PORT OF SEATTLE TERMINAL 91 UNDERWATER REGRADING

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ABSTRACT

The Port of Seattle completed an underwater regrading project at the Terminal 91 Cruise Ship Terminal in February 2016. Removal of shoaling along the dock face to restore project depths required that a number of issues be addressed. The site is within a Formerly Used Defense Site (FUDS) and Discarded Military Munitions (DMMs) have been discovered in the sediment in the past. The US Army Corps of Engineers (USACE) is conducting a Feasibility Study on this site to address the DMM issue. Landfills will not accept dredged material that may contain DMM waste, which made conventional dredging and disposal cost prohibitive. In addition, the site is under an existing Agreed Order with the department of Washington State Department of Ecology (Ecology) for possible contaminated sediments. Other issues included potential prop wash and scour by cruise ships and political issues with the local Native American Tribes that have treaty fishing rights in the area. Based on these constraints, underwater regrading was selected as the best solution to temporarily restore project depth for cruise vessels.

The project was the culmination of three years of negotiations with Federal, State, and local agencies, including USEPA, USACE, Ecology, Washington State Department of Natural Resources (DNR), and two Native American Tribes.

Additional key highlights of the project included:

- Approximately 383 cubic meters of material was relocated, which removed the shoal that was critically impacting cruise operations.
- A clamshell digging bucket was used to relocate shoal material.
- Sediments were moved to adjacent deeper water without lifting bucket through water column to the water surface, which helps to reduce or eliminate the release and resuspension of contaminants.
- Water quality was monitored for compliance and results were excellent.
- Underwater sonar technology was also used to monitor construction.
- Sediment samples were collected and analyzed pre and post regrading.
- Construction was accomplished by using an existing on-call maintenance dredging/regrading contract.
- Work on site was accomplished in 4 days.
- Total cost of construction was less than $50K.

Keywords: dredging, underwater grading, high spot knockdown, contaminated sediment, munitions.

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INTRODUCTION

Port of Seattle's Terminal 91 (T-91) is located in an industrial area in the Interbay neighborhood of Seattle, as shown in Figure 1. The two piers located at Terminal 91were built by the Port soon after its establishment in 1911. In 1941 the U.S. Navy took ownership, consolidating multiple parcels into T-91 as it exists today. The Port reacquired the facility in the 1970s. It is currently a multi-purpose terminal, including a two-berth cruise ship terminal.

A shoal formed along the face of the dock at Pier 91East (P-91E). The shoal area was intermittent and narrow. It was less than 3-5 meters wide and up to 1 meter above project depth. The lack of project depth was impacting cruise vessel use of the berth, potentially requiring the use of tides to access and depart the berth during some periods with low water.

Figure 1. Terminal 91 Location.

BACKGROUND

Site Background

Environmental investigations at the T-91 site have been ongoing since the early 1980s. It is regulated under both a Resource Conservation and Recovery Act (RCRA) permit and a Washington State Model Toxics Control Act (MTCA) Agreed Order (AO). The 2012 AO deferred cleanup action on any contamination identified in the submerged lands, including the cruise terminal berthing area for up to ten years.

In addition to possible chemical contamination, DMMs have been identified in the submerged lands by the USACE. These DMMs are a result of former Navy operations at T-91. The USACE has performed a Remedial Investigation under the FUDS Military Munitions Response Program to determine the nature and extent of DMMs. In 2010 and 2011, FUDS performed a time critical removal action, removing 25 DMMs that were at or near the surface of the seabed. USACE recently completed a draft Feasibility Study[3] to identify cleanup options related to DMMs.

Project Description

In 2013, the Port began the process of obtaining permits to restore project depths at P-91E. Pre-dredging sediment sampling was performed in September 2013. This sampling effort identified an area of elevated PCBs

[3] The USACE's Feasibility Study has options for addressing any remaining DMMs. Those options include dredging (which would remove any remaining DMMs) of submerged lands adjacent to piers 90 and 91.

(polychlorinated biphenyls) as well as exceedances of metals and PAHs (polyaromatic hydrocarbons). In light of these sample results, Ecology notified the Port that it must now address the contaminants in the Submerged Lands under an amendment to the current AO.

Also, based upon USACE investigations, additional DMMs could be buried in the sediments. Dredging DMMs sediment requires finding a disposal solution. Landfills will not knowingly accept sediment with DMMs, requiring cost prohibitive sediment screening. On-site disposal of DMMs was not feasible, as DMMs are considered to be RCRA waste.

Conventional dredging methods would require the Port to handle and dispose of DMMs. As a result of the anticipated costs associated with dredging, the Port evaluated other methods to address the shoal. Underwater regrading was determined to be the most cost-effective and environmentally protective approach. Similar regrading techniques, as interim alternatives to conventional dredging methods, have been permitted and performed successfully at other Ports and USACE districts in California and Oregon (Hermans et.al. 2006).

Subsequent to pre-project sediment sampling, the proposed project boundaries for the regrading were revised to exclude the area of elevated PCBs, leaving that area to be addressed in the future. Advance maintenance removal was also excluded from the proposed plan. Reducing the removal area and depth significantly reduced the maintenance removal volume, while still providing project depth for the cruise vessels. The total volume of the shoal was calculated at 214 cubic meters.

Multibeam Bathymetric Surveys

Multibeam bathymetric condition survey data was collected to identify the shoal area and possible relocation areas. These areas are shown in Figure 2. There was some concern regarding possible erosion from cruise vessel propeller wash in the relocation areas. Coast & Harbor Engineering conducted a study to assist the Port with analysis and engineering related to the stability of a proposed regrade at Pier 91E (CHE 2015). As a result of their analysis, prop wash prone areas were to be avoided for relocated material and the contract documents used only the primary relocation areas shown in Figure 2 for the relocated material.

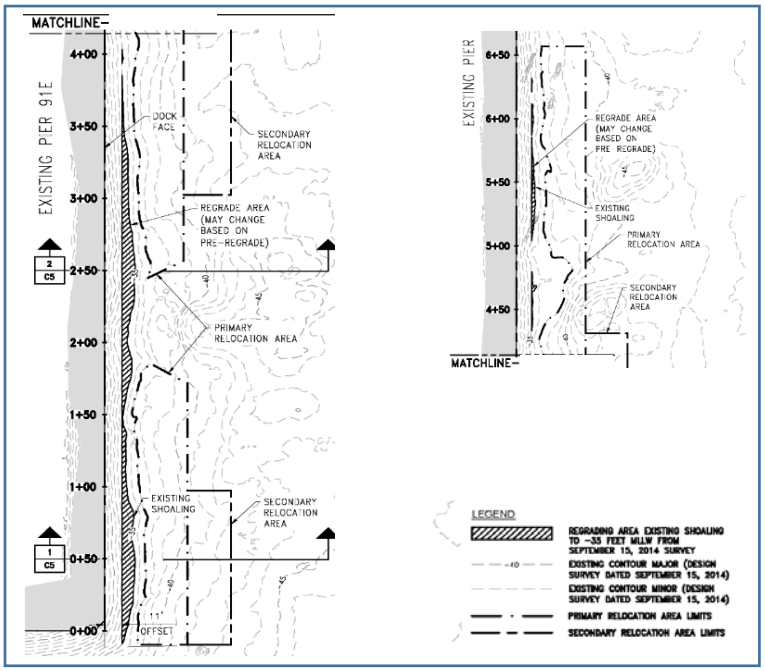

Figure 2. T91E Condition Survey.

Sediment Sampling

In 2013, sediment along the east berth of Pier 91 from Station 0+50 to Station 10+50 was characterized (Windward 2013). Five sediment cores were collected and one composite sample was created to characterize the shoaling material. Five z-layer samples were characterized. The surface composite sample exceeded the Dredged Material Management Program DMMP criteria for a range of contaminants including mercury, bulk TBT, PAHs, PCBs and 1,4-dichlorobenzene. The z-layer samples exceeded Dredged Material Management Program (DMMP) criteria for mercury, lead, zinc, TBT, PAHs, PCBs and SVOCs (including 1,4-dichlorobenzene) at more than one location. The highest concentration of PCBs was measured in the z-sample collected from Station 10+50. As a result, the northern project limits were reduced to Station 6+50 to avoid this area. Divers were used to locate the vibracore samples, as previous attempts to sample in this area had been unsuccessful.

In 2015, three surface sediment samples were collected, one from the shoal material and two in the existing sediment relocation area (Windward 2015). Concentrations of PAHs and PCBs exceeded the sediment cleanup objectives in the relocation area samples and the dioxin and furan TEQs were above the DMMP disposal site management objective of 4ng/kg toxic equivalence (TEQ) in all three samples.

In 2016, subsequent to completion of regrading, eight surface sediment samples were collected to characterize the post-regrade (4 samples) and relocation (4 samples) areas (Windward 2016). Sediment concentrations of metals, PAHs, and PCBs were above Washington State Sediment Management Standard values in both the regrade area and the sediment relocation area.

Permits and Regulatory Approvals

Because the project is not using conventional dredging methods, the Port worked with regulatory agencies and subject matter experts to ensure that adverse environmental impacts would be mitigated. Ecology required the work to be performed under a new amendment to the AO. This allowed the work to be completed under an USACE Nationwide Permit #38, Cleanup of Hazardous and Toxic Waste. Ecology also required the AO amendment to include steps to investigate sediment quality on and around the project area. A sediment investigation has been initiated in the area subsequent to completion of the regrading.

The project was the culmination of three years of negotiations with Federal, State, and local agencies, including the USEPA, USACE, Ecology, DNR, and two Native American Tribes, as illustrated in Figure 3.

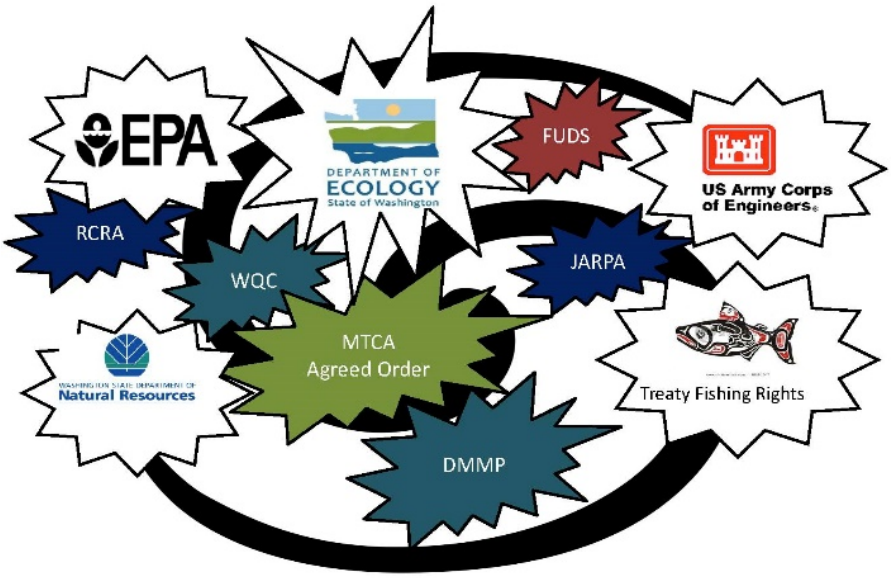

Figure 3. Regulatory Minefield for T-91E Coordination.

MAINTENANCE APPROACH

Underwater Regrading Description

Underwater regrading was selected as the maintenance approach that would satisfy the Port's need for a maintenance methodology that could provide project depths and be approved by the permitting agencies for implementation. Underwater regrading is the process of moving shoal material to a deeper underwater area that is adjacent to the shoal without bringing the shoal material to the water surface. Underwater regrading can be done by dragging a beam on the bottom or by using a dredging bucket.

The Port chose to conduct this regrading work using a clamshell digging bucket. Based upon previous difficult vibracore sediment sampling, the shoal material was anticipated to be primarily sand, rock, and shell debris rather than fine grained material. In past regrading projects, beam regrading has not been effective in this type of material and a dredging bucket has been required to move the shoals (Hermans, et. 2006). As shown in Figure 4, the open dredge bucket was lowered to the bottom, closed into the shoal material, lifted sufficiently to clear the bottom, moved into position over the designated relocation area, opened to release the shoal material, closed and the moved back to the shoal material. The regrading bucket was not to be lifted into the water column any further than required to clear the bottom while swinging the bucket (< 1 meter).

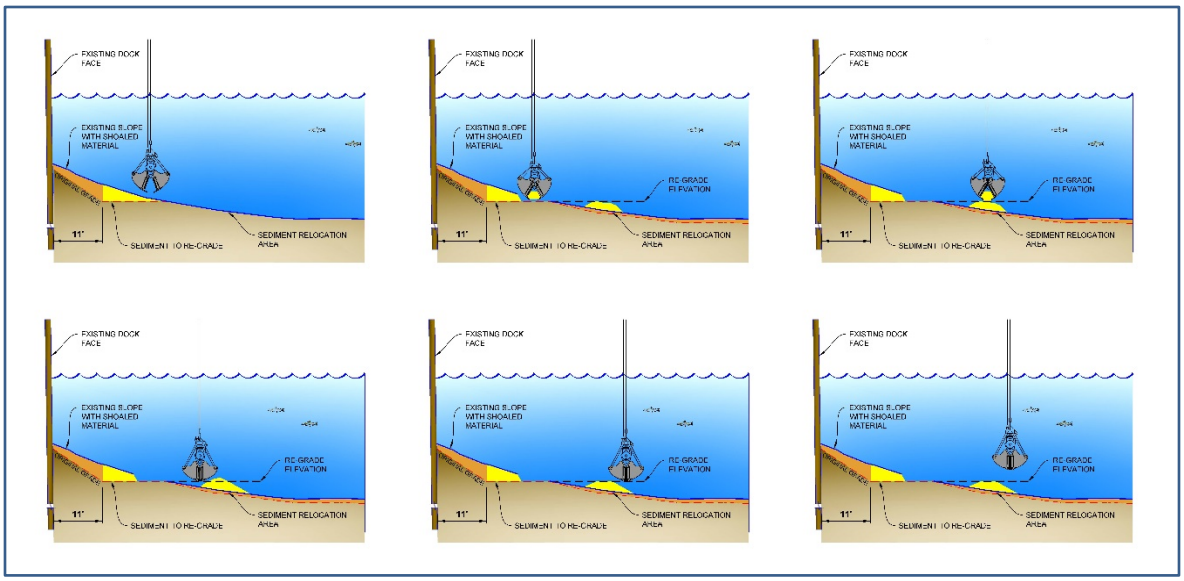

Figure 4. Underwater Regrading Process Steps.

Underwater Regrading Project Advantages/Disadvantages

Advantages of using underwater regrading included the following:

- Underwater regrading did not bring the shoal material to the surface, which eliminated the need to dispose of RCRA waste or screen for potential DMMs.
- Conducting the underwater regrading using a dredge digging bucket did not require contractor to configure non-standard equipment for the project, which reduced the potential cost.
- Required less equipment than dredging (no disposal barge or offloading equipment).
- Potentially less water quality impact due to not moving sediments through water column and no barge return water.

Disadvantages of using underwater regrading included the following:

- This was the first underwater regrading project in Puget Sound, although successful projects had been conducted in Portland, OR and Long Beach CA.
- Potential for moving contaminated sediments or DMMs to other area.

PROJECT IMPLEMENTATION

Construction

The Port contracted with American Construction Company (American). American was directed to perform underwater regrading maintenance at P-91E between Stations -0+20 and Station 6+50 during the 2015-2016 in-water construction season. American conducted underwater regrading during the period of February 5, 2016 to February 8, 2016. The work was observed by Dalton, Olmsted & Fuglevand, Inc. (DOF) staff.

The required project elevation was -10.7 meter (-35 feet) MLLW. The allowable potential regrade overdepth allowance was .6 meter (2 feet) and the depths in the relocation area were to remain deeper than -11.3 meter (-37 feet) MLLW. Approximately 214 cubic meters of material was to be regraded. As a result of upslope sloughing into the project area as the shoal material was relocated, approximately 383 cubic meters of material was removed. Figure 5 is an isopach comparison of pre- and post-regrade survey data that shows where the material was removed and its final project location.

The regrading was accomplished with a 3.8 cubic meter Esso digging bucket, as shown in Figure 6 with American's derrick. The bucket positions where relocated material was placed are shown in Figure 5, based on American's WinOps GPS-based navigation system. The Figure 5 isopach shows that the relocated material was released into the primary relocation area but significant amounts of the material moved into the secondary relocation areas.

Removal bucket locations are not shown in this figure. Multiple bucket bites were often removed from a bucket location shown on the bucket records. American had to regrade most of the project area up to 3 passes to remove the material and achieve project depths. Based upon previous attempts to obtain sample cores in this area, the material appeared to be consolidated. It appears, based upon the Figure 5 isopach, that the slope material sloughed into the project area after regrading. The regrading occurred during the day and then the multibeam progress survey was accomplished the following night. The areas where project depth was not present were then regraded the next day until project depth was achieved.

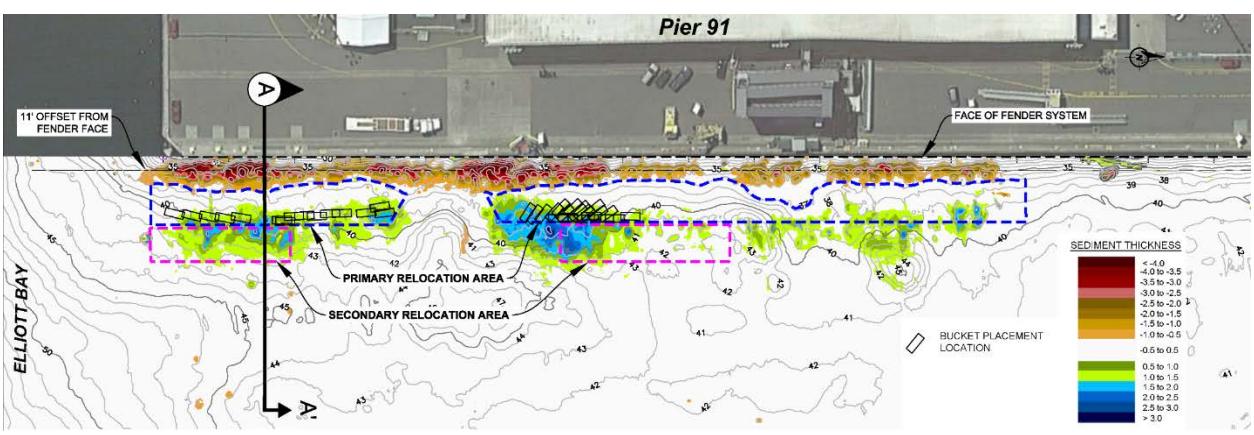

Figure 5. Isopach Comparison of the Pre- and Post-Regrade Survey Data.

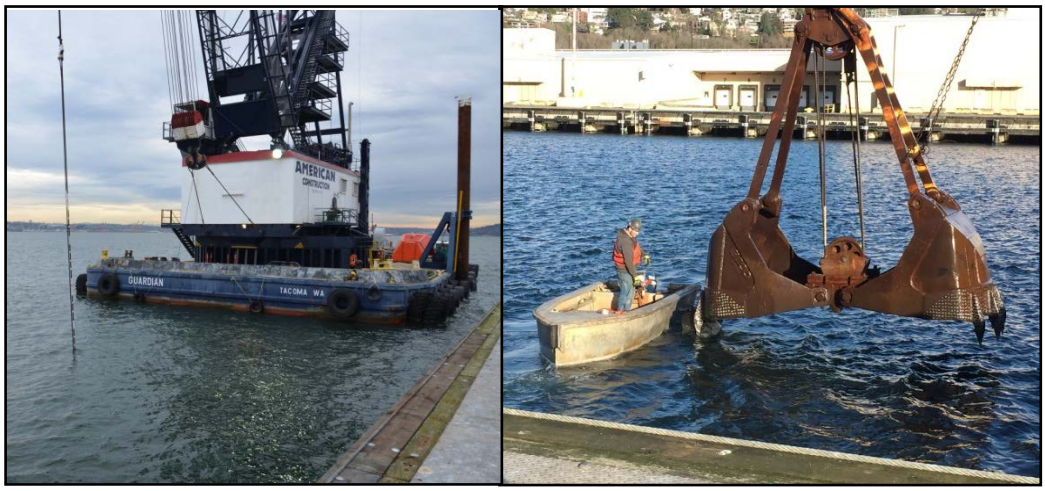

Figure 6. American's Derrick and 3.8 cubic meter Digging Bucket.

Water Quality Monitoring During Underwater Regrading

Real time water quality sampling per the terms of the permits was conducted by DOF personnel.Sampling stations were located 50, 100, and 150 feet down current (north or south) of the dredge. When WQM samples were collected 50 feet from the regrading, the derrick operation was stopped to allow the WQM sampling vessel to safely operate. These samples were informational and not required by the permits. Sample stations at 150 feet from operations were the Water Quality Certification compliance limits and at 100 feet for early warning.

Water quality monitoring samples were collected as follows:

- Samples of the project area and the background area were collected the day prior to regrading.
- WQM samples were collected approximately hourly February 5, 7, and 8, 2016.
- Limited WQM samples were collected on February 6, 2016 after 14:00 as discussed above.

The compliance limit of 5 NTU over background was not exceeded at the compliance location of 150 feet interval. Only one sampling event exceeded the 5 NTU limit at the 50 foot interval at the mid depth sample and a water sample was collected for chemistry analysis for informational purposes.

Water Sample Chemistry Analysis

On February 6, the 15:20, mid-depth sample at 50 feet from regrading operations exceeded 5 NTU. Although this was not a compliance sample, a water sample was collected for analysis. The results for the sample and the associated equipment blank showed that none of the analytes were detected at concentrations above AWQC (Ecology Ambient Water Quality Criteria).

BlueView Monitoring

BlueView technology uses a 2D mulitbeam imaging sonar that provides real time imagery. The BlueView system was mounted on a mast under the derrick hull and could be directed vertically and horizontally with the use of a pan and tilt mount. BlueView creates video-like imagery of underwater areas, structures, and objects of interest, even in low visibility conditions. The BlueView equipment was mounted on the derrick for regrading activities on February 5 and 6, 2016.

During regrading, the following operations were observed by the BlueView equipment:

- Bucket placement.
- Bucket closing.
- Bucket transiting between removal and relocation areas.

The following observations were made using the Blue View equipment:

- Little or no turbidity was observed as the bucket closed in regrading area.
- Material was observed to fall from bucket when bucket was not able to close completely, such as when rock, broken piling or debris was caught in bucket.
- Piling/logs, tires, chain/cable, and other miscellaneous debris was observed on the bottom. Debris picked up in the removal area was placed in the relocation area. Large debris was located with GPS coordinates for future pick-up by the Port.
- Occasional plume of turbidity or air bubbles were observed when the bucket opened in the relocation area.

POST-CONSTRUCTION ANALYSIS

American's bucket prints for relocation show that the relocated shoal material was placed within the primary relocation areas. Based upon the difficulty of obtaining sediment samples, the concern was that the material in the relocation area could stack and reduce project depths. As a result, American was asked to place the material in the deepest relocation area at the downslope edge of the areas. However, it appears that below the rocky somewhat consolidated surface, the material was finer grained. When the material was released into the relocation area, the shoal material was more of a slurry that flowed downhill from the primary relocation area into the secondary relocation area, as shown in the isopach in Figure 5. The majority of the relocated shoal material remained within the permitted relocation area.

A subsequent multibeam condition bathymetric survey was conducted in August 2016, approximately 6 months after the underwater regrading was completed. Figure 7 is an isopach which shows that relocated material has been stable during this 6 month period with cruise vessels using the berth. The isopach shows no change in the relocated material areas.

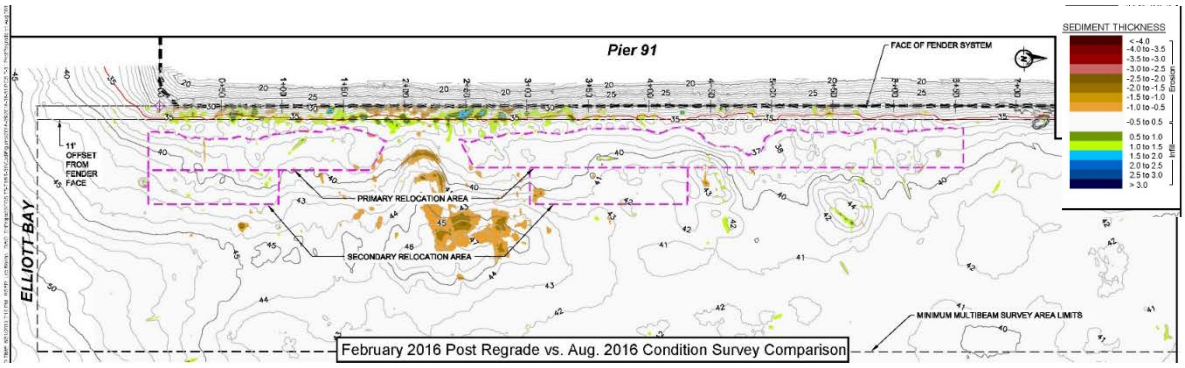

Figure 7. Isopach Comparison of the **Post Regrade and 6 month Condition After Regrade Survey Data.**

LESSONS LEARNED

Contracting

Maintenance dredging projects, including this underwater regrading project are subject to public works laws and policies, which include competitive selection process for professional services contracts and construction contracts. For professional services, the Port learned from previous project lessons and established ongoing Indefinite Delivery, Indefinite Quantity (IDIQ) contracts specific for professional services work related to maintenance dredging. This saves three to six months of contract selection time when project needs arise, such as this underwater regrading project.

The Port also established an on-call construction contract for on-going maintenance dredging construction needs over a 3 year period. This allows the Port to be ready for construction as soon as the permits are received, saving another three to six months of time to the schedule.

Project Costs

Table 2 below illustrates that a significant amount of effort was spent on design, environmental services and Port oversight. The high non-construction costs reflect the complexity of environmental and permitting issues associated with this project, the amount of agency and tribal negotiations, and the resulting changes to the design and additional studies resulting from these negotiations. The success in underwater regrading saved the Port millions of dollars that would have been needed to dredge the sediment with potential DMMs.

Table 2. Project Cost Breakdown.

Type	Cost	% of Total
Design and Environmental Services (Consultant Services)	$648K	57%
Port Management (Project Management, Environmental Management, Construction Management, Contract Administration, etc.)	$430K	39%
Construction	$50K	4%
Total	$1,128K	100%

Relocation Areas

At P-91E the regraded material should be placed in the shallowest part of the relocation area (the upslope limits) to allow the material to flow down slope. For this project, the material stacking to shallower than project depths was not an issue. For other projects, an impact area buffer around the relocation area should be included to allow for relocated material potential to move after placement in the relocation area.

Closely monitor height of bucket above the bottom when material is released in the relocation area, to prevent contractor from raising bucket greater than 3 feet above bottom at release.

CONCLUSIONS

Underwater regrading was a successful interim solution for restoring project depths at P-91E until the DMMs and contaminated sediments can be addressed by future actions. Using on-call dredging/regrading contracting allowed the project to proceed when permits were received with less than 1 month remaining in the in-water work window, and it allowed this project to be combined with another project, thus reducing mobilization/demobilization costs.

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CITATION

Chu, C. and Case O'Bourke, N. "Port of Seattle Terminal 91 Underwater Regrading," *Proceedings of the Western Dredging Association Dredging Summit & Expo '17*, Vancouver, Canada, June 26-29, 2017.

ACKNOWLEDGEMENTS

Mr. Marcel Hermans, Port of Portland, provided information on Port of Portland underwater grading permits and construction.

Ms. Janna Watanabe and Mr. Armond Morad, Port of Long Beach, provided information on Port of Long Beach maintenance dredging permits and construction.

Ms. Susan McGroody, Ph.D., Windward Environmental, LLC, provided sediment sampling and environmental expertise to the project.

Mr. James Glaeser, Northwest Hydro, Inc., provided multibeam surveys to the project.

Mr. Vladimir Shepsis, P.E., Coast and Harbor Engineering, Inc., a division of Hatch Mott MacDonald, provided coastal engineering and sedimentation expertise to the project

Mr. Peter Soles, Glosten, provided cruise vessel modeling expertise to the project.