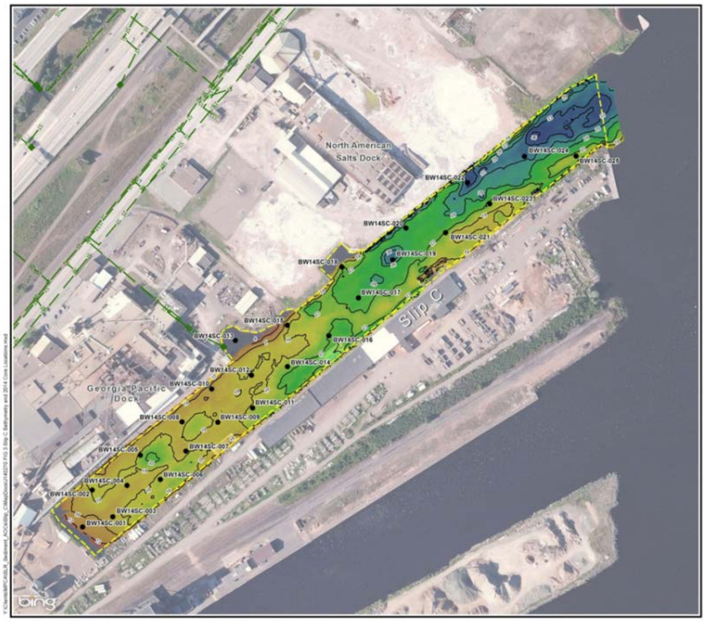
FINAL FOCUSED FEASIBILITY STUDY
SLIP C

SR#1012
Duluth, Minnesota
MPCA Work Order #3000014275



Prepared for:

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CLEAN WATER LAND & LEGACY AMENDMENT

Great Lakes RESTORATION

Prepared by:

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5 Empire Drive
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June 2016
Revision 00
BWJ150329

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Executive Summary

This Focused Feasibility Study (FFS) for Slip C (Site) presents: a summary of current Site conditions; a discussion of remedial action objectives (RAOs); and the identification, screening, evaluation, and comparison of potential alternatives. This report was prepared by Bay West LLC (Bay West) in accordance with the Minnesota Pollution Control Agency (MPCA) Contract Work Order No. 3000014275.

The Site was studied as a part of the St. Louis River (SLR) Area of Concern (AOC; see **Section 1.2**). Funding to complete an FFS was obtained through the United States Environmental Protection Agency (USEPA), Great Lakes Legacy Act (GLLA) and state funding through the Minnesota Legacy Fund and the Wisconsin Knowles-Nelson Stewardship Fund. Detailed investigations identified sediments contaminated with polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins/dibenzofurans (dioxins), mercury, cadmium, copper, lead, nickel, and zinc. Bay West completed a Sediment Remedial Investigation (RI) Report in 2015 that evaluated these chemical compounds and their concentrations in sediment identifying primary contaminants of concern (COCs). The Sediment RI Report identified lead as the primary COC for the Site.

Contaminated sediment was generally identified in the western portion of the Site and considered to present a high likelihood of significant effects to benthic invertebrates from exposure to surficial sediments at the Site.

As identified in the SLR Remedial Action Plans (RAPs): RAP Stage I, MPCA and Wisconsin Department of Natural Resources [WDNR], 1992; and RAP Stage II, MPCA and WDNR, 1995; and later proven with testing, Slip C, SR#1012, Duluth Harbor, Duluth, Minnesota (**Figure 1**), is potentially contributing to the following impairments in the SLR (AOC):

- Fish consumption advisories;
- Degradation of the benthos; and
- Restrictions on dredging.

Areas that are contributing to river sediment impairments should be addressed through remedial activities, as recommended by the RAP. In addition, addressing the contaminated sediments from the Site would also help in the reduction of the impaired water resulting from bioaccumulative toxins in the St. Louis River.

Remedial Action Objectives Developed by the MPCA for the Site

RAOs for the Site were developed based on the requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; 40 Code of Federal Regulations [CFR] §300.430[e][2][i]), which defines RAOs as a listing of the COCs and media of concern, potential exposure pathways, and remediation goals. Specific RAOs were developed from a review of the results of site characterization activities, site-specific risk and fate and transport evaluations, and an initial review of Applicable or Relevant and Appropriate Requirements (ARARs). The following RAOs for the Site include goals for the protection of human health and the environment:

1. Minimize or remove exposure to sediment contaminants that bioaccumulate in the food chain and contribute to fish consumption advisories.
2. Minimize or remove exposure of the benthic organisms to contaminated sediments above sediment cleanup goals.

3. Preserve water depth to enable the current and/or planned use of the slip.
4. Enhance aquatic habitat, if conditions allow, in a manner that contributes to the removal of beneficial use impairments (BUIs).

Alternatives were identified and screened to determine if they could meet these RAOs. The following alternatives were evaluated in this FFS:

Alternative 1: No Action – The NCP at Title 40 CFR provides that a No Action Alternative should be considered at every site. The No Action Alternative should reflect the site conditions described in the baseline risk assessment and RI. The No Action Alternative included within this FFS does not include any treatment or engineering controls, institutional controls (ICs), or monitoring. There are no costs associated with the No Action Alternative. A No Action Alternative applied to the Site would not meet criteria for protection of human health and the environment, but is included as an alternative for comparison purposes.

Alternative 2: Monitoring and Institutional Controls – This alternative does not provide any immediate improvement to protectiveness but is included as a possible placeholder to be used as an interim response. An interim response may be required should funding sources be unavailable until a later date or be distributed based on site prioritization. The monitoring and ICs alternative would consist of evaluating trends in sediment chemical concentrations, sediment toxicity, and COC bioaccumulation within aquatic organisms (i.e., benthic organisms) over time. ICs appropriate for maintaining protectiveness of human and environmental health would be implemented, if applicable, until sufficient contaminant degradation, transformation, isolation, or other natural recovery processes reduce Site-related risks to acceptable levels; however, natural recovery of contaminated sediments is not anticipated within a reasonable time frame at the Site, or should an alternative remedy be implemented. The approximate present cost associated with Alternative 2 is $330,000.

Alternative 3: Cap and Armor – This alternative would consist of constructing a 0.95-meter thick cap (sand plus armor; 3.1 feet) over approximately 6.4 acres with sediment concentrations exceeding the cleanup level (CUL; Midpoint Sediment Quality Targets [SQTs]) for COCs. Prior to cap construction, a limited amount of sediment “grading” may be conducted to prevent excessive gradients and/or excessively shallow areas after cap construction. Armoring will be completed across the entire cap to prevent scouring due to prop wash as the slip is actively used. Approximately 22,000 cubic yards of sand and 10,000 cubic yards of cobble will be used for the cap and armoring, respectively. Following cap construction, ICs would be implemented to protect the capped area. The approximate present cost associated with Alternative 3 is $5,100,000.

Alternative 4: 1-Meter Dredge, Cap, and Armor – This alternative would consist of dredging 1 meter (3.3 feet) of sediments exceeding the CUL, in an 6.4-acre area, and capping. Total cap thickness will be 0.95-meter, sand plus armor. The dredged sediments would be transported by barge to a staging area, stabilized with amendment materials as needed, transported by roadway, and disposed of at an off-site landfill. The benefits of dredging 1 meter prior to cap placement would be offsetting draft loss due to capping. Armoring will be completed across the entire cap to prevent scouring due to prop wash as the slip is actively used. Total dredge sediment volume is anticipated to be 34,000 cubic yards. Approximately 22,000 cubic yards of sand and 10,000 cubic yards of cobble will be used for the cap and armoring, respectively. Following cap construction, ICs would be implemented to protect the capped area. The approximate present cost associated with Alternative 4 is $11,000,000.

Alternative 5: Dredge with Thin-Layer Cover – This alternative would consist of complete removal of all sediments exceeding the CUL in a 6.4-acre area. The dredged sediments would be transported by barge to a staging area, stabilized with amendment materials as needed, transported by roadway, and disposed of at an off-site landfill. Following sediment removal, a 0.15-meter (0.5 feet) thin-layer sand cover would be placed to reduce surface concentration of dredge residuals through mixing of the upper sediment layer. The total dredge volume is anticipated to be 120,000 cubic yards (including over dredge); however, this volume may increase based on pre-design vertical delineation results. ICs and a long-term monitoring (LTM) program would not be implemented following completion of remedy construction if complete removal of contaminated sediments is achieved. The approximate present cost associated with Alternative 5 is $19,000,000.

The objectives of Alternative 3, 4, and 5 at the Site are to: limit exposure of human receptors to contaminated sediments; limit exposure of aquatic organisms to contaminated sediments and thereby limit transfer of chemical contaminants to higher trophic organisms; and enhance the aquatic habitat in a manner that contributes to the removal of BUIs if conditions allow.

Comparative Analysis Summary:

The comparative analysis of the alternatives is presented in **Section 5.0**. Alternatives 3, 4, and 5 were all protective of human health and the environment. Alternative 1 was not protective and will not be considered. Alternative 2 does not provide any immediate improvement to protectiveness. Should funding sources be unavailable until a later date or be distributed based on site prioritization it may be useful to implement Alternative 2. No significant difference in the balancing criteria score was found between Alternatives 3 through 5 other than cost. More information is needed prior to selecting a preferred alternative. The modifying criteria, state/support agency acceptance, and community acceptance are assessed formally after the public comment period. Stakeholder and community input will provide valuable insight as the MPCA considers information for the selection of a preferred alternative. The MPCA will conduct outreach activities to resource managers, current slip users, the public and local units of government prior to the public comment period.

Further studies are recommended during the design phase of the selected alternative. These recommended studies, depending on the alternative selected, may include:

- Hydrodynamic study to understand the depositional and scouring forces in the slip to inform design;
- Dock wall stability should be investigated to determine potential dredging/capping impacts, should one of these alternatives be selected;
- Stormwater sewer evaluation, including an evaluation of sediment input and potential sediment capture systems, to evaluate the need to limit sediments entering the Site;
- Additional surface sampling to understand if incoming stormwater deposition is contaminated, thus a continuing source of contamination;
- Investigate vertical extent of contaminated sediment if needed to support the dredging alternative;
- Modeling pore water transport and attenuation for engineered cap design; and
- Evaluation of future and current use of the slip and required water depths.

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Acronyms and Abbreviations

%	percent
µg/kg	micrograms per kilogram
AC	activated carbon
amsl	above mean sea level
AOC	area of concern
ARAR	Applicable or Relevant and Appropriate Requirement
Bay West	Bay West LLC
bss	below sediment surface
BUI	beneficial use impairment
CAD	confined aquatic disposal
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
ch. or chs.	chapter or chapters
COC	contaminant of concern
CSM	conceptual site model
CUL	cleanup level
DEDA	Duluth Economic Development Authority
dioxins	polychlorinated dibenzo-p-dioxins/dibenzofurans
EA	EA Engineering, Science, and Technology, Inc., PBC
EMNR	Enhanced Monitored Natural Recovery
FFS	Focused Feasibility Study
GAC	granular activated carbon
GHG	Greenhouse Gas
GLI	Great Lakes Initiative
GLLA	Great Lakes Legacy Act
GSR	Green Sustainable Remediation
IC	institutional control
IDT	Interlake/Duluth Tar
ITRC	Interstate Technology and Regulatory Council
IZ	isolation zone
LF	linear feet
LTM	long-term monitoring
MDH	Minnesota Department of Health
MDNR	Minnesota Department of Natural Resources
MERLA	Minnesota Environmental Response and Liability Act
mg/kg	milligrams per kilogram
MNR	Monitored Natural Recovery
MPCA	Minnesota Pollution Control Agency
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/kg	nanograms per kilogram
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
O&M	operation and maintenance
OIRW	Outstanding International Resource Water
ORP	oxidation reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PBAZ	potentially bioactive zone
PCB	polychlorinated biphenyl
PFC	perfluorochemical
RAO	Remedial Action Objective
RAP	Remedial Action Plan
RBSE	Risk-Based Site Evaluation
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RME	reasonable maximal exposure
ROD	Record of Decision
ROM	rough order of magnitude
SDS	State Disposal System
SLR	St. Louis River
SLRIDT	St. Louis River/Interlake/Duluth Tar
SOW	Statement of Work/Cost Estimate
SQT	sediment quality target
SSV	Sediment Screening Value
TBC	to be considered
TEQ	toxicity equivalency
U.S.	United States
UECA	Uniform Environmental Covenants Act
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
WCA	Wetland Conservation Act
WDNR	Wisconsin Department of Natural Resources
WLSSD	Western Lake Superior Sanitary District

1.0 INTRODUCTION AND BACKGROUND

The St. Louis River (SLR), located on the border between Minnesota and Wisconsin, is the second-largest United States (U.S.) tributary to Lake Superior and has a special significance in the region. The lower estuary empties into the Duluth-Superior Harbor, the largest freshwater seaport in North America. It serves as a geographic boundary for Wisconsin and Minnesota, and provides regional shipping access to Lake Superior.

Development along the SLR over the past 130 years has contributed to contaminated sediments. In 1987, concerns over environmental quality conditions prompted the designation of 73 miles of the lower SLR, which includes the segment from Cloquet, Minnesota, to the Duluth/Superior harbor, as 1 of 43 Great Lakes Areas of Concern (AOCs). The Minnesota Pollution Control Agency (MPCA) and Wisconsin Department of Natural Resources (WDNR) worked together to divide the SLR AOC into Sediment Assessment Areas for the purposes of evaluation and prioritization of remediation and restoration activities. Contaminated sediments were identified and characterized through several studies that included the collection and analysis of sediments and biota samples throughout the AOC.

Historical sediment contamination in the SLR AOC has resulted in impaired uses, including degradation of bottom-feeding invertebrate communities, increased incidence of fish tumors and other abnormalities, fish consumption advisories, and restrictions on dredging, resulting in nine beneficial use impairments (BUIs; MPCA, 2008). BUIs are a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause any 1 of the 14 established use impairments, or other related uses, such as the microbial objective for waters used for body contact recreational activities (joint commission). The MPCA and WDNR are currently working together to implement a comprehensive long-term plan to restore beneficial use and delist BUIs in the SLR AOC. Many of the BUIs in the AOC are linked to the presence of sediment contaminants. Some sediment-derived contaminants also appear suspended in the water column and carried by the SLR to Lake Superior.

As identified in the SLR Remedial Action Plans (RAPs): RAP Stage I, MPCA and WDNR, 1992; and RAP Stage II, MPCA and WDNR, 1995; and the Sediment Remedial Investigation (RI) Report, St. Louis River, Slip C, Duluth, Minnesota, Bay West LLC (Bay West) 2015 (Sediment RI Report), Slip C is potentially contributing to the following impairments in the SLR AOC:

- Fish consumption advisories;
- Degradation of the benthos; and
- Restrictions on dredging;

Areas that are contributing to river sediment impairments should be addressed through remedial activities, as recommended by the Sediment RI Report. According to the MPCA, it is recommended by many programs that biotoxins be reduced with in the St. Louis River estuary and harbor. Removing or isolating the contaminated sediments from the surface water/sediment interface will help in the reduction of the impaired water resulting from bioaccumulative toxins in the SLR AOC.

This Focused Feasibility Study (FFS) was prepared to evaluate remedial alternatives for contaminated sediment at the Site. The scope of this FFS does not consider alternatives for any other matrix such as soil, surface water, or groundwater that may be impacted at the Site.

This report was developed pursuant to the Bay West Master Contract No. 63186 and MPCA Contract Work Order No. 3000014275, dated July 21, 2015, and accompanying the Scope of Work/Cost Estimate (SOW) for the Site. Funding to complete the FFS for the Site comes from the United States Environmental Protection Agency (USEPA), Great Lakes Legacy Act (GLLA), and state funding through the Minnesota Legacy Fund and the Wisconsin Knowles-Nelson Stewardship Fund.

This FFS was written in general accordance with the MPCA Site Response Section Guidance Document Draft Guidelines on Remedy Selection (MPCA, 1998), the Minnesota Environmental Response and Liability Act (MERLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300, along with other Minnesota and federal rules, statutes, and guidance.

1.1 Report Organization

Section 1.0 presents general background information including the Site history and a summary of current Site conditions. **Section 2.0** discusses Applicable or Relevant and Appropriate Requirements (ARARs) and summarizes Remedial Action Objectives (RAOs) to provide the framework for alternative evaluations for the Site. **Section 3.0** and **Section 4.0** present alternatives descriptions and the NCP remedy selection criteria used in this FFS. **Section 5.0** presents an evaluation of alternatives against standards and criteria. References are presented in **Section 6.0**.

1.2 Site Location and Current Use

The SLR estuary covers an area of approximately 12,000 acres and comprises numerous large bays, peninsulas, and islands (**Figure 1**). Upstream of the AOC, the river is characterized by shallow meanders and sandy gravel bars. The character of the river changes abruptly near Cloquet, Minnesota, as it starts its steep descent to Lake Superior. This portion of the watershed is characterized by deeply incised river channels and canyons. Five dams were constructed on this reach of the river, resulting in the creation of five reservoirs within the AOC that may significantly impact downstream flow and water levels. As the river approaches Lake Superior, the current dissipates and the SLR takes on the characteristics of a lake. Just prior to entering Lake Superior at the Duluth Ship Canal and the Superior Entry, the river forms a large embayment protected by two long sandbars (i.e., Minnesota and Wisconsin Points). These sandbars form the longest natural freshwater baymouth sandbars in the world. Two inner spits, Rice’s Point and Conner’s Point, divide the port into inner and outer harbors (Crane et al., 2000).

Slip C, SR1012, is an active shipping slip in the Duluth Harbor basin located at the far northwestern corner of Superior Bay within the inner portion of the Duluth Harbor (**Figure 2**) and is the northernmost slip in a series of slips located on the eastern side of Rice’s Point. The Site is approximately 2,500 feet in length and runs approximately parallel along its length to Railroad Street and U.S. Interstate 35 (oriented west-east, with the head of the slip at the western end). The toe of the slip opens into the Duluth Harbor. The Site is approximately 215 feet wide. Average water depth in the slip was 21.3 feet (corrected against the low water datum) during the July 2014 sampling event, with an average sediment elevation of 581.5 feet above mean sea level (amsl). Lake Superior low water datum is 601.1 amsl.

The area immediately surrounding the Site is highly industrialized, as it has been for over a century. Current slip tenants include a paper/pulp manufacturing company and a mineral production company on the northern side of the slip and a timber company along the southern side. One known storm sewer outlet enters the slip adjacent to the paper/pulp manufacturing dock (Bay West, 2015).

1.3 Site History

The Duluth/Superior region experienced a dramatic rise in population during the late 19th and early 20th centuries as the region began to take advantage of local resources including vast forests, iron ore, and the natural harbor (known today as the Duluth-Superior Harbor) located on Lake Superior. Construction of the Soo Locks at Sault Ste. Marie, Michigan, in 1855 and dredging of the Duluth-Superior Harbor, beginning as early as the mid-1800s, contributed significantly to the port's growth and establishment as a primary shipping harbor. Thriving industries within the region included forest products, smelting, grain milling and transport, and the transport of iron ore, coal, and limestone. Many of these industries were concentrated in the Duluth/Superior harbor at Rice's Point in Minnesota and Connor's Point and Howard's Bay in Wisconsin. Many of these industries are still present and operating within the harbor today. The Sediment RI Report details site specific historic use. Generally the Site has been used for industrial/commercial purposes as previously discussed.

Historic photo of Slip C, Duluth Harbor (date unknown).

1.4 Site Characterization

1.4.1 <u>Site Geology</u>

Regional geology in the Duluth area consists primarily of materials deposited during the last glaciation, and more recently as river sediment, overlying Precambrian igneous and sedimentary bedrock. These materials consist of silts, sands, and gravels that were deposited as the glaciers retreated northward. Fine grained sediment, primarily red silt and clay, was deposited in the ancestral glacial Lake Duluth. This red silt and clay occurs over much of the lower elevations in the Duluth area.

Bedrock units underlying the area consist of olivine gabbro and anorthositic gabbro members of the Duluth Complex, and the sedimentary units of the Fond du Lac Formation. The Duluth Complex is lower Precambrian, and the Fond du Lac Formation is upper Precambrian in age. The gabbroic members of the Duluth Complex form the hills to the west of the St. Louis River and Lake Superior shore (MPCA, 1995).

Surficial geology identified at the Site consists of glacial deposits associated with the Superior Lobe (noncalcareous drift, igneous and metamorphic clasts), Nickerson Moraine Association ground moraine deposits (clayey till, locally calcareous). Additionally, subsurface studies and excavations on adjacent properties have shown extremely heterogeneous materials buried in the subsurface.

The piers adjacent to the Site were created through historic filling while the Site was maintained through periodic dredging.

1.4.2 Site Hydrology

The regional groundwater flow system in the area generally flows from the Minnesota and Wisconsin uplands and discharges to Lake Superior and the St. Louis River estuary. Although a Site-specific groundwater study has not been performed, groundwater is anticipated to flow radially out from the piers adjacent to the Site into the Duluth Harbor.

1.4.2.1 Physical Influences

There are many physical influences operating throughout the Site. Site sediments have been moved, mixed, and removed by a variety of forces at work on the waters in the bay. Periodic maintenance dredging has occurred at the Site since its construction.

Bathymetry obtained from June 2014, **Figure 3**, as described in the Sediment RI Report, depicts shallower sediment to the north and deeper sediment to the south in the slip. Erosional forces that may be responsible for differences in bathymetry include:

- Wave action in the bay;
- River flow;
- Seiche-induced flow;
- Stormwater flow; and
- Propeller turbulence from boats moving in and out of the slip.

According to the National Oceanic and Atmospheric Administration (NOAA) and the Great Lakes Dashboard Project, Lake Superior water level elevations have ranged from 599.5 feet to 603.4 feet amsl since measurements began in 1918 (NOAA, 2016). Seasonal water level fluctuations of Lake Superior affect water level elevations at the Site and may affect Site remedies; however, these effects have not been studied.

For a detailed discussion of each of the forces and their effects on the slips see Section 7.1 of the Detailed Investigation of the Minnesota Slip (Streitz and Johnson, 2005).

1.4.3 Nature and Extent of Contamination

The nature and extent of contamination were delineated by several studies in the Duluth/Superior Harbor that included the collection and analysis of sediments and sediment depth measurements in the Site. Bay West completed the Sediment RI Report for the Site, which summarizes historic data and 2014 sediment data collected by Bay West. The findings of the Sediment RI Report are summarized in **Section 1.4.3.1**. **Section 1.4.3.2** presents screening criteria used to evaluate sediment chemical contaminant concentrations. **Section 1.4.3.3** presents a discussion on the contaminants of concern (COCs) and **Section 1.4.3.3** presents the depth, thickness, and volume of contaminated sediments.

1.4.3.1 Previous Studies

Section 1.5, in the Sediment RI Report, identifies and summarizes historic sediment investigations completed at the Site. The Report details the following historic contaminants identified at the Site: polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins/dibenzofurans (dioxins), mercury, cadmium, copper, lead, nickel, and zinc.

Section 5.5, in the Sediment RI Report, summarizes sediment investigation completed by Bay West in 2014 and identifies lead as the primary COC. A significant exposure pathway was found to be incomplete for human receptors; therefore, a Preliminary Sediment Ecological Risk-Screening Evaluation was used to identify lead as the primary contaminant for the Site.

1.4.3.2 Screening Criteria

Numerical sediment quality targets (SQTs), adopted for use in the SLR AOC to protect benthic invertebrates, can be used throughout Minnesota as benchmark values for making comparisons to surficial sediment chemistry measurements. Level I and Level II SQTs for the protection of sediment-dwelling organisms are available for 8 trace metals, 13 individual PAHs, total PAHs (all 13 priority PAHs), total PCBs, and 10 organochlorine pesticides. In addition, Level I and Level II SQTs for dioxins were adopted for the protection of fish, as insufficient information is available for sediment-dwelling organisms. SQTs are highly useful when evaluating risk for a specific compound or a group of compounds (i.e., total PCBs and total PAHs).

Contaminant concentrations below the Level I SQTs are unlikely to have harmful effects on sediment-dwelling organisms (i.e., benthic invertebrates). Contaminant concentrations above the Level II SQTS are more likely to result in harmful effects to benthic invertebrates (MPCA, 2007). Based on conversations with the MPCA, a qualitative comparison value midway between the Level I SQTs and Level II SQTs (i.e., Midpoint SQT) were used as criteria to identify, rank, and prioritize sediment-associated COCs within the Site.

Sediment Screening Values (SSVs) were developed to provide a human health-based toxicity value specifically related to sediment for the U.S. Steel Superfund site in the SLR (Minnesota Department of Health [MDH], 2013). The SSVs were developed using reasonable maximal exposures (RMEs) specific to the U.S. Steel site and the Lower SLR. The Updated Human Health Screening Values for St. Louis River Sediments: U.S. Steel site, dated April, 2013, describes the updated SSVs. Chemical concentrations in water-covered sediments at or below the SSVs are considered safe for the general public; however, chemical concentrations in sediments exceeding the SSVs should not be considered unsafe because the SSVs were developed using conservative measures of exposure, bioavailability, and toxicity. Based on ongoing ambient concentration studies, some SSVs likely approach, or are less, than ambient concentrations in sediment, including SSVs for mercury, benzo(a)pyrene equivalents, PCBs, and dioxins. Further, the SSVs do not include RMEs specific to the Site and are not intended to be used as sediment cleanup values; therefore, SSVs for PAHs, PCBs, dioxins, and mercury will not be used to identify, rank, and prioritize sediment-associated COCs within the Site. Following finalization of the ambient concentration studies, SSVs for COCs may need to be reviewed for applicability to the Site. SSVs for other COCs, as discussed in **Section 1.4.3.3**, are greater than the respective Midpoint SQTs, therefore, those SSVs will not be used to identify, rank, and prioritize sediment-associated COCs within the Site.

1.4.3.3 Contaminants of Concern

Sediment contaminants and Site COCs are identified in **Section 1.4.3.1**, listed in **Table 1**, and discussed in depth in the Sediment RI Report which identified lead as the primary COC at the Site.

Through discussions with the MPCA and review of available sediment analytical data, it was determined that for the purposes of this FFS, any contaminant exceeding the Midpoint SQT will be considered a COC. The following contaminants are identified COCs at the Site: lead, PAHs, PCBs, dioxins, mercury, cadmium, copper, nickel, and zinc. Lead will remain the primary COC based on exceedance frequency and spatial distribution, as described in the Sediment RI Report and PAHs, PCBs, dioxins, mercury, cadmium, copper, nickel, and zinc are considered secondary COCs. Additionally, distribution of secondary COCs at the Site corresponds with spatial distribution of primary COC exceedances; therefore, addressing primary COCs at the Site will subsequently address contamination associated with secondary COCs. Contaminant confirmation sampling and short and/or long-term monitoring (LTM), if completed at the Site, will include both lead and secondary COCs. Lead contamination will be discussed in detail below as it is considered the primary COC at the Site.

Primary COC-impacted sediments with concentrations exceeding the Midpoint SQT, the remedial footprint area, appear primarily at the head of the slip in a 6.40-acre area (**Figure 4**). These contaminated sediments occur at varying depths throughout the sediment column in the remedial footprint area. Depth of contamination did not exceed 573 feet amsl (max draft depth) in any samples, except for sample locations BW14SC-001, 002, 005, 006, 010, 011, and 015 which exhibited Midpoint SQT exceedances in the samples collected from an elevation of 573 feet amsl. These sample locations are discussed in detail in **Section 1.4.3.4**.

Primary COC concentrations exceeding the Midpoint SQT at the surface suggest an ongoing source of contamination (Bay West, 2015). Prior to remedy implementation at the Site, ongoing sources of contamination should be investigated and remediated in order to prevent recontamination of the Site.

Figure 4 presents lead sampling locations and level of SQT exceedance when applicable. **Figure 5** identifies specific areas of concern within the Site based on action level exceedances at any of the sampled depth intervals.

1.4.3.4 Depth, Thickness, and Volume of Contaminated Sediment

The depth and volume calculations and assumptions discussed below are based on a bathymetric survey of the Site completed in 2014 by Bay West and analytical data collected for the Sediment RI Report.

The 2014 bathymetric survey is the most up-to-date bathymetric survey available. Bay West has assumed the 2014 bathymetric survey is accurate for the purposes of this report but recommends that should an alternative be implemented, a bathymetric survey should be completed and assumptions updated.

The total area of the Site is approximately 12 acres. Lake Superior low water datum is 601.1 feet amsl. The 2014 Bay West bathymetry survey depicts the depth to sediment ranging from approximately 13 to 23 feet at the head of slip to 19 to 36 feet at the toe of slip. The average depth to sediment within Site in 2014 was approximately 21.3 feet (Sediment RI Report, 2015). **Figure 3** presents the 2014 bathymetry survey.

Analytical data from the Sediment RI Report indicates that contaminated sediment is generally present within the 0.15 to 0.5 meter (0.5 to 1.6 feet) and 0.5 to 1.0 meter (1.6 to 3.3 feet) intervals throughout Site. **Figure 5** identifies specific areas of concern within the Site based on action level exceedances and/or depth to contamination.

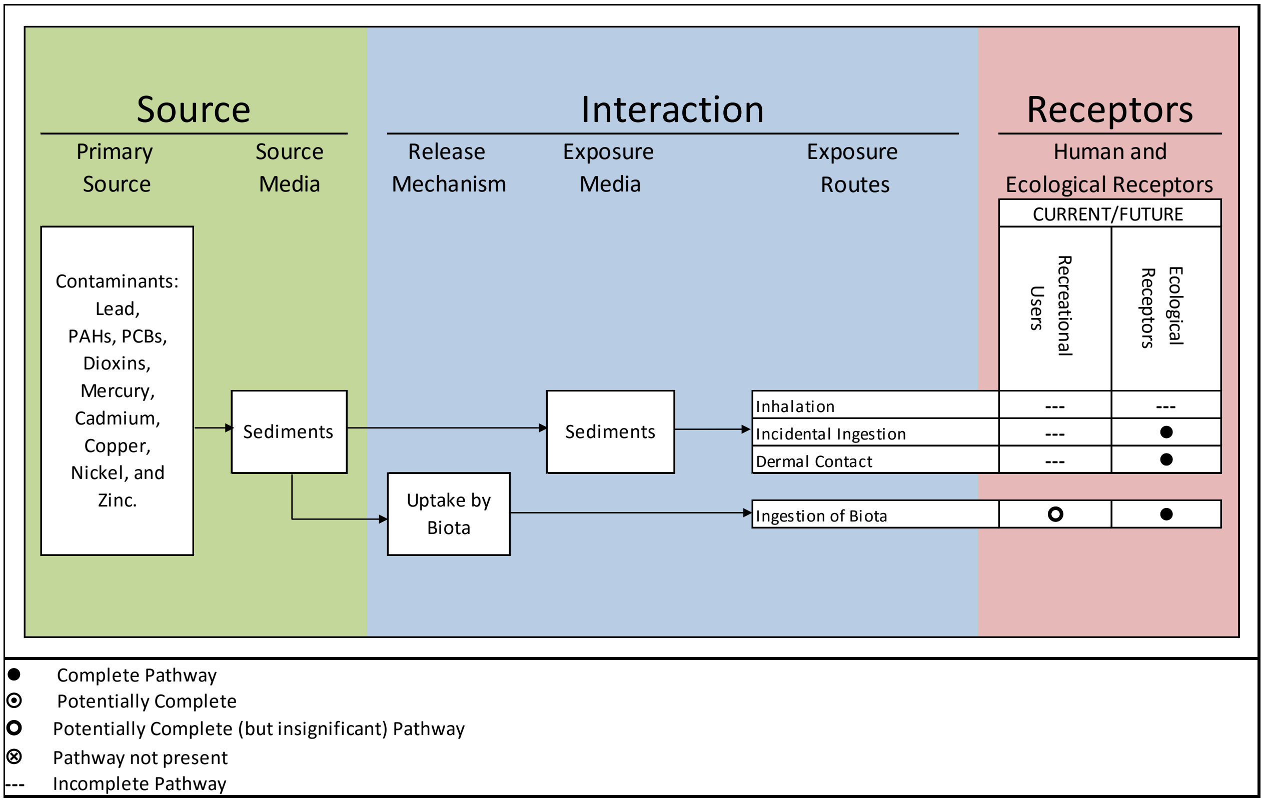
The vertical extent of contamination in seven locations, BW14SC-001, 002, 006, 005, 011, 010 and 015, is unknown. Bay West sampling was not completed beyond an elevation of 573 feet amsl based on discussions with the MPCA regarding potential dredge depths at the slips. An elevation of 573 feet amsl is considered the limit of dredging within the slips by the MPCA as this is the maximum ship draft depth permissible in the St. Lawrence Seaway lock and dam system. Alternative 5, Dredge with Thin-Layer Cover, requires that all contaminated sediment exceeding Midpoint SQTs within the remedial footprint area be removed. To accomplish this the vertical extent of contamination will need to be delineated for these locations during the remediation pre-design phase. These areas will likely need to be excavated beyond an elevation of 573 feet amsl in the remedial footprint area to achieve removal of contaminated sediment exceeding Midpoint SQTs.

The potentially bioactive zone (PBAZ) is the area within the sediment where significant biological activity may be present. Should dredging occur, a minimum average dredge depth of 0.5 meter (1.6 feet) should be completed to remove contamination within the PBAZ. There is no definitive scientific consensus on the maximum depth to which flora and fauna penetrate sediment but based on a compilation of available studies Bay West developed the Draft Technical Memorandum, Remedial Action Objectives, Preliminary Remedial Goals, Potentially Bioactive Zone Thicknesses, SR#276 – U.S. Steel Duluth Works Site, October 2015 (Draft Technical Memo). The Draft Technical Memo identifies potential thicknesses within the PBAZ and is further described in **Section 1.4.4.2**. From the Draft Technical Memo it can be concluded that the PBAZ for the Site is located within the first 0.5 meter due to water depth at the slip. Anticipated dredge depth to adequately protect the PBAZ should be 0.5 meter or more in areas of concern at the Site.

Approximately 17,000 cubic yards of contaminated sediment are estimated to be located in the PBAZ of Slip C assuming a PBAZ depth of 0.5 meter at Slip C in the area identified as having contamination (6.4 acres).

1.4.4 Exposure Pathways

Exposure pathways represent the linkages among contaminant sources, release mechanisms, exposure pathways and routes, and receptors to summarize the current understanding of the risks to human health and the environment due to contamination. The following is an exposure pathway diagram completed for the COCs at the Site. A “complete” exposure pathway means that evidence exists that a COC may be released from a source and may be transported into and through the environment to an exposure point where a receptor is assumed to be present.



The following sections provide greater detail on the human health and ecological exposure pathways.

1.4.4.1 Risk to Human Health

Significant exposure pathways are incomplete for human receptors based on the Sediment RI Report. The current use of the Site is for ship and barge traffic related to land-based industrial operations surrounding the slip. Information to date indicates that the proposed future use of the Site will be consistent with the current use. The property surrounding the Site is private property, preventing access to recreational users; therefore, other exposure pathways (i.e., incidental ingestion of, and dermal contact with, contaminated sediments) are incomplete for recreational users.

The COCs are generally non-volatile and not emitted from the waters of the Site; since the risk of inhalation and dermal contact are mitigated, the only remaining pathway for human exposure to contamination from the Site is fish consumption. The Site is relatively small and currently does not provide a high-quality habitat for spawning and foraging for feeder fish; however, fish consumption advisories are in effect for selected fish species in the SLR AOC due to elevated concentrations of PCBs and mercury found in fish tissue (MDH, 2014). Fish consumption advisories and MDH meal advice are currently in place for PCBs and mercury, which are secondary COCs at the Site (MDH, 2014). PCB and mercury advisories are not considered a risk at the Site based on Site use as an industrial shipping slip; recreational fishing activities are prohibited on-site.

In summary, risk to human health from contaminated sediments in the Site is low. The potentially complete pathway for human exposure to contamination at the Site through ingestion of biota via fish consumption is considered insignificant.

1.4.4.2 Ecological Risks

Contaminated sediments within the Site are located within the PBAZ. The PBAZ is the area within the sediment where significant biological activity may be present. There is no definitive scientific consensus on the maximum depth to which flora and fauna penetrate sediment but the MPCA's selection of an appropriate PBAZ thickness is based on a weight-of-available-evidence approach and professional opinion. Due to the large uncertainty in this type of analysis, the PBAZ incorporates an element of conservatism (i.e., greater depth) to provide an additional safety factor. Three designated PBAZ thicknesses are applicable in the habitat, water depth, and substrate types, as described below from the Draft Technical Memorandum, Remedial Action Objectives, Preliminary Remedial Goals, Potentially Bioactive Zone Thicknesses, SR#276 – U.S. Steel Duluth Works Site, October 2015 (Bay West, 2015):

Backshore/Foreshore Habitat Zone (Shoreline, Riparian and Wet Transition Areas)

(Minimum PBAZ thickness = 1.2 meters [3.9 feet])

Applicable in:

- Shoreline/beach areas;
- Sediment flats that are exposed due to periodic low water levels or seiche;
- Open water/wet transition areas;
- Areas potentially available to deep burrowing mammals; and
- Areas potentially available for deep rooted herbaceous and/or woody plants.

Emergent Aquatic Vegetation Habitat Zone (off the Shoreline)

(Minimum PBAZ thickness = 1.0 meter [3.3 feet])

Applicable in:

- Emergent aquatic vegetation areas;
- Areas with potential for transitioning to emergent aquatic vegetation habitat (i.e., areas with substrates and water depths conducive to establishment of emergent vegetation now or in the future); and
- Areas potentially susceptible to deep burrowing amphibians, reptiles or crustaceans.

Submerged Aquatic Vegetation and Deep Water Habitat Zone

(Minimum PBAZ thickness = 0.5 meter [1.6 feet])

Applicable in:

- Areas that support submerged aquatic vegetation habitat with no potential to transition to emergent aquatic vegetation or wetland habitat;
- Areas with water depths too deep to support emergent vegetation but may support benthic organisms; and
- Areas with a substrate not conducive to deeply rooted aquatic vegetation, wetland herbaceous or woody vegetation, or deep burrowing mammals, amphibians, or crustaceans (i.e., areas armored for erosion control or areas with root barriers or other engineering controls).

The Submerged Aquatic Vegetation and Deep Water Habitat Zone, minimum PBAZ thickness of 0.5 meter, corresponds to the entirety of habitat observed at the Site (**Figure 6**). Habitat in the Site is relatively homogeneous due to the nature of the Site; it is designed to be deep water to accommodate the docking of large vessels. As previously discussed due to multiple physical forces, depth to sediment in the Site is deeper at the toe versus the head of the Site. Minimum depth observed at the head of the Site remains significant enough to be considered Submerged Aquatic Vegetation and Deep Water Habitat Zone.

Complete ecological exposure pathways include the following:

- Exposure to ecological receptors through incidental ingestion and dermal contact with sediments; and
- Ingestion of biota that have consumed contaminated sediments.

Based on a comparison of the complete ecological exposure pathways and available analytical data summarized in **Section 1.4.3**, sediments with concentrations of COCs that exceed the Midpoint SQT value are considered a risk to the benthic community and the larger ecological environment, where they are found.

In summary, the analysis of the Sediment RI Report sediment data and available exposure pathways indicated that COCs are present at the Site and an ecological exposure pathway is complete; therefore, a potential risk to ecological health from contaminated sediments exists at the Site.

1.4.5 Conceptual Site Model

The development of a conceptual site model (CSM) allows data obtained during ongoing investigations to be integrated in an iterative approach that increases the understanding of the physical and environmental setting of the Site and the fate and transport of COCs. This section incorporates the site history, regional hydrologic and geologic settings discussed in **Sections 1.3**, **1.4.1**, and **1.4.2** with site-specific data and observations that were collected through Site investigations, site reconnaissance, and conversations with the MPCA and the Duluth Seaway Port Authority. The CSM provides a baseline for consideration of how remedy alternatives could be implemented to protect human and environmental health at the Site. The CSM is illustrated in **Figure 6**.

Industrial sources at the Site and in the SLR likely began contributing contaminants to the SLR as early as 1900s, as previously discussed in **Section 1.3**. These waste streams have since been removed or significantly minimized from the SLR. Although, the storm sewer outfall in the central portion of the north slip wall may continue to contribute to the deposition of contaminated sediment from land-based sources.

The current site conceptual model is that the Site has retained significant levels of COCs from industrial activities and historical Site uses, based on the previous SLR and Site investigations. Industrial sources of COCs have been significantly reduced, if not eliminated, with only ambient COC concentrations now entering from the SLR and slip activities. Additionally, physical influences impacting sediment distribution as described in **Section 1.4.2** include: wave action in the bay, river flow, seiche-induced flow, and propeller turbulence from boats moving in and out of the Site.

Receptors that are potentially exposed to COCs include the following human and ecological receptors:

- Benthic and aquatic invertebrates;
- Mammals and birds consuming fish, benthic and aquatic invertebrates; and
- Undetermined receptors if future maintenance dredging is needed.

Reducing surface sediment concentrations or chemical bioavailability is the primary goal of sediment remediation processes. The deposition of cleaner sediment that buries and isolates COCs below the upper bioturbation layer reduces risk of chemical exposure to benthic receptors and to humans through ingestion of contaminated fish or shellfish or by direct contact. No models have been developed for the Site to predict sediment deposition rates, but based on assumptions made about the hydrodynamic environment at the Site, sedimentation is likely minimal and Monitored Natural Recovery (MNR) is not a viable component of the selected remedy.

2.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND REMEDIAL ACTION OBJECTIVES

Remedial actions for releases and threatened releases of hazardous substances, pollutants, or contaminants must be selected and carried out in accordance with state and federal requirements. These requirements are referred to as ARARs. RAOs specify COCs, media of concern, potential exposure pathways, and remediation goals. Initially, Site remediation goals for the COCs are developed based on readily available information such as chemical-specific ARARs or other reliable information. The Site RAOs are modified, as necessary, as more information becomes available during the FFS process.

This section presents the preliminary ARARs, RAOs, and COCs to be used in the development of this FFS. The final ARARs, RAOs, and COCs will be developed in the Record of Decision (ROD) for the Site.

2.1 Applicable or Relevant and Appropriate Requirements

This preliminary ARAR section summarizes the MPCA, Minnesota Department of Natural Resources (MDNR), and MDH ARARs, and to be considered (TBC) criteria for aquatic sediment associated with the Site. Local and federal ARARs have also been included; however, the list may not include all applicable local and federal ARARs.

The NCP (40 CFR 300.5) defines “applicable” requirements as: “those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA [Comprehensive Environmental Response, Compensation, and Liability Act] site.” Only those promulgated state standards identified by a state in a timely manner that are substantive and equally or more stringent than federal requirements may be applicable.

The NCP (40 CFR 300.5) further defines “relevant and appropriate” requirements as: “those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that, while not ‘applicable’ to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.” Like “applicable” requirements, the NCP also provides that only those promulgated state requirements that are identified in a timely manner and are more stringent than corresponding federal requirements may be relevant and appropriate.

ARARs generally fall into one of the following three classifications:

- **Chemical-specific:** These ARARs are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in numerical values. These values establish an acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. These requirements provide the basis for protective Site remediation levels for the COCs in the designated media.
- **Location-specific:** These ARARs generally restrict certain activities or limit concentrations of hazardous substances solely because of geographical or land use concerns. Requirements addressing wetlands, historic places, floodplains, or sensitive ecosystems and habitats are potential location-specific ARARs.

- **Action-specific:** These ARARs are restrictions on the conduct of certain activities or the operation of certain technologies at a particular site. Examples of action-specific ARARs would be regulations dictating the design, construction, and/or operating procedures for dredging, on-site landfilling, or capping. Action-specific requirements do not themselves determine the cleanup alternative, but define how the chosen cleanup alternative should be achieved.

In addition, criteria, advisories, guidance, and proposed standards developed by federal and state environmental and public health agencies that are not legally enforceable, but contain helpful information, are collectively referred to as TBCs. TBCs can be helpful in carrying out selected remedies or in determining the level of protectiveness of selected remedies. TBCs are meant to complement the use of ARARs, not compete with or replace them. TBCs are included, where appropriate, in the chemical-, location-, and action-specific discussions.

Several federal and state laws govern or provide the framework for remedial actions. Remedial actions must comply with substantive portions of these laws or acts, which were also reviewed during the ARAR development process. The following provides a summary of laws and acts that do not readily fall into one of the chemical-, location-, or action-specific classifications, but are applicable to the Site:

ARAR/TBC	Citation	Description/Potential Application
CERCLA	42 United States Code (USC) §§9601 et seq.	Federal Superfund Law
NCP	40 CFR part 300	Provides organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants.
MERLA	Minn. Stat. §§115B.01 to 115B.20	State Superfund Law.
Water Pollution Control Act	Minn. Stat. chapter (ch.) 115	Administration and enforcement of all laws relating to the pollution of any waters of the state.
Duty to Notify and Avoid Water Pollution	Minn. Stat. §115.061	Requires notification and recovery of discharge pollutants to minimize or abate pollution of the waters of the state.
Pollution Control Agency	Minn. Stat. ch. 116	Provides organizational structure and procedures for responding to problems relating to water, air, and land pollution.
Water Law	Minn. Stat. chs. 103A, 103B, 103C, 103D, 103E; 103F, and 103G	Provides regulations pertaining to any waters of the state, including surface water, wetlands and groundwater.
Safe Drinking Water Act	42 USC §§300f et seq.	Established to protect the quality of drinking water (above or underground).
Clean Water Act	33 USC §§1251 et seq.	Establishes structure for regulating discharges of pollutants and regulating quality standards for surface waters.
Resource Conservation and Recovery Act (RCRA)	42 USC §§6901 et seq.	Establishes RCRA Program and Regulations.
Clean Air Act	42 USC §§7401 et seq.	Regulates air remissions from stationary and mobile sources.

2.1.1 Chemical-Specific ARARs and TBCs

The following are the chemical-specific ARARs and TBCs associated with the sediments and shall be used to develop site-specific cleanup levels (CULs):

ARAR/TBC	Citation/Source	Description/Application
Sediment		
SSVs	MDH, 2013. Public Health Consultation, Updated Human Health Screening Values for SLR Sediments: U.S. Steel Site, April	To be used as benchmark values for making comparisons to surficial sediment chemistry measurements.
SQTs	Guidance for the Use and Application of SQTs for the Protection of Sediment-dwelling Organisms in Minnesota	To be used as benchmark values for making comparisons to surficial sediment chemistry measurements.
All Media		
Contaminated Sediments Remediation	Contaminated Sediments Remediation. http://www.itrcweb.org/contseds_remedy-selection/	Guidance to assist in selecting remedial technology most appropriate for a specific site.
Contaminated Sediment Remediation	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, USEPA, December 2005	Guidance to assist in selecting remedial technology most appropriate for a specific site.
Contaminated Sediment Remediation	Use of Amendments for In Situ Remediation at Superfund Sediment Sites, USEPA, April 2013	Guidance to assist in situ remediation.
Site screening guidelines	Working Draft Site Screening Evaluation Guidelines. MPCA Risk-Based Site Evaluation (RBSE) Manual (09/98)	Guidelines and criteria for screening human health and ecological risks.

Sediment

Human Health Risk

SSVs are tools for screening contaminated sediments for potential impacts to human health; however, as described in **Section 1.4.3.2,** SSVs will not be used to evaluate sediment contamination at the Site. Further, the potentially complete human health exposure pathway will be mitigated by addressing ecological exposure pathways.

Ecological Risk

To achieve protection and restoration of habitat, minimize exposure of the benthic organisms to contaminated sediments and movement of contaminants up the food chain, Preliminary Sediment Remediation Goals were developed for use in this FFS. The MPCA does not have sediment quality standards. SQTs, adopted for use in the SLR AOC, can be used throughout the state as benchmark values for making comparisons to surficial sediment chemistry measurements as described in **Section 1.4.3.2**. The Midpoint SQT will be used to identify, evaluate, and prioritize sediment-associated risk to ecological health.

All Media

This guidance document assists in selecting remedial technology most appropriate for a specific site based on contaminated sediment and site specific characteristics (http://www.itrcweb.org/contseds_remedy-selection/).

The USEPA document, Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, presents remedial options available for contaminated sediments discussing advantages and limitations associated with the options.

The USEPA document, Use of Amendments for In Situ Remediation at Superfund Sediment Sites, presents remedial options using amendments available for contaminated sediments discussing advantages and limitations associated with the options.

The MPCA Site Screening and Evaluation Document presents an overall process for conducting a Tier 1 evaluation of the various exposure pathways at a site. The screening criteria worksheet can be found at the MPCA website (https://www.pca.state.mn.us/waste/risk-based-site-evaluation-guidance).

2.1.2 Location-Specific ARARs and TBCs

The location-specific ARARs and TBCs for the Site are as follows:

ARAR/TBC	Citation/Source	Description/Application
Waters of the State and Groundwater Protection	Minn. Stat. 103G and 103H	Groundwater protection, nondegredation, and best management practices.
Floodplain Management and Wetlands Protection	40 CFR Part 6, Appendix A, Section 6.a.(1)	Requires agencies to evaluate potential effects of actions in a floodplain to avoid adverse impacts.
Shoreland and Floodplain Management	Minn. Rules ch. 6120	Conserves economic and natural environmental values (MDNR).
St. Louis County Land Use Ordinances	St. Louis County Zoning Ordinances, ch. 1003	Floodplain management, Manages on-site waste disposal and other site activities.
Shoreland Management	Duluth City Code §51-26 et seq.	The City of Duluth requires a permit for any excavation or grading above the Ordinary High Water Mark within 300 feet of a river.
Endangered Species Act	16 USC §1531 et seq. 50 CFR §17.11-12	Conservation of threatened and endangered plants and animals and their habitats.
Endangered, Threatened, Special Concern Species	Minn. Rules ch. 6134 Minn. Statute, Section 84.0895	Protection of endangered, threatened, special concern species (MDNR).
Migratory Bird Treaty Act	16 USC Chapter 7, Subchapter II §§703 and 712.2	Protects migratory birds and their ecosystems.
MDH Advisory for St. Louis River	MDH	Provides fish consumption advisories.

The Site is located within the Lake Superior Drainage Basin. Surface water quality standards and provisions for Class 2B and 3B waters apply. In addition, USEPA and the Great Lakes states agreed in 1995 to a comprehensive plan to restore the health of the Great Lakes. The Final Water Quality Guidance for the Great Lakes System, also known as the Great Lakes Initiative (GLI), includes criteria for states to use when setting water quality standards for 29 pollutants, including bioaccumulative chemicals of concern, and prohibits the use of mixing zones for these toxic chemicals. Because the surface water at the Site is within the drainage basin of Lake Superior, the ARARs specified in the GLI, Minn. Rules ch. 7052 are applicable to the Site. Requirements of the Great Lakes Water Quality Agreement of 2012 apply to the Site. In addition, the surface waters adjacent to the Site are identified as an Outstanding International Resource Water (OIRW). The objective for OIRW is to maintain water quality at existing conditions when the quality is better than the water quality standards. Generally, OIRWs are considered surface water quality standards applicable to the St. Louis River for Class 2B and OIRWs, as set forth in Minn. Rules, chs. 7050 and 7052, and to the additional surface water quality standards for the St. Louis River, as set forth in Minn. Rules ch. 7065. The OIRW was established after the ROD was issued.

As stated in Minn. Rules ch. 7050.0210 Subp. 2:

> *Nuisance conditions prohibited. No sewage, industrial waste, or other wastes shall be discharged from either point or nonpoint sources into any waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum, visible oil film, excessive suspended solids, material discoloration, obnoxious odors, gas ebullition, deleterious sludge deposits, undesirable slimes or fungus growths, aquatic habitat degradation, excessive growths of aquatic plants, or other offensive or harmful effects.*

Title 40 CFR Part 6, Appendix A, Section 6 Requirements: Requires federal agencies to evaluate the potential effects of actions taken within a floodplain to avoid adversely impacting floodplains wherever possible.

Title 40 CFR Part 6, Appendix A, Section 6.a.(1) Floodplain/Wetlands Determination: Before undertaking an Agency action, each program office must determine whether or not the action will be located in or affect a floodplain or wetlands. The Agency shall utilize maps prepared by the Federal Insurance Administration of the Federal Emergency Management Agency (Flood Insurance Rate Maps or Flood Hazard Boundary Maps), Fish and Wildlife Service (National Wetlands Inventory Maps), and other appropriate agencies to determine whether a proposed action is located in or will likely affect a floodplain or wetlands. If there is no floodplain/wetlands impact identified, the action may proceed without further consideration of the remaining procedures set in this section. If floodplain/wetlands impact is identified, this section presents procedures that must be taken.

Shoreland and Floodplain Management (Minn. Rules Ch. 6120): Provides standards and criteria intended to preserve and enhance the quality of surface waters, conserve the economic and natural environmental values of shorelands, and provide for the wise use of water and related land resources of the state. St. Louis County Zoning Ordinances, ch. 1003, establish additional floodplain management and manage site activities such as on-site waste disposal.

Shoreland Management Permit (Duluth City Code §51-26 et seq.), as defined by the City of Duluth: Requires a permit for any excavation or grading above the Ordinary High Water Mark within 300 feet of a river. Each alternative will involve some of these activities. The substantive requirements of this permit are found in the ordinance and may govern removal of natural vegetation, grading and filling, placement of roads, sewage and waste disposal, and setbacks.

The Endangered Species Act (16 U.S.C.A. §1531 et seq.) and the Minnesota Endangered, Threatened, Special Concern Species Act (Minn. Rules ch. 6134): Protect threatened and endangered plants and animals and their habitats.

Title 16 United States Code (USC) Chapter 7, Subchapter II §§703 and 712.2. (The Migratory Bird Treaty Act): Protects migratory birds and their ecosystems by specifying the taking, killing, or possessing migratory birds unlawful. Public Law 95-616, an amendment to this act, provides measures to protect identified ecosystems of special importance to migratory birds such as bald eagles against pollution, detrimental alterations, and other environmental degradations.

The MDH has established various fish consumption advisories for the SLR due to the presence of perfluorochemicals (PFCs), PCBs, and mercury in water and sediments.

2.1.3 Action-Specific ARARs and TBCs

The following summarizes the action-specific ARARs for the Site. In addition, Occupational Safety and Health Standards (Minn. Rules ch. 5205) for worker health, safety, and training are applicable to remedial actions performed at the Site.

ARAR/TBC	Citation/Source	Description/Application
Waters of the State (both surface and underground)	Minn. Rules ch. 7050 and 7052	Surface water quality during remedy construction.
Wetland Conservation Act (WCA)	Minn. Stat. §§103G.221-.2373	Protection of wetlands.
Wetlands Conservation	Minn. Rules 8420	Protection of wetlands, wetland functions for determining public values.
Floodplain Management Order	Executive Order 11988 and 40 CFR Part 6, Appendix A	Regulates remedial action implementation in floodplains.
Section 404 Permit and Section 401 Certification (Clean Water Act)	33 CFR pts 320 and 323; 33 USC §1341	Applies to discharge of dredged or fill material into waters of the U.S.
National Pollutant Discharge Elimination System (NPDES)/ State Disposal System (SDS) permits	Clean Water Act 33 USC §1342	Surface water quality requirements for discharges of pollutants to waters of the state.
Section 10 (Rivers and Harbors Act of 1899)	33 USC 403	Applies to activities that will obstruct or alter any navigable water of the U.S.
Work in Public Waters	Minn. Stat. §103G.245	Permit requirements applicable to work in public waters that will change or diminish its course, current, or cross-section.
Public Water Resources	Minn. Rules ch. 6115	Water appropriation permitting, standards and criteria for alterations to structure of public water (MDNR).
Minnesota Sediment Quality Targets	Guidance for the Use and Application of Sediment Quality Targets for the Protection of Sediment-dwelling Organisms in Minnesota, MPCA Document Number: tdr-gl-04	Establishes procedures for PBAZ caps and covers.
Western Lake Superior Sanitary District (WLSSD)	WLSSD Industrial Pre-Treatment Ordinance	Requirements for any dredge water discharged into public sanitary sewers.
Construction and Use of Public Sewers	Minn. Rules ch. 4715	Governs the use of sewers and public water systems if any dredge water is disposed of in public sewers.

ARAR/TBC	Citation/Source	Description/Application
MDNR Invasive Species Management	Minn. Statutes 84D.02	Requirements for sediment transportation if invasive species are present.
Solid Waste	Minn. Rules ch. 7035	Requirements and standards for solid waste facilities.
Hazardous Waste	Minn. Rules ch. 7045	Hazardous waste listing, and generator, transport, and facility standards.
Air Pollution Emissions and Abatement	Minn. Stat. §116.061	Duty to notify and abate excessive or abnormal unpermitted air emissions.
Ambient Air Quality Standards	Minn. Rules ch. 7009	Provides air quality standards.
Preventing Particulate Matter From Becoming Airborne and Emission Standards	Minn. Rule pts. 7011.0150 and 7011.8010	Provides measures to control dust and emission standards for hazardous air pollutants.
Noise Pollution Control	Minn. Rules ch. 7030	Noise standards applicable to remedy construction.

Water Quality

If any activity associated with the remedial actions results in an unregulated release, in accordance with the Water Pollution Control Act and Minn. Stat. 115.061, Duty to Notify, a notification and recovery of any pollutants discharged to minimize or abate pollution of the waters of the state is required.

In accordance with Minn. Rules ch. 7050, surface water quality standards for the maintenance and preservation of surface water quality during remedy construction, including discharges from treatment/work and stormwater runoff zones, shall be based on surface water quality standards that currently apply to Class 2B and OIRWs, as set forth in Minn. Rules, chs. 7050 and 7052, and to the additional surface water quality standards for the St. Louis River set forth in Minn. Rules ch. 7065. Therefore, if water is discharged directly to the waters on or adjacent to the Site, it shall be treated to a level that meets applicable surface water discharge standards. Groundwater non-degradation and standards for the protection of groundwater during remedy construction are presented in Minn. Rules 7060.

During remediation, the MPCA would consider the areas in which work is performed as "treatment/work zones," to which the surface water quality standards normally applicable to the St. Louis River would temporarily not apply. These treatment/work zones would be physically separated from adjacent waters through the use of engineering controls such as single or multiple silt curtains, inflatable dams, sheet piling, or other measures. During construction of the remedy, any discharges occurring within those controlled treatment/work zones, such as the discharge of capping material during capping operations, the release of contaminants during dredging operations, or runoff from activities on shore, would not be subject to water quality standards. Rather, water quality standards would apply outside of the treatment/work zone, beyond the outermost engineering control structure where the water from the treatment/work zone is discharged. Other discharges occurring during remedy construction that are not included in a treatment/work zone, including discharges of treated dredge water, and discharges of stormwater runoff from shoreland modifications outside of the treatment/work zones, would also be subject to regulation.

If water is discharged, it would be treated to a level that meets applicable surface water discharge standards. The MPCA water quality standards may apply to these discharges. Final standards would be determined by the MPCA prior to implementation of the remedial actions. In the event that a standard is exceeded, further management practices would likely be required during remedy construction to reduce the amount of suspended contaminants escaping the treatment/work zone.

Wetlands, Shoreland, and Floodplain Management

In accordance with Minn. Rules ch. 7050, wetlands at the Site are classified as unlisted wetlands, Class 2B and 3B waters. In accordance with Minn. Rules ch. 8420, compliance with wetland ARARs will involve consultation with the MDNR to determine the category of wetlands present at the Site and any avoidance, mitigation, and replacement that may be necessary. Water quality standards for the maintenance and preservation of surface water quality during remedy construction including discharges from treatment/work and stormwater runoff zones shall be based on surface water quality standards that currently apply to Class 2B and 3B waters and shall comply with Minn. Stat. §§103G.221-.2373. Standards and specifications applicable to shoreland and floodplain management can be found in Executive Order 11988 and 40 CFR Part 6, Appendix A, Minn. Rules ch. 6120.

Minn. Stat. §103G.222 provides that a wetland replacement plan must be approved by the Local Governmental Unit before any Wetland Conservation Act (WCA) wetlands may be drained or filled, unless draining or filling falls within the “De Minimis” exemption or another exemption of Minn. Stat. §103G.2241. WCA wetlands are those wetlands that are not public water wetlands regulated by the MDNR and United States Army Corps of Engineers (USACE). WCA wetlands would be located above the Ordinary High Water Mark. The South St. Louis Soil and Water Conservation District provides additional guidance regarding WCA requirements for the Site at the following website: http:// www.southstlouisswcd.org/wcact.html.

Permits and Certifications

Possible permits for cleanup activities include the following:

Section 404 Permit (Clean Water Act): Required for discharge of dredged or fill material into waters of the United States. The substantive requirements of this permit shall be met for alternatives that dredge or fill waters of the state. USACE evaluates applications for Section 404 permits. Substantive requirements that may be incorporated within a Section 404 permit for off-site activities can be found in 33 CFR Parts 320 and 323.

Section 401 Certification: The Clean Water Act, 33 USC §1341, requires that any application for a federal permit that may result in a discharge to a navigable water must be accompanied by a certification from the affected state indicating that the discharge will comply with all applicable water quality standards and effluent limitations of the Act. Thus, a Section 401 certification or a 401 certification waiver for remedial action at the Site would be necessary before the USACE may issue a Section 404 permit, and a certification may be necessary before the USACE may issue a Section 10 permit if that permit authorizes a “discharge.”

National Pollutant Discharge Elimination System (NPDES; Clean Water Act 33 USC §1342): Discharges of pollutants to waters of the state associated with construction of the selected remedy would be subject to the requirements applicable to a NPDES permit. Discharges could include the discharge of capping material, the discharge of contaminants released and suspended by dredging operations, the discharge of treated dredge water during dredging operations, and the discharge of stormwater runoff from shoreland modifications. These types of discharges would be subject to the same regulatory standards and controls that would apply under an MPCA permit. In addition, NPDES General Permit number MNG990000 has been required for managing dredged materials; however, this permit has expired and has not been renewed. According to Managing Dredged Materials in the State of Minnesota (MPCA, 2009), an individual NPDES/State Disposal System (SDS) Dredge Materials Management permit may be required. A NPDES Construction Permit and a Stormwater Pollution Prevention Plan are required by the MPCA if more than 1 acre of land is disturbed by excavation activities.

Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403): A Section 10 permit is required from the USACE for any construction in or over any navigable water, or the excavation or discharge of material into such water, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters. The substantive requirements that may be incorporated within a Section 10 permit can be found in 33 CFR Parts 320 and 322.

Work in Public Waters (Minn. Stat. §103G.245): A permit from the MDNR is necessary for any work in public waters that will change or diminish its course, current, or cross-section. If an alternative under consideration involves dredging or capping, a public waters permit from the MDNR may be required. The substantive requirements that the MDNR may incorporate within its public waters permit are codified in statute and at Minn. Rules, ch. 6115. These requirements include compensation or mitigation for the detrimental aspects of any major change in the resource. The MDNR permits may require restoration of bathymetry (water depth) and habitat substrate (bottom) as part of the public waters permit. The MDNR would set the specific cover depth and composition requirements.

Additionally, if capping of contaminated sediments is conducted, requirements would include specifications for cap construction. In situ caps constructed for the containment of contaminated sediment must contain an isolation zone (IZ) and a PBAZ. The IZ is the portion of the cap that is applied directly over the contaminated sediments and is designed to isolate and attenuate the Site contaminants that could potentially be transported upward into the PBAZ at concentrations above the CULs by diffusion or advection transport mechanisms. The PBAZ is the area within the cap above the IZ where significant biological activity may potentially be present. The thickness and material specifications for the IZ and PBAZ should be determined based on pore water transport and attenuation modeling.

Air Emissions and Waste Management Permits: In accordance with Minn. Stat. §116.081, a permit is required for the construction, installation or operation of an emission facility, air contaminant treatment facility, treatment facility, potential air contaminant storage facility, storage facility, or system or facility related to the collection, transportation, storage, processing, or disposal of waste, or any part thereof, unless otherwise exempted by any agency rule now in force or hereinafter adopted, until plans have been submitted to the agency, and a written permit granted by the agency.

On-Site Disposal: The placement of dredged sediment into an on-site confined aquatic disposal (CAD) area and any subsequent seepage from the CAD, if implemented, would be regulated by the MPCA under the requirements applicable to an SDS permit. The legal requirements for an SDS are found in Minn. Stat. §115.07, Minn. Rules, Parts 7065.0100 to 7065.0160 and in other MPCA water quality rules including Minn. Rules chs. 7050 and 7052.

Discharge into Sewers: A permit from the Western Lake Superior Sanitary District (WLSSD) will be necessary if any dredge water is discharged into the public sewers. Pretreatment standards that would likely apply can be found at:

http://www.wlssd.duluth.mn.us/pdf/WLSSDPretreatmentOrdinance.pdf.

The permit will also include requirements to ensure that there will be no detrimental effects to their bio-solids program. A WLSSD permit would also represent compliance with Minn. Rule, Part 4715.1600 and the MPCA water rules governing indirect discharges.

Invasive Species: A prohibited/regulated invasive species permit will be required to transport sediment to a landfill, if invasive species are present near the proposed work area.

CERCLA provides for waiving of necessary permits for on-site work, provided the work is conducted in compliance with the substantial conditions of such permits. Although the permits themselves may not be required on CERLCA Sites, compliance with the substantial conditions of these identified permits shall be met.

Construction and Use of Public Sewers

Minn. Rules ch. 4715 governing the use of sewers and public water systems would apply if any water associated with remedial activities is disposed of in public sewers.

Waste Management

Solid and hazardous waste management requirements and standards can be found in Minn. Rules chs. 7035 and 7045, respectively. USEPA guidance has consistently stated that Superfund remedies involving movement of contaminated material within the area of a Site where such material is already located (sometimes referred to as an AOC) do not create a "waste" that is subject to RCRA (42 USC §§6901 et seq.) or other waste management requirements. Remedy alternatives that require contaminated materials to be moved to an off-site land disposal site are considered to generate waste that must be managed under applicable waste management requirements.

St. Louis County Zoning Ordinances, ch. 1003, establish additional floodplain management and manage site activities such as on-site waste disposal.

Ambient Air Quality Standards

Air quality standards applicable to releases into the air from cleanup activities include Min. Stat. 116.061, Air Pollution Emissions and Abatement. During remedy construction, activities such as transportation, storage and placement of capping material may result in particulate matter becoming airborne. Minn. Rules ch. 7009 establishes ambient air quality standards for criteria pollutants regulated under the Clean Air Act. Compliance points shall be selected in accordance with Minn. Rules ch. 7009. The ambient air quality standards for particulate matter that apply to remedial actions are found at:

https://www.revisor.mn.gov/rules/?id=7009.0080

Control of the generation of airborne particulate matter during remedy construction is regulated in Minn. Rule part 7011.0150, *Preventing Particulate Matter from Becoming Airborne*, which includes measures to control dust that may be generated during remedy construction activities such as transportation, storage, and placement of capping material, which shall be addressed in the remedial design plan. Minn. Rules part 7011.8010, Site Remediation, incorporates the National Emission Standards for Hazardous Air Pollutants applicable during Site remediation activities.

Noise Pollution Control

Minn. Rules ch. 7030 establishes noise standards for various land uses. Compliance points will be selected in accordance with Minn. Rules ch. 7030. The noise standards that will apply to the selected remedial action can be found at:

https://www.revisor.leg.state.mn.us/rules/?id=7030.0040

2.1.4 Other Considerations

Other considerations under MERLA set forth the regulatory requirements, RAOs and CULs that must be met by a remedy to meet the legal standard for a remedy under MERLA and the threshold criterion for protection of public health and welfare and the environment. A remedy, as defined under MERLA, must also include any monitoring, maintenance and institutional controls (ICs) and other measures that MPCA determines are reasonably necessary to ensure the protectiveness of the selected remedy over the long term.

It is particularly important to consider the requirements for long-term assurance of protectiveness where the remedy alternatives involve the use of capping or containment to manage contaminated media within the Site. Some requirements may also be necessary to ensure long-term protectiveness of alternatives that involve excavation or dredging and off-site disposal of contaminated soil or sediment.

In addition, MERLA requires the MPCA to consider the planned use of the property where the release of contaminants is located when determining the appropriate standards to be achieved by a remedy.

Long-Term Assurance of Protectiveness

MERLA requires that a remedy include measures that are reasonably required to ensure the ongoing protectiveness of a remedy once the components of the remedy have been constructed and entered their operational phase. Such measures may include, but are not limited to, ICs and monitoring and maintenance requirements. This section discusses the measures that MPCA determines are reasonably necessary to ensure long-term protectiveness.

Institutional Controls

ICs are legally enforceable restrictions, conditions or controls on the use of property, groundwater or surface water at a property that are reasonably required to ensure the protectiveness of a remedy or other response actions taken at the Site. Areas of the Site where contaminated media remains in place after remedial construction will be subject to ICs (such as easements and restrictive covenants) that are legally binding on current and future owners of the property to ensure ongoing protection from disturbance of or exposure to the contamination. Restrictions on use may also be required for areas of the Site where contaminated media are treated and/or removed and where some residual contamination may remain.

Minn. Stat. §115B.16, subd. 2, requires an Affidavit Concerning Real Property Contaminated with Hazardous Substances to be recorded with the St. Louis County recorder by the owner of the property. The Uniform Environmental Covenants Act (UECA) and the authority for requiring environmental covenants can be found in Minn. Stat. ch. 114E. This statute requires MPCA approval of environmental covenants (which include restrictive covenants and access) when there is an environmental response project (which includes superfund cleanups) is overseen by the MPCA. Because the Site is not platted, the UECA may not apply and other ICs such as a City Ordinance may be required to prevent anchoring, fishing, dredging, and other activities that may disturb a cap or contaminated sediments left in place.

Long-Term Operation and Maintenance, Monitoring, and Contingency Action

On-site containment facilities and capping of impacted media (sediment) or any other alternative that may leave impacted media on-site will require post-construction monitoring, operation and maintenance (O&M), and contingency action plan to ensure that ARARs, RAOs and CULs that apply to the alternative are fully achieved and maintained over time.

General details of the post-construction monitoring, O&M, and contingency action plan requirements would be set forth in the FFS, along with an estimate of the cost to carry out each activity.

Sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required.

Planned Use of Property

In a provision entitled "Cleanup Standards" (Minn. Stat. §115B.17, subd. 2a), MERLA provides that when MPCA determines the standards to be achieved by response actions to protect public health and welfare and the environment from a release of hazardous substances, the agency must consider the planned use of the property where the release is located. The purpose of this provision of MERLA is to allow the MPCA to select cleanup standards that provide a level of protection that is compatible with the uses of the Site property that can be reasonably foreseen.

The specific properties directly affected by the remedies are currently used as industrial land. The cleanup standards must provide protection of public health and welfare and the environment that is consistent with any planned or potential future uses of the Site, including natural resource and habitat restoration, navigation and recreational uses. These cleanup standards are also compatible with the use of the adjacent land for residential, recreational, habitat restoration, or commercial and industrial use.

Industrial land use adjacent to the Site includes barge and large vessel traffic at the Site. A water depth (draft) may be required as part of the remedy to maintain current Site use in the future. Draft requirements must be considered in all dredging and capping scenarios. As part of the modifying criteria, State/support agency and community acceptance, draft requirements should be determined. As previously discussed, sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required.

2.2 Remedial Action Objectives

The RAOs developed by the MPCA for the Site are:

1. Minimize or remove exposure to sediment contaminants that bioaccumulate in the food chain and contribute to fish consumption advisories.
2. Minimize or remove exposure of the benthic organisms to contaminated sediments above sediment cleanup goals.
3. Preserve water depth to enable the current and/or planned use of the Site.
4. Enhance aquatic habitat, if conditions allow, in a manner that contributes to the removal of BUIs.

The following subsection presents preliminary sediment CULs developed to achieve these RAOs.

2.2.1 Preliminary Sediment CULs

The remedy should meet the Preliminary CULs, to achieve protection of human health (through fish consumption), restoration of habitat, to minimize exposure of benthic organisms to contaminated sediments and to stop movement of contaminants up the food chain. The Midpoint SQT for lead, cadmium, copper, mercury, nickel, zinc, Total PAHs, PCBs, and dioxins will serve as CULs for lead, cadmium, copper, mercury, nickel, zinc, Total PAHs, PCBs, and dioxins. The following table presents the CUL for the COCs identified in **Section 1.4.3.3**.

Slip C Preliminary Sediment Cleanup Levels			
Contaminant of Concern	**Units**	**Cleanup Level**	**Maximum Concentration Detected**
Lead	mg/kg	83	382
Cadmium	mg/kg	3	6.5
Copper	mg/kg	91	148
Mercury	mg/kg	0.64	3
Nickel	mg/kg	36	40
Zinc	mg/kg	0.64	589
Total PAH	µg/kg	12,300	113,234
PCBs	µg/kg	370	390
Dioxin	ng TEQ/kg	11.2	23.26

Notes:
µg/kg – micrograms per kilogram
mg/kg – milligrams per kilogram
ng TEQ/kg = nanograms toxic equivalency per kilogram

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

3.1 Remedial Technology Identification and Screening Process

Potential technologies for addressing conditions at the Site were identified based upon professional experience of Bay West staff, discussions between Bay West and MPCA staff, and guidance developed for the remediation of contaminated sediment sites (USEPA, 2005; Interstate Technology and Regulatory Council [ITRC], 2014). Information collected during the Sediment RI Report was used to compile the CSM and identify feasible technologies for the Site.

A qualitative approach was used to screen technologies using a three-part ranking system where each technology was evaluated on effectiveness, implementability, and relative cost:

- Effectiveness was evaluated by the predicted ability of the technology under consideration to ensure long-term protection of human health and the environment while minimizing short-term impacts during implementation, as well as the technology's ability to meet RAOs.
- Implementability was evaluated by considering the technical and administrative feasibility of the technology. Technical feasibility includes the ability to achieve RAOs and the avoidance of creating additional risk during implementation, including the degree of disruption in the project area. Administrative feasibility includes the consideration of permits required for technology implementation, availability of disposal facilities and equipment necessary for the technology, and coordination with applicable agencies and stakeholders.
- Relative costs used for technology screening were based on engineering judgment, rather than detailed estimates. Detailed cost estimates were compiled for each individual alternative, which incorporate technologies meeting screening criteria, and are presented in **Section 3.3**.

Table 2 presents a summary of the technology screening results. The following sections describe the technologies that were screened using the three-part ranking system.

3.1.1 Institutional Controls

ICs are legally enforceable restrictions, conditions, or controls on the use of property, ground water, or surface water at a contaminated site that are reasonably required to ensure the protectiveness of a remedy or other response actions taken at the Site. If contaminated sediments remain in place after remedial actions are taken, the Site would be subject to ICs (such as easements and restrictive covenants) that are legally binding on current and future owners of the property to ensure ongoing protection from disturbance of or exposure to the contamination. Most remedial alternatives include ICs until LTM indicates that risk reduction has been achieved and the RAOs have been met (ITRC, 2014). The following information obtained from USEPA sediment remediation guidance (USEPA, 2005) details ICs likely appropriate for use at the Site.

Fish consumption advisories are informational devices that are frequently already in place and incorporated into sediment site remedies. Commercial fishing bans are government controls that ban commercial fishing for specific species or sizes of fish or shellfish. Usually, state departments of health are the governmental entities that establish these advisories and bans. An advisory usually consists of informing the public that they should not consume fish from an area, or consume no more than a specified number of fish meals over a specific period of time from a particular area. Sensitive sub-populations or subsistence fishers may be subject to more stringent advisories. Advisories can be publicized through signs at popular fishing locations, pamphlets, or other educational outreach materials and programs. Consumption advisories are not enforceable controls and their effectiveness can be extremely variable (USEPA, 2005).

For any alternative where subsurface contamination remains in place (e.g., capping, MNR, or an in-water confined disposal site), waterway use restrictions may be necessary to ensure the integrity of the alternative. Examples include restricting boat traffic in an area to establish a no-wake zone, or prohibiting anchoring of vessels. In considering boating restrictions, it is important to determine who can enforce the restrictions, and under what authority and how effective such enforcement has been in the past. In addition, a restriction on easements for installing utilities, such as fiber optic cables, can be an important mechanism to help ensure the overall protectiveness of a remedy (USEPA, 2005).

Where contamination remains in place, it may be necessary to work with private parties, state land management agencies, or local governments to implement use restrictions on nearshore areas and adjacent upland properties. For example, construction of boat ramps, retaining walls, or marina development can expose subsurface contamination and compromise the long-term effectiveness of a remedy. Where contaminated sediment exceeding CULs is identified in proximity to utility crossings or other infrastructure and temporary or permanent relocation of utilities in support of a dredging remedy may not be feasible or practical, capping may be desirable even though temporary cap disruption may be necessary periodically (USEPA, 2005).

ICs are incorporated into each of the remedial alternatives developed for this FFS.

3.1.2 Monitoring

Monitoring is the collection and analysis of data (chemical, physical, and/or biological) over a sufficient period of time and frequency to determine the status and/or trend in one or more environmental parameters or characteristics. Monitoring should not produce a “snapshot in time” measurement, but rather should involve repeated sampling over time in order to define the trends in the parameters of interest relative to clearly defined management objectives. Monitoring is recommended for all types of sediment remedies both during and after remedial action and can be classified as construction monitoring and performance monitoring (also referred to as LTM), respectively. Monitoring may be recommended for some of the alternatives for a variety of reasons, including the following: 1) to assess compliance with design and performance standards; 2) to assess short-term remedy performance and effectiveness in meeting sediment CULs; and/or 3) to evaluate long-term remedy effectiveness in achieving RAOs and in reducing human health and/or environmental risk. In addition, monitoring data are usually needed to complete the five-year review process where a review is conducted.

Monitoring activities applicable to the Site could include one or more of the following based on the selected remedy:

- Collection of sediment chemical data to ensure that CULs have been achieved (due to dredging, in situ treatments, or degradation);
- Measurements of cover/cap thicknesses to ensure continued isolation of contaminants;
- Visual or physical observation of cap integrity;
- Measurement of COC concentrations in cover/cap material to ensure that contaminants are not migrating into or through the cover/cap; and
- Measurement of toxicity to and bioaccumulation of COCs within aquatic organisms such as benthics and fish in order to evaluate reduction trends.

Construction monitoring may also be performed to ensure that contamination or nuisance materials are not released during construction activities. Construction monitoring activities applicable to the Site include one or more of the following:

- Turbidity monitoring to ensure that the off-site release of suspended sediments containing COCs is mitigated during dredging and/or cover/cap placement;
- Air monitoring to ensure that the off-site release of nuisance and/or contaminated dusts is mitigated during construction activities such as the mixing of sediments and amendment materials, hauling over dirt or gravel roadways, and excavation or other intrusive Site work;
- Periodic sampling of treated dredge contact water to mitigate contaminant inputs to water bodies or local sewage systems and to ensure that treated water meets permit or municipality requirements;
- Periodic sampling of dredged materials to ensure that landfill requirements for acceptance are achieved;
- Periodic sampling of imported materials (e.g., cover/cap materials, shoreline restoration materials, etc.) to mitigate impacts to water bodies or upland areas as a result of placement; and
- Pre- and post-construction soil sampling to access impacts of construction activities on lands used during the construction phase.

Both construction and performance monitoring (referred to as LTM) are incorporated into each of the remedial alternatives developed for this FFS.

3.1.3 Monitored Natural Recovery

MNR is defined by the National Research Council as a remediation practice that relies on natural processes to protect the environment and receptors from unacceptable exposures to contaminants. This remedial approach depends on natural processes to decrease chemical contaminants in sediment to acceptable levels within a reasonable time frame. With MNR, contaminated sediments are left in place and monitored for ongoing physical, chemical, and biological processes that transform, immobilize, isolate, or remove contaminants until they no longer pose a risk to receptors. Natural processes that contribute to MNR may include sediment burial, sediment erosion or dispersion, and contaminant sequestration or degradation (for example, precipitation, adsorption, or transformation). These natural processes, discussed in detail below, can reduce exposure to receptors (and thus reduce risk) and contribute to the recovery of the aquatic habitat and the ecological resources that it supports. MNR can be used alone or in combination with active remediation technologies to meet RAOs (ITRC, 2014).

3.1.4 Enhanced Monitored Natural Recovery

Enhanced Monitored Natural Recovery (EMNR) relies on the same natural processes as MNR to decrease chemical contaminants in sediment but includes the application of material or amendments to enhance these natural recovery processes. EMNR can use several technologies including, but not limited to, thin-layer capping and introduction of reactive amendments such as activated carbon (AC). Thin-layer caps (typically up to 1 foot) are often applied as part of an EMNR approach. These caps enhance ongoing natural recovery processes, while minimizing effects on the aquatic environment. Thin-layer caps are not intended to completely isolate the affected sediment, as in a conventional isolation capping remedy. This layer also accelerates the process of physical isolation, which continues over time by natural sediment deposition (ITRC, 2014).

3.1.5 In Situ Treatment

In situ sediment treatment involves applying or mixing of an amendment into sediments. Mixing may be achieved either passively, through natural biological processes such as bioturbation, or actively through mechanical means such as augers. In situ treatment technologies can achieve risk reduction in environmentally sensitive environments such as wetlands and submerged aquatic vegetation habitats, where sediment removal or containment by capping might be harmful. Treatment amendments typically reduce concentrations of freely dissolved chemicals that are available for exposure to organisms or that may be mobilized and transferred from sediment to the overlying water column (ITRC, 2014). The following in situ treatment technologies were screened in this evaluation:

- Immobilization – Immobilization treatments add chemicals or cements to reduce the leachability of contaminants. Mechanisms include solidification (encapsulation) or stabilization (chemical or absorptive reactions that convert contaminants to less toxic or mobile forms);
- Enhanced bioremediation – Microbial degradation by bacteria or fungi is enhanced by adding materials such as oxygen, nitrate, sulfate, hydrogen, nutrients, or microorganisms to the sediment;
- Oxidation/reduction – Chemicals are injected into sediment to act as an oxidant/electron acceptor to facilitate aerobic decomposition of organic matter;
- Chemical oxidation – The addition of chemical oxidizers to sediment can cause the rapid and complete chemical destruction of many toxic organic chemicals;
- Phytoremediation – Phytoremediation uses plant species to remove, transfer, stabilize, and destroy contaminants in sediment. Generally limited to sediments in shallow water zones and low concentrations; and
- Adsorption – Adsorbents can be used as sediment amendments for in situ treatment of contaminants. Sorption of metals and organics can take place simultaneously with a suitable combination of sorbents.

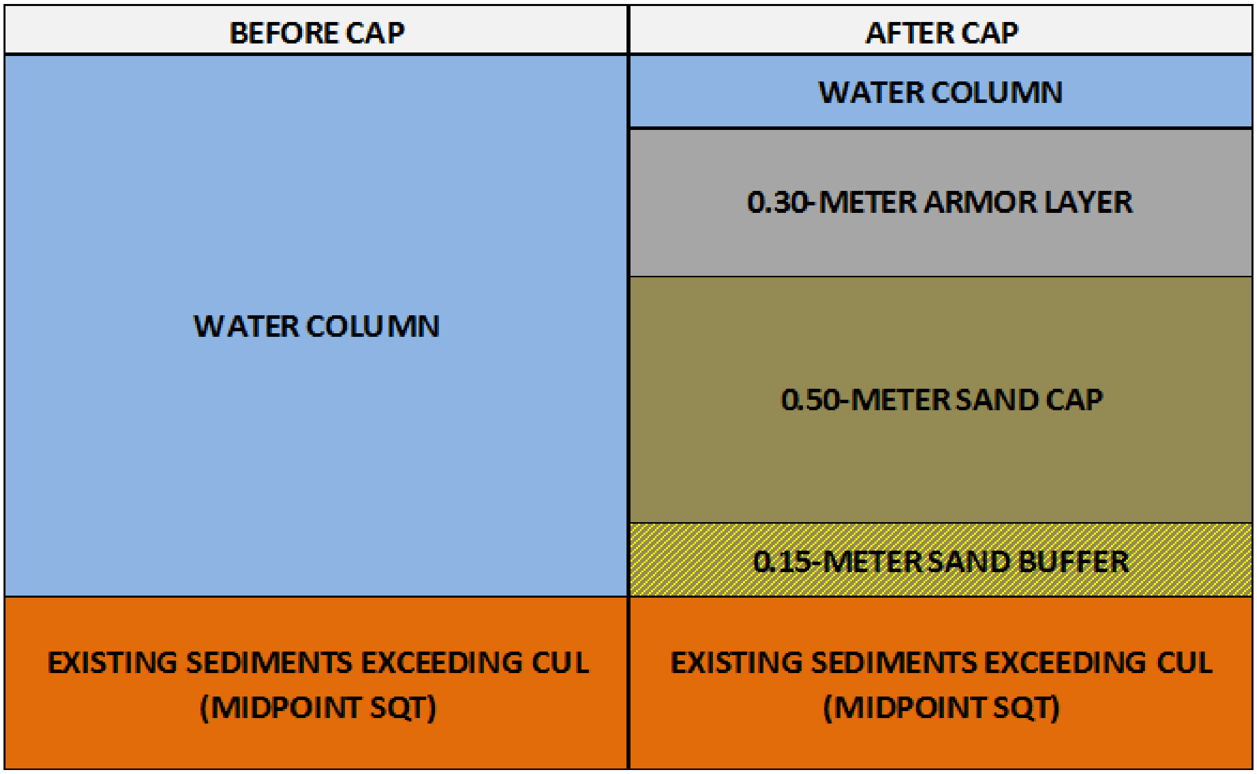
3.1.6 Capping

Capping is the process of placing a clean layer of sand, sediments, or other material over contaminated sediments in order to mitigate risk posed by those sediments. The cap may also include geotextiles to aid in layer separation or geotechnical stability, amendments to enhance protectiveness, or additional layers to armor and maintain its integrity or enhance its habitat characteristics.

When amendments are mixed directly into sediments, the resulting remedy is termed “in situ treatment.” When these amendments are added to cap material, the remedy is called an “amended cap,” and the amendments enhance the performance of the cap material. The same amendment used in the same proportions is generally more effective at isolating contaminants when used in a cap than when placed directly into sediments. The amended cap provides the benefits of capping in addition to the benefits of the treatment amendment (ITRC, 2014).

A cap designed for use at the Site should consist of at least two parts; an IZ and a PBAZ. The IZ is the portion of the cap that is applied directly over the contaminated sediments and is designed to isolate and attenuate contaminants that could potentially be transported upward into the PBAZ by diffusion or advection transport mechanisms. The PBAZ is the area within the cap above the IZ where biological activity may potentially be present. The PBAZ thickness can be estimated based on the potential organisms (both plant and animal) that may be present or take up residency once the cap is constructed. Contaminant levels should not exceed CULs for

COCs throughout the entire thickness of the PBAZ. The figure below shows a typical cap cross-section, for specific cap design see **Figures 8** through **10**.



Cap design considerations for the Site include the following, as also noted for the SLR Interlake/Duluth Tar Site (Service Engineering Group, 2003):

- Control of contaminant transport through the cap via cap amendments or IZs;
- Use of materials suitable for benthic habitat such as fine to medium-grained sand;
- Use of erosion controls where appropriate such as armoring to prevent scour from prop wash and other sources; and
- Maintenance or creation of water depths suitable for current and/or planned Site use.

Additional concerns regarding cap design, construction, and long-term effectiveness include ebullition of gases originating from below the cap, mixing of cap materials with contaminated sediments during cap construction, and strength of in situ sediments and their ability to support the cap during placement.

3.1.7 Dredging and Excavation

Dredging consists of the removal of contaminated sediment from water bodies in order to reduce risks to human health and the environment. Removal is particularly effective for source control (mass removal of hot spots) but potentially less effective for overall risk reduction because of resuspension and residual contamination. The three methods of contaminated sediment removal are mechanical dredging, hydraulic dredging, and excavation. As with any type of removal operation, additional technologies are required to appropriately handle the removed sediment. Dredged material handling technologies may involve transport, dewatering, treatment, and or disposal of sediment (ITRC, 2014). Mechanical dredging, hydraulic dredging, and excavation were screened independently in this evaluation.

After removal, the contaminated sediment can be treated or disposed of in a controlled setting, such as an off-site landfill or other treatment, storage, and disposal facility, an on-site aquatic or terrestrial confined disposal facility (CDF), or a facility that converts the sediment to a reusable product. Disposal methods were evaluated independently from dredging and excavation and are described further in **Section 3.1.9**.

3.1.8 Dewatering

Dewatering may be necessary to prepare dredged materials for disposal. Dewatering reduces the water content and hence the volume and weight of the disposed sediment. If the material is to be reused or further treated, dewatering also leads to reduced transportation cost and improves handling properties. The nature and extent of dewatering needed depends on the sediment characteristics and the type of dredging, transport, and disposal methods planned for the removed material (ITRC, 2014). Dewatering technologies may rely upon gravity draining and evaporation processes (e.g., spreading and geotextile bags), mechanical processes (e.g., filter presses), and chemical conditioning (e.g., polymer additions and stabilization additives). The type of dewatering technology selected for use may depend upon the amount of space available for dewatering, the distance of the dewatering space from dredging operations, discharge options for treated dredge contact water, project scope, and cost of implementing the technology.

3.1.9 Disposal

Disposal of dredged or excavated sediment is the placement of materials into a controlled site or facility to permanently contain contaminants within the sediment. Management is achieved through the placement of materials into facilities such as sanitary landfills, hazardous material landfills, CDFs, or CAD facilities. Off-site landfills are generally used for dredged material disposal when on-site disposal is not feasible or when off-site disposal is more cost effective.

Landfills have been used for sediment volumes of over 1 million cubic yards. Typically, some type of on-site or near-site disposal facility is used at sites where dredged material volumes greater than 200,000 cubic yards are generated. Landfilling is also favored at smaller or moderately sized sites, where transportation is feasible. The associated hazards and cost of transporting and landfilling large volumes of sediment make this disposal method somewhat less desirable than other solutions. Other considerations, such as public and stakeholder acceptance, lack of access to suitable on-site land- or water-based disposal facilities, and proximity to an existing off-site landfill may support the landfilling option.

CDFs are constructed to isolate dredged sediment from the surrounding environment. CDFs can be located upland, near shore, or in the water (as an island). Material staging or a temporary CDF may be necessary for dewatering dredged sediment. CDFs represent a common disposal method and typically are built for larger volume sites (200,000 cubic yards or more of sediment).

The CAD method deposits dredged material within a nearby body of water. A pre-existing depression within the sediment surface is preferred, though one can be created if necessary. Dredged sediment is deposited in the depression and capped with clean material. This process carries with it the same risks associated with using capping as a remedy. The goal of moving the contaminated sediment to the aquatic disposal site is to reduce the risk of exposure to contaminated materials (ITRC, 2014).

Disposal at landfills, CDFs, and CADs were screened independently in this evaluation.

3.1.10 Remedial Technology Screening Results

Table 2 documents the technology screening process and results. The following remedial technologies were determined to be the most effective, implementable, and cost-effective and were retained for assembling the alternatives described in **Section 3.3**:

- ICs;
- Monitoring;
- Capping;
- Mechanical Dredging;
- Gravity and Chemical Conditioning Dewatering; and
- Landfill Disposal.

3.2 Implementation Assumptions

This section describes important factors and assumptions for implementing one or more of the alternatives presented in **Section 3.3**.

3.2.1 Staging Area Identification

Implementation of alternatives involving capping and/or dredging of sediments would require identification and construction of a staging area in which to stage and conduct all construction support activities. Based on conversations between Bay West and the Duluth Seaway Port Authority, City of Duluth, and MPCA, the most likely staging area location would be Hallett Dock #7. Hallett Dock #7 is located approximately 7 miles upriver of the Site and is located within part of the Interlake/Duluth Tar (IDT) Superfund site. It is currently being considered for purchase by the Duluth Seaway Port Authority and, therefore, could serve as a staging facility for future remediation projects throughout the Duluth/Superior Harbor. Although previous remedial activities have resulted in capping of sediments between Hallett Dock #7 and lands to the west, the end of the dock is nearly 500 feet in width and could potentially be used as a mooring location for sediment/cap material transport barges operating between Hallett Dock #7 and remediation sites (Sharrow, 2016).

Hallett Dock #7 is not currently used for barge mooring, berthing, or as a staging area, but has served similar purposes in the past. The facilities are currently in fair to poor condition and may require repairs before use. Inspection of the dock walls and their suitability for use should be conducted prior to the design phase. For the purposes of this FFS, the dock end wall was assumed to be in acceptable condition for mooring barges and the dock suitable for use as a staging area for all alternatives. Satellite imagery indicates the presence of a large paved area at the end of Hallett Dock #7, which is appropriately sized for stockpiling materials and stabilizing dredged sediments.

3.3 Development of Alternatives

This section describes the alternatives developed for the Site. The alternatives were developed using the selected remedial technologies discussed in **Section 3.1**, the 2014 sampling data summarized in the Sediment RI Report, and the CSM. Sediment sample data from the Sediment RI Report was used to estimate the depth and spatial extent of the remedial areas for the primary COC as presented in **Figure 5**. A summary of the proposed alternatives is presented in **Table 3**. Calculations used to determine volumes, rates, and time frames related to remedy construction are presented in Table 1 in **Appendix B**. Assumptions made to compile cost estimates were incorporated into a Technical Analysis and are included in **Appendix B**.

The total present value costs for alternatives presented within this FFS should be considered to be rough order of magnitude (ROM) costs. Based on the Association for the Advancement of Cost Engineering ROM classification chart, estimates presented in this FFS are considered Class 4. Class 4 estimates are considered Schematic Designs; 15 to 20% of the level of effort required to have a complete estimate has been done. Actual cost of the project could be 50% greater or 30% less (+50/-30) than the estimates developed thus far. ROM cost estimates for the FSS were compiled using a variety of sources. These sources include construction cost data from RSMeans estimating software for open shop pricing in Duluth, Minnesota; current Bay West and state contract rates for labor, equipment, and sample analysis; personal communication with vendors; historic cost data from projects similar in size and scope; other FFS documents, presentations, or technical papers that provided estimated or real construction cost data; and available online vendor pricing of materials. Present value calculations are included in Table 5 in **Appendix B**.

3.3.1 Alternative 1: No Action

The NCP at 40 CFR provides that a No Action alternative should be considered at every site. A No Action alternative should reflect the site conditions described in the baseline risk assessment and RI. A No Action alternative does not typically include any treatment, engineering controls, or ICs but may include monitoring (USEPA, 2005). A No Action alternative applied to the Site would not meet criteria for protection of human health and the environment. The No Action alternative included within this FFS does not include any treatment or engineering controls, ICs, or monitoring. There are no costs associated with the No Action alternative.

3.3.2 Alternative 2: Monitoring and Institutional Controls

This alternative would consist of monitoring Site conditions over an extended period of time to evaluate trends in sediment chemical concentrations, sediment toxicity, and COC bioaccumulation within aquatic organisms (i.e., benthic organisms). A 30-year time frame was evaluated for the purposes of this FFS to remain consistent with the monitoring and evaluation time frames associated with other alternatives. ICs appropriate for maintaining protectiveness, when applicable, of human and environmental health would continue to be implemented for an indefinite period of time and until sufficient contaminant degradation, transformation, isolation, or other natural recovery processes reduce Site-related risks or should an alternative remedy be implemented.

No construction activities to remove, cap, or treat contaminated sediments would be conducted as part of the Monitoring and Institutional Controls Alternative and no new ICs would be implemented, as none have been identified that would be protective of the identified ecological exposure pathway. This alternative does not provide any immediate improvement to protectiveness but is included as a possible placeholder to be used as an interim response. An interim response may be required should funding sources be unavailable until a later date or be distributed based on site prioritization. The major components of Alternative 2 are described in the following sections.

3.3.2.1 Long-Term Monitoring

LTM would include collection of Site data to determine trends in sediment chemical concentrations, sediment toxicity, and bioaccumulation of Site COCs in benthic organisms. Fish tissue would likely not be included in the LTM program due to wide habitat ranges and the infeasibility of attributing tissue concentrations of contaminants with a specific site. Monitoring activities would be conducted to track or estimate the time frame to when remedial goals would be met and to ensure that contamination is not increasing or migrating to an extent to increase risks to human health (through fish consumption) or the environment.

Data collection would be conducted periodically for an indefinite period of time or until remedial goals are achieved. For the purposes of this FFS, it was assumed that data collection would occur once every 5 years, starting at year zero, for a period of 30 years, totaling seven events. If no remedial or developmental activity has taken place to reduce or isolate sediment contamination after 30 years then monitoring will likely continue.

Data collection will consist of the following:

- Collection of sediment chemical data for COCs;
- Collection of sediments and toxicity testing on benthic macroinvertebrates;
- Collection of sediments and bioaccumulation testing on benthic macroinvertebrates; and
- Bathymetric surveys.

Potential monitoring locations are presented in **Figure 7**.

3.3.2.2 Institutional Controls

No relevant or applicable ICs have been identified that would provide protection for the benthic community for this alternative.

3.3.2.3 Cost

Calculations used to determine unit rate costs for each of the alternatives are presented in Table 2 in **Appendix B**. Other project costs determined on a lump sum basis are presented in Table 3 in **Appendix B**. The monitoring and evaluation program and associated costs developed for each alternative are presented in Table 4 in **Appendix B**. The costs associated with each alternative are presented as Class 4 (+50/-30) estimates and are appropriate for remedial design alternative evaluations only.

The estimated total present value cost for Alternative 2 is $330,000. **Table 4** presents a detailed breakdown of the estimated costs associated with Alternative 2.

3.3.3 Alternative 3: Cap and Armor

The Cap and Armor alternative would consist of constructing a cap over areas of sediment with COC concentrations exceeding the CUL. Areas of the Site exceeding the CUL are presented in **Figure 5** and equal approximately 6.4 acres. The objective of capping sediments at the Site is to: limit exposure of aquatic organisms to contaminated sediments and thereby limit transfer of chemical contaminants to higher trophic organisms, and enhance the aquatic habitat in a manner that contributes to the removal of BUIs if conditions allow. The cap design should be congruent with current and/or planned use of the Site.

It should be noted that the cap would be constructed in areas of the Site currently suitable and/or used for mooring vessels (**Figure 8**); therefore, armoring will be completed across the entire cap. Current water depth within this area – the westernmost half of the Site – ranges from approximately 13 to 23 feet; thus, construction of a 0.95-meter cap (sand plus armor; 3.1 feet) would reduce the available draft by approximately 0.95 meter and result in post-construction water depths ranging from approximately 10 to 20 feet. It is assumed that implementation of this alternative is congruent with current Site use regardless of the loss in available draft.

Following cap construction, ICs would be implemented and LTM would commence. The major components of the Cap and Armor alternative are described in the following sections.

3.3.3.1 Cap Design

Cap material would consist of natural materials suitable for benthic and aquatic plant habitat yet resist migration due to physical forces occurring within the Site, such as wave action, prop wash, and ice scour. Typical capping materials include medium- to coarse-grained sands and armoring consisting of cobbles (placed over sand) in areas susceptible to erosive forces. Specific gradation requirements for cap materials would likely be incorporated into the final remedy design. See **Figure 8** for cap design.

The cap thickness should be sufficient to protect aquatic life from burrowing into contaminated sediments below and prevent against contaminated sediments mixing with cap materials due to plant or animal bioturbation. This "zone" of animal and plant activity is referred to as the potentially bioactive zone or PBAZ, as discussed in **Section 3.1.6**. In addition to the PBAZ thickness, additional sand should be placed to account for mixing of contaminated sediments and capping material during cap construction. For the purposes of this FFS, a PBAZ thickness of 0.5 meter (1.6 feet) – corresponding to a submerged aquatic vegetation "habitat zone" – was assumed, along with an additional 0.15 meter (0.5 feet) of cap to account for mixing of sediments and capping material during construction.

It was assumed for the purposes of the cost analysis that sand would be purchased from an upland borrow source. Previously dredged materials, such as those contained within the Erie Pier CDF, could also be investigated for use at the Site as capping material. Armoring would also be purchased from an upland borrow source and would be placed only in areas susceptible to prop wash. The area assumed to receive armoring is shown on **Figure 8**. A total of approximately 22,000 cubic yards of sand and 10,000 cubic yards of cobble (armoring material) would be required for cap construction.

3.3.3.2 Long-Term Monitoring

LTM would commence after remedy implementation and would include collection of Site data to: ensure that cap integrity is maintained as long as COCs remain in sediments above the CUL; ensure that ICs continue to be enforced as long as COCs remain in sediments above the CUL; and to ensure that sediment contaminants are not migrating into or through the cap.

LTM data collection would be conducted periodically for an indefinite period of time or until concentrations of COCs in sediments beneath the cap attenuate to levels below the CULs and are deemed protective of human health (through fish consumption) and the environment. For the purposes of this FFS, it was assumed that data collection would occur once every 5 years for a period of 30 years. The first monitoring event will take place 5 years from remedy completion. It is assumed that a pre-design investigation will take place prior to remedy design and will serve as baseline data for comparison to future monitoring and evaluation events. Pre-design costs were not included in the cost analysis. If attenuation of COC concentrations to levels below the CULs does not occur after 30 years, then monitoring will likely continue.

Data collection will consist of the following:

- Collection of sediment samples from below the cap to be analyzed for Site COCs;
- Collection of cap samples to be analyzed for Site COCs;
- Measurements/coring of cap thicknesses to ensure continued isolation of contaminants and physical observation of cap integrity;
- Bathymetric surveys; and
- Review of IC enforcement status.

Potential monitoring locations are presented in **Figure 8**.

3.3.3.3 Institutional Controls

ICs applicable to this alternative include those that would protect future cap integrity. These include prevention of anchoring within the footprint of capped areas, prevention of future construction of docks or piers or other invasive improvements to existing dock walls, and prevention of future dredging activities within the Site.

3.3.3.4 Cost

Calculations used to determine unit rate costs for each of the alternatives are presented in Table 2 in **Appendix B**. Other project costs determined on a lump sum basis are presented in Table 3 in **Appendix B**. The monitoring and evaluation program and associated costs developed for each alternative are presented in Table 4 in **Appendix B**. The costs associated with each alternative are presented as Class 4 (+50/-30) estimates and are appropriate for remedial design alternative evaluations only.

The estimated total present value cost for Alternative 3 is $5,100,000. **Table 5** presents a breakdown of the estimated costs associated with Alternative 3.

3.3.4 Alternative 4: 1-Meter Dredge, Cap, and Armor

The 1 Meter (3.3 feet) Dredge, Cap, and Armor alternative would consist of dredging 1 meter of sediment within the area of COC concentrations exceeding the CULs. Areas of the Site exceeding the CULs are presented in **Figure 5** and equal approximately 6.4 acres. The dredged sediments would be transported by barge to a staging area, stabilized with amendment materials as needed, transported by roadway, and disposed of at an off-site landfill. Once dredging is complete the area would be capped. The objective of capping sediments at the Site is to: limit exposure of aquatic organisms to contaminated sediments and thereby limit transfer of chemical contaminants to higher trophic organisms, and enhance the aquatic habitat in a manner that contributes to the removal of BUIs if conditions allow. The purpose of including dredging in the alternative is to provide an offset to draft losses as a result of cap placement. The cap design should be congruent with current and/or planned use of the Site.

It should be noted that the cap would be constructed in areas of the Site currently suitable and/or used for mooring vessels (**Figure 9**); therefore, armoring will be completed across the entire cap. Current water depth within the area – the westernmost half of the Site – ranges from approximately 13 to 23 feet; this depth will be maintained by dredging 1 meter prior to cap placement.

Following cap construction, ICs would be implemented and LTM would commence. The major components of the 1-Meter Dredge, Cap, and Armor alternative are described in the following sections.

Consolidation and capping alternatives were not considered based on Site use and volume of contaminated sediment on-site. Sediment volumes would require a relatively large area of consolidation not available within the Site without significantly impacting draft.

3.3.4.1 Dredging Implementation

Dredging will be included in Alternative 4 to offset loss in draft as a result of cap placement. Dredging would include removal of 1 meter of sediments with COC concentrations exceeding the CUL. Areas of the Site exceeding the CUL are presented in **Figure 5** and equal approximately 6.4 acres. The total volume of in situ sediments requiring removal is estimated to be 34,000 cubic yards.

Sediments mechanically dredged from the Site are expected to have entrained and interstitial water (i.e., dredge contact water) making them unsuitable for direct and/or immediate transportation to an off-site landfill. Therefore, dredged sediments would require dewatering/stabilization in order for them to pass the paint filter test (i.e., essentially no free water) and make them suitable for transportation and disposal. One method of dewatering/stabilizing sediments would rely upon the addition of amendments (such as Portland Cement) to the dredged sediments and was incorporated into Alternative 4 cost analysis.

Dredge contact water would be generated during dredging activities from two sources: interstitial water contained within the dredged sediments and surface water enclosed within the bucket during dredging. Dredge contact water would require treatment prior to discharge. Discharge options for dredge contact water could include discharging to the WLSSD sanitary sewer or back into the SLR. The selected discharge location would determine the extent of treatment required to meet acceptance or permit requirements. Discharge location and treatment options should be investigated further during the design phase; however, for the purposes of this FFS, a system comprises solids settling/clarification, sand filtration, bag filtration, and granular activated carbon (GAC) was assumed for the cost analysis. The disposal option evaluated for Alternative 4 is off-site landfill disposal. Stabilized sediments would be periodically sampled to ensure that landfill requirements for disposal are continuously met It is assumed that sediments dredged from the Site will be classified as non-hazardous based on historic sample concentrations. Potential off-site landfills evaluated for this FFS include Vonco V Waste Management Campus located at 1100 West Gary Street in Duluth, Minnesota (approximately 12 miles west of the Site) and Shamrock Environmental Landfill located at 761 Highway 45 in Cloquet, Minnesota (approximately 20 miles west of the Site).

3.3.4.2 Cap Design

Cap material would consist of natural materials suitable for benthic and aquatic plant habitat yet resist migration due to physical forces occurring within the Site, such as wave action, prop wash, and ice scour. Typical capping materials include medium- to coarse-grained sands and armoring consisting of cobbles (placed over sand) in areas susceptible to erosive forces. Specific gradation requirements for cap materials would likely be incorporated into the final remedy design. See **Figure 9** for cap design.

The cap thickness should be sufficient to protect aquatic life from burrowing into contaminated sediments below and prevent against contaminated sediments mixing with cap materials due to plant or animal bioturbation. This “zone” of animal and plant activity is referred to as the potentially bioactive zone or PBAZ, as discussed in **Section 3.1.6**. In addition to the PBAZ thickness, additional sand should be placed to account for mixing of contaminated sediments and capping material during cap construction. For the purposes of this FFS, a PBAZ thickness of 0.5 meter (1.6 feet) – corresponding to a submerged aquatic vegetation “habitat zone” – was assumed, along with an additional 0.15 meter (0.5 feet) of cap to account for mixing of sediments and capping material during construction.

It was assumed for the purposes of the cost analysis that sand would be purchased from an upland borrow source. Previously dredged materials, such as those contained within the Erie Pier CDF, could also be investigated for use at the Site as capping material. Armoring would also be purchased from an upland borrow source and would be placed only in areas susceptible to prop wash. The area assumed to receive armoring is shown on **Figure 9**. A total of approximately 22,000 cubic yards of sand and 10,000 cubic yards of cobble (armoring material) would be required for cap construction.

3.3.4.3 Long-Term Monitoring

LTM would commence after remedy implementation and would include collection of Site data to: ensure that cap integrity is maintained as long as COCs remain in sediments above the CUL; ensure that ICs continue to be enforced as long as COCs remain in sediments above the CUL; and to ensure that sediment contaminants are not migrating into or through the cap.

LTM data collection would be conducted periodically for an indefinite period of time or until concentrations of COCs in sediments beneath the cap attenuate to levels below the CULs and are deemed protective of human health (through fish consumption) and the environment. For the purposes of this FFS, it was assumed that data collection would occur once every 5 years for a period of 30 years. The first monitoring event will take place 5 years from remedy completion. It is assumed that a pre-design investigation will take place prior to remedy design and will serve as baseline data for comparison to future monitoring and evaluation events. Pre-design costs were not included in the cost analysis. If attenuation of COC concentrations to levels below the CULs does not occur after 30 years then monitoring will likely continue.

Data collection will consist of the following:

- Collection of sediment samples from below the cap to be analyzed for Site COCs;
- Collection of cap samples to be analyzed for Site COCs;
- Bathymetric surveys and coring to determine cap thicknesses;
- A review of IC enforcement status.

Potential monitoring locations are presented in **Figure 9**.

3.3.4.4 Cost

Calculations used to determine unit rate costs for each of the alternatives are presented in Table 2 in **Appendix B**. Other project costs determined on a lump sum basis are presented in Table 3 in **Appendix B**. The monitoring and evaluation program and associated costs developed for each alternative are presented in Table 4 in **Appendix B**. The costs associated with each alternative are presented as Class 4 (+50/-30) estimates and are appropriate for remedial design alternative evaluations only.

The estimated total present value cost for Alternative 4 is approximately $11,000,000. **Table 6** present breakdowns of the estimated costs associated with Alternative 4. It should be noted that the condition of dock walls is unknown and stability concerns could occur due to dredging; therefore, stability of the dock walls should be investigated during the remedial design phase. Costs related to reconstruction of the dock walls were not incorporated into the cost analyses for Alternative 4 as the entity to which costs would be incurred cannot be identified at this time and the magnitude of reconstruction is unknown.

3.3.5 <u>Alternative 5: Dredge with Thin-Layer Cover</u>

A dredging alternative would consist of complete removal of all sediments with COC concentrations exceeding the CULs. Pre-design investigation, as previously discussed, will determine the vertical extent of contamination at sample locations BW14SC-001, 002, 005, 006, 010, 011, and 015 and additional dredging in these areas will be completed as necessary.

Removal of contaminated sediments would mitigate exposure of aquatic and human receptors (through fish consumption) to sediment contaminants and also increase draft in dredged areas of the Site, thus allowing for achievement of RAOs. The dredged sediments would be transported by barge to a staging area, stabilized with amendment materials as needed, transported by roadway, and disposed of at an off-site landfill. Following sediment removal, a 0.15 meter thin-layer sand cover would be placed to reduce surface concentration of dredge residuals through mixing of the upper sediment layer. ICs and a LTM program would not be implemented following completion of remedy construction if complete removal of contaminated sediments is achieved. Complete removal was assumed for the purposes of this FFS and, therefore, IC/LTM costs are not incorporated into the cost analysis.

The major components of this alternative are described in the following sections.

3.3.5.1 Dredging Implementation

A dredging alternative would include removal of all sediments with COC concentrations exceeding the CUL, as stated previously. Areas of the Site exceeding the CUL are presented in **Figure 5** and equal approximately 6.4 acres. Dredging would be conducted down to the maximum depth of observed sediment contamination within each area of the Site. For the purposes of this FFS, it is assumed that dredging will take place to and average depth of approximately 8.0 feet (2.4 meters) below sediment surface (bss) within areas of the Site identified as exceeding the CUL for the primary COC concentrations (**Figure 10**). The total volume of in situ sediments requiring removal is estimated to be 110,000 cubic yards. Over-dredging of sediments may be conducted to ensure that contamination is removed in a time- and energy-efficient manner and to reduce the mass of dredge residuals remaining after dredging completion. A 1 foot (0.3 meter) over-dredge is assumed which would increase the total dredge volume to 120,000 cubic yards. The approximate volume may increase based on pre-design vertical delineation results, but for the purposes of this FFS, 120,000 cubic yards will be the assumed volume of contamination.

It was assumed for the purposes of this FFS that a 0.15 meter thin-layer sand cover would be constructed over the entire remedial area following dredging completion. The cover would be constructed to reduce the concentration of dredge residuals on the sediment surface through mixing of residual sediments and clean sand and also to improve benthic habitat. Final cover specifications would be determined during the design phase.

Sediments mechanically dredged from the Site are expected to have entrained and interstitial water (i.e., dredge contact water) making them unsuitable for direct and/or immediate transportation to an off-site landfill. Therefore, dredged sediments would require dewatering/stabilization in order for them to pass the paint filter test (i.e., essentially no free water) and make them suitable for transportation and disposal. One method of dewatering/stabilizing sediments would rely upon the addition of amendments (such as Portland Cement) to the dredged sediments and was incorporated into the Dredge alternative cost analysis. Dredge contact water would be generated during dredging activities from two sources: interstitial water contained within the dredged sediments and surface water enclosed within the bucket during dredging. Dredge contact water would require treatment prior to discharge. Discharge options for dredge contact water could include discharging to the WLSSD sanitary sewer or back into the SLR. The selected discharge location would determine the extent of treatment required to meet acceptance or permit requirements. Discharge location and treatment options should be investigated further during the design phase; however, for the purposes of this FFS, a system comprises solids settling/clarification, sand filtration, bag filtration, and GAC was assumed for the cost analysis. The disposal option evaluated for the Dredge alternative is off-site landfill disposal. Stabilized sediments would be periodically sampled to ensure landfill requirements for disposal are continuously met. It is assumed that sediments dredged from the Site will be classified as non-hazardous based on historic sample concentrations. Potential off-site landfills evaluated for this FFS include Vonco V Waste Management Campus located at 1100 West Gary Street in Duluth, Minnesota (approximately 12 miles west of the Site) and Shamrock Environmental Landfill located at 761 Highway 45 in Cloquet, Minnesota (approximately 20 miles west of the Site).

3.3.5.2 Cost

Calculations used to determine unit rate costs for each of the alternatives are presented in Table 2 in **Appendix B**. Other project costs determined on a lump sum basis are presented in Table 3 in **Appendix B**. The costs associated with each alternative are presented as Class 4 (+50/-30) estimates and are appropriate for remedial design alternative evaluations only.

The estimated total present value cost for Alternative 5 is $19,000,000. **Table 7** presents a breakdown of the estimated costs associated with Alternative 5. As stated previously, dredging may impact dock wall stability and reconstruction may be necessary. Costs related to reconstruction were not incorporated into the cost analysis for the Alternative 5 as the entity to which costs would be incurred cannot be identified at this time and the magnitude of reconstruction is unknown.

4.0 REMEDY SELECTION CRITERIA

The alternatives were evaluated and compared using the NCP remedy selection criteria outlined below and in general accordance with USEPA guidelines for feasibility studies (USEPA, 1990). The NCP remedy selection criteria are divided into three groups based on the function of the criteria in remedy selection. The NCP definitions of each criterion are included below. Green Sustainable Remediation (GSR) criteria were also evaluated during this FFS and are included as a fourth group of criteria. Additional detail may be added from MPCA and/or USEPA guidance where appropriate.

4.1 Threshold Criteria

The Threshold Criteria relate to statutory requirements that each alternative must satisfy in order to be eligible for selection and include the following.

4.1.1 Overall Protection of Human Health and the Environment

Alternatives shall be assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the Site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals. Overall protection of human health and the environment draws on the assessment of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

4.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The alternatives shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility citing laws or provide grounds for invoking a waiver.

4.2 Primary Balancing Criteria

The Primary Balancing Criteria are the technical criteria upon which the detailed analysis is primarily based and include the following.

4.2.1 Long-Term Effectiveness and Permanence

Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, as appropriate, include the following:

1. Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities: The characteristics of the residual should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

2. Adequacy and reliability of controls, such as containment systems and ICs, that are necessary to manage treatment residuals and untreated waste: This factor addresses, in particular, the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posted should the remedial action need replacement.

4.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the Site. Factors that shall be considered, as appropriate, include the following:

1. The treatment or recycling processes the alternatives employ and materials they will treat;
2. The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated or recycled;
3. The degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling and the specification of which reductions(s) are occurring;
4. The degree to which the treatment is irreversible;
5. The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and
6. The degree to which treatment reduces the inherent hazards posed by principal threats at the slip.

4.2.3 Short-Term Effectiveness

The short-term impacts of alternatives shall be assessed considering the following:

1. Short-term risks that might be posed to the community during implementation of an alternative;
2. Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;
3. Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigating measures during implementation; and
4. Time until protection is achieved.

4.2.4 Implementability

The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

1. Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy;
2. Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions); and
3. Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and the availability of prospective technologies.

4.2.5 Costs

The types of costs that shall be assessed include the following:

1. Capital costs, including both direct and indirect costs;
2. Annual O&M costs; and
3. Net present value of capital and O&M costs.

The USEPA guidance document "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (USEPA, 2000) was used to develop cost estimates presented in this FFS. The cost estimates developed for this FFS are primarily for the purpose of comparing remedial alternatives during the remedy selection process, not for establishing project budgets.

4.3 Modifying Criteria

The third group is made up of the Modifying Criteria specified below. These last two criteria are assessed formally after the public comment period, although to the extent that they are known will be factored into the identification of the preferred alternative.

4.3.1 State/Support Agency Acceptance

Assessment of state/agency concerns may not be completed until comments on this FFS are received, but may be discussed, to the extent possible, in the proposed plan issued for public comment. The state/agency concerns that shall be assessed include the following:

1. The state's/agency's position and key concerns related to the preferred alternative and other alternatives; and
2. State/agency comments on ARARs or the proposed use of waivers.

4.3.2 Community Acceptance

This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until comments on the proposed plan are received.

4.4 Green Sustainable Remediation

The last group is made up of the GSR criteria specified below. There are six criteria included with this analysis, which are then summarized to provide each alternative with an overall GSR rating. The six GSR criteria evaluated with this FFS include the following:

- Greenhouse Gas (GHG) Emissions;
- Toxic Chemical Usage and Disposal;
- Energy Consumption;
- Use of Alternative Fuels;
- Water Consumption; and
- Waste Generation.

5.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The purpose of the comparative analysis is to identify and compare advantages and disadvantages of each evaluated alternative relative to one another with respect to remedy selection criteria presented in **Section 4.0** in order to determine which of the alternatives best meets those criteria. The comparative analysis is documented in this section and summarized in **Table 8**. **Table 10** presents a numerical comparison of the evaluated alternatives.

5.1 Threshold Criteria

5.1.1 Overall Protection of Human Health and the Environment

Only those alternatives that would meet the threshold criteria of providing overall protection of human health and the environment were carried forward with the comparative analysis. Alternatives 1 and 2 are not protective of human health or the environment, but were carried forward. Alternative 1 is required for analysis under the NCP. Should anticipated future Site use change, Alternative 2 may provide an interim alternative in which monitoring is completed while future use and a suitable alternative are determined. Alternative 3, 4, and 5 would adequately protect human health and the environment from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the Site. Alternatives 3 through 5 would eliminate, reduce, or control exposure to contaminated sediment; however, contaminated sediment would remain in-place under Alternatives 3 and 4 requiring monitoring to ensure long-term effectiveness. Alternative 5 would provide the highest level of protection, since contaminated sediments would be removed from the aquatic environment.

5.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

As previously described, Alternatives 1 and 2 do not meet the threshold criteria, but were carried forward. Alternatives 3 through 5 comply with the identified ARARs.

5.2 Balancing Criteria

5.2.1 Long-Term Effectiveness and Permanence

Alternatives 1 and 2 are not effective in the long-term or permanent. Alternatives 3 and 4 are effective in the long-term. However, contaminated sediment would remain in place under Alternatives 3 and 4, requiring long-term O&M and ICs to ensure long-term effectiveness, therefore, they are not as permanent. Disposal of sediment at an off-site landfill would be equally effective in the long-term. Since all contaminated sediments would be removed, Alternative 5 would provide the most permanence, even though contaminants would not be permanently destroyed.

In summary, Alternative 5 will provide a high achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the CULs. Alternatives 3 and 4 will provide a moderate to high achievement of this criterion. Alternatives 3 and 4 isolate contaminated sediments through capping, more over Alternative 4 removes approximately 1 meter of contaminated sediment in the aquatic environment above the CUL. Alternatives 1 and 2 provide no achievement of these criteria. No physical barriers or contaminated sediment removal occur in these alternatives.

5.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

Treatment of contaminants sediments to reduce toxicity, mobility, or volume is not a major component of any of the evaluated alternatives. However, with Alternatives 4 and 5, the addition of a solidification agent to dredged sediment is proposed as a means to bind excess free water. Addition of the solidification agent would indirectly reduce the toxicity and mobility of sediment disposed of at an off-site landfill. The amount of dredged sediment to be removed from the environment and stabilized is included in **Table 3**. Therefore, removal of contaminants from the aquatic environment and treatment of the sediments would provide a reduction in toxicity and mobility of contaminants. Removal and treatment of the contaminants would be considered permanent.

Alternatives 1 through 3 would not provide a reduction in the toxicity, mobility, or volume through treatment. Alternative 4 removes a portion (1 meter) of contaminated sediment. In addition, for Alternatives 3 and 4 the contaminated sediment would be capped in-place, reducing the mobility of the sediment.

In summary, Alternative 5 will provide the highest achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the CULs. Alternative 4 would be the next highest with partial removal of contaminated sediment. Some contaminated sediment would remain in place underneath a 0.95-meter cap. Alternative 3 will provide a moderate achievement of this criterion, since contaminated sediment would remain in the aquatic environment underneath a 0.95-meter cap. Alternatives 1 and 2 provide no achievement of this criterion as no reduction in mobility is provided.

5.2.3 Short-Term Effectiveness

Short-term effectiveness associated with Alternatives 1 and 2 are moderate. No adverse impacts due to remediation activities would occur but risks from contaminated sediments are not addressed in either Alternative. The rest of the alternatives would have some short-term risks during implementation of the remedy. Alternatives 3, 4, and 5 require varying amounts of dredging and/or capping that may impact short-term effectiveness. The potential short-term risks increase as the volume of contaminated sediment to be dredged increases due to additional coordination and due to the uncertainty of the slip wall stability. The potential short-term risks to the community and workers with Alternatives 3, 4, and 5 are associated with increase boat/barge traffic, safety, noise, and related impacts due to working in the Duluth Harbor and other publicly accessible locations. For Alternatives 4 and 5 there are also potential short term risks to workers from dust created from stabilization agents that are stockpiled and mixed. Truck transportation of dredged sediments to an off-site landfill would also have an increase in the short-term risks to the community and workers.

Short-term adverse effects to aquatic habitat and biota would be similar among Alternatives 3, 4, and 5, and would include displacement of fish and smothering of benthic organisms; however, Alternative 3 would likely present less adverse effects since no dredging will take place only capping. Benthic organisms would be expected to be re-established for all alternatives within several growing seasons.

Short-term adverse effects to surface water may also occur during dredging and capping/habitat restoration activities. Surface water control structures have shown that they are reliable in minimizing these short-term adverse effects.

Short-term risks with dock wall stability during dredging operations for Alternatives 4 and 5 are also a concern and increase significantly with the total dredging option.

Table 3 presents the estimated time for construction completion at the Site. The time frame estimates do not include additional construction time that would be required at the staging area including: construction of a gravel staging pad, stabilization, and off-site transportation to a landfill (Alternatives 4 and 5).

Overall, Alternative 3 will have the highest achievement of the short-term effectiveness criterion followed by Alternatives 1 and 2. Alternatives 4 and 5 will have low achievement of this short-term effectiveness criterion due to an increase in short-term risks from construction truck traffic to an off-site landfill.

5.2.4 Implementability

There are no implementability concerns with Alternative 1. There are minimal implementability concerns with Alternative 2. Dredging, capping, restoration, surface water control structures, as well as monitoring and O&M that would be required under Alternatives 3, 4, and 5 are all technically feasible and implementable from an engineering perspective. These technologies have been implemented successfully at other sediment sites and could be readily implemented at the slip. Services and materials are available for implementing each component of the remedy.

Dredging contaminated sediment with significant debris may pose additional but not insurmountable difficulties (Alternatives 4 and 5). Vertical extent of contamination is unknown at this time; extent of contamination may increase the difficulty to implement (Alternative 5). Vertical extent of contamination should be defined prior to implementation of an alternative. In addition, there are concerns with the stability of the dock walls during dredging activities (Alternatives 4 and 5). Dock wall inspection should be conducted prior to implementing an alternative; this cost estimate is not included for Alternatives 4 and 5. There would be a higher risk to the stability of the dock walls under a total removal scenario (Alternative 5). Therefore, the total removal scenarios would likely provide the lowest achievement of the implementability criterion.

Weather could significantly impact productivity, particularly if done in the early spring or late fall. High winds in the late fall produce large waves that could impact productivity. Barge traffic would be postponed in the spring until ice breaking in the harbor is completed. Winter or freezing conditions in the fall could also impact productivity. Alternative 5 has the longest estimated time to complete and, therefore, would be the most impacted by weather.

Monitoring can be completed to evaluate the effectiveness of the remedy. Monitoring the effectiveness of the remedy could be more challenging, as dredging will be conducted under water; however, specialized equipment is available. Dock wall inspection, equipment staging and surface water controls would also be necessary to accommodate Alternatives 3, 4, and 5.

Implementability also includes administrative feasibility of the remedy. As with most sediment remediation activities, multiple state and federal agencies and other stakeholders input is required, providing a lower achievement of administrative feasibility of implementing a remedy. Additional time will be required to obtain any necessary approvals and permits from other agencies. Both Alternatives 4 and 5 will require more coordination with other regulatory agencies than Alternative 3, as no off-site disposal will be required. Permits for capping, however, would be required for Alternatives 3 and 4.

In summary, Alternative 1 has no actions to be implemented, so will provide the greatest achievement of the implementability criterion. Alternative 2 has minimal actions implemented so will be the second most implementable. Alternative 3 is third easiest to implement since it requires no dredging. Alternative 4 will provide a moderate achievement of the implementability criterion, as less dredging and shorter schedule are anticipated. In contrast, Alternative 5 will provide the lowest achievement of the implementability criterion because of the quantity of dredging and the longer schedule.

5.2.5 Cost

Cost estimates developed for each alternative are included in **Section 3.0** and summarized in **Table 3**. The cost estimates include the following: capital costs, including both direct and indirect costs; annual O&M costs; and net present value of capital and O&M costs. **Tables 4** through **7** provide the detailed breakdown of cost estimates.

Several factors that could greatly affect cost could not be reasonably estimated during this FFS and are not included in the estimated costs. These factors, which should be evaluated during final design, include:

- Dock Wall Repair: The risks of damage to and stability of dock walls described within this report increases as dredging volume increases. The vertical area of dock wall to be exposed during dredging for Alternative 5 is significantly larger compared to Alternative 4. The costs for repair of significant damage to larger areas of dock wall could be significant. Additional measures to ensure dock wall stability during construction should be considered during the design phase. These measures, however, could add both time and cost to the remedial actions.
- Sediment traps or other means of limiting incoming sediment to maintain appropriate water depth may be required; this need will be further evaluated in the design phase of this project. If sediment traps are implemented, long-term maintenance of these traps such as sediment removal will be required. Costs for installation and/or maintaining these sediment traps are not included.
- While this FFS assumes that Former Hallet Dock #7 will be used as a staging area for Alternatives 4 and 5, costs associated with preparing Former Hallet Dock #7 for staging use and renting it are not included in this estimate and could significantly impact the final cost.
- Additional costs for habitat enhancement materials are dependent on final design and are not included.

In summary, Alternative 1 provides the most cost effective option, followed by Alternatives 2, 3, 4, and 5, respectively. Alternative 3 provides the most cost effective option that includes addressing contaminated sediments at the Site. Alternative 5 will provide the lowest achievement of the cost criterion. **Table 10** presents a numerical score that compares the cost for all alternatives.

5.3 Modifying Criteria

The modifying criteria, State/support agency acceptance and community acceptance are assessed formally after the public comment period, and to the extent that they are known will be factored into the identification of the preferred alternative.

5.3.1 State Support/Agency Acceptance

State/agency input will be assessed to assist in determining the appropriate alternative for the Site. Key factors that will influence alternative selection include but are not limited to knowledge of future Site use, maintaining draft at the Site, Site remediation prioritization, and funding source availability. Alternatives 1 through 5 will be formally assessed after public comment period.

5.3.2 Community Acceptance

The Site is currently utilized as an industrial slip. The area immediately surrounding the Site is highly industrialized, as it has been for over a century. Current slip tenants include a paper/pulp manufacturing company and a mineral production company on the northern side of the slip and a timber company along the southern side (Bay West, 2015).

Any remediation work completed at the Site will need to be coordinated with slip tenants to minimize impacts to tenant activities during remediation. As shown in **Table 3**, the total estimated time needed for on-site construction is 14 weeks for Alternative 3, 21 weeks for Alternative 4, and 30 weeks for Alternative 5. Based on the estimated time needed for on-site construction, it is likely that Alternatives 3 through 5 will impact Site industrial use. Coordination with slip tenants will be critical to ensure minimal disruption to tenants and to ensure that work is completed over one season during early spring to late fall prior to winter freeze.

Alternatives 3, 4, and 5 will be heavily influenced by slip tenant comment. As shown in **Table 10**, the numerical difference between the three alternatives is minimal. Tenant input will have the potential to strongly shift the numerical total for each of these alternative more clearly identifying a preferred alternative. Slip tenants may require specific draft at the Site to accommodate shipping barges and boating vessels as part of their Industrial activity. Alternative 3 decrease draft, Alternative 4 maintains current draft, and Alternative 5 will increase draft at the Site. Additionally, Alternatives 4 and 5 involve dredging, which, as previously described, may impact dock wall stability and substantially impact costs.

5.4 Green Sustainable Remediation Criteria

GSR criteria presented in **Table 9** and discussed below were not included in the numerical alternative comparisons presented in **Table 10**.

5.4.1 Greenhouse Gas Emissions

Alternative 1 would not produce GHG emissions. GHG emissions production from Alternative 2 would be limited to equipment mobilized for periodic sampling. Alternatives 3, 4, and 5 would result in GHG emissions from the mobilization, operation, and demobilization of all fuel-powered construction equipment required to dredge and/or install the cap/cover. Alternatives 4 and 5 would also produce emissions during transport by water to the handling area and during transport by land to the disposal facility; however, Alternative 4 would produce less GHG emissions than Alternative 5 because the amount of dredging is considerably less with Alternative 4. Reduction of emissions can be accomplished by using equipment that is compliant with the latest USEPA non-road engine standards and retrofitting older equipment with appropriate filters.

5.4.2 Toxic Chemical Usage and Disposal

Portland cement is the stabilization agent used for Alternatives 4 and 5. There are no other toxic chemical usage and disposal considerations associated with these alternatives.

5.4.3 Energy Consumption

Alternative 1 would not consume fossil fuels. Alternative 2 would consume minimal fossil fuels for periodic sampling events. Alternative 3 would result in the consumption of fossil fuels for the mobilization, operation, and demobilization of all diesel-powered construction equipment associated with the installation of the cap material, considerably less than Alternatives 4 and 5. Alternatives 4 and 5 would result in the consumption of fossil fuels for the mobilization, operation, and demobilization of all diesel-powered construction equipment associated with the dredging, hauling, and disposal of the contaminated sediment and the installation of the cap/cover material. Because the amount of sediment removed in Alternative 4 is considerably less than in Alternative 5, the energy consumption for sediment dredging and hauling would be less than Alternative 5.

5.4.4 Use of Alternative Fuels

Alternative 1 would not require the use of alternative fuels. Biodiesel blended fuels (B10 or B20) could be used as a supplemental fuel source for all diesel powered construction equipment associated with Alternatives 2 through 5.

5.4.5 Water Consumption

Alternative 1 would not require the consumption of water. There are few water consumption considerations associated with Alternatives 2 through 5. Alternative 2 would consume the least amount of water required to decontaminate personnel and sampling equipment. A minimal quantity of water would be required to decontaminate personnel and equipment during sediment dredging and/or capping activities with Alternatives 3 through 5. Water treatment associated with dredging is not considered water consumption.

5.4.6 Waste Generation

Alternatives 1 and 3 would not generate waste. Alternatives 4 and 5 would generate waste that includes the dredged contaminated sediments. Alternative 5 would generate significantly more waste than Alternative 4 because all the contaminated sediment would be removed from the Site and disposed of.

5.5 Comparative Analysis Summary

The comparative analysis of alternatives narrative discussion and quantitation table did not clearly identify a superior alternative to address the contamination at the Site. Alternatives 3, 4, and 5 were all protective of human health and the environment. No significant difference in the balancing criteria score was found between these alternatives other than cost. Alternative 1 was not protective and will not be selected nor will it be considered further. Alternative 2 is not protective although provides an interim alternative with continued monitoring. Should future Site use change, Alternative 2 could be implemented until future Site use is determined and an appropriate Alternative can be implemented. At this time it is understood that future Site use will remain the same.

The modifying criteria, State/support agency acceptance, and community acceptance are assessed formally after the public comment period. Stakeholder and community input will provide valuable insight as the MPCA considers information for the selection of a preferred alternative. The MPCA will conduct outreach activities to resource managers, current slip users, the public and local units of government prior to the public comment period. Current slip user input could heavily sway which alternative is chosen if slip boat and large vessel traffic is determined to have specific draft requirements.

Further studies are recommended during the design phase of the preferred alternative. These recommended studies, depending on the alternative selected include:

- Hydrodynamic study to understand the depositional and scouring forces in the Site to inform design and placement of armoring.
- Stormwater sewer evaluation, including an evaluation of sediment input and potential sediment capture systems, to evaluate the need to limit sediments entering the Site.
- Additional surface sampling to understand if incoming stormwater deposition is contaminated, thus a continuing source of contamination.
- Investigate vertical extent of contaminated sediment if needed to support the dredging alternative;
- Pore water transport and attenuation modeling for engineered cap design; and
- Future and current use of the slip study and required water depths.

6.0 REFERENCES

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Figures

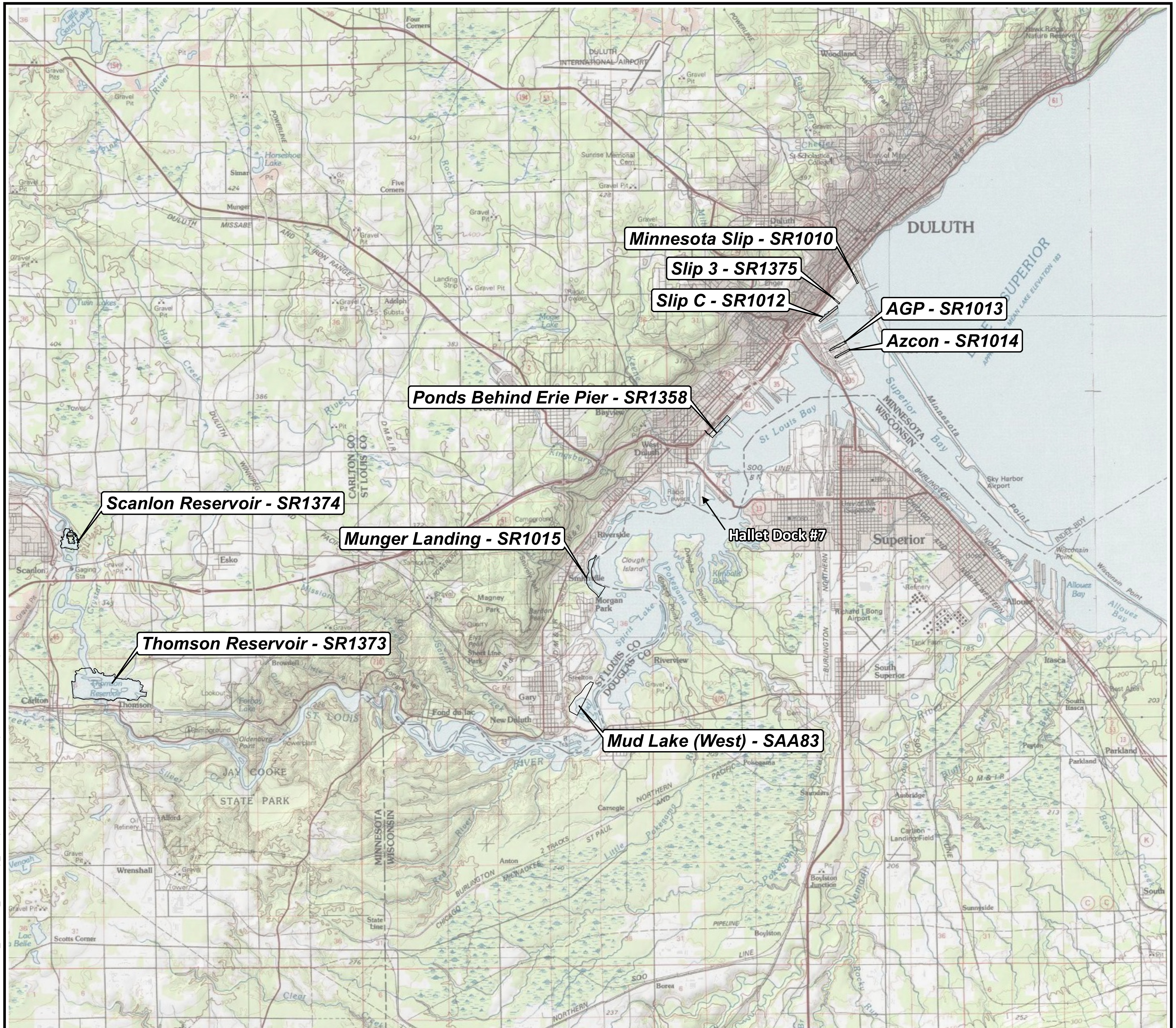
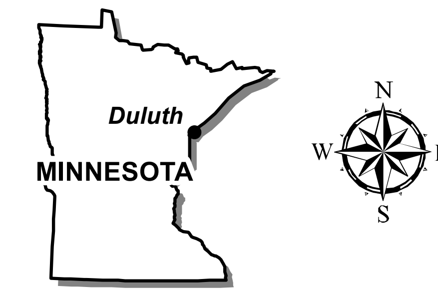


Figure 1

Site Location Map

Slip C
SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemap: National Geographic Society, i-cubed

0 2 4 Miles
0 3 6 Kilometers

1 inch = 10,000 feet

Site Location (Labeled on map)

CLEAN WATER LAND & LEGACY AMENDMENT

Bay West
Customer-Focused Environmental & Industrial Solutions

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Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 1 Slip C Site Location Map.mxd

Figure 2

Site Map

Slip C
SLR Sediment AOCs

Duluth, MN

Duluth
MINNESOTA

N E S W

Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet

0 50 100 Meters

1 inch = 200 feet

- Sediment Sample (Bay West 2014)
- Historical Sediment Sample (2010/2014)
- Original Historical Sample Location *
- Sewer Outfall
- Bathymetry Elevation Contour Line
- SS Sanitary Sewer
- ST Storm Sewer
- Slip C Site Boundary
- Parcel Boundary (With Property Owners)

NOTE: * - Location accuracy of historical samples SLC11, SLC12, and SLC13 noted as low; therefore, locations were adjusted to reflect likely area of collection

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Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 2 Slip C Site Map.mxd

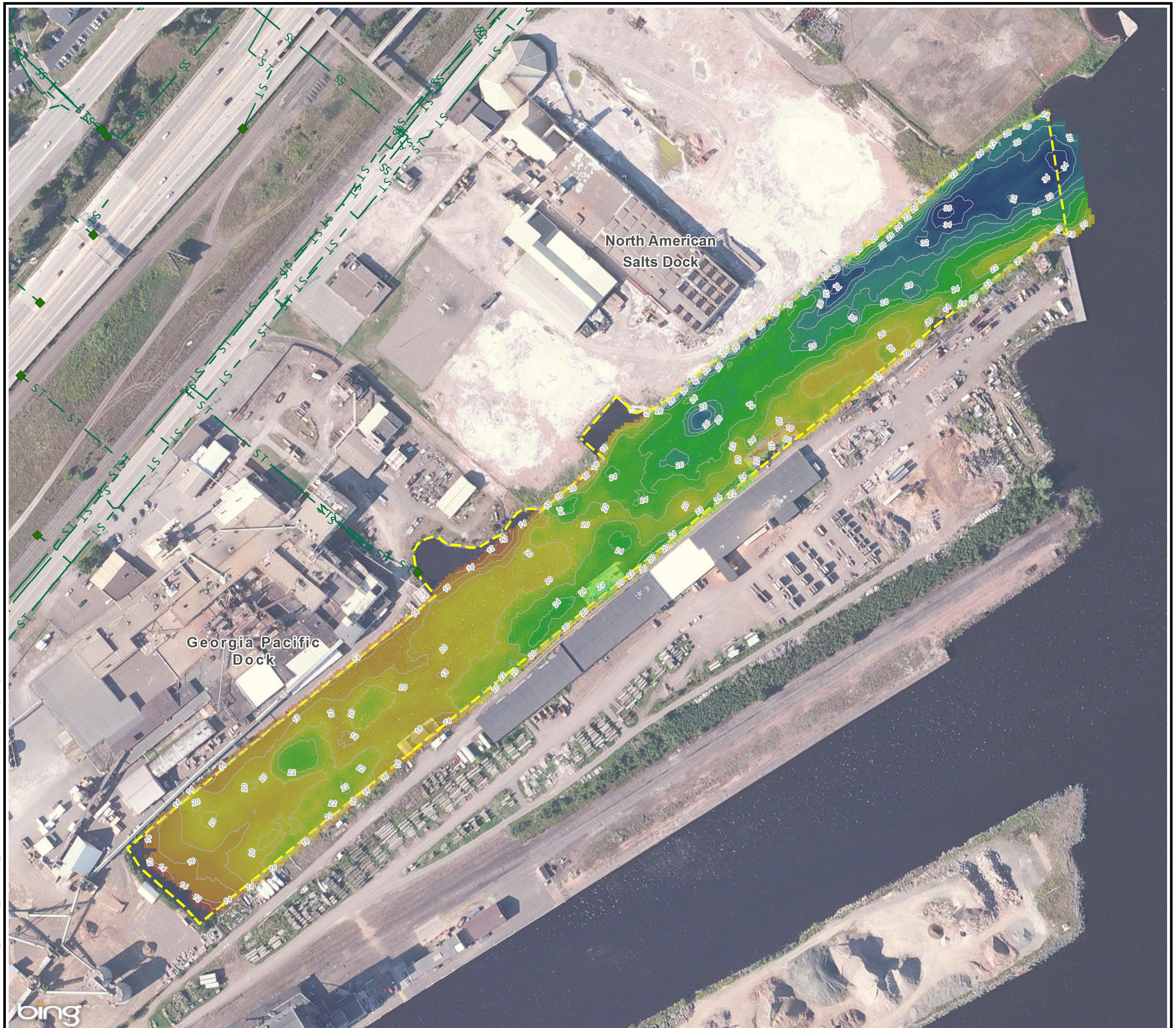

Figure 3

Bathymetry

Slip C
SLR Sediment AOCs

Duluth, MN

Duluth
MINNESOTA

N
W E
S

Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet

0 50 100 Meters

1 inch = 200 feet

- Sewer Outfall
- Bathymetry Elevation Contour Line
- SS Sanitary Sewer
- ST Storm Sewer
- Slip C Site Boundary

Water Depth

ELEVATION ABOVE MSL	DEPTH BELOW CHART DATUM
591 ft	10 ft
578 ft	23 ft
565 ft	36 ft

(Based on June 2014 Bathymetric Survey)

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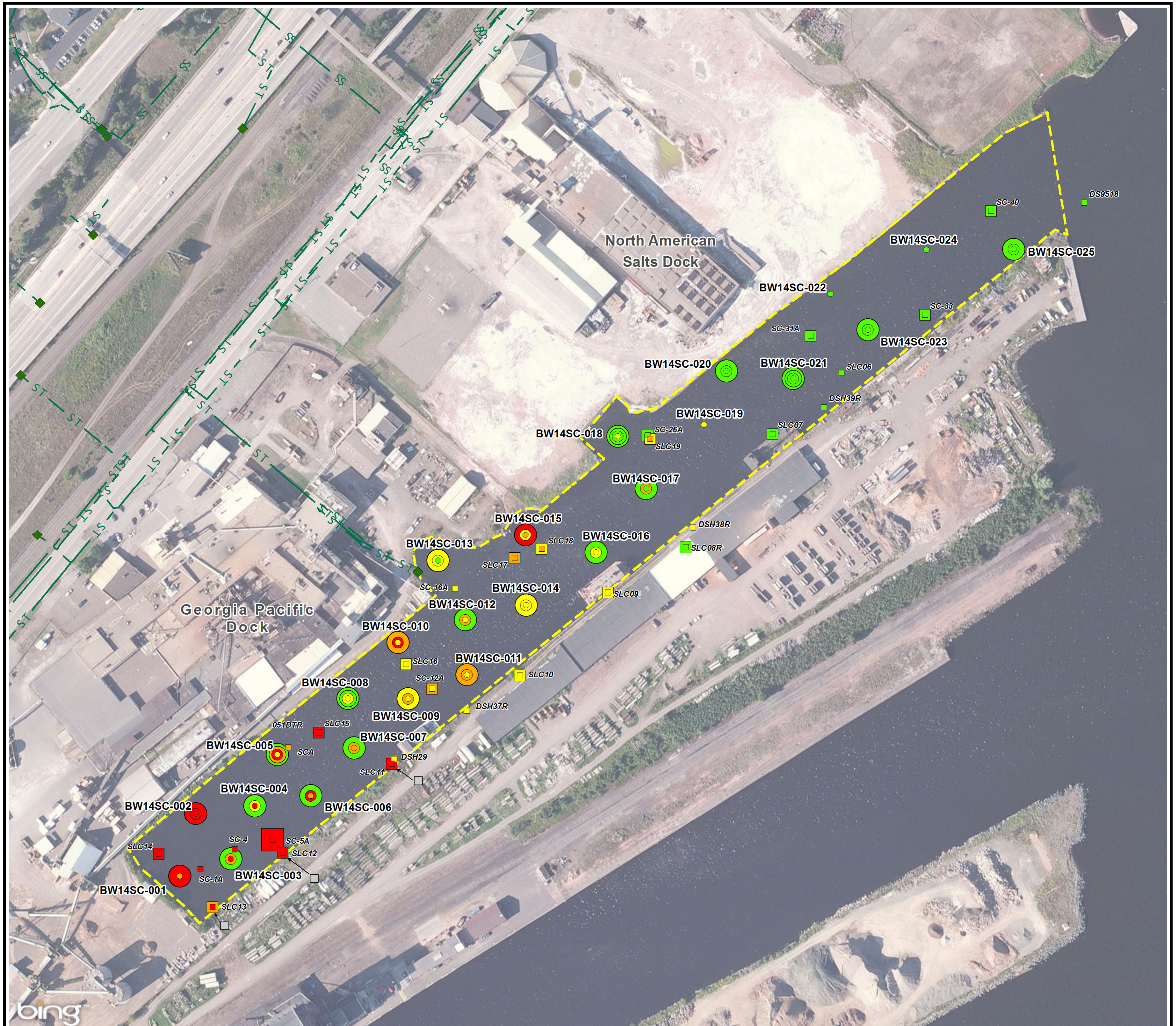
Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 3 Slip C Bathymetry.mxd



Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 4 Slip C Lead SQT Results.mxd

Figure 4

Lead SQT Results

Slip C
SLR Sediment AOCs

Duluth, MN

Duluth
MINNESOTA

N E S W

Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet
0 60 120 Meters
1 inch = 200 feet

Sewer Outfall
Original Historical Sample Location *
Sanitary Sewer
Storm Sewer
Slip C Site Boundary

Sample Type

Sediment Sample (Bay West 2014)
Sediment Sample (Historical)

Sample Interval

0-0.15 m
0.15-0.50 m
0.50-1.0 m
>1.0 m

Lead SQT Comparison

Does not exceed Level 1 SQT (36 mg/kg)
Exceeds Level 1 SQT (36 mg/kg)
Exceeds Midpoint SQT (83 mg/kg)
Exceeds Level 2 SQT (130 mg/kg)

NOTE: * - Location accuracy of historical samples SLC11, SLC12, and SLC13 noted as low; therefore, locations were adjusted to reflect likely area of collection

Bay West
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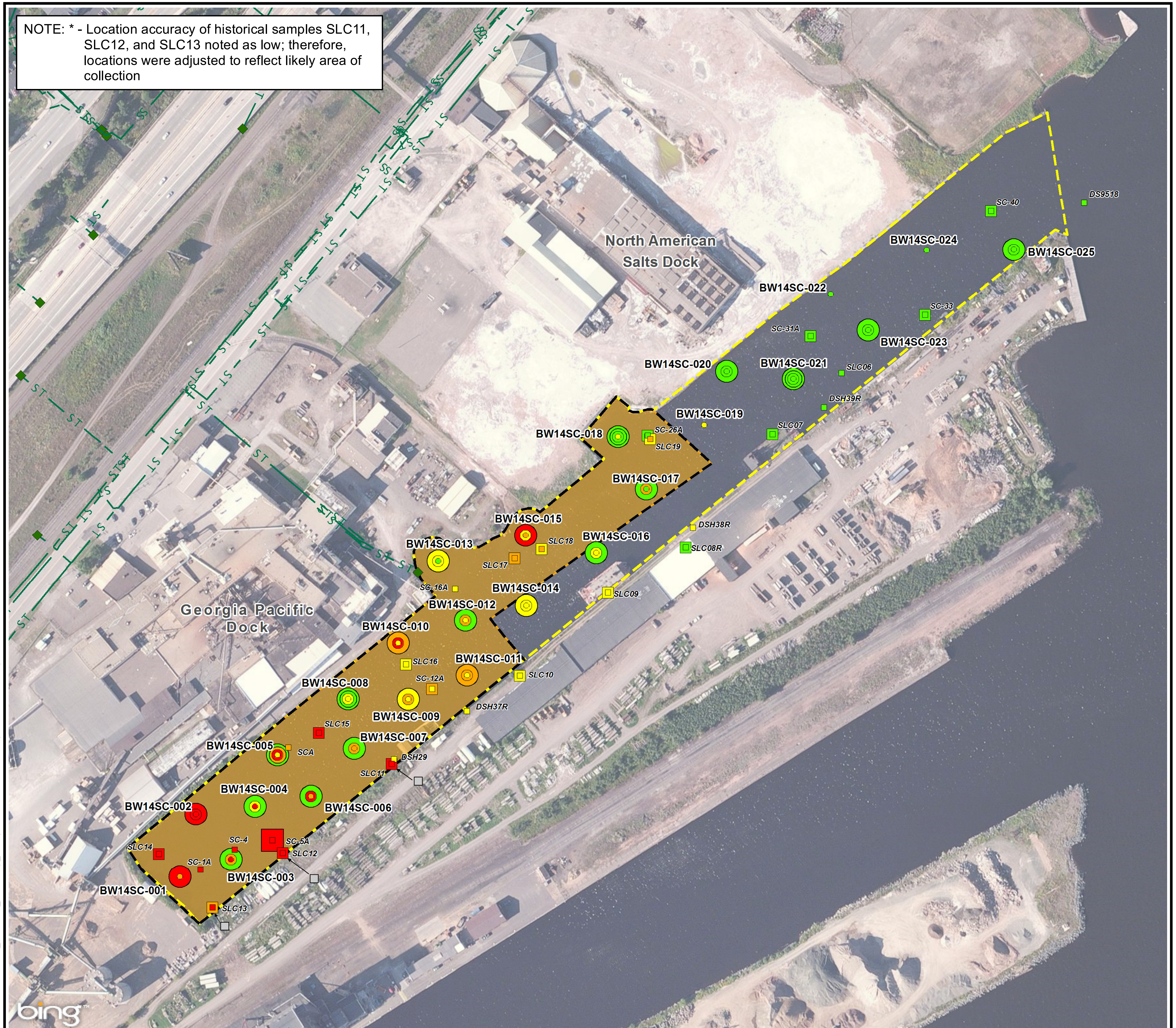

Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 5 Slip C Remedial Footprint.mxd

Figure 5

Remedial Footprint

Slip C
SLR Sediment AOCs

Duluth, MN

N W E S

Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet
0 60 120 Meters

1 inch = 200 feet

- Original Historical Sample Location *
- Sewer Outfall
- SS Sanitary Sewer
- ST Storm Sewer
- Slip C Site Boundary
- Remedial Footprint (6.40 Acres)

Sample Type

- Sediment Sample (Bay West 2014)
- Sediment Sample (Historical)

Sample Interval

- 0-0.15 m
- 0.15-0.50 m
- 0.50-1.0 m
- >1.0 m

Lead SQT Comparison

- Does not exceed Level 1 SQT (36 mg/kg)
- Exceeds Level 1 SQT (36 mg/kg)
- Exceeds Midpoint SQT (83 mg/kg)
- Exceeds Level 2 SQT (130 mg/kg)

Lead SQT Exceedance Areas

- Estimated Area Exceeding Midpoint SQT (6.40 Acres)

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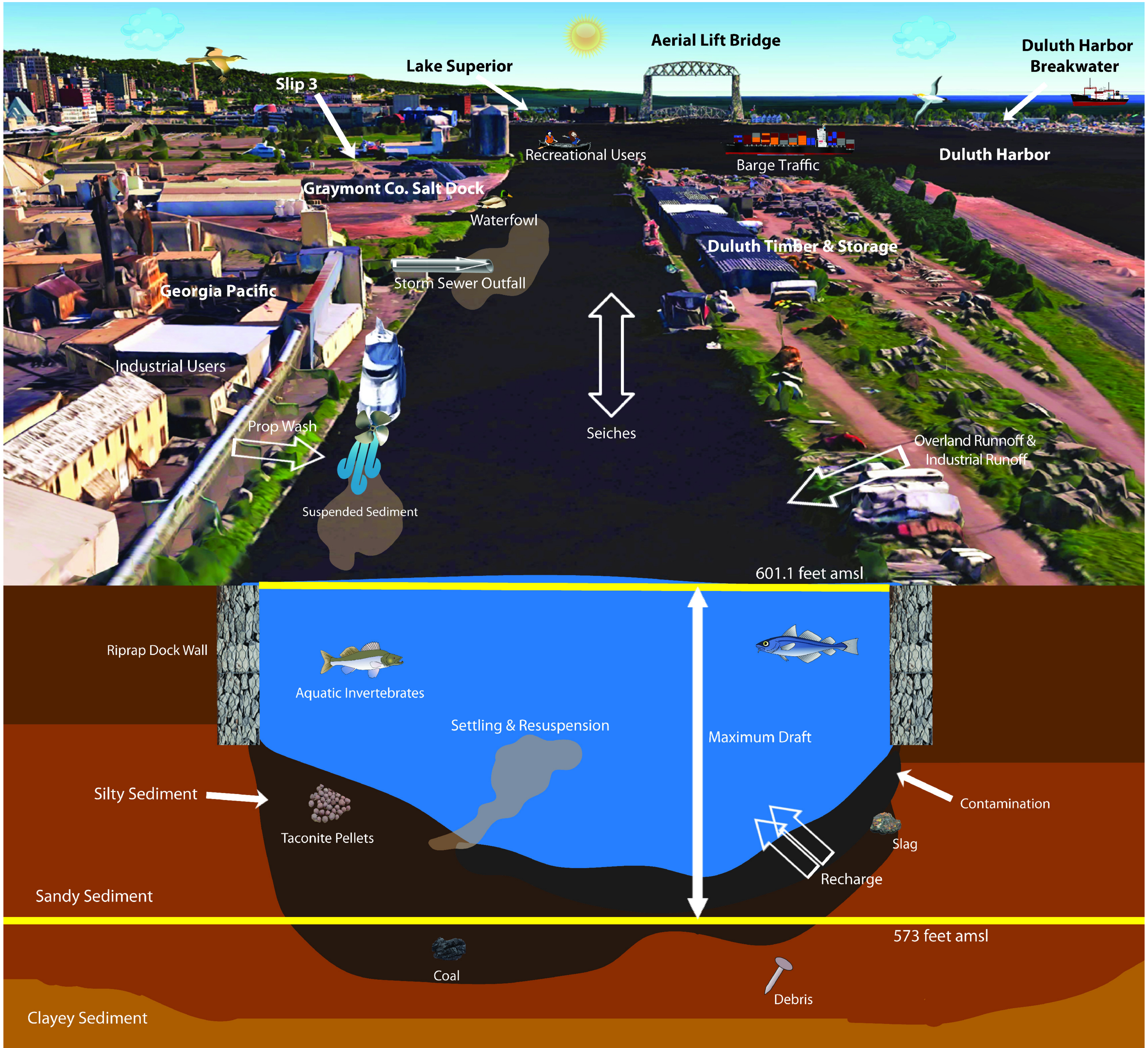
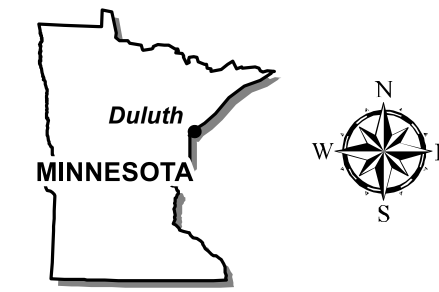


Figure 6

Conceptual Site Model

Slip C
SLR Sediment AOCs

Duluth, MN



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Drawn By: S.G. Date Drawn/Revised:5/10/2016 Project No.J150329

Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 6 Slip C Conceptual Site Model.mxd

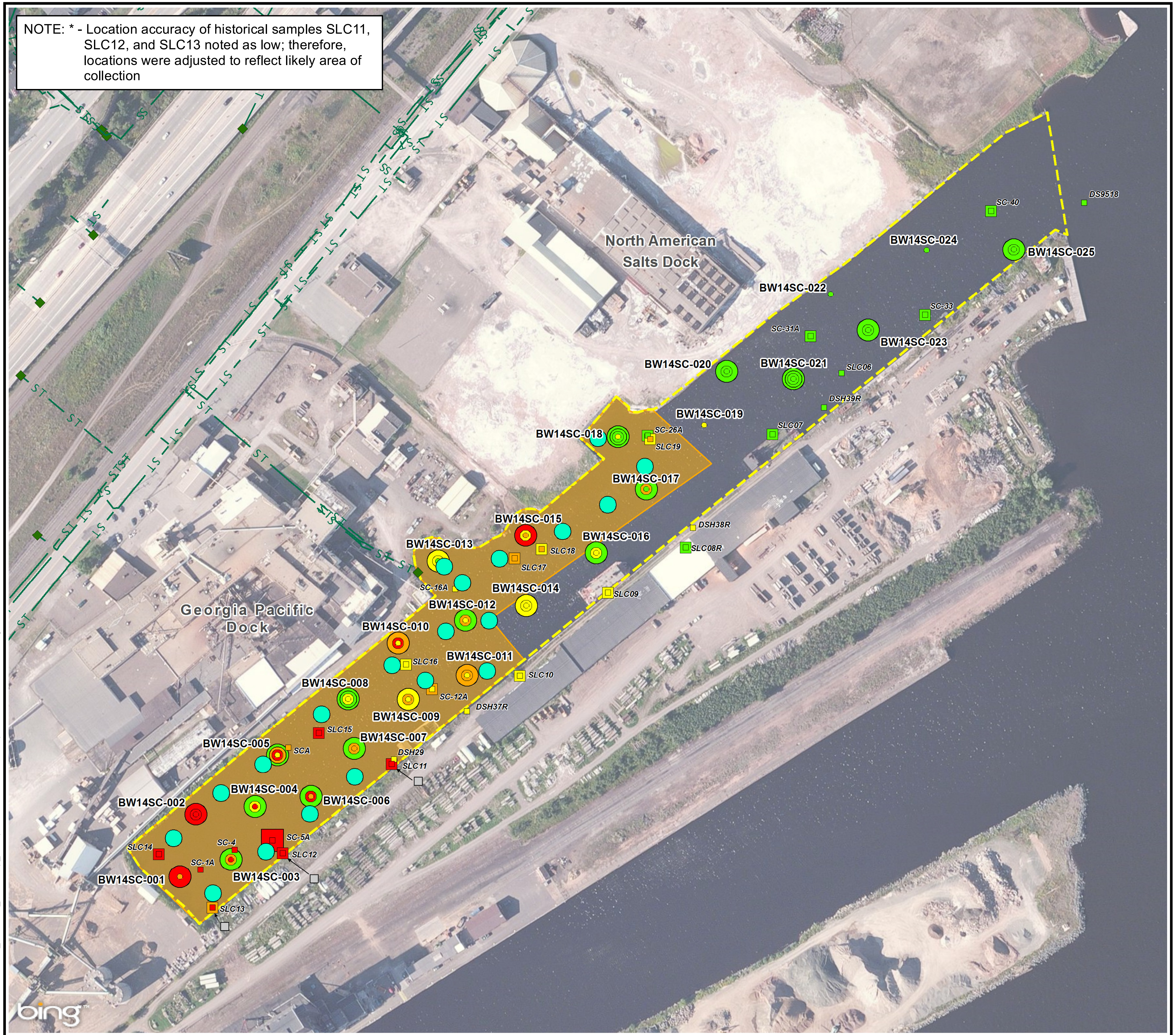
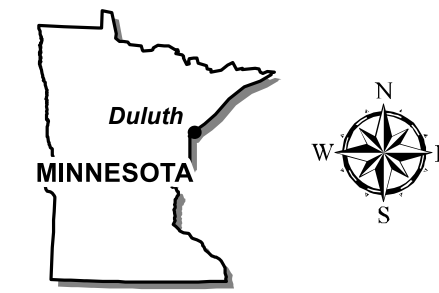


Figure 7

Alternative 2 - Monitoring and Institutional Controls

Slip C
SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet
0 60 120 Meters
1 inch = 200 feet

- Original Historical Sample Location *
- Proposed Monitoring Location
- Sewer Outfall
- Sanitary Sewer
- Storm Sewer
- Slip C Site Boundary

Sample Type

- Sediment Sample (Bay West 2014)
- Sediment Sample (Historical)

Sample Interval

- 0-0.15 m
- 0.15-0.50 m
- 0.50-1.0 m
- >1.0 m

Lead SQT Comparison

- Does not exceed Level 1 SQT (36 mg/kg)
- Exceeds Level 1 SQT (36 mg/kg)
- Exceeds Midpoint SQT (83 mg/kg)
- Exceeds Level 2 SQT (130 mg/kg)

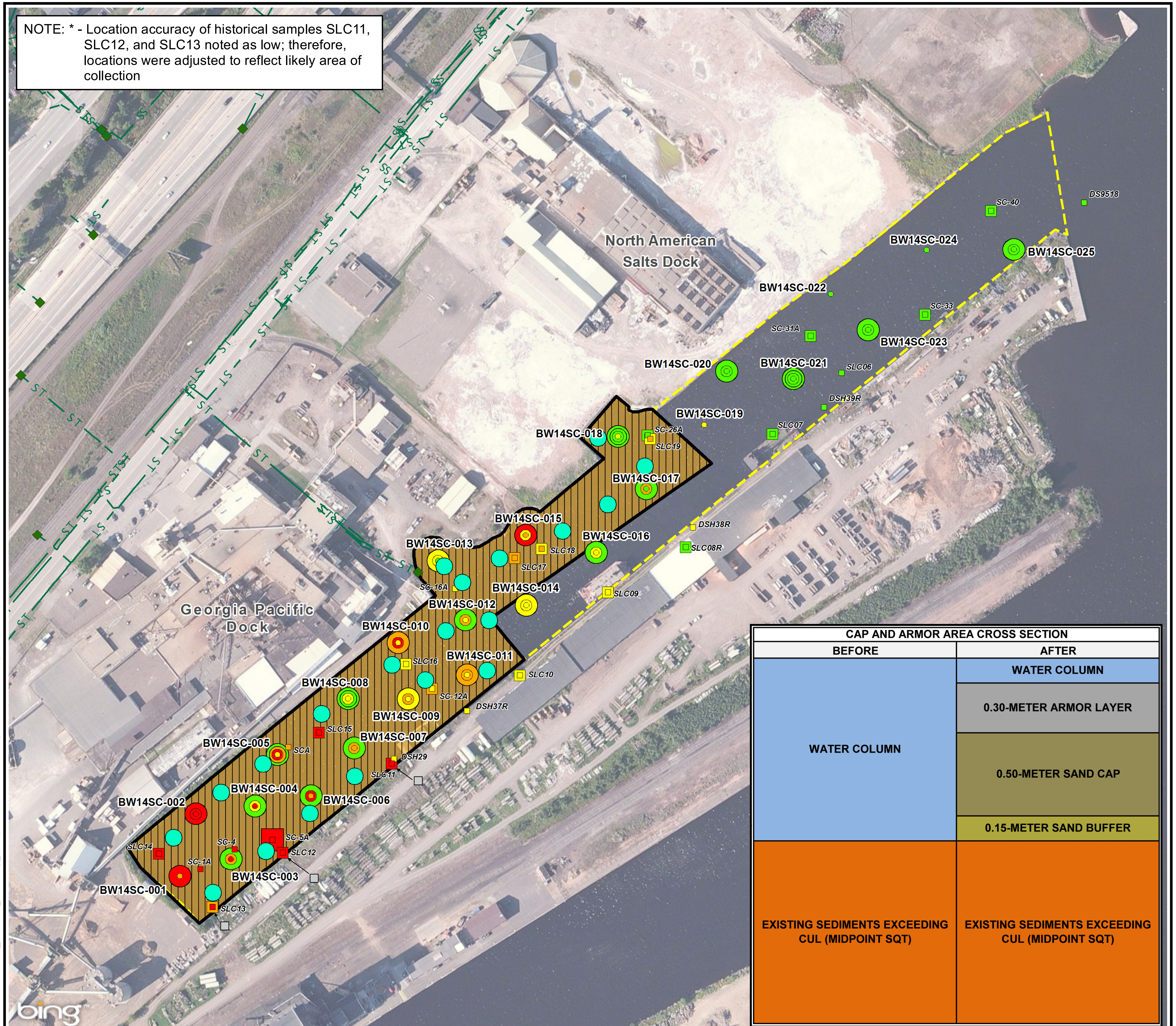
Lead SQT Exceedance Areas

- Estimated Area Exceeding Midpoint SQT (6.40 Acres)

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: S.G. Date Drawn/Revised:5/9/2016 Project No.J150329

Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 7 Slip C Alternative 2 Monitoring and Institutional Controls.mxd

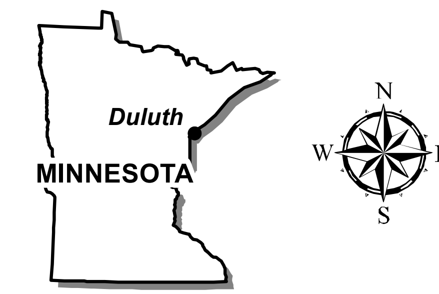


Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 8 Slip C Alternative 3 Cap and Armor.mxd

Figure 8

Alternative 3 - Cap and Armor

Slip C
SLR Sediment AOCs
Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet
0 60 120 Meters

1 inch = 200 feet

- Proposed Monitoring Location
- Original Historical Sample Location *
- Sewer Outfall
- SS Sanitary Sewer
- ST Storm Sewer
- Slip C Site Boundary
- Armored Area
- Cap Area

Sample Type

- Sediment Sample (Bay West 2014)
- Sediment Sample (Historical)

Sample Interval

- 0-0.15 m
- 0.15-0.50 m
- 0.50-1.0 m
- >1.0 m

Lead SQT Comparison

- Does not exceed Level 1 SQT (36 mg/kg)
- Exceeds Level 1 SQT (36 mg/kg)
- Exceeds Midpoint SQT (83 mg/kg)
- Exceeds Level 2 SQT (130 mg/kg)

Lead SQT Exceedance Areas

- Estimated Area Exceeding Midpoint SQT (6.40 Acres)

Bay West
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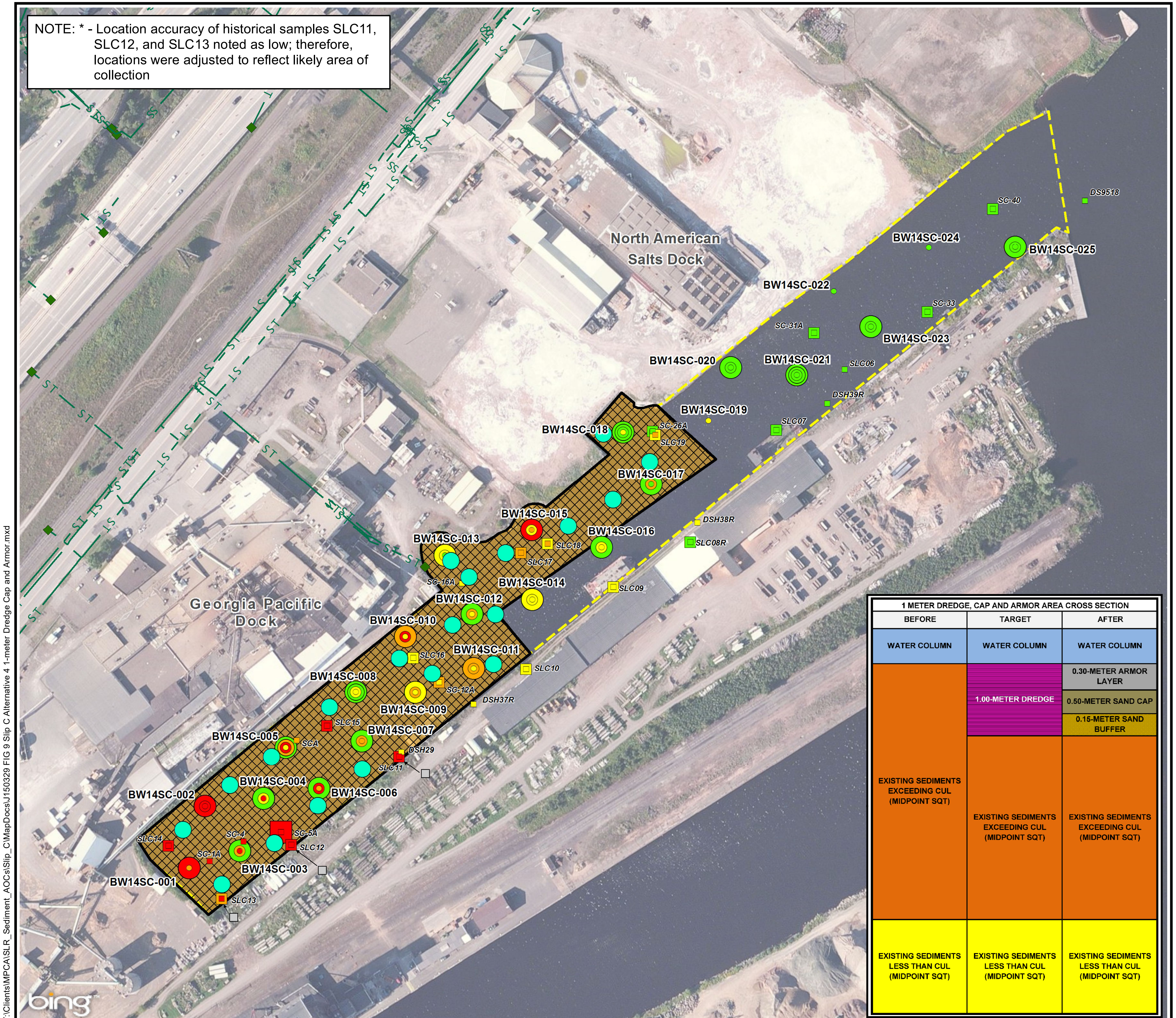


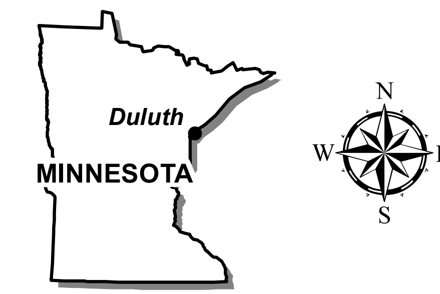
Figure 9

Alternative 4 - 1-Meter Dredge, Cap, and Armor

Slip C

SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet
0 60 120 Meters

1 inch = 200 feet

- Proposed Monitoring Location
- Original Historical Sample Location *
- Sewer Outfall
- Sanitary Sewer
- Storm Sewer
- Slip C Site Boundary
- Armored Area
- 1-Meter Dredge and Cap

Sample Type

- Sediment Sample (Bay West 2014)
- Sediment Sample (Historical)

Sample Interval

- 0-0.15 m
- 0.15-0.50 m
- 0.50-1.0 m
- >1.0 m

Lead SQT Comparison

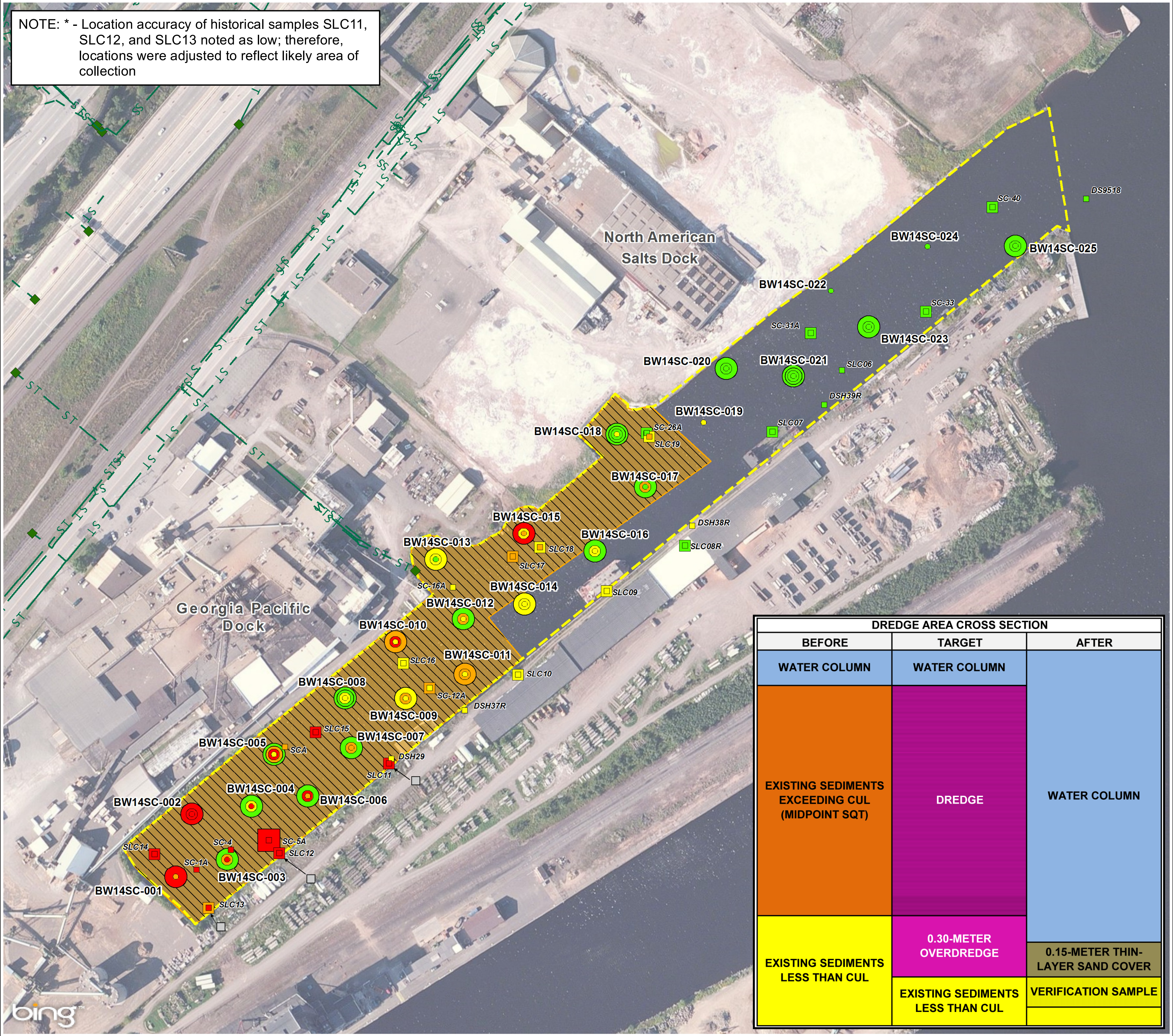
- Does not exceed Level 1 SQT (36 mg/kg)
- Exceeds Level 1 SQT (36 mg/kg)
- Exceeds Midpoint SQT (83 mg/kg)
- Exceeds Level 2 SQT (130 mg/kg)

Lead SQT Exceedance Areas

- Estimated Area Exceeding Midpoint SQT (6.40 Acres)

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: S.G. Date Drawn/Revised:6/29/2016 Project No.J150329



Y:\Clients\MPCA\SLR_Sediment_AOCs\Slip_C\MapDocs\J150329 FIG 10 Slip C Alternative 5 Dredge with Thin Layer Cover.mxd

Figure 10

Alternative 5 - Dredge with Thin-Layer Cover

Slip C
SLR Sediment AOCs

Duluth, MN

Duluth
MINNESOTA

N
W E
S

Map Projection: NAD 1983 UTM Zone 15 N
Basemao: Microsoft Bing WMS

0 200 400 Feet
0 60 120 Meters
1 inch = 200 feet

Sewer Outfall
Original Historical Sample Location *
Sanitary Sewer
Storm Sewer
Slip C Site Boundary
Dredge and Cover

Sample Type

Sediment Sample (Bay West 2014)
Sediment Sample (Historical)

Sample Interval

0-0.15 m
0.15-0.50 m
0.50-1.0 m
>1.0 m

Lead SQT Comparison

Does not exceed Level 1 SQT (36 mg/kg)
Exceeds Level 1 SQT (36 mg/kg)
Exceeds Midpoint SQT (83 mg/kg)
Exceeds Level 2 SQT (130 mg/kg)

Lead SQT Exceedance Areas

Estimated Area Exceeding Midpoint SQT (6.40 Acres)

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: S.G. Date Drawn/Revised:5/9/2016 Project No.J150329

Tables

Table 1
Contaminants of Concern Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Contaminants of Concern	Units	Cleanup Level	Maximum Concentration Detected
Lead	mg/kg	83	382
Cadmium	mg/kg	3	6.5
Copper	mg/kg	91	148
Mercury	mg/kg	0.64	3
Nickel	mg/kg	36	40
Zinc	mg/kg	0.64	589
Total PAH	µg/kg	12,300	113,234
PCBs	µg/kg	370	390
Dioxin/Furans	ng TEQ/kg	11.2	23.26

Notes:

µg/kg – micrograms per kilogram

mg/kg – milligrams per kilogram

ng TEQ/kg = nanograms toxic equivalency per kilogram

Table 2
Technologies Screening Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Category	Technology	Description	Applicability	Ranking						Retained for Consideration	Rationale
				Effectiveness		Implementablility		Relative Cost			
Institutional Controls	Institutional Controls	Institutional controls in the form of an environmental restrictive covenant or conditions of future permits may be used to prevent exposure and contact with impacted soil or sediment by restricting land uses or disturbances to the material.	May consist of fish consumption advisories, commercial fishing bans, waterway use restrictions, or deed restrictions	○	Effective in meeting RAOs when combined with other remedies.	●	Easily implemented with little disruption to the Site.	$	Minimal but there are long term costs associated with initiating and maintaining institutional controls.	Yes.	Some institutional controls already in place; however, additional controls are expected to be a required component of any remedy.
Monitoring and Evaluation	Monitoring	The collection and analysis chemical, physical, and/or biological data over a sufficient period of time and frequency to determine the status and/or trend in one or more environmental parameters or characteristics.	Monitoring should be conducted to asses compliance with design and performance standards; to assess short-term remedy performance and effectiveness in meeting sediment cleanup levels; and/or to evaluate long-term remedy effectiveness in achieving RAOs and in reducing human health and/or environmental risk.	○	Effective in meeting RAOs when combined with other remedies.	●	Highly implementable with no disturbance to the Site.	$	The main cost is associated with laboratory analysis.	Yes.	Monitoring is expected to be a required component of any remedy.
Natural Recovery	Monitored Natural Recovery	MNR leaves impacted sediment in place and relies on ongoing, naturally occurring processes to isolate, destroy, or reduce exposure or toxicity of impacted sediment.	Burial of contaminated sediments does not appear to be occurring at the Site and deposition rates are not likely sufficient to isolate COCs in reasonable timeframe and concentrations do not appear to be reducing.	⊗	Burial does not appear to be occurring and current data does not indicated the extent of MNR effectiveness in COC reduction.	●	Highly implementable with no disturbance to the Site.	$	The main cost of NR is associated with monitoring.	No.	Effectiveness at the Site has not been demonstrated and does not appear to be effective under current conditions.
	Enhanced Monitored Natural Recovery	EMNR adds amendments to the sediment to accelerate physical isolation process and facilitates re-establishment of benthic or plant habitat. May include a granular or carbon sorbent cover (over sediments) or biological stimulants (to soil).	EMNR is not effective because burial is not likely occurring at sufficient rates at the Site.	⊗	Burial does not appear to be occurring and current data does not indicated the extent of EMNR effectiveness in COC reduction.	◉	Implementable; however, requires site access, staging area, and placement equipment. Impact to Site operation can be minimal with advanced planning.	$$	Greater initial cost than NR due to thin cover or amendment placement however remedy will not achieve RAOs.	No.	Effectiveness at the Site has not been demonstrated and does not appear to be effective under current conditions.
Capping	Capping	Capping provides a physical barrier and chemical isolation from COCs. Caps may be constructed from clean sediment, sand, gravel, geotextiles, liners, reactive or absorptive material and may consist of multiple layers. Granular sediment caps can provide erosion protection and limit bioturbation.	Cap thickness depends on bioactive zone (BAZ) thickness requirements, which vary by habitat, substrate and water depth. A cap may alter hydrologic conditions and Site use.	◉	Highly effective and preventive technology. COCs have low solubility and mobility. Short term movement of COCs in pore water is possible during consolidation. Armoring required to prevent scour due to propeller wash.	◉	Implementable. Consolidation of sediments may be required to minimize spatial placement of cap, maintenance may be required depending on hydrologic conditions.	$$$	Capping costs are generally less than sediment removal, and depend on cap thickness, material, lateral extent and surface water engineering factors. Material costs for a synthetic cap are generally higher than a granular cap.	Yes.	Proven effective method to control exposure and erosion.

Category	Technology	Description	Applicability	Ranking						Retained for Consideration	Rationale
				Effectiveness		Implementablility		Relative Cost			
Excavation and Removal	Mechanical Dredging	Sediment is lifted to the surface using a mechanical excavator or crane and placed on a barge for transport. Removed sediment has a similar moisture content as the in situ material, requiring dewatering prior to disposal. Residual cover is typically needed to manage remaining impacts.	Mechanical dredging is implementable within the Site and areas for staging equipment and dewatering are available. Sediment resuspension controls expected to be needed.	◉	Highly effective and preventative technology; however, resuspension may limit effectiveness.	◉	Requires dredging equipment and up land staging infrastructure for sediment treatment and transportation. Less staging space required than hydraulic dredging.	$$$	Main capital costs include equipment mobilization, staging area development, equipment operation, residual cover materials, and construction and operation of a containment area for dredged material.	Yes.	Suitable for dredging within slips.
	Hydraulic Dredging	Hydraulic dredging captures water with the sediment and removes it by pumping the sediment slurry typically through a pipeline to the dewatering location or final disposal site. High water content of slurry requires significant dewatering. Residual cover is typically needed to manage remaining impacts.	Hydraulic dredging unfavorable due to small scale of Site and distance from dewatering and disposal area.	●	Highly effective and preventative technology with less resuspension than mechanical dredging.	○	Implementable; however, requires large staging area for dewatering equipment, requires more water treatment than mechanical dredging.	$$$$	Additional treatment and disposal costs due to greater water content of the slurried sediment.	No	Not suitable for small volume removal areas and staging area for dewating prohibitively far from Site .
	Mechanical Removal in Dry Conditions	Water is diverted or drained from the excavation area using a containment barrier such as a cofferdam to allow for excavation of dry sediment with conventional equipment (e.g. backhoe). Typically limited to shallow areas.	Well suited for shallow areas and geometry that allows for construction of containment barrier and water diversion.	●	Effective and proven technology. Allows for visual inspection during removal. Minimal resuspension/redeposition. High degree of accuracy.	○	Feasible in small-volume removal areas. Site preparation difficult due to water management.	$$$	Costs are similar to mechanical dredging, with the added cost to construct diversion or containment structures.	No	Not suitable when compared to mechanical dredging.
Disposal	Off-Site	Removed sediment is transported to an offsite disposal location that will accept the waste. Dewatering of sediments is generally required before transport.	Transportation of large volumes of sediment would create significant truck traffic through the surrounding community for a long duration.	●	Effective at meeting RAOs, low risk of spills during transportation.	◉	Disruption to neighbors during trucking, may result in limited work hours. Seasonal restrictions may also apply.	$$$$	Costs for offsite disposal include dewatering, water treatment, loading and transportation costs and landfill disposal fees. Transportation costs depend on distance to the landfill.	Yes.	Suitable. Industrial area results in minimal disruption to community. Onsite storage facilities are not available.
	Confined Disposal Facility (CDF)	CDFs are engineered structures enclosed by dikes and specifically designed to contain sediment. CDFs may be located either upland (above the water table), near-shore (partially in the water), or completely in the water (island CDFs).	Land in the vicinity of the Site is not available for a CDF.	●	Most widely used method for disposal and has been demonstrated effective.	○	Requires high level of design, detailed knowledge of dredge plans, requires large permanent area for construction, and treatment of discharge.	$$$	Costs for a CDF include engineering and design costs, materials for dikes and suspended solids control, and construction equipment and labor.	No	Based on the surrounding land use consolidation areas are not developed or feasible.
	On-site Contained Aquatic Disposal (CAD)	Dredged or excavated sediment is disposed within a natural or excavated depression elsewhere in the water body.	A suitable location to accommodate entire sediment volume is not available. Areas of sufficient depth to hold some volume are currently used for ship docking.	○	May be effective at containing COCs due to low mobility/solubility.	⊗	A suitable location to accommodate entire sediment volume is not available.	$$$	Specialized equipment for a CAD may be required, especially if the disposal site is in deep water. Dredging to create a CAD would add cost.	No	Based on the Site characteristics as wells as its use for ship docking, a suitable location is not available at the Site to accommodate the required disposal volume.

Table 2
Technologies Screening Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Category	Technology	Description	Applicability	Ranking						Retained for Consideration	Rationale
				Effectiveness		Implementablility		Relative Cost			
In Situ Treatment	Immobilization	Immobilization treatments add chemicals or cements to reduce the leachability of COCs. Mechanisms include solidification (encapsulation) or stabilization (chemical or absorptive reactions that convert COCs to less toxic or mobile forms).	Implementation at a sediment site is difficult due to submerged work requirement and restricting future Site use.	○	Is effective for COCs. Stabilization of sediments reduces erosion potential. May result in poor environment for benthic community.	⊗	Sediment mixing can be difficult. May require dewatering. Requires equipment for mixing. Solidified sediment would restrict future Site use.	$$$	Costs for solidification or stabilization affected by the quantity and type of reagents added to the waste and the need for specialized equipment for mixing reagents with sediment.	No	Not proven to be effective for sediments. Costly and more difficult to implement than other technologies.
	Enhanced Bioremediation	Microbial degradation by bacteria or fungi is enhanced by adding materials such as oxygen, nitrate, sulfate, hydrogen, nutrients, or microorganisms to the sediment.	Can be effective for COCs.	○	Requires specific geochemical parameters to be successful (temperature, Ph, nutrient availability)	○	Easily implemented with little disruption to the Site.	$$$	Costs of enhanced bioremediation are relatively low, but several treatments and monitoring similar to MNR may be required.	No	Difficult to implement sub aqueously.
	Oxidation/Reduction	Chemicals are injected into sediment to act as an oxidant/electron acceptor to facilitate aerobic decomposition of organic matter.	chemical addition may create toxic conditions.	○	Chemical addition may create toxic conditions.	○	Bench-scale testing and pilot-scale testing required to determine the type, concentration, and quantity of oxidant and amendments required.	$$$	Costs include bench- or pilot-scale tests. Monitoring may be required.	No	Not proven safe for subaqueous conditions.
	Chemical Oxidation	The addition of chemical oxidizers to sediment can cause the rapid and complete chemical destruction of many toxic organic chemicals.	Limited effectiveness for Site COCs.	⊗	Addition of chemicals may form temporarily toxic conditions for benthic or aquatic organisms	◉	Pilot studies would be required to determine the effectiveness of specific oxidants for COCs.	$$$	Costs include bench- or pilot-scale tests to determine effectiveness, oxidants for injection, and a delivery system. Monitoring may also be required.	No	Limited effectiveness. Chemical addition may create toxic conditions.
	Phytoremediation	Phytoremediation uses plant species to remove, transfer, stabilize, and destroy COCs in soil and sediment. Generally limited to sediments in shallow water zones and low concentrations.	Habitat restoration not likely necessary, technology not effective in deep areas of reservoir.	○	Effective only in shallow contaminated areas, which are sparse at the Site.	●	Implementation involves planting and in some cases harvesting with little disruption to the Site.	$$	Primary costs are purchasing and planting applicable species. Monitoring may also be required.	No	May be implemented for habitat restoration, but not effective alone.
	Adsorption	Adsorbents can be used as sediment amendments for in situ treatment of COCs. Sorption organics can take place simultaneously with a suitable combination of sorbents.	May be useful as EMNR amendment.	◉	Sorption organics can take place simultaneously with a suitable combination of sorbents.	◉	Sorbent amendments can be delivered to the sediment in the form of pellets that are dense enough to sink through the water column and are resistant to re-suspension while being worked into the sediments	$$	The main costs include the adsorbent material, and a method for depositing it on the surface sediment. Monitoring may also be required.	No	Not retained as sole remedy, but may be useful as capping or ENR amendment.

Table 2
Technologies Screening Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Category	Technology	Description	Applicability	Ranking						Retained for Consideration	Rationale
				Effectiveness		Implementablility		Relative Cost			
Dewatering	Passive Dewatering	Passive dewatering relies on natural evaporation and drainage to remove moisture from the sediment. Drainage may be driven by gravity or assisted with a vacuum pump. Passive dewatering may occur in CDFs, lagoons, tanks, or temporary holding/rehandling facilities.	Dewatering will occur during barge transport and Hallet dock 7 could be used to serve as a staging area for further passive dewatering.	○	Passively dewatered sediments may not have low enough water content for landfill disposal, so supplemental technologies may be required.	◉	Implementable with small volume of removed sediments at Site. Time frames for passive dewatering likely longer than for mechanical dewatering.	$$	Costs to consider include construction of a dewatering facility or adequately sized CDF.	Yes.	Appropriate for off-site disposal when used with hydruospoic amendment addition.
	Sediment Reworking	Reworking sediments to promote drainage, and mixing sediments with excavation equipment can enhance passive dewatering.	If a CDF is constructed, sediment reworking could be performed within the CDF.	◉	Sediment mixing and reworking would facilitate a timelier and more complete dewatering.	◉	Mixing and reworking sediments would decrease time needed to dewater with passive methods. Reworking and mixing could be done with standard excavation equipment already required for the project.	$$	Cost savings are expected over passive dewatering alone due to time saved.	No	Not appropriate for offsite disposal.
	Hydrospoic Amendment Addition	Dredged sediments are mixed with amendments such as slags or cementitious materials to remove moisture and improve strength and stability.	Could be used to enhance dewatering in conjunction with passive dewatering	◉	Effectiveness of amendments depend on the moisture content of removed sediment. Pre-treatment dewatering likely required due to hydraulic dredging for maximum effectiveness and to achieve desired geotechnical properties.	◉	Would require staging, mixing, and curing areas. However, the process can be completed in a relatively short time frame. Amendment addition creates a greater volume and mass, which needs to be considered in disposal options. Likely requires pre-treatment dewatering.	$$	Costs include amendment materials and mixing equipment. Costs increase with increased moisture content. Both the addition rate and the bulking factor of treated material should be considered when evaluating costs of amendment material.	Yes.	Appropriate for off-site disposal when used with passive dewatering.
	Geotextile Tube Dewatering	Sediment slurry from hydraulic dredging is pumped into the geotextile tube and filtered by the geotextile fabric. Sediment is retained within the geotextile tube, while free liquids pass through the exterior of the tube.	Not applicable to mechanical dredging, which is retained for alternatives for the Site.	⊗	Not applicable to mechanical dredging which is retained for alternatives for the Site.	⊗	Not applicable to mechanical dredging which is retained for alternatives for the Site.	$$$	Costs include flocculent and coagulant materials, cost of geotextile tubes and construction of staging area.	No	Not appropriate for use with mechanical dredging.
	Mechanical Dewatering	Mechanical dewatering technologies include use of plate filters, presses, centrifuges or other equipment to squeeze, press, or draw water from dredged sediment.	Requires homogeneous waste stream provided by hydraulic dredging methods and site sediments.	◉	Generally works best with a homogeneous waste stream produced via hydraulic dredging. Selection of specific mechanical dewatering equipment depends on treatment or disposal methods that follow.	◉	Faster than passive dewatering and requires less space. Production rates depend on size and quality of the dewatering device and on the solids content of the input stream.	$$$$	Costs of mechanical dewatering are generally higher than passive dewatering due to the energy and equipment requirement.	No	Not cost effective.
	Rapid Dewatering Systems	A system that continuously processes the slurry from a hydraulic dredge and separates solids into piles of debris; shells; and gravel, sand, and fines. Includes polymer addition and flocculation, which may remove some COCs.	Not applicable to mechanical dredging, which is retained for alternatives for the Site.	⊗	Not applicable to mechanical dredging which is retained for alternatives for the Site.	⊗	Not applicable to mechanical dredging which is retained for alternatives for the Site.	$$$	Not applicable to mechanical dredging, which is retained for alternatives for the Site.	No	Not applicable to mechanical dredging which is retained for alternatives for the Site.

Category	Technology	Description	Applicability	Ranking						Retained for Consideration	Rationale
				Effectiveness		Implementablility		Relative Cost			
Water Treatment	Filtration	Filters remove solids and sediments from wastewater, also removing absorbed COCs from the waste stream. Flocculants may be added to the waste stream to facilitate solids removal.	Filtration is a standard method for water treatment and would be effective at removing site COCs sorbed to suspended sediments in the waste stream.	○	Filters can be selected based on the required particulate size. Treatability study to determine if filtration is effective at reducing the COC concentration.	◉	Filtration is a widely used method for water treatment. Selection of the filtration methods and type requires engineering design and site specific knowledge of the waste stream.	$$$	Costs depend on change out frequency of filtration material.	Yes.	Effective for COC removal when used in combination with liquid adsorption.
	Liquid Adsorption	Involves pumping water through a vessel containing granular activated carbon (GAC), organoclay, or another adsorbent material; dissolved compounds to adsorb to its surface.	Multiple liquid adsoprtion technologies would be applicable for COC removal.	◉	Multiple liquid adsorption technologies are available for COC removal. Detailed identification of the most effective technology would need to be completed prior to treatment.	◉	Liquid adsorption systems are widely available, have a relatively small footprint, and require a relatively short timeframe for treatment.	$$$	Costs include adsorbent and adsorbent vessels. The adsorbent must be recharged or replaced periodically. Power is required for pumping.	Yes.	Effective for COC removal.
	Advanced Oxidation	Advanced oxidation uses UV light and the addition of strong oxidizers to destroy organic constituents in water.	Advanced oxidation is applicable for treating most organics, including PAHs; however, it is not applicable to lead.	○	Advanced oxidation is applicable for treating most organics.	◉	Advanced oxidation systems are widely available, have a relatively small footprint, and require a relatively short timeframe for treatment. Handling and storage of oxidizers would require special safety precautions.	$$$$	Costs may be higher because of energy requirements to power UV lights.	No	Not applicable for lead removal and cost too high.

	Effectiveness	Implementability	Relative Cost
⊗	Not effective at reaching RAOs	Not implementable at the Site	$$$$ - High
○	Partially effective for some COCs or Site areas	Difficult to implement	$$$ - Medium-high
◉	Effective under certain conditions	Implementable, requires technical knowledge	$$ - Moderate
●	Demonstrated effective technology	Readily implemented	$ - Low

Table 3
Alternatives Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Alternative	Alternative 1: No Action	Alternative 2: Monitoring and Institutional Controls	Alternative 3: Cap & Armor	Alternative 4: 1 Meter Dredge, Cap and Armor	Alternative 5: Dredge with Thin-Layer Cover
Total Present Worth Cost	$0	$333,000	$5,112,000	$10,826,000	$19,049,000
Cover/Cap Area	0 acres	0 acres	6.40 acres (Cap)	6.40 acres (Cap)	6.40 acres (Cover)
Dredge Area	0 acres	0 acres	0 acres	6.40 acres	6.40 acres
Cover Volume - Sand/Armor	0 CY/ 0 CY	0 CY/ 0 CY	21,993 CY/ 10,119 CY	21,993 CY/ 10,119 CY	5,059 CY/ - CY
Dredge Volume	0 CY	0 CY	0 CY	33,867 CY	115,192 CY
Construction Timeframe	0 weeks	0 weeks	14 weeks	21 weeks	30 weeks
Monitoring Program	None	Chemical and physical sediment; benthic toxicity and bioaccumulation; bathymetric survey; institutional control review	Chemical sediment and cap; cap integrity; bathymetric survey; Institutional control review	Chemical sediment and cap; cap integrity; bathymetric survey; Institutional control review	Chemical sediment and cap; cap integrity; bathymetric survey; Institutional control review

Note: Alternatives 4 through 5 cost estimates do not include costs associated with potential dock wall repair/re-enforcement

Table 4
Cost Estimate - Alternative 2: Monitoring and Institutional Controls
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Implementation						
Implementation Plan Report	Lump Sum	$11,000.00	1	$11,000	$11,000	Work Plan, Field Sampling Plan, QAPP
			SUBTOTAL	$11,000	$11,000	
Monitoring and Evaluation						Every 5 years for 30 years plus yr 0
Monitoring and Evaluation Report	Each	$4,000.00	7	$28,000	$13,000	Labor and equipment; every 5 years for 30 years plus yr zero
Field Sampling	Event	$34,000.00	7	$238,000	$107,000	Chemical, physical, toxicity and bioaccumulation (benthics), every 5 years for 30 years + yr 0
Sample Analysis	Event	$52,338.00	7	$366,366	$165,000	Every 5 years for 30 years + yr 0
Bathymetric Survey	Each	$10,000.00	7	$70,000	$32,000	
Institutional Control Review	Each	$1,500.00	7	$10,500	$5,000	
			SUBTOTAL	$712,866	$322,000	
			TOTAL	**$724,000**	**$333,000**	

Notes:

All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Table 5-Appendix B for present value calculations.

Assumptions are based on professional judgment and experience of specialists at Bay West. Actual project costs will be highly dependent upon final design.

Table 5
Cost Estimate - Alternative 3: Cap and Armor
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
Mobilization/Demobilization	Lump Sum	$ 195,000	1	$ 195,000	$ 195,000	
Relocation of Dock Tenant During Construction	Month	$ 10,000	4	$ 40,000	$ 40,000	*Doubled from Slip 3*
Purchase Sand and Import to Staging Area	CY	$ 20.80	21993	$ 457,000	$ 457,000	
Purchase Armoring Materials and Import to Staging Area	CY	$ 44.28	10119	$ 448,000	$ 448,000	
Level/Slope Sediment Prior to Capping	Lump Sum	$ 146,000.00	1	$ 146,000	$ 146,000	
Barge Cover/Cap Materials to Slip	CY	$ 19.38	32112	$ 622,000	$ 622,000	
Construct Cover/Cap	CY	$ 33.85	21993	$ 745,000	$ 745,000	
Construct Armoring Layer	CY	$ 33.85	10119	$ 343,000	$ 343,000	
Construction Monitoring/CQA and Oversight	Week	$ 15,000.00	14	$ 210,000	$ 210,000	
Sample Analysis	Lump Sum	$ 18,000	1	$ 18,000	$ 18,000	
Monthly Operating Expenses and Site Security	Month	$ 21,000.00	2.5	$ 53,000	$ 53,000	
Implement Institutional Controls	Lump Sum	$ 25,000.00	1	$ 25,000	$ 25,000	
			SUBTOTAL	$ 3,302,000	$ 3,302,000	
Long-Term Monitoring						
Monitoring and Evaluation Report	Each	$ 4,000	6	$ 24,000	$ 8,631	
Field Sampling	Event	$ 34,000	6	$ 204,000	$ 73,366	
Sample Analysis	Event	$ 21,618	6	$ 130,000	$ 46,648	
Bathymetric Survey	Each	$ 10,000	6	$ 60,000	$ 21,578	
Institutional Control Review	Each	$ 1,500	6	$ 9,000	$ 3,237	
			SUBTOTAL	$ 427,000	$ 153,460	
			TOTAL	$ 3,729,000	$ 3,455,460	
			25% Contingency	$ 932,250	$ 863,865	
		CONSTRUCTION GRAND TOTAL		$ 4,661,250	$ 4,319,325	
Professional and Technical Services						
Remedial Design (6%)	Lump Sum	$ 280,000	1	$ 280,000	$ 280,000	
Project Management and Permitting (5%)	Lump Sum	$ 233,000	1	$ 233,000	$ 233,000	
Construction Management (6%)	Lump Sum	$ 280,000	1	$ 280,000	$ 280,000	
			SUBTOTAL	$ 793,000	$ 793,000	
			TOTAL	**$ 5,454,000**	**$ 5,112,000**	

Notes:

All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Table 5-Appendix B for present value calculations.

Assumptions are based on professional judgment and experience of specialists at Bay West. Actual project costs will be highly dependent upon final design.

Table 6
Cost Estimate - Alternative 4: 1 Meter Dredge, Cap and Armor
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
Mobilization/Demobilization	Lump Sum	$ 351,734	1	$ 352,000	$ 352,000	
Construct Staging Area	Lump Sum	$ 285,789	1	$ 286,000	$ 286,000	
Relocation of Dock Tenant During Construction	Month	$ 10,000	4	$ 40,000	$ 40,000	*(Doubled from Slip 3)*
Mechanically Dredge Sediments	CY	$ 20.12	33867	$ 681,000	$ 681,000	
Turbidity Controls	Lump Sum	$ 75,000.00	1	$ 75,000	$ 75,000	
Barge Dredged Sediments to Staging Area	CY	$ 12.92	33867	$ 438,000	$ 438,000	
Sediment Offloading and Stabilization	CY	$ 18.48	33867	$ 626,000	$ 626,000	
Sediment Transportation and Disposal	Ton	$ 22.66	59267	$ 1,342,700	$ 1,342,700	
Water Treatment	Gallon	$ 0.09	3121870	$ 275,300	$ 275,300	
Purchase Sand and Import to Staging Area	CY	$ 20.80	21993	$ 457,000	$ 457,000	
Purchase Armoring Materials and Import to Staging Area	CY	$ 44.28	10119	$ 448,000	$ 448,000	
Barge Cover/Cap Materials to Slip	CY	$ 19.38	32112	$ 622,300	$ 622,300	
Construct Cover/Cap	CY	$ 33.85	21993	$ 744,500	$ 744,500	
Construct Armoring Layer	CY	$ 33.85	10119	$ 342,500	$ 342,500	
Construction Monitoring/CQA and Oversight	Week	$ 15,000	21	$ 315,000	$ 315,000	
Sample Analysis	Lump Sum	$ 33,879	1	$ 33,900	$ 33,900	
Monthly Operating Expenses and Site Security	Month	$ 21,000	5	$ 105,000	$ 105,000	
Implement Institutional Controls	Lump Sum	$ 25,000.00	1	$ 25,000	$ 25,000	
			SUBTOTAL	$ 7,209,200	$ 7,209,200	
Long-Term Monitoring						
Monitoring and Evaluation Report	Each	$ 4,000	6	$ 24,000	$ 8,631	
Field Sampling	Event	$ 34,000	6	$ 204,000	$ 73,366	
Sample Analysis	Event	$ 21,618	6	$ 129,708	$ 46,648	
Bathymetric Survey	Each	$ 10,000	6	$ 60,000	$ 21,578	
Institutional Control Review	Each	$ 1,500	6	$ 9,000	$ 3,237	
			SUBTOTAL	$ 426,708	$ 153,460	
			TOTAL	$ 7,635,908	$ 7,362,660	
			25% Contingency	$ 1,908,977	$ 1,840,665	
			CONSTRUCTION GRAND TOTAL	$ 9,544,885	$ 9,203,325	
Professional and Technical Services						
Remedial Design (6%)	Lump Sum	$ 573,000	1	$ 573,000	$ 573,000	
Project Management and Permitting (5%)	Lump Sum	$ 477,000	1	$ 477,000	$ 477,000	
Construction Management (6%)	Lump Sum	$ 573,000	1	$ 573,000	$ 573,000	
			SUBTOTAL	$ 1,623,000	$ 1,623,000	
			TOTAL	**$ 11,168,000**	**$ 10,826,000**	

Notes:

All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Table 5-Appendix B for present value calculations.

Assumptions are based on professional judgment and experience of specialists at Bay West. Actual project costs will be highly dependent upon final design.

Table 7
Cost Estimate - Alternative 5: Dredge
With Thin-Layer Cover
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
Mobilization/Demobilization	Lump Sum	$ 194,000	1	$ 194,000	$ 194,000	
Construct Staging Area	Lump Sum	$ 285,789	1	$ 285,789	$ 285,789	
Relocation of Dock Tenant During Construction	Month	$ 10,000	4	$ 40,000	$ 40,000	*Doubled from Slip 3*
Mechanically Dredge Sediments	CY	$ 20.12	115192	$ 2,318,000	$ 2,318,000	
Turbidity Controls	Lump Sum	$ 75,000.00	1	$ 75,000	$ 75,000	
Barge Dredged Sediments to Staging Area	CY	$ 12.92	115192	$ 1,488,000	$ 1,488,000	
Sediment Offloading and Stabilization	CY	$ 18.48	115192	$ 2,129,300	$ 2,129,300	
Sediment Transportation and Disposal	Ton	$ 22.66	201586	$ 4,567,000	$ 4,567,000	
Water Treatment	Gallon	$ 0.09	10484770	$ 924,700	$ 924,700	
Purchase Cover/Cap Materials and Import to Staging Area	CY	$ 20.80	5059	$ 105,200	$ 105,200	
Barge Cover/Cap Materials to Slip	CY	$ 19.38	5059	$ 98,000	$ 98,000	
Construct Cover/Cap	CY	$ 33.85	5059	$ 171,300	$ 171,300	
Construction Quality Assurance and Oversight	Week	$ 15,000	30	$ 450,000	$ 450,000	
Sample Analysis	Lump Sum	$ 56,129	1	$ 56,129	$ 56,129	
Monthly Operating Expenses and Site Security	Month	$ 21,000	6	$ 120,750	$ 120,750	
			SUBTOTAL	$ 13,023,168	$ 13,023,168	
			25% Contingency	$ 3,255,792	$ 3,255,792	
		CONSTRUCTION GRAND TOTAL		$ 16,278,959	$ 16,278,959	
Professional and Technical Services						
Remedial Design (6%)	Lump Sum	$ 980,000	1	$ 980,000	$ 980,000	
Project Management and Permitting (5%)	Lump Sum	$ 810,000	1	$ 810,000	$ 810,000	
Construction Management (6%)	Lump Sum	$ 980,000	1	$ 980,000	$ 980,000	
			SUBTOTAL	$ 2,770,000	$ 2,770,000	
			TOTAL	**$ 19,049,000**	**$ 19,049,000**	

Notes:

All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Table 5-Appendix B for present value calculations.

Assumptions are based on professional judgment and experience of specialists at Bay West. Actual project costs will be highly dependent upon final design.

Table 8
Comparative Analysis Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Monitoring and Institutional Controls	Alternative 3: Cap and Armor	Alternative 4: 1-Meter Dredge, Cap, and Armor	Alternative 5: Dredge with Thin-Layer Cover
Threshold Criteria					
Overall Protection of Human Health & Environment	Provides **no achievement** of protection of Human Health and the Environment as contaminant concentrations remain with minimal controls to prevent exposure.	Provides a **low achievement** of protection of Human Health and the Environment as contaminant concentrations remain with minimal controls to prevent exposure.	Provides a **moderate to high achievement** of protection of Human Health and the Environment. Contaminated sediment would remain in place but contaminants would be completely isolated.	Provides a **moderate to high achievement** of protection of Human Health and the Environment. Majority of contaminated sediment would remain in place but contaminants would be completely isolated.	Provides a **high achievement** of protection of Human Health and the Environment. Only residual contaminated sediment would remain in place; however, it is anticipated that the residual contamination will not exceed the RAOs.
ARARs	Provides a **no achievemen**t of ARARs since chemical-specific TBCs are not met for sediment. Location and action-specific ARAR s do not apply to this alternative.	Provides a **low achievemen**t of ARARs since chemical-specific TBCs are not met for sediment. Location and action-specific ARAR s do not apply to this alternative.	Provides a **moderate achievement** of ARARs if implemented properly; however, COCs may not be reduced to concentrations less than RAOs in a reasonable time frame.	Provides a **moderate achievement** of ARARs if implemented properly; however, COCs may not be reduced to concentrations less than RAOs in a reasonable time frame.	Provides a **high achievement** of ARARs if implemented properly. Contaminants above the RAOs would be removed.
Primary Balancing Criteria					
Long-term Effectiveness and Permanence	Provides a **no achievement** of long-term effectiveness and remedy is not long-term effective or permanent.	Provides a **low achievement** of long-term effectiveness and remedy is not long-term effective or permanent.	Provides a **moderate to high achievement** of long-term effectiveness and permanence because it isolates contaminated sediments from receptors; however, monitoring, and possible reapplication of the cap material may be necessary as all contaminants would remain in place.	Provides a **moderate to high achievement** of long-term effectiveness and permanence because it isolates contaminated sediments from receptors; however, monitoring, and possible reapplication of the cap material may be necessary as all contaminants would be consolidated and remain in place. Additionally dredged contaminated sediments would be placed in a disposal facility requiring long-term O&M.	Provides a **high achievement** of long-term effectiveness. Contaminated sediments would be permanently removed from the Site; however, contaminated sediments would be placed in a disposal facility requiring long-term O&M.
Reduction of Toxicity, Mobility or Volume through Treatment	Provides a **low achievement** of this criterion as no reduction in toxicity, mobility, or volume is provided.	Provides a **low achievement** of this criterion as no reduction in toxicity, mobility, or volume is provided.	Provides a **moderate achievement** of this criterion as all contaminated sediment that exceed the RAOs would be left in place; however, mobility would be reduced at the time of cap placement.	Provides a **moderate achievement** of this criterion as all contaminated sediment that exceed the RAOs would be left in place; however, mobility would be reduced at the time of cap placement. Sediment removed would be treated through stabilization.	Provides a **high achievement** of this criterion by removing all contaminated sediments that exceed the RAOs. The removed sediments would be treated through stabilization.
Short-term effectiveness	Provides a **high achievement** of this criterion as no actions are implemented, so no risks to the community would result from remedy implementation; however, receptors would continue to be exposed to contaminated sediment.	Provides a **high achievement** of this criterion as no actions are implemented, so no risks to the community would result from remedy implementation; however, receptors would continue to be exposed to contaminated sediment.	Provides a **moderate to high achievement** of this criterion since installation of the cap which would displace the benthic community. Risks to workers is moderate.	Provides a **low achievement** of this criterion since it would take a longer amount of time than Alternatives 3 and would affect aquatic habitat longer. Installation of the cap would displace the benthic community. Risks to workers is moderate. Off-site disposal lowers the effectiveness due to a slight increase in short-term risks from truck traffic to an off-site landfill.	Provides a **low achievement** of this criterion since it would take longer to implement on-site dredging and would affect the aquatic habitat longer. Off-site disposal lowers the effectiveness due to a slight increase in short-term risks from truck traffic to an off-site landfill.
Implementability	Provides a **high achievement** of this criterion as no actions would be implemented.	Provides a **high achievement** of this criterion as no actions would be implemented.	Provides a **moderate to high achievement** of implementability since it only requires placement of cap material using proven methods with a moderate to high level of complexity.	Provides a **moderate to low achievement** of implementability since it requires dredging, staging and placement of cap material using proven methods with a moderate to high level of complexity.	Provides a **moderate to low achievement** of implementability since it requires a large amount of dredging and staging coordination.
Cost (1)	$ -	$ 333,000	$ 5,112,000	$ 10,826,000	$19,049,000
Modifying Criteria					
State Support / Agency Acceptance	TBD	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD	TBD

Notes
(1) Cost are presented as Present Value.
M = Million
TBD = To Be Determined

Table 9
GSR Comparative Analysis Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Monitoring and Institutional Controls	Alternative 3: Cap and Armor	Alternative 4: 1 Meter Dredge, Cap, and Armor	Alternative 5: Dredge with Thin-Layer Cover
Threshold Criteria					
Green Sustainable Remediation (GSR) Criteria*					
Green House Gas (GHG) Emissions	Total GHG emissions are limited to equipment mobilization/demobilization related to sampling activities.	Total GHG emissions are limited to equipment mobilization related to sampling activities.	Total GHG emissions produced during cap material delivery and placement and equipment mobilization related to sampling activities.	Total GHG emissions produced during dredging activities, hauling wastes by land to landfill, cap material delivery, and placement and equipment mobilization related to sampling activities.	Total GHG emissions are limited to dredging activities and hauling wastes by land to landfill. More dredging and hauling generates more GHG emissions.
Toxic Chemical Usage and Disposal	No toxic chemicals are used or disposed.	No toxic chemicals are used or disposed.	No toxic chemicals are used or disposed.	Portland cement used to stabilize dredged material.	Portland cement used to stabilize dredged material.
Energy Consumption	Fossil fuels are limited to equipment mobilization/demobilization for sampling activities.	Fossil fuels are limited to equipment mobilization for sampling activities.	Fossil fuels are limited to the equipment mobilization for sampling activities and thin cover placement operations.	Fossil fuels are limited to the equipment mobilization for sampling activities, dredging activities, hauling wastes by land to landfill and cap material delivery and placement operations.	Fossil fuels are required for equipment mobilization for sampling activities, dredging activities, and hauling wastes by land to landfill. More dredging and hauling requires more fossil fuels.
Use of Alternative Fuels	Does not warrant the use of alternative fuels.	Does not warrant the use of alternative fuels.	Alternative fuels could be used to run heavy construction equipment.	Alternative fuels could be used to run heavy construction equipment.	Alternative fuels could be used to run heavy construction equipment.
Water Consumption	No water consumption is necessary.	No water consumption is necessary.	Little water consumption is necessary.	Little water consumption is necessary.	Little water consumption is necessary.
Waste Generation	No waste generation.	No waste generation.	No waste generation.	30,427 yd^3 of sediment for disposal will be generated.	83,304 yd^3 of sediment for disposal will be generated.
GSR Criteria Summary	Provides a **high achievement** of the GSR criterion.	Provides a **high achievement** of the GSR criterion.	Provides a **moderate to high achievement** of the GSR criterion.	Provides a **low achievement** of the GSR criterion.	Provides a **low achievement** of the GSR criterion.

Notes
**GSR critera are not included in numerical comparisons on Table 3 and Table 10*

Table 10
Numerical Comparative Analysis Summary
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Monitoring and Instututional Controls	Alternative 3: Cap and Armor	Alternative 4: 1-Meter Dredge, Cap, and Armor	Alternative 5: Total Dredge
Overall Protection of Human Health & Environment	0	0.5	2.5	2.5	3
ARARs	0	0	2	2	3
Long-term Effectiveness and Permanence	0	0	2	2.5	3
Reduction of Toxicity, Mobility or Volume through Treatment	0	0	2	2.5	3
Short-term effectiveness	2	2	2.5	1.5	1
Implementability	3	3	2.5	1	1.5
Cost (1)	3	3	2	1	0.5
State Support / Agency Acceptance	TBD	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD	TBD
Total Numerical Value	**8**	**8.5**	**15.5**	**13**	**15**

Notes

(1) Cost are presented as Present Value.

Ratings are based on achievement of criterion: low achievement; moderate achievement; and high achievement.

Scores are based on 0 = no achievement, 1 = low achievement; 2 = moderate achievement; and 3 = high achievement.

GSR criteria not included in this numerical comparison.

Appendix A

Record of Communication

Appendix A – Record of Communications
Feasibility Study
Slip C
Minnesota Pollution Control Agency

- **3/18/2016** – Call with Duluth Seaway Port Authority - Attendees: Jim Sharrow, Deborah DeLuca (Port Authority); Dirk Pohlmann, Chris Musson, Jonna Bjelland (Bay West).

  Jurisdiction/Plans of Port Authority for use of slip/Plans to improve? etc.

  Port Authority is an agency of the state; have direct authority only over owned lands…so just Azcon Slip; own half of slip (south side/half); is tasked with representing maritime industry; interest in maintaining industrial water front; interest in maintaining future possibility of maritime slips; must get authority from direct owners for access; Port Authority is an intermediary and can speak on behalf of general interest of harbor; interest in preserving maritime access and zoning for maritime use; works with planning group (Metropolitan Interstate Commission) to prepare planning docs given to city council for the City's comprehensive plan; member of a subgroup of the MIC – Harbor Technology Advisory Committee.; **City's development plan available on MIC website.**

  Hallett Dock #7/Potential staging areas

  Port Authority had a purchase agreement in place; was going through due diligence; not as positive as they.

  thought; may not go through with closing of the deal; still owned by XIK; could look at the dock on south side of slip C; wood products dock – contact Max Tolbert – Duluth Timber; could also look at other end of General Mills dock; General Mills elevator is for sale; somewhat undeveloped land; other half of property owned by Duluth Timber.

  Hallet Dock#7; owned by XIK; slip only 14' deep, outer end has about 18' of water; capped as part of superfund remedy; could likely use the channel dock wall, probably not the slip; was a large building there and concrete slab is still present. Rough cost to replace a dock wall is $3,000 – $4,000 per lineal foot, but will depend on dock construction; less for repair.

  AZCON Slip

  Port Authority has had discussions with MPCA about filling the AZCON slip; Port has had discussions with AZCON about purchasing their side of the slip; not been successful to date; If Port Authority had ownership it could be filled – turned into a CAD; Port Authority would need about 7 acres for laydown; existing portion owned by Port Authority not available; being rebuilt for maritime use and all land is accounted for; MPCA objective is to have this.

  completed by 2020 if they can (remedial activities – per Port Authority). No record of dredging since Port Authority came into being in 1989.

  Dredging

  Have to acquire permits; MPCA, USACE, and DNR work together to issue; DNR may impose fish windows, but these areas are likely not prime fish spawning areas; done on a case by case basis; would dictate what months out of the year dredging can be accomplished; Port Authority is currently dredging; dredge materials – legacy going to landfill– few hundred yards – remainder is coming ashore and going onto Port Authority dock; most of it clean sand and going into construction projects; dock repair cost is $17.7 million; Lunda subcontracted to Veit for dredging.

Port Authority will give Bay West status update on Hallett Dock #7 purchase.

- Chris Musson of Bay West corresponded with Omar's Sand and Gravel, Inc. (Omar's) of Carlton, Minnesota via email and phone between February 10 and 18, 2016. The Thomson Reservoir alternative scopes were discussed with John, a long-term employee at Omar's, and it was stated that projects on the scale of Thomson Reservoir are conducted regularly by Omar's. It is assumed they could supply for the Slip alternatives. Supply, loading, and transportation services are offered by Omar's, and large quantities of washed sand are always kept in stock (i.e., stockpiled and ready for load-out). Quotes for supply and delivery of crushed concrete and washed sand were supplied to Bay West, but it was requested that pricing information be kept confidential (this pricing was incorporated into cost estimates). Gradation reports for two types of washed sand were also supplied to Bay West.
- Chris Musson of Bay West corresponded with Kyle Backstrom of SKB Environmental Services/Shamrock Trucking (Shamrock Landfill) located in Cloquet, Minnesota via phone and email on February 10, 2016. The Thomson Reservoir Dredging Alternative scope was discussed and Mr. Backstrom stated that Shamrock Landfill would have capacity to accept the dredge material and could also supply trucking services. No discount for use of sediment as daily cover would likely be given as large quantities of daily cover are already available. A rough estimate cost of $16 per ton for disposal and approximately $100 per hour per 23.5-ton end dump truck was supplied. It is assumed that these costs will be applicable to the slip alternatives.

Appendix B

Technical Analysis

Appendix B – Technical Analysis
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Five remedial alternatives involving monitoring and/or construction activities at Slip C (the Site) were developed and evaluated as part of the Slip C Focused Feasibility Study (FFS) and include the following:

Alternative 1 – No Action;
Alternative 2 – Monitoring and Institutional Controls;
Alternative 3 – Sediment Capping and Armoring;
Alternative 4 – 1 Meter Dredge, Sediment Capping and Armoring; and
Alternative 5 – Dredge with Thin-Layer Cover.

Class 4 rough order of magnitude cost analyses (+50/-30) were developed for each of these alternatives and are summarized within Section 3 of the FFS document. This Technical Analysis serves to provide the calculations and outline the assumptions used to compile each of the alternative cost analyses.

Cost estimates were compiled using a variety of sources. These sources include construction cost data from RSMeans estimating software for open shop pricing in Duluth, Minnesota; current Bay West and state contract rates for labor, equipment, and sample analysis; personal communication with vendors; historic cost data from projects similar in size and scope; other FFS documents, presentations, or technical papers that provided estimated or real construction cost data; and available online vendor pricing of materials.

The selection of construction equipment, production rates, remedial volumes, remedial action areas, and other "design-type" elements used as a starting point to develop alternative costs are based on a current understanding of Site conditions at this early feasibility study-level stage.

This document is divided into the following sections:

Section 1: Remedial Areas and Volumes
Section 2: Construction Equipment and Production Rates
Section 3: Staging Area
Section 4: Construction Implementation Assumptions
Section 5: Environmental Controls and Construction Monitoring
Section 6: Material Transport between Site and Staging Area
Section 7: Sediment Stabilization
Section 8: Dredge Contact Water Treatment
Section 9: Transportation and Disposal
Section 10: Cover/Cap Materials
Section 11: References

The following tables were used to calculate values incorporated into each alternative cost analysis and are included within this Technical Analysis:

Appendix B Table 1: Volume, Rate, and Time Frame Calculations
Appendix B Table 2: Unit Rate Calculations
Appendix B Table 3: Lump Sum Costs
Appendix B Table 4: Monitoring and Evaluation Costs
Appendix B Table 5: Present Value Calculations

Many of the assumptions used to compile the cost analyses for the alternatives are included within the tables. Those aspects of alternative development not readily apparent within the tables and the Slip C FFS text are described in the following sections.

Appendix B – Technical Analysis
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Section 1: Remedial Areas and Volumes

Areas targeted for remedial action (remedial areas) include those with lead and dioxin concentrations exceeding the Midpoint Sediment Quality Target, also referred to as the preliminary cleanup level. Lead is considered the "driving" contaminant of concern for the Site and remedial efforts to address lead are also assumed to address dioxin contamination. Remedial areas are presented in Figure 5 of the Slip C FFS document. Remedial areas were developed based on sample results obtained in 2010 and 2014, bathymetric data, and professional judgement. Remedial areas total 8 acres in size.

Two important factors should be noted regarding the total volume of contaminated sediment calculation:

1. Overburden sediments (i.e., sediments with lead concentrations less than the preliminary cleanup level but located above [vertically] sediments exceeding the preliminary cleanup level) were included within the calculation. Overburden sediments were included because overburden sediments would require consolidation/removal in order to reach contaminated sediments below.
2. The volume of contaminated sediments exceeding the Midpoint Sediment Quality Target was determined using available sample results and data and arc GIS spatial analyst tools.

Additionally, a 0.30-meter (1-foot) over-dredge was assumed over all dredge areas.

Section 2: Construction Equipment and Production Rates

Mechanical means of cap construction were evaluated for the purposes of this FFS as mechanical equipment was assumed to be more readily available and offer a more cost-effective approach for placing small volumes of cap material as compared to hydraulic methods. Additionally, the lack of available nearby upland space in which to stage hydraulic equipment makes hydraulic methods less feasible to implement. The cap construction method evaluated for this FFS includes a barge-mounted long-reach excavator or derrick crane with environmental clamshell bucket. The daily production rate for capping activities was conservatively estimated at 432 cubic yards per day. This rate is derived from the use of a 3-cubic-yard bucket filled 80%, an average cycle time of 3 minutes, and an active placement time frame of 9 hours per day. This rate was developed by modifying the estimated dredge production rate to be more conservative, which uses the same equipment but assumes a 2-minute cycle time. The conservative nature of the production rate was chosen to represent inefficiencies related to a short construction duration (several weeks) and the learning curve associated with equipment use, the increased difficulty of placing sand in multiple thin lifts (to maintain underlying sediment integrity during cap placement) with mechanical equipment, and the potential for debris to be located at the Site.

Mechanical methods for sediment removal were selected over hydraulic methods for the same reasons as outlined above for capping equipment. Additionally, the lack of a nearby confined disposal facility (CDF) or other dewatering facility negates the use of hydraulic dredging methods altogether. The dredging method evaluated for this FFS includes a barge-mounted long-reach excavator or derrick crane with environmental clamshell bucket. The dredging production rate was estimated partially based on U.S. Environmental Protection Agency (USEPA) sediment remediation guidance (USEPA, 2005), which provides production rates for various sizes of mechanical buckets based on an 80% fill and cycle time of 2 minutes. These rates range from 63 cubic yards per hour for smaller buckets to 252 cubic yards per hour for larger buckets. Another source used to determine the dredge production rate was the St. Louis River/Interlake/Duluth Tar (SLRIDT) Data Gap Report (Service, 2002), in which a review of previous projects and discussions with interested parties resulted in a recommended dredge production rate of 50 cubic yards per hour.

Based on these two sources the dredge production rate for the Site was conservatively estimated at 72 cubic yards per hour. A conservative production rate was selected because the amount of debris at the Site is unknown and debris removal was not incorporated into this FFS. This rate assumes a 3-cubic yard bucket filled 80%, a 2-minute cycle time, and an active dredging time frame of 9 hours per day. Dredging downtime is estimated at 3 hours per day to account for morning meetings/safety briefings, startup times, shutdown times, and periods of down time throughout the day. These factors equate to a daily production rate of 650 cubic yards per day.

Section 3: Staging Area

Satellite imagery indicates the presence of a large paved area at the end of Hallett Dock #7, which is appropriately sized for stockpiling materials and stabilizing dredged sediments; therefore, it was assumed for the purposes of the cost analyses that minimal work would be required in order to use Hallett Dock #7 as a staging area for capping and/or dredging operations. The dock end is nearly 500 feet in length and was assumed to be useable for barge mooring and material onloading/offloading in its current condition. Staging area upgrades for alternatives involving only capping would likely include installation of site fencing to protect construction equipment and prevent unauthorized personnel from entering the staging area while the remedy is being implemented. Construction of a lined, bermed, and paved dewatering pad was assumed for the dredging alternative. It is unknown whether access to power is available at Hallett Dock #7; however, due to the short remedial project duration (several weeks), the use of generators to power office trailers, lights, pumps, water treatment operations, etc. was assumed for the cost analysis.

Section 4: Construction Implementation Assumptions

Alternatives with Cover/Cap Elements

A general order of operations was assumed in order to facilitate costing of alternatives involving cover or cap elements. This order of operations was used to assist in selecting construction equipment, labor, production rates, time frames, etc. The general order of operations for cover/cap placement is described below.

- Clean washed sand meeting project specifications would be purchased from a local upland borrow source and imported to the staging area at Hallett Dock #7 via on-road dump trucks during normal daytime working hours. Sand would be dumped at the sand stockpile area at a volume equaling or exceeding the volume of sand placed into Slip 3 on a daily basis.
- During late afternoon or early nighttime hours, the empty transport barge would arrive at the staging area at Hallett Dock #7. An end loader would be used to transfer sand from the sand stockpile area and onto a conveyor to load the transport barge. Once the barge was loaded, the nighttime shift would be complete and the barge would remain moored overnight.
- Early the following morning, the transport barge would travel down river to the Site in time for commencement of daily capping activities.
- A barge-mounted excavator or crane with clamshell bucket would remove capping material from the transport barge and place materials into Slip C throughout the day. A skid loader located on the transport barge will consolidate capping materials as needed.
- Once the transport barge was emptied, cap construction would cease for the day. The transport barge will return to the staging area at Hallett Dock #7 where it would again be loaded during a nighttime shift.

Alternatives with Dredge Elements

A general order of operations was assumed in order to facilitate costing of dredging alternatives. This order of operations was used to assist in selecting construction equipment, labor, production rates, time frames, etc. The general order of operations for dredging alternatives is described as follows:

- Contaminated sediments would be removed using a barge-mounted mechanical dredge with environmental clamshell bucket. An Real Time Kinematic (RTK) Global Positioning System (GPS) system would be used to track the position/cut of the bucket and the dredge's progress.

- Dredged sediment would be immediately placed into an adjacent sediment transport barge. The sediment transport barge would be sufficiently sized to hold an entire days' worth of dredged sediments. Both the dredge barge and sediment transport barge would be repositioned as needed by tug boat.
- After dredging has been completed for the day, the sediment transport barge would travel up-river to the staging area.
- Once moored at the staging area, multiple pumps would be used to rapidly dewater the overlying dredge contact water contained within the barge. A derrick crane would unload the sediments from the barge and place them onto a lined, paved, and bermed sediment dewatering/stabilization pad.
- An end loader would collect the unloaded sediments and mix in amendment material – such as Portland Cement – for dewatering/stabilization. The mixed sediments would be stockpiled for up to several days while stabilization occurs.
- During normal daytime operating hours, an end loader would be used to load on-road dump trucks with stabilized sediment. The trucks would transport the stabilized sediments to an off-site landfill for disposal.
- Water pumped from the transport barge, drained from stabilizing sediments, and precipitation accumulated on the dewatering/stabilization pad would be treated on a batch basis using an on-site treatment plant. Treated water would be discharged to the local publicly owned treatment works (POTW), Western Lake Superior Sanitary District (WLSSD) system.

Other methods of transporting sediments to the pad, such as a rail hopper and conveyor system, and methods of mixing dredged sediments with amendments, such as on-barge mixing, could be used and would be specified during the project design or project bidding phase. The methods outlined above were incorporated into the cost analysis and are assumed appropriate for the volume of material to be handled.

Section 5: Environmental Controls and Construction Monitoring

Environmental controls and construction monitoring are important elements in mitigating environmental impacts occurring as a direct result from construction activities and also in ensuring remedial/construction goals are achieved. Environmental controls can include surface water control structures (e.g., silt curtains, sheet piling, and absorbent boom), lined sediment dewatering pads, tire washes, stormwater controls, and site fencing (for protection of human health). Construction monitoring can include turbidity monitoring during dredging activities, air monitoring during intrusive site activities, treated dredge contact water sampling, post-dredge verification sampling, cap thickness verification coring, bathymetric surveys, imported materials sampling, dewatered sediment sampling, and collection of pre- and post-construction upland soil samples within the staging area footprint. Alternatives involving capping as a remedy would likely require less controls and monitoring than alternatives incorporating dredging.

For the purposes of this FFS, it was assumed that alternatives consisting of capping or cover placement would incorporate the following control and monitoring elements:

- Fencing at the Hallett Dock #7 staging area;
- Chemical and physical sampling of imported cover/cap materials to ensure that they are suitable for use; and
- Cap thickness verification coring and bathymetric surveys to ensure that cap specifications are achieved.

Alternatives consisting of dredging sediments would require controls and monitoring as listed above for cover/cap placement and in addition:

- Hallett Dock #7 staging area fencing, stormwater controls (if applicable), and a lined and bermed dewatering pad;

- Surface water controls;
- Real-time turbidity monitoring;
- Post-dredge verification sampling;
- Dewatered sediment sampling; and
- Treated dredge contact water sampling;

Surface water controls and turbidity monitoring will be particularly important for preventing off-site migration of suspended and potentially contaminated sediments. Surface water control structures evaluated for this FFS include the use of two sets of non-structural barriers, with each set consisting of an oil absorbent boom and a "full height" turbidity/silt curtain anchored to the bed with a permeable fabric at the top 5 feet to accommodate the flow of water across the curtain while isolating suspended sediment. One of the turbidity barriers would be maintained within approximately 15 feet of the dredge. The second turbidity barrier would be placed near the "mouth" of Slip C and would allow for movement of the transport barge in and out of the Site.

Turbidity monitoring would be conducted using real-time cellular monitoring buoys to ensure that potentially contaminated sediments are not being excessively suspended into the water column and transported downgradient during dredging. An allowable concentration of total suspended solids (TSS) above background would be determined during the design phase. A site-specific TSS: turbidity correlation would then be conducted so that a turbidity monitoring value could be established.

Section 6: Material Transport Between Site and Staging Area

In order to limit the frequency and travel time between the sites, the use of a large transport barge was assumed and would be sufficiently sized to hold an entire days' worth of cap materials or dredged sediments. Use of a large transport barge would limit movement of the barge and materials between the sites to two times per day. Costs to transport the barge between the sites were estimated on an hourly basis from values provided within The Great Lakes Towing Company schedule of rates (The Great Lakes Towing Company, 2013).

Section 7: Sediment Stabilization

Sediments mechanically dredged from the Site are expected to have entrained and interstitial water (i.e., dredge contact water) making them unsuitable for direct and/or immediate transportation to an off-site landfill. Therefore, dredged sediments would require dewatering/stabilization in order for them to pass the paint filter test (i.e., essentially no free water) and make them suitable for transportation and disposal. The dewatering/stabilization process would rely upon the addition of amendments to the dredged sediments, along with gravity draining of entrained and interstitial water onto the sediment stabilization pad ("pad").

The pad would be constructed prior to commencement of dredging activities. The pad would be a primary feature of the sediment staging area and must be large enough so that four operations could be conducted on the pad at once. These operations include: offloading dredged sediments from the transport barge and placing them on the pad; end loader or dozer transport of offloaded dredged sediments to a mixing area and subsequent mixing of sediments with an amendment such as Portland Cement; stockpiling of amended sediments for several days if necessary to attain adequate cohesiveness; and loadout of dewatered sediments into on-road dump trucks. The constructed pad would be lined, paved, and bermed to contain contaminated sediments and to facilitate gravity draining of interstitial water and precipitation falling onto the pad into a sump area. Dredge contact water collected in the sump would be pumped into frac tanks (i.e., equalization tanks) and treated. Construction of a 250-foot by 250-foot pad was incorporated into the cost analysis of the dredging alternative.

The dewatering/stabilization process would incorporate the use of binders (i.e., amendments) that generate a cementitious reaction with the available water and solid matrix of the dredged sediments. Common amendments for sediment dewatering/stabilization include Portland Cement, fly ash, lime cement, and lime kiln dusts. These amendments are powdered materials that require enclosed transport and storage systems to reduce dust migration and premature hydration. Some materials, such as fly ash, may be available locally at a substantially reduced cost relative to Portland Cement. For the purposes of this FFS it was assumed that solidification with 15% Portland Cement by volume would be conducted. Pilot scale or treatability studies should be conducted during the design phase to identify desirable amendment materials and amendment rates.

Section 8: Dredge Contact Water Treatment

The construction scenario evaluated for the FFS includes mechanical dredging of sediments into a large transport barge and then barge transport of the dredged sediments to the staging area, 7 miles upstream of the Site. Some of the interstitial water within the dredged sediments will rise to the surface within the transport barge during the day and during transport to the staging area. This water would be pumped from the transport barge and into frac/equalization tanks upon the barge reaching the staging area, after which sediments would be offloaded and placed onto the stabilization pad.

Further gravity dewatering of sediments would occur once placed on the pad. Interstitial water drained from the sediments as well as precipitation accumulated on the pad would gravity drain into a sump. Dredge contact water collected in the sump would be pumped into the frac/equalization tanks and be combined with contact water pumped from the transport barge.

It is estimated that 218 gallons of water will be generated per bucket of sediment dredged assuming a 3-cubic yard bucket, 80% fill, and 20% by volume entrained and interstitial water content. It is estimated that 270 buckets of sediment will be dredged on a daily basis assuming a 2-minute cycle time and an active dredging duration of 9 hours per day. This equates to a total daily dredge contact water generation of approximately 59,000 gallons.

Treatment of dredge contact water would likely occur on a batch basis. Treatment over a 10-hour duration would require a system capable of treating at a rate of approximately 100 gallons per minute.

The cost analysis for treatment of dredge contact water includes rental rates for equipment, costs for procuring media and filters, disposal costs of media and filters, and labor. A per-gallon-treated unit cost was calculated by summing total daily operating costs by the volume of water treated in a single day (59,000 gallons). Costs were obtained from a contractor quote provided for a different project but relevant to the scale of dredging activities evaluated for the Site.

Section 9: Transportation and Disposal

Transportation costs for sediment disposal were estimated on a per ton basis using truck rental and operator rate data obtained from RSMeans cost estimating software. It was assumed that each truck would carry 12 tons or 16 cubic yards (1.4 tons per cubic yard) and would complete 1 round trip per hour and 7 round trips per day. Correspondence with local landfill and sand and gravel companies indicate that transportation costs could be less than the $13.90 per cubic yard or $9.93 per ton estimated rate, but the estimated rate was retained within the cost estimates to provide a conservative scenario.

Disposal costs were obtained for the Vonco V Waste Management Campus (obtained during compilation of the Minnesota Slip Feasibility Study) located at 1100 West Gary Street in Duluth, Minnesota (approximately 12 miles west of the Site) and Shamrock Environmental Landfill located at 761 Highway 45 in Cloquet, Minnesota (approximately 20 miles west of the Site). Costs for these two disposal facilities were comparable for the purposes of this FFS, at $12 per ton and $16 per ton (not including environmental fees and taxes) respectively. The Vonco V landfill was used for the cost analysis due to its closer proximity to the Site.

The final volume of sediments requiring disposal will be a result of in situ volume, bulking of sediments as they are dredged and handled, and the addition of stabilizing agents during the dewatering process. For the purposes of this FFS, sediment bulking was assumed at 10% and amendment addition was assumed at 15% by volume. An average density of 1.4 tons per cubic yard was assumed for dredged and stabilized sediment.

Section 10: Cover/Cap Materials

Potential sources of cover/cap materials include materials from an upland borrow location (e.g., sand and gravel pit), sediments previously dredged for navigational purposes, and common earth upland soil. Natural materials such as dredged sediments and common earth upland soils often contain fine-grained components which make placement more difficult (ITRC, 2014). It was assumed for the purposes of the cost analyses that upland borrow materials would be used as no apparent source of dredged materials is readily available near the Site. Upland borrow material consisting of clean, washed sand was assumed for alternatives incorporating sand cover or cap elements. The exact grain size specifications would be developed during the design phase but would likely consist of medium to coarse grain sands that would withstand mild erosive forces in the slip. Cobble obtained from an upland borrow location was also assumed for alternatives requiring cap armor.

For the sand cover and sand cap alternatives, it was assumed that sand will be purchased from an upland borrow location and loaded into trucks at a rate of $6.90 per CY based on pricing procured from a local supplier. Rip rap or cobbles used as armor over cap materials was estimated at $30.38 per cubic yard based on available online pricing. Assumptions used for importing materials to the site were the same as those for transportation and disposal of dewatered sediments, as described in **Section 9**.

Section 11: References

USEPA, 2005. “Contaminated Sediment Remediation Guidance for Hazardous Waste Sites.”

Interstate Technology and Regulatory Council (ITRC) Contaminated Sediments Team, 2014. “Contaminated Sediments Remediation – Remedy Selection for Contaminated Sediments,” August.

Appendix B: Table 1
Volume, Rate, and Timeframe Calculations
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Volume of Sediment Exceeding Midpoint SQT			
Area exceeding Midpoint SQT (acres)	6.4		
Estimated depth of contamination (feet)	4.36	1.33 (meter)	
Volume of contamination (cubic yards)	106,101		
Cap/Cover Volumes			
Alternative 3: Cap and Armor			
Remedial area (acres)	6.4		
BAZ thickness (feet)	1.64	0.5 (meter)	
IZ thickness or "mixing layer" (feet)	0.49	0.15 (meter)	
Total volume of sand (cubic yards)	21,993		
Armored area (acres)	6.40	(armor entire area of cap, all actively used)	
Armored depth (feet)	1.0	0.30 (meter)	
Total armor volume (cubic yards)	10,119		
Alternative 4: 1 Meter Dredge, Cap and Armor			
Remedial area (acres)	6.40		
BAZ thickness (feet)	1.64	0.5 (meter)	
IZ thickness or "mixing layer" (feet)	0.49	0.15 (meter)	
Total volume of sand (cubic yards)	21,993		
Armored area (acres)	6.40	(armor entire area of cap, all actively used)	
Armored depth (feet)	1.0	0.3 (meter)	
Total armor volume (cubic yards)	10,119		
Alternative 5: Dredge			
Remedial area (acres)	6.40		
Cover thickness (feet)	0.49	0.15 (meter)	
Total volume of sand (cubic yards)	5,059		
Dredge, Transport, and Disposal Volumes			
Alternative 4: 1 Meter Dredge, Cap, and Armor			
Contaminated sediment volume (cubic yards)	33867		Assume no over dredge (6.40 acres x 1 meter)
Over-dredge depth (feet)	0	0 (meter)	
Over-dredge volume (cubic yards)	0		
Total dredge volume (cubic yards)	33,867		
10% by volume bulking factor (cubic yards)	3387		
15% by volume solidification agent (cubic yards)	5080		
Transport/Disposal volume (cubic yards)	42,334		
Transport/Disposal weight (tons)	59,267		
Alternative 5: Dredge			
Contaminated sediment volume (cubic yards)	106101		
Over-dredge depth (feet)	0.98	0.3 (meter)	
Over-dredge volume (cubic yards)	9091		
Total dredge volume (cubic yards)	115,192		
10% by volume bulking factor (cubic yards)	11519		
15% by volume solidification agent (cubic yards)	17279		
Transport/Disposal volume (cubic yards)	143,990		
Transport/Disposal weight (tons)	201,586		
Dredge Production Rate			
Bucket size (cubic yards)	3.0		
Percent fill	80		
Sediment per bucket (cubic yards)	2.4		
Minutes per cycle	2.0		
Active dredging duration per day (hours)	9.0		
Daily production (cubic yards)	648		
Cover/Cap Production Rate			
Bucket size (cubic yards)	3.0		
Percent fill	80		
Sediment per bucket (cubic yards)	2.4		
Minutes per cycle	3.0		
Active dredging duration per day (hours)	9.0		
Daily production (cubic yards)	432		

Dredge Contact Water Generation			
Conversion: 1 cubic yard equals 202 fluid gallons			
Bucket size (cubic yards)	3.0		
Percent fill	80		
Sediment per bucket (gallons)	485		
Entrained and free water at 20% by volume (gallons)	97		
Surface water in bucket (gallons)	121		
Total water per bucket (gallons)	218		
Dredge Contact Water Treatment Volume			
Alternative 4: 1 Meter Dredge, Cap, and Armor			
Water generated per bucket (gallons)	218		
Buckets per day	270		
Total volume of water generated per day (gallons)	58,903		
Treatment timeframe per day (hours)	10		
Treatment rate (gallons per minute)	98		
Total volume of water generated per day (gallons)	58903		
Dredging duration (days)	53		
Total project duration volume (gallons)	3,121,870		
Alternative 5: Dredge			
Water generated per bucket (gallons)	218		
Buckets per day	270		
Total volume of water generated per day (gallons)	58,903		
Treatment timeframe per day (hours)	10		
Treatment rate (gallons per minute)	98		
Total volume of water generated per day (gallons)	58903		
Dredging duration (days)	178		
Total project duration volume (gallons)	10,484,770		
Construction Timeframe			
Alternative 3: Cap and Armor			
Construct staging area and mobilize/setup equipment (days)	5		Fencing, signs, office trailers
Implement construction (days)	85		10 days leveling, 60 days capping
Breakdown equipment/demobilize and site restoration (days)	5		
Total time on-site (days)	95		
	14	weeks	assume working everyday of the week
Alternative 4: 1 Meter Dredge, Cap and Armor			
Construct staging area and mobilize/setup equipment (days)	8		
Dredge	53		
Construct cap	51		
Place armor	24		
Breakdown equipment/demobilize and site restoration (days)	8		
Total time on-site (days)	144		
	21	Weeks	assume working everyday of the week
Alternative 5: Dredge			
Construct staging area, mobilize and setup equipment	10		
Dredge sediments (days)	178		
Construct thin-layer cover (days)	12		
Breakdown equipment/demobilize and site restoration (days)	10		Assume dewatering pad left in place
Total time on-site (days)	210		
	30	Weeks	assume working everyday of the week

Appendix B: Table 2
Unit Rate Calculations
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Dredge Sediments					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Equipment					
Derrick crane or large long-reach excavator	Day	$2,656.44	1	$2,656	
3 - 5 cubic yard bucket	Day	$70.00	1	$70	
RTK DGPS for dredge	Day	$190.00	1	$190	
Dredge barge	Day	$355.00	1	$355	
Dredge barge tug	Day	$1,168.41	1	$1,168	
Survey vessel with GPS and survey	Day	$792.77	1	$793	
Labor					
On-site project management	Day	$1,200.00	1	$1,200	
Foreman	Day	$854.00	1	$854	
Surveyor	Day	$1,020.00	1	$1,020	
Mechanic	Day	$980.00	1	$980	
Derrick crane (dredge) operator	Day	$1,106.00	1	$1,106	
Dredge hand	Day	$812.00	1	$812	
Laborer	Day	$812.00	1	$812	
Lodging and Per-Diem	Day	$146.00	7	$1,022	7 laborers
			TOTAL	$13,038	
			DAILY PRODUCTION (CY)	648	
			UNIT RATE (CY)	$20.12	

Barge Dredged Sediment to Staging Area					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Transport barge	Day	$827.00	1	$827	
Transport services	Day	$7,545.00	1	$7,545	14 miles round trip; 2 hours per trip; after hours tug charge
			TOTAL	$8,372	
			DAILY PRODUCTION (CY)	648	
			UNIT RATE (CY)	$12.92	

Sediment Offloading and Solidification					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Equipment & Materials					
Offload crane	Day	$466.00	1	$466	
Clamshell bucket	Day	$70.00	1	$70	
Loader	Day	$985.00	1	$985	Used during two shifts
Lights	Unit	$99.16	8	$793	four on pad; four on barge
Storage silo	Day	$100.00	1	$100	
Portland cement	Tons	$120.00	54.4	$6,532	6 percent by weight; sediment 1.4 tons per cubic
			SUBTOTAL	$8,946	
Labor					
Crane operator (night shift)	Hour	$79.00	8	$632	
Loader operator (night shift)	Hour	$79.00	8	$632	
Loader operator (day shift)	Hour	$79.00	8	$632	Load trucks with stabilized sediment
Laborer (day shift)	Hour	$58.00	8	$464	Load trucks with stabilized sediment
Lodging, per-diem, mileage	Day	$168.00	4	$672	4 laborers
			SUBTOTAL	$3,032	
			TOTAL	$11,978	
			DAILY PRODUCTION (CY)	648	
			UNIT RATE (CY)	$18.48	

Sediment Hauling and Landfill Disposal					
Transport sediments to landfill	Ton	$9.93	1	$9.93	
Dispose of sediments at landfill					Vonco V Landfill in Duluth
Disposal	Ton	$12.00	1	$12.00	
Environmental Fee	Ton	$0.27	1	$0.27	
Industrial Solid Waste Tax	Ton	$0.46	1	$0.46	
			UNIT RATE (TON)	$22.66	

Water Treatment					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Equipment	Day	$1,140.00	1	$1,140.00	
Materials	Day	$1,253.81	1	$1,253.81	
Disposal	Day	$612.38	1	$612.38	Cost distributed over 1 month (21 working days) of treatment
Plant operator	Day	$980.00	1	$980.00	
Plant laborer	Day	$812.00	1	$812.00	
Labor, per-diem, and mileage	Day	$168.00	2	$336.00	Two laborers
			TOTAL	$5,134	
			DAILY PRODUCTION (Gal.)	58903.2	
			UNIT RATE (Gal.)	$0.08716	
			WLSSD FEE (Gal.)	$0.00103	
			COMBINED UNIT RATE (Gal.)	$0.08819	

Appendix B: Table 2
Unit Rate Calculations
Focused Feasibility Study
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Purchase and Import Cap Material					
Purchase sand from upland borrow source	CY	$6.90	1	$6.90	
Import sand to staging area	CY	$13.90	1	$13.90	40 mile cycle; 15 minute wait
			UNIT RATE (CY)	$20.80	
Purchase and Import Armor Material					
Purchase rip rap from upland borrow source	CY	$30.38	1	$30.38	
Import rip rap to staging area	CY	$13.90	1	$13.90	40 mile cycle; 15 minute wait
			UNIT RATE (CY)	$44.28	
Barge Materials to Slip C					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Transport barge	Day	$827.00	1	$827	
Transport services	Day	$7,545.00	1	$7,545	14 miles round trip; 2 hours per trip; after hours charge
			TOTAL	$8,372	
			DAILY PRODUCTION (CY)	432	
			UNIT RATE (CY)	$19.38	
Place Cover/Cap					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Equipment					
Derrick crane (place)	Day	$466.00	1	$466	
3 - 5 cubic yard bucket (place)	Day	$70.00	1	$70	
RTK DGPS for Derrick crane	Day	$190.00	1	$190	
Derrick barge	Day	$684.00	1	$684	
Derrick barge tug	Day	$1,168.41	1	$1,168	
Skid loader (consolidate barge materials)	Day	$366.00	1	$366	
Survey vessel with GPS and survey	Day	$792.77	1	$793	
End loader (load)	Day	$1,265.00	1	$1,265	
Conveyor (load)	Day	$508.00	1	$508	
Labor					
On-site project management	Day	$1,200.00	1	$1,200	
Foreman	Day	$854.00	1	$854	
Surveyor	Day	$1,020.00	1	$1,020	
Mechanic	Day	$980.00	1	$980	
Derrick crane operator	Day	$1,106.00	1	$1,106	
Dredge hand	Day	$812.00	1	$812	
Laborer (trucks)	Day	$812.00	1	$812	
Laborer (conveyor)	Day	$1,106.00	1	$1,106	
End loader operator	Day	$1,106.00	1	$1,106	
Lodging and Per-Diem	Day	$13.10	9	$118	
			TOTAL	$14,624	
			DAILY PRODUCTION (CY)	432	
			UNIT RATE (CY)	$33.85	
Place Armor					
Same cost as place cover/cap	Day	$14,624	1	$14,624.00	
			DAILY PRODUCTION (CY)	432	
			UNIT RATE (CY)	$33.85	
Construction Quality Assurance					
Description	Unit	Unit Cost	Quantity	Extended	Comments
QA/QC and federal oversight personnel	Week	$10,200.00	1	$10,200	Two staff
Lodging and per-diem	Week	$1,460.00	1	$1,460	Two staff
Truck and mileage	Week	$1,142.00	1	$1,142	Includes mileage
Boat and sampling/monitoring equipment	Week	$663.00	1	$663	1 boat and equipment set
Turbidity monitoring buoys and software	Week	$500.00	1	$500	Two buoys
Air monitoring equipment	Week	$800.00	1	$800	4 monitoring stations
			UNIT COST (WEEK)	$15,000	Rounded
Monthly Operating Expenses and Site Security					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Field Offices					
Office trailers and storage boxes (3)	Month	$942.00	3	$3,888.00	Includes utilities, equipment, and supplies for three units
Security Guard	Month	$17,280.00	1	$17,280.00	$40 per hour; 108 hours per week
			UNIT RATE (MONTH)	$21,000	Rounded

Appendix B: Table 3
Lump Sum Costs
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Description	Unit	Unit Cost	Quantity	Extended	Comments
Lump Sum Costs - Alternative 1: No Action					
No lump sum costs associated with Alternative 1.					
Lump Sum Costs - Alternative 2: Long-Term Monitoring and Institutional Controls					
No lump sum costs associated with Alternative 2.					
Lump Sum Costs - Alternative 3: Cap & Armor					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Mobilization/Demobilization					
Office trailers (3) and connex boxes to staging area	Mile	$12.26	240	$2,942	Within 20 miles of site
End loader to staging area	Each	$957.00	2	$1,914	Hauled on 40-ton trailer; within 20 miles of site
Hopper and conveyor to staging area	Each	$957.00	2	$1,914	Hauled on 40-ton trailer; within 20 miles of site
Capping material transport barge to slip (water mob)	Hour	$1,634.00	8	$13,072	Assume 4 hour mob and 4 hour demob
Transport barge skid loader to staging area	Each	$789.00	2	$1,578	Hauled on 20-ton trailer; within 20 miles of site
Capping barge and derrick crane (water mob)	Hour	$1,634.00	8	$13,072	Assume 4 hour mob and 4 hour demob
Survey vessel with GPS and survey to staging area	Each	$283.00	2	$566	
Dredge barge tug to staging area	Each	$957.00	2	$1,914	
Additional mileage for non-local equipment	Mile	$2.52	1000	$2,520	Assume 2 items (tug, survey vessel); 250 miles away
Work trucks to staging area	Mile	$0.56	1500	$840	3 work trucks, 250 miles one way
Install staging area fencing	LF	$5.39	1500	$8,085	Install fencing around staging area perimeter
Staging area setup/breakdown	Day	$14,624.00	4	$58,496	Setup/breakdown staging area; 2 days each
Capping equipment setup and breakdown	Day	$14,624.00	6	$87,744	Setup/breakdown equipment; 3 days each
				$195,000	Rounded
Level/Slope sediment prior to capping	Day	$14,624.00	10	$146,000.00	Assume 10 days
Construction Monitoring/CQA Sample Analysis					
Imported materials sampling	Lump Sum	$0.00	1	$0	Labor included in Construction Quality Assurance
Grain Size (ASTM D422 w/ Hydrometer)	Sample	$375.00	20	$7,500	One sample every 1,000 CY or 3 samples minimum (20000 cubic yards sand)
VOCs (EPA 8260B)	Sample	$65.00	20	$1,300	One sample every 1,000 CY or 3 samples minimum
SVOCs (8270D)	Sample	$165.00	20	$3,300	One sample every 1,000 CY or 3 samples minimum
RCRA Metals	Sample	$70.00	20	$1,400	One sample every 1,000 CY or 3 samples minimum
PCBs (EPA 8082A)	Sample	$60.00	20	$1,200	One sample every 1,000 CY or 3 samples minimum
MN Dept. of Ag List 2 Pesticides (EPA 8270D M)	Sample	$165.00	20	$3,300	One sample every 1,000 CY or 3 samples minimum
Sand Cover Thickness Verification	Lump Sum	$0.00	1	$0	Labor included in Construction Quality Assurance
				$18,000	
Lump Sum Costs - Alternative 4: 1 Meter Dredge, Cap and Armor					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Mobilization/Demobilization					
Costs from Alternative 3 above	Lump Sum	$195,000.00	1	$195,000	Alternative 3: Mob cap costs
Additional costs from Alternative 5 below	Lump Sum	$156,734.00	1	$156,734	Alternative 5: Mob dredge costs
			TOTAL	$351,734	
Repair Dock Wall	LF	$3,500.00	360	$1,260,000	Repair up to 360' of dock wall (20% of wall in construction area)
Construct Staging Area					
Costs from Alternative 5 Below	Lump Sum	$285,788.55	1	$285,789	Alternative 5: Construct Staging Area costs
Construction Monitoring/CQA Sample Analysis					
Costs from Alternative 3 above	Lump Sum	$18,000.00	1	$18,000	Alternative 3: Construction Monitoring/CQA Sample Analysis
Dredge Contact Water Treatment					
TSS (SM 2540 D)	Sample	$14.00	14	$196	Sampled twice per week (7 weeks)
Select Metals* (EPA 6020A/7471B)	Sample	$134.00	14	$1,876	Sampled twice per week
Low-level Mercury	Sample	$85.00	14	$1,190	Sampled twice per week
Dewatered Sediment Samples					
TCLP metals* (EPA 6020A/7471B)	Sample	$110.00	31	$3,410	One sample every 1,000 cubic yards (30,000 cubic yards)
TCLP semivolatiles (EPA 8270D/1311)	Sample	$200.00	31	$6,200	One sample every 1,000 cubic yards
Flash Point	Sample	$10.00	31	$310	One sample every 1,000 cubic yards
pH (EPA 9045)	Sample	$10.00	31	310	One sample every 1,000 cubic yards
Paint Filter	Sample	$10.00	31	$310	One sample every 1,000 cubic yards
DRO w/ Silica Gel Cleanup (WI DRO)	Sample	$45.00	31	$1,395	One sample every 1,000 cubic yards
GRO (WI GRO)	Sample	$22.00	31	$682	One sample every 1,000 cubic yards
			TOTAL	$33,879	Rounded
Lump Sum Costs - Alternative 5: Dredge					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Mobilization/Demobilization					
Office trailers (3) and connex boxes to staging area	Mile	$12.26	240	$2,942	Within 20 miles of site
Dredge barge and derrick crane (water mob)	Hour	$1,634.00	8	$13,072	Assume 4 hour mob and 4 hour demob of units within
Sediment transport barge to slip (water mob)	Hour	$1,634.00	8	$13,072	Assume 4 hour mob and 4 hour demob
Offload crane to staging area	Each	$2,796.00	2	$5,592	Hauled on 50-ton trailer; within 20 miles of site
Survey vessel with GPS and survey to staging area	Each	$283.00	2	$566	Towed behind work truck on 3 ton trailer
End Loader to staging area	Each	$957.00	2	$1,914	Hauled on 40-ton trailer; within 20 miles of site
Telehandler to staging area	Each	$957.00	2	$1,914	Hauled on 40-ton trailer; within 20 miles of site
Work trucks to staging area	Mile	$0.56	1500	$840	3 work trucks, 250 miles one way
Hopper and conveyor to staging area	Each	$957.00	2	$1,914	Hauled on 40-ton trailer; within 20 miles of site
Additional mileage for non-local equipment	Mile	$2.52	1000	$2,520	Assume 2 items (tug, survey vessel); 250 miles away
Dredge equipment setup and breakdown	Day	$13,038	6	$78,228	Setup/breakdown equipment; 3 days each
Water treatment equipment	Lump Sum	$71,000	1	$71,000	
			TOTAL	$194,000	Rounded
Repair Dock Wall	LF	$3,500.00	360	$1,260,000	Repair up to 360' of dock wall (20% of wall in construction area)

Appendix B: Table 3
Lump Sum Costs
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Construct Staging Area					
Construct sediment stabilization pad					250 feet by 250 feet stabilization pad
Rough grade pad area	100,000 ft^2	$4,801.00	0	$0	
Haul aggregate base course	CY	$5.56	1157	$6,430	
Place 6-inch aggregate base course	SY	$5.17	6944	$35,903	
Fine grade aggregate base course for drainage	SY	$0.50	6944	$3,472	
Install geotextile below and above geomembrane	SY	$2.10	13889	$29,167	
Install geomembrane liner (HDPE, 40 - 120 mil)	SF	$0.60	62500	$37,500	
Haul binder and paving courses	CY	$8.33	675	$5,626	
Lay binder course	SY	$9.51	6944	$66,042	
Pave	SY	$8.03	6944	$55,764	
Install bunker blocks around perimeter	LF	$504.00	75	$37,800	
Construct site fencing	LF	$5.39	1500	$8,085	
				$285,789	
Imported materials sampling	Lump Sum	$0.00	1	$0	Labor included in Construction Quality Assurance
Grain Size (ASTM D422 w/ Hydrometer)	Sample	$375.00	5	$1,875	One sample every 1,000 CY or 3 samples minimum (4500 cubic yards)
VOCs (EPA 8260B)	Sample	$65.00	5	$325	One sample every 1,000 CY or 3 samples minimum
SVOCs (8270D)	Sample	$165.00	5	$825	One sample every 1,000 CY or 3 samples minimum
RCRA Metals	Sample	$70.00	5	$350	One sample every 1,000 CY or 3 samples minimum
PCBs (EPA 8082A)	Sample	$60.00	5	$300	One sample every 1,000 CY or 3 samples minimum
MN Dept. of Ag List 2 Pesticides (EPA 8270D M)	Sample	$165.00	5	$825	One sample every 1,000 CY or 3 samples minimum
Turbidity Monitoring	Lump Sum	$0.00	1	$0	Labor included in Construction Quality Assurance
Post-Dredge Verification Sampling	Lump Sum	$0.00	1	$0	Labor included in Construction Quality Assurance
	Sample	$70.00	126	$8,820	One sample every 2500 square feet; plus dups (5% of samples) ; plus 2 (250500 ft2)
Sand Cover Thickness Verification	Lump Sum	$0.00	1	$0	Labor included in Construction Quality Assurance
Dredge Contact Water Treatment					
TSS (SM 2540 D)	Sample	$14.00	37	$518	Sampled twice per week (19 weeks)
Select Metals* (EPA 6020A/7471B)	Sample	$134.00	37	$4,958	Sampled twice per week
Low-level Mercury	Sample	$85.00	37	$3,145	Sampled twice per week
Dewatered Sediment Samples					
TCLP metals* (EPA 6020A/7471B)	Sample	$110.00	84	$9,240	One sample every 1,000 cubic yards (83304 cubic yards)
TCLP semivolatiles (EPA 8270D/1311)	Sample	$200.00	84	$16,800	One sample every 1,000 cubic yards
Flash Point	Sample	$10.00	84	$840	One sample every 1,000 cubic yards
pH (EPA 9045)	Sample	$10.00	84	$840	One sample every 1,000 cubic yards
Paint Filter	Sample	$10.00	84	$840	One sample every 1,000 cubic yards
DRO w/ Silica Gel Cleanup (WI DRO)	Sample	$45.00	84	$3,780	One sample every 1,000 cubic yards
GRO (WI GRO)	Sample	$22.00	84	$1,848	One sample every 1,000 cubic yards
			TOTAL	$56,129	

Turbidity Controls					
Description	Unit	Unit Cost	Quantity	Extended	Comments
Turbidity curtain, 30' x 250'	SF	$4.97	15000	$74,475	Two curtains
Oil absorbent boom	LF	$3.13	0	$0	No booms - COC is lead
Oil absorbent boom disposal	LF	$2.50	0	$0	
Anchors	Each	$150.00	4	$600	
Markers	Each	$100.00	2	$200	
			TOTAL	$75,000	Rounded

Appendix B: Table 4
Monitoring Elements
Focused Feasibility Study
Slip C
Minnesota Pollution Control Agency

Monitoring and Evaluation Costs - Alternative 1: No Action

No monitoring and evaluation costs associated with Alternative 1.

Monitoring and Evaluation Costs - Alternative 2: Long-Term Monitoring and Institutional Controls

Monitoring Elements	Unit	Cost	Extended	Total	Comment
Monitoring and Evaluation Report	Each	$4,000.00	7	$28,000	Every 5 years for 30 years
Field Sampling	Event	$34,000.00	7	$238,000	Every 5 years for 30 years
Sample Analysis	Event	$52,338.00	7	$366,366	Every 5 years for 30 years
Lead (EPA 6020A)	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Cadmium	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Copper	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Nickel	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Zinc	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Mercury	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
PAHs	*Sample*	*$70.00*	*43*	*$3,010.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
PCBs	*Sample*	*$60.00*	*43*	*$2,580.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Dioxin/Furans (8290A)	*Sample*	*$595.00*	*20*	*$11,900.00*	*20 locations; 2 intervals (composite samples); includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Grain Size (ASTM D422 w/ Hydrometer)	*Sample*	*$375.00*	*5*	*$1,875.00*	*Needed for tox/bio*
TOC Quad Burn (EPA 9060A)	*Sample*	*$105.00*	*5*	*$525.00*	*Needed for tox/bio*
10-d toxicity C. tenants	*Sample*	*$1,638.00*	*5*	*$8,190.00*	*5 locations*
28-d toxicity H. azteca	*Sample*	*$2,013.00*	*5*	*$10,065.00*	*5 locations*
28-d bioaccumulation	*Sample*	*$2,013.00*	*5*	*$10,065.00*	*5 locations*
				$52,338.00	*Rounded*
Bathymetric Survey	Each	$10,000.00	7	$70,000	Every 5 years for 30 years
Institutional Control Review	Each	$1,500.00	7	$10,500	Every 5 years for 30 years
				$713,000	Rounded

Monitoring and Evaluation Costs - Alternative 3: Cap

Monitoring Elements	Unit	Cost	Extended	Total	Comment
Monitoring and Evaluation Report	Each	$4,000.00	6	$24,000	Every 5 years for 30 years
Field Sampling	Event	$34,000.00	6	$204,000	Every 5 years for 30 years
Sample Analysis	Event	$21,618.00	6	$129,708	Every 5 years for 30 years
Lead (EPA 6020A)	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups*
Cadmium	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Copper	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Nickel	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Zinc	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Mercury	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
PAHs	*Sample*	*$70.00*	*43*	*$3,010.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
PCBs	*Sample*	*$60.00*	*43*	*$2,580.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Dioxin/Furans (8290A)	*Sample*	*$595.00*	*20*	*$11,900.00*	*20 locations; 2 intervals (composite samples); includes 3 dups*
Cap thickness checks	*Lump Sum*	*$0.00*	*1*	*$0.00*	*Cost included in labor and equipment*
				$21,618.00	*Rounded*
Bathymetric Survey	Each	$10,000.00	6	$60,000	Every 5 years for 30 years
Institutional Control Review	Each	$1,500.00	6	$9,000	Every 5 years for 30 years
				$427,000	Rounded

Monitoring and Evaluation Costs - Alternative 4: 1 Meter Dredge, Cap and Armor

Monitoring Elements	Unit	Cost	Extended	Total	Comment
Monitoring and Evaluation Report	Each	$4,000.00	6	$24,000	Every 5 years for 30 years
Field Sampling	Event	$34,000.00	6	$204,000	Every 5 years for 30 years
Sample Analysis	Event	$21,618.00	6	$129,708	Every 5 years for 30 years
Lead (EPA 6020A)	*Sample*	*$16*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups*
Cadmium	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Copper	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Nickel	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Zinc	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Mercury	*Sample*	*$16.00*	*43*	*$688.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
PAHs	*Sample*	*$70.00*	*43*	*$3,010.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
PCBs	*Sample*	*$60.00*	*43*	*$2,580.00*	*20 locations; 2 intervals; includes 3 dups (70% more samples than Slip 3, 70% larger area)*
Dioxin/Furans (8290A)	*Sample*	*$595.00*	*20*	*$11,900.00*	*20 locations; 2 intervals (composite samples); includes 3 dups*
Cap thickness checks	*Lump Sum*	*0*	*1*	*$0.00*	Cost included in labor and equipment
				$21,618.00	Rounded
Bathymetric Survey	Each	$10,000.00	6	$60,000	Every 5 years for 30 years
Institutional Control Review	Each	$1,500.00	6	$9,000	Every 5 years for 30 years
				$427,000	Rounded

Monitoring and Evaluation Costs - Alternative 5: Dredge

No monitoring and evaluation costs associated with Alternative 5.

Appendix B: Table 4
Monitoring Elements
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Field Sampling Event					
Description	Unit	Cost	Extended	Total	
Project Management	Hour	$115.00	30	$3,450.00	Project coordination
Scientist II	Hour	$84.00	10	$840.00	Field event planning and coordination
QA/QC	Hour	$94.00	20	$1,880.00	Chemical, tox/bio, tissue results
Field Sampling					
Field Labor	Person	$4,452.00	4	$17,808.00	5 hours meetings; 40 hr sampling; 8 hr mob/demob
Truck	Day	$75.00	10	$750.00	2 trucks; boat and office trailer
Mileage	Mile	$0.57	750	$423.75	
Pontoon	Day	$200.00	5	$1,000.00	
Vibracore rental	Lump Sum	$2,500.00	1	$2,500.00	Includes freight
Disposables	Lump Sum	$1,500.00	1	$1,500.00	Vibracore tubing
Office trailer	Day	$75.00	5	$375.00	
GPS	Day	$75.00	5	$375.00	
Generator	Day	$45.00	5	$225.00	
Drum	Each	$105.00	2	$210.00	
Sediment bundle	Day	$65.00	5	$325.00	
Fuel	Lump Sum	$50.00	1	$50.00	
IDW Disposal	Lump Sum	$250.00	1	$250.00	
Lodging	Night	$100.00	16	$1,600.00	
Per-Diem	Day	$35.00	20	$700.00	
			TOTAL	$34,000.00	Rounded

Bathymetric Survey Break-Down					
Parameter	Unit	Cost	Extended	Total Cost	Comment
Daily labor cost					
Scientist III	Hour	$109	16	$1,744	Prep equipment; mob/demob; perform survey
Field Tech II	Hour	$64	16	$1,024	Prep equipment; mob/demob; perform survey
Lodging	Night	$100	2	$200	1 night each
Per-diem	Day	$36	4	$144	2 days each
Daily equipment cost					
Boat	Day	$200	2	$400	
Fuel	Day	$25	1	$25	
Multi-beam survey equipment	Day	$1,500	2	$3,000	
GPS	Day	$75	2	$150	
Truck	Day	$75	2	$150	
Mileage	Mile	$0.56	350	$196	
Data reduction/mapping	Hour	$109	20	$2,180	
GIS	Hour	$64	10	$640	
			TOTAL	$10,000	Rounded

Appendix B: Table 5
Present Value Calculations
Focused Feasibility Study
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Discount rate used for present worth calculations: 7.00%
Present worth calculation is: [(2016 Cost)/(1.07^Event Year 1)]+[(2016 Cost)/(1.07^Event Year 2)]+…
Year 0 is 2016.

Alternative 1: No Action	2016 Costs	Years						Total Present Worth	Note
No Costs Associated with this Alternative									

Alternative 2: Monitoring and Institutional Controls	2016 Costs	Years						Total Present Worth	Note
Implementation									
Implementation Plan Report	$11,000	0						$11,000	
Investigate Applicability of Meal Guidelines to Lead	$0	0						$0	
Monitoring and Evaluation Costs									
Monitoring and Evaluation Report	$4,000	5	10	15	20	25	30	$12,631	
Field Sampling	$34,000	5	10	15	20	25	30	$107,366	
Sample Analysis	$52,338	5	10	15	20	25	30	$165,274	
Bathymetric Survey	$10,000	5	10	15	20	25	30	$31,578	
Institutional Controls Site Review	$1,500	5	10	15	20	25	30	$4,737	

Alternative 3: Cap & Armor	2016 Costs	Years						Total Present Worth	Note
Construction Costs									
Mobilization/Demobilization	$195,000	0						$195,000	
Relocation of Dock Tentant During Construction	$40,000	0						$40,000	
Purchase Sand and Import to Staging Area	$457,000	0						$457,000	
Purchase Armoring Materials and Import to Staging Area	$448,000	0						$448,000	
Level/Slope Sediment Prior to Capping	$146,000	0						$146,000	
Barge Cover/Cap Materials to Slip	$622,000	0						$622,000	
Construct Cover/Cap	$745,000	0						$745,000	
Construct Armoring Layer	$343,000	0						$343,000	
Construction Monitoring/CQA and Oversight	$210,000	0						$210,000	
Sample Analysis	$18,000	0						$18,000	
Monthly Operating Expenses and Site Security	$53,000	0						$53,000	
Implement Institutional Controls	$25,000	0						$25,000	
Long-Term Monitoring									
Monitoring and Evaluation Report	$4,000	5	10	15	20	25	30	$8,631	
Field Sampling	$34,000	5	10	15	20	25	30	$73,366	
Sample Analysis	$21,618	5	10	15	20	25	30	$46,648	
Bathymetric Survey	$10,000	5	10	15	20	25	30	$21,578	
Institutional Control Review	$1,500	5	10	15	20	25	30	$3,237	
Professional and Technical Services									
Remedial Design (6%)	$ 280,000	0						$280,000	
Project Management and Permitting (5%)	$ 233,000	0						$233,000	
Construction Management (6%)	$ 280,000	0						$280,000	

Appendix B: Table 5
Present Value Calculations
Focused Feasibility Study
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Alternative 4: 1 Meter Dredge, Cap and Armor	**2016 Costs**	**Years**						**Total Present Worth**	**Note**
Construction Costs									
Mobilization/Demobilization	$352,000	0						$352,000	
Construct Staging Area	$286,000	0						$286,000	
Relocation of Dock Tentant During Construction	$40,000	0						$40,000	
Mechanically Dredge Sediments	$681,000	0						$681,000	
Turbidity Controls	$75,000	0						$75,000	
Barge Dredged Sediments to Staging Area	$438,000	0						$438,000	
Sediment Offloading and Stabilization	$626,000	0						$626,000	
Sediment Transportation and Disposal	$1,342,700	0						$1,342,700	
Water Treatment	$275,300	0						$275,300	
Purchase Sand and Import to Staging Area	$457,000	0						$457,000	
Purchase Armoring Materials and Import to Staging Area	$448,000	0						$448,000	
Barge Cover/Cap Materials to Slip	$622,300	0						$622,300	
Construct Cover/Cap	$744,500	0						$744,500	
Construct Armoring Layer	$342,500	0						$342,500	
Construction Monitoring/CQA and Oversight	$315,000	0						$315,000	
Sample Analysis	$33,900	0						$33,900	
Monthly Operating Expenses and Site Security	$105,000	0						$105,000	
Implement Institutional Controls	$25,000	0						$25,000	
Long-Term Monitoring									
Monitoring and Evaluation Report	$4,000	5	10	15	20	25	30	$8,631	
Field Sampling	$34,000	5	10	15	20	25	30	$73,366	
Sample Analysis	$21,618	5	10	15	20	25	30	$46,648	
Bathymetric Survey	$10,000	5	10	15	20	25	30	$21,578	
Institutional Control Review	$1,500	5	10	15	20	25	30	$3,237	
Professional and Technical Services									
Remedial Design (6%)	$573,000	0						$573,000	
Project Management and Permitting (5%)	$477,000	0						$477,000	
Construction Management (6%)	$573,000	0						$573,000	

Alternative 5: Dredging	**2016 Costs**	**Years**						**Total Present Worth**	**Note**
Construction Costs									
Mobilization/Demobilization	$194,000	0						$194,000	
Construct Staging Area	$285,789	0						$285,789	
Relocation of Dock Tentant During Construction	$40,000	0						$40,000	
Mechanically Dredge Sediments	$2,318,000	0						$2,318,000	
Turbidity Controls	$75,000	0						$75,000	
Barge Dredged Sediments to Staging Area	$1,488,000	0						$1,488,000	
Sediment Offloading and Stabilization	$2,129,300	0						$2,129,300	
Sediment Transportation and Disposal	$4,567,000	0						$4,567,000	
Water Treatment	$924,700	0						$924,700	
Purchase Cover/Cap Materials and Import to Staging Area	$105,200	0						$105,200	
Barge Cover/Cap Materials to Slip	$98,000	0						$98,000	
Construct Cover/Cap	$171,300	0						$171,300	
Construction Quality Assurance and Oversight	$450,000	0						$450,000	
Sample Analysis	$56,129	0						$56,129	
Monthly Operating Expenses and Site Security	$120,750	0						$120,750	
Professional and Technical Services									
Remedial Design (6%)	$ 980,000	0						$980,000	
Project Management and Permitting (5%)	$ 810,000	0						$810,000	
Construction Management (6%)	$ 980,000	0						$980,000	