the removal of the wharf. Figure 7 shows sedimentation rates before (left) and after (right) removal of Wharf 8. It is clear that in some areas the sedimentation rate is increased, and in some areas it is decreased, as flows more easily enter Central Basin. This figure also shows the increase or decrease in annual sedimentation volumes predicted to occur following Wharf 8 removal in each of the delineated areas.

The removal of Wharf 8 does result in an overall increase in sedimentation in the Central Basin; however, it is relatively small. The overall increase in sedimentation volume in all zones shown here is approximately 1,750 cubic meters per year. The primary change caused by Wharf 8 removal is a redistribution of sedimentation farther into the basin, and farther south. These results are intuitive since removal of Wharf 8 would results in higher ebb current velocities on the eastern edge of the project site, and thus sediment is less likely to settle there.

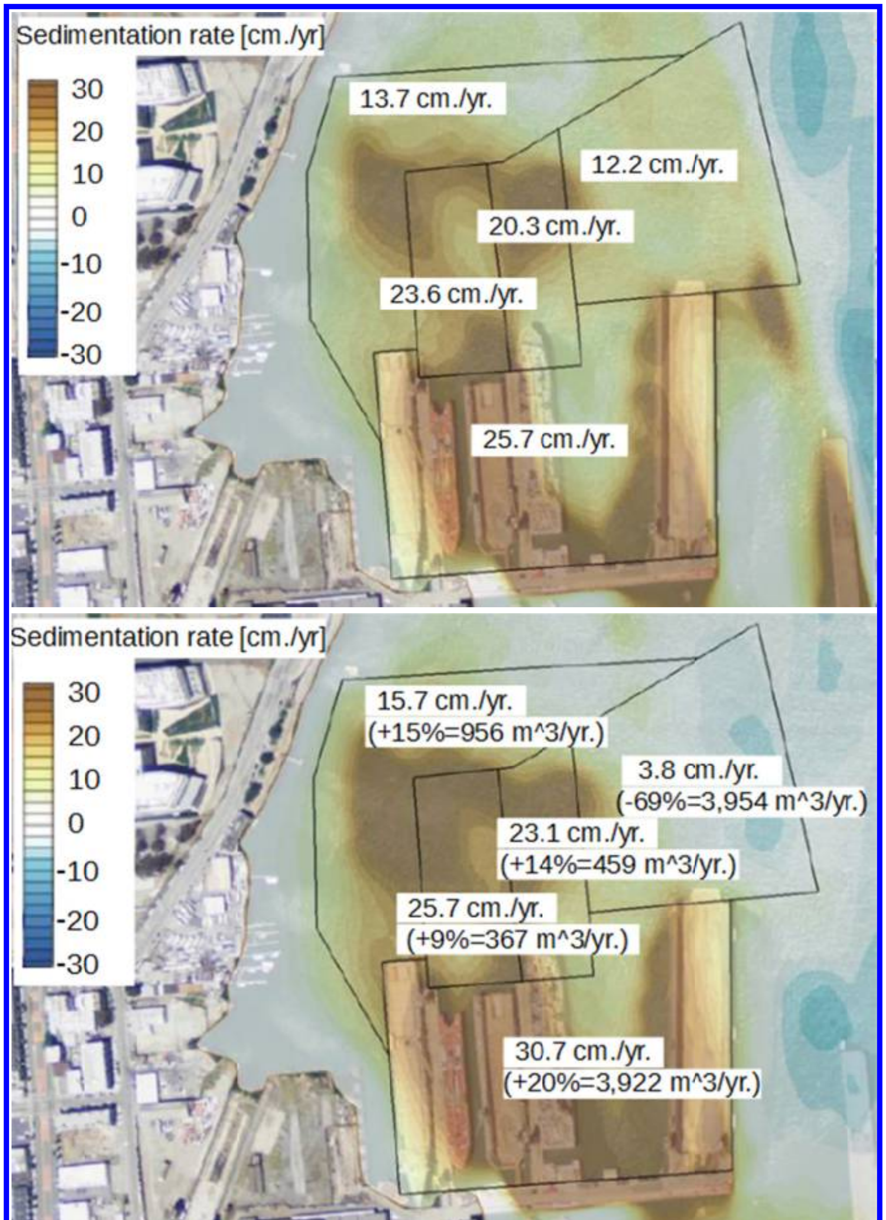

Figure 7. Sedimentation rates with Wharf 8 in place (top) and rates/changes in rates following Wharf 8 removal (bottom).

Another potential impact of Wharf 8 removal that was identified was increased wave penetration into the basin during southeast storm events, which are the most severe in the area. Computational fluid dynamics modeling was performed to analyze the impact of removing Wharf-8 on the extreme wave climate of the central basin. The 100-year storm significant wave height of approximately 2.1 meters with peak period of 6.0 seconds was used in the modeling to calculate transmission through Wharf 8. Figure 8 shows snapshots of the modeling results (wave profiles color contoured with pressures) over the course of a single wave period.

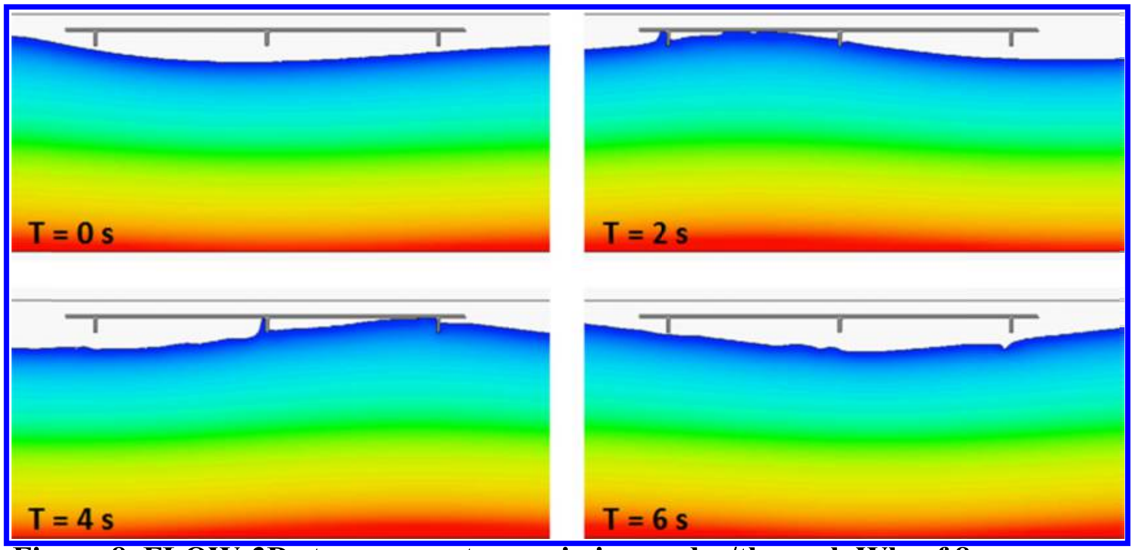

Figure 8. FLOW-3D storm wave transmission under/through Wharf 8.

Time histories of the water surface elevation behind Wharf 8 were analyzed both with and without the structure in place to determine the relative levels of wave transmission through the structure, and whether the structure provides any significant wave protection due to the low-hanging breams. Results indicate that even at MHHW tidal elevation, when the wave crests impact the down-standing beams on the wharf, transmission below/through the structure was 95%. Kriebel (2004) was applied to determine the transmission across the timber screen section of the wharf. Using conservative assumptions regarding the timber screen draft and porosity (i.e., assumptions that limit transmission further), results still indicate greater than 90% wave transmission through the screen section. Based on the modeling and analysis results, it was found that removal of Wharf 8 is likely to have little effect on the overall storm wave climate in Central Basin.

CONCLUSIONS

Bay wide modeling of hydrodynamics and sediment transport morphology was performed, as well as wave transmission analysis, to evaluate the potential impacts of removing a derelict wharf from Central Basin. The Bay wide hydrodynamic model was calibrated and sediment transport modeling was performed. The transport model provided accurate predictions of volumetric sedimentation rates in several zones in Central Basin defined by various dredged depths. The calibrated model was used to simulate the change in sedimentation pattern after removal of Wharf 8, and it was concluded that removing the wharf would result in a reduction of the sedimentation rate on the east end of the project site, but a slight increase in sedimentation on the west end. Wave transmission analysis and modeling indicated that Wharf 8 removal was not likely to significantly affect storm wave transmission into Central Basin.

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Sediment Removal and Material Placement below Existing Structures: Challenges and Case Studies

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Abstract

When sediment-related remediation or maintenance is required at developed waterfronts, construction is often necessary below existing overwater structures such as piers, wharves, and docks. Sediment removal and placement of materials (e.g., sand, rock, and capping materials) below existing structures present unique challenges to the permitting, design, and construction phases of a sediment management and remediation project. This paper reviews the various challenges that exist for marine work below existing structures and discusses several methods for accomplishing work in these constrained settings. Additional observations are provided for regulatory permitting considerations and unique quality assurance/quality control methods that apply to marine work below existing structures are presented. Pertinent case studies are described for illustration purposes.

INTRODUCTION

The shoreline and nearshore areas of industrial and port-related facilities are, by their very nature, populated by a variety of structural installations. Many of these take the form of overwater structures, which are generally pile-supported or cantilevered out over the water. When remedial action, sediment management, or dredging is required in and around these facilities, some of the necessary work often needs to occur below these existing structures. Marine construction below overwater structures is a significantly more complex process when compared to open-water areas, as overwater structures pose obstacles to design engineers and contractors. An example of a complex condition typically encountered under an overwater structure is illustrated in Figure 1. This paper discusses various methods used in practice to accomplish under-structure remediation (removal of materials, placement of materials, and containment of in-situ sediments) and some of the permitting and quality assurance considerations that are associated with under-structure work.

Figure 1. Typical Under-structure Conditions, Including a Series of Piles, Batter Piles, Timber Lagging, and Shoreline

Permitting. Prior to starting the design phase, it is important to determine whether under-structure remediation will help meet the cleanup goals of the project. Dredging next to existing structures may result in leftover residuals directly underneath the pier, wharf, or dock. These residuals can pose significant challenges for achieving targeted cleanup goals. From a permitting standpoint, it is important to discuss these challenges with the regulatory agencies prior to the design phase. Addressing challenges early will allow both parties to come to a reasonable agreement on cleanup goals, thus reducing risk during the construction phase and increasing the ability to successfully execute the project. If under-structure remediation does not provide adequate cleanup, the benefit of conducting the remediation should be discussed and evaluated with the owner and regulatory agencies.

Challenges of Completing Work Below Existing Structures. The challenges of completing under-structure remediation stems from the lack of reliable information and construction feasibility. An important step in determining if material removal below existing structures is feasible is to assess the existing condition of the structure (e.g., pile locations, embedment depths, and other structural details) and determine if the structure's stability will be compromised. For example, removing material around piles reduces the overall pile-loading capacity and may cause instability to the structure if too much material is removed. Alternatively, placing sand placement around existing piles generally increases the forces around the pile, which may shift the point of fixity of the pile. An appropriate evaluation of potential stability impacts should be conducted in collaboration with a structural engineer.

In addition, sediment conditions below the existing structure may pose difficulties for both the removal and addition of material below the structure. Tightly spaced piles may limit equipment access and the presence of rock, debris, or remnant piles could inhibit dredging and sloughing of material away from the structure. Debris may be present and even prevalent, potentially including under-structure scaffolding, cathodic protection, old utilities, and spalled concrete that has fallen away or remnants of previous repairs that could include concrete, grout, formwork, and reinforcing.

Finally, the geometry of the structure may also pose a challenge to remediation efforts. With changing code and loading requirements over the extended life of a marine structure, the design of prior additions or repairs may vary greatly and different pile sizes, groupings, and spacing as well as different deck heights, bent sizes, and fender spacing may be present over the extent of the structure.

REMOVAL OF MATERIALS BELOW EXISTING STRUCTURES

The feasibility to dredge below existing structures is dependent upon design, presence of debris and broken piles, under-structure slope conditions, and ability of equipment to access the area without potentially damaging the existing structure. If removal of materials below the existing structure is deemed technically feasible (i.e., removal of materials will not cause instability of the structure), then several methods are available to complete this work, as discussed below.

Direct Removal of Materials. If it is possible to remove the decking of the overwater structure (in segments or in total) or to temporarily relocate the structure, then typical sediment removal methods can be used. However, if sediment removal must occur below the existing structure, specialized construction equipment is required. Two technologies that exist to directly remove material under structures are a mechanical dredge (typically operated using a traditional or modified barge-mounted long-reach excavator) and hydraulic alternatives. Three methods of direct removal include:

1. If there is sufficient space between the bottom of the structure and the water surface for a small barge and excavator, then the existing sediment can be dredged directly using mechanical dredging.

2. If the excavator and barge is unable to be located under the structure, an excavator with a telescoping arm may be used to reach under the structure.

3. Dependent on the material type, it may be possible to "drag" the sediment from under the structure to open water where it may be dredged into a haul barge. This process may not be supported by the regulatory agencies, as it may be viewed as temporary sediment stockpiling on the seabed and has the potential to create greater sediment resuspension than traditional mechanical dredging techniques due to the additional handling.

An example of one hydraulic alternative for removing the sediment below an existing structure is through a long-reach hydraulic suction hose, potentially using diver-assisted equipment. A diver-assisted suction dredge is a commercially certified, umbilical-supported diver operation with hand-vacuum dredge units. Diving operations could be deployed from a dive-support platform above water. Hydraulic under-structure dredging can incur high costs compared to other techniques and can be labor-intensive (and therefore, relatively slow). Other feasibility concerns to consider are the significant volume of water generated and the potential for debris and broken piles to clog the dredge.

Hydraulic dredging was used successfully at the Pete Archer Rowing Center in Long Beach, California. The project involved removing approximately 380 cubic meters (500 cubic yards) of clean sediment below an existing dock, which was grounding periodically and incurring damage as a result of sediment buildup. Due to low production rates and in-situ debris encountered during dredging, the project took approximately 8 working days to complete. Figure 2 illustrates diver-assisted hydraulic dredging at the Pete Archer Rowing Center.

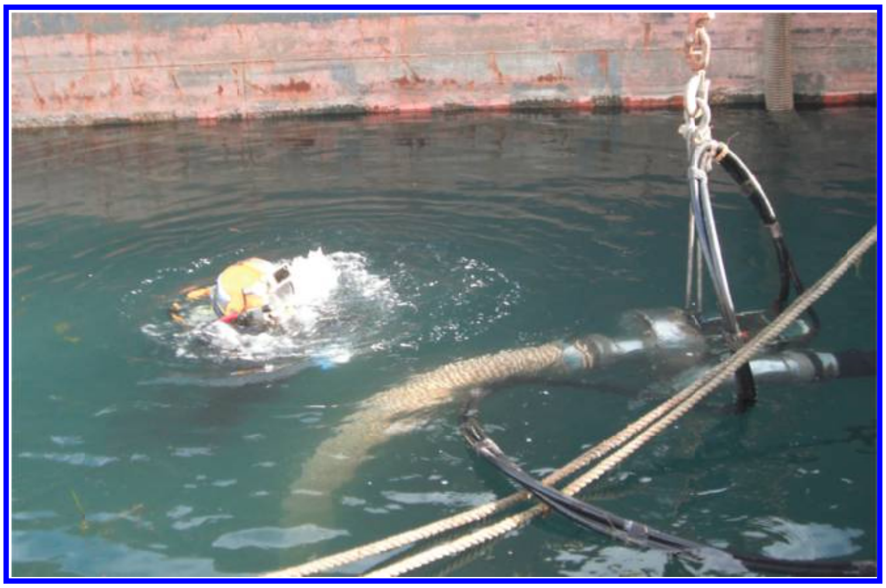

Figure 2-1. Diver-assisted Hydraulic Dredging System Using a System of a Cutterhead Dredge and Hoses.