THOMSON RESERVOIR DECISION SUMMARY
MINNESOTA POLLUTION CONTROL AGENCY
REMEDIATION DIVISION

Site Name:	Thomson Reservoir
Address:	Carlton County, Thomson Minnesota
SR/AI Number:	SR0001373/AI196230
Project Manager:	Steven Schoff
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STATEMENT OF PURPOSE

This Decision Summary presents the selected remedial action for the Thomson Reservoir section of the St. Louis River Area of Concern (SLRAOC or St. Louis River AOC) and summarizes the facts and determinations made by the Minnesota Pollution Control Agency (MPCA) in approving the selected response actions. MPCA has selected Alternative 6: Enhanced Monitored Natural Recovery with Broadcast Amendment. The response action is designed to prevent transfer of contaminants of concern (COCs) from the sediment into the pore water, which will reduce bioaccumulation into the food web.

SITE BACKGROUND

The Thomson Reservoir (Reservoir) was constructed in 1908 and consists of multiple earthen or concrete dams located in the south portion of the Reservoir used to control water flow. Water enters the Reservoir from the northwest and the northeast, from the St. Louis River (SLR) and the Midway River, respectively. Water discharges from the Reservoir primarily through sluiceways to the Forbay Channel for power generation and is also routed through Dams #3 and #4 to control pool levels and river flow, which empty to the SLR immediately upstream of the Highway 210 Bridge.

The Reservoir dam is a hydroelectric and water level control dam operated by Minnesota Power. The normal operating water level range for the Reservoir is 1059.38 to 1069.38 feet above mean sea level (amsl). Water level range varies due to multiple demands on water use, including storing water for electricity generation during periods of peak demand, maintaining Minnesota Department of Natural Resources (MDNR) minimum flow requirements from Dams #3 and #4 to the SLR to protect aquatic habitat (Schubauer-Berigan and Crane, 1996), and enhancing whitewater recreation during periods of low water flow.

Under normal operations, the Reservoir has an average water surface area of approximately 330 acres. The Reservoirs the first slow water pool storage reservoir downstream from Cloquet. As the SLR and Midway River discharge to the Reservoir, flow slows due to channel expansion, resulting in the deposition of sediments. Since its construction, fine sediment buildup has occurred behind the dams and depositional areas within the reservoir basin. The City of Carlton and Town of Thomson are located adjacent to the Reservoir. Carlton is located southwest and Thomson is located south of the Reservoir. North and east of the Reservoir are predominantly forested lands**.** The Reservoir is downstream of historical industrial waste water discharges associated primarily with the municipal discharges, building materials manufacturing, and paper manufacturing. These waste streams were removed from the SLR in 1979 when they were rerouted to Western Lake Superior Sanitary District (WLSSD). Other possible non-point sources contributing to reservoir sediment contamination include landfills, runoff, and atmospheric sources.

All the property directly bordering the Reservoir is owned by Minnesota Power. Minnesota Power, in cooperation with the University of Minnesota Duluth (UMD) Outdoor Program, provides a carry down access point for paddlers at the UMD Outpost Pier located east of Dams #3 and #4, approximately 500 feet north of Highway 210.

SITE HISTORY From 1908 to the present, the Reservoir has been used for hydroelectric generation. Historical discharge directly to the SLR, upriver of the Reservoir, includes the following: municipalities, building materials manufacturing, paper manufacturing, and match manufacturing. There is little detail available on the chemical constituents of the waste streams of the abovementioned discharges; available data for two facilities (the building materials manufacturer and the paper manufacturer) are discussed below.

The building materials facility manufactured acoustical tile and a cushioning material in automobile dashboards, shoes, and other items. Select analytical data was available from the waste stream for 1975 and 1977. When compared to current water quality data, the 1975 effluent data showed elevated metals and phenols levels; however, the 1975 sample was not analyzed for mercury. Similarly, the 1977 effluent data showed elevated mercury levels when compared to current water quality data, but it was not analyzed for polychlorinated biphenyls [PCBs] or polychlorinated dibenzo-p-dioxins/dibenzofurans [dioxins].

The paper manufacturer began operation in 1928, located half a mile downstream of Cloquet. Wastewater was discharged to the St. Louis River from this facility for approximately 50 years. Over the course of the plant's operation, wastewater was subject to various forms of treatment, some more protective than others. In 1975 and 1977, effluent from two of the paper manufacturer's outfalls was analyzed for heavy metals and phenols. Both the 1975 and 1977 effluent analytical data for mercury and phenols were elevated when compared to current water quality standards.

Dioxins and PCBs were not analyzed for in the paper manufacturer effluent during the 1975 and 1977 sampling events. In 1987, due to increased concern over dioxins contamination, effluent from the paper manufacturer (which had begun discharging to WLSSD in 1979) and WLSSD influent were analyzed then for dioxins. Dioxins refer to a broad class of compounds that vary in toxicity. To minimize analytical costs associated with the effluent and influent sampling, 2,3,7,8-tetrachlorodi-benzo-p-dioxin (2,3,7,8-TCDD), the most toxic dioxin congener, was the only dioxin compound analyzed. The concentration of 2,3,7,8-TCDD in suspended solids from WLSSD influent was 260 nanograms/kilogram and the paper manufacturer effluent concentrations were 620 nanograms/kilogram, corresponding with estimates that the paper manufacturer contributed nearly half of the dioxin in the WLSSDs influent stream. Discharge of the paper manufacturer waste stream to the SLR prior to discharge to the WLSSD was likely a significant source of the dioxins found in the Reservoir. The direct discharge of Dioxins to the Reservoir from this source and other possible sources ended with the 1979 hook-up of the Paper Company, other industries, and upstream municipalities to the WLSSD system.

DESCRIPTION OF CONTAMINANTS

In 2010-2011, The United States Environmental Protection Agency (USEPA) and United States Army Corps of Engineers (USACE) conducted an extensive sediment characterization project in the St. Louis River AOC. MPCA used the AOC-wide sediment characterization data as a baseline for its planning level analysis of the assessment data, which determined areas of the SLRAOC in need of remediation, additional investigation, or restoration. The MPCA conducted an investigation of sediment quality in the Reservoir as documented in the 2020 Focus Feasibility Study (FFS) Report for the Reservoir. Based on this study, contaminated sediments are located in a 146-acre remedial area. The Reservoir has been identified as a "Remedial Action Area" for the SLRAOC where remedial action to mitigate contaminated sediment is needed. The remedial action is driven by the ecological risk to benthic organisms in the sediment. Numerical sediment quality targets (SQTs), adopted for use in the SLR AOC to protect benthic invertebrates, can be used as benchmark values to assess ecological risk. 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). A qualitative comparison value midway between the Level I SQTs and Level II SQTs (i.e., Midpoint SQT) was used to establish criteria to identify, rank, and prioritize sediment-associated COCs within the Site.

Contaminants present include dioxins and mercury. Dioxin is the main contaminate of concern and is the driver of the remediation. Dioxins were primarily sampled over the 0.0 to 0.15-meter and 0.15 to 0.50-meter intervals. The average concentration of dioxins over these intervals was 33.59 nanograms per kilogram (ng/kg), well above the Level I SQT of 0.85 ng/kg, the Midpoint SQT of 11.20 ng/kg, and the Level II SQT of 21.50 ng/kg. Exceedances of the SQTs occurred for both sampled intervals. Due to the large percentage of SQT exceedances within both intervals and numerous exceedances of the Midpoint SQT, Level II SQTs, dioxins are a COC for the Reservoir. Spatially, dioxins Midpoint SQT exceedances appear to be deposited in four areas within the Reservoir, primarily in low energy areas of the western and eastern extents of the Reservoir, as well as low energy areas between islands located just south of the SLR entry point into the Reservoir. Based on sediment and bioaccumulation results, dioxins are considered a COC for the Reservoir due to numerous exceedances of the Midpoint SQT. The volume of contaminated sediments is estimated to be between 290,000 to 380,000 cubic yards. The Reservoir is a high priority for remedial action in the SLRAOC based on:

- Exceedance of the Midpoint Sediment Quality Target (SQT) for Dixons over a 146 acre remedial area of the 330 acre reservoir.
- Presence of bio-accumulating contaminants that contribute to fish advisories in the SLRAOC.
- Large area of bioactive zone sediments and benthic habitat impacted by contaminants.

Contaminated sediment identified in the 146 acre remedial area is considered to present a high likelihood of significant effects to benthic invertebrate communities.

As identified in the St. Louis River Remedial Action Plan (RAP), dated 2016, and later verified in the Final Focused Feasibility Study Report Thompson Reservoir, dated June 2020, the Reservoir is contributing to the following beneficial use impairments to the SLRAOC:

1) Restrictions on dredging; and
2) Degradation of the benthos environment.

The RAP indicates that areas contributing to river sediment impairments should be addressed through remedial activities. In addition to river sediment impairments, the St. Louis River, including the Duluth/Superior Harbor, is listed as impaired water on the Clean Water Act 303(d) list for bioaccumulative toxins. Toxins include mercury, PCBs, and pesticides (DDT, dioxin, etc.). Removing or isolating the contaminated sediments in the Reservoir from the surface water/sediment interface will help in the reduction of the impaired water resulting from bioaccumulative toxins in the SLRAOC.

Risk to human health

The Reservoir is in a rural area adjacent to the City of Carlton and the Town of Thomson. Access to the Reservoir is limited, with much of the surrounding land under ownership by Minnesota Power. There are no public swimming beaches located at the Reservoir. The portion of the SLR directly upstream of Thomson Reservoir is a popular kayaking route with a carry-down access point at the UMD Outpost Pier and a Kayak and Canoe Center (UMD Kayak and Canoe Center Institute Outpost) located on the southern shore of the Reservoir slightly east of Dams #3 and #4. Kayaking, canoeing, rafting, boating, and fishing occur at the Reservoir. Residential homes located in the Town of Thompson do not have direct access to the Reservoir due to property boundaries, fencing and other barriers. Public exposure to the contaminated sediments in the Reservoir is possible, but limited, given the depth and location of the contaminated sediments. All information to date indicates that the proposed future use of the Reservoir is consistent with the current use.

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 (Minnesota Department of Health [MDH], 2000). The State of Minnesota does not have guidance for a dioxins-specific fish consumption advisory; however, current fish consumption advisories for PCBs and mercury are expected to also be protective of potential dioxin concentrations found in fish from the Site.

Dioxins are generally non-volatile and not emitted from the waters of the Reservoir; therefore, the inhalation exposure pathway is considered incomplete for human receptors.

There is a potential that contaminated sediments at the Reservoir are contributing bioaccumulative contaminants into the fish food chain and contributing to the overall impaired use in the SLRAOC. However, risk to human health from direct exposer to contaminated sediments in the Reservoir is low.

Ecological risks

Fish and other aquatic organisms accumulate some chemicals, which, based on the 2016 fish tissue results, include dioxins from food and sediment that they ingest or through direct partitioning from water to biological tissues.

Complete ecological exposure pathways include the following:

- Direct contact and ingestion of contaminated sediments; and,
- Ingestion of biota that have bioaccumulated contaminated sediments.

Dioxins are generally non-volatile and not emitted from the waters of the Reservoir; therefore, the inhalation exposure pathway is considered incomplete for ecological receptors.

A comparison of the complete ecological exposure pathways and available analytical data indicates 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 data and available exposure pathways indicated that COCs are present at the Reservoir and exposure pathways are complete; therefore, contaminated sediments at the Reservoir pose a potential risk to ecological receptors.

SELECTION AND DESCRIPTION OF REMEDY

The remediation project at the Reservoir should accomplish the following remedial action objectives (RAOs) for the protection of ecological receptors:

- Minimize or remove exposure to sediment contaminants that bioaccumulate in the food chain;
- Minimize or remove exposure of the benthic organisms to contaminated sediments above sediment cleanup goals; and
- Maintain current reservoir operating capacity and functionality.

A Focused Feasibility Study (FFS), dated June 2020, evaluated alternatives to remediate contaminated sediments that pose a potential risk to receptors. Alternatives were identified and screened to determine if they met the RAOs. The following alternatives were evaluated in the FFS.

Alternative 1: No Action. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR part 300, 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 remedial investigation (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.

Alternative 2: Monitored Natural Recovery. This alternative includes collection of data commencing with a Baseline Characterization but continuing for an additional period of five years. The baseline characterization consists of hydrological investigation; bathymetric survey data collection; SLR-specific data review to determine background concentrations of COCs; and physical, chemical, and biological testing of Reservoir sediments and biota. The Baseline Characterization is necessary to determine current impacts to biota arising from contaminated sediments and to identify potential natural recovery processes within the Reservoir. During this five-year period, natural recovery processes and their trends will be monitored to quantify changes in sediment concentrations, extent of sediment deposition (i.e., isolation of contaminated sediments with clean deposits), observed toxicity to benthos, and/or observed bioaccumulative effects in benthos and fish. The approximate present value cost associated with Alternative 2 is $640,000.

Alternative 3A: Enhanced Monitored Natural Recovery. The Enhanced Monitored Natural Recovery (EMNR) Alternative includes construction of a 0.15-meter (0.5-foot) thin-layer sand cover over contaminated sediments (i.e., sediments with COC concentrations exceeding the cleanup level [CUL; **Section 2.2.1**]) to expedite natural recovery processes occurring within the Reservoir (primarily isolation) and to provide some immediate improved benthic habitat. The thin-layer cover would be placed over 146 acres of contaminated sediments and would require approximately 147,000 cubic yards of sand (including a 4-centimeter [1.5-inch] over-placement). Monitored Natural Recovery (MNR), as presented for Alternative 2, will be conducted following thin-layer cover construction to monitor natural recovery processes and cover integrity. The approximate present value cost for Alternative 3A is $10,000,000.

Alternative 3B: Enhanced Monitored Natural Recovery with Reactive Cover Amendment. This alternative includes construction of a thin-layer sand cover as presented for Alternative 3A, but also incorporates a reactive reagent, such as carbon-based sorbent, mixed into the cover. Addition of reagent would reduce availability of Site COCs in sediments and sediment pore water to aquatic organisms (primarily through contaminant sequestration) and thereby limit transfer of chemical contaminants to higher trophic organisms. The reactive cover would be placed over the same 146 acres of contaminated sediment as Alternative 3A, and would require approximately 147,000 cubic yards of sand and reagent materials. MNR, as presented for Alternative 2, will be conducted following reactive cover construction to monitor natural recovery processes and cover integrity. The approximate present value cost for Alternative 3B is $33,000,000.

Alternative 4: Potentially Bioactive Zone (PBAZ) Cap. This alternative includes construction of a 0.5- to 1.2-meter-thick sand cap over 146 acres of contaminated sediments. The constructed cap thickness will be equal in thickness to the PBAZ, which is determined by the varying habitat areas at the Site, and therefore provide contaminant isolation from aquatic plant and animal life. Construction of a cap will also mitigate exposure to human receptors, although human health criteria are not being used as cleanup criteria at this time. MNR, as presented for Alternative 2, will be conducted following cap construction to monitor natural recovery processes and cap integrity. The estimated volume of sand required to construct the cap is 560,000 cubic yards. The approximate present value cost for Alternative 4 is $29,000,000.

Alternative 5: Dredging with Thin-Layer Cover. This alternative consists of hydraulically dredging approximately 350,000 cubic yards of contaminated sediments over 146 acres of the Reservoir and subsequent construction of a thin-layer sand cover over dredged locations. This alternative would significantly reduce the volume of contaminated sediments within the Site while providing isolation from dredge residuals and/or other contamination remaining after dredging completion. MNR, as presented for Alternative 2, will be conducted following dredging and subsequent thin-layer cover construction to monitor natural recovery processes and cover integrity. The approximate present value cost for Alternative 5 is $54,000,000.

Alternative 6: Enhanced Monitored Natural Recovery with Broadcast Amendment. This EMNR with broadcast amendment alternative would consist of applying a thin 0.01-meter layer of amendment material directly on top of the sediment surface in areas with sediment concentrations of COCs exceeding the preliminary clean up levels (CULs; i.e., areas of the reservoir with exceedances of the Midpoint SQT for dioxins), hereafter referred to as remedial areas. Amendment material would be mixed into the sediments over time through bioturbation. The chosen amendment would reduce exposure of aquatic life to COCs through sequestration of sediment contaminants. Monitoring of sediment chemical concentrations, sediment toxicity, and bioaccumulation of COCs in aquatic life would be conducted until sufficient contaminant sequestration, degradation, transformation, or other natural recovery processes reduce risks to acceptable levels. A monitoring period and implementation of ICs would be conducted following the construction phase as detailed for Alternative 6. Monitoring and enforcement of ICs would continue indefinitely until RAOs are achieved for the Reservoir, but a period of 30 years was used for incorporation into each alternative's cost analysis. The approximate present value cost associated with Alternative 6 is $20,000,000.

The FFS included a comparative analysis to identify and compare advantages and disadvantages of each of the alternatives. This evaluation was done using the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) remedy selection criteria in general accordance with United States Environmental Protection Agency (EPA) guidelines for feasibility studies (EPA, 1990) which divides criteria into three groups.

1. **Threshold Criteria**, which relate to federal statutory requirements that each alternative must satisfy in order to be eligible for selection and including:
    - Overall protection of human health and the environment in both short and long term
    - Compliance with applicable or relevant and appropriate requirements (ARARs) under federal, state, or local environmental laws and regulations
2. **Primary Balancing Criteria**, which are the technical criteria upon which the detailed analysis is based on, including:
    - Long-term effectiveness and permanence
    - Reduction of toxicity, mobility, or volume through treatment
    - Short-term effectiveness
    - Implementability

- Costs

3. **Modifying Criteria based on state agency and community acceptance.**

COMPARATIVE ANALYSIS OF ALTERNATIVES

The purpose of the comparative analysis is to identify and compare advantages and disadvantages of each evaluated alternative, with respect to remedy selection criteria, in order to determine which of the alternatives best meets those criteria.

Threshold Criteria

Only those alternatives that would meet the threshold criteria of providing overall protection of ecological receptors and would attain compliance with ARARs were carried forward for comparative analysis. Based on available information, all alternatives discussed will achieve some protection of ecological receptors from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the Site to varying degrees.

Alternative 1 would not achieve the criteria. Alternative 2 would provide a low achievement of protection because all contaminated sediment would be left in place and no actions would be performed to isolate contaminated sediments from receptors. Alternative 2 relies on ICs and natural sedimentation to slowly isolate and biodegrade contaminants. Sedimentation rates at the Reservoir may range between less than 1 millimeter per year (Beak, 1992) and 50 millimeters per year (Schubauer-Berigan and Crane, 1996). Based on ITRC guidance, sites with net sedimentation rates of 5 millimeters per year are candidates for MNR (ITRC, 2014); however, sedimentation data for the Reservoir is sparse and the uncertainty of sedimentation at the Reservoir is high. Therefore, Alternative 2 may provide protection of human health and ecological receptors over time. ARARs would not be met for sediment because contamination would remain in place.

Alternatives 3A, 3B, 4, 5, and 6 would eliminate or control exposure to contaminated sediment over time; however, contaminated sediment would remain in place under Alternatives 3A, 3B, 4, and 6 and require monitoring to assure long-term effectiveness. Further, hydrodynamics of the Reservoir, including sediment erosion and deposition, are limited or unknown; therefore, uncertainty of the ability for Alternatives 3A, 3B, 4, and 6 to meet threshold criteria is high. Alternatives 3A, 3B, and 6 would rely on natural sedimentation to isolate contaminated sediment from receptors. Natural sedimentation rates at the Reservoir are currently poorly understood. Alternative 4 would provide a higher level of protection than Alternatives 3A, 3B, and 6 because contaminated sediments would be isolated and a new PBAZ would be established; however, contaminated sediments would remain in place and there is a high degree of uncertainty regarding the overall effectiveness of Alterative 4 due to a lack of understanding of the Reservoir's hydrodynamics. Alternative 5 would provide the highest level of protection, since contaminated sediments would be removed from the aquatic environment; however, the depth of sediments impacted with dioxins is currently not known, complete removal of all contaminated sediment may not be feasible, and the ability to meet threshold criteria is uncertain.

In summary, Alternative 1 provides no protection of ecological receptors and a low achievement of ARARs. Alternative 2 provides a low degree of protection of ecological receptors and a low achievement of ARARs. For both Alternatives 1 and 2, additional evaluation is necessary to determine environmental effects. Alternatives 3A, 3B, 4, and 6 provide moderate to moderately high protection of ecological receptors and attains compliance with ARARs. Alternative 5 provides the highest level of protection of ecological receptors and also attains compliance with ARARs.

Balancing Criteria

<u>Long-Term Effectiveness and Permanence</u>

Alternative 1 does not achieve long-term effectiveness or permanence. Alternative 2 provides a low achievement of long-term effectiveness or permanence as the MNR at the Reservoir is currently poorly understood and this Alternative may not achieve RAOs in a reasonable time frame.

Based on ITRC guidance, sites with net sedimentation rates of 5 millimeters per year are candidates for MNR (ITRC, 2014). Alternatives 2, 3A, 3B, and 6 may be effective in the long-term because historical sedimentation data indicates sedimentation rates at the Reservoir are above 5 millimeters per year and range between 28 and 50 millimeters per year; however, there is limited sediment erosion and deposition data for the Reservoir that creates a high level of uncertainty of the long-term effectiveness and permanence of these alternatives. Unknown factors in the hydrodynamic model, such as the erosion of contaminated sediments and the effects of periodic flooding, may also reduce the long-term effectiveness and permanence of Alternatives 2, 3A, 3B, and 6. Additionally, contaminated sediment would remain in place under Alternatives 2, 3A, 3B, and 6, requiring a monitoring and evaluation period and ICs to assure long-term effectiveness; therefore, these alternatives have a low to moderate degree of permanence. Of these three alternatives, Alternative 2 would achieve the lowest level of long-term effectiveness and permanence because it relies only on natural sedimentation, which may be inadequate to isolate contaminated sediments. Alternative 3A would achieve a higher level of long-term effectiveness and permanence than Alternative 2 because natural sedimentation would be supplemented by the 0.15-meter thin-layer cover, accelerating the process of physical isolation. Alternative 3B would provide a higher level of long-term effectiveness and permanence than Alternative 3A because the amended thin-layer cover material would likely reduce exposure to contaminants through flux while also accelerating the process of physical isolation. Alternative 6 may provide a higher level or long-term effectiveness than Alternative 3A because the broadcast amendment would likely reduce exposure due to sequestration of sediment contaminants, similar to Alternative 3B; however, Alternative 6 does not provide the benefit of isolation from contaminants, as does Alternative 3A/3B. Bench-scale testing indicates that Alternative 3B and Alternative 6 will likely be effective in the long term when amendment materials mix into underlying sediments and sequester sediment contaminants throughout the entire PBAZ.

Alternative 4 has a potential to have a higher degree of long-term effectiveness than Alternatives 2, 3A, 3B, and 6 as it completely isolates the contamination under a cap. However, uncertainties in long term hydrodynamic variability of the Reservoir and potential to disrupt the cap in places lowers the confidence that Alternative 4 will remain protective in the long term.

Dredging and disposal of dewatered sediment at an off-site landfill under Alternative 5 would be the most effective long-term alternative when compared to Alternatives 2, 3A, 3B, 4, and 6. All accessible contaminated sediments would potentially be removed under Alternative 5, providing the most permanence. The depth of sediments impacted with dioxins is currently not known and complete removal of all contaminated sediment under Alternative 5 may not be feasible.

In summary, Alternative 5 would provide the highest degree of long-term effectiveness, followed by Alternative 4 because contaminants would either be removed completely or made inaccessible by a cap. However, further information would need to be collected regarding the implementability of Alternative 5 and hydrodynamic uncertainties of the Reservoir. Alternatives 3A, 3B, and 6 provide moderate long-term effectiveness and permanence because these alternatives rely on natural sedimentation, which is currently not well understood. Alternatives 1 and 2 provide the lowest degree of long-term effectiveness and permanence.

<u>Reduction of Toxicity, Mobility, or Volume through Treatment</u>

Treatment of contaminants sediments to reduce toxicity, mobility, or volume is not a major component of any of the evaluated alternatives.

Alternatives 1, 2, and 3A would not provide a reduction in the toxicity, mobility, or volume through treatment; however, mobility of contaminants would be reduced over time providing adequate sedimentation is occurring at the Reservoir. The amended material utilized in Alternative 3B and 6 would provide some reduction of toxicity by reacting with contaminated materials that pass through the thin-layer cover through ebullition, infiltration, and bioturbation processes. Similarly, Alternative 4 would not provide a reduction in the toxicity, mobility, or volume through treatment; however, mobility of contaminants would be reduced at the time of the remedial action because contaminated sediments would be capped in place and toxicity would be reduced over time through natural processes.

Alternative 5 would not provide a reduction in the toxicity, mobility, or volume through treatment; however, the volume of contaminated sediment would be reduced at the Reservoir because all accessible contaminated sediment would be removed from the aquatic environment. The removal of contaminants from the aquatic environment would provide a reduction in toxicity, mobility, and volume of contaminants within the Reservoir. Removal of the contaminants would be considered permanent.

In summary, Alternatives 1, 2, and 3A provide the lowest degree of toxicity, mobility, and volume reduction through natural processes. Alternative 3B and 6 are the only remedies that achieve reduction of toxicity, mobility, or volume through treatment via amendment material, which places them at a moderate to high level of achievement of these criteria. Alternative 4 effectively reduces the mobility of contaminated sediments and would reduce the toxicity over time, providing a moderate to high level of achievement of these criteria. Alternative 5 would provide the highest degree of reduction of volume through removal of contaminated sediment from the aquatic environment.

Short-Term Effectiveness

There are no short-term risks associated with Alternative 1. Alternative 2 sampling and monitoring activities would have no short-term risks, with the exception of minimal risk to site workers during sampling efforts that is mitigated through the Site Safety and Health Plan (SSHP). The rest of the alternatives would have short-term risks during implementation of the remedy. Alternatives 3A, 3B, 4, 5, and 6 require varying amounts of capping or dredging that may impact short-term effectiveness. The potential short-term risks increase as the complexity of each alternative increases. Alternatives 6, 3A, 3B, 4, and 5 have a respectively increasing degree of complexity. The potential short-term risks to the community and workers with Alternatives 3A, 3B, 4, 5, and 6 are associated with increased boat/barge and trucking traffic, daily job hazards, and contact with contaminated materials, dust, and noise.

No short-term adverse effects to aquatic habitat and biota are associated with Alternatives 1 and 2, with the exception of continued exposure to contaminated sediments.

Short-term adverse effects to aquatic habitat and biota would be similar among Alternatives 3A, 3B, 4, 5, and 6, and would include displacement of fish and smothering or removal of benthic organisms; however, the degree of these effects varies with each alternative. Alternative 6 would result in the least amount of short-term adverse effects, followed by Alternatives 3A and 3B because benthic organisms would likely survive placement of broadcast amendment or thin-layer cover material. Under Alternatives 3A and 3B, benthic organisms would benefit from immediate access to 0.15 meters of contaminant-free habitat to reside in; however, benthic organisms would still have access to contaminated sediments within their natural habitat until natural sedimentation provides adequate isolation of contaminated sediment. Alternative 4 would have more short-term adverse effects because benthic organisms would not survive cap placement and former habitat would be smothered; however, cap design and construction incorporating habitat zones and associated PBAZ thicknesses would prevent exposure of newly established benthic organism colonies to contaminated sediments.

Alternative 4 would have immediate short-term impacts to the power-generating potential of Thomson Reservoir because the alternative includes construction of a cap up to 1.20 meters in thickness. This cap thickness would reduce the overall capacity of the reservoir and limit the power-generating capabilities of the hydroelectric generator in Forbay Reservoir.

Alternative 5 would likely present similar adverse effects as Alternative 4 since dredging contaminated sediments would result in a complete loss of the established habitat and benthic community. Additionally, the thin-layer cover placed following dredging would not provide as much habitat for benthic communities to recover. The total depth of contamination is not currently known; therefore, if contaminated sediments are not completely removed benthic organisms may be exposed to contamination not previously accessible. 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 thin-layer cover and cap placement, as well as dredging activities. Surface water control structures have shown that they are reliable in minimizing these short-term adverse effects.

In summary, Alternative 6 will have the highest level of achievement of the short-term effectiveness criterion followed by Alternative 3A and 3B. Alternative 1 and 2 and will have a moderate achievement of this short-term effectiveness criterion. Alterative 4 and 5 have a low achievement of short term effectiveness due to an increase in short-term risks from construction activities and immediate destruction of existing benthic communities and habitat.

Implementability

Alternative 1 presents no concerns with implementability and Alternative 2 provides few concerns. It may be difficult to enforce Alternative 2's ICs that limit access to the Reservoir. Varying degrees of capping, dredging, upland construction, surface water control structures, and/or monitoring and evaluation would be required under Alternatives 3A, 3B, 4, 5, and 6. These alternatives are 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. Services and materials are available for implementing each component of Alternatives 3A, 3B, 4, 5, and 6.

Alternative 5 includes dredging contaminated sediment that is in contact with subgrade (bedrock) that may pose additional, but not insurmountable, difficulties. Additionally, depth of contamination is currently not known; therefore, if the depth of contamination is significantly greater than what is currently estimated, removal of all contaminated sediment under Alternative 5 may be difficult to implement.

Weather could significantly impact productivity of Alternatives 3A, 3B, 4, 5, and 6, particularly if done in the early spring or late fall. High winds in the late fall produce large waves that could impact productivity. Winter or freezing conditions in the fall could also impact productivity or shorten the construction season altogether. Alternative 5 has 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 agency and stakeholder input is required; therefore, the administrative feasibility of implementing a remedy is lower. Additional time will be required to obtain any necessary approvals and permits from other agencies. Alternatives 3A, 3B, 4, 5, and 6 will require extensive coordination and concurrence with Minnesota Power, the entity that manages the Reservoir and owns much of the surrounding land. Several of these alternatives will impact the capacity of the Reservoir and would require extensive construction for lay-down and staging areas, which could pose difficulties to implementation.

Alternative 5 will require more coordination with other regulatory agencies than Alternatives 3A, 3B, 4, and 6 because off-site disposal will be required. However, Alternatives 3A, 3B, 4, and 6 will require coordination to obtain permits for capping. Alternatives 1 and 2 will require the least amount of coordination with regulatory agencies and stakeholders.

In summary, Alternative 1 provides the highest level of achievement of the implementability criterion. Alternative 2 is then the next easiest to implement since it requires only sampling and monitoring. Alternatives 3A, 3B, and 6 have the next highest level of achievement of implementability, respectively, because they impact the Reservoir the least, require a shorter implementation schedule, and are generally less complex compared to Alternatives 4 and 5. Alternative 5 is more complex than Alternative 4, and will require the most permitting and a longer construction schedule; therefore, Alternative 5 achieves the lowest implementability ranking of all the alternatives.

Cost

Cost estimates were developed for each alternative. Cost estimates include capital costs for professional/technical services, construction activities, and ICs, monitoring and evaluation costs over a 5-year period, and periodic costs such as bathymetric surveys. Costs are presented as present value in each respective alternative cost estimate with a base year of 2016 and a discount rate of 7%.

Cost estimates are presented as ROM costs as insufficient data exists in which to delineate the horizontal and vertical extent of contamination at the Site, and significant assumptions regarding contaminated sediment volumes and the spatial extent of contamination were made to facilitate cost estimating. Full delineation of remedial areas is essential for conducting cost estimating as unit volumes (i.e., volume of sediments requiring removal, transportation, disposal, etc.; volume of cover/cap materials to be purchased, placed, etc.) have a dramatic influence over total project cost. For example, larger scale projects typically see reduced costs per unit of material dredged/placed due to economies of scale and potential efficiencies gained by working several shifts in a single day (e.g., 16-hour or 24-hour production days) and through maximizing use of rented equipment/facilities and constructed upland support features. Additionally, changes in unit volumes can increase the total project cost rapidly as individual cost elements can be more expensive than sediment removal or cover/cap placement alone, such as transportation, disposal, sediment dewatering and contact water treatment, and purchase of amendments, treatment media, or other consumables.

Reservoir hydrodynamics are poorly understood. Development of a hydrodynamic model would be beneficial in defining erosive and depositional areas of the Reservoir. Definition of erosive areas could add to total project cost as additional armoring materials could be required over sand cover/cap areas to prevent scouring. Definition of depositional areas of the Reservoir could reduce total project costs as alternatives involving natural recovery through contaminant isolation could be implemented.

In summary, the cost estimates provided within this FFS should be considered to be ROM costs and should be refined after additional Reservoir data is collected. As compiled, Alternative 1 has no cost. Alternative 2 is the most cost effective option; however, it only includes a baseline study and a monitoring and evaluation period of 5 years. Alternative 3A is the next most cost-effective option as only a thin-layer sand cover is required. Alternatives 6 is the next most cost-effective option as it requires application of amendment material, which is significantly more expensive than sand used in Alternative 3A. Alternative 4 is similar in cost effectiveness to Alternative 3B, but it requires significantly more sand than Alternative 3A. Alternative 3B is significantly more costly than Alternatives 3A and 6 because it requires both sand and amendment material. Alternative 5 is the least cost effective option as it requires complete removal of contaminated sediments, transportation and disposal of contaminated sediments, and placement of thin-cover material.

Modifying Criteria

On July 30, 2020 a MPCA press release announced the clean-up options for the Thomson Reservoir in the St. Louis River Estuary. The public was given thirty days to comment on the plan. No comments were received. MPCA has been in regular coordination with Minnesota Power to ensure that the proposed remedial action is consistent with the current and planned future power generation at the site. MPCA has also provided an opportunity for area resource managers to comment on the proposed remedial action.

Green Sustainable Remediation Criteria

<u>Green House Gas Emissions</u>

Alternative 1 produces no GHG. Alternative 2 would only produce GHG emissions associated with mobilization/demobilization and boat operation associated with sampling efforts. Alternatives 3A, 3B, 4, 5, and 6 would result in GHG emissions from the mobilization, operation, and demobilization of all fuel-powered construction equipment required to construct the cap/cover, and/or dredge. Alternative 5 would also produce emissions during transport by truck to the disposal facility. 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.

<u>Toxic Chemical Usage and Disposal</u>

There is no known toxic chemical usage or disposal associated with these alternatives.

<u>Energy Consumption</u>

Alternative 1 has no energy consumption. Alternative 2 would consume minimal amounts of fossil fuels compared to the other alternatives. Alternatives 3A, 3B, 4, 5, and 6 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 cover/cap material. The amount of cover/cap material placed in Alternatives 3A and 3B is considerably less than in Alternative 4; therefore, the energy consumption for cover/cap construction for Alternatives 3A and 3B would be less than Alternative 4. Alternative 5 would require the greatest amount of energy to implement.

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 3A, 3B, 4, 5, and 6.

Water Consumption

Alternatives 1 and 2 would not require the consumption of water. There are few water consumption considerations associated with Alternatives 3A, 3B, 4, 5, and 6. A minimal quantity of water would be required to decontaminate personnel and equipment during sediment dredging activities associated with Alternative 5, and water utilized for hydraulic dredging would be sourced from the Reservoir, treated during the dewatering process, and returned to the Reservoir.

Waste Generation

Alternatives 1, 2, 3A, 3B, 4, and 6 would not generate a significant amount of waste. Alternative 5 would generate a large volume of waste that includes the dredged contaminated sediments.

Comparative Analysis Summary

The comparative analysis of alternatives narrative discussion did not clearly identify a superior alternative to address the contamination at the Reservoir; however, Alternatives 3B and 6 received the highest overall numerical scores in the alternative analysis.

Bench-scale treatability testing was completed on sediments collected from the Scanlon Reservoir (which are assumed to be similar in composition and COCs to the Thompson Reservoir sediments) to evaluate the effectiveness of different activated carbon (AC) amendments and doses to reduce the bioavailability of dioxins/furans in reservoir sediments using two AC particle size ranges; a silt-sized powdered activated carbon (PAC) and a fine sand-sized granular activated carbon (GAC). The results of the bench-scale treatability study indicated that different AC amendments and doses (PAC at 2% and 4% dose, and GAC at 4% dose) are likely to be effective at significantly reducing bioavailable concentration of dioxins in reservoir sediments. Application methods will be retained for further engineering and cost evaluations.

The United States Army Engineer Research and Development Center (ERDC) conducted a literature review evaluating whether a remedial alternative involving AC might affect mercury toxicity and bioaccumulation. Review of available research indicated that AC may be a useful sorbent for reducing the potential for mercury bioaccumulation. In addition, the use of AC for in-situ sediment remediation does not appear to increase the potential for mercury toxicity and bioaccumulation in water or sediments.

The modifying criteria, state/support agency acceptance, and community acceptance were assessed formally after the public comment period. Stakeholder and community input provided valuable insight for MPCA in the selection of a preferred alternative. The MPCA released the findings of the FFS and invited resource managers, the public, and local units of government prior to the public comment period.

Based on the information provided in the FFS report and on input provided by adjacent property owners, comments from the public meeting and other stakeholders, the MPCA staff has selected **REMEDIAL ALTERNATIVE 6: Enhanced Monitored Natural Recovery with Broadcast Amendment** as the preferred option. Some of the primary reasons for selecting Alternative 6 as the preferred option are summarized below.

- Alternative 6 is protective of human health and the environment.
- Alternative 6 is cost effective and is the only alternative that reduces the toxicity, mobility, or volume of contamination through treatment.
- Primary stakeholders, including adjacent property owners, support Alternative 6, which will not adversely affect the current or planned future uses of the Reservoir.

DETAILED DESCRIPTION OF SELECTED REMEDIAL ALTERNATIVE 6: Enhanced Monitored Natural Recovery with Broadcast Amendment

This EMNR with broadcast amendment alternative would consist of applying a thin 0.01-meter layer of amendment material directly on top of the sediment surface in the remedial areas with sediment concentrations of COCs exceeding the preliminary clean up levels (CULs; i.e., areas of the Site with exceedances of the Midpoint SQT for dioxins). Amendment material would be mixed into the sediments over time through bioturbation. The chosen amendment would reduce exposure of aquatic life to COCs through sequestration of sediment contaminants. Monitoring of sediment chemical concentrations, sediment toxicity, and bioaccumulation of COCs in aquatic life would be conducted until sufficient contaminant sequestration, degradation, transformation, or other natural recovery processes reduce risks to acceptable levels. A monitoring period and implementation of ICs would be conducted following the construction phase as detailed for Alternative 6.

Long-Term Monitoring

The LTM plan will be developed in the Remedial Design phase of the project and commence after remedy implementation.

Institutional controls

ICs will be necessary to ensure contaminated sediments will remain in-place and the remedy remains protective of human health and the environment. The IC plan will be developed in the remedial design phase of the project and implemented following remedy construction.

Cost

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 6, is $20,000,000.

PUBLIC COMMENTS AND RESPONSES

On July 30, 2020 an MPCA press release announced the clean-up options for the Thomson Reservoir in the St. Louis River Estuary. The public was given thirty days to comment on the plan. No comments were received.

MPCA site decision

The selected response actions are consistent with the Minnesota Environmental Response and Liability Act, Minn. Stat. §§ 115B.01 to .18, and are not inconsistent with the Federal Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. § 9601 et seq and the National Contingency Plan, 40 C.F.R Part 300. I have determined the selected response actions are protective of public health, welfare, and the environment.

Signature: Kathy Sather Date (mm/dd/yyyy): 11/24/2020

(This document has been electronically signed.)

Kathy Sather
Division Director
Remediation Division