St. Louis River Area of Concern

Beneficial Use Impairment Removal Recommendation for

*Excessive Loading of Sediment and Nutrients*

February 12, 2020

To Be Submitted to:

U.S. EPA-Region 5
77 W. Jackson Boulevard
Chicago, IL 60604

Prepared by these implementing agencies:

With major funding support from the:
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ACRONYMS

- AOC – Area of Concern
- BUI – beneficial use impairment
- ca. – circa
- CBOD – carbonaceous biological oxygen demand
- chl α – chlorophyll α
- CWA – Clean Water Act
- CWMP – Coastal Wetland Monitoring Program
- DO – dissolved oxygen
- DOP – dissolved orthophosphorus
- EPT – Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies)
- FdL – Fond du Lac Band of Lake Superior Chippewa
- HSPF – Hydrologic Simulation Program—FORTRAN
- IBI – index of biotic integrity
- IEC – index of ecological condition
- MAs – management actions
- µg/L – microgram per liter
- mg/L – milligram per liter
- MNDNR – Minnesota Department of Natural Resources
- MPCA – Minnesota Pollution Control Agency
- N – nitrogen
- NRCS – Natural Resources Conservation Service
- ntu – nephelometric turbidity unit
- RAP – Remedial Action Plan
- SLRAOC – St. Louis River Area of Concern
- SLRE – St. Louis River Estuary
- TN – total nitrogen
- TIN – total inorganic nitrogen
- TMI – trimetric index
- TP – total phosphorus
- TSI – trophic state index
- TSS – total suspended solids
- UMD – University of Minnesota Duluth
- USEPA-GLNPO – U.S. Environmental Protection Agency – Great Lakes National Program Office
- USEPA-GLTED – U.S. Environmental Protection Agency – Great Lakes Toxicology and Ecology Division
- USGS – U.S. Geological Survey
- WDNR – Wisconsin Department of Natural Resources
- WLSSD – Western Lake Superior Sanitary District
### COMPARISON OF UNITS USED TO EXPRESS CONCENTRATIONS:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Also Described As</th>
<th>Equals</th>
</tr>
</thead>
<tbody>
<tr>
<td>milligram per litter</td>
<td>mg/L</td>
<td>Part per million (ppm)</td>
<td>1/10^6 or 0.000001</td>
</tr>
<tr>
<td>microgram/L</td>
<td>µg/L</td>
<td>Part per billion (ppb)</td>
<td>1/10^9 or 0.000000001</td>
</tr>
</tbody>
</table>

Conversions: $1 \, \mu g/L = 0.001 \, mg/L$ or $1 \, mg/L = 1000 \, \mu g/L$

Within this document, mg/L will be the base unit used. Where scientists have used $\mu g/L$ in their papers, the mg/L conversion will be shown in brackets to ease comparisons.
Executive Summary

Background

The United State and Canada designated 43 Areas of Concern (AOC) across the Great Lakes in 1987, including the St. Louis River Area of Concern (SLRAOC). They were designated because significant environmental damage at those locations caused specific types of Beneficial Use Impairments (BUIs). At the time of AOC designation, the International Joint Commission identified 14 BUIs in the Great Lakes Water Quality Agreement that were to be assessed at each AOC to determine their applicability. Only nine BUIs applied to the SLRAOC. Once the BUIs were identified, removal targets for each were established and management actions (MAs) to achieve the targets for each BUI were identified.

Once the MAs for a BUI are completed, a removal package is prepared for public review and, ultimately, concurrence by the U.S. Environmental Protection Agency.

This document addresses the Excessive Loading of Sediments and Nutrients BUI (BUI 6), which is a modification of the “Eutrophication or Undesirable Algae” BUI from the Great Lakes Water Quality Agreement to address the SLRAOC-specific conditions. All five MAs that apply to BUI 6 are completed and the BUI 6 removal target and its four criteria are met. The removal criteria and brief conclusions pertaining to the studies applicable to each are included in the executive summary below. Detailed summaries of the studies and findings for each MA are included in the main body of this document and the study reports prepared for each management action are included in the appendices.

The voluntary AOC program was established to address “legacy” issues. These were environmental problems that caused ecosystem impairments at the time of the AOC designation and largely occurred before modern environmental regulations were in place. Legacy issues significantly impacted geographically-defined sites rather than regional-scale stressors.

For the SLRAOC, examples of legacy issues are unregulated discharge of industrial and municipal waste, dredging and filling in the estuary, wood waste deposited in the river, and extensive logging – all of which exacerbated erosion and sedimentation problems. Since then, the Clean Water Act (CWA) and other environmental regulations are being implemented to protect the environment and human health from these types of large-scale problems.

The scope of the AOC program does not include “modern” issues that are the responsibility of many state and federal agencies under a variety of natural resources, environmental, and public health program authorities. Some examples of modern issues are: contaminants of emerging concern, water-related climate change impacts, non-compliance of point source permits, and impairments identified and regulated under the CWA. Figure ES-1 depicts the differences between the AOC and existing agency programs.
Figure ES 1: The Program Scope of the St. Louis River Area of Concern

As it relates to the removal of the Excessive Loading of Sediment and Nutrients BUI discussed in this report, consider climate change effects as an example of the difference between legacy and modern impacts. The SLRAOC is experiencing more frequent and intense storm events and these are affecting the intensity of seiche impacts, which are, in turn, impacting sediment and nutrient conditions in western Lake Superior and the SLRE. These are modern impacts that fall under the purview of the CWA, not the SLRAOC program. The Future Actions section of this document lists a variety of future needs to be addressed by other agency programs.

It is important to note that the assessments associated with each MA are time limited. Once a MA is completed, there is not an effort to return to the endpoint of the studies to add data gathered by other agency programs since the conclusion of the study. Similarly, many implementation activities pertinent to BUI 6 are already underway by other agency programs that are outside the SLRAOC program. More recent data and activities are not reported here. Additionally, regulatory programs are ever-evolving and terminology in place when the BUI 6 studies were completed have not been substituted by newer terminology (e.g., turbidity impairments under the CWA are now TSS impairments).

The Removal Target and Criteria Have Been Met

The removal target will have been met when: \textit{Nutrient and sediment levels have not been shown to impair water quality and habitat, and do not restrict recreation, including fishing, boating, or body contact in the estuary and within western Lake Superior based on the following criteria:}
1. All federal, state, and local point source and nonpoint source discharge permits in the AOC are in compliance with regard to controlling sources of nutrients (particularly nitrogen and phosphorous), organic matter, and sediment;

CONCLUSION: As confirmed by the WDNR, all eight pollutant discharge elimination system permits within the SLRAOC area are in substantial compliance as of December 2019. MPCA has confirmed that there are 32 pollutant discharge elimination system permits within the SLRAOC area, of which only 21 have nitrogen, phosphorus, TSS and/or CBOD effluent limits and/or monitoring requirements. One industrial permittee is noncompliant for TSS and is following MPCA’s compliance processes to address the noncompliance issues.

Additionally, WLSSD and the City of Duluth are working to meet the conditions of a federal Consent Decree to reduce inflow and infiltration into the sanitary sewer system as a means to reduce sanitary sewer overflows.

Both the City of Superior and the City of Duluth have also invested in stormwater management practices and outreach to reduce the impacts of non-point source, urban runoff.

2. Total phosphorus concentrations in the Lake Superior portion of the AOC do not exceed 0.010 mg/L (upper limit of oligotrophic range);

CONCLUSION: Multiple data sources indicated that the Lake Superior portion of the AOC met this criterion (Table ES-1). The Lake Superior data from the 2012 and 2013 BUI study (MA 6.01) showed that TP values were slightly higher than the BUI criterion of 0.010 mg/L for Lake Superior’s western arm, with an average of 12.7 μg/L [0.0127 mg/L]. Additional water quality parameters sampled during the study show that DO was generally near saturation and the chl α concentrations were consistent with an oligotrophic water body. Paleolimnological study results (MA 6.03) for the Lake Superior sample location concluded (1) water quality improvement from past periods of higher TP concentrations and (2) current prevailing concentrations of phosphorus did not exceed the TP criterion. Specifically, diatom-inferred TP results for the Lake Superior core indicated that western Lake Superior concentrations of TP were 3 - 6 μg/L (0.003 to 0.006 mg/L). TP results from USEPA’s Great Lakes Biological Monitoring Program showed that from 1996-2015 the mean western Lake Superior TP concentration was 2.6 μg/L [0.0026 mg/L] and the range was 1.0 to 8.0 μg/L [0.001 to 0.008 mg/L] and never exceeded the criterion.

Data from this assessment was collected in nearshore conditions, which were likely biased toward St. Louis River conditions due to river water mixing with the lake at the sample sites.
2. The USEPA’s Great Lakes Biological Monitoring Program sampling point is not located within the boundary of the SLRAOC.

3. There are no exceedances of the most protective water quality standard for either state in the western basin of Lake Superior due to excessive inputs of organic matter or algal growth attributed to loadings from wastewater overflows into the St. Louis River;

CONCLUSION: Data used to assess St. Louis River water quality against the BUI removal criteria (MA 6.01-6.04) do not indicate that any excessive input of organic matter or algal growth exist as BUI criteria have been met. Wastewater overflows are prohibited by Wisconsin Administrative Code Chapter NR 210.21 and are administered in Minnesota by State Statute 115.03, Minnesota Rule 7050.0210 and Minnesota Rule 7053.0205.

Wastewater overflows, including sanitary sewer overflows, treatment facility overflows and combined sewer overflows have been drastically reduced since the time of AOC listing. Wastewater permits administered by the states have included conditions to reduce and report overflow events. In addition, as of August 2016, all facilities in Wisconsin were required to have developed and be actively implementing a Capacity, Management, Operation, and Maintenance program for operation and maintenance of sanitary sewer collection systems with goals to help address issues of inflow and infiltration which are the primary causes of overflow events. Minnesota’s wastewater permitees have met similar facility management requirements. Upgrades to wastewater and collection systems in the past decade have resulted in significant reductions in overflow events.

4. Total phosphorus concentrations within the St. Louis River portion of AOC do not exceed an interim guide of 0.030 mg/L (upper limit of mesotrophic range) or the most restrictive water quality standards. This ensures that anthropogenic sources and activities in the St. Louis River AOC do not result in excessive productivity and nuisance conditions within the St. Louis River Estuary.

CONCLUSION: The 5 MA’s that have been completed for this BUI indicated that water quality improvements in the SLRE and Nemadji River watershed have resulted in the majority of the AOC meeting the phosphorus criterion (see Table ES-1). In addition, other water quality parameters (TSS, DO and chl α) indicate nutrients and sediments are not causing an impairment. Data showed a dramatic decline in TP concentrations and sediment loading in the SLRAOOC since the time of listing.
## Table ES-1: Summary of Water Quality Results for Management Action 6.04

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLRE (Fdl dam to Lake Superior)</th>
<th>Lake Superior&lt;sup&gt;1&lt;/sup&gt; (Bellinger 2016)</th>
<th>Western Lake Superior&lt;sup&gt;2&lt;/sup&gt; (USEPA’s GL Biological Monitoring 1996-2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>~60% of area below 30 µg/L [0.030 mg/L]</td>
<td>Average = 12.7 µg/L [0.0127 mg/L]</td>
<td>Average = 2.6 µg/L [0.0026 mg/L]</td>
</tr>
<tr>
<td>TSS</td>
<td>&gt;85% of area below 15 mg/L</td>
<td>Average = 4.4 mg/L [0.0044 mg/L]</td>
<td>not assessed</td>
</tr>
<tr>
<td>DO</td>
<td>&gt;5.5 mg/L; no hypoxia</td>
<td>Average = 12.2 mg/L</td>
<td>not assessed</td>
</tr>
<tr>
<td>chl α</td>
<td>&gt;70% of area below 10 µg/L [0.010 mg/L]; oligotrophic to mesotrophic</td>
<td>Average = 2.7 µg/L [0.027 mg/L]; oligotrophic</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

1 The interim TP guide for Lake Superior is 0.010 mg/L. Data from this assessment was collected in nearshore conditions, which were likely biased toward SLRE conditions due to seiche mixing.

2 The USEPA’s Great Lakes Biological Monitoring Program sampling point (SU 19) is not located within the boundary of the SLRAOC

A BUI technical team of subject matter experts was established to evaluate the removal strategy and review the findings from each study and offer recommendations to address any deficiencies until the target and criteria were met (see Appendix 11 for the technical team members and their affiliations).

A public information process was conducted to obtain input from interested parties on the information provided in the removal package.

Multiple lines of evidence support a removal recommendation for this BUI. The results of the BUI 6 studies, along with support from the BUI 6 technical team, SLRAOC partners, and stakeholders have resulted in this recommendation by the SLRAOC Coordinators, leaders, and executive managers to remove the Excessive Loading of Sediments and Nutrients BUI from the SLRAOC.
Purpose

The purpose of this document is to provide the information needed to support a recommendation to remove the Excessive Loading of Sediment and Nutrients Beneficial Use Impairment (BUI) in the St. Louis River Area of Concern (SLRAOC).

St. Louis River Area of Concern Background

The 1987 US-Canada Great Lakes Water Quality Agreement designated the SLRAOC as one of 43 areas with significant environmental degradation. The SLRAOC is spatially large and geographically complex, spanning the Minnesota and Wisconsin state lines and including tribal interests (see Figure 1).

The SLRAOC is jointly managed by four implementing agencies: the Fond du Lac Band of Lake Superior Chippewa (FDL), the Minnesota Department of Natural Resources (MNDNR), the Minnesota Pollution Control Agency (MPCA), and the Wisconsin Department of Natural Resources (WDNR). MPCA and WDNR are the delegated authorities that manage official transactions with the U.S. Environmental Protection Agency - Great Lakes National Program Office (USEPA-GLNPO). Dozens of stakeholder organizations are also involved in activities related to the SLRAOC.

Efforts to reverse the BUIs are located primarily within the 12,000-acre St. Louis River Estuary (SLRE), where water from the St. Louis River and Lake Superior mix. The twin port cities of Duluth, MN and Superior, WI are located on either side of the estuary.

A Stage I Remedial Action Plan (RAP) identified these nine BUIs (MPCA and WDNR, 1992):

1. Restrictions on Fish and Wildlife Consumption
2. Degradation of Fish and Wildlife Populations
3. Fish Tumors or Other Deformities; removed in 2017
4. Degradation of Benthos
5. Restrictions on Dredging Activities
6. Eutrophication or Undesirable Algae (SLRAOC name: Excessive Loading of Sediment and Nutrients)
7. Beach Closings (SLRAOC name: Beach Closing and Body Contact Restrictions)
8. Degradation of Aesthetics; removed in 2014
9. Loss of Fish and Wildlife Habitat

The Great Lakes Water Quality Agreement “Eutrophication or Undesirable Algae” BUI was modified to become the SLRAOC’s “Excessive Loading of Sediment and Nutrients” BUI 6 for two reasons. First, with the end of wholesale logging and lumber milling and the improvement of wastewater treatment in the area, the St. Louis River was no longer characterized as eutrophic. Second, undesirable algal blooms were not an identified concern. However, the delivery of excessive loads of sediment and nutrients remained as an important local concern, so BUI 6 was established to ascertain the effects of the estuary’s unique turbidity, algae, and nutrient conditions.

A Stage II RAP was completed in 1995 and it was later superseded by the 2013 St. Louis River Area of Concern Implementation Framework: Roadmap to Delisting (MPCA and WDNR, 1995 and 2013, respectively). The 2013 RAP was a comprehensive listing of the BUIs, their removal targets, and the management actions (MAs) needed to achieve those targets. The 2013 RAP has been updated annually thereafter to document progress and changes to the RAP implementation plan and schedule (MPCA and WDNR, 2014-2019).

It is important to understand that the voluntary AOC program was created to address “legacy” issues or environmental problems that caused ecosystem impairments at the time of the AOC designation and largely occurred before modern environmental regulations were in place. Legacy issues significantly impacted geographically-defined sites rather than regional-scale stressors.

For the SLRAOC, examples of legacy issues are unregulated discharge of industrial and municipal waste, dredging and filling in the estuary, wood waste deposited in the river, and extensive logging – all of which exacerbated erosion and sedimentation problems. Since then, the Clean Water Act (CWA) and other environmental regulations are being implemented to protect the environment and human health from these types of large-scale problems.

The scope of the AOC program does not include “modern” issues that are the responsibility of many state and federal agencies under a variety of natural resources, environmental, and public health program authorities. Some examples of modern issues are: contaminants of emerging concern, water-related climate change impacts, non-compliance of point source permits, and impairments identified and regulated under the CWA. Figure 2 depicts the differences between the AOC and existing agency programs.
Figure 2: The Program Scope of the St. Louis River Area of Concern

As it relates to the removal of the Excessive Loading of Sediment and Nutrients BUI discussed in this report, consider climate change effects as an example of the difference between legacy and modern impacts. The SLRAOC is experiencing more frequent and intense storm events and these are affecting the intensity of seiche impacts, which are, in turn, impacting sediment and nutrient conditions in western Lake Superior and the SLRE. These are modern impacts that fall under the purview of the CWA, not the SLRAOC program. The Future Actions section of this document lists a variety of future needs to be addressed by other agency programs.

**BUI Information**

**Rationale for Listing**

The SLRAOC’s RAP describes the rationale for listing this BUI as follows:

*Prior to the improvements in wastewater treatment in the late 1970s, water quality and biological investigations characterized the St. Louis River Estuary (SLRE) as low in dissolved oxygen and high in total phosphorus and total suspended solids. At that time, the Western Lake Superior Sanitary District (WLSSD) treatment plant was built and the Superior wastewater treatment plant was upgraded. Since then, many indicators of trophic status have shown improvements. For instance, concentrations of total phosphorus have decreased and dissolved nitrogen has shown variable*
decline in St. Louis Bay. The loading of phosphorus to the estuary from point sources has been reduced substantially. At the time of AOC listing, further work was needed to ascertain the effects of nonpoint source loadings to the system and to Lake Superior. Despite the reductions in point source loadings, phosphorus concentrations in the estuary remained at levels where eutrophic conditions might be expected. Algal biomass was lower than would be expected, however, given these high phosphorus concentrations. Chlorophyll a concentrations measured in the estuary were similar to levels found in mesotrophic or oligotrophic waters. Several investigators proposed that reduced light penetration caused by turbidity and color may be a limiting factor for algal growth in the estuary. Although persistent water quality problems associated with eutrophication were not observed in the estuary, the high levels of nutrients and sediments being delivered to Lake Superior were determined to be an important concern. Therefore, the RAP used a modification of the International Joint Commission eutrophication criterion to reflect local conditions.

The St. Louis River Watershed, which drains to the St. Louis River and the SLRE near Lake Superior, has experienced more than 150 years of urban and industrial development that has altered land use, water quality, and aquatic ecosystems. Prior to the passage of the CWA, discharges from industrial and municipal sources were unregulated. Inadequately treated wastewater discharges, disposal of sawmill and paper mill waste products into the river, and runoff of forest debris in the wake of landscape-scale logging all contributed to low oxygen levels that negatively impacted aquatic life across the food web. The barren, post-logging landscape also contributed excessive loading of sediments, resulting in increased turbidity and nutrient concentrations (e.g., phosphorus, nitrogen) in the river.

The CWA spawned both state and federal laws used to control point source discharges. Because municipalities and industries can no longer discharge directly to the river without treatment to meet effluent standards, improved wastewater treatment and manufacturing processes have helped restore the water quality in the SLRE.

**Removal Target**

With the involvement of stakeholders, a removal target for the Excessive Loading of Sediments and Nutrients BUI was established (MPCA and WDNR 2011), stating that the removal target will be reached when:

*Nutrient and sediment levels have not been shown to impair water quality and habitat, and do not restrict recreation, including fishing, boating, or body contact in the estuary and within western Lake Superior based on the following criteria:*

1. All federal, state, and local point source and nonpoint source discharge permits in the AOC are in compliance with regard to controlling sources of nutrients (particularly nitrogen and phosphorous), organic matter, and sediment; and
2. Total phosphorus concentrations in the Lake Superior portion of the AOC do not exceed 0.010 mg/L (upper limit of oligotrophic range); and
3. There are no exceedances of the most protective water quality standard for either state in the western basin of Lake Superior due to excessive inputs of organic matter
or algal growth attributed to loadings from wastewater overflows into the St. Louis River; and,

4. Total phosphorus concentrations within the St. Louis River portion of AOC do not exceed an interim guide of 0.030 mg/L (upper limit of mesotrophic range) or the most restrictive water quality standards. This ensures that anthropogenic sources and activities in the St. Louis River AOC do not result in excessive productivity and nuisance conditions within the St. Louis River Estuary.

The interim guides used for the removal criteria are estimations based on existing standards. Although the St. Louis River holds some features in common with other rivers and flow-through lakes, this ecosystem is unique because of the implications of residence time, mixing, and biogeochemistry resulting from landward forcing of lake water (i.e., the result of seiche or storm surge) that mixes the lake and tributary waters. The Interim Status Indicators selected (see Table 1) are part of the BUI 6 Blueprint, (MPCA and WDNR, 2013, Appendix D).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Target</th>
<th>Location</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water column TSS</td>
<td>15 mg/L</td>
<td>St. Louis River portion of AOC</td>
<td>Draft MN criteria for north river region (MPCA, May 2011)</td>
</tr>
<tr>
<td></td>
<td>10 mg/L</td>
<td>Lake Superior portion of AOC</td>
<td>Draft MN criteria for class 2A waters (MPCA, May 2011)</td>
</tr>
<tr>
<td>Water column TP</td>
<td>30 µg/L</td>
<td>St. Louis River portion of AOC</td>
<td>Final Delisting Target: Note the discrepancy between current MN and WI TP criteria that might also be used for the SLR AOC - MN draft TP criterion for the north river region is 55 µg/L (MPCA, 2011); WI TP criterion for St. Louis River is 100 µg/L (WDNR, November 2010; N.R. 102.06(3)(a))</td>
</tr>
<tr>
<td></td>
<td>10 µg/L</td>
<td>Lake Superior portion of AOC</td>
<td>Final Delisting Target: Note WI, but not MN, has a TP criteria that should be considered of 5 µg/L (WI TP standard for Lake Superior of 5 µg/L includes open and nearshore waters- WDNR, November 2010; N.R. 102.06(5))</td>
</tr>
<tr>
<td>Chlorophyll a</td>
<td>10 µg/L</td>
<td>St. Louis River portion of AOC</td>
<td>Draft MN criteria for north river region (MPCA, November 2010)</td>
</tr>
<tr>
<td></td>
<td>1.3 µg/L</td>
<td>Lake Superior portion of AOC</td>
<td>Number derived from Annex 4 of the Great Lakes Water Quality Agreement target TP loading of 3400 metric tons per year (U.S. 1983); corresponding TP is 5 µg/L. 7050.0222 Specific Water Quality Stds for Class 2; Aquatic Life and Recreation</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>3 µg/L</td>
<td>MN Class 2A</td>
<td></td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>7 mg/L</td>
<td>MN Class 2A</td>
<td>Daily minimum and compliance with the standard 50% of the days at which the flow of receiving water is equal to the $Q_{90}$</td>
</tr>
<tr>
<td>(NH₃)</td>
<td></td>
<td></td>
<td>Criteria are many and varied, depending on agency and methodology. Therefore, it is not appropriate at this time to list existing Wisconsin and Minnesota standards as an interim status indicator without further review and historical data analysis.</td>
</tr>
</tbody>
</table>
In addition, the following measurable indicators are applicable to discharge permits and wastewater overflows.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Measurement Basis</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal, state, and local permitted dischargers, including MS4s in the AOC</td>
<td>Determined through review by WDNR and MPCA</td>
<td>All permittees in compliance with regard to controlling sources of nutrients (particularly nitrogen and phosphorus), organic matter, and sediment</td>
</tr>
<tr>
<td>Municipal wastewater collection systems and WWTP permittees within the AOC</td>
<td>Determined through review by WDNR and MPCA</td>
<td>All permittees in compliance with permit conditions with regard to controlling sewage overflows</td>
</tr>
</tbody>
</table>

The SLRAOC RAP interprets this to mean that the removal of the Excessive Loading of Sediment and Nutrients BUI will be justified when:

1. All federal, state, and local point source and nonpoint source discharge permits in the AOC are in compliance with regard to controlling sources of nutrients (particularly nitrogen and phosphorus), organic matter, and sediment.

2. Assessment of current water quality data for the Lake Superior and the SLRE portions of the SLRAOC indicate that water quality meets the water quality goals established by the strategy described below.

3. Watershed management objectives for the Nemadji River watershed that are in the Nemadji Basin Plan (NRCS, 1998) are adopted and progress towards implementing the objectives is being made.

The RAP goes on to explain that:

*Total phosphorus data alone will not provide the level of confidence needed to show that nutrient and sediment concentrations do not impair water quality and habitat and do not restrict recreation, including fishing, boating, or body contact in the estuary. Therefore, to protect and restore the condition of the SLRAOC related to the listing of this BUI, a thorough review of historical data and a statistical analysis of the current water quality condition based on the recommended seven status indicators listed below are necessary. These analyses will allow the BUI Technical Team to assess the trends and current condition of the SLRE in relation to BUI removal. The seven status indicators include:*

- Chemical – total phosphorus, un-ionized ammonia, dissolved oxygen
- Biological – chlorophyll a
- Physical – total suspended solids (TSS) and turbidity or other loading metric based on tons of sediment
- Watershed – progress toward meeting management objectives to reduce runoff rates and sediment delivery in the Nemadji River watershed
The RAP further acknowledges that:

This work is not intended to set or replace State water quality standards, but to develop BUI removal objectives agreeable to both States and FdL that are consistent with the intent of the BUI removal target. The BUI removal objective water quality goals are to: protect the riverine and estuarine portions of the AOC from a eutrophic classification, to protect the Lake Superior portion of the AOC from a mesotrophic classification, and to achieve desired levels of sediment and nutrient loading to Lake Superior. SLRAOC managers and the BUI Technical Team decided that additional water quality goals were not necessary for BUI removal. Sufficient information is available to justify BUI removal using the parameters in the BUI removal target.

Removal Strategy

Five management actions were established in the RAP to support the removal of the Excessive Loading of Sediments and Nutrients BUI and all have been completed (see Table 2).

<table>
<thead>
<tr>
<th>Mgmt. Action</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.01</td>
<td>Perform Area-Wide Water Quality Sampling and Analyses</td>
<td>Identify data needs, develop sampling design based on Bellinger et al. (2012) and evaluate results.</td>
</tr>
<tr>
<td>6.02</td>
<td>Perform Expanded Historical Data Analysis</td>
<td>Conduct a thorough review of current and historical data and a statistical analysis of the six water quality indicators (total phosphorus, un-ionized ammonia, dissolved oxygen, chlorophyll a, TSS and turbidity) and evaluate long-term trends in water quality.</td>
</tr>
<tr>
<td>6.03</td>
<td>Paleolimnological Investigation</td>
<td>Perform a paleolimnological investigation of the St. Louis River Estuary to reconstruct the algal and geochemical history and develop models to characterize trends in natural and anthropogenic drivers in water quality.</td>
</tr>
<tr>
<td>6.04</td>
<td>Develop Water Quality Goals (Compilation of 6.01, 6.02, and 6.03)</td>
<td>Assess results of 6.01, 6.02, and 6.03 and determine appropriate water quality goals for the reference condition of biological, chemical and physical indicators of water quality.</td>
</tr>
<tr>
<td>6.05</td>
<td>Assessment and Implementation Planning in the Nemadji River Basin</td>
<td>Assess sediment impairments through biological, water quality, and sediment monitoring, and HSPF modelling of historic sediment loads. Support implementation of the Nemadji Basin project recommendations to reduce sedimentation through stakeholder and landowner planning efforts.</td>
</tr>
</tbody>
</table>

The strategy outlined in the RAP for each of the management actions is described below.

Strategy for MA 6.01 – Perform Area-Wide Water Quality Sampling and Analyses

Perform area-wide water quality analyses in the SLRE based on the 2012 monitoring protocols in Bellinger et al. The objective of this project is to work with SLRAOC program staff and other groups responsible for monitoring and assessing conditions in the SLRE to identify data needs, develop a
sampling design to meet those needs, and evaluate the relevancy of the results. Analysis of the water quality indicators will be used to estimate conditions within geographic zones and/or estuary-wide. Results will be used to report whether the SLRE is trending toward or has reached the reference condition or range of conditions considered reasonable for the estuary. Understanding changes in water quality and associated biological conditions that meet BUI removal objectives is the focus of this work and it will include the six chemical water quality status indicators to:

a. Provide a summary of the six chemical water quality indicators for a period of two to three years and
b. Assess and verify the relevance of all six status chemical indicators within the SLRE or by geographic zone, if necessary, to determine if the estuary is impaired for these parameters based on agreed-upon reference conditions and accounting for any unique conditions.

Strategy for MA 6.02 – Perform Expanded Historical Data Analysis

Perform an expanded historical data set analysis based on methodologies used in Hoffman (2011) to evaluate long-term trends in water quality as it relates to the six chemical status indicators. Determine the appropriate water quality goals for the reference condition of any or all of the status indicators appropriate for the SLRE and western portion of Lake Superior that will meet approval by Minnesota and Wisconsin as appropriate for the SLRAOC.

Strategy for MA 6.03 – Paleolimnological Investigation

Perform a paleolimnological investigation of the SLRE to reconstruct the algal and geochemical history for approximately the last 300 years (management action 6.03). Diatom-based (i.e., microfossil algae) models will be applied to identify historical temporal and spatial variations in biological (i.e., chlorophyll, algal load), chemical (i.e., phosphorus, ammonia) and physical (i.e., TSS, turbidity) water quality indicators. Combined with the results of the monitoring data and trend analyses described in the strategies for 6.01 and 6.02, the paleolimnological data will provide quantitative and qualitative reconstructions of the important physical, chemical and biological trends that have resulted from natural and anthropogenic drivers.

Strategy for MA 6.04 – Develop Water Quality Goals (Compilation of 6.01, 6.02, and 6.03)

Determine the appropriate water quality goals for the reference condition of any or all of the status indicators appropriate for the SLRE and western portion of Lake Superior that will meet approval by Minnesota and Wisconsin as appropriate for the SLRAOC.

Strategy for MA 6.05 – Assessment & Implementation Planning in the Nemadji River Basin

Document progress toward meeting watershed management objectives from the Nemadji Basin Plan (NRCS, 1998) as an indicator of sediment loading to the SLRAOC. The Nemadji plan established watershed objectives to reduce runoff rates and sediment delivery from the Nemadji River watershed into SLRAOC.

Once the work for the five management actions is complete, the RAP directs an assessment of the status of the SLRE in relation to BUI removal:

1. For the water quality indicators:
   a. If the assessments show the current conditions are sustained and the water quality has improved to where it meets the water quality goals, then removal targets are met.
   b. If the assessments show the current conditions are not sustained and water quality is not meeting the water quality goals, then removal targets are not met. Determine possible
sources and develop an action plan to address the source(s). Then, re-evaluate annually until it can be shown that water quality meets applicable water quality goals for two consecutive years.

2. For the watershed indicator:
   a. If watershed management objectives for the Nemadji watershed are met or progress over time to meet the objectives can be demonstrated, this information will help support removal of the sediment loading aspect of this BUI.

It is important to note that the assessments associated with each MA are time limited. Once a MA is completed, there is not an effort to return to the endpoint of the studies to add data gathered by other agency programs since the conclusion of the study. Similarly, some implementation activities pertinent to BUI 6 are already underway by other agency program that are outside the SLRAOC program. More recent data and activities are not reported here. Additionally, regulatory programs are ever-evolving and terminology in place at the time BUI 6 studies were completed have not been substituted by newer terminology (e.g., turbidity impairments under the CWA are now TSS impairments).

Management Actions Methods, Findings, and Conclusions

6.01 Area-Wide Water Quality Sampling and Analyses

Historical and current water quality conditions for a variety of parameters were evaluated to compare concentration estimates with BUI removal criteria established by SLRAOC stakeholders. Current water quality condition was assessed both seasonally and spatially using data collected in 2012 and 2013 (MA 6.01). For the historical component, 60 years of water quality data (1953 – 2013) from two fixed stations was used to determine how nutrient and sediment concentrations and loads changed in the SLRE (MA 6.02). These MA’s were combined into one scientific paper, Water quality in the St. Louis River Area of Concern, Lake Superior: Historical and current conditions and delisting implications (see Appendix 1). This work was completed by the U.S. Environmental Protection Agency – Great Lakes Toxicology and Ecology Division (EPA-GLTED) under the direction of Dr. Joel Hoffman and Dr. Brent Bellinger (Bellinger, et al., 2016) and has been summarized below (see Appendix 1 for the scientific paper).

6.01 Methods

Long-term water quality trends in the SLRE were assessed at both the Highway 23 Bridge (i.e., upper estuary) from 1953 to 2013 and the Interstate 535/US Highway 53 John A. Blatnik Bridge (i.e., lower estuary) from 1973 to 2013 (see Figure 3). Data were available for dissolved oxygen (DO), total phosphorus (TP), total nitrogen (TN), dissolved nitrate/nitrite-N, ammonium/ammonia-N, and TSS. Chlorophyll α (chl α) was not available as a historical measurement. This summary focused on trends in both concentration and loadings for TSS and TP, in particular, as well as trends in DO concentration. For TSS and TP, a conservative mixing model was used to estimate the concentration in the river, absent a lake effect. The study was intended to better understand how water quality has changed from the industrial era to the present day and whether the levels today meet BUI removal objectives.
Current water quality conditions for the estuary were assessed from 2012-2013 for TP, TSS, DO, and chl α to estimate the proportion of the estuary’s surface area below the BUI removal criteria concentrations. A random, spatially balanced sampling design was developed to provide unbiased, area-weighted water quality concentration estimates for DO, TP, and TSS across the SLRAOC (see Figure 3). The design was then used to determine the areal extent of the SLRAOC that either met or was in exceedance of a specific water quality criteria. The sampling event locations were identified and subsequently assigned to three zones with distinct hydrologic and geochemical character: River (i.e., upper estuary), Bay (i.e., central estuary or St. Louis Bay), and the Harbor (i.e., lower estuary or Superior Bay).

6.01 Findings – Historic Water Quality Trends (1953-2013)
Sediment and nutrient loads, as represented by TSS and TP, respectively, declined between 1953 and 2013. See Figure 4, where:
- panels A and C: temporal trends in monthly TP and TSS concentrations
- panels B and D: annual TP and TSS loads
- monitoring stations: upper estuary (closed circles) and lower estuary (open circles)
- dashed lines = BUI removal criteria of 0.030 mg/L TP and 15 mg/L TSS.
Annual mean TP concentrations and loads to Lake Superior declined significantly over time; the change in concentration was faster at the lower estuary station than the upper estuary station. Since 2000, TP concentrations at the upper estuary stations have generally ranged between 20 and 50 µg/L [0.020 and 0.050 mg/L]. Though concentrations have declined, monthly and annual average TP concentrations frequently exceeded the BUI removal criterion of 30 µg/L [0.030 mg/L] over the period of record; however, the majority of concentrations greater than the criterion precede 1990. The ratio between the mean annual load and river discharge (known as the mean mass per unit discharge), revealed a decline over time, indicating that the decline in TP load was the result of changes in TP concentration rather than discharge. The decline in TP concentration can be attributed to a combination of factors, including reduced TP inputs to the system, improved retention of TP within the watershed, and reduced resuspension of legacy organic matter inputs. Through time, TP concentrations in the lower estuary were higher than in the upper estuary, implying there were internal TP sources (e.g., resuspension of sediment) or tributary additions. From 2002 to 2012, the estimated mean annual TP load was 76 tons at the upper estuary station and 133 tons at the lower estuary station, for an average annual net addition of 57 tons.

Annual mean TSS concentrations significantly declined over time at both stations; as with TP concentrations, the decline was faster at the lower estuary station than the upper estuary station.
Average annual TSS concentrations were above the interim status indicator of 15 mg/L (see Table 1) three times prior to 1978. After 2000, relatively low TSS concentrations (≤5 mg/L) were measured at both stations except for two instances (2007, 2012) in which elevated TSS concentrations (31.0 and 16.3 mg/L, respectively) coincided with large discharge events (354 and 120 m$^3$/s, respectively).

Annual TSS loads to the SLRE declined over time at both stations, until the 2012 flood. TSS loads to Lake Superior also declined faster at the lower estuary station than the upper estuary station. Notably, at the beginning of the time-series, the estuary between stations was a source of TSS, compared to its current neutral status or that of a TSS sink, which suggested a substantial shift in TSS dynamics within the estuary. As with TP loads, the ratio of the mean annual load and discharge (i.e., the volume-weighted mean TSS) declined over time, indicating that the change in TSS load was due to change in TSS concentration rather than discharge.

A long-standing concern for water quality in the SLRAOC has been low DO (see Appendix 1). Historically, this was strongly influenced by the discharge or dumping of materials with high biological oxygen demand, such as wood waste and sewage. At both monitoring stations, the last recording of summer hypoxia (<2 mg/L DO) was 1964; DO values <5 mg/L were infrequent after 1975. The period for which hypoxia was present somewhere in the river was likely longer than the time series suggest because the available longitudinal DO concentration data indicated that the lowest DO concentrations in the river were typically located between the upper and lower estuary stations (i.e., between river km 20 and 35). Nevertheless, low DO concentrations have not been observed in the thalweg (i.e., the deepest part of the river channel) since the mid-1970s. At the upper estuary station, late-summer (July–September) DO concentrations increased from 1953 to ca. 1990, after which it leveled-off and possibly declined slightly (generally, between 7 and 9 mg/L). Data from the lower estuary followed a similar pattern. Since 2000, monthly summer concentrations were always above 5.5 mg/L at both stations.

### 6.01 Findings – Current Water Quality Conditions (2012-2013)

In both 2012 and 2013, about 60% of SLRE area between Fond du Lac dam and Lake Superior was below the BUI removal criterion for TP of 30 μg/L [0.030 mg/L]; thus, 40% of SLRE area exceeded the TP removal criterion. The spatial distribution of TP is shown in Figure 5 for 2012 and in Figure 6 for 2013. The highest TP exceedances were seen in “hotspots” that had unique characteristics compared to normal SLRE conditions (i.e., primarily near wastewater treatment facility outfalls or in clay-influenced bays). System-wide TP concentrations ranged from 4.7 μg/L [0.0047 mg/L] to 195.4 μg/L [0.1954 mg/L] with a median concentration across years of 28.7 μg/L [0.0287 mg/L]. The weighted mean TP concentration for 2012 (30.9 μg/L [0.0309 mg/L]) and 2013 (30.7 μg/L [0.0307 mg/L]) were not significantly different from the BUI criterion (30 μg/L [0.030 mg/L]). The TP hotspots identified in the Wisconsin clay-influenced bays justified the study included as part of MA 6.04.
Figure 5: 2012 Total Phosphorus Results from Management Action 6.01

Figure 6: 2013 Total Phosphorus Results from Management Action 6.01
At least 85% of the area of the SLRE between Fond du Lac dam and Lake Superior had TSS concentrations below the 15 mg/L interim status indicator in both years. TSS concentrations varied from 2.3 mg/L to 71.4 mg/L, with a median concentration of 8.6 mg/L. The weighted mean TSS concentrations for 2012 (12.0 mg/L) and 2013 (9.9 mg/L) were significantly below the BUI criterion of 15 mg/L.

Chlorophyll α concentration data were not available in the time-series monitoring to assess trophic status. For both years, over 70% of the area of the SLRE between Fond du Lac dam and Lake Superior had chl α concentrations below the interim status indicator of 10 µg/L [0.010 mg/L], as listed in Table 1. Chlorophyll α concentrations ranged from 0.6 µg/L [0.0006 mg/L] (October 2013) to 49.9 µg/L [0.0499 mg/L] (September 2012). The weighted mean chl α concentrations in 2012 and in 2013 were significantly below the BUI criterion.

For the Lake Superior portion of the SLRAOC, TP concentrations were greatest in June and averaged 12.7 µg/L [0.0127 mg/L]. Average TSS concentration was 4.4 mg/L, ranging from 0.4 to 15.1 mg/L. Dissolved oxygen was always at or near 100% saturation; concentration for the season averaged 12.2 mg/L. Chlorophyll α concentration was greatest in June (4.5 mg/L) and averaged 2.7 mg/L.

It should be noted that the Lake Superior sampling locations for this study were just outside of the estuary and were influenced by river water mixing with the lake, which likely contributed to higher results than would have been seen in the open water areas of Lake Superior (Figure 3). Additional data from the USEPA’s Great Lakes Biological Monitoring Program and the paleolimnology study (MA 6.03) were used as additional lines of evidence to justify that Lake Superior BUI removal criteria have been met.

6.01 Conclusions – Area-Wide Water Quality Sampling and Analyses

Since the 1950s, there has been a dramatic decline in TP concentrations in the SLRAOC, with concentrations generally ranging from 80-380 µg/L [0.080 – 0.380 mg/L] in the 1950s to 20-50 µg/L [0.020 – 0.050 mg/L] in the 2000s. In 2012 and 2013, about 60% of SLRE area between Fond du Lac dam and Lake Superior was below the BUI removal criterion of 30 µg/L [0.030 mg/L]. Similarly, there has been a dramatic decline in TSS, with concentrations generally ranging from 7-20 mg/L in the 1950s to 1-10 mg/L in the 2000s. At least 85% of the area of the SLRE between Fond du Lac dam and Lake Superior had TSS concentrations below 15 mg/L, the interim status indicator, in 2012 and 2013. Along with these changes, DO concentrations improved and no indications of hypoxia (<2 mg/L) have been observed in the SLRE thalweg since 1964. The current chl α concentrations observed in the SLRE are generally indicative of an oligotrophic to mesotrophic waterbody, ranging from <1 µg/L [0.001 mg/L] to nearly 50 µg/L [0.050 mg/L]. In 2012 and 2013, over 70% of the area of the SLRE between Fond du Lac dam and Lake Superior had chl α concentrations below the interim status indicator of 10 µg/L [0.010 mg/L].

In the Lake Superior portion of the SLRAOC, the DO was generally near 100% saturation and the chl α concentrations were consistent with an oligotrophic water body. Total phosphorus values measured near the estuary entry points (average of 12.7 µg/L [0.0127 mg/L]) were generally higher than typical values measured in offshore waters in the western arm of Lake Superior (generally <5 µg/L [<0.005 mg/L]). Nearshore environments of Lake Superior are expected to be more productive (and closer to
the upper limits of the oligotrophic range) than offshore waters, due to riverine and other nearshore inputs. Most of the SLRE area and Lake Superior were below the status indicators for each parameter (See Table 3).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLRE (FdL dam to Lake Superior)</th>
<th>Lake Superior¹ (Bellinger 2016)</th>
<th>Western Lake Superior² (USEPA’s GL Biological Monitoring 1996-2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>~60% of area below 30 µg/L [0.030 mg/L]</td>
<td>Average = 12.7 µg/L [0.0127 mg/L]</td>
<td>Average = 2.6 µg/L [0.0026 mg/L]</td>
</tr>
<tr>
<td>TSS</td>
<td>&gt;85% of area below 15 mg/L</td>
<td>Average = 4.4 mg/L [0.0044 mg/L]</td>
<td>not assessed</td>
</tr>
<tr>
<td>DO</td>
<td>&gt;5.5 mg/L; no hypoxia</td>
<td>Average = 12.2 mg/L</td>
<td>not assessed</td>
</tr>
<tr>
<td>chl α</td>
<td>&gt;70% of area below 10 µg/L [0.010 mg/L]; oligotrophic to mesotrophic</td>
<td>Average = 2.7 µg/L [0.027 mg/L]; oligotrophic</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

¹ The interim TP guide for Lake Superior is 0.010 mg/L. Data from this assessment was collected in nearshore conditions, which were likely biased toward SLRE conditions due to seiche mixing.

² The USEPA’s Great Lakes Biological Monitoring Program sampling point (SU 19) is not located within the boundary of the SLRAOC.

6.02 Perform Expanded Historical Data Analysis

Management Action 6.02 was to conduct a thorough review of current and historical data and conduct a statistical analysis of the six water quality indicators (TP, un-ionized ammonia, DO, chl α, TSS and turbidity) and evaluate long-term trends in water quality. To establish long term trends in the portion of the SLRE below the Fond du Lac dam, staff from USEPA-GLTED analyzed data sets from four stations in the lower St. Louis River that were monitored by the MPCA from the early 1950’s (for some sites) until 2008 when their Milestone Monitoring Program was discontinued. The collected data were provided by MPCA to USEPA-GLTED and subsequently included in the public STORET database. The milestone stations utilized were the MN Hwy 23 Bridge, the Oliver Bridge, the former Arrowhead Bridge/U.S. Hwy 2 Bong Bridge, and the U.S. Hwy 53 Blatnik Bridge. The length of time for the data series at each location varied.

Dissolved inorganic nitrogen, TP, and TSS data were available from October 1974 and May 1975 from the four locations. Historic data were not available for chl α, soluble reactive phosphate, or TN for these stations. To characterize current conditions, data collected by USEPA-GLTED researchers were analyzed. Data from April-September 2002-2007 at numerous locations were available, though only one station was sampled regularly within the same year.

Data analyzed for MA 6.02 was merged with the 1953-2013 data evaluated as part of the 6.01 Area-Wide Water Quality Sampling and Analyses effort and published in Bellinger, et al., 2016 (see Appendix 1). Findings and conclusions for the merged data sets were described in MA 6.01, above.
6.03 Paleolimnological Investigation

6.03 Methods and Findings
The historical magnitude and extent of sediment and nutrient impacts had not been well understood for the years preceding water quality improvements due to environmental regulations and systematic long-term monitoring of water quality (pre-1953-1973, depending on location). Therefore, a paleolimnology study of the SLRE was initiated to close the knowledge gap. To help understand this history, seven cores were taken from SLRE sites believed to have undisturbed sediments and continuous depositional environments (see the red dots on Figure 7). These cores provided good representation of the conditions present in the SLRE; they represent western Lake Superior, the St. Louis River thalweg, and the nearshore portions of the SLRE.

![Figure 7: Paleolimnological Core Locations for Management Action 6.03](image)

The cores were evaluated for retrospective analyses by the Natural Resources Research Institute. The primary goal, especially related to the excessive loading of sediment and nutrients BUI, was to determine pre-industrial water quality conditions and to track, through time, the anthropogenic impacts and the extent of loading reductions. In order to do this, sediments in the core samples were dated.
using isotopic analyses and fossil remains (i.e., diatoms, pigments, pollen, and phytoliths) were identified in concordance with other stratigraphic indicators (i.e., organic and inorganic materials, contaminants, and sedimentation rates) to reconstruct the history of the system from 1850 to the present. That work (Reavie, et al., 2016; Alexson et al. 2018) was summarized here and contained in Appendix 2.

Diatoms in relation to water quality
Diatom assemblages were assessed from sediment intervals and these assemblages were used to infer trophic conditions using a regional diatom-based model for Great Lakes coastlines. Interpretations were based on diatom-based models that contained known species responses to water quality, which were applied to fossil assemblages. The diatom records indicated varying ecological histories and trajectories depending on the location within the SLRE. Deeper core locations (e.g., near the federal navigation channel, Lake Superior) indicated water quality improvement from past periods of higher total phosphorus concentrations and algal productivity, and that current, prevailing concentrations of phosphorus did not exceed the SLRAOC BUI removal phosphorus criterion of 0.030 mg/L. However, the near-coastal (e.g., North Bay, Pokegama Bay, Allouez Bay) reconstructions revealed a recent increase in inferred phosphorus. At these locations, the inferred phosphorus levels based on the diatom species model would have been in exceedance of the BUI removal criterion. It is noteworthy that the earliest dated concentrations (~1850) were also inferred to be above the criterion, reflecting the productivity of these systems at that time.

One core was taken in Lake Superior within the AOC boundary. Inferred phosphorus concentrations from the Lake Superior core showed concentrations of TP ranging from 3 - 6 μg/L [0.003 to 0.006 mg/L]. This was well below the Lake Superior BUI criterion of 0.010 mg/L.

Geochemistry in relation to water quality and nutrient loading
Algal pigment concentrations in the sediment profiles concurred with diatom-based inferences. Main channel cores did not indicate recent increases in algal abundance, however the increasing presence of cyanobacterial pigments in two bays (North Bay, Billings Park) indicated increases in potentially undesirable algae; an indicator of increasing nutrients in those locations.

Historical sediment accumulation rates (organic and inorganic) indicated that recent sediment loads to the estuary remained higher than loads estimated around 1850. However, three sites (Lake Superior, Allouez Bay and Billings Park) exhibited reduced sediment loads since the peak period of development in the mid-20th century. This finding aligned with the results of other sediment load studies in the Nemadji River watershed.

In addition to water quality information, cores were analyzed for heavy metals and organic contaminants indicative of human activity and industrialization. This work was intended to better understand general trends and to see if the science behind the analysis could provide a line of evidence that supports overall water quality improvement through time. Mercury was included as a marker of human activities such as mining, burning of fossil fuels, and untreated sewage disposal. Sediment mercury concentrations peaked in the mid-1900s, but more recently declined to near pre-impact...
concentrations, indicating recent decreases in some combination of direct atmospheric deposition, watershed runoff, and point source domestic and industrial discharges. There were distinct mid-1900s peaks in cadmium, zinc, lead, tin, antimony and magnesium, likely resulting from watershed disruptions that exposed materials to erosion and runoff and/or industrial discharges. With improved regulation of these activities, a concurrent reduction in metals was seen. Sedimentary organic contaminants analyzed from the single core from the harbor had concentrations below the detection levels.

6.03 Conclusions – Paleolimnological Investigation
Overall, paleolimnological results from Lake Superior and the main stem of the estuary indicated improvements in nutrient loads or a discontinuation in the enrichment trends that were observed through the 1970s. Since the onset of environmental regulations, there have been clear improvements in TP concentrations in the water column, as inferred from paleo-diatom analyses from three mid-channel cores and one core from western Lake Superior, largely due to wastewater treatment and stormwater management improvements that have occurred in the SLRAOC over the past ~40 years.

Increasing nutrient loads were seen in the three nearshore/bay cores. However, in terms of nearshore phosphorus, the study generated evidence that pre-industrial impact concentrations of phosphorus likely exceeded the BUI removal criterion of 30 mg/L for TP by approximately 10 – 15 µg/L [0.010-0.015 mg/L] for TP. Also, nearshore changes in water quality may have been the result of phenomena outside the rationale for listing this BUI, such as climate change, increasing precipitation, phosphorus recycling, and perhaps other indirect mechanisms. A more detailed paleolimnology investigation, including speciation of phosphorus and development of nutrient (i.e., carbon, nitrogen, and phosphorus) budgets for the system would be needed to determine the factors influencing the nearshore areas.

These data indicated that BUI removal objectives were being met in over fifty percent of the SLRE. The clay-influenced Wisconsin bays were an area where the removal objectives were not being met and was another reason why the clay-influenced bays study was added as a BUI 6 activity (see Section 6.04). It is noteworthy that the earliest dated estuary phosphorus concentrations (~1850) were inferred to be above the BUI criterion, reflecting the productivity of these systems before industrial influence and putting the BUI removal criteria into context with the natural productivity of the nearshore areas.

The inferred phosphorus data of the Lake Superior core did not exceed the removal criteria (0.010 mg/L).

The overall improvement seen is one line of evidence to support BUI 6 removal, given the rationale for listing.

6.04 Develop Water Quality Goals (Compilation of 6.01, 6.02, and 6.03)
The purpose of MA 6.04 was to assess the findings of MAs 6.01, 6.02, and 6.03 and determine appropriate water quality goals for the reference condition of biological, chemical, and physical indicators of water quality in the SLRAOC and to use the MA findings to determine if the SLRAOC met these goals. Since the numeric BUI criteria were recommended based on interim values, the BUI Technical Team was tasked with evaluating those criteria. After reviewing results of four assessments
performed under AOC management actions, the BUI Technical Team agreed that the indicators included in the BUI removal target were an appropriate goal to justify BUI removal and additional water quality goals were not needed for BUI removal evaluation. The upper limit of mesotrophic range (0.030 mg/L) was identified as being appropriate for riverine and estuarine portions, while the upper limit of oligotrophic range (0.010 mg/L) was deemed appropriate for the Lake Superior portion of the SLRAOC.

Although these three MAs showed that sediment and nutrient conditions were improving in the SLRE, the improvements were not uniformly distributed throughout the SLRE. In particular, clay-influenced nearshore bays in Wisconsin had higher nutrient levels than the rest of the SLRAOC; however, eutrophication that might be expected under those conditions was absent. Additionally, these same bays had higher sediment loads than the rest of the SLRAOC. No comprehensive dataset existed to determine if these higher nutrient and sediment conditions were having a negative impact on aquatic life. As a result, a study was added to MA 6.04 to assess the clay-influenced bays in the Wisconsin portion of the SLRAOC and determine if any additional AOC action was needed and whether site-specific water quality goals for these bays would be appropriate (Roesler, 2018; Appendix 3).

**Background: Saint Louis River Estuary Clay-Influenced Bay Assessment**

A BUI removal criterion of 0.030 mg/L for TP was established for the SLRAOC. This criterion was established to ensure that anthropogenic sources and activities in the SLRAOC were not resulting in excessive productivity and nuisance conditions within the SLRE. Diatom-inferred TP concentrations from sediment core analyses (Reavie, et al., 2016) indicated that TP concentrations in some SLRE bays exceeded the BUI removal criterion, but they had been at or above this criterion prior to development in this watershed.

Three bays on the Wisconsin side of the SLRE were selected for monitoring and assessment: Allouez Bay, Pokegama Bay, and Kimball’s Bay (Figure 8). These sites were selected because very limited pre-existing water quality data was available for these bays and because they are the major clay-influenced bays within the SLRE. Watersheds for these bays contain clay-rich soils that are highly erodible and prone to high rates of surface runoff.
The monitoring at these three bays was intended to:
- Document the current water quality and biotic conditions in these SLRE clay-influenced bays.
- Determine if current nutrient and suspended solids concentrations are negatively affecting aquatic life.
- Provide data that could be used to determine if site specific water quality goals are warranted.

Methods
The three bays were monitored twice per month during May – October of 2017 for water quality, algae, sediment chemistry, and benthic invertebrates. Tributary streams for the bays were monitored for water quality. Pre-existing water quality and biotic information was reviewed and summarized (Roesler, 2018). A companion project to assess fish communities in the bays was also conducted in 2017 (Nelson, 2019).

Findings: Clay-Influenced Bay Characteristics and Water Quality
The three bays had some unique characteristics relative to nearby main channel waters that influenced their water quality during the 2017 sampling period, as described below.

- **Allouez Bay** is the largest (1,011 acres) and shallowest and it is subject to frequent wind-induced mixing. The mouth of the bay is adjacent to the Superior entrance to Lake Superior and seiche-induced backflows of Lake Superior water influence the bay.

- **Allouez Bay** was mostly well-mixed, with intermittent thermal and DO stratification. There were indications that seiche-induced inputs of cooler Lake Superior water flowed along the bay bottom at times. Mean TP, TSS, and chl $\alpha$ concentrations were 85 $\mu$g/l [0.085 mg/L], 21 mg/L, and 7.1 $\mu$g/l [0.071 mg/L], respectively. TP and TSS concentrations were highest in May and
October when more runoff and suspended sediment were entering the bay. Chl α concentrations were highest in June and August when runoff and suspended sediment loads were lower and water clarity was higher than the other months.

- Pokegama Bay (441 acres) has the largest watershed area and so its water quality is heavily influenced by Pokegama River inflow. The bay is also affected by wetlands that fringe its narrow upstream end.

- Pokegama Bay also was mostly well-mixed, with intermittent thermal and DO stratification. Lower DO concentrations occurred more frequently at the surface in the upstream end of the bay, likely due to decomposing organic matter and overall high respiration rates in the fringe wetlands. There were likely occasional releases of sediment phosphorus from wind mixing of intermittently anoxic bottom waters in deeper areas of the bay, in addition to runoff-driven pulses of phosphorus from the fringe wetlands. Such intermittent inputs of phosphorus, and nitrogen (mostly as ammonium-N), are a characteristic of shallow lakes, ponds, and embayments. Mean TP, TSS, and chl α concentrations were 121 µg/L [0.121 mg/L], 32 mg/L, and 6.2 µg/L [0.062 mg/L], respectively. TP and TSS concentrations were highest in May and October at the two more downstream monitoring stations when more watershed runoff was entering the bay. TP and TSS concentrations were more variable at the most upstream monitoring station which is most strongly influenced by variability in Pokegama River inflows. Just as occurred in Allouez Bay, chl α concentrations were highest in July and August when watershed runoff was low and water clarity was higher than the other months.

- Kimball’s Bay (101 acres) is the smallest of the three bays. Steep sloped, wooded banks line the bay’s perimeter. The narrowness of the bay and the high wooded banks, along with its greater mean depth (Table 1) tend to minimize the frequency and extent of wind-induced mixing relative to other bays, although it is still a shallow system. The single water quality monitoring site in the bay is close to the bay mouth and strongly influenced by seiche-induced mixing of main channel and Lake Superior water.

- Kimball’s Bay was more frequently stratified (i.e., temperature, DO, and other parameters) than other bays, despite the seiche influence. Phosphorus release from sediment during periods of bottom water anoxia was evident and prolonged during July and August. Inflow from the small tributary stream appeared to be mostly flowing along the bottom of the bay and producing higher turbidity (implying higher TSS) near the bottom. Mean TP, TSS and chl α concentrations were 63 µg/l [0.063 mg/L], 5 mg/L, and 7.6 µg/L [0.076 mg/L], respectively. TP concentrations were somewhat higher in May and October and increased from mid-June to early September, presumably due to sediment phosphorus release. As for the other bays, TSS levels were higher in May and October and chl α levels were higher in July through early September when water clarity was higher.
For the three bays, mean TP concentrations were 2-4 times higher than those found in the rest of the SLRE (Bellinger, et al., 2016). Mean chl α concentrations were lower than those found in the rest of the SLRE. Mean TSS concentrations were lower at the Kimball’s Bay site and higher at the Allouez and Pokegama Bay sites compared to the rest of the SLRE (see Table 4).

Table 4. Summary of Mean Total Phosphorus, Total Suspended Solids and Chlorophyll α Concentrations in 2017

<table>
<thead>
<tr>
<th>Size (acres)</th>
<th>Mean Depth (ft)</th>
<th>Mean TP (µg/L)</th>
<th>Mean TSS (µg/L)</th>
<th>Mean Chl α (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allouez Bay</td>
<td>1,011</td>
<td>6</td>
<td>85 [0.085 mg/L]</td>
<td>21 [0.021 mg/L]</td>
</tr>
<tr>
<td>Pokegama Bay</td>
<td>441</td>
<td>5</td>
<td>121 [0.121 mg/L]</td>
<td>32 [0.032 mg/L]</td>
</tr>
<tr>
<td>Kimball’s Bay</td>
<td>101</td>
<td>12</td>
<td>63 [0.063 mg/L]</td>
<td>5 [0.005 mg/L]</td>
</tr>
<tr>
<td>Estuary Mean</td>
<td>NA</td>
<td>NA</td>
<td>31 [0.31 mg/L]</td>
<td>11 [0.011 mg/L]</td>
</tr>
</tbody>
</table>

(Bold #s indicates values higher than the estuary mean)

Water quality monitoring was also conducted in the tributary streams that enter these bays. Stream TP and TSS concentration means ranged from 106-224 µg/L [0.106-0.224 mg/L] and 28-106 mg/L, respectively. Watershed non-point sources of phosphorus include pasture and hayfield runoff (including the influence of manure spreading), barnyards, and septic systems. Streambank and bluff erosion along streams is not believed to be a large phosphorus source (Bahnick, 1977), but is believed to be the largest source of TSS. Additional tributary information is contained in the full report in Appendix 3.

Findings: Bay Chlorophyll α Relationship to Other Trophic State Indices

Chl α concentrations in the three bays were much lower than would be predicted based on TP concentrations using either the Carlson Trophic State Index (TSI; Carlson, 1977, used to measure biological productivity) or the MN and WI statistical modeling of relationships between TP, Secchi depth, and chl α for inland lake assessments (MPCA, 2016 and WDNR, 2020). Chl α concentrations were only 3-18% of what is typically found at the TP concentrations predicted by the Carlson, 1977 equations. Water clarities (i.e., Secchi depths) were also lower (i.e., poorer) than typical for comparable chl α concentrations.

Total algal cell densities were highest in all bays in July, August, and September. Pokegama Bay had the highest total cell density on July 10th (10,343 cells/ml). All algal phyla occurred in higher densities during those three months. Total suspended solids concentrations and turbidity were lower during these months, which increased light availability for algal growth (see further discussions below). Water temperatures were higher during these months which can also promote algal growth.

Poor light availability due to suspended sediment and dissolved organic carbon (as opposed to nutrients like phosphorus and nitrogen) likely limits algal growth in the bays, as also happens in shallow, turbid lakes. The brown “tea” color of SLRE waters, from dissolved organic matter draining from wetlands, also contributes to lower light availability for algal growth, as well as its high variability. Lack of typical TSI
parameter relationships complicates water quality goal setting since it makes it difficult to predict responses to water quality improvements.

Findings: Bay Sediment Characteristics
Mean clay content of sediment in all three bays (40 – 46%) was significantly higher than that found in the remainder of the central and lower SLRE, where clay content averaged about 14.7% (NOAA DIVER 2018); this was not surprising given the clay-rich soils in the watersheds of the bays. Clay content of sediment (% clay) was moderately well correlated with phosphorus concentration ($R^2 = 0.75$) and iron concentration ($R^2 = 0.76$); this was also not surprising since iron readily attaches to the extensive bonding surfaces of clay particles and phosphorus attaches to the iron.

Findings: Clay-Influenced Bay Biological Indicators
Multiple biological indicators were assessed to provide a better understanding of how water quality conditions affect the habitat and overall biological health of the bays. Four biological areas were examined and described below: benthic macroinvertebrates, aquatic macrophytes, wetlands, and the fishery. The results for each community, separately and collectively, provided further lines of evidence that an impairment does not exist. The bays were shown to sustain adequate biological health despite TP conditions that exceeded the BUI removal criterion.

Benthic Macroinvertebrates
The trimetric index (TMI) (Angradi, et al., 2016), an index of benthic invertebrate community quality, was developed specifically for the SLRE. Due to their unique clay conditions, Allouez and Pokegama Bays were excluded from the development of the TMI and the accompanying ephemerid density index. This complicated the interpretation of the benthic data conditions reported, however the TMI was the most useful benthic invertebrate indices available for these bays and provide a basis of comparison to the rest of the SLRE.

The median TMI value was poor for Allouez Bay, fair for Pokegama Bay, and poor for Kimball’s Bay. The quality of the benthic invertebrate community in all three bays was below average in comparison to the rest of the SLRE. The physical characteristics of sediment with high clay content (and corresponding high-water content) likely provided poor habitat for some benthic invertebrates in these bays. Periods of anoxia at two sites in Kimball’s Bay probably also contributed below average benthos.

The median ephemerid (mayflies) density index value (Angradi et al. 2016) was good for Allouez Bay, excellent for Pokegama Bay, and poor for Kimball’s Bay, with Allouez and Pokegama Bays above average in comparison to the rest of the SLRE.

Aquatic Macrophytes
Aquatic macrophyte surveys from 2004-2015 were summarized and statistically analyzed (Danz, et al., 2017) to develop the Coefficient of Conservatism ($C^*$) as an index of tolerance to disturbance (see Table 5). Mean $C^*$ values for Allouez and Pokegama Bays were similar and somewhat higher than the mean for all SLRE surveys, while Kimball’s Bay was substantially poorer, likely due to physical conditions and less littoral zone area in the bay compared to the other Bays and SLRE.
Wetlands

Recent wetland monitoring data (2011-2017) was available for all three bays from the Great Lakes Coastal Wetland Monitoring Program (Brady, 2018).

Wetland nutrient, turbidity, and chl α concentrations were generally similar to those found at open water sampling sites in 2017, although Kimball’s Bay TP concentrations were higher than in open water.

Daytime DO concentrations in wetlands were low (<3 mg/L) for 5-25% of the measurements, with Kimball’s Bay having the most low oxygen periods.

Wetland macroinvertebrate IBI’s were taken from the Coastal Wetland Monitoring Program (CWMP) data for Allouez and Pokegama Bays for 2011 and 2012. Most Allouez Bay sites showed moderate impacts, while Pokegama Bay showed moderate impacts to most pristine.

Wetland fish IBI ratings for 2011, 2013, 2015, and 2016 for Allouez Bay ranged from moderate impacts to mild degradation. The rating for the 2017 fish study (Nelson, 2018) was generally similar; Pokegama Bay showed mild impacts and Kimball’s Bay showed moderate degradation.

Wetland bird and frog survey results (2012-2013) were also available for Allouez and Pokegama Bays (Tozer 2014) and for one or more years during 2014-2017 for all three bays (Brady, 2018). A summary of the wetland bird and frog survey assessments were compiled in Table 6 and Table 7.

<table>
<thead>
<tr>
<th>Year</th>
<th>Allouez Bay</th>
<th>Pokegama Bay</th>
<th>Kimball’s Bay</th>
<th>L. Superior Coastal Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Fair IBI</td>
<td>Fair IBI</td>
<td>NA</td>
<td>Fair for 14 sites</td>
</tr>
<tr>
<td>2013</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Fair for 14 sites</td>
</tr>
<tr>
<td>2014</td>
<td>High quality IEC</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2015</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2016</td>
<td>High quality IEC</td>
<td>Mildly impacted</td>
<td>Degraded</td>
<td>NA</td>
</tr>
<tr>
<td>2017</td>
<td>High quality IEC</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Allouez Bay</th>
<th>Pokegama Bay</th>
<th>Kimball’s Bay</th>
<th>L. Superior Coastal Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Good</td>
<td>Very Good</td>
<td>NA</td>
<td>Excellent for 13 sites</td>
</tr>
<tr>
<td>2013</td>
<td>Good</td>
<td>Very Good</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2014</td>
<td>Excellent</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2015</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2016</td>
<td>Excellent</td>
<td>Moderately Impacted</td>
<td>Moderately Impacted</td>
<td>NA</td>
</tr>
<tr>
<td>2017</td>
<td>Excellent</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

C* = coefficient of conservatism, an index of tolerance to disturbance. **NC = not comparable because a number of species and species per plot are influenced by the size of area surveyed and survey methods, and so the data do not offer a simple means of comparison.
Fishery
Bay fisheries were monitored during 2017 using gill nets and shoreline electrofishing and compared to 2017 estuary wide gill netting data from MNDNR (Nelson, 2019). Results are summarized in Table 8.

Table 8. Comparison of 2017 St. Louis River Gill Net Data for Management Action 6.04

<table>
<thead>
<tr>
<th>Gill Net Data</th>
<th>Allouez Bay</th>
<th>Kimballs Bay</th>
<th>Pokegama Bay</th>
<th>21 MN SLRE gill net sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of species</td>
<td>12</td>
<td>6</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>Median number of species/net lift</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Mean fish/net lift</td>
<td>39.9</td>
<td>3.6</td>
<td>19.3</td>
<td>27.5</td>
</tr>
<tr>
<td>Mean kg fish/net lift</td>
<td>21.9</td>
<td>1.3</td>
<td>8.3</td>
<td>13.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gill Net plus Electrofishing Data</th>
<th>Allouez Bay</th>
<th>Kimballs Bay</th>
<th>Pokegama Bay</th>
<th>21 MN SLRE gill net sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of species</td>
<td>22</td>
<td>15</td>
<td>21</td>
<td>not applicable</td>
</tr>
<tr>
<td>Number of native species</td>
<td>18</td>
<td>14</td>
<td>16</td>
<td>not applicable</td>
</tr>
<tr>
<td>Number of non-native species</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>not applicable</td>
</tr>
<tr>
<td>Number of intolerant species</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

Allouez and Pokegama Bays gill net data was generally similar to data collected by the MNDNR during 2017 from 21 SLRE gill net sites for number of species/net lift, mean fish/net lift, and mean kg of fish/net lift. Data from Kimball’s Bay indicated a poorer fish community than the MNDNR data averaged from 21 sites within the SLRE.

The conclusion from the fishery survey report stated: “Despite turbid conditions that may lead to the perception of poor water quality or habitat, locally popular sport fish species like walleye, northern pike, black crappie, and yellow perch were well represented in both Allouez and Pokegama Bays. Other species of interest to anglers and state fisheries management agencies were also found in these bays including lake sturgeon, muskellunge, bluegill, and channel catfish. While increased turbidity in Allouez and Pokegama Bays may influence the presence or abundance of specific species, it has not diminished the fishery value or eliminated desirable gamefish species from these areas.” (Nelson, 2019)

Biological Indicators Summary
Although nutrient and sediment loads were higher in the clay-influenced bays than in the other areas of the SLRE, this study showed that biotic health was not limited as a result, as seen in the summary of available biological indicators for the three bays in Table 9.
Table 9: Summary of Biological Indicators for Management Action 6.04

<table>
<thead>
<tr>
<th>BIOLOGICAL COMMUNITY</th>
<th>INDICATOR</th>
<th>ALLOUEZ BAY</th>
<th>KIMBALLS BAY</th>
<th>POKEGAMA BAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benthic invertebrates</td>
<td>Trimetric index(^1)</td>
<td>median = poor (poorer than average for SLRE)</td>
<td>median = poor (poorer than average for SLRE)</td>
<td>median = fair (poorer than average for SLRE)</td>
</tr>
<tr>
<td>Ephemeric mayflies</td>
<td>Ephemeric density index(^1)</td>
<td>median = good (better than average for SLRE)</td>
<td>median = poor (poorer than average for SLRE)</td>
<td>median = excellent (better than average for SLRE)</td>
</tr>
<tr>
<td>Aquatic macrophytes</td>
<td>Species richness(^2)</td>
<td>155</td>
<td>74</td>
<td>148</td>
</tr>
<tr>
<td>Aquatic macrophytes</td>
<td>Species richness per plot(^2)</td>
<td>8.8</td>
<td>5.0</td>
<td>5.8</td>
</tr>
<tr>
<td>Aquatic macrophytes</td>
<td>Mean C value(^2)</td>
<td>5.6; species that tolerate moderate disturbance; better than SLRE mean value of 5.06</td>
<td>3.6; generalist species that are tolerant of disturbance; poorer than SLRE mean value of 5.06</td>
<td>5.4; species that tolerate moderate disturbance; better than SLRE mean value of 5.06</td>
</tr>
<tr>
<td>Bay fish</td>
<td>multiple(^5,7); no applicable IBI available</td>
<td>Number fish/gill net lift = 145% of 21 site SLRE mean; kg fish/gill net lift = 168% of 21 site SLRE mean; number species/gill net lift = 112% of 21 site SLRE median; % native species = 92%; number of intolerant species = 4; &quot;...popular sport fish species...are well represented in Allouez Bay.&quot;</td>
<td>Number fish/gill net lift = 13% of 21 site SLRE mean; kg fish/gill net lift = 10% of 21 site SLRE mean; number species/gill net lift = 38% of 21 site SLRE median; % native species = 99%; number of intolerant species = 4</td>
<td>Number fish/gill net lift = 70% of 21 site SLRE mean; kg fish/gill net lift = 63% of 21 site SLRE mean; number species/gill net lift = 112% of 21 site SLRE median; % native species = 79%; number of intolerant species = 3; &quot;...popular sport fish species...are well represented in ... Pokegama Bay.&quot;</td>
</tr>
</tbody>
</table>
Table 9 (continued): Summary of Biological Indicators for Management Action 6.04

<table>
<thead>
<tr>
<th>BIOLOGICAL COMMUNITY</th>
<th>INDICATOR</th>
<th>ALLOUEZ BAY</th>
<th>KIMBALLS BAY</th>
<th>POKEGAMA BAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland Macroinvertebrates</td>
<td>Wetland macroinvertebrate IBI&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2011, 2012 = moderately impacted; not enough non-clay influenced SLRE surveys to allow comparison.</td>
<td>IBI not available</td>
<td>2011, 2012 median = mildly impacted; not enough non-clay influenced SLRE surveys to allow comparison.</td>
</tr>
<tr>
<td>Wetland Vegetation</td>
<td>Wetland vegetation IBI&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2011-2017 median = moderately impacted = median for non-clay influenced SLRE surveys</td>
<td>2014, 2016 = moderately degraded, which is poorer than the median for non-clay influenced SLRE surveys (moderately impacted).</td>
<td>2011, 2012, 2016 median = moderately impacted = median for non-clay influenced SLRE surveys</td>
</tr>
<tr>
<td>Wetland Fish</td>
<td>Wetland fish IBI&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2011-2017 median = moderately impaired to moderately degraded, which is slightly poorer than the median for non-clay influenced SLRE surveys (moderately impaired).</td>
<td>2014 = moderately degraded, which is poorer than the median for non-clay influenced SLRE surveys (moderately impaired).</td>
<td>2012 = mildly impacted, which is better than the median for non-clay influenced SLRE surveys (moderately impaired).</td>
</tr>
<tr>
<td>Wetland Birds</td>
<td>Bird IBI&lt;sup&gt;b&lt;/sup&gt;</td>
<td>31.8; fair - just below median value of 33.3 found for 14 Lake Superior coastal wetlands, mostly outside of SLRE</td>
<td>no data</td>
<td>34.0; fair - just above median value of 33.3 found for 14 Lake Superior coastal wetlands, mostly outside of SLRE</td>
</tr>
<tr>
<td>Wetland Birds</td>
<td>Bird IEC&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2014, 2016, 2017 median = high quality, which is better than the median for non-clay influenced SLRE surveys (moderately impacted)</td>
<td>2016 = degraded, which is poorer than the median for non-clay influenced SLRE surveys (moderately impacted)</td>
<td>2016 = mildly impacted, which is better than the median for non-clay influenced SLRE surveys (moderately impacted)</td>
</tr>
<tr>
<td>Wetland Frogs</td>
<td>Frog IBI&lt;sup&gt;b&lt;/sup&gt;</td>
<td>60.0; good - below median value of 86.5 found for 13 Lake Superior coastal wetlands, mostly outside of SLRE</td>
<td>no data</td>
<td>70.3; very good - below median value of 86.5 found for 13 Lake Superior coastal wetlands, mostly outside of SLRE</td>
</tr>
<tr>
<td>Wetland Frogs</td>
<td>Frog IEC&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2014, 2016, 2017 median = reference condition, which is better than the median for non-clay influenced SLRE surveys (mildly impacted)</td>
<td>2016 = moderately degraded, which is poorer than the median for non-clay influenced SLRE surveys (mildly impacted)</td>
<td>2016 = moderately impacted, which is poorer than the median for non-clay influenced SLRE surveys (mildly impacted)</td>
</tr>
</tbody>
</table>
Conclusions: Clay-Influenced Bays
Considering the findings of the SLRE Clay-Influenced Bay Assessment, members of the BUI Technical Team reached agreement that establishing site specific water quality goals for the Wisconsin bays would not be necessary. Many standard indicators were not tailored to these unique estuary and clay-influenced conditions and best professional judgement was needed to properly interpret these results. Although this study was a comprehensive look at the bays, tributary streams and biota, it was limited to one season of water quality data and only limited conclusions could be made. However, the biological condition in the bays was dependent on water quality and a better long term indicator of bay health was shown to be the condition of aquatic life. Despite some differences seen amongst the bays and between the bays and the remainder of the SLRE, the study did not indicate that the biota in these environments were impaired by higher levels of sediment and nutrients. In fact, the study found that some of these areas contained unique high quality habitats and species assemblages.

Monitoring of aquatic life in the SLRE will continue because aquatic life is one beneficial use addressed under MPCA’s and WDNR’s 303(d) programs. One goal of these 3030(d) programs is to reverse identified impairments and protect beneficial uses according to the requirements of the CWA.

6.04 Overall Conclusions: Develop Water Quality Goals (Compilation of 6.01, 6.02, & 6.03)
The findings of MA 6.01, 6.02, 6.03 and the SLRE Clay-Influenced Bay Assessment support BUI removal.

The comprehensive approach used to assess the current status against BUI criteria included studies that detailed historical, current, and site-specific water quality and biologic indicators. The BUI Technical Team was part of the review and discussion of each of the studies. Due to the magnitude of unique conditions and habitats found in the AOC, specific water quality goals were not established in addition to the BUI removal target. BUI criteria for the SLRE (0.030 mg/L) and Lake Superior (0.010 mg/L) remained an appropriate measure of nutrient improvements for the SLRAOC.

Estuary Conditions
The BUI Technical Team and AOC Coordinators concluded that, given a large percentage of the area in the SLRE is clay-influenced bays that have unique water quality indicators that are due to natural
background conditions, 60\% of the SLRE meeting the BUI criterion of 0.030 mg/L phosphorus during the study period fulfilled the criteria for BUI removal. The clay-influenced bay study supported the hypothesis that the SLRE ecosystem was reasonably well adapted to current sediment, nutrient, and other biophysical conditions, and no AOC impairment caused by excessive sediment and nutrients remained. Additional water quality indicators were used to support this conclusion, including improving trends in TSS, DO, and chl α (see Table 10).

Lake Superior Conditions
The BUI Technical Team and AOC Coordinators concluded that information from MA 6.01, 6.03 and 6.04 suggested average Lake Superior water quality was not exceeding the BUI criterion of 0.010 mg/L TP; therefore, the BUI removal criterion was met.

Multiple data sources were used to evaluate the Lake Superior-specific BUI criterion. The inferred phosphorus conditions from the paleological core (MA 6.03) showed that Lake Superior conditions had not exceeded the BUI criterion. The core location is within the AOC boundary and showed concentrations of TP ranging from 3 - 6 μg/L [0.003 to 0.006 mg/L].

MA 6.01 also gathered data from Lake Superior sample locations, but the average values were slightly above the criterion (0.0127 mg/L). This is attributed to data from this assessment being collected in nearshore conditions, which were likely biased toward St. Louis River conditions due to river water mixing with the lake at the sample sites. DO and chl α data were consistent with oligotrophic waters.

Additional data from the Western Lake Superior sampling point (SU 19) of the USEPA’s Great Lakes Biological Monitoring Program were reviewed to supplement the findings in MA’s 6.01 and 6.03. This sampling point was not located within the boundary of the SLRAOC, but still provided a longer-term record of the nutrient conditions in the western portion of Lake Superior compared to the data collected in MA 6.01. Select data available from USEPA’s Great Lakes Environmental Database via the Central Data Exchange (https://cdx.epa.gov/) was used for this comparison. Data from 1996-2015 showed the mean western Lake Superior TP concentration was 2.6 μg/L [0.0026 mg/L] and the range was 1.0 to 8.0 μg/L [0.001 to 0.008 mg/L] (Table 10, Figure 9). Data selected for BUI comparison represented upper water column samples including epilimnion (top 10 m) or spring integrated sample designations. Hypolimnetic or deep-water samples were excluded from the BUI comparison.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLRE (Fdl dam to Lake Superior)</th>
<th>Lake Superior¹ (Bellinger 2016)</th>
<th>Western Lake Superior² (USEPA’s GL Biological Monitoring 1996-2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>~60% of area below 30 μg/L [0.030 mg/L]</td>
<td>Average = 12.7 μg/L [0.0127 mg/L]</td>
<td>Average = 2.6 μg/L [0.0026 mg/L]</td>
</tr>
<tr>
<td>TSS</td>
<td>&gt;85% of area below 15 mg/L</td>
<td>Average = 4.4 mg/L [0.0044 mg/L]</td>
<td>not assessed</td>
</tr>
<tr>
<td>DO</td>
<td>&gt;5.5 mg/L; no hypoxia</td>
<td>Average = 12.2 mg/L</td>
<td>not assessed</td>
</tr>
<tr>
<td>chl α</td>
<td>&gt;70% of area below 10 μg/L [0.010 mg/L]; oligotrophic to mesotrophic</td>
<td>Average = 2.7 μg/L [0.027 mg/L]; oligotrophic</td>
<td>not assessed</td>
</tr>
</tbody>
</table>
The interim TP guide for Lake Superior is 0.010 mg/L. Data from this assessment was collected in nearshore conditions, which were likely biased toward SLRE conditions due to seiche mixing.

The USEPA’s Great Lakes Biological Monitoring Program sampling point (SU 19) is not located within the boundary of the SLRAOC.

Figure 9: 1996-2015 Lake Superior Upper Water Column Total Phosphorus at SU 19
Great Lakes Biological Monitoring Program

6.05 Nemadji River Basin Studies

The Nemadji River Basin comprises a large portion of the SLRAOC (see Figure 10).

Figure 10: Map of the Nemadji River Basin within the St. Louis River Area Concern
In geologic terms, the Nemadji River Basin is relatively young. The Nemadji River and its tributary streams are still changing to reach slope equilibrium after elevations changed when the Laurentide ice sheet retreated approximately 10,000 years ago. As the river and stream channels adjust, steep valley walls, sloughing clay banks, and high sediment loading to the SLRE and Lake Superior result. Historic logging and agricultural practices have exacerbated the erosion problem in some areas. By removing old growth forest cover and draining wetlands, stormwater runoff to the channel and peak flows are increased. The Nemadji River Basin Project Report (NRCS, 1998) outlines many recommended actions and best management practices to help reduce the impacts of land use on peak flows and sediment loading in the Nemadji River Basin.

As a follow-up to the NRCS Report, and to show progress towards implementing the report’s objectives has been made, several studies were conducted in the Nemadji River Basin to assess sediment impairments and evaluate the <40% open lands watershed objective that was previously a BUI removal objective. As part of MA 6.05, WDNR (through the Great Lakes Protection Fund) and Carlton County, MN funded a GIS based open lands assessment in the Nemadji River Watershed. A comparison of 2002 data to the 2014 analysis showed that the <40% open land objectives in the Nemadji River Basin Plan had not been met (Appendix 4; Community GIS, 2016). However, there were several issues with requiring this objective to be met for BUI removal and the <40% open lands objective was removed from the BUI removal strategy in 2014 and MA 6.05 was adapted to assess the biological condition of the Nemadji River and to determine if excessive sediment is an impairment.

The open lands assessment identified small hydrological units within the Nemadji River watershed exceeding 40% open land status by digitizing agricultural and urban land and timber stands <15 years in age. The 280,787-acre Nemadji watershed with its 171 sub-watersheds were delineated for this study, of which 26.9% had more than 40% open land.

While land use trends have an impact on peak flows and erosion in the basin, there are several caveats to using the <40% open lands objective in the Nemadji Basin in the RAP. The “open land” classification includes urban, agriculture, grasslands, hay fields, shrublands, and young forest; but each of these land cover types influences peak flows differently (Verry 1976, Verry et al. 1983, Verry 1986). Verry’s work found that at moderate percentages (40-60%) open lands, snowmelt peak flows are desynchronized and thus reduced. Because of this desynchronization and the differences in water uptake among different types of open lands, there is a lack of consensus among resource managers about what the appropriate percent open lands target should be. Also, because “slow the flow” efforts are not limited to reforestation (but also include wetland restoration, ditch plugging, elimination of unused roads, field borders, filter strips, etc.), using the percent of open lands in the basin as the target metric does not accurately assess physical results of efforts that have been implemented to reduce sediment in the Nemadji River. In fact, initial assessments of fish and macroinvertebrates at several sites on the Nemadji in Wisconsin do not indicate there is an impairment due to sediment (Roesler, 2014).

The adapted MA 6.05, described in the following sections, justifies BUI removal based on historical sediment load modeling and biological conditions, and implementation of the Nemadji Basin Plan...
through stakeholder and landowner planning workshops in the Nemadji River Basin. The planning component included communication of the results of the open lands assessment to stakeholders and landowners in the Nemadji Basin.

SLRAOC managers adopted the strategy to evaluate the Nemadji River through: sediment monitoring and HSPF modelling of historic sediment loads, biological and water quality assessments, and planning efforts to better understand the following conditions.

1. Sediment loading:
   a. During pre-settlement, peak agriculture, and current conditions using an existing HSPF model.
      i. See Appendix 5: Current and Historical Sediment Loading in the Nemadji River Basin (Butcher, 2016)
      i. See Appendix 6: Sediment Characteristics of Northwestern Wisconsin’s Nemadji River, 1973-2016 (Fitzpatrick, 2020)

2. The health of natural biological communities through an assessment of fish, macroinvertebrate, and water quality samples.
   a. See Appendix 7: Lower Nemadji River-Douglas County Fish Community Survey (Nelson, 2015)
   b. See Appendix 8: Nemadji River and Tributaries Water Quality Assessment (Roesler, 2014)
   c. See Appendix 9: Lower Nemadji River Water Quality and Macroinvertebrate Community Assessment (Roesler, 2015)

3. How making progress towards meeting watershed management objectives identified in the Nemadji River Basin Project Report (NRCS 1998) is advanced by completing an implementation planning effort aimed at educating citizens and local government officials in the Nemadji River Basin and identifying landowners to implement best management practices on their property.

Each of the listed projects is summarized below and the full reports are contained in the appendices noted above.

Current and Historic Sediment Loading in the Nemadji River Basin

Methods and Findings

As part of their obligation to identify impaired waters and make Total Maximum Daily Load determinations, MPCA developed Hydrologic Simulation Program—FORTRAN (HSPF) models for all eight of the basins in Minnesota. One of the basin models encompasses both the Minnesota and Wisconsin portions of the Nemadji River watershed. These models were developed to better understand water quality and predict how it could change under different land management practices.
Tetra Tech used MPCA’s existing HSPF basin model to evaluate and document changes in sediment loading caused by the conversion of land use from old growth evergreen forest to agriculture and new growth forests. The basin-wide HSPF model was calibrated and modified to provide watershed-level detail for the Nemadji River watershed portion of the basin. The model represented sediment loading from both upland and channel sources and provided a credible match to observed suspended sediment concentrations and loads at multiple monitoring points. Due to its relatively coarse spatial scale, the model was not an ideal simulation tool to specifically address loading from bluff slumping, believed to be the major source of sediment loading in the Nemadji. Nonetheless, the Nemadji model provided a useful framework to investigate potential changes in sediment loading over time.

Analyses with the HSPF model were used to compare current conditions to the probable sediment loading patterns under pre-settlement conditions (prior to harvesting of the mature white pine forests that previously covered most of the watershed) and under peak agriculture conditions. A date around 1930 was selected for peak agriculture primarily due to the availability of the Bordner Survey maps that provide a detailed representation of land use and land cover in Wisconsin during the Great Depression. (In fact, peak agriculture in the basin may have occurred somewhat later, during the 1940s and 1950s, but comparable land use surveys are not available for that time period.) Pre-settlement conditions were based on survey notes from the original Land Office grants in the watershed in the 1850s.

Initial settlement of the watershed was followed by harvest of the old-growth evergreen forest, followed by drainage and conversion to agricultural uses. Massive fires further altered the watershed and its sediment generating characteristics at the beginning of the 20th century. The early period of forest harvest included massive disruption to the natural stream network as channels were straightened and de-snagged to promote floating of logs to mills in Superior, WI, including use of splash dams that were used to build up flow and then dynamited to so logs could move downstream. Insufficient records existed to simulate the likely massive impacts on sediment loading that occurred from these events.

By the 1930s almost all of the old growth forest had been cut and areas that were previously in mature white pine had either been replaced by subsistence agriculture (primarily small grains) or reverted to second-growth deciduous aspen forest. These conditions promoted increased sediment loading from the uplands and also increased peak flows in the streams, which likely exacerbated erosion from stream banks and bluffs. Another important change was the drainage of wetlands, which were estimated to have declined from 38% of the watershed during the pre-settlement era to 13% of the watershed ca. 1930. This caused a loss in the wetland functions of mitigating peak erosive flows in streams and trapping sediment eroded from the uplands. Since the 1930s, wetlands have increased to approximately 17% of the watershed, but most of the recovery has been in herbaceous wetlands rather than the pre-settlement dominance of forested wetlands.

A major unknown in the analyses was how channel geometry may have changed from pre-settlement conditions. No data were available for the pre-settlement period, but anecdotal evidence suggests that stream channels may have been more stable, with greater roughness (due to large wood debris), greater sinuosity (and thus smaller slope), and less entrenchment of stream channels.
It must be recognized, however, that the Nemadji watershed is geologically young, with unstable clay soils. The Nemadji River is a highly erosive system influenced by ongoing slope adjustments to post-glaciated conditions, especially the changing base levels in Lake Superior resulting from glacial recession.

Application of the HSPF model suggests that upland sediment loads in the Nemadji watershed increased more than threefold from pre-settlement conditions to ca. 1930, but have since recovered to the point that current upland loads are less than twice pre-settlement loads. The major sediment source in the Nemadji is from bank and bluff contributions (estimated at about 75% of the total load). The bank and bluff contributions do not change much under model simulations that assume channel geometry presettlement is similar to current conditions. However, reasonable assumptions about pre-settlement channels with greater sinuosity and lower gradient prior to logging suggest this component, while still significant, may be about 27% less than under current conditions.

In summary, clear-cut logging during the late 19th century increased sediment loads over three-fold from the pre-settlement era. The end of landscape-scale logging decreased sediment loading. Additional progress in reducing loads has been made since the peak agriculture period, but upland loads were still estimated to be nearly double those that would have occurred under pre-settlement white pine and forested wetland cover.

The total sediment load is primarily derived from channel erosion and bluff slumping where the river intersects the valley walls, a natural characteristic of the watershed. That problem is exacerbated by changes in land use in the watershed that increase peak flows. Therefore, reducing erosive flows in the Nemadji and its tributaries (e.g., through wetland restoration) can help ameliorate, but not eliminate, sediment loads from these sources.

Processes such as evolving head cuts, ongoing expansion of the drainage network, and responses to changing base levels in Lake Superior that affect channel bank and bluff erosion may not be readily amenable to management interventions.

It should be noted that the modeling conducted for this analysis is limited in its predictive power because the HSPF model is constructed at a relatively coarse scale (approximately HUC12 sub-basins) and quantitative data on contributions from bluff and channel bank sources is lacking. Nonetheless, the model provides a credible basin-scale indication of the changes that have likely occurred over time. Use of a finer-scale model informed by detailed stream surveys would help in identifying local hotspots of sediment loading where management intervention might be beneficial. More sophisticated channel evolution models, informed by detailed channel measurements, would also help to better constrain model predictions.

Methods and Findings

Over the last 45 years, a variety of sediment samples were collected and analyzed periodically using different field and analytical techniques by the USGS, the WDNR, and the MPCA at the USGS stream gage on the Nemadji River near South Superior (USGS identification number 04024430). Most of the samples were of suspended sediment concentration. In 1973-86, the USGS collected samples for suspended-sediment concentration analysis and a limited number of bedload samples, including two in 1978. Starting in 2006 and continuing through the present, the WDNR and MPCA have been collecting TSS data.

Three objectives were identified for this study:

1. Develop a calibration curve between suspended sediment-concentration (SSC) and total suspended solids (TSS) data.
2. Compare SSC-based sediment rating curves from the 1973-86 with adjusted TSS-based curves from 2006-15 and determine if there has been a change in suspended sediment discharge.
3. Describe 2015-16 total sediment discharges, comparing USGS and WDNR data, which were determined directly by collecting suspended sediment, bedload and bed material samples and measuring suspended sediment discharge and bedload discharge and indirectly by calculating total sediment discharge using the modified Einstein procedure.

Study methods included:

- Gathering published historical and ongoing sediment concentration, water discharge, and sediment discharge data collected by the USGS, WDNR, and MPCA at the USGS stream gage on the Nemadji River.
- Collecting comparative measurements of suspended sediment, bedload, and bed material in 2015-16.
- Calculating instantaneous total sediment discharges for 2015-16 samples by summing the measured suspended sediment discharge and bedload discharge.
- Calculating the estimated total sediment discharge using the modified Einstein procedure.
- Comparing sediment concentration-water discharge rating curves using analysis of covariance.

Hydrologic conditions were variable over the two periods of historical suspended sediment data collection. Mean annual flows during 2006-15 were about 84% less than during 1973-86. In contrast, two extreme floods in 2011 and 2012 were over 2.5 times larger than any peak flow in the 1973-86 period.

The 2009-16 annual total sediment discharges ranged from a low of 18,000 tons/year in 2015 to almost 180,000 in 2012. Bedload discharges ranged from 20 percent of the total sediment discharge during low mean annual flow years to only 5 to 6% during high flow years. A sediment rating curve for suspended sediment concentration and water discharge for 2006-15 had a similar slope but a lower intercept than its 1973-86 counterpart. Although not statistically significant, the negative offset resulted in a potential
reduction of about 15% of the annual suspended sediment discharge for an example data set of annual discharges from 2009-16. Altogether, these various data sets collected over different time periods and using different methods helped to describe present and past sediment characteristics as well as provide a calibration tool for future sediment data collection.

The hydrologic context with what is seeming to have more year-to-year variability will likely become more important than the overall value of annual loading at face value. The 10-fold increase in the size of sediment discharges during extreme floods compared to more average flood condition suggests that restoration done at the mouth of the Nemadji River needs to be resilient to large floods and sporadic, highly variable sediment deposition, even though overall the amount of suspended sediment per unit of water discharge may have been reduced.

6.05 Sediment Loading Assessment Conclusions
Results from both sediment loading assessments document a recovery from higher sediment loading in the past. These results support the efforts of the Nemadji River Basin Plan (NRCS, 1998) and the “slow the flow” initiative as watershed management programs continue making progress toward sediment load reduction and meeting plan objectives.

Lower Nemadji River-Douglas County Fish Community Survey
Methods and Findings
This work was completed to assess the fish community present in the Lower Nemadji River watershed (Nelson, 2015). Electrofishing sampling was conducted at six wadable and non-wadable stations. This method was chosen because it eliminated bias from net locations, mesh sizes or openings on nets or traps, or fish behavior and allowed for standardized Index of Biotic Integrity sampling. All captured fish were identified by species. Gamefish and panfish species were measured to the nearest tenth of an inch and larger individuals were weighed. All other non-gamefish species were counted. All fish captured in the survey were released back to the river, except for voucher species used to confirm species identification.

At the time of the study, the Nemadji River supported a diverse, primarily native, fish assemblage; 24 different fish species were documented in the 6 stations assessed in 2015. Minnows were the most abundant and widely distributed fish species and were represented mainly by common and emerald shiners. Silver redhorse, shorthead redhorse, rock bass, smallmouth bass and walleyes were also widely distributed throughout the Nemadji River, but didn’t occur in the higher abundance seen in the minnow species. Muskellunge, largemouth bass, yellow perch, and channel catfish were also present, but in smaller numbers.

The fish communities from each station were scored and rated using the Lake Superior warmwater IBI rating to determine if the site is degraded and to what extent. Despite not being able to incorporate weight data, the non-wadable stations that were assessed scored between 56.25 and 75 points and were minimally rated from “Fair” to “Good”. The IBI score for the wadable stations were rated as
“Excellent”. Despite relatively poor instream and riparian habitat in the Lower Nemadji River and some difficulty sampling fish, the fish communities documented reflected good water quality. In some instances, the lower scores for the IBI metrics reflected lower fish diversity in the Lake Superior basin rather than environmental degradation.

Nemadji River and Tributaries Water Quality Assessment
Methods and Findings
The Nemadji River and five of its tributaries (Crawford Creek, Black River, Balsam Creek, Clear Creek, and Mud Creek) were monitored for fish and macroinvertebrate communities, water chemistry, and stream habitat from 2008-2010 to assess water quality conditions and to determine if these streams should be placed on Wisconsin’s 303d list of impaired waters (Roesler, 2014).

Fish communities were assessed by electroshocking and calculating IBI ratings. Macroinvertebrate communities were assessed by collecting kick samples from riffles. Water samples were collected and field parameters were measured following standard WDNR protocols. Stream habitat was assessed based on fish community-temperature relationships.

Fish community IBIs on the Nemadji River, Black River, Balsam Creek, and Mud Creek were rated excellent and Clear Creek was rated good. Crawford Creek was rated as fair. Macroinvertebrate IBI ratings were excellent or good at all sites except Crawford Creek, which was rated as fair. Hilsenhoff biotic index ratings (mostly influenced by organic matter loading and the resultant dissolved oxygen concentrations) ranged from good to excellent. Streams ranged from cool-cold headwaters to warm mainstems.

Sampling frequency and duration for water chemistry varied by site; no water samples were collected from the Black River. Median concentrations of TP and TN were low to moderate at the two Nemadji River sites. These sites had low concentrations of ammonia and nitrate plus nitrite. All sites had fairly high TSS concentrations, fairly high turbidity, and fairly low transparency. Daytime DO concentrations were generally good. Median conductivities ranged from 195 – 520 µmhos/cm and pH median values ranged from 7.5 to 8.0.

Common stream concerns in this area include:
- High peak flows resulting from rapid runoff from clay soils.
- Low base flows resulting from limited groundwater discharge.
- Stream bed scouring and bank erosion resulting from high peak flows.
- High bed loads of sand and silt, reducing the substrate quality for fish and macroinvertebrates.
- High TSS and turbidity, and low transparency resulting from erosion of clay soils.

The Nemadji River was added to Wisconsin’s 303d list in 2010 based on the state’s narrative standard due to its high sediment load (Wisconsin does not have a standard for turbidity or TSS). The Nemadji River was placed on Minnesota’s 303d list in 2004 due to exceedances of Minnesota’s turbidity.
standard. The two states are working together to develop a comprehensive turbidity Total Maximum Daily Load for the entire watershed. Crawford Creek was placed on Wisconsin’s 303d in 1998 due to chronic aquatic toxicity. The data collected from this project did not support 303d listing of any of the other streams monitored.

Lower Nemadji River Water Quality and Macroinvertebrate Community Assessment
Methods and Findings
Past water quality monitoring in the lower 8.8 miles of the Nemadji River was affected by Lake Superior’s seiche causing partial backflow in the lower river. Previously, the most downstream water quality data was collected at the County Rd C crossing, 11.9 miles above the river mouth. Furthermore, deep water and lack of coarse substrate discouraged macroinvertebrate sampling, with the most downstream macroinvertebrate sample previously collected at County Rd W, 31.2 miles above the river mouth. With higher percentages of urban and agricultural land use in the lower portion of the watershed, inflow from Crawford Creek and discharges from point source outfalls could have been expected to contribute to poorer water quality and macroinvertebrate communities in the lower portion of the watershed, which is only 3.7% of the total watershed area. Therefore, monitoring of water quality and macroinvertebrate sampling were done in 2015 to evaluate lower river conditions (Roesler, 2015).

Water quality monitoring was conducted monthly at three sites from May to October on the second Wednesday of each month to provide a systematic, random distribution of samples. A Kemmerer sampler was used to collect water samples near the river center, where the river continued to move downstream, in an attempt to avoid the seiche effects of observed backflows moving upstream near the stream banks. Water quality samples were collected and field parameters were measured following standard DNR protocols.

Macroinvertebrate communities were assessed by collecting kick samples at six sampling sites. Due to the lack of riffles and scarcity of coarse substrate (gravel/cobble), all but one sample was collected from woody debris draped with leaf packs and other vegetative debris. One sample was collected from cobble substrate to allow a comparison of a nearby sample collected from woody debris/leaf snags. Samples were preserved in 85% ethanol before the macroinvertebrates were counted and identified to the lowest possible taxa. Biotic indices and other statistics were generated.

Water quality results were as follows:

- DO concentrations exceeded the 5 mg/L water quality standard for fish and aquatic life.
- Conductivity ranged from 93 to 275 µmhos/cm; lowest conductivity occurred when flows were higher.
- Transparency ranged from 3 to 65 cm; lowest transparencies occurred during highest flows. Soil erosion was greatest during high flows.
- TP concentrations ranged from 33 to 501 µg/L [0.033 to 0.501 mg/L]; they were highest when flows were highest. Median TP concentrations (49–56.3 µg/l [0.049-0.0563 mg/L]) were below Wisconsin’s stream water quality standard of 75 µg/L [0.075 mg/L].
Dissolved orthophosphorus (DOP) concentrations ranged from <1.7–13 µ/L [<0.0017-0.013 mg/L]. The percent of TP as DOP ranged from 2.2 – 25%, with a tendency for DOP to comprise a smaller percentage of TP when flows were higher and more particulate bound TP was present.

Total Kjeldahl nitrogen concentrations ranged from 0.56 to 1.62 mg/L; highest concentrations occurred when flows were higher.

Ammonium-nitrogen and nitrate plus nitrite-nitrogen concentrations were very low (they ranged from <0.0150 – 0.0303 mg/L and <0.0190 – 0.0868 mg/L, respectively).

TSS concentrations and turbidity ranged from 5.8 – 393 mg/L and turbidity ranged from 7.1 – 729 nephelometric turbidity units (ntu’s). Both parameters were much higher during high flows. Median turbidities ranged from 24.9 to 26.9 ntu’s; very close to Minnesota’s 25 ntu standard.

Other factors that may be impacting water quality:

- During seiche events, the water back-flowing up the lower reach of the Nemadji River is derived mostly from the SLRE, with additional contributions from Lake Superior. In general, backflow of SLRE water is expected to contribute to lower TP, TSS, and DO concentrations, higher nitrate-nitrogen concentrations, and conductivity and temperature increases.

- Water quality conditions are dominated by upstream inputs. Runoff from the lower Nemadji River sub-watershed is expected to increase concentrations or loads of TP less than 3%. Increased concentrations or loads of TN and TSS are also likely to be small.

- Crawford Creek’s watershed is about half the area of the Lower Nemadji River sub-watershed and about 1.8% of the total Nemadji River watershed. The creek is contaminated with creosote and PAH’s from a former wood preserving facility, contributing a slight increase in downstream Nemadji River conductivities.

- Three point sources have discharges to the lower Nemadji River that may be impacting its water quality.
  - The Superior combined sewer treatment plant discharges intermittently following heavy rainfalls, when Nemadji River flows are usually high, and so considerable dilution capacity is usually available. However, discharges can, at times, have high concentrations of BOD5 (2-60 mg/L), E. coli (100-250,000cfu/100ml), ammonia (0.2-5.36 mg/L), TP (40-793 µg/L [0.040-0.793 mg/L]), and TSS (9-189 mg/L).
  - Enbridge Energy had a much larger than usual pipeline pressure test in 2015 that resulted in water discharges during most of October, slightly increasing TP in the river. At that time, average concentrations of BOD5, ammonia, and TSS were unlikely to produce measurable impacts in the Nemadji River. Conductivity of the discharges was not reported, so that was a possible contributor to higher conductivities in the river.
  - The Burlington Northern Sante Fe Railway Company discharge is comprised primarily of runoff from the taconite storage pile plus a small amount of treated maintenance water; both are treated in a retention/settling pond. With the exception of chloride, this point source appears unlikely to produce measurable impacts to the Nemadji River.

There may be other potential influences on temperature and DO. The Nemadji River widens, deepens, and slows between County Rd C and U.S. Highway 2/53. Solar radiation inputs may also be a contributor.
to the increases. DO decreases may be due to reduced oxygen solubility that is a function of temperature increases and sediment oxygen demand might be higher in the lower river if temporary deposition of organic solids is occurring due to reduced stream velocities.

Macroinvertebrate sampling did not occur at multiple sites as planned due to low discharge rates and inadequate current velocities that did not meet Wisconsin’s protocols for applying WDNR macroinvertebrate biotic indices for streams or rivers. Furthermore, the periodic backflows prevented any accumulation of leaf packs or other vegetative debris on a suitable sampling substrate. Despite this, very healthy macroinvertebrate communities were found at all six sites. All samples had high macroinvertebrate IBIs rated as excellent. Hilsenhoff biotic index values ranged from good to excellent, indicating oxygen availability is consistently good and little organic pollution is present (Table 11). Species richness ranged from 19 to 41. Percent EPT individuals (Ephemeroptera-mayflies, Plecoptera-stoneflies, Trichoptera-caddisflies) was high (40-75%), and percent Chironomidae individuals was low (2-21%), which both also suggested good water quality.

### Table 11. 2015 Lower Nemadji River Macroinvertebrate Sample Results for Management Action 6.05

<table>
<thead>
<tr>
<th>Site</th>
<th>SWIMS station #</th>
<th>Date</th>
<th>Macroinvertebrate Index of Biotic Integrity (MIBI)</th>
<th>MIBI Condition Category</th>
<th>Hilsenhoff Biotic Index (HBI)</th>
<th>HBI Condition Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nemadji R. 15 m DS Dedham Rd.</td>
<td>10044435</td>
<td>11/02/2015</td>
<td>8.75</td>
<td>excellent</td>
<td>3.99</td>
<td>Very good</td>
</tr>
<tr>
<td>Nemadji R. 25 m US Finn Rd.</td>
<td>163233</td>
<td>10/22/2015</td>
<td>9.04</td>
<td>excellent</td>
<td>4.96</td>
<td>Good</td>
</tr>
<tr>
<td>Nemadji R. 10 m DS Finn Rd.</td>
<td>163233</td>
<td>10/22/2015</td>
<td>9.32</td>
<td>excellent</td>
<td>2.78</td>
<td>Excellent</td>
</tr>
<tr>
<td>Nemadji R. 135 m DS STH 35</td>
<td>163048</td>
<td>11/02/2015</td>
<td>8.69</td>
<td>excellent</td>
<td>3.85</td>
<td>Very good</td>
</tr>
<tr>
<td>Nemadji R. 60 m US CTH C</td>
<td>163003</td>
<td>10/22/2015</td>
<td>11.62</td>
<td>excellent</td>
<td>3.73</td>
<td>Very good</td>
</tr>
<tr>
<td>Nemadji R. 3 mi. DS CTH C</td>
<td>10044397</td>
<td>10/22/2015</td>
<td>11.34</td>
<td>excellent</td>
<td>3.61</td>
<td>Very good</td>
</tr>
</tbody>
</table>
Two samples were collected at one station from different substrates for comparison. The downstream sample was collected from leaf packs snagged on woody debris, while the upstream sample was collected from cobble. The cobble had fairly heavy coatings of periphyton and silt. The sample from cobble had a similar macrophyte IBI, a poorer Hilsenhoff biotic index, higher species richness, a lower percent EPT, and a higher percent Chironomids. The coatings of periphyton and entrapped silt on the cobble substrate were probably a major reason for these differences.

Overall, the high quality of the macroinvertebrate community found in the lower Nemadji River is consistent with past findings for the Nemadji River, despite higher levels of turbidity and sediment loads.

6.05 Water Quality and Biotic Assessment Conclusions
Results from the three assessments document that the biota in the Nemadji River do not indicate an impaired condition in relation to BUI status. These results show that many sites in the Nemadji River Basin contain high quality species assemblages despite the wide variety of sediment conditions present.

Nemadji River Watershed Implementation Planning
Methods, Findings, and Conclusions
The purpose of this project was to conduct Nemadji River implementation planning activities as an element of the BUI removal strategy. The work was completed in two phases. During the first phase, a Nemadji River Implementation Plan (Plan) was developed that included the following activities:

- Developed a Nemadji Watershed Implementation Strategy
- Compiled a landowner database
- Compiled natural resource information for the watershed
- Compiled watershed maps
- Developed a newsletter and mail to resident landowners (approximately 1600 residents)
- Conducted a watershed informational workshop
- Coordinated with the Carlton County Soil and Water Conservation District

Implementation of the Plan began during the second phase, during which these activities were conducted by Douglas County, WI:

- Convened and coordinated a Wisconsin stakeholder group
- Developed informational workshops to provide information on water quality issues.
- Identified a minimum of 3-5 landowners who agreed to explore cost-share opportunities to implement best management practices on their property.
- Maintained communication with the Carlton County Soil and Water Conservation District and other groups involved with Nemadji Watershed research to identify ways to continue to collaborate on outreach activities.
- Developed supporting documents that included the Implementation Plan, a map of parcels for landowners that scheduled site visits, stakeholder committee contacts and meeting agendas, an open house flyer, a workshop invitation, a landowner site visit form, a newsletter, and photos.
At the close of this grant project, primary considerations for next steps were recommended, as follows:

- Identifying needs for project design assistance, cost share and other support for implementing best management practices for reducing runoff and erosion
- Developing strategies for continuing funding and outreach efforts in the watershed
- Expanding watershed partnerships to include groups such as (for example) Northern Institute of Applied Climate Science, West Wisconsin Land Trust, Wisconsin Towns Association, Wisconsin Farmers Union, Ruffed Grouse and American Woodcock Society. This will form the foundation for a coalition with the capacity to further develop and implement watershed protection, restoration and participation into the future and beyond any one grant-funded project.

As a result of this work, Douglas County, Wisconsin increased the local capacity for addressing watershed issues in the Nemadji River through the engagement of landowners, community leaders, and local decision-makers. Educational workshops have increased stakeholder knowledge of water resource problems and provided information on best management practices to reduce runoff and facilitate the implementation of projects that will improve watershed health. These accomplishments documented important progress in the effort to promote and implement the Nemadji River Basin Plan (NRCS, 1998) objectives and fulfilled the intent of the Nemadji River Watershed BUI removal strategy.

6.05 Overall Conclusions
The comprehensive assessments and planning effort included in MA 6.05 document Nemadji River Basin water quality, sediment loading, and biological conditions. Results do not indicate that an impairment exists in relation to the SLRAOC BUI removal. Watershed level management and implementation of best management practices identified by MA 6.05 will continue outside of the AOC program.

Future Actions
Sediment and nutrient management in relation to water quality and habitat is an ongoing effort needed on a watershed scale. Following the completion of the management actions for BUI 6, a variety of future actions outside of the AOC program still exist, including: planning, monitoring, and research needs. Additionally, there are a number of programs that are already implementing actions related to modern issues. The following descriptions portray a sampling of the ongoing programs and additional needs, but it is not intended to be a fully inclusive list.

Planning and Program Implementation
The MPCA has completed a Watershed Restoration and Protection Strategy for the upper portion of the Nemadji River Watershed located in Minnesota (MPCA, 2017). This includes a compilation of slump inventories, which show locations that may be contributing to erosion-based P.
Implementation planning for the Minnesota portion of the Nemadji River Watershed is being led by the Carlton County Soil and Water Conservation District following Minnesota’s One Watershed One Plan process (https://carltonswcd.org/nemadji-1w1p). The plan is expected to be ready in late 2020.

The cities of Duluth and Superior are implementing Municipal Separate Storm Sewer System Permit programs to manage stormwater in their communities. Implementation of these ongoing programs helps manage runoff and its resultant erosion.

The MNDNR, MPCA, and WDNR websites that contain SLRAOC information will be maintained as information repositories from which stakeholders will be able to obtain information generated to complete this BUI. Although it contains some SLRAOC project information, the St. Louis River Stories and Science website (www.stlouisriverestuary.org) goes beyond the goals of the SLRAOC. It is currently being maintained by the University of Wisconsin-Extension staff and its continuance will depend on future communication needs identified by the broader SLRE community and the ability to obtain continued funding.

Water Quality and Biological Monitoring
The MPCA currently completes high-resolution stream monitoring at major tributaries to the SLRE. This tributary monitoring approach is in place and will continue in the future. TSS, TP, dissolved orthophosphate, nitrogen and total Kjeldahl nitrogen are sampled 35 times per year and are paired with USGS flow data. This allows the MPCA to determine concentrations and loadings specific to the main tributaries to the estuary on an annual basis. The St. Louis River sampling location is at Scanlon, MN and the Nemadji River sampling site is near South Superior, WI (see Figure 11). The St. Louis River sampling location has consistently low levels of TP and TSS. In general, the Nemadji River carries higher sediment and phosphorus loads to the estuary. This monitoring effort will continue into the future and drives the modeling used to develop Watershed Restoration and Protection Strategies for these two watersheds. MPCA is prepared to ensure that activities are managed so that water quality standards are met at the outlets of these major watersheds.

![Figure 11: Location of USGS Gaging Stations on the St. Louis and Nemadji Rivers](image)
Moving forward, MPCA and WDNR monitoring staff are conversing to determine what approach and frequency of surface water monitoring in the estuary is appropriate under existing state monitoring programs to determine ambient conditions for aquatic recreation and aquatic life uses.

MPCA and WDNR also have ongoing programs to monitor surface waters and identify impairments under Section 303(d) of the Clean Water Act. Additionally, each agency administers permit programs to address impairments if found in the future. Three tributaries to the St. Louis River are considered impaired for total phosphorus: Bear Creek, Bluff Creek and the Pokegama River; however, these tributaries are located in the clay plain and assessing these waters based on statewide water quality standards may not be appropriate. At this time, there are no 303(d) nutrient impairments in the St. Louis River within Minnesota’s portion of the SLRAOC. The Nemadji River is listed as impaired for turbidity in both Minnesota and Wisconsin and is being managed jointly under Total Maximum Daily Load rules.

The Lake Superior National Estuarine Research Reserve routinely monitors water quality under its System-Wide Monitoring Program, which began in 2013. This program perpetuates the long-term data series collected by MPCA under the Milestone Monitoring Program. The Reserve collects and analyzes TSS and nutrients (i.e., TP, TN, dissolved nitrate-N, ammonium/ammonia-N), as well as chl α and DO at both upper river (Oliver Bridge) and lower river (Blatnik Bridge) sites. The sampling locations and collection methodology allow for direct comparison of results to historic MPCA data. Current and future (i.e., post-2013) data can thus be added to the historic sediment and nutrient annual load estimates (using methods of Bellinger et al., 2016) to evaluate long-term water quality trends post BUI 6 removal. This congruence will allow for critical assessment of sediment and nutrient dynamics as the SLRE exits an historic period strongly affected by unregulated discharges and poor land use practices to an era of recovery. The Reserve will continue monitoring water quality to assess impacts from current and future stressors such as precipitation regimes, flood events, and warming temperatures. Additionally, the continuation of chl α and DO monitoring will help assess how future changes impact SLRE’s productivity.

There are many other monitoring programs that may also continue to generate SLRE data in the future, such as:

- USEPA’s Biological Monitoring Program
- USEPA GLTED’s mission-oriented research, including the Cooperative Science and Monitoring Initiative program, as well as remedy and restoration effectiveness monitoring for the AOC program
- CWMP’s coastal wetland monitoring

There is a need to determine how to integrate all these monitoring efforts to develop a collaborative and comprehensive SLRE monitoring program by assessing current monitoring efforts, identifying future monitoring needs and funding sources, and creating a structure to collaboratively administer a comprehensive monitoring program for the SLRE.
Research

Sediment and nutrient cycling and predictors of harmful algal blooms in the SLRE are poorly understood. Based on similar observations in degrading systems in western Lake Erie and southern Lake of the Woods (Ontario and Minnesota, respectively), the nearshore eutrophication observed in the SLRE may be due to factors such as periodic recycling of stored sedimentary phosphorus (regulated by the extent and duration of oxygen depletion during warm months coupled with intermittent wind mixing events). These conditions may be further aggravated by climate change related to increased winds and stormwater runoff, more frequent and larger storms, stronger thermal stratification in the ice-free season, or other indirect mechanisms, such as water clarity, light penetration, and nutrient availability. As described above, comprehensive, long-term water quality monitoring with periodic data evaluation and public reporting is needed, including a more detailed paleolimnology investigation of the nearshore environment coupled with a speciation of phosphorous study, development of a nutrient budget, long-term chl α data collection, and a comprehensive food web study. This knowledge will help develop an understanding of factors that may be contributing to nearshore eutrophication in the SLRE, identify vulnerabilities, and provide anticipatory and cost-effective management of the SLRE.

More frequent and intense storms and flood events cause peak flows that generate outliers in data sets that skew background data. An evaluation of peak flows over time is needed to identify how TP and TSS correlate with high flows and at what point higher loads cause nutrient resuspension. In particular, an assessment of the 2012 flood is needed to determine its effect on post-2013 conditions. Further, a cumulative frequency analysis for both base flow and peak flow regimes is needed to determine the effects of each.

UMD is conducting multiple research efforts related to nutrients and sediments, including evaluating the effect of nutrient and water clarity changes on algal productivity and erosion risk in the Nemadji River Watershed.

Pursuit of the actions described above will be the responsibility of individual organizations, or collaborations of organizations, acting under authorities outside of the AOC program that will exist after BUI 6 has been removed.

BUI Assessment Conclusions

With the completion of the five MA’s and their review and interpretation by the BUI Technical Team, the BUI Target has been reached for each of the BUI criteria, as summarized below (see Table 12).
Table 12: Summary of Water Quality Results for Management Action 6.04

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLRE (FDL dam to Lake Superior)</th>
<th>Lake Superior¹ (Bellinger 2016)</th>
<th>Western Lake Superior² (USEPA’s GL Biological Monitoring 1996-2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>~60% of area below 30 µg/L [0.030 mg/L]</td>
<td>Average = 12.7 µg/L [0.0127 mg/L]</td>
<td>Average = 2.6 µg/L [0.0026 mg/L]</td>
</tr>
<tr>
<td>TSS</td>
<td>&gt;85% of area below 15 mg/L</td>
<td>Average = 4.4 mg/L [0.0044 mg/L]</td>
<td>not assessed</td>
</tr>
<tr>
<td>DO</td>
<td>&gt;5.5 mg/L; no hypoxia</td>
<td>Average = 12.2 mg/L</td>
<td>not assessed</td>
</tr>
<tr>
<td>chl α</td>
<td>&gt;70% of area below 10 µg/L [0.010 mg/L]; oligotrophic to mesotrophic</td>
<td>Average = 2.7 µg/L [0.027 mg/L]; oligotrophic</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

¹ The interim TP guide for Lake Superior is 0.010 mg/L. Data from this assessment was collected in nearshore conditions, which were likely biased toward SLRE conditions due to seiche mixing.
² The USEPA’s Great Lakes Biological Monitoring Program sampling point (SU 19) is not located within the boundary of the SLRAOC.

The Removal Target and Criteria Have Been Met

Nutrient and sediment levels have not been shown to impair water quality and habitat, and do not restrict recreation, including fishing, boating, or body contact in the estuary and within western Lake Superior based on the following criteria:

1. All federal, state, and local point source and nonpoint source discharge permits in the AOC are in compliance with regard to controlling sources of nutrients (particularly nitrogen and phosphorous), organic matter, and sediment;

CONCLUSION: As confirmed by the WDNR, all eight pollutant discharge elimination system permits within the SLRAOC area are in substantial compliance as of December 2019. MPCA has confirmed that there are 32 pollutant discharge elimination system permits within the SLRAOC area, of which only 21 have nitrogen, phosphorus, TSS and/or CBOD effluent limits and/or monitoring requirements. One industrial permittee is noncompliant for TSS and is following MPCA’s compliance processes to address the noncompliance issues.

Additionally, WLSSD and the City of Duluth are working to meet the conditions of a federal Consent Decree to reduce inflow and infiltration into the sanitary sewer system as a means to reduce sanitary sewer overflows.

Both the City of Superior and the City of Duluth have also invested in stormwater management practices and outreach to reduce the impacts of non-point source, urban runoff.

2. Total phosphorus concentrations in the Lake Superior portion of the AOC do not exceed 0.010 mg/L (upper limit of oligotrophic range);
CONCLUSION: Multiple data sources indicated that the Lake Superior portion of the AOC met this criterion (Table ES-1). The Lake Superior data from the 2012 and 2013 BUI study (MA 6.01) showed that TP values were slightly higher than the BUI criterion of 0.010 mg/L for Lake Superior’s western arm, with an average of 12.7 μg/L [0.0127 mg/L]. Additional water quality parameters sampled during the study show that DO was generally near saturation and the chl α concentrations were consistent with an oligotrophic water body. Paleolimnological study results (MA 6.03) for the Lake Superior sample location concluded (1) water quality improvement from past periods of higher TP concentrations and (2) current prevailing concentrations of phosphorus did not exceed the TP criterion. Specifically, diatom-inferred TP results for the Lake Superior core indicated that western Lake Superior concentrations of TP were 3 - 6 μg/L (0.003 to 0.006 mg/L). TP results from USEPA’s Great Lakes Biological Monitoring Program showed that from 1996-2015 the mean western Lake Superior TP concentration was 2.6 μg/L [0.0026 mg/L] and the range was 1.0 to 8.0 μg/L [0.001 to 0.008 mg/L] and never exceeded the criterion.

1 Data from this assessment was collected in nearshore conditions, which were likely biased toward St. Louis River conditions due to river water mixing with the lake at the sample sites.
2 The USEPA’s Great Lakes Biological Monitoring Program sampling point is not located within the boundary of the SLRAOC.

3. There are no exceedances of the most protective water quality standard for either state in the western basin of Lake Superior due to excessive inputs of organic matter or algal growth attributed to loadings from wastewater overflows into the St. Louis River;

CONCLUSION: Data used to assess St. Louis River water quality against the BUI removal criteria (MA 6.01-6.04) do not indicate that any excessive input of organic matter or algal growth exist as BUI criteria have been met. Wastewater overflows are prohibited by Wisconsin Administrative Code Chapter NR 210.21 and are administered in Minnesota by State Statute 115.03, Minnesota Rule 7050.0210 and Minnesota Rule 7053.0205.

Wastewater overflows, including sanitary sewer overflows, treatment facility overflows and combined sewer overflows have been drastically reduced since the time of AOC listing. Wastewater permits administered by the states have included conditions to reduce and report overflow events. In addition, as of August 2016, all facilities in Wisconsin were required to have developed and be actively implementing a Capacity, Management, Operation, and Maintenance program for operation and maintenance of sanitary sewer collection systems with goals to help address issues of inflow and infiltration which are the primary causes of overflow events. Minnesota’s wastewater permittees have met similar facility management requirements. Upgrades to wastewater and collection systems in the past decade have resulted in significant reductions in overflow events.

4. Total phosphorus concentrations within the St. Louis River portion of AOC do not exceed an interim guide of 0.030 mg/L (upper limit of mesotrophic range) or the most restrictive
water quality standards. This ensures that anthropogenic sources and activities in the St. Louis River AOC do not result in excessive productivity and nuisance conditions within the St. Louis River Estuary.

CONCLUSION: The 5 MA’s that have been completed for this BUI indicated that water quality improvements in the SLRE and Nemadji River watershed have resulted in the majority of the AOC meeting the phosphorus criterion. In addition, other water quality parameters (TSS, DO and chl α) indicate nutrients and sediments are not causing an impairment. Data showed a dramatic decline in TP concentrations and sediment loading in the SLRAOC since the time of listing.

Public Involvement Process Complete at the end of the public involvement process.

Tentative language: Many types of public involvement activities are conducted as part of the SLRAOC program. Some are specific to projects and BUIs and others are related to the SLRAOC program more broadly and they are too numerous to be mentioned here. Three specific activities fall in the public involvement realm for this BUI:

1. **The activities associated with the BUI 6 technical team** (see Appendix 11 for the members and their affiliations). The technical team members assisted the SLRAOC Coordinators with activities associated with reaching the RAP’s BUI 6 removal target, including: making recommendations on data collection and analyses, reviewing the findings, and providing input on the removal package.

2. **The process to obtain public input on the BUI removal package.** A thirty-day public comment period about the BUI 6 removal recommendation was held from February 24, 2020 through March 24, 2020. A public meeting was scheduled for March 19, 2020; stakeholders participated. Comments received were taken into consideration during the preparation of the final removal package. The comments received, responses to them, and letters of support were included in Appendix 11.

3. **Additional outreach.** A presentation about the BUI 6 removal recommendation was made at the St. Louis River Summit on March 3, 2020 and to the Harbor Technical Advisory Committee on March 4, 2020.

Removal Recommendation Complete at the end of the public involvement process.

Tentative language: The results of the BUI 6 studies show multiple lines of evidence that, taken together, demonstrate improved conditions warranting a removal recommendation for BUI 6. Such a recommendation is supported by the BUI 6 technical team; the SLRAOC partners; and the SLRAOC Coordinators, leaders, and executive managers who collectively request that the Excessive Loading of Sediments and Nutrients BUI be removed from the SLRAOC. Feedback received during the public comment period and from the outreach presentations indicate that ________________.
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