TARGETED DREDGING OF NEAR-SHORE DEBRIS AND SEDIMENT, UPPER TRENTON CHANNEL, DETROIT RIVER: A CASE STUDY

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ABSTRACT

Under regulatory orders, dredging was conducted to remove up to 30,000 cubic yards (cy) (22,900 m^3) of contaminated sediments and debris along approximately 1,200 ft (366 m) of the west shoreline of the Upper Trenton Channel, Detroit River in Riverview Michigan. The objective was removal of overlying materials to the surface of a regional clay layer prior to installation of a sheet pile groundwater barrier along the shoreline for closure of an historical upland waste disposal area. Water depths ranged up to 27 ft (8.2 m) and current velocities up to 2.4 feet per second (0.73 meters per second [m/s]). The project is presented as a case study with focus on project definition to satisfy regulatory requirements, design and performance of the turbidity control system, equipment selection and performance in debris and fine-grained materials, the contractors' approaches to satisfying performance-based specifications, dredged material handling, and review of project completion metrics.

This project area experiences periodic high river velocities, a major design issue for turbidity controls. This design challenge was met using a sheet pile flow deflection wall coupled with a single heavy fabric silt curtain with piling and cable support, and overlapping sections. Velocity measurements and hydrodynamic modeling were used for design, to test alternative configurations and potential impacts to an adjacent bridge pier. A dual criteria turbidity action level was requested in the permit and compliance monitoring utilized telemetric data collection, visual time-trend monitoring and alarm notification of exceedences. Dredging employed shore-based long reach excavators and barge mounted cranes operating clam shells and a Cable Arm environmental clamshell. During dredging, shoreline bank slopes were field-modified from design for stability and the sheet pile wall installation immediately followed dredging. Dredging was performed in fall 2006 and contingency planning had to consider potential for freeze-out.

Debris separation from sediments was a regulatory requirement. Debris had significant impacts on production rates and equipment durability. Field modification to dredge cut reporting was implemented to deal with repeat damage to position sensors in removing large debris. In meeting these challenges, dredging was completed in the November 2006 – January 2007 period. This presentation will be a useful case study review to future projects conducted in similar settings and with similar requirements.

Keywords: Dredging, environmental, sediment, Detroit River, silt curtain, turbidity, side slopes.

INTRODUCTION

The Trenton Channel is the western branch of the Detroit River located downstream of Detroit, Michigan that discharges to Lake Erie (Figure 1). The Trenton Channel is part of the Detroit River Great Lakes Area of Concern (http://www.epa.gov/glnpo/aoc/detroit.html). Sediment quality impairment in the Trenton Channel is associated with a history of dense urban development and intense industrial activity over a period of a more than a century along the Detroit River. Various remediation activities have been implemented or are underway along sections of the shoreline. Along one section in the City of Riverview, Michigan, a historical waste disposal area situated on a 37-acre (10.9 hectares) parcel with 3 acres (1.2 hectares) in the Trenton Channel is the focus of a regulatory order requiring removal of sediments and containment of materials on the upland site within a containment system

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involving a cap, barrier walls, and hydraulic controls. This portion of the shoreline was a marshland adjacent to the River that was historically filled and armored with construction debris and rubble and was the site of a planned marine shipping terminal in the 1970s. Site preparation included installation of a sheet pile bulkhead along the upstream portion of the site. The Site is adjoined on the downstream side by a public boat launch facility and immediately adjacent to that a vehicular bridge spanning the channel (Figure 2). To satisfy requirements of a regulatory order, it was necessary to remove sediments situated below the Low Water Datum on the parcel of property occupied by the historical waste disposal area and the adjacent public boat launch parcel. The order required removal using an environmental bucket of sediments defined by a Sediment Removal Plan (SRP), or up to maximum volume of 30,000 cubic yards (cy) (22,900 m^3). Removal volumes were to be quantified with pre- and post-dredge surveys.

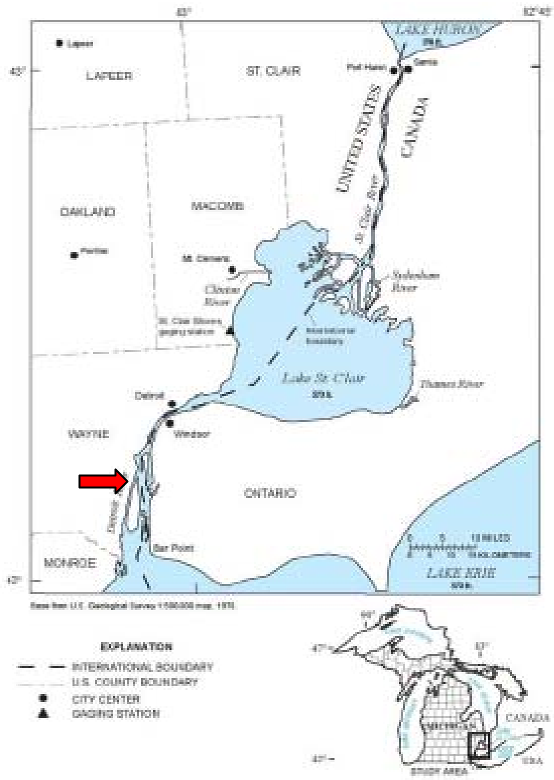

Figure 1. Site location.

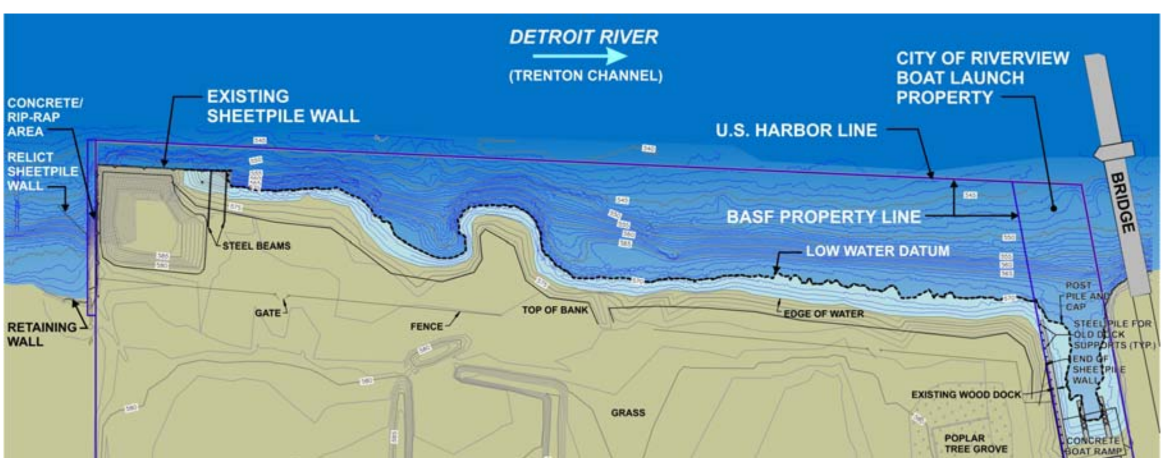

Figure 2. Sediment removal area conditions.

Site Characterization

Water depths ranged up to 27 ft (8.2 m) prior to dredging and current velocities up to 2.4 feet per second (fps) (0.73 m/s). Existing side slopes along the bank varied from the vertical bulkhead to rubble slopes of approximately 2:1 and more gradual slopes of approximately 5:1 (Figure 3).

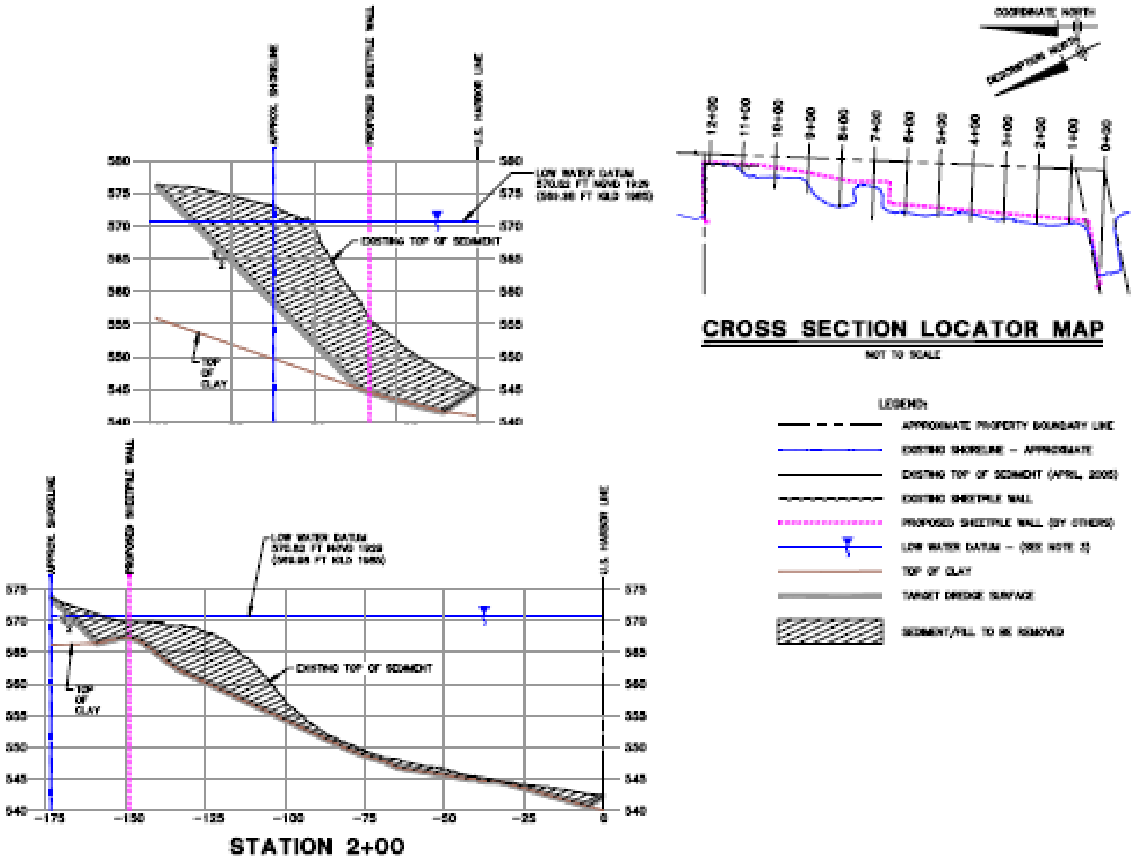

Figure 3. Sediment removal area cross sections.

Side-scan sonar survey revealed debris over much of the Site and shoreline inspection revealed large concrete rubble at the top of the slopes along the bank. Thickness of the armor layer and fill composition beneath this material were undetermined. Site characterization data included 37 sediment cores collected by vibra-coring and 48 geotechnical borings collected for various purposes through a series of sampling programs. The site is underlain by a regional clay unit that forms the river bottom in parts of the channel. Fill, debris, and river sediments are situated over this regional clay layer, which dips from the west to the east toward the river. The total thickness of sediment, fill, and debris over the surface of clay ranged from 24 ft to less than 1 ft (7.3 to less than 0.3 m). Sediments contained various contaminants associated with the multitude of industrial sources upstream and along the banks of the channel, including oil and grease, PAHs, metals, napthalenes, PCBs, and other organic compounds.

Sediment Geotechnical Data

Sediment probing data, the available borings, and the sonar survey results indicated a mixture of materials ranging from large debris to gelatin-like mud in protected areas. Debris included broken concrete, brick, steel cable, miscellaneous construction rubble. Gravely sediments were present in some areas at the upstream end of the site. Fine grained sediments were present along most of the shoreline and in the boat launch area. Geotechnical results for sediments sampled by vibra coring in soft sediment areas are shown in Table 1.

Table 1. Summary of geotechnical data for sediments.

Statistic/Parameter	n	Max	Min	Avg	Median
Water Content (%)	35	208	7.7	67	53
Liquid Limit	32	104	21	54	51
Plastic Limit	32	38	12	24	27
Plasticity Index	32	70	3.0	30	22
Percent Finer than #200 Sieve (%)	35	98	0.3	70	77
Hydrometer % -2µm (%)	35	38	0.0	26	29
Soil Particle Density	35	2.7	2.4	2.6	2.6
Bulk Density (kg/m^3)	35	2,420	1,250	1,750	1,630
Dry Density (kg/m^3)	35	2,240	400	1,200	1,060
Porosity	35	0.8	0.2	0.5	0.6

Stabilization mix tests were conducted to evaluate Portland Type I mix ratios required to achieve adequate bearing strength to support cap construction. Results indicated a mix ratio of 5 percent by volume would achieve strength of 20 pounds per square inch (138 kilopascals) in 28 days; however, the contractor elected not to perform stabilization at the time of placement in favor of allowing sediments to drain in the disposal cell to be stabilized in place later if needed.

DESIGN AND CONSTRUCTION

Characteristics of the materials to be removed necessitated a mechanical dredging approach and water depths and site configuration necessitated a combination of shore-based and barge-based operations. The dredging project was designed as a combination of shore-based excavation using excavators with toothed buckets for debris removal and cut-back of the shoreline, and barged-based cranes operating clamshells for debris removal from water and an environmental bucket for removal of mud sediments. Dredged material was disposed at the upland site for eventual confinement within a cap and barrier wall system. Permit requirements included maintaining a turbidity barrier system and continuous turbidity monitoring and comparison to action levels. Dewatering of dredged material was accomplished by allowing percolation to groundwater within the site.

A joint permit from the Michigan Department of Environmental Quality (MDEQ) and the U.S. Army Corps of Engineers (USACE) was required for the project. A turbidity control system (whose design was supported by modeling analysis), required monitoring for compliance with turbidity action levels, and environmental windows were established in the permit through discussions with these agencies.

Turbidity Control Systems

The site experiences significant periodic flow velocity increases and normally high river velocities at the upstream end of the sediment removal area, which was a major design issue for turbidity controls. Velocity measurements and hydrodynamic modeling were used to evaluate alternative turbidity control configurations and potential impacts to an adjacent bridge pier. An existing USACE RMA2 model for the Trenton Channel (Hotlschlag and Koschik, 2002) was refined in the area of the site and used to predict flow velocities for various turbidity barrier systems utilizing a silt curtain as the barrier for most of the perimeter with a sheet pile deflection wall at the upstream end. Simulations indicate a suitable design would be a sheet pile flow deflection wall perpendicular to the river flow with the downstream end angled downstream coupled with a single heavy fabric silt curtain with piling and cable support (Figure 4).

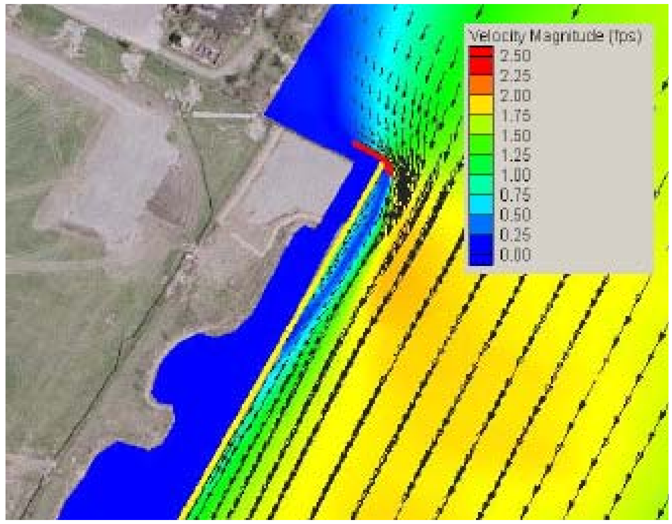

Figure 4. Hydraulic model simulation results for turbidity barrier system.

Anticipated silt curtain performance in this configuration was reviewed with a vendor to select fabric weight (a 22 ounce per square foot PVC-coated impermeable polyester curtain was selected) and provide added confidence that the stresses on the curtain would not be excessive. Stresses were reduced through the use of closely-spaced anchor piles, accounting for locations of normal forces on the curtain due to a predicted return eddy (See Figure 4). In the field the silt curtain was installed with overlapping (with laps in the downstream direction like fish scales), bolt-joined sections to control turbidity releases at the joints. The top was attached to a floating boom and the bottom weighted with a continuous chain. The curtain was attached to the piles with lashing. Piles (8-inch diameter steel pin piles) were placed to anchor the curtain. The curtain was weaved through the piles to limit billowing in either direction from the planned alignment.

The sheet pile flow deflection wall installation was left to the contractor's means and methods in the design and specifications. The contractor selected an installation utilizing a stone buttress to support the toe of the wall. Clay thicknesses over bedrock were not adequate to support the toe of driven pile sections. This temporary wall was stiffed with a whaler and attached to the existing wall for support.

A dual criteria turbidity action level was granted in the permit which was 150 percent of upstream turbidity, or 50 ntu above upstream turbidity, which ever is greater. This avoided unnecessary project delays should turbidity remain somewhat elevated downstream during periods when the river is running exceptionally clear, and accounts for potentially noisy data when the river is running turbid. Downstream monitoring stations were positioned 250 ft (76 m) and 600 ft (183 m) from the downstream edge of the silt curtain. The 250 ft station served as an early warning station where exceedences would trigger contingency action. The 600 ft station was essentially the compliance point. Turbidity was recorded at 10-minute intervals and evaluated on a 60-minute rolling average basis (of the 6 prior readings). Telemetry transmittal from solar powered piling mounted monitoring stations relayed data to the dredge cab and job trailer on land. Visual monitoring of trends on a multi-panel monitor display and an alarm notification to the monitor screen provided basis for immediate response to problematic turbidity levels. Visual observation of the perimeter of the turbidity containment system was also conducted to detect plumes emitting from the enclosure. Contingency actions were required by the permit in response to either visible plumes or exceedence of turbidity criteria at the downstream monitoring stations. Contingencies included supplemental monitoring with a hand-held turbidity meter to locate releases, diver observation of the curtain if necessary, adjustment to dredging operations, and halting of dredging operations if exceedences persisted for more than 3 hrs.

The turbidity control system worked well (Figure 5). Minor turbidity releases from the point of attachment to the sheet pile wall occurred early in the project but corrective actions reduced this. No turbidity exceedences during dredging operations occurred that were not explained by other causes (e.g. small fish caught in the sensor apparatus cage, algal mass buildup, or temporary disturbances of the sensor, etc.).

Figure 5. Aerial photo of sediment removal area during dredging.

Dredge Plan

A Sediment Removal Plan (SRP) was prepared that defined the surface of the underlying clay layer and side slope positions necessary to clear the alignment of a sealed sheet pile barrier wall to be installed along the shoreline. Adequate interim side slope stability was developed to allow for installation of the sheet pile wall. The dredge plan target elevations was prepared assuming slopes of 2:1 along the shoreline based on observed side slopes in upland test pits and existing maximum slopes, and 3:1 around the other sides of the dredge cut (Figure 6). Twelve sub areas were established and dredging was required by the regulatory orders to dredge in an upstream to downstream and shoreline toward harbor line order to minimize recontamination by flow of suspended material to dredged areas.

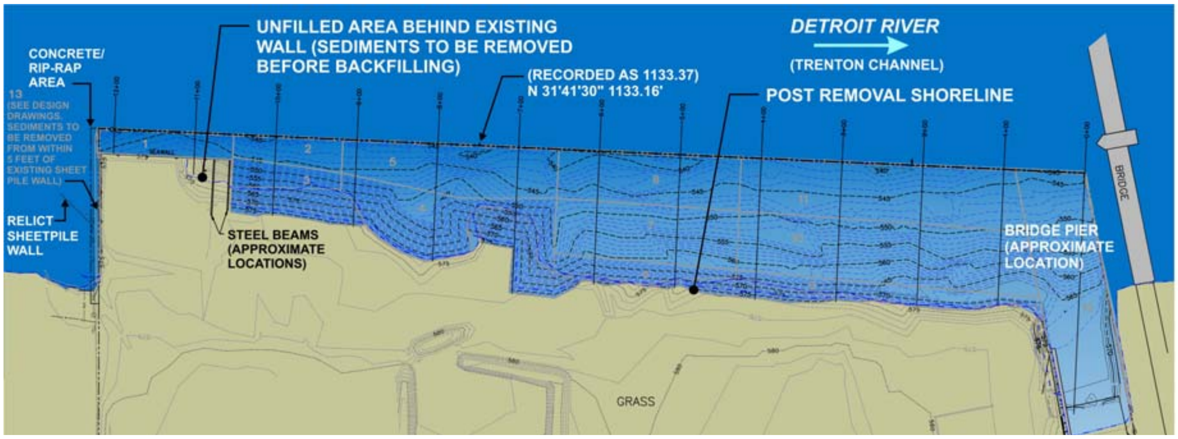

Figure 6. Dredge plan target elevations.

Dredging employed shore-based long reach excavators and barge mounted cranes (See Figure 5) operating clam shells and the Cable Arm environmental clamshell. Transport of near shore dredged material was by dump truck loaded directly from the shore-based excavators. Two dredge scows were used to transport dredged material removed by barge-based cranes to an off-loading area at the upstream end of the Site where a second crane (American 5299C) unloaded the barges to transport trucks. Free water from the barges was pumped to an infiltration lagoon near the center of the Site. Ultimate debris volume was between 30 and 40 percent of dredged material volume and exceeded expectations due to incomplete characterization of the thickness of the debris layer along the shoreline. The original dredge plan involved separation of debris using a grizzly screen; however due to the type (debris included steel cable, steel banding, and re-enforced concrete) and amount of debris, this was abandoned and truck loads containing primarily debris were unloaded in a debris stockpile area. When sediments were dredged, these materials were dumped into an earthen-bermed lagoon confined within the cap and barrier wall groundwater containment system scheduled for later construction (Figure 7).

Figure 7. Dredged material off-loading area.

During dredging, shoreline bank slopes were field-modified from design for stability. Sheet pile wall installation immediately followed dredging. Moderate slumping of side slopes, which were originally established at approximately 2:1 occurred following dredging, which was evident in post-dredging survey data. Contactor completion requirements for dredging were to achieve final elevations within 1 foot of the target dredge surface allowing for a +/- 6 inch (+/- 15.2 cm) survey accuracy in single-beam survey transects used for pre- and post-dredging bathymetric analysis. No residual sediment thickness nor residual contaminant level requirements existed for this project.

Dredging progress was monitored with the Clam Vision software so that the operators could observe progress on an in-cab monitor relative to the dredge plan elevations in real time (Figure 8). In some areas the dredge plan elevations that were based on the estimated top of clay surface initially resulted in removal of significant amounts of clay to achieve the plan elevations. A field modification was made to confirm where clay was encountered based on visual inspection of material recovered in the bucket and logging these locations. This avoided unnecessary removal of clay yet still achieved the objectives of the project. The inaccuracy in the estimated top of clay elevation resulted from variations in the clay surface and subjective interpretation of geotechnical boring logs from various programs, not all of which were collected for the explicit purpose of defining the clay elevation and as such were not logged in detail in that regard.

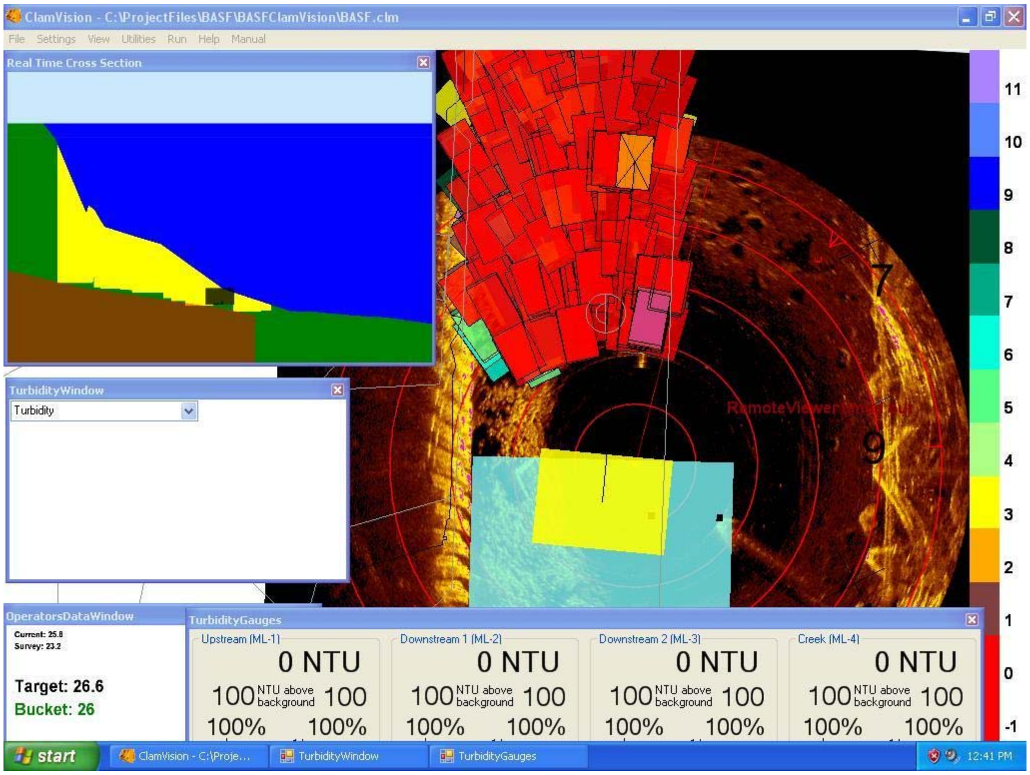

Figure 8. Clam Vision view screen.

Debris removal and handling was a major issue with implementation of the project due to the volume and type of debris and limited initial productivity. Initial removal from shore was performed with a long reach excavator (CAT330B Long Reach) with cut elevation sensors on the boom and bucket. Debris damage to the bucket pin and position sensors resulted in discontinuation of the end of bucket position and an assumed cut elevation equal to depth of cut with the bucket curled was used. A larger excavator (CAT365) was used to increase production later. Dredging by the crane based barges used an open clamshell at intervals for debris removal and a 4-yard Cable Arm environmental bucket for production dredging.

Dredging was performed in fall 2006 and contingency planning had to consider potential for freeze-out. Weather conditions were exceptionally good allowing for project completion without ice complications. Total period of dredging, following installation of turbidity controls, was approximately 10 weeks, beginning in early November 2006 with completion in early January 2007.

CONCLUSIONS

The dredging project was successfully implemented within a limited seasonal window with good performance of the turbidity control systems and removal of required materials to allow the rest of the site remediation activities to progress. The design and performance of the turbidity control systems and permit turbidity limits and monitoring requirements were important in meeting the schedule without turbidity-related delays. Weather conditions were also very favorable. Available information for turbidity system design included sufficient field flow velocity measurements on transects across the project area, a detailed hydraulic modeling analysis, and vendor review of the design concept and input on expected performance of the silt curtain. To mitigate loads on the curtain associated with the fairly swift flow of the Trenton Channel, tight spacing of anchor piles, lashing of the curtain to the piles, bolting the panel joints, and placement of the piles on the inside of the curtain contributed to its performance – with careful attention by the contractor to correctly install and support the curtain. The approach of specifying the dredge plan elevation as the contractor requirement subject to accuracy of surveys worked well, although contingencies for side slope failure and areas were the dredged plan was not accurate relative to actual bottom of sediments required field adjustment to account for these situations. Significant debris and delays associated with equipment change outs and limited recovery of material due to the amount of debris present caused initial delays in progress. The importance of debris interference in dredging along similar historically filled or industrial shorelines should be a major consideration. Methods for characterizing debris at depth and production rates are limited, short of test removal operations, which in this case would have facilitated design and planning. Overall, the project was implemented successfully in a relatively short time window and satisfied regulatory requirements and compliance with applicable permits was maintained.

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ACKNOWLEDGEMENTS

The authors wish to thank Jerry Swain of Faust Corporation of Detroit, Michigan. Faust Corporation was the dredging contractor for this project. Cable Arm provided dredging operations monitoring support to the contractor and bathymetric survey services.