A STUDY IN CONTRASTS: TWO YEARS OF DREDGING AT THE ST. LOUIS RIVER/INTERLAKE/DULUTH TAR (SLRIDT) SITE

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ABSTRACT

The past two years at the St. Louis River/Interlake/Duluth Tar (SLRIDT) site represent a study in dredging contrasts; one year presented a simple, flat dredge prism in an estuarine bay; the next a complex dredge prism on a steep slope to a dredged shipping channel, which straddles the Minnesota-Wisconsin state line.

The SLRIDT site is located on the St. Louis River, approximately 6.4 kilometers (4 miles) from its confluence with Lake Superior, in a mixed industrial/residential neighborhood. A combination remedy including capping and dredging was initiated in 2006 with construction of a surcharged cap and an on-site contained aquatic disposal (CAD) facility for contaminated sediment disposal.

Polycyclic aromatic hydrocarbon (PAH)-impacted sediment was dredged and placed in the CAD during the 2007 and 2008 construction seasons. In 2007, sediment was dredged from Stryker Bay, a shallow, sheltered bay with a simple dredge prism and well-defined PAH-impacted sediment layer. Residents, some with riparian rights, occupy the western shore of Stryker Bay. The eastern shore is occupied by ongoing industrial operations, making coordination and communication important for the 24-hour/day, 7-day/week remediation operations.

In 2008, dredging activities concentrated on a more complex dredge prism adjacent to, and within, a federal navigation channel, with much more pervasive PAH-impacted sediment. The dredge prism in Wisconsin had to be refined based on sediment core data, while dredging continued, in order to meet a PAH-concentration-based standard in the post-dredge surface, as required by the Wisconsin regulatory agency. The Minnesota regulatory agency site-specific standard is defined by Normal Dredge Residue mass and thickness measurements from pilot areas, rather than a PAH-concentration-based standard.

The two dredging scenarios also presented confirmation survey challenges. In Stryker Bay, attaining accurate subaqueous survey data in shallow water depths required refining the methodology, as did surveying adjacent to the river channel in deep water with river currents.

Keywords: PAHs, Normal Dredge Residue, sheltered bay, navigation channel, contaminated sediment.

INTRODUCTION

The SLRIDT site (Site) is located on the St. Louis River, approximately 4 miles from its confluence with Lake Superior (Figure 1). Prior to Response Action (RA) construction, the Site was the most upstream active dock facility in the Duluth/Superior Harbor.

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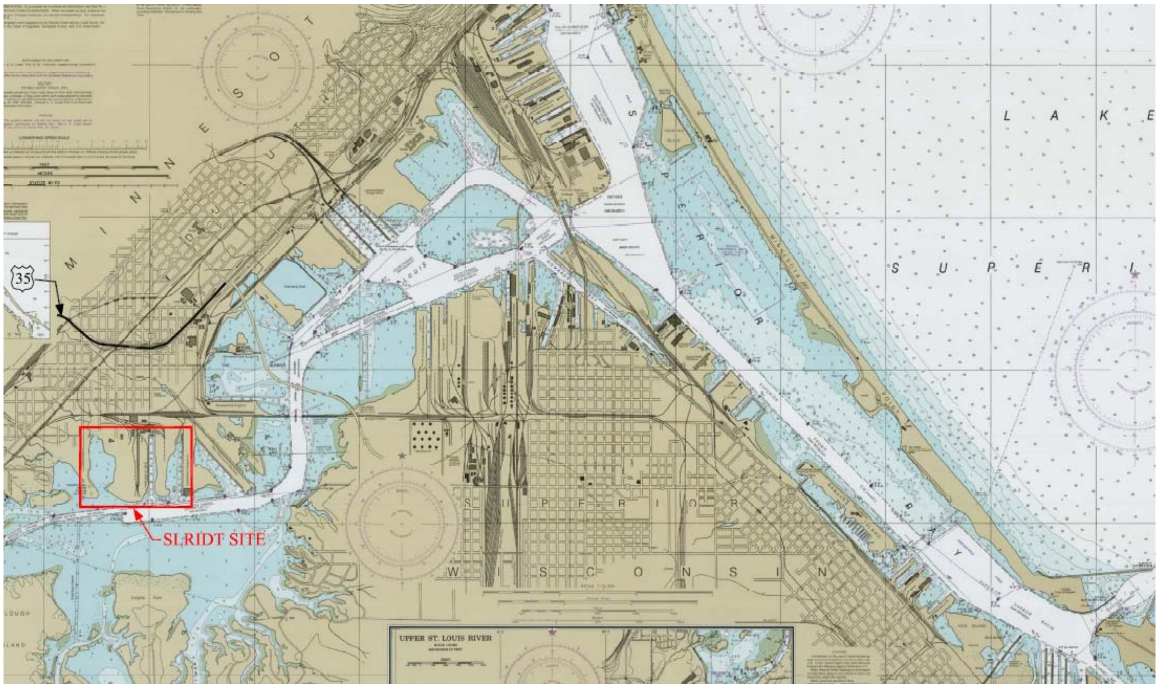

Figure 1. Duluth/Superior Harbor on Lake Superior. The Site is shown in the boxed area.

The Site was home to historic steel-making, manufactured gas production and tar refining facilities. These facilities operated in various capacities from the late 1800's through the early 1960's. Throughout this time period, man-made peninsulas were constructed with manufacturing by-products such as slag, ash and other fill, creating a shallow sheltered bay (Stryker Bay) and two commercial docks with 609.8-meter (2,000-foot)-long deep-draft boat slips (Docks/Slips 6 and 7). The mouths of these water bodies open to a Federal Navigation Channel (Minnesota Channel), which is the deepest portion of the St. Louis River (~ 9.1 meter (30 feet)). Water depths are depicted in Figure 2.

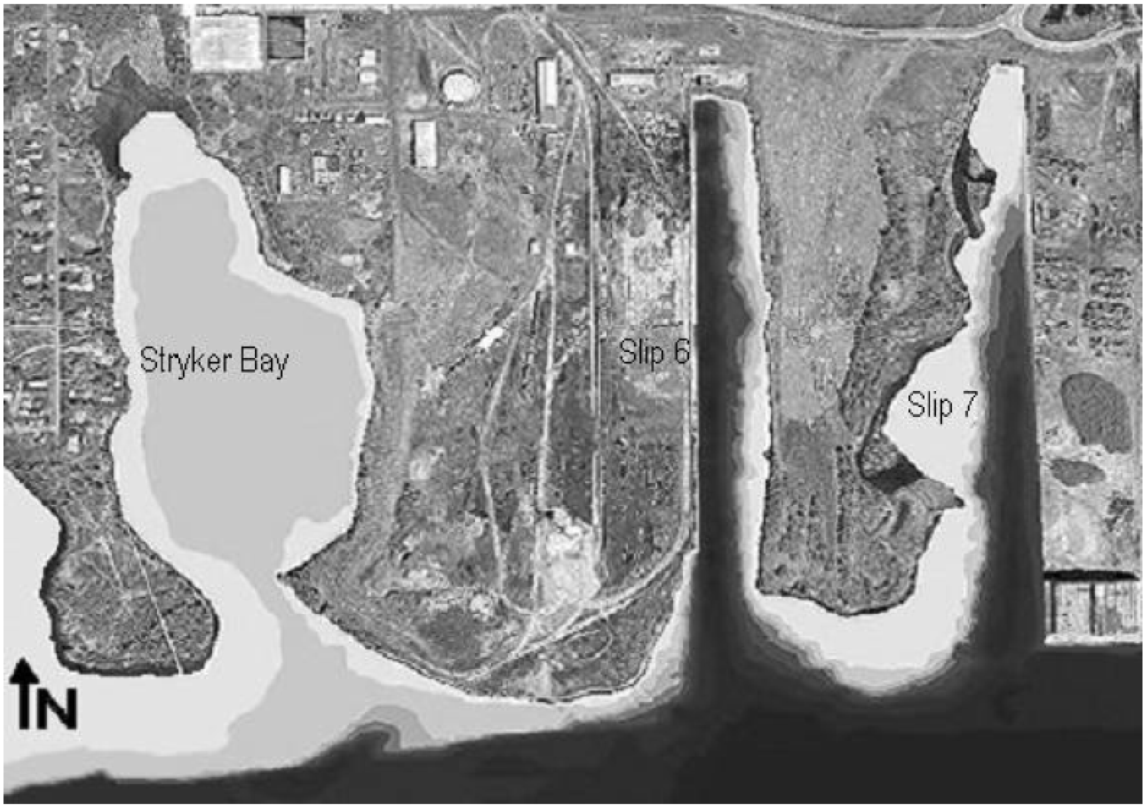

Figure 2. SLRIDT Site. Shallow Water Shown in Light Gray

Releases from a coke oven and by-products recovery plant, water-gas plant, and associated coal tar refineries caused the sediments of Stryker Bay and Slips 6 and 7 to be contaminated by polycyclic aromatic hydrocarbons (PAHs) at concentrations as high as 35,000 mg/Kg.

While the highest concentrations of PAHs are localized in 4-5 "hot spots", the majority of Stryker Bay and the boat slips, and areas of the MN Channel have PAH concentrations above the site clean-up goal of 13.7 ppm total PAHs (Figure 3).

A hybrid dredge/cap Remedial Design/Response Action Plan (RD/RAP) was negotiated to cap the areas of the highest PAH concentrations, and dredge portions of Stryker Bay and the MN Channel to the site-specific clean-up goal. The RD/RAP included dredging the majority of Stryker Bay to remove contaminated sediments, and allow room for a post-dredge sand cover and placement of an environmental medium, while maintaining water depths suitable for fish habitat and recreational boating. Portions of the channel river sediments were identified to be dredged for contaminant removal, and to allow for cut-slope armoring without placing aggregate material in the Federal Navigation Channel.

The RD/RAP also called for materials dredged at the site to be deposited in a Contained Aquatic Disposal (CAD) cell constructed in Slip 6. A rock dike with an impermeable clay liner was constructed at the mouth of Slip 6 to isolate the CAD water from the river during response actions. Contaminated sediments are hydraulically placed in the CAD using a barge-mounted tremie. After dredging is completed the CAD will receive a 0.91-to 1.52 meter (3-to 5-foot)-thick sand cap, with placement of environmental medium on the sand for habitat enhancement.

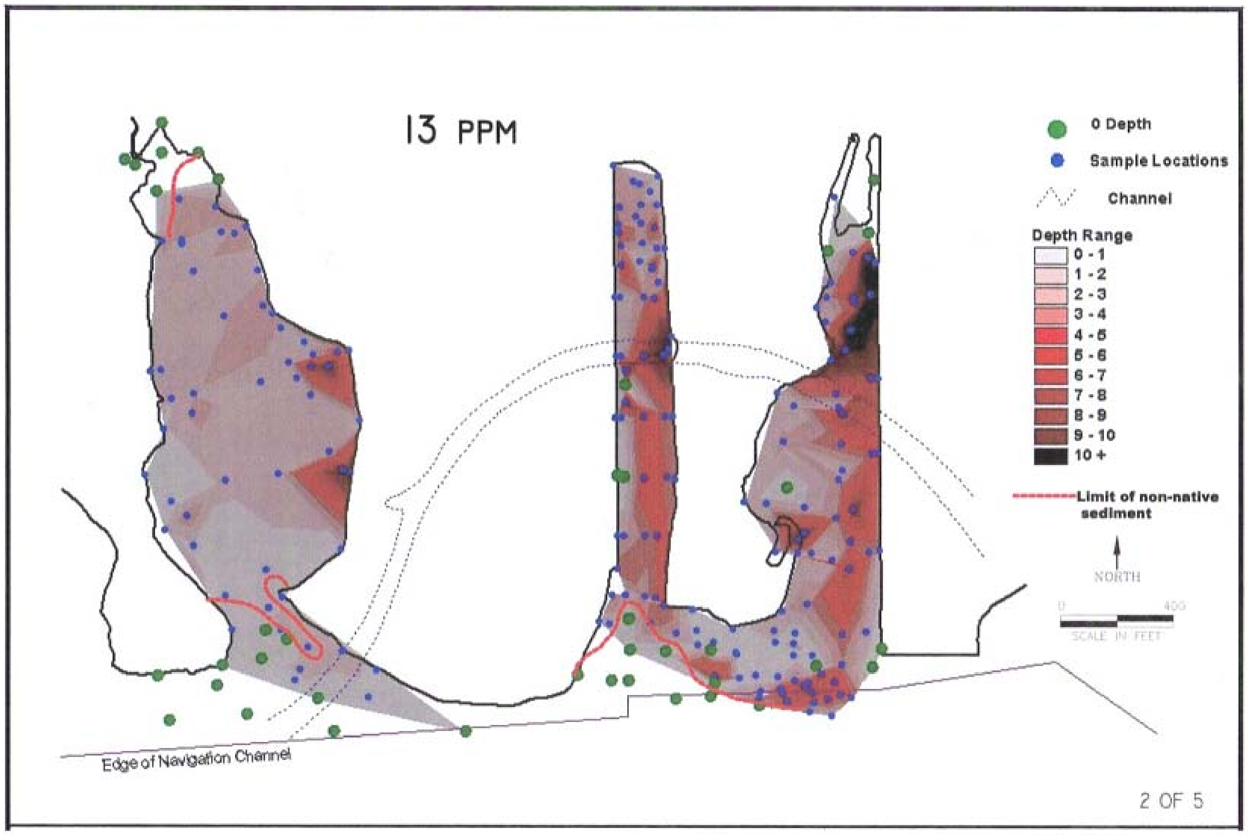

Figure 3 - Extent and depth of PAH contamination at the Site. Darker areas are thicker. Note the contamination extends somewhat into the adjacent state of Wisconsin, and into the Federal Navigation Channel, but is mostly confined to backwater areas. Typical thickness is about 60 cm, with maximum thickness of about 3 meters.

Stryker Bay

Stryker Bay is a shallow, sheltered bay of approximately 15 hectares (37 acres) with a maximum water depth of 1.8 meters (6 feet). The Lake Superior seiche effect causes surface water levels to vary by up to 0.3 to 0.61 meter (1 to 2 feet) per day, on an approximately 7-hour cycle. A constricted mouth combined with the seiche flows causes increased bi-directional currents that maintain a 1.52-1.83 meter (5-6 foot) channel at the mouth.

The western shore of Stryker Bay is residential, with some private docks for recreational boating. The bay has had thick aquatic vegetation in recent history, with emergent wetland communities at the northern end. A small un-named creek and two storm water sewers flow into the north end of the bay. Surficial sediments consist of silts and clays with smaller isolated areas of peat and sand. Contaminated sediments are typically located in a well-defined layer of dark-brown to black clayey silt with a naphthalene odor and tarry sheen. The contaminated sediments overlay native red to light brown glacial lake-deposited clays.

In Stryker Bay the combination remedy involved capping the thickest and most-highly contaminated sediments with an activated carbon mat barrier and surcharged sand cap. The approximately 4.5- hectares (11-acre) sand cap was surcharged to increase the consolidation rate in order to attain a sufficient water depth to maintain the pre-response action character of the bay. The relatively shallow (< 0.91 meter (3 feet) deep) contaminated sediments in the

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remainder of the bay were dredged and placed in the CAD. The two areas are separated by a 609.8-meter (2,000-foot) long sheet pile wall.

The dredge prism in Stryker Bay was designed in large, flat-bottomed units typically several acres in size (Figure 4). Dredge cuts ranged from <1 foot to 4 feet in depth, with an over-dredge allowance of six inches. The Response Action Contractor (RAC) created 29 Dredge Management Units (DMUs), each approximately one acre in size. Each of the DMUs was individually surveyed and approved.

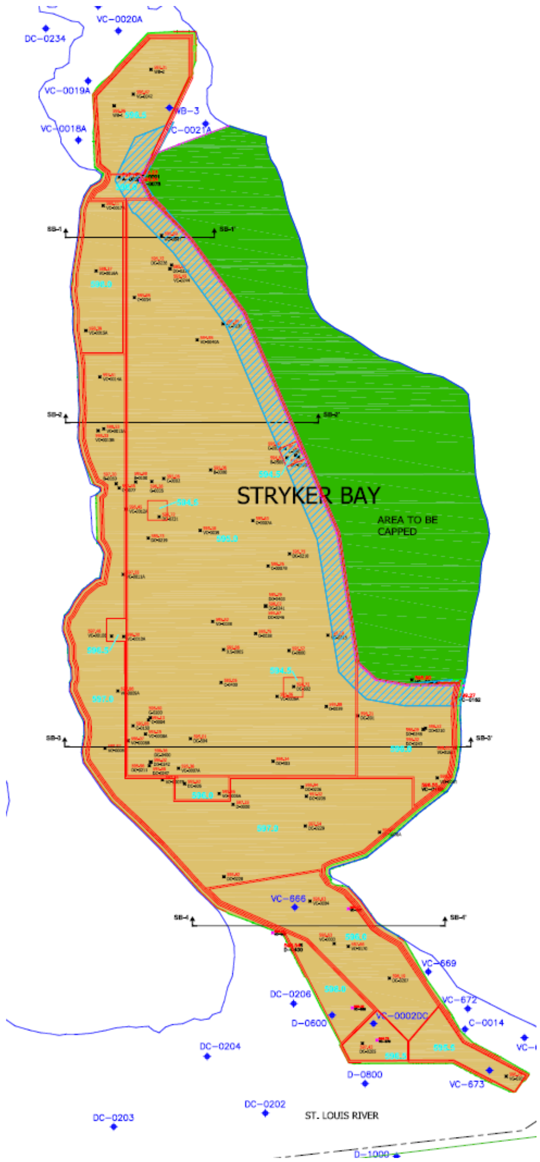

Figure 4. Stryker Bay Dredge Prism

Environmental Concerns and Controls

A comprehensive environmental monitoring program was developed and implemented to ensure that air and surface water quality, as well as noise levels, did not have a negative impact on the surrounding environment or residents, due to the nearby residences west and north of the site, and the surface water standards applied to a Great Lakes tributary.

Air quality was measured in the residential neighborhood and at the site boundaries during dredging activities in Stryker Bay. Dedicated sampling sheds contained acute and chronic sampling instruments, and results were posted to the project website (www.slridt.com). The acute air quality was measured using Aromatic-Specific Laser Ionization Detectors (ArSLIDs) and the results were uploaded to the project website in real-time. The chronic air quality was measured over a 48-hour period each week using a high volume Polyurethane Foam (PUF) air sampler with laboratory analysis for EPA Method TO-13A. Additionally, green, yellow and red lights were mounted to the sheds to inform the public of the current air quality at each monitoring station. A weather station was installed at the site to monitor wind direction and speed, and these parameters were also available to the public on the website. Throughout the dredging activities in Stryker Bay, air quality remained at, or near, background levels.

Noise levels were monitored weekly, or as complaints arose. A one-hour average test was conducted during daytime (0700-2200 military time) and nighttime (2200-0700) shifts to determine compliance with Minnesota Pollution Control Agency (MPCA) noise standards. Noise levels became a concern, especially on calm nights. Resident complaints were addressed by either moving dredging activities to DMUs further from the residents, or offering to provide off-site lodging to the resident. Most residents decided to accept the elevated noise levels to avoid prolonging the project schedule.

The RD/RAP required installation of surface water quality structures to isolate work areas from the St. Louis River, in order to ensure response actions did not diminish water quality in the river. A combination of turbidity curtains, water dams and weir walls were utilized to keep turbidity and contaminants from entering the river, as well as control the water levels in Stryker Bay. Typically, a turbidity curtain was installed around the dredge barge to establish a moon pool, and a secondary structure was placed at, or outside of, the mouth of Stryker Bay. The turbidity curtains had permeable panels just beneath the floats to allow some water to flow through the curtain. Prior to completing the isolation of a work area, fish were removed from the bay using copper sulfate as an irritant to “herd” them out. After the fish were “herded” out of Stryker Bay, a water dam and weir wall were constructed across the mouth as the outer-most water quality control structure.

Surface water quality samples were collected weekly outside of the outermost water quality control structure for each water body with active response actions for the following parameters:

- Metals (Ar, Cd, Cr, Cu, Fe, Pb, Ni, Zn)
- Mercury
- Hexavalent Chromium
- Cyanide (free)
- Benzene, ethyl benzene, toluene and xylenes (BETX)
- Polynuclear aromatic hydrocarbons (PAHs) – 17 site–specific analytes
- Total suspended solids (TSS)
- pH
- Turbidity

These samples were compared to upriver and downriver background samples collected during the same event, to assess whether the source of any analyte detections were related to Site response actions. Very few samples (<0.1%) had results that exceeded a surface water standard. These exceedances were usually due to a breach in a turbidity curtain.

Dredging in Stryker Bay

Record low water levels in the Lake Superior watershed and the St. Louis River during 2007, required bathymetric surveys in Stryker Bay to be performed in waders and boats using an with a real-time kinetic (RTK) GPS/survey pole due to varied and shallow water depths, rather than using sonar, as originally proposed by the RAC. In some overgrown areas along the shorelines where trees blocked satellite signals, a total station was used in place of the GPS. A 7.6-meter by 7.6-meter (25-foot by 25-foot) grid was utilized for data points, and all survey systems were calibrated to site benchmarks set by an independent registered land surveyor.

A pre-construction survey was completed to document site conditions, and for comparison to post-dredge bathymetric surveys for dredged sediment volume calculations. Because of the difficulty of collecting data at exactly the same grid point repeatedly, pre- and post-dredge survey data was utilized to create surfaces for comparison. Areas between data points on the surfaces were interpolated by the software. Anomalies in surfaces were typically resolved through data review (pole heights and data reduction mistakes were the most common errors), or ground-truthing with additional survey shots.

The RAC conducted dredging operations at SLRIDT on a 24/7 schedule during Duluth's construction season (May-November). Dredging in Stryker Bay was accomplished through the use of a barge-mounted excavator equipped RTK GPS positioning system for location and elevation. The excavator used an "environmental" clamshell bucket with a 1.53 cubic meter (2 cubic yard (cy)) capacity. This bucket was gasketed and vented, and was designed to create a relatively flat cut to minimize overdredging and "scalloping" of the dredged bottom. Dredging was performed within a turbidity curtain "moon pool", the primary water quality control structure. Best Management Practices (BMPs) and performance requirements proscribed in the RAP included:

- Achieve at least 95% removal of target material;
- 6-inch allowable overdredge;
- Work slopes from top to bottom;
- Multiple bites is not allowed, each bucket must be brought to the surface and emptied;
- Bottom stockpiling is not allowed;
- Barges must not overflow or leak contaminated sediment or slurry water;
- Dredge bucket must be properly sized and must not be overfilled;
- Aquatic vegetation, if present, must be harvested and composted before dredging.

Dredged materials were placed into a slurry hopper barge located adjacent to the dredge barge. The slurry hopper had a bar screen above it to separate any large debris, which typically consisted of large branches, bricks, concrete and re-bar found along the eastern shore of Stryker Bay. Sediment that passed through the screen was mixed into a slurry, using return water from the CAD, for hydraulic transport and tremie placement in the CAD. The slurry and return water lines were constructed of 20.3-centimeter (8-inch) high-density polyethylene (HDPE) pipe that extended up to a mile, depending on the location of the dredge in Stryker Bay and the tremie barge in the CAD. Water displaced in the CAD by the deposited dredged sediments was treated by a water filtration plant and discharged back to the St. Louis River in Slip 7.

Prior to production dredging, a two-acre pilot area in Stryker Bay was dredged in accordance with the MPCA-required BMPs. This pilot area served to evaluate dredge equipment, BMPs, production rates, and perhaps most importantly, Normal Dredge Residue (NDR). NDR was agreed upon by the Responsible Parties (RPs) and the MPCA as the measure of dredging success, along with survey verification of 95% removal of target material, rather than establishing a dredged surface PAH concentration standard. The NDR standard was applied to each DMU to evaluate successful completion. Twenty sediment cores were collected in the two-acre pilot dredge area to determine the NDR standard. The residue was evident in these cores through the contrasting colors of dredge residue and the underlying native sediment. Figure 5 depicts a typical core with the dredge residue and native sediment layers. Once the dredge residue thickness was measured and recorded, the residue was removed from each core and weighed. Each core's residue was then dried in an oven and a dry weight was recorded. The pilot area dredge residue thickness and mass were used to determine the NDR standard for the remainder of Stryker Bay. After production dredging began, and after a DMU had been dredged and surveyed, ten cores per acre were collected to evaluate dredge residue. The mean residue thickness or mass in each DMU was compared to the 95% upper confidence level of the NDR to determine whether the DMU was completed. If this measure was not met, additional dredging would need to be performed in that DMU. For additional completion documentation, one sample of dredge residue was collected per acre for total PAH analysis, however this measure was not used to determine whether the DMUs were completed successfully.

Figure 5. Typical NDR Cores. Note the contrast between the dark brown and black dredge residue and the light brown underlying native sediments.

Performance

The RAC experienced good dredging conditions in the relatively soft sediments and flat, shallow dredge prism of Stryker Bay. One small area (< 1 acre) of stiff clay along the western shoreline required dredged material transport by barge instead of slurry. Of the 86,017 estimated cubic meters (112,500 estimated cubic yards) of contaminated material targeted for removal in Stryker Bay, 110,400 were documented as removed (98%). Approximately 1529 cubic meters (2,000 CY) of material was removed from outside the allowable overdredge limit (2%). Twenty-nine of the 30 DMUs passed the NDR thickness standard, with the other DMU passing the NDR mass standard.

MINNESOTA CHANNEL

The MN Channel portion of the SLRIDT site consists of extremely shallow (< 0.61 meter (2 feet)), calm water transitioning to deep water with flow rates of more than 30 cm/sec along the transition slope. The dredged mouths of the two former shipping slips and the federal navigational channel (the Minnesota Channel) reach depths up to 9.1 meter (30 feet) of water. Land use adjacent to this work area is industrial, with no private residents.

Sediment types in this area of the Site consist of inter-bedded sands, silts, clays and peat with some consolidated slag deposits, underlain by native silts and clays. PAH contamination in the Minnesota Channel area of the site is much more pervasive than in Stryker Bay, with each of the non-native sediment types potentially requiring remediation.

The combination remedy in the Minnesota Channel involved dredging PHA-contaminated sediments in Wisconsin and the deep portions of Minnesota. This deep-water dredging requires dredging the channel slopes in Minnesota, adjacent to the Wisconsin dredge prisms to maintain a stable slope (Figure 6). These slopes and the shallower areas in Minnesota require capping and armoring using sand, gravel and cobble to protect against the remaining contaminated sediments from erosion.

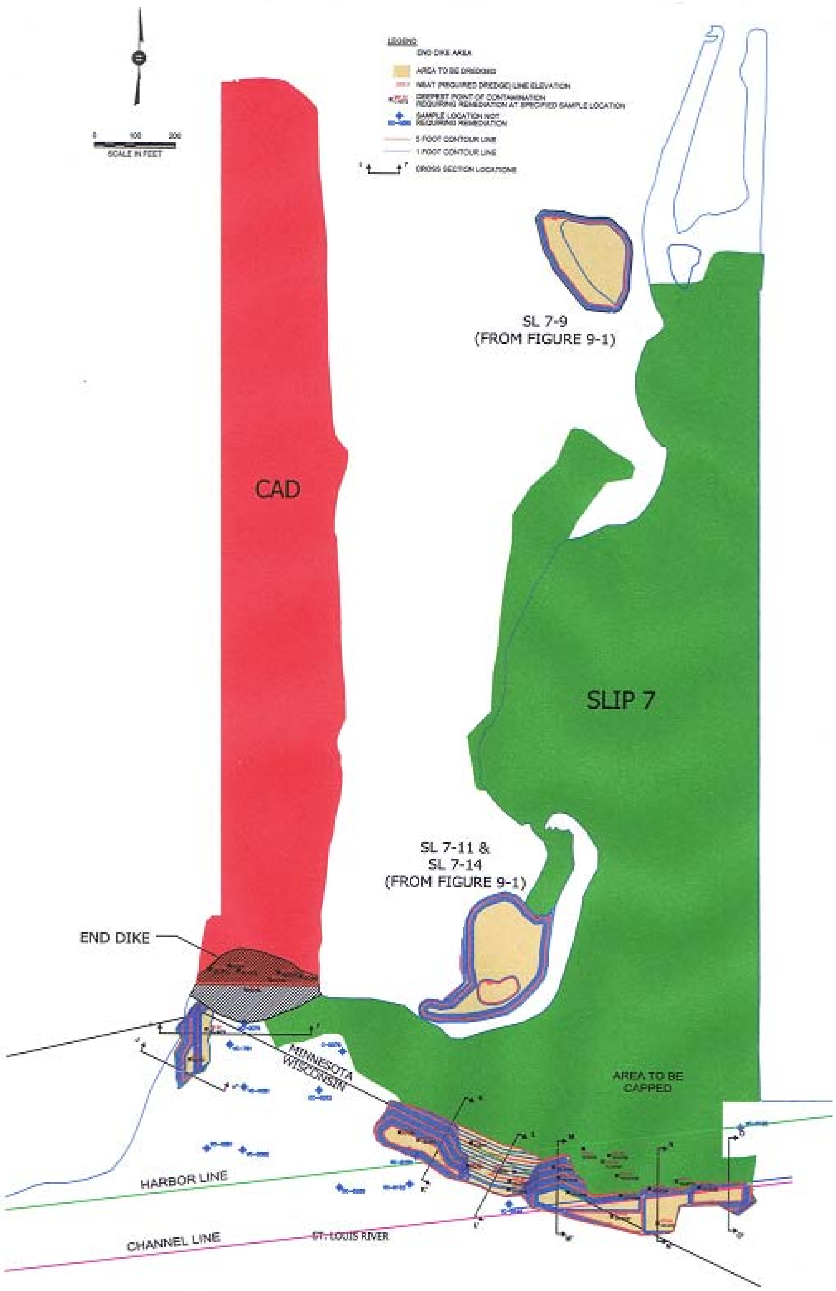

Figure 6. MN channel dredge prisms

The dredge prism in the Minnesota Channel area of the Site was designed to remove contaminated sediments and to provide stable slopes along the main navigational channel. Dredge cuts ranged from <1 foot to approximately 8 feet in depth, with an over-dredge allowance of six inches. Cut slopes were generally designed at 4H:1V or shallower.

Environmental Concerns and Controls

Dredging in the Minnesota Channel work area did not commence until 2008, after Stryker Bay dredging was completed in the fall of 2007. During the winter months of 2007/08, new reduced environmental monitoring requirements were negotiated. Due to the lack of air emission detections in Stryker Bay, and the more remote location of the Minnesota Channel work area, air and noise monitoring were required by the MPCA on an as-needed basis only, implemented only if there were complaints or requests from the public.

Surface water quality parameters were reduced to turbidity, pH and PAHs only. Due to the nature of the work area, turbidity curtains were the sole form of water quality control structure. These curtains were staged to encompass smaller work areas, as well as the dredge barge moon pool, and ranged in height from 1.52 to 9.15 meters (5 to 30 feet). Maintenance of the curtains in the harsher current and wind environment of the open river channel required a greater level of attention than the turbidity curtains in Stryker Bay. As in Stryker Bay, a very small percentage of surface water samples (< 0.1%) exceeded the surface water quality standards, and exceedances were typically related to turbidity curtain operation failures.

Dredging in the MN Channel

Bathymetric surveys in the Minnesota Channel work area were performed in waders and boats using an RTK GPS/survey pole due to the highly variable water depths and the inability to reliably repeat sonar surveys. A 7.6-meter by 7.6-meter (25-foot by 25-foot) grid was utilized for data points, and all survey systems were calibrated to site benchmarks set by an independent registered land surveyor.

A pre-construction survey was completed to document site conditions, and for a comparison to post-dredge bathymetric surveys for volume calculations. Pre- and post-dredge survey data was reduced and evaluated as in Stryker Bay.

For the Minnesota Channel work area dredging, the RAC chose to utilize a barge-mounted crane equipped with an RTK GPS positioning system for location, and cable markings for elevations. The bucket was a 1.53 cubic meter (2 cubic yard) capacity traditional clamshell. This bucket was gasketed and vented, and had teeth to penetrate the slag and debris. BMPs and performance requirements were consistent with Stryker Bay work.

Dredged materials were placed into a slurry hopper barge located adjacent to the dredge barge and delivered to the CAD in the same manner as the Stryker Bay dredged materials, and again water displaced in the CAD by the deposited dredged sediments was treated by a water filtration plant and discharge back to the St. Louis River.

Areas in Wisconsin identified as having sediments with total PAH concentrations greater than 13.7 ppm were required to be dredged, and divided into 15 sample cells (~10 per acre). After 95% of the dredge prism target material was removed and confirmed through survey, composite samples were collected from cores of the top approximately one foot (15 cm) of the post-dredge sediment surface. If the total PAH concentration (of the 17 site-specific PAHs) in a sample was less than 13.7 ppm, the area was considered successfully completed.

The deep water portion of Minnesota in the navigation channel, which is approximately one acre in size, cannot be capped due to U.S. Army Corps of Engineers (USACE) requirements. This area will be dredged to remove sediments with total PAH concentrations above 13.7 ppm. The NDR in this one-acre pilot dredge area will be determined using the same protocol as Stryker Bay. These NDR cores, along with one residue sample for total PAH analysis, will be used for completion documentation.

Dredging of the channel slopes adjacent to the dredged areas in Wisconsin is intended solely to provide stable slopes for the placement of cap and armor materials in Minnesota, and therefore, no dredge completion standards have been established by the MPCA. Confirmation surveys will document the new slope shape and dredged volume removed for payment.

Performance

To date, the RAC has completed approximately one-half of the dredging in the Minnesota Channel work area, based on surface area, and approximately two-thirds by volume. A significant portion of the work area to date has contained hard slag, which for a cable-actuated clamshell creates low production rates. Approximately153 cubic meters (200 CY) of slag and timber have been cleared from the hopper screen and placed into roll-off dumpsters for off-site disposal. Of the 15,751 estimated cubic meters (20,600 estimated cubic yards) of contaminated material targeted for removal in the completed portion of the Minnesota Channel work area, 15,223 cubic meters (19,910 cubic yards) were documented as removed (97%). Approximately 1713 cubic meters (2,240 CY) of material was removed from outside the allowable overdredge limit (11%).

Of the seven Wisconsin surface sample cells completed to date, one cell failed the initial chemistry standard. Subsequently, dredging was performed to remove an additional one to two feet of sediment in the cell which exceeded the Wisconsin standard. The sample cell was then quartered, and a composite sample was collected from a core in each quarter. The average PAH concentration in these samples was acceptable to the Wisconsin regulators, and the cell was approved as successfully completed.

CONCLUSIONS

The dredging activities in Stryker Bay and the Minnesota Channel area at the SLRIDT site have occurred in two very different environments, utilizing different dredging technologies, and resulted in very different results. Performance in Stryker Bay has been good, with 98% of the target material removed with only 2% of the total yardage coming from below the allowable overdredge limit. While 97% of the target material has been removed in the areas worked to date in the Minnesota Channel portion of the Site, 11% of the total yardage has come from below the allowable overdredge limit. This additional material creates additional disposal costs. Lower dredging production rates in the more-difficult Minnesota Channel area of the Site also caused the dredging to take longer than projected.

Several factors likely account for the contrast in the two work areas. The Stryker Bay dredge prism consisted of shallow, relatively homogeneous soft sediments, with a well-defined, distinct contamination layer. The sediments in the Minnesota Channel area were interbedded with sand and slag and the pervasive nature of the PAH distribution resulted in a much more complex dredge prism. The ability for the hydraulic clamshell to dredge in soft silts and clays provided more accurate elevation control than the sometimes large slag chunks and timbers allowed for in the slopes of the Minnesota Channel area.

Secondly, the excavator with X, Y and Z RTK GPS capabilities allowed for greater accuracy and precision during dredging in Stryker Bay. The cable markings utilized on the crane barge in the Minnesota Channel area likely played a significant role in the reduced elevation accuracy of the dredge cuts.

Lastly, the nature of a hydraulic excavator with a clamshell could have provided additional “feel” and control in reaching target elevations and handling debris. With a cable crane, the clamshell bucket can be influenced by bottom contours, large debris and currents, especially in the relatively deep water and high current environment of the river channel. Also, the bucket closing force was insufficient to penetrate hard slag or to cut through smaller debris and timber.

For the remainder of river channel dredging work, the RAC has mobilized a large excavator with a modified bucket and an X, Y and Z RTK GPS system. This equipment change may provide the control and accuracy required to achieve results similar to Stryker Bay dredging in the MN Channel.