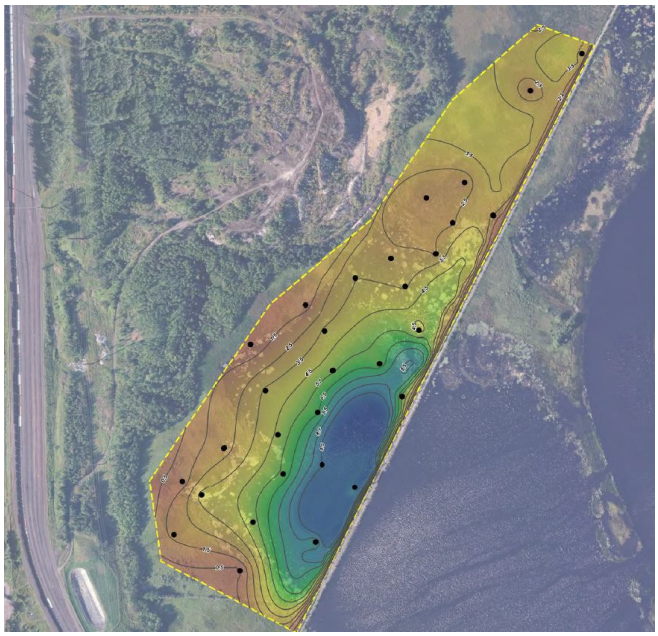
FOCUSED FEASIBILITY STUDY ADDENDUM
Mud Lake West

Duluth, Minnesota
MPCA Work Order #3000024325



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Acronyms and Abbreviations

%	percent
AOC	area of concern
ARAR	Applicable or Relevant and Appropriate Requirement
Bay West	Bay West LLC
BTV	background threshold value
CFR	Code of Federal Regulations
COC	contaminant of concern
CSM	conceptual site model
CUL	cleanup level
EMNR	Enhanced Monitored Natural Recovery
FFS	Focused Feasibility Study
GHG	greenhouse gas
IC	institutional control
LTM	long-term monitoring
MDH	Minnesota Department of Health
MNR	Monitored Natural Recovery
MPCA	Minnesota Pollution Control Agency
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/kg	nanograms per kilogram
O&M	operation and maintenance
PBAZ	potentially bioactive zone
RAO	Remedial Action Objective
RAP	Remedial Action Plan
RI	Remedial Investigation
ROM	rough order of magnitude
SAA	Sediment Assessment Area
SLR	St. Louis River
TEQ	toxic equivalency
U.S.	United States
WDNR	Wisconsin Department of Natural Resources

1.0 INTRODUCTION AND BACKGROUND

1.1 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 between 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 (SAAs) 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.

Areas that are contributing to river and harbor sediment impairments should be addressed through remedial activities, as recommended by the remedial action plans (RAPs). According to the MPCA, it is recommended by many programs that biotoxins be reduced within the SLR 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.

SAA #83 Mud Lake West (the Site) comprises a 39-acre wetland area in the SLR estuary (**Figure 1** and **Figure 2**). The majority of the Site is marshland with open water located in the center of the lake and along the railroad embankment that divides Mud Lake West from Mud Lake East. The marshland areas consist primarily of cattails at the northern end of the Site and a mix of cattail and bog areas at the south and southwestern ends of the Site.

A Focused Feasibility Study (FFS) was prepared in June 2017 (Bay West, 2017) to evaluate remedial alternatives for contaminated sediment at the Site. The FFS presented a summary of the Site, Applicable or Relevant and Appropriate Requirements (ARARs) and remedial action objectives (RAOs). The FFS also presented the development and screening of the following remedial alternatives:

- Alternative 1: No Action
- Alternative 2: Enhanced Monitored Natural Recovery (EMNR) with Broadcasted Amendment
- Alternative 3: EMNR with Thin-Layer Amended Cover
- Alternative 4: Dredging with Wetland Restoration
- Alternative 5: Dredge Open Water Areas/EMNR with Thin-Layer Amended Cover in Wetland Areas

The remedial alternatives were then scored based on threshold criteria, primary balancing criteria, and modifying criteria. Areas of the remedial footprint exist within Wisconsin and remedial actions would be funded and implemented in cooperation with the WDNR; however, for the purposes of this FFS, remedies to address contamination at the Site and associated costs have been developed for the entire remedial footprint. The FFS should be reviewed prior to reading this

document for an understanding of the Site history, previous work completed at the Site, and the complete FFS evaluation process.

1.2 Purpose

The purpose of this FFS Addendum is to present revised remedial alternatives for the site. Remedial alternatives were revised based on additional data gathering and stakeholder input. Revisions include the addition of Alternative 2, the combining of Alternative 3 and Alternative 4 from the FFS, and modification of Alternative 5. Remedial alternatives also include updated remedial footprint areas and associated material volumes based on updated remedial footprint criteria. For the purposes of this FFS Addendum, the revised remedial alternatives include the following:

- Alternative 1: No Action
- Alternative 2: Monitored Natural Recovery (MNR; new alternative)
- Alternative 3: Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover (a combination of former Alternative 3 and former Alternative 4)
- Alternative 4: Dredging and Off-site Disposal
- Alternative 5: Dredge Hotspot Areas of Site/EMNR in Wetland and Open Water Areas

This document summarizes remedial alternative development and Site updates, describes the revised remedial alternatives in detail, and provides an updated comparative analysis of the revised remedial alternatives.

2.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

2.1 Development of Alternatives

This section describes the Site updates since the 2017 FFS and the alternatives developed for the Site. The alternatives were developed using the selected remedial technologies discussed in Section 3.1 of the FFS, Site data collected during previous investigations and the 2015 Remedial Investigation (RI; Bay West, 2015), the conceptual site model (CSM) and input from stakeholders.

As part of developing and revising remedial alternatives for this FFS Addendum, the criteria used to define the remedial footprint was updated based on stakeholder input, recently developed background threshold values (BTVs), and projects of similar size, environment, and contaminants of concern (COCs). The following criteria was used to define the remedial footprint and hotspot footprint:

- Remedial footprint
    - BTV of 24.9 nanograms per kilogram (ng/kg) toxic equivalency (TEQ) for dioxins
- Hotspot footprint
    - 50 ng/kg TEQ for dioxins

Based on these criteria, the refined remedial footprint for the Site is 22.31 acres in size and the refined hotspot footprint for the site is 4.42 acres in size. Summarized sediment chemical data and the refined remedial and hotspot footprints are presented in **Figure 3**. The change in remedial footprint and hotspot areas has been carried through each of the remedial alternatives.

Additional remedial alternative refinement was done to focus on less invasive methods of cleanup. An MNR alternative was developed for this site (Alternative 2) because the dioxin concentrations for most of the site are very close to the BTV and are also relatively low compared to other sites in the SLR AOC. Former Alternative 2 and Alternative 3 from the FFS were combined into a single alternative (Alternative 3 in this FFS Addendum) that applies each cover technology (broadcast amendment and thin-layer sand/amendment cover) to environments best suited for each technology. The name for Alternative 4 was updated to provide clarity in the alternative implementation. Alternative 5 was updated to limit dredging to the newly defined hotspot area and apply amended covers in a similar manner as Alternative 3.

A summary of the proposed alternatives is presented in **Table 1**. Calculations used to determine volumes, rates, and time frames related to remedy construction are available upon request from the MPCA. Assumptions made to compile cost estimates were incorporated into a Technical Analysis and are also included in Appendix C of the FFS.

A bioaccumulation study is currently being conducted at the site to supplement existing bioaccumulation data. Results from this study will inform the MPCA's selection of a preferred alternative; however, this FFS Addendum evaluates the remedial alternatives for the Site as it is currently understood. The bioaccumulation data will be included in a data summary report made available for public review upon publishing.

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 percent (%) 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 LLC

(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. Preset value calculations are included in Table 5 in **Appendix B**.

2.1.1 Alternative 1: No Action

This alternative remains unchanged from the FFS. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at Title 40 Code of Federal Regulations (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 remedial investigation. 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. The No Action Alternative could potentially be a viable alternative if a future toxicity/bioaccumulation study indicates that concentrations of Site COCs in sediments pose no significant detrimental effects to aquatic life (i.e., benthics and fish).

2.1.2 Alternative 2: Monitored Natural Recovery

This alternative was not previously evaluated in the FFS. It consists of a monitoring and evaluation period of 30 years and implementation of ICs. Potential monitoring locations are presented in **Figure 4**. The objective of this alternative is to provide data to determine the potential for natural recovery processes at the Site. Based on the relatively low concentrations of COCs in sediment resulting in a lower probability of toxic/bioaccumulative effects in marine organisms (i.e., benthics and fish), MNR may be a viable remedial alternative and was therefore evaluated.

MNR would include collection of Site data to monitor reduction trends in sediment toxicity to benthic organisms and COC bioaccumulation in benthic and fish tissue; and to ensure that ICs continue to be enforced as long as COCs remain in sediments above the cleanup level (CUL).

MNR data collection would be conducted periodically for an indefinite period of time or until concentrations of COCs in sediments attenuate to levels below the CULs and are deemed protective of human health and the environment. For the purposes of this FFS Addendum, it was assumed that data collection would occur once every 5 years for a period of 30 years. 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 cores or sediment profile imagery to observe mixing of amendment material throughout the sediment column;
- Collection of sediment samples to be analyzed for Site COCs;
- Collection of sediment samples for benthic toxicity and bioaccumulation analysis;
- Collection of fish tissue samples for bioaccumulation analysis;
- Bathymetric survey of the entire site on Year 5; and
- Review of IC enforcement status.

Potential monitoring locations are presented in **Figure 4**.

ICs applicable to this alternative include those that would protect against direct human contact with contaminated sediments and ingestion of contaminants through fish consumption. The Minnesota Department of Health (MDH) currently communicates fish consumption guidelines for the lakes and rivers of Minnesota. Advisories for consumption of fish within the SLR and below

the Fond du Lac Dam are in place for 11 species of fish due to the presence of mercury and PCBs within fish tissue. No specific advisories are in place related to COCs. It is currently unknown whether the meal advice provided within the fish consumption guidelines is protective for these compounds; therefore, the applicability of meal guidelines to COCs would require investigation. Postings warning of contaminated sediments would be posted near potential Site access locations and would be modified according to changes in Site use (e.g., placed along walking/biking paths if developed in the future).

The approximate present value cost associated with Alternative 2 is $225,000. **Table 2** presents the breakdown of the estimated costs associated with Alternative 2.

2.1.3 Alternative 3: Enhanced Monitored Natural Recovery with Broadcast Amendment and Thin-Layer Amended Cover

This alternative combines former Alternative 2 and Alternative 3 from the FFS and would consist of constructing a 0.15-meter (0.5-foot) amended sand thin-layer cover in open water areas and broadcasting amendment in wetland areas (31 tons per acre, or approximately 1 centimeter in thickness) over sediments with COC concentrations exceeding the CULs. The objective of this alternative is to reduce the availability of Site COCs to aquatic organisms through addition of an amendment material and subsequent sequestration of contaminants, and to provide some immediate isolation of contaminated sediments in open water areas through construction of 0.15 meters of clean amended substrate. Construction of the Alternative 3 would take place in both open water and wetland areas of the Site.

Implementation of this alternative assumes that approximately 13,400 cubic yards of sand and 1,200 cubic yards of amendment would be applied over a 22.3-acre area. ICs would be implemented and long-term monitoring (LTM) would commence following construction of the amended covers.

The approximate present value cost associated with Alternative 3 is $5,551,000. **Table 3** presents the breakdown of the estimated costs associated with Alternative 3. EMNR application areas and implementation details for Alternative 3 are depicted on **Figure 5**.

2.1.4 Alternative 4: Dredging and Off-site Disposal

This alternative remains unchanged from the FFS with the exception of the name and remedial footprint. This alternative and would consist of complete removal of all sediments with COC concentrations exceeding the CULs, totaling 85,900 cubic yards of sediment. Removal of contaminated sediments would mitigate exposure of aquatic and human receptors to sediment contaminants, thus allowing for achievement of RAOs. The dredged sediments would be slurried and pumped via pipeline to a sediment dewatering area, stabilized over a period of several months, excavated, loaded onto trucks, and disposed of at an off-site landfill. Dredging would take place in both open water and wetland areas of the Site. Following sediment removal, a sand cover would be placed to reduce the surface concentration of dredge residuals through mixing of the upper sediment layer and to restore wetland areas. Approximately 26,100 cubic yards of sand would be required following dredging. 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 approximate present value cost associated with Alternative 4 is $16,172,000. **Table 4** presents the breakdown of the estimated costs associated with Alternative 4. Dredging areas and implementation details are depicted on **Figure 6**.

2.1.5 Alternative 5: Dredge Hot Spot Areas/Enhanced Monitored Natural Recovery in Wetland and Open Water Areas

This alternative is similar to how it was presented in the FFS, presenting a hybrid approach utilizing dredging elements from Alternative 4 in hotspot areas only and EMNR elements from the revised Alternative 3 within the updated remedial footprint. This alternative would consist of complete removal of all sediments with COC concentrations exceeding the hotspot criteria using similar technology as was proposed for Alternative 4, totaling 13,400 cubic yards. Removal of contaminated sediments in hotspot areas would mitigate exposure of aquatic and human receptors to the most contaminated sediment. Sediment removal would not be conducted within open water areas and wetland areas outside the hotspot area in order to minimize intrusive construction activities. Instead, an EMNR approach would be utilized within these areas and would consist of constructing a 0.15-meter (0.5-foot) amended sand thin-layer cover in open water areas and broadcasting amendment in wetland areas (31 tons per acre, or approximately 1 centimeter in thickness) over sediments with COC concentrations exceeding the CULs, as was proposed for Alternative 3. The objective of the EMNR portion of this alternative is to reduce the availability of Site COCs to aquatic organisms through addition of an amendment material and subsequent sequestration of contaminants, and to provide some immediate isolation of contaminated sediments in open water areas through construction of 0.15 meters of clean amended substrate.

The approximate present value cost associated with Alternative 5 is $11,955,000. **Table 5** presents the breakdown of the estimated costs associated with Alternative 5. EMNR application areas, hotspot dredging areas, and implementation details are depicted on **Figure 7**.

3.0 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 of the FFS in order to determine which of the alternatives best meets those criteria. The comparative analysis is documented in this section and summarized in **Table 6** and **7**. **Table 8** presents a numerical comparison of the evaluated alternatives.

3.1 Threshold Criteria

3.1.1 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. Alternative 1 would not meet the threshold criteria but was carried forward as it is required for analysis under the NCP. Alternative 2 provides a low achievement of threshold criteria because additional study of natural processes at the site to bury and degrade COC-impacted sediment is required. Alternatives 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; however, contaminated sediment would remain in place under Alternatives 3 and 5 requiring monitoring to ensure long-term effectiveness. Alternative 4 would provide the highest level of protection, since contaminated sediments would be removed from the aquatic environment.

3.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Only alternatives that meet threshold criteria were carried forward, as stated previously. Alternative 1 does not meet the threshold criteria, but was carried forward as it is required for analysis under the NCP. Alternatives 2, 3, 4, and 5 comply with the ARARs identified in Section 2 of the FFS.

3.2 Balancing Criteria

3.2.1 Long-Term Effectiveness and Permanence

Alternative 1 is not effective in the long-term or permanent. Alternative 2 maybe be effective and permanent in the long term; however, RAOs may not be achieved in a reasonable time frame because the natural degradation processes are poorly understood at the Site. Alternatives 3, 4, and 5 are effective in the long-term; however, contaminated sediment would remain in place under Alternatives 3 and 5, requiring long-term operation and maintenance (O&M) and ICs to ensure long-term effectiveness and, 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 4 would provide the most permanence, even though contaminants would not be permanently destroyed in the landfill.

In summary, Alternative 4 would provide a high achievement of this criterion by removing all of the contaminated sediment in the aquatic environment above the CULs. Alternative 2 would achieve a low achievement as RAOs may not be achieved. Alternatives 3 would provide a moderate achievement of this criterion, since amendment materials would eventually mix into the sediment column and sequester contaminants within the most biologically active sediment zone; however, deeper contamination may remain, and future addition of amendment material may be required. Alternative 5 would provide a moderate to high achievement of this criterion as it combines dredging in certain areas of the Site and amendment placement in others.

3.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 1, 2, and 4 would not provide a reduction in the toxicity, mobility, or volume through treatment; however, Alternative 4 would remove all contaminated sediment from the aquatic environment and place it in a maintained landfill. Alternatives 3 and 5 would reduce the toxicity, mobility, or volume of sediment contaminants through sequestration of sediment contaminants in contact with amendment materials (i.e., near the sediment surface) rendering them unavailable to biota with the added benefit in Alternative 5 being that the most contaminated sediment would be removed from the Site; however, it is unlikely that bioturbation processes would mix amendment materials to the maximum depth of contamination and, therefore, some contamination would remain in place indefinitely. Amendment materials applied on the sediment surface would also reduce contaminant mobility into the water column by providing a sorptive barrier between contaminated sediments and the water column.

In summary, Alternative 4 would provide a high achievement of this criterion because it both reduces the volume and toxicity of COCs via amendment materials mixed into the sediment column and reduces the volume of COCs through dredging. Alternative 3 would provide a moderate to high achievement of this criterion by reducing the toxicity and mobility of sediment contaminants through treatment via amendment materials mixed into the sediment column. Alternative 4 would provide a moderate achievement as no reduction of toxicity, mobility, or volume would take place through treatment but all COCs would be removed via dredging. Alternatives 1 and 2 would not achieve this criterion since no reduction of toxicity, mobility, or volume would take place.

3.2.3 Short-Term Effectiveness

There are no short-term risks associated with Alternative 1 as no actions would be implemented at the Site. The rest of the alternatives would have some short-term risks during implementation of the remedy. Alternative 4 requires dredging of 0.5 to 0.7 meters of sediment and would result in removal of the entire potentially bioactive zone (PBAZ) and temporary destruction of plant and animal habitat over the entire remedial area. Additionally, dredging of sediments would remove contamination from beneath the water column and require multiple transfers of contaminated sediments (and dredge contact water) by Site workers until eventual landfill disposal, thus creating additional opportunities for exposure to Site workers. Alternative 5 only requires dredging in hotspot areas of the Site to 0.7 meters, therefore, has fewer short-term adverse effects to aquatic communities and Site workers than Alternative 4.

Short-term adverse effects to aquatic habitat and biota from Alternatives 3 would include displacement of fish and smothering of benthic organisms because a 1.03-centimeter-thin layer of amendment material would be placed in wetland areas and a 0.15-meter-thin (6-inch-thin) layer amended sand cover in open water areas.

Alternative 2 provides the least short-term adverse effects that are limited only to site workers as they are conducting MNR sampling.

Benthic organisms would be expected to be re-established for all alternatives within several growing seasons.

In summary, Alternative 1 and 2 would provide a high achievement of the short-term effectiveness criterion as there would be no impact to surrounding community and aquatic habitat and little to now risk to Site workers. Alternative 3 would have a moderate to high achievement of the short-term effectiveness criterion due to an increase in short-term adverse effects to aquatic biota during cover construction; however, impacts are anticipated to be small. Alternative 5 would have a moderate achievement of the short-term effectiveness criterion due to the adverse effects to benthic organisms and Site workers through handling of contaminated sediments dredged from

hotspot areas and through cover placement in the remaining remedial footprint. Alternative 4 would have a low achievement of the short-term effectiveness criterion as it presents the greatest adverse effects to benthic organisms and the greatest risks to Site workers through handling of contaminated sediments over a longer duration of time as compared to Alternative 5.

3.2.4 Implementability

There are no implementability concerns associated with Alternative 1 and 2.

Application of cover materials to wetland and open water areas included in Alternative 3 and Alternative 5 requires specialized equipment such as marsh buggies that are capable of both navigating open water and traversing upland areas. Such equipment is available but somewhat specialized. Additionally, application of cover materials would require barging of materials from a nearby staging area or a staging area located along the SLR, such as Hallett Dock #7. It is anticipated that Hallett Dock #7 would be available as a staging area but this assumption assumes purchase of Hallett Dock #7 by the Duluth Seaway Port Authority and successful coordination of future access agreements. For these reasons Alternatives 3 provides a moderate to high level of achievement of the implementability criterion.

Dredging, dewatering, and water treatment that would be required under Alternatives 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 Site; however, implementation of these alternatives would require more time and resources than Alternative 3. Additionally, access to properties in which to dewater sediments and treat dredge contact water would be essential to implementation of these alternatives. It is unknown if adjacent properties are available for use. For these reasons Alternatives 4 would provide a low to moderate level of achievement of the implementability criterion. Alternative 5 would provide a low level of achievement because it involves the implementation issues with both the application of cover materials and dredging.

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 and any Site activities would be postponed in the spring until ice melt is completed. Winter or freezing conditions in the fall could shorten the construction season. Alternatives 4 and 5 have the longest estimated time to complete and, therefore would stand to be the most impacted by weather.

Implementability also includes administrative feasibility of the remedy. As with most sediment remediation activities, multiple state and federal agencies and other stakeholder input is required, providing a lower achievement of administrative feasibility of implementing a remedy. Additional time would be required to obtain any necessary approvals and permits from other agencies. Alternatives 4 and 5 would likely require more coordination with other regulatory agencies than Alternative 3, as off-site disposal is required for Alternatives 4 and 5.

In summary, Alternative 1 has no actions to be implemented and thus provides a high achievement of the implementability criterion. Alternative 2 only includes MNR sampling with no implementation concerns, providing a high achievement of this criterion. Alternative 3 is the next easiest to implement since it only requires cover construction and provides a moderate to high achievement of this criterion. Alternatives 4 and 5 provide a low to moderate and low achievement, respectively, of the implementability criterion due to increased coordination with other regulatory agencies and landowners, and due to increased time and materials required for implementation of dredging.

3.2.1 Cost

Cost estimates developed for each alternative are included in Section 3.0 of the FFS and summarized in **Table 1**. The cost estimates include capital costs, including both direct and indirect costs; annual O&M costs; and net present value of capital and O&M costs.

In summary, Alternative 1 provides the most cost-effective option ($0), followed by Alternative 2 ($225,000) because it requires only monitoring. Alternative 3 ($5,551,000) is the next most cost-effective as no dredging is required. Alternative 5 ($11,955,000) is the next most cost-effective as dredging is limited to hotspot areas resulting in a much lower volume of contaminated sediment disposal which results in lower dewatering, water treatment, hauling, and disposal costs. Alternative 4 is the least cost-effective as it requires dredging of all contaminated sediments within the remedial footprint and subsequent dewatering, water treatment, hauling, and disposal costs associated with the larger dredge volume. Additionally, a large volume of sand is required to restore the wetland areas, which adds to the total project cost.

3.3 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.

3.3.1 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, Site remediation prioritization, and funding source availability. Alternatives 1 through 5 will be formally assessed after public comment period.

3.3.2 Community Acceptance

Lands surrounding the Site are privately owned and access is limited to trespassers and a historic train tour that travels through the Site on weekends from mid-June through mid-October. The Superior and Mississippi Railroad Company (http://lsmrr.org) operates the tours on railroad tracks owned by the City of Duluth. Recent conversations between Bay West, the MPCA, and the City of Duluth revealed that a future recreational path may be constructed through the Site, and part or all of the causeway might be removed as part of a potential habitat restoration project.

Any remediation work completed at the Site involving application of amendments or construction of a cover would require construction of a mooring area adjacent to the railroad embankment (i.e., driving of dolphin pilings) and passing of materials over the railroad tracks; therefore, coordination with the City of Duluth and the Superior and Mississippi Railroad Company would be required for implementation of Alternatives 3 and 5, which incorporate amendment placement or sand cover construction. Train tour interruptions could be minimized by working weekdays only or performing construction activities prior to mid-June, when tours begin. As noted previously, the City of Duluth is exploring the possibility of removing some or all of the railroad causeway at the Site; therefore, this consideration should be examined further during the design phase.

Additional coordination would be required with the current or future owners of Hallett Dock #7 for use as a material staging area. The total estimated time required for on-site construction activities for Alternatives 3 is shorter than Alternatives 4 and 5. The majority of work related to implementation of Alternatives 3 would take place directly on-Site and presumably at a privately owned staging area. It is anticipated that community acceptance of 3 will be high based on the factors outlined above.

Any remediation work completed at the Site involving dredging would require sourcing of a nearby dewatering area in which to pump and subsequently dewater dredged sediments; therefore, coordination with a nearby property owner such as U.S. Steel would be required for implementation of Alternatives 4 and 5. Implementation of Alternatives 4 and 5 would also result in increased truck traffic in the nearby neighborhood of Gary, and may require additional coordination with City of Duluth officials. Alternatives 4 and 5 have substantially longer construction durations than Alternatives 3. It is anticipated that community acceptance of Alternatives 4 and 5 will be high because these alternatives involve complete removal of contamination in at least a portion of the Site and because the Site is not widely used by the community.

Mechanical dredging of sediments and subsequent barging of sediments to an off-site sediment dewatering area such as Hallett Dock #7 was not evaluated as part of this FFS. Additionally, construction of a material staging and/or sediment dewatering area at the western shoreline of the Site within wetland areas was not evaluated for this FFS. These scenarios could be considered depending on stakeholder and community acceptance of the proposed alternatives.

3.4 Green Sustainable Remediation Criteria

3.4.1 Greenhouse Gas Emissions

Alternative 1 would have no greenhouse gas (GHG) emissions. Alternatives 2 would have limited GHG emissions during sampling activities. Alternatives 3, 4, and 5 would result in GHG emissions from the mobilization, operation, and demobilization of all fuel-powered construction equipment required to construct the cover and/or dredge. Alternatives 4 and 5 would also produce emissions during transport of sediments by truck to the disposal facility. Reduction of emissions can be accomplished by using equipment that is compliant with the latest U.S. Environmental Protection Agency (USEPA) non-road engine standards and retrofitting older equipment with appropriate filters.

3.4.2 Toxic Chemical Usage and Disposal

There are no known toxic chemicals associated with these alternatives.

3.4.3 Energy Consumption

Alternative 1 would consume no additional energy. Alternatives 2, 3, 4, and 5 would result in the consumption of fossil fuels for the mobilization, operation, and demobilization of all gas- and diesel-powered construction equipment associated with the dredging, hauling, and disposal of the contaminated sediment and the installation of cover materials. Only placement of cover materials is required for Alternative 3 whereas Alternatives 4 and 5 require dredging and cover placement, resulting in more fossil fuel consumption.

3.4.4 Use of Alternative Fuels

Alternatives 1 and 2 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 3, 4, and 5.

3.4.5 Water Consumption

Alternatives 1 and 2 would not require the consumption of water. A minimal quantity of water would be required to decontaminate personnel and equipment during sediment dredging activities associated with Alternatives 3, 4, and 5.

3.4.6 Waste Generation

Alternatives 1, 2, and 3 would not generate waste. Alternatives 4 and 5 would generate waste that includes the dredged contaminated sediments, contaminated dewatering pad materials, and any non-recyclable water treatment media that would be removed from the Site and disposed of.

3.5 Comparative Analysis Summary

The comparative analysis of alternatives narrative discussion and quantitation table identified Alternatives 3 as a more appropriate alternative than Alternatives 1, 2, 4, and 5 to address contamination at the Site. Alternative 1 does not achieve overall protection of human health and the environment, does not achieve ARARs, is not effective in the long-term, does not reduce toxicity, mobility, or volume of contamination, and is not effective in the short-term; however, this alternative is implementable and cost-effective. Alternative 2 may achieve overall protection of human health and the environment, achieve ARARs, and be effective in the long-term; however, this alternative may not achieve these criteria in a reasonable timeframe. Alternative 2 does not reduce toxicity, mobility, or volume of contamination through treatment, and is not effective in the short-term; however, this alternative is implementable and cost-effective. Alternatives 3, 4, and 5 are all protective of human health and the environment and achieve ARARs. Alternatives 3 and 5 have similar long-term effectiveness and reductions in toxicity, mobility, or volume of contaminants; with Alternative providing more effectiveness and reduction in volume due to hotspot dredging. Alternatives 2 and 3 are superior in the short-term effectiveness criterion because durations to implement these alternatives are the shortest, with the exception of Alternative 1. Alternatives 2 and 3 are also the least complex of the alternatives with exception of Alternative 1, making Alternatives 2 and 3 also the most implementable. Of Alternatives 2, 3, 4, and 5, Alternative 2 is the most cost-effective and is the MPCA's preferred Alternative; however, the preferred alternative could change based on ongoing bioaccumulation studies being conducted for the site.

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 Site users, the public and local units of government prior to the public comment period.

3.6 Additional Considerations

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

- Bench and/or pilot scale testing of amendment materials to determine the most appropriate material for use at the Site. Potential amendment materials include activated carbon, bauxite, biopolymers, permeable Organoclay, phosphate additives (i.e., apatite), and zeolite (USEPA, 2013);
- Bench and/or pilot scale testing to determine appropriate application rates for the selected amendment material;
- Physical sediment characteristics assessment to aid in designing remedial actions involving dredging and/or capping; and
- Evaluation of potential dewatering areas within close proximity of the Site, including use of U.S. Steel property, if Alternative 4 or 5 is selected.

In addition, additional pre-design investigation and analysis might be warranted, in order to refine the remedial footprint, or to justify a need for a remedial action or provide basis for monitored natural recovery.

- Biological assessments to evaluate effects of contaminated sediments on Site biota, which could include benthic toxicity and bioaccumulation testing, paired with sediment chemistry analysis for dioxins (currently underway at the time of publishing).
- Comparison of Site bioaccumulation data to similar data within the SLR estuary.

Pending the City of Duluth's decision on the preferred use of the Mud Lake causeway, additional data gaps might need to be addressed to evaluate the impact of partial or total causeway removal on the selected alternative:

- A hydrodynamic study to understand natural processes such as depositional and scouring forces to inform design and placement of cover materials.

4.0 REFERENCES

Bay West, 2015. “Draft Sediment Remedial Investigation Report, Mud Lake West, Duluth Minnesota.” December.

Bay West, 2017. “Final Focused Feasibility Study, Mud Lake West, Duluth, Minnesota.” June.

USEPA, 2013. “Use of Amendments for In Situ Remediation at Superfund Sediment Sites.” April.

Figures

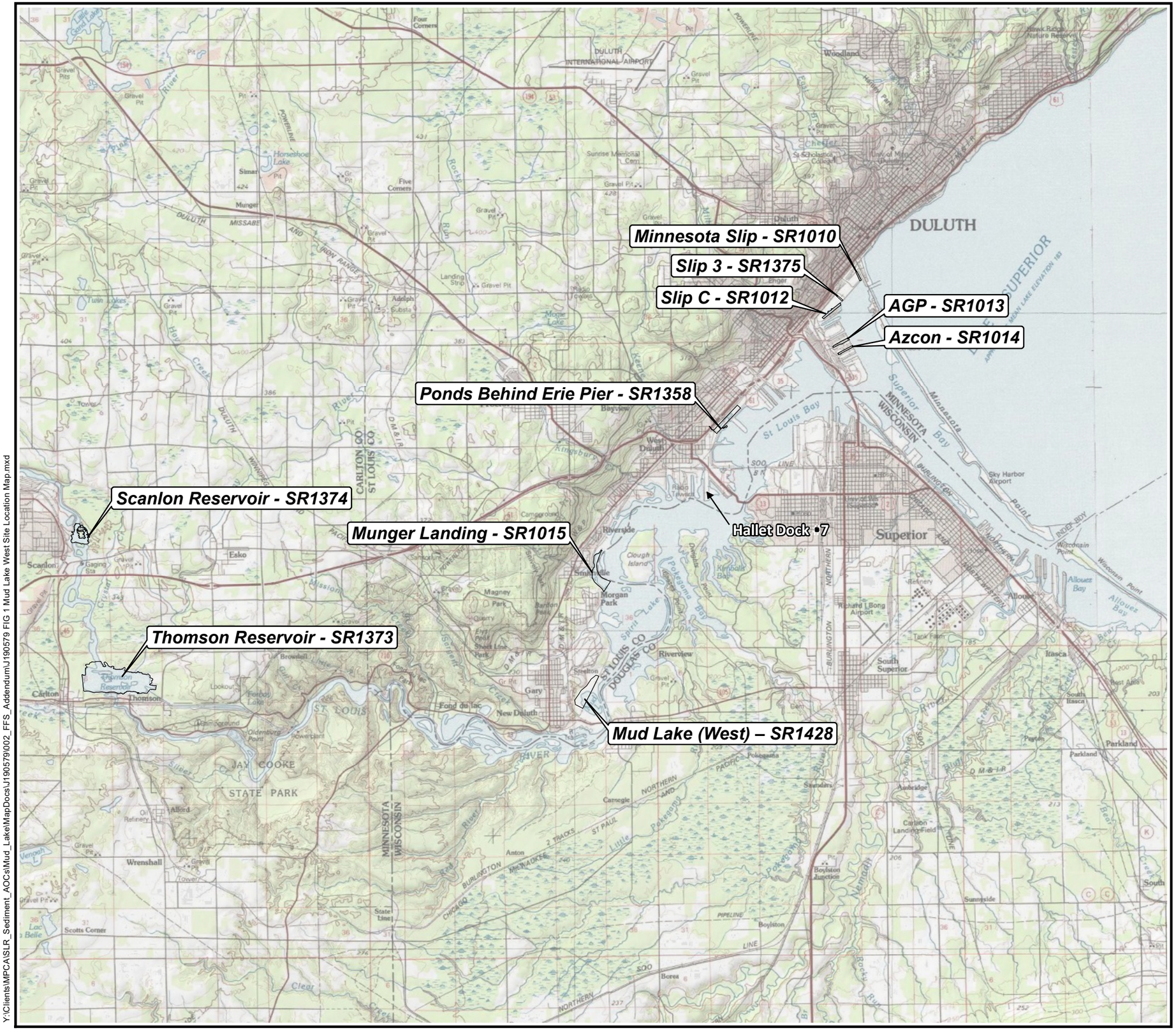
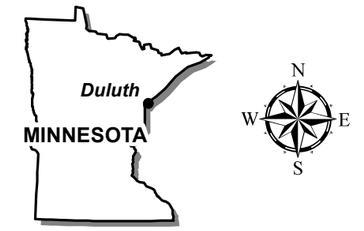


Figure 1

Site Location Map

Mud Lake West 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

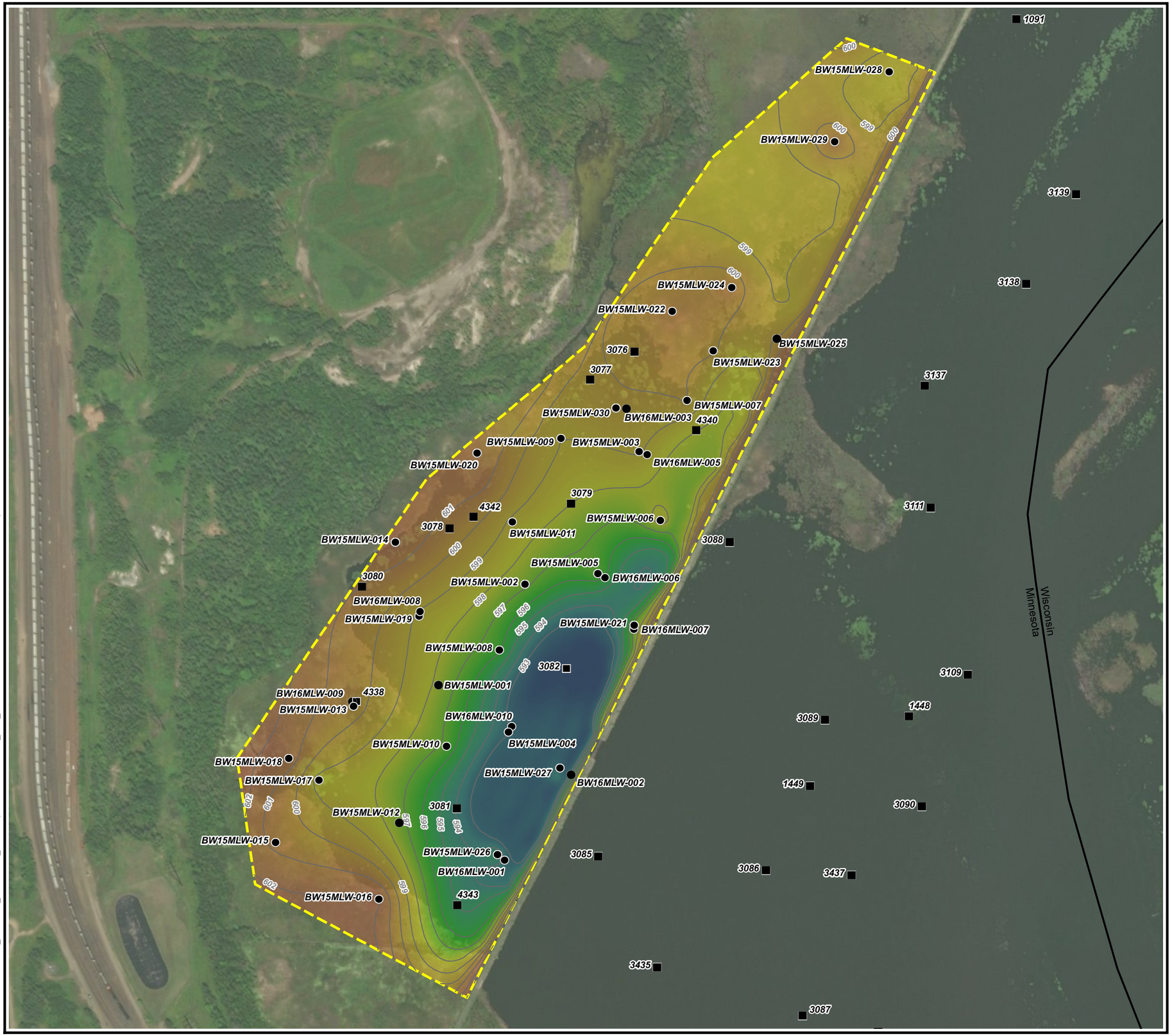
Site Location (Labeled on map)

CLEAN WATER LAND & LEGACY AMENDMENT

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: NJ | Date Drawn/Revised:7/24/2019 | Project No.J190579

Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_Lake\MapDocs\J190579002_FFS_Addendum\J190579 FIG 1 Mud Lake West Site Location Map.mxd

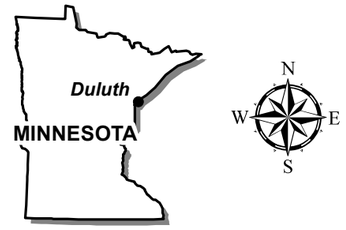


Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_Lake\MapDocs\J190579\002_FFS_Addendum\J190579 FIG 2 Mud Lake West Site Map.mxd

Figure 2

Mud Lake West Site Map

Mud Lake West
SLR Sediment AOCs
Duluth, MN



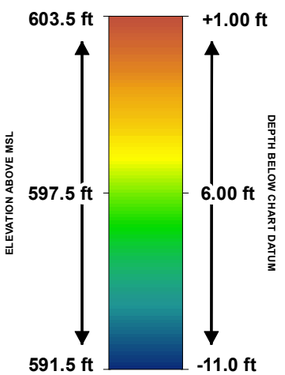
Map Projection: NAD 1983 UTM Zone 15 N
Basemap: Microsoft Bing WMS

0 350 700 Feet

0 100 200 Meters

- Sediment Sample (Bay West)
- Historical Sediment Sample
- Bathymetry Elevation Contour
- State Border
- Mud Lake (West) – SR1428

Water Depth



Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: NJ | Date Drawn/Revised:7/29/2019 | Project No.J190579

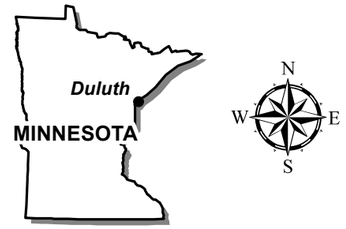
Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_Lake\MapDocs\J190579002_FFS_AddendumJ190579 FIG 3 Mud Lake West Remedial Footprint.mxd

Figure 3

Remedial Footprint

Mud Lake West
SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemap: ESRI World Imagery WMS, 8/16/2018

0 350 700 Feet

0 100 200 Meters

Sample Results

- TEQ Fish < 24.9 ng/kg
- TEQ Fish > 24.9 ng/kg
- TEQ Fish > 50 ng/kg

Hotspot
TEQ Fish = 50 mg/kg
Hotspot Acreage = 4.42

Remedial Footprint
TEQ Fish = 24.9 ng/kg (BTV)
Remedial Footprint Acreage = 22.33

Open Water (17.33 Acres)
Wetland (5.00 Acres)

Mud Lake (West) – SR1428

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: N.J. Date Drawn/Revised:8/12/2019 Project No.J190579

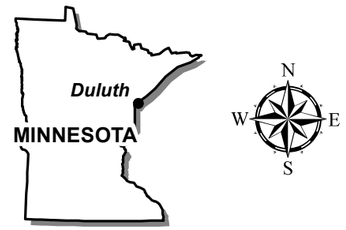
Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_LakeMapDocs\J190579\002_FFS_Addendum\J190579 FIG 4 Mud Lake West Alternative 2 Monitored Natural Recovery.mxd

Figure 4

Alternative 2: Monitored Natural Recovery

Mud Lake West SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemap: ESRI World Imagery, 8/16/2018

0 350 700 Feet

0 100 200 Meters

Proposed Monitoring Location

Remedial Areas (22.33 Acres)

Mud Lake West Site Boundary

Sample Results

- TEQ Fish < 24.9 ng/kg
- TEQ Fish > 24.9 ng/kg
- TEQ Fish > 50 ng/kg

Bay West
Customer-Focused Environmental & Industrial Solutions

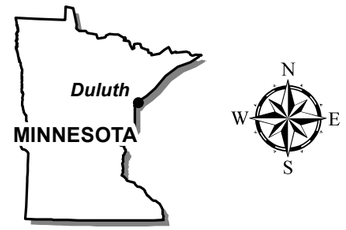
Drawn By: NJ Date Drawn/Revised:7/29/2019 Project No.J190579

Figure 5

Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover

Mud Lake West SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemap: ESRI World Imagery, 8/16/2018

0 350 700 Feet

0 100 200 Meters

- Proposed Monitoring Location
- Open Water Areas - 17.33 Acres (0.15m amended thin-layer cover)
- Wetland Areas - 5.00 Acres (1.03 cm broadcast amendment cover)
- Remedial Areas (22.33 Acres)
- Mud Lake West Site Boundary

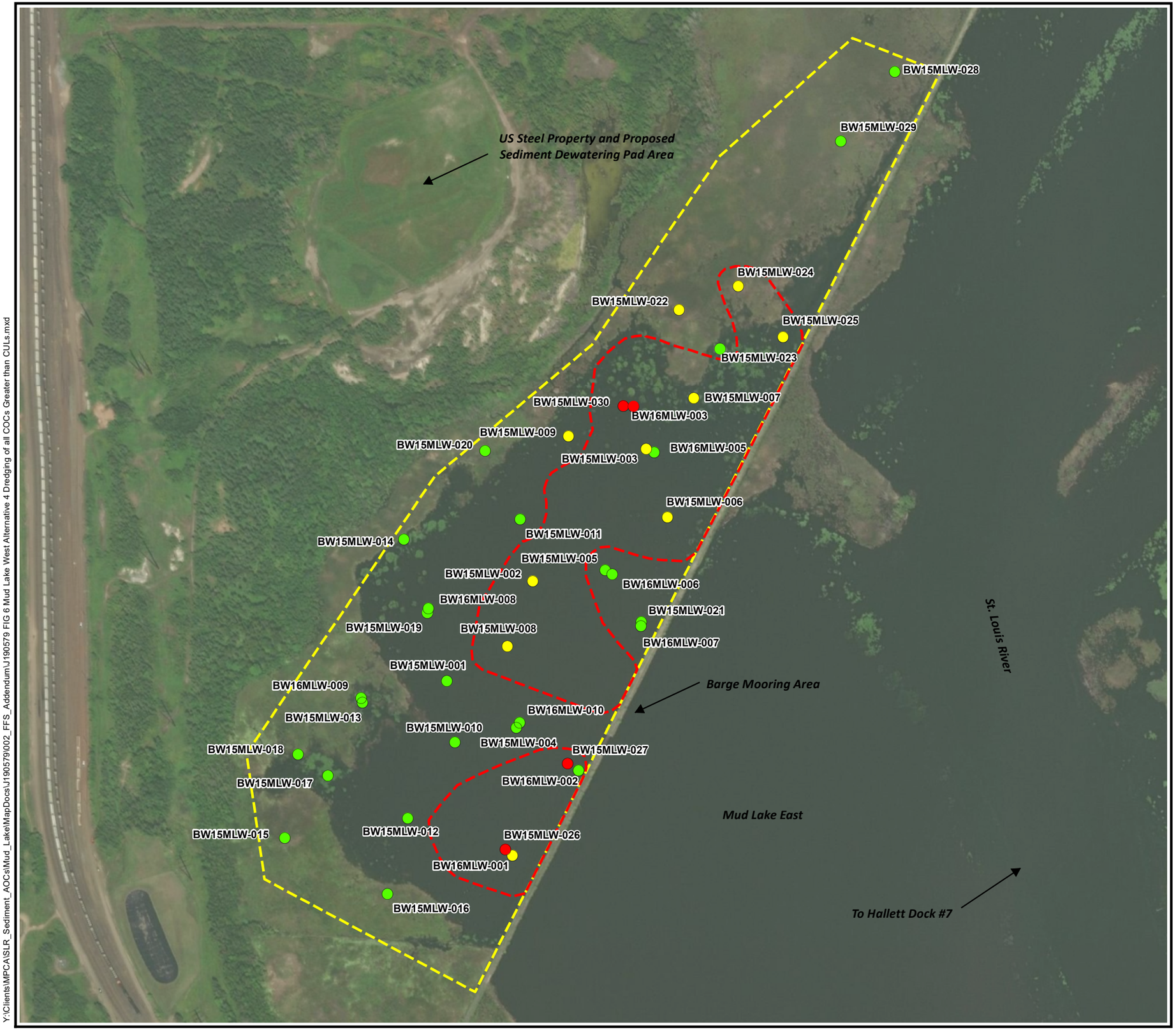
Sample Results

- TEQ Fish < 24.9 ng/kg
- TEQ Fish > 24.9 ng/kg
- TEQ Fish > 50 ng/kg

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: NJ Date Drawn/Revised:7/29/2019 Project No.J190579

Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_Lake\MapDocs\J190579\002_FFS_Addendum\J190579 FIG 5 Mud Lake West Alternative 3 Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover.mxd

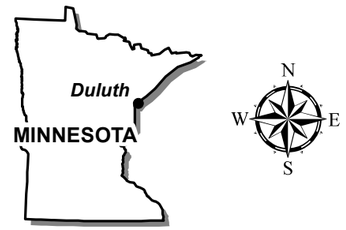


Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_LakeMapDocs\J190579\002_FFS_Addendum\J190579 FIG 6 Mud Lake West Alternative 4 Dredging of all COCs Greater than CULs.mxd

Figure 6

Alternative 4: Dredging and Off-Site Disposal

Mud Lake West
SLR Sediment AOCs *Duluth, MN*



Map Projection: NAD 1983 UTM Zone 15 N
Basemap: ESRI World Imagery WMS, 8/16/2018

0 350 700 Feet

0 100 200 Meters

Remedial Areas (22.33 Acres, 0.7m Dredge)

Mud Lake West Site Boundary

Sample Results

- TEQ Fish < 24.9 ng/kg
- TEQ Fish > 24.9 ng/kg
- TEQ Fish > 50 ng/kg

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: NJ | Date Drawn/Revised:7/29/2019 | Project No.J190579

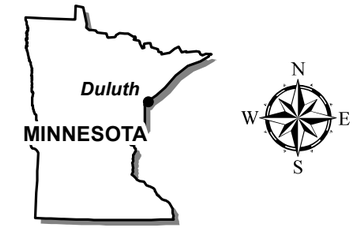
Y:\Clients\MPCA\SLR_Sediment_AOCs\Mud_Lake\MapDocs\J190579002_FFS_AddendumJ190579 FIG 7 Mud Lake West Alternative 5 Dredge Hotspot Areas of Site EMNR in Wetland and Open Water Areas.mxd

Figure 7

Alternative 5: Dredge Hotspot Areas of Site/EMNR in Wetland and Open Water Areas

Mud Lake West SLR Sediment AOCs

Duluth, MN



Map Projection: NAD 1983 UTM Zone 15 N
Basemap: ESRI World Imagery WMS, 8/16/2018

0 350 700 Feet

0 100 200 Meters

Proposed Monitoring Location

Open Water Areas - 17.33 Acres (0.15m amended thin-layer cover)

Wetland Areas - 5.00 Acres (1.03cm broadcast amendment cover)

Remedial Areas (22.33 Acres)

Hotspot Areas (4.42 Acres, 0.7m Dredge)

Mud Lake West Site Boundary

Sample Results

- TEQ Fish < 24.9 ng/kg
- TEQ Fish > 24.9 ng/kg
- TEQ Fish > 50 ng/kg

Bay West
Customer-Focused Environmental & Industrial Solutions

Drawn By: N.J. Date Drawn/Revised:7/29/2019 Project No.J190579

Tables

Table 1
Alternatives Summary
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Alternative	Alternative 1: No Action	Alternative 2: Monitored Natural Recovery	Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover	Alternative 4: Dredging and Off-Site Disposal[2]	Alternative 5: Dredge Hotspot Areas of Site/EMNR in Wetland and Open Water Areas
Total Present Worth Cost	$0	$225,000	$5,551,000	$16,172,000	$11,955,000
Cover/Cap Area	0 acres	0 acres	5 acres (1.03-cm [0.4-inch] broacast amendment cover); 17.33 acres (0.15-meter [6-inch] amended thin-layer cover)	5 wetland sand cover acres (0.46-meter [1.5-feet] sand cover); 17.33 open water and cover acres (0.15-meter [6-inch] sand cover)	5 acres (1.03-cm [0.4-inch] broacast amendment cover); 17.33 open water acres (0.15-meter [6-inch] amended thin-layer cover)
Dredge Area[1]	0 acres	0 acres	0 acres	5 wetland acres (0.5-meter [1.5-feet] dredge depth); 17.33 open water acres (0.7-meter [2.6-feet] dredge depth)	4.42 hotspot acres (0.7-meter [2.6-feet] dredge depth)
Cover Volume - Sand/Amendment	0 CY/ 0 CY	0 CY/ 0 CY	13400 CY/ 1200 CY	26100 CY/ 0 CY	13400 CY/ 1200 CY
Dredge Volume[1]	0 CY	0 CY	0 CY	85900 CY	18800 CY
Construction Timeframe	0 weeks	0 weeks	11 weeks	9 weeks dredge; 15 weeks place cover, excavation and disposal of dewatered sediment; 24 weeks total	13 weeks dredge and place cover materials; 3 weeks excavation and disposal of dewatered sediments; 16 weeks total
Monitoring Program	None	Chemical and physical sediment; benthic toxicity and bioaccumulation; fish tissue; bathymetric surveys	Chemical and physical sediment and cover; benthic toxicity and bioaccumulation; fish tissue	None	Chemical and physical sediment and cover; benthic toxicity and bioaccumulation; fish tissue; wetland areas only
Notes					

[1]Dredge areas and volumes include 1-foot overdredge

[2]Dredging of all COCs Greater than CULs

Table 2
Cost Estimate - Alternative 2: Monitored Natural Recovery (New Alternative)
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
No construction costs associated with this alternative						
Long-Term Monitoring						
Implementation Plan Report	Each	$ 11,000	1	$ 11,000	$ 11,000	Work Plan, Field Sampling Plan, QAPP
Monitoring and Evaluation Report	Each	$ 4,000	6	$ 24,000	$ 8,631	Every 5 years for 30 years
Field Sampling	Event	$ 34,000	6	$ 204,000	$ 73,366	Every 5 years for 30 years
Sample Analysis	Event	$ 34,000	6	$ 204,000	$ 73,366	Every 5 years for 30 years
Bathymetric Survey	Each	$ 10,000	6	$ 60,000	$ 21,578	Every 5 years for 30 years
Institutional Control Review	Each	$ 1,500	6	$ 9,000	$ 3,237	Every 5 years for 30 years
			TOTAL	$ 501,000	$ 180,178	
			25% Contingency	$ 125,250	$ 45,044	Contingency does not include amendment materials
		LONG-TERM MONITORING GRAND TOTAL		$ 626,250	$ 225,222	
Professional and Technical Services						
No professional and technical services associated with this alternative						
			TOTAL	**$ 626,000**	**$ 225,000**	

Notes:
All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Appendix A 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 3
Cost Estimate - Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover (Combined Alternative of Former Alternative 3 and 4 in FFS)
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
Mobilization/Demobilization	Lump Sum	$ 213,000	1	$ 213,000	$ 199,065	All construction occurs on Year 1
Rent Hallett Dock #7 for Staging Area	Month	$ 10,000.00	5	$ 50,000	$ 46,729	
Install and Remove Dolphin Pilings	Lump Sum	$ 95,000.00	1	$ 95,000	$ 88,785	
Purchase Amendment Materials and Stockpile at Staging Area	Ton	$ 3,000.00	692	$ 2,076,690	$ 1,940,832	
Purchase Sand and Stockpile at Staging Area	CY	$ 20.80	13420	$ 279,135	$ 260,874	
Load and Barge Materials Between Staging Area and Site	CY	$ 50.00	14634	$ 731,720	$ 683,851	Includes sand and amendment materials
Construct Cover in Wetland Areas	CY	$ 79.04	272	$ 21,494	$ 20,088	Broadcast amendment, 54.4 CY per acre
Construct Cover in Open Water Areas	CY	$ 32.07	14362	$ 460,625	$ 430,491	6 inch cover; sand and amendment (54.4 CY per acre)
Construction Monitoring/CQA and Oversight	Week	$ 12,802	11	$ 140,822	$ 131,609	
Monthly Operating Expenses and Site Security	Month	$ 21,000	5	$ 105,000	$ 98,131	
Implement Institutional Controls	Lump Sum	$ 5,000	1	$ 5,000	$ 4,673	Site postings
			SUBTOTAL	$ 4,178,486	$ 3,905,127	
Long-Term Monitoring						
Monitoring and Evaluation Report	Each	$ 4,000	6	$ 24,000	$ 8,631	Every 5 years for 30 years
Field Sampling	Event	$ 34,000	6	$ 204,000	$ 73,366	Every 5 years for 30 years
Sample Analysis	Event	$ 61,470	6	$ 368,820	$ 132,641	Every 5 years for 30 years
			SUBTOTAL	$ 596,820	$ 214,638	
			TOTAL	$ 4,775,306	$ 4,119,765	
			25% Contingency	$ 674,654	$ 544,733	Contingency does not include amendment materials
		CONSTRUCTION GRAND TOTAL		$ 5,449,960	$ 4,664,499	
Professional and Technical Services						
Remedial Design (6%)	Lump Sum	$ 327,000	1	$ 327,000	$ 327,000	Year 0
Project Management and Permitting (5%)	Lump Sum	$ 272,000	1	$ 272,000	$ 254,206	Year 1
Construction Management (6%)	Lump Sum	$ 327,000	1	$ 327,000	$ 305,607	Year 1
			SUBTOTAL	$ 926,000	$ 886,813	
			TOTAL	**$ 6,376,000**	**$ 5,551,000**	

Notes:
All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Appendix A 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 4
Cost Estimate - Alternative 4: Dredging and Off-Site Disposal
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
Mobilization/Demobilization	Lump Sum	$ 190,000	1	$ 190,000	$ 177,570	All construction occurs on Year 1
Site Work	Lump Sum	$ 572,000	1	$ 572,000.00	$ 534,579	
Rent Hallett Dock #7 for Staging Area	Month	$ 10,000	9	$ 90,000	$ 84,112	
Install and Remove Dolphin Pilings	Lump Sum	$ 95,000	1	$ 95,000	$ 88,785	
Mechanically Dredge Sediments and Pump to Staging Area	CY	$ 8.10	85912	$ 696,245	$ 650,696	
Turbidity Controls	Lump Sum	$ 30,000	1	$ 30,000	$ 28,037	
Treat Dredge Contact Water (per CY sediment removed)	CY	$ 40.00	85912	$ 3,436,477	$ 3,211,661	"All-in" ROM estimate including mob/demob, materials, equipment, labor, and disposal
Purchase Sand and Stockpile at Staging Area	CY	$ 20.80	26080	$ 542,464	$ 506,976	
Load and Barge Materials Between Staging Area and Site	CY	$ 50.00	26080	$ 1,304,000	$ 1,218,692	
Construct Cover in Wetland Areas	CY	$ 91.00	12100	$ 1,101,100	$ 1,029,065	
Construct Cover in Open Water Areas	CY	$ 32.07	13980	$ 448,359	$ 419,027	
Wetland Restoration	Lump Sum	$ 84,000	1	$ 84,000	$ 78,505	
Excavate and Load Dewatered Sediments	CY	$ 6.90	85912	$ 592,850	$ 554,065	
Transportation and Disposal of Dewatered Sediments	Ton	$ 17.66	120277	$ 2,123,519	$ 1,984,597	1.4 tons per cubic yard
Construction Monitoring/CQA and Oversight (Labor/Equipment)	Week	$ 12,802	24	$ 307,248	$ 287,148	
Construction Monitoring and Sample Analysis	Lump Sum	$ 55,000	1	$ 55,000	$ 51,402	
Monthly Operating Expenses and Site Security	Month	$ 21,000	6	$ 126,000	$ 117,757	
			SUBTOTAL	$ 11,794,261	$ 11,022,674	
			25% Contingency	$ 2,948,565	$ 2,755,669	
		CONSTRUCTION GRAND TOTAL		$ 14,742,827	$ 13,778,343	
Professional and Technical Services						
Remedial Design (6%)	Lump Sum	$ 880,000	1	$ 880,000	$ 880,000	Year 0
Project Management and Permitting (5%)	Lump Sum	$ 740,000	1	$ 740,000	$ 691,589	Year 1
Construction Management (6%)	Lump Sum	$ 880,000	1	$ 880,000	$ 822,430	Year 1
			SUBTOTAL	$ 2,500,000	$ 2,394,019	
			TOTAL	**$ 17,243,000**	**$ 16,172,000**	

Notes:

All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Appendix A 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 5: Dredge Open Water Areas/Enhanced MNR in Wetland and Open Water Areas
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Description	Unit	Estimated Unit Cost	Estimated Quantity	Extended Value	Present Value	Comments
Construction Costs						
Mobilization/Demobilization	Lump Sum	$ 214,000	1	$ 214,000	$ 200,000	All construction occurs on Year 1
Site Work	Lump Sum	$ 572,000	1	$ 572,000	$ 534,579	
Rent Hallett Dock #7 for Staging Area	Month	$ 10,000	10	$ 100,000	$ 93,458	
Install and Remove Dolphin Pilings	Lump Sum	$ 95,000	1	$ 95,000	$ 88,785	
Mechanically Dredge Sediments and Pump to Staging Area	CY	$ 8.10	18826	$ 152,569	$ 142,588	Hot spot areas only
Turbidity Controls	Lump Sum	$ 30,000	1	$ 30,000	$ 28,037	
Treat Dredge Contact Water (per CY sediment removed)	CY	$ 50.00	18826	$ 941,300	$ 879,720	
Purchase Sand and Stockpile at Staging Area	CY	$ 20.80	13420	$ 279,135	$ 260,874	Open water thin-cover sand and amendment
Purchase Amendment Materials and Stockpile at Staging Area	Ton	$ 3,000.00	1214	$ 3,643,316	$ 3,404,968	Wetland areas only (5 percent of 6-inch cover by volume)
Load and Barge Materials Between Staging Area and Site	CY	$ 50.00	14634.4037	$ 731,720	$ 683,851	
Construct Cover in Wetland Areas	CY	$ 91.00	943	$ 85,768	$ 80,157	Broadcast amended cover
Construct Cover in Open Water Areas	CY	$ 32.07	14362	$ 460,625	$ 430,491	6 inch amended thin-layer cover
Excavate and Load Dewatered Sediments	CY	$ 6.90	18826	$ 129,912	$ 121,413	
Transportation and Disposal of Dewatered Sediments	Ton	$ 17.66	26356	$ 465,329	$ 434,886	1.4 tons per cubic yard
Construction Monitoring/CQA and Oversight (Labor/Equipment)	Week	$ 12,802.00	16	$ 204,832	$ 191,432	
Construction Monitoring and Sample Analysis	Lump Sum	$ 55,000.00	1	$ 55,000	$ 51,402	
Monthly Operating Expenses and Site Security	Month	$ 21,000.00	16	$ 336,000	$ 314,019	
Implement Institutional Controls	Lump Sum	$ 5,000.00	1	$ 5,000	$ 4,673	Site postings
			SUBTOTAL	$ 8,501,506	$ 7,945,333	
Long-Term Monitoring						
Monitoring and Evaluation Report	Each	$ 4,000	6	$ 24,000	$ 8,631	Every 5 years for 30 years
Field Sampling	Event	$ 34,000	6	$ 204,000	$ 73,366	Every 5 years for 30 years
Sample Analysis	Event	$ 37,082	6	$ 222,000	$ 80,016	Every 5 years for 30 years
			SUBTOTAL	$ 450,000	$ 162,013	
			TOTAL	$ 8,951,506	$ 8,107,346	
			25% Contingency	$ 2,237,877	$ 2,026,837	
			CONSTRUCTION GRAND TOTAL	$ 11,189,383	$ 10,134,183	
Professional and Technical Services						
Remedial Design (6%)	Lump Sum	$ 671,000	1	$ 671,000	$ 671,000	Year 0
Project Management and Permitting (5%)	Lump Sum	$ 559,000	1	$ 559,000	$ 522,430	Year 1
Construction Management (6%)	Lump Sum	$ 671,000	1	$ 671,000	$ 627,103	Year 1
			SUBTOTAL	$ 1,901,000	$ 1,820,533	
			TOTAL	**$ 13,090,000**	**$ 11,955,000**	

Notes:
All values are based on 2016 dollars with an assumed discount rate of 7 percent per year. See Appendix A 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. 0.071909855

Table 6
Comparative Analysis Summary - Threshold, Balancing, and Modifying Criteria
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Monitored Natural Recovery	Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover	Alternative 4: Dredging and Off-Site Disposal[2]	Alternative 5: Dredge Hotspot Areas of Site/EMNR in Wetland and Open Water Areas
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 **low achievement** of protection of Human Health and the Environment as contaminant concentrations remain with minimal controls to prevent exposure; however RAOs would be achieved over time.	Provides a **moderate achievement** of protection of Human Health and the Environment. Sediment contaminants would be reduced through addition of an amendment material and controlled by providing an amendment layer between contaminated sediments and the water column. The addition of thin-layer sand/ammendment cover in open water further separates contaminats from contact. May require monitoring to ensure effectiveness and future additions of amendment material.	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.	Provides a **moderate to high** achievement of protection of Human Health and the Environment. Sediment contaminants would be reduced through addition of an amendment material and controlled by providing an amendment layer between contaminated sediments and the water column. Includes complete removal of sediments within a portion of the Site.
ARARs	Provides **no achievement** 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 achievement** of ARARs; however, COCs may not be reduced to concentrations less than RAOs in a reasonable time frame.	Provides a **moderate to high 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.	Provides a **moderate to high achievement** of ARARs if implemented properly; however, COCs may not be reduced to concentrations less than RAOs in a reasonable time frame.
Primary Balancing Criteria					
Long-term Effectiveness and Permanence	Provides **no achievement** of long-term effectiveness and remedy is not long-term effective or permanent.	Provides a **low achievement** of long-term effectiveness and permanence because sediment contaminants would eventually be sequestered and degraded by natural processes and rendered unavailable to biota within the most biologically active zone; however, natural processes may not occur at rates to achieve RAOs in a reasonable timeframe.	Provides a **moderate achievement** of long-term effectiveness and permanence because sediment contaminants would eventually be sequesterd by amendment and thin-layer cover materials and rendered unavailable to biota within the most biologically active zone; however, sequestration of contaminants at deeper intervals may not occur and monitoring and possible reapplication of amendment/thin-layer cover material may be necessary as contaminants would remain in place.	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.	Provides a **moderate to high achievement** of long-term effectiveness and permanence because sediment contaminants would eventually be sequesterd by amendment materials and rendered unavailable to biota; however, sequestration of contaminants at deeper intervals may not occur and monitoring and possible reapplication of amendment material may be necessary as contaminants would remain in place. Contaminated sediments would be permanently removed from a portion of the Site.
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 **no achievement** of this criterion as no reduction in toxicity, mobility, or volume through treatment is provided.	Provides a **moderate to high achievement** of this criterion as the toxicity and mobility of sediment contaminants would be reduced through addition of an amendment and thin-layer cover material at the sediment surface; however, it is possible that deeper sediment contamination could remain in place indefinitely.	Provides a **moderate** achievement of this criterion as no reduction in toxicity, mobility, or volume is provided through treatment; however, the volume of contaminated material would be completely reduced through dredging.	Provides a **moderate to high achievement** of this criterion as the toxicity and mobility of sediment contaminants would be reduced through addition of an amendment material near the sediment surface within a portion of the Site; however, it is possible that deeper sediment contamination could remain in place indefinitely. While not through treatment, the volume of contaminated material in the hotspot area would be reduced through dredging.
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 remedial actions are implemented, so no risks to the community would result from remedy implementation and risk to workers is low; however, receptors would continue to be exposed to contaminated sediment.	Provides a **moderate to high achievement** of this criterion since the least disruptive cover placement method would be used in open water and wetland environments; however, the cover materials would temporarily displace the benthic community. Risks to workers is low.	Provides a **low to moderate achievement** of this criterion since dredging and removal of the PBAZ would take place across the entire remedial area. Risks to Site workers is moderate, but for a longer duration of time than Alternative 5.	Provides a **moderate achievement** of this criterion since dredging would remove the PBAZ in open water areas of the Site. No dredging would occur in wetland areas. Risks to workers is moderate.
Implementability	Provides a **high achievement** of this criterion as no actions would be implemented.	Provides a **high achievement** of this criterion as only monitoring would be required.	Provides a **moderate to high achievement** of implementability since it only requires placement of cover material using proven methods with a low to moderate level of complexity.	Provides a **moderate achievement** of implementability since it requires a large amount of dredging and staging coordination.	Provides a **moderate achievement** of implementability since it requires a large amount of dredging and staging coordination.
Cost[1]	$0	$225,000	$5,551,000	$16,172,000	$11,955,000
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.
[2] Dredging of all COCs Greater than CULs
** Not included in numerical comparison on (Table 5-2).*

Table 7
Comparative Analysis Summary - Green Sustainable Remediation Criteria
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Evaluation Criteria	**Alternative 1: No Action**	**Alternative 2: Monitored Natural Recovery**	**Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover**	**Alternative 4: Dredging and Off-Site Disposal[1]**	**Alternative 5: Dredge Hotspot Areas of Site/EMNR in Wetland and Open Water Areas**
Green House Gas (GHG) Emissions	None.	None.	Total GHG emissions produced during cover material delivery and placment and equipment mobilization related to sampling activities.	Total GHG emissions produced during mob/demob activities, cover material delivery and placement, dredging, and mobilization related to sampling activities.	Total GHG emissions produced during mob/demob activities, cover material delivery and placement, dredging, and mobilization related to sampling activities.
Toxic Chemical Usage and Disposal	None.	No toxic chemicals are used or disposed.	No toxic chemicals are used or disposed.	No toxic chemicals are used or disposed.	No toxic chemicals are used or disposed.
Energy Consumption	None.	Fossil fuels are limited to the equipment mobilization for sampling activities.	Fossil fuels are limited to mob/demob activities, cover material delivery and placement, and mobilization related to sampling activities.	Fossil fuels are limited to mob/demob activities, cover material delivery and placement, dredging, and mobilization related to sampling activities.	Fossil fuels are limited to mob/demob activities, cover material delivery and placement, dredging, and mobilization related to sampling activities.
Use of Alternative Fuels	None.	None.	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	None.	No water consumption is necessary.	Little water consumption is necessary.	Little water consumption is necessary.	Little water consumption is necessary.
Waste Generation	None.	No waste generation.	No waste generation.	Contaminated sediments, dewatering pad materials, media	Contaminated sediments, dewatering pad materials, media
GSR Criteria Summary	Provides a **high achievement** of the GSR criterion.	Provides a **high achievement** of the GSR criterion.	Provides a **moderate achievement** of the GSR criterion.	Provides a **low achievement** of the GSR criterion.	Provides a **low achievement** of the GSR criterion.

Notes

[1] Dredging of all COCs Greater than CULs
TBD = To Be Determined

Table 8
Numerical Comparative Analysis Summary
Focused Feasibility Study
Mud Lake West
Minnesota Pollution Control Agency

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Monitored Natural Recovery	Alternative 3: Enhanced MNR with Broadcast Amendment and Thin-Layer Amended Cover	**Alternative 4: Dredging and Off-Site Disposal[2]**	Alternative 5: Dredge Hotspot Areas of Site/EMNR in Wetland and Open Water Areas
Overall Protection of Human Health & Environment	0	1	2	3	2.5
ARARs	0	1	2.5	3	2.5
Long-term Effectiveness and Permanence	0	1	2	3	2.5
Reduction of Toxicity, Mobility or Volume through Treatment	0	0	2.5	2	3
Short-term effectiveness	3	3	2.5	1	2
Implementability	3	3	2.5	1.5	1
Cost[1]	3	3	2.5	0.5	2
State Support / Agency Acceptance	TBD	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD	TBD
Total Numerical Value	**9**	**12**	**16.5**	**14**	**15.5**

Notes

[1] Cost are presented as Present Value.

[2] Dredging of all COCs Greater than CULs

Ratings are based on achievement of criterion: no achievement, low achievement; moderate achievement; and high achievement.

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

Scoring for cost are based on the following cost breakpoints: > $ 20 million = low achievement; $10-20 Million = moderate achievement; and < $10 million = high achievement.

GSR criteria not included in this numerical comparison.

See Table 6 for a discussion of each criterion.