RAINY-LAKE OF THE WOODS

State of the Basin Report

3RD EDITION

March 2022

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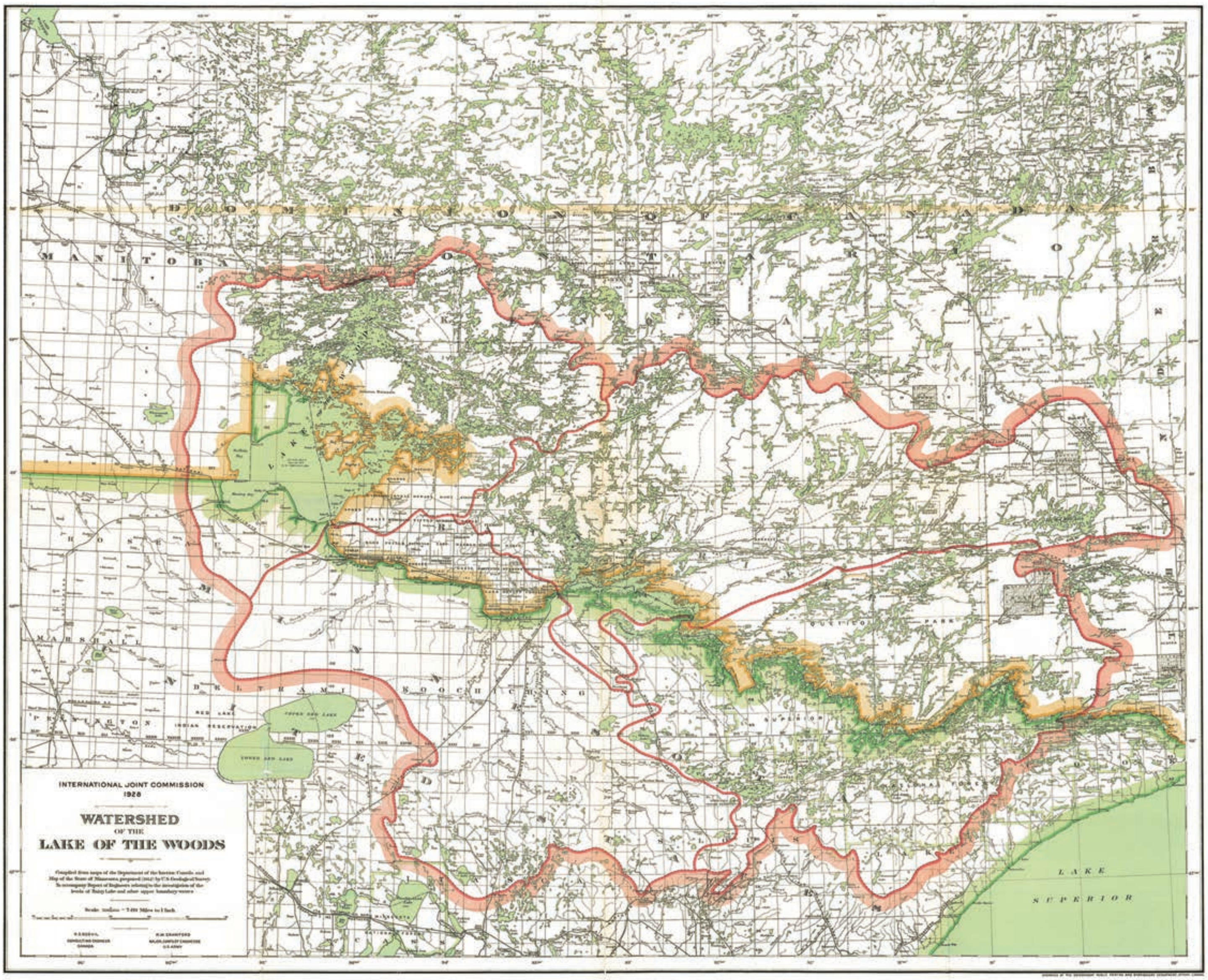
Editors' Note

This report was a collaborative effort, and its completion would not have been possible without the contributions of numerous researchers, resource managers and agencies in the basin. We extend special thanks to the Western Science and Indigenous Advisors for their contributions.

The information contained in this State of the Basin Report – 3rd Edition was compiled and/or synthesized by the Editors and the Editorial Committee from information in the original 2009 and 2014 reports and from published and unpublished research that has become available since 2014.

This project was undertaken with the financial support of the International Joint Commission, the Lake of the Woods Water Sustainability Foundation, the Government of Canada through the federal Department of Environment and Climate Change – Lake Winnipeg Basin Program, Grand Council Treaty #3, and inestimable in-kind contributions from researchers, resource managers and agencies in the Rainy-Lake of the Woods Basin. We extend our great thanks to all these contributors. We also thank Patrice Nelson for graphical design and layout of this report.



The Rainy-Lake of the Woods Watershed, IJC 1928

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Pelicans (Lee Grim)

AIS	Aquatic Invasive Species
AMC	Adaptive Management Committee
BsM	Broadscale Monitoring
CCGF	Climate Change Guidance Framework
Chl-*a*	Chlorophyll *a*
DESC	Dorset Environmental Science Centre
ECCC	Environment and Climate Change Canada
EOPR	Ecosystem Objectives and Phosphorus Reduction
FAU	Fisheries Assessment Unit
FMZ	Fisheries Management Zone
FWC	Flow weighted concentrations
GCT3	Grand Council Treaty #3
HUCs	Hydrologic Unit Codes
IJC	International Joint Commission
IJC O&A	International Joint Commission Objectives and Alerts Study
IMA	International Multi-Agency Arrangement
IRLWWB	International Rainy-Lake of the Woods Watershed Board
IRLWWF	International Rainy-Lake of the Woods Watershed Forum
IWI	International Watershed Initiative
LF	Little Fork River
LoW	Lake of the Woods
LOWWSF	Lake of the Woods Water Sustainability Foundation
LPP	Lake Partner Program (MECP)
MPCA	Minnesota Pollution Control Agency
MNDNR	Minnesota Department of Natural Resources
MECP	Ministry of the Environment Conservation and Parks
MNO	Métis Nation of Ontario
NDMNRF	Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry
NWOMC	Northwestern Ontario Métis Community
P	Phosphorus
PWQO	Ontario Provincial Water Quality Objectives
RR	Rainy River
TP	Total Phosphorus
SCWRS	St. Croix Watershed Research Station
SDW	Specially Designated Waters
SOBR	State of the Basin Report
THg	Total Mercury
THgaq	Total Aqueous Mercury
MeHgaq	Aqueous Methyl Mercury
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USGS	United States Geological Survey
UNDRIP	The United Nations Declaration on the Rights of Indigenous Peoples
USNPS	United States National Park Service
VNP	Voyageurs National Park
WLC	Water Levels Committee
WQMS	Water Quality Monitoring and Surveylance division, Environment and Climate Change Canada

EXECUTIVE SUMMARY

This 2022 Rainy-Lake of the Woods (R-LoW) State of the Basin Report (SOBR) involves a multinational project partnership of:

- the Lake of the Woods Water Sustainability Foundation (LOWWSF)
- the International Multi-Agency Arrangement (IMA), a multinational collaborative of 11 agencies, government, US Tribal, and non-government organizations
- Grand Council Treaty #3 (Indigenous government)
- the International Rainy-Lake of the Woods Watershed Board (IRLWWB)

The focus of this report is to update findings with respect to key priority issues since 2014.

This SOBR update provides the IRLWWB, partners in the project, and the public with a current understanding of priority issues in the R-LoW Basin. It includes an assessment of progress since the last report in 2014, a gap analysis, and recommendations going forward to enhance work-planning, public communication tools, and relationship building with Indigenous peoples. The latter includes Indigenous perspectives and the inclusion of Indigenous Knowledge systems.

The focus of this report is to update findings with respect to key priority issues since 2014. These include nutrients and algal blooms, climate change, contaminants, aquatic invasive species, water levels/erosion and fish and fisheries. Additional chapters include watershed governance, Anishinaabe Nation in Treaty #3, Métis Nation of Ontario, US Tribes, human health, emerging concerns, gap analyses, and recommendations. Some of these recommendations are new and some are not, but were identified in previous SOBRs (2009, 2014) and have not been addressed.

Watershed Governance

Water governance is the reference to the authorities, states and Nations that have the decision-making authority, this is exemplified through the Boundary Waters Treaty between the US and Canada in the Rainy – Lake of the Woods Basin. What makes this basin and governance systems more complex is that the United States and Canada are not the only Nations with jurisdiction in the basin as US Tribes, Northwestern Ontario Métis Community – MNO, and Anishinaabe Nation in Treaty #3 all have rights and jurisdiction as Nations in the watershed. With those rights and jurisdictions come Treaty relationships predating the Boundary Waters Treaty of 1909 that must be upheld. In acknowledgement of these Nations and jurisdictions, watershed planning, decision-making and protection must shift to develop equitable space for Indigenous Knowledge systems, cultural protocols and processes, and governance to develop mechanisms of respectful and meaningful joint decision-making and governance. Additionally, the multi-jurisdictional nature of the basin is more complex, with sub-national jurisdictions (e.g., provincial and state) that also have roles and responsibility in these respects.

By moving forward in this direction, pathways can be charted that not only ensure the protection of the basin for future generations, but jointly move both the US and Canada towards the overarching goals of reconciliation.

This chapter explores the current context of water governance and decision-making in the Rainy-Lake of the Woods Basin. It discusses successes and where there are opportunities and major gaps to be addressed. Pathways forward and areas of future work, study, questions and research are outlined that are then built upon by the understanding and acknowledgement of each Indigenous Nation in Chapter 2. Throughout the report, blue boxes are interwoven into the text. The aim of these boxes is to provide insight into continued pathways forward and considerations to develop and create equitable space for Indigenous Knowledge systems, cultural protocols, and governance. In the pathways forward, the questions outlined are meant to provide a starting point for these discussions and are not exhaustive in nature, they include:

- What does it mean to be a Treaty Partner and uphold a Treaty Relationship in the International Rainy-Lake of the Woods Basin?
- How do the predating Indigenous Treaties and the Boundary Waters Treaty work together?
- What are the past grievances and historical concerns that have to be acknowledged to move forward?
- What mechanisms are currently in place to create equitable space for Indigenous Knowledge systems, cultural protocols, and governance and what still needs to be created?
- How do Indigenous Nations in the basin view Water Governance, Regulation and Management?
- What is the vision and process to water protection in the Rainy-Lake of the Woods Basin that is respectful of all Nations and jurisdictions in the basin?

This chapter explores what the current context of water governance and decision making in the Rainy-Lake of the Woods Basin is, where the opportunities are, successes have been and the major gap to be addressed is.

Anishinaabe Nation of Treaty #3, Northwestern Ontario Métis Community - MNO, and US Tribes

Prior to European contact, before the founding of Canada and the United States, before the creation of the IJC, before the writing of Federal Constitutions and the Boundary Waters Treaty, Nations existed in the basin. These Nations have inherent rights with additional rights recognized in treaties (Thompson, 2020) with the colonial states. Through understandings of the sacred relationships and responsibilities concerning water, each of these Nations has laws and protocols for protection of water for future generations. However, the structures, laws and acts which form the framework for water governance in the basin today do not acknowledge these rights, relationships, and responsibilities. This report provides an overview of these topics to further understanding, to acknowledge history, and to help advance reconciliation:

- Indigenous Nations in the basin
- Anishinaabe Nation in Treaty #3
- Northwestern Ontario Métis Community - MNO
- Red Lake Nation
- 1854 Treaty Authority

The information shared in this report is preliminary and an overview in nature. In order to move forward, it is important that discussions are had with each Indigenous Nation on how and what decision-making and governance in the basin looks like. The information in Chapter 1 and Chapter 2 is provided to ask the questions and provoke thought towards creating equitable space for Indigenous Knowledge systems, protocols, and governance. The contents of Chapter 2 summarizes the governance systems and ongoing work of each of the Indigenous Nations, to further understand and highlight the worldview and knowledge that resides in the basin. Some of the work outlined may be geographically outside the Rainy- Lake of the Woods Basin but is included to continue to share a separate understanding of treaty relationships and governance outside of western knowledge systems and be respectful of the jurisdiction of each Indigenous Nation.

The information shared in this report is preliminary and an overview in nature. In order to move forward it is important that discussions are had with each Indigenous Nation on how and what decision-making and governance in the basin looks like.

Nutrients and Algal Blooms

Algal blooms and the nutrient phosphorus continue to be concerns in some areas of the basin and in Lake of the Woods (LoW) in particular. There is no evidence of significant changes in phosphorus concentrations since the 2014 SOBR for the areas of the R-LoW Basin described in this report. The Rainy River headwaters are, with few exceptions, below 20 µg/L total phosphorus (TP). In the Rainy River itself, TP has remained remarkedly consistent with an average of 33 µg/L over the past decade. In Lake of the Woods, characterizing an average TP is difficult due to substantial spatial and temporal variability. In the southern basin of LoW, high TP of 50 µg/L or above is often measured in late summer and fall. The north end of Lake of the Woods shows some concentrations above 30 µg/L in central areas with <20 µg/L in more isolated areas. The average TP in the outflow to the Winnipeg River at Kenora is about 23 µg/L, albeit with significant seasonal variation. It is recognized that total phosphorus concentrations below 20 µg/L are required to limit the chance of nuisance algal blooms.

There has been a great deal of progress with respect to understanding and managing nutrients and their impact on algal blooms since 2014. In all cases the research has focused on phosphorus (P) which is the nutrient that controls the growth of algae in the basin. All measurements presented here are as total phosphorus (TP).

There have been three key initiatives undertaken since 2014. These are:

1. Minnesota's Total Maximum Daily Load (TMDL) study to address water quality impairment in the south basin of Lake of the Woods (LoW).

This study recommends phosphorus reductions necessary to eliminate impaired waters status in the south end of LoW.

2. International Joint Commission (IJC) Objectives and Alerts (O&As) study to update current O&As for the boundary waters. This study recommends that water quality objectives for phosphorus be developed for individual segments of the boundary waters. Quantitative objectives will be derived in phase 2 of the project.

3. Environment and Climate Change Canada's (ECCC) Lake of the Woods Science Program (2016–2020) and Ecosystem Objective and Phosphorus Reduction Scenario development efforts have been underway to establish desired reductions in TP loads and to describe water quality links to algal blooms.

Tools are being developed to use satellite images to determine the extent, density, and severity of algal blooms in Lake of the Woods by Environment and Climate Change Canada (EOLakeWatch). These tools may allow the future examination of nutrient-bloom relationships.

Climate Change

Climate change is indicated as a stress-multiplier in many of the research initiatives described in this report. Addressing the root causes of climate change will involve action at a high level of governance.

The IJC's International Watersheds Initiative (IWI) is examining climate change as one of its strategic initiatives. A Climate Change Guidance Framework (CCGF) recommends planning guidance methods that can be used by the IJC's control boards, and watershed and pilot watershed boards. The purpose of the CCGF is to provide responsible systems with the ability to maintain ecosystems and economic and social benefits while constraining climate change impacts within preferred ranges relative to water levels and flow management. This will help to address future change and uncertainties. The framework will provide clear guidance to the boards for addressing climate change using the best available science and stakeholder input. This framework is an iterative document and will be updated as climate change knowledge is improved. It is important to note that this initiative concerns adaption to climate change with no direction towards reducing the causes of climate change.

The IRLWWB's Adaptive Management Committee (AMC) was established in June 2020 following a recommendation in the Rainy and Namakan-Lakes Rule Curve review report of 2017 indicating a need for adaptive management to ensure the new rule curves (ratified in the 2018 Supplementary Order) continue to perform as expected. The AMC's overall objective is to consider information collected by resource agencies and others during the interim that indicate impacts due to changes to the 2018 rule curves. The AMC would make necessary recommendations to the IRLWWB and oversee the Board's implementation of the IJC's CCGF.

Climate change is indicated as a stress multiplier in many of the research initiatives described in this report. Addressing the root causes of climate change will involve action at a higher level of governance.

Contaminants

Mercury (Hg) remains the major contaminant of concern and this is with respect to the consumption of fish. Both Ontario and Minnesota have consumption restrictions for fish because of mercury content for most lakes in the basin. Minnesota has a State-wide Total Maximum Daily Load (TMDL) for mercury, which was last revised in 2020. The TMDL lists lakes impaired for Hg – mostly for fish tissue but also for some water exceedances. The TMDL includes all impaired lakes noting those that have been added or removed from impairment.

There is some indication that Hg in the environment is decreasing. Wet Hg deposition at two regional Minnesota Mercury Deposition Network sites decreased by an average of 22 percent from 1998–2018 with much of the decrease prior to 2009, and relatively flat trends since then. In four Voyageur's National Park (VNP) lakes, epilimnetic methylmercury (MeHgaq) concentrations declined by an average of 44 percent and total mercury (THgaq) in epilimnetic lake water by an average of 27 percent. However, for the three lakes with long-term biomonitoring, mercury concentrations in biota declined with statistical significance in only one lake. Blanchfield et al. (2021) presented further evidence for recovery of mercury contaminated fish populations.

In September 2021, the Minnesota Department of Natural Resources (MNDNR) confirmed the presence of zebra mussel larvae in Rainy Lake, near International Falls.

Potential contamination from mining activities in the basin remains a concern with the Community Advisory Group (CAG) that reports to the IRLWWB. Efforts are underway to comprehensively map mining activity in the basin.

Aquatic Invasive Species

A project titled *AIS Risk Assessment for Rainy – Lake of the Woods Watershed. Phase I (2019)*, now completed (Bell and Vellequette, 2021), provides a coarse scale analysis regarding aquatic invasive species (AIS) risks in the basin. The first phase of this project initiated a broad-scale qualitative assessment of the relative risks of AIS to the R-LoW Basin including:

- a binational list of AIS of concern to local waters
- identification of gaps in knowledge
- a focus on areas in need of risk prevention

Based on proximity, ease of transport or introduction and known impact to R-LoW or other impacted ecosystems the ten species prioritized to perform the first risk evaluations are:

- *Bythotrephes longimanus* (spiny waterflea)
- *Faxonius rusticus* (rusty crayfish)
- *Neogobius melanostomus* (round goby)
- *Dreissena polymorpha* (zebra mussel)
- *Bithynia tentaculata* (mud bithynia, faucet snail)

- *Potamopyrgus antipodarum* (New Zealand mudsnail)
- *Butomus umbellatus* (flowering rush)
- *Nitellopsis obtusa* (starry stonewort)
- *Myriophyllum spicatum* (Eurasian watermilfoil)
- *Phragmites australis australis* (common reed)

In September 2021, the Minnesota Department of Natural Resources (MNDNR) confirmed the presence of zebra mussel larvae in Rainy Lake, near International Falls. Four of five water samples taken in July of 2021 contained zebra mussel larvae, suggesting the presence of a reproducing population in Rainy Lake. These samples followed up on a July 2020 report of a single adult zebra mussel found by anglers in Rainy Lake. Previously, MNDRR found zebra mussel larvae in the southern basin of Lake of the Woods (2019), and adults in a few lakes upstream of the Rainy River. Adult reproductive colonies have not yet been located or confirmed in either Rainy Lake or Lake of the Woods.

The impacts with respect to flooding are outlined in this report including water level impacts on wild rice.

Water Levels/Erosion

Water levels and flows out of the Namakan chain of lakes and Rainy Lake are controlled as prescribed by rule curves which maintain seasonal water levels between the highest or lowest water levels that will provide the best water usage for a wide variety of stakeholders.

The Rainy and Namakan Lake rule curves have been reviewed extensively and updated in recent years. The final report *Managing Water Levels and Flows in the Rainy River Basin* was completed and submitted to the IJC in 2017 with the subsequent establishment by the IJC of the 2018 Rule Curves for Rainy and Namakan Lakes.

The impacts with respect to flooding are outlined in this report including water level impacts on wild rice. This review also examines the impact of current drought conditions in the basin.

Many studies now include estimates of the phosphorus load to the basin that results from erosion. Tools are being developed to determine the origins of suspended solids in tributaries (sediment fingerprinting) as a first step towards reducing loads associated with suspended solids.

Fish & Fisheries

Indications that the walleye fishery in parts of the basin are unsustainable are discussed with an overview of fisheries management throughout the basin and in shared boundary waters.

Human Health

Human health concerns are discussed as they relate to drinking water and to environmental risks including cyanobacterial toxins, mercury in the environment including fish, and blastomycosis.

Emerging Concerns and Gap Analysis

Emerging concerns should remain much lower than those noted for more developed watersheds. The IRLWWB's Community Advisory Group maintains concerns around mining in the watershed such that the need for developing an inventory of mining activities should be considered a gap.

Groundwater information remains sparse and may constitute a gap with respect to some studies, but it is unclear how groundwater gaps relate to the current list of concerns.

The lack of information available for the assessment of rule curve impacts on Rainy River has been highlighted as a major data gap. (IRLWWB – Sixth Annual Report, April 2018-March 2019).

Recommendations are presented to identify gaps and future needs related to the priority concerns in the basin.

The multijurisdictional nature of the basin must be respected by highlighting Indigenous Knowledge systems and to illustrate how western and Indigenous Knowledge systems can work together through the lens of two eyed seeing.

Recommendations

Recommendations are presented to identify gaps and future needs related to the priority concerns in the basin, including governance, nutrients and algal blooms, climate change, contaminants, aquatic invasive species, water levels and erosion, fish and fisheries, and others. Some of these recommendations, such as the need for a core monitoring program, are not new but were identified in previous SOBRs (2009, 2014), and have not been addressed.

Governance

1. Research into the historical impacts to and grievances with Indigenous Nations.
2. Further understand the responsibilities of Treaty Partnerships and Relationships.
3. Further understand the relationship of Indigenous Treaties with the Boundary Waters Treaty.
4. Research the vision and process to water protection in the Rainy-Lake of the Woods Basin that is respectful of all Nations and jurisdictions in the basin.
5. Indigenous Engagement to understand how each nation seeks to be included in decision-making and governance and how Indigenous Nations view Water Governance, Regulation and Management.
6. Development of understanding of western mechanisms and how they impact the Boundary Waters Treaty (UNDRIP, FPIC, Truth and Reconciliation Commission, etc.). What mechanisms need to be created?
7. Establish table of Indigenous Nations in the basin.

8. Establishment of a shared vision or agreement for the basin inclusive of Indigenous Nations.
9. Explore what frameworks of co-management can be applied to the R-LoW Basin?
10. Explore what mechanisms are available for data sharing across the basin and inclusion of Indigenous Nation monitoring data in all below categories?

Nutrients and algal blooms

1. Core monitoring program should be established to monitor effects of nutrient reduction strategies.
2. Relationship between nutrients and satellite derived bloom intensity should be formed.
3. Explore the relevance of nitrogen limitation.

Climate change

1. Continue to recognize and advocate for reduced emissions of greenhouse gasses.

Contaminants

1. Develop a watershed mining activity map.
2. Continue and expand public awareness of mercury contamination in fish.

Aquatic invasive species

1. Complete phase 2 of risk assessment.
2. Harmonize AIS prevention efforts (regulations and Best Management Practices) in the full watershed.

Water levels/erosion

1. Develop tools to address the effects of drought.
2. Explore need for better understanding with respect to groundwater (little is known).
3. Explore the effects of lake volume on algal blooms.

Fish & fisheries

1. Continued support for ON/MN Fish Atlas.

Other

1. Consider sustainability in management decisions.
2. Examine aspects of changing human activity in the basin.
3. Continue to improve multinational governance models.
4. Continue to embrace the concept of adaptive management.
5. Establish core monitoring requirements.
6. Encourage summaries and synthesis for existing data.

INTRODUCTION

The previous State of the Basin Reports (SOBR 2019, SOBR 2014) are available from the Lake of the Woods Water Sustainability Foundation (LOWWSF) website at https://lowwsf.com/sobr. The current 3rd Edition SOBR 2022 builds on information in the previous reports with updates on the priority concerns in the basin, from published and unpublished research that has become available since 2014.

This report contains an overview of governance in the basin (Chapter 1) and a chapter to describe Indigenous Knowledge systems and worldview from the standpoint of the Anishinaabe Nation of Treaty #3, US tribes and the Northwestern Ontario Métis Community - MNO (Chapter 2). The information described in Chapter 2 is based on publicly available information and reviewed by the editorial committee. No interviews, engagement sessions or consultations were done in the development of the report, and it is meant to provide a foundation for future work and moving forward. It is strongly recommended to work with each Indigenous Nation in the basin to further understand the rights, cultures, knowledge systems, protocols, and jurisdictions and how that may be braided into decision-making in the basin.

Throughout the report, blue boxes will be interwoven into the text. The aim of these boxes is to provide insight into continued pathways forward in the development and creation of equitable space for Indigenous Knowledge systems, cultural protocols, and governance.

Throughout the report, blue boxes will be interwoven into the text. The aim of these boxes is to provide insight into continued pathways forward in the development and creation of equitable space for Indigenous Knowledge systems, cultural protocols, and governance.

Previous state of the basin reviews covered a wide range of topics to describe current conditions for as many aspects of biological and chemical processes as was practical and where data for these were available. The scope of this report has been reduced to focus on any changes that have occurred since 2014 in the primary areas of concern. These were identified within previous reports (IJC Objectives & Alerts, IJC Plan of Study) as **nutrients, contaminants, climate change, aquatic invasive species, and erosion/water levels**. Since 2014, there have been additional concerns with respect to the health of the fishery in the north end of Lake of the Woods (LoW) such that fish and fisheries are added as a concern in this report. In addition, aspects of human health concerns are included here.

A review of key presentations at the International Rainy-Lake of the Woods Watershed Forum (IRLWWF) between 2014 and 2021 indicates that the focus of recent research is generally aligned with previously identified concerns. Key presentations are listed in Appendix 1 and abstracts for individual presentations in each year are available on the LOWWSF website, https:/lowwsf.com/forum-proceedings.

This 3rd State of the Basin Report relies heavily on the findings of several key studies completed since 2014, namely:

- Minnesota's Total Maximum Daily Load (TMDL) study
- Environment and Climate Change Canada's (ECCC) Lake of the Woods Science Program (2016-2020) and Ecosystem Objective and Phosphorus Reduction Scenario development
- International Rainy and Namakan Lakes Rule Curves Study Board (2017)
- IRLWWB – Annual Reports
- MNDNR/OMNRF (now NDMNRF) 2017 Ontario–Minnesota Boundary Waters Fisheries Atlas
- International Joint Commission (IJC) Objectives and Alerts Study 2019 – phase 1
- Lake of the Woods Watershed Monitoring and Assessment Report - MPCA 2016
- Minnesota Pollution Control Agency (MPCA) 2020 Rainy River Study
- Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites, MPCA, June 2014
- Development and application of a risk assessment tool for AIS in the R-LoW Basin

This report includes a summary of the work that has been completed or is underway in the basin. Chapter 11 highlights the importance of actively addressing the key concerns identified in this and previous reports. It is important to highlight the fact that action is being taken to actively address concerns.

Finally, it is important to circle back and examine the recommendations provided in previous key reports to establish if these recommendations are still valid and, more importantly, have they been followed? A list of previous recommendations following key reports is provided in Chapter 13.

The scope of this report has been reduced to focus on any changes that have occurred since 2014 in the primary areas of concern. Generally, this report examines the current conditions in 2021 and attempts to determine whether there have been changes since the 2nd edition SOBR was published.

Overview

The International Rainy-Lake of the Woods Basin (Figure 1) is located within the Lake Winnipeg Watershed and Winnipeg River drainage basin, this basin spans roughly 400 km east to west and 260 km north to south in the transboundary area. Sixty percent of this area is in Ontario, including the territory of the Anishinaabe Nation in Treaty #3 and homeland of the Northwestern Ontario Métis community – MNO; a small portion of the Canadian side is also in Manitoba. The remaining 40% is in Minnesota, inclusive of the Territories of 1854 Treaty Authority and Red Lake Band areas.

Throughout history, the basin was formed by glacier melt and the retreat of Lake Agassiz in, which LoW was formed along with other large lakes (DeSellas et al., 2009).

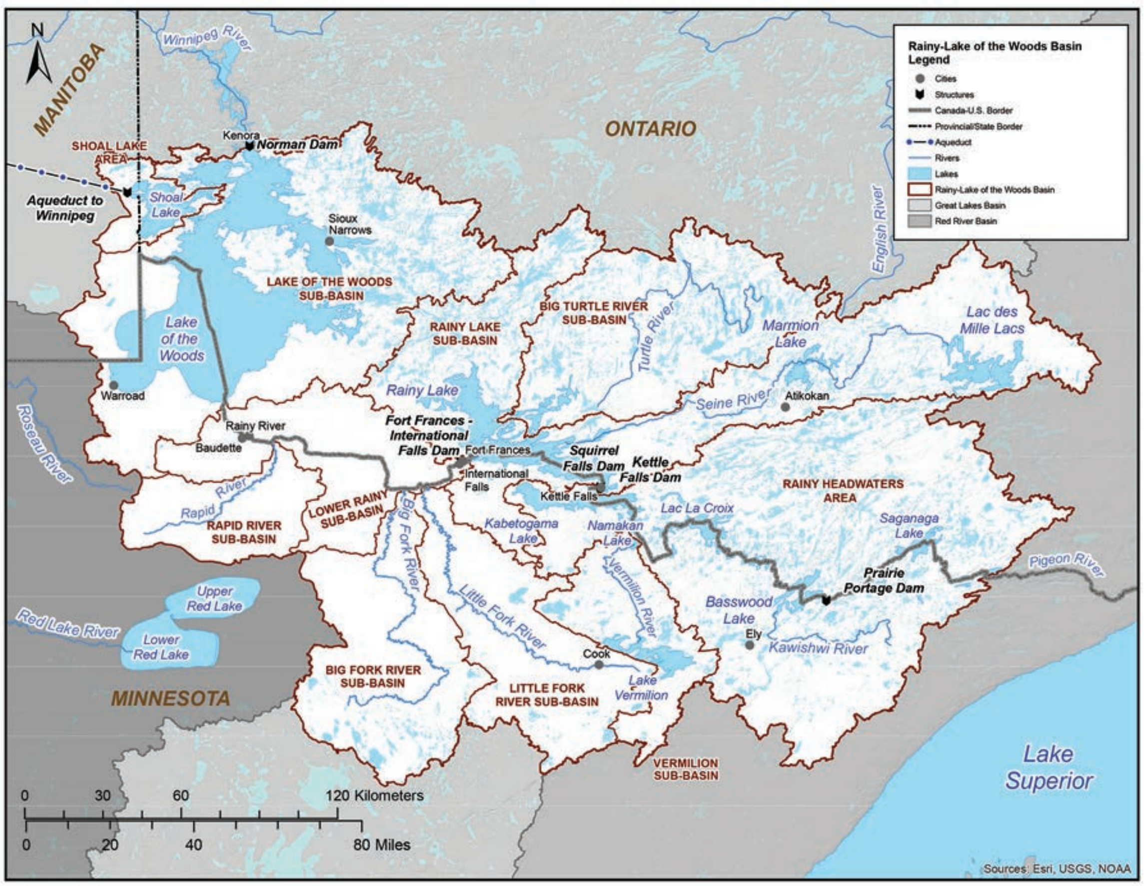


Figure 1 – The Lake of the Woods-Rainy River Basin.

Today, this transboundary basin traverses through jurisdictions of Canada, US and Indigenous Nations of US Tribes, Northwestern Ontario Métis Community - MNO and the Anishinaabe Nation in Treaty #3. All of whom have rights and decision-making authority as rights holders in the basin. This doesn't include recognition of Nations downstream in the basin through further reaches of the Lake Winnipeg Basin. In acknowledgement of these Nations and jurisdictions, watershed planning, decision-making and protection must shift to develop equitable space for Indigenous Knowledge systems, cultural protocols and processes, and governance in order to develop mechanisms of respectful and meaningful joint decision-making and governance. By moving forward in this direction, pathways can be charted that not only ensure the protection of the basin for future generations, but jointly move both the US and Canada towards the overarching goals of reconciliation.

Jurisdictions in the Rainy-Lake of the Woods Basin, illustrated in Figure 2, are:

- Canada (Ontario and Manitoba)
- United States (Minnesota)
- Anishinaabe Nation in Treaty #3
- Northwestern Ontario Métis Community – MNO
- Red Lake Nation
- 1854 Treaty Authority

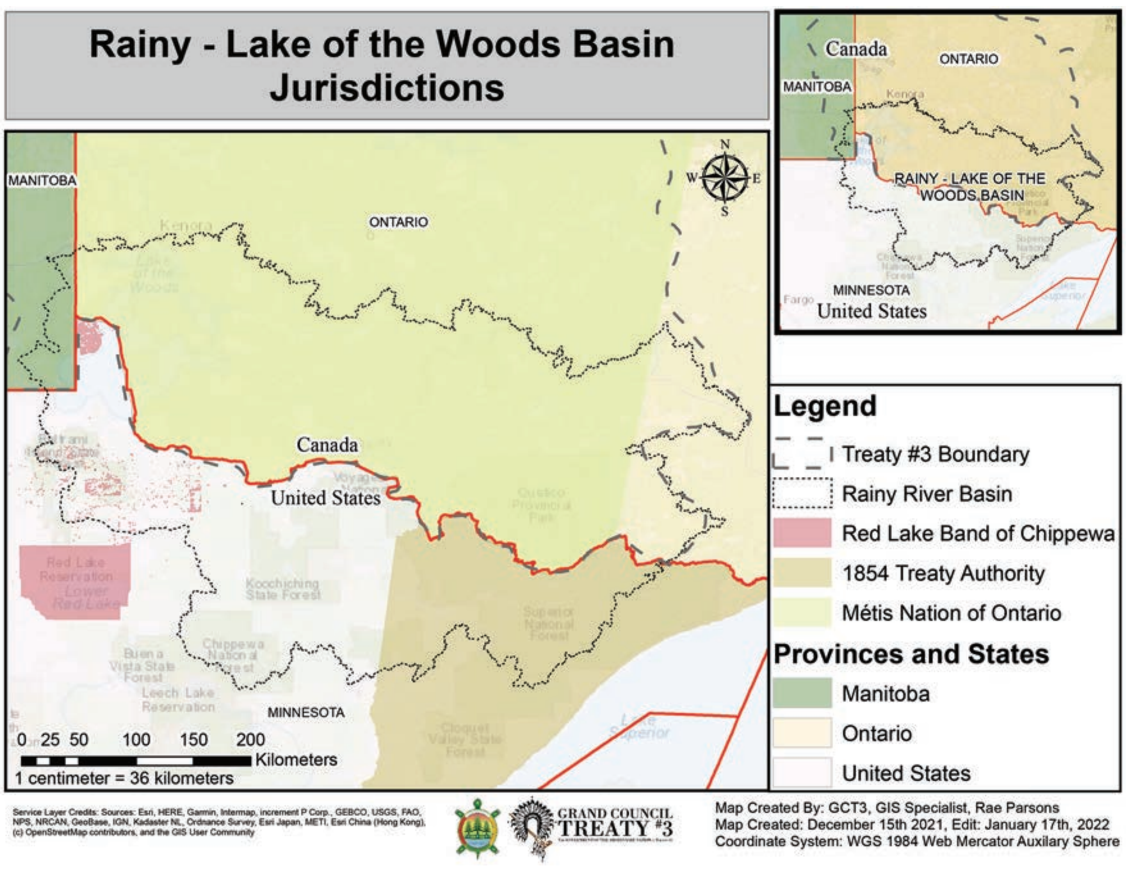


Figure 2 – Jurisdictional Map of the Rainy-Lake of the Woods Basin.

In order to shift towards the development and creation of equitable space for Indigenous Knowledge systems and governance, there first needs to be recognition of the current system of governance and what dynamics may be seen through the lens of multiple Nations. Water Governance, Water Regulation and Water Management form three tiers of decision-making and authority over activities (Craft, 2020) in the Rainy-Lake of the Woods Basin.

Even with strong relationships being formed and a multitude of activities and projects underway as a foundation between the US and Canada Governments, watershed agencies and Indigenous Nations in the Rainy – Lake of the Woods Basin, a major gap continues to be the development of mechanisms to create equitable space for knowledge systems and governance protocols outside of the western colonial approach. More broadly speaking, Indigenous Nations are included as stakeholders as opposed to rights holders, and the protocols in place are in need of change to create equitable space for Indigenous systems in a model for collaborative governance. This section of the State of the Basin Report briefly looks at these three tiers of decision-making in the current context and what mechanisms and future work is needed in order to create the space at the highest level of decision-making in respect of the multiple Nations and jurisdictional rights in the basin. These mechanisms and the creation of equitable space will allow for a progressive approach to water management, pathways forward in reconciliation, and the overall better protection of water for future generations.

Canadian Constitution Act 1982

The Canadian Constitution Act 1982, formally entrenched Aboriginal and treaty rights in the Supreme Law of Canada. Section 35 of the Constitution Act, 1982 provides:

35(1) The existing aboriginal and treaty rights of the aboriginal people in Canada are hereby recognized and affirmed.

35(2) In this Act, Aboriginal Peoples of Canada includes the Indian, Inuit and Métis Peoples of Canada.

Current State of Governance

Decision-making in relation to water can be divided into three tiers as noted above, Water Governance, Water Regulation and Water Management. Figure 3 shares a brief overview of these tiers in relation to the Rainy-Lake of the Woods Basin. Water Governance is the development of the structures and mechanisms to make decisions. These structures outline the decision-making processes and mandate that outlines who may use the water, their purpose and the legal obligations that must be met (Craft, 2020). In the Rainy-Lake of the Woods Basin, this tier of decision-making and mandate resides in the jurisdiction of both Canada and the United States due to the transboundary nature of the basin. An example of the assertion of this jurisdiction is through the ratification of the Boundary Waters Treaty of 1909 setting out the rights, obligations, and interests in relation to transboundary waters between the two countries. Today, this treaty forms the basis for the International Joint Commission and the International Rainy-Lake of the Woods Watershed Board demonstrating that both Canada and the United States are equal partners in holding up the relationship.

Water Regulation is the process of operating and implementing (Craft, 2020) the mandate set out in Water Governance. This tier is where water regulation and control occur. In the Rainy-Lake of the Woods Basin, the control occurs through the implementation of rule curves for Rainy and Namakan lakes that are monitored through the Water Levels Committee of the IRLWWB, and in the Lake of the Woods, regulation between levels of 1056 and 1061 feet above sea level is accomplished through the Lake of the Woods Control

Board. Both systems of regulation tie to the Water Governance tier through the provision of IJC orders for the rule curves, and through the 1925 Lake of the Woods Convention and Protocol forming the International Lake of the Woods Control Board. Regulators make decisions based on the structures set by both Canada and the United States.

Water Management, in essence is the on-the-ground decisions that inform the development of policies for the regulation of water (Craft, 2020). These on-the-ground decisions do not impact the core elements set out in Water Governance but are the day-to-day decisions working together with Water Regulation. In the Rainy-Namakan lakes system, dam operators make decisions inside the rule curves on the flow of water throughout the basin. The Water Levels Committee monitors these operations and hydrologic conditions, and may provide the operators with management directions, within the rule curves. For Lake of the Woods, adaptive strategies (seasonal or as needed) are set by the LWCB to balance multiple interests while maintaining water levels within the set lower and upper elevation bounds.

Figure 3 – Governance, Regulation and Management as it relates to the Rainy-Lake of the Woods.

The decisions made at the Water Regulation and Water Management Tiers are a culmination of many interests especially across the Rainy-Lake of the Woods Basin, where cottage country, archeological concerns, hydro generation, navigation, and resource industries are all prominent. It is in this culmination of many interests where the rights and interests of Indigenous Nations often are found. In the Rainy-Lake of the Woods Basin this includes seats on the International Rainy-Lake of the Woods Watershed Board and input or comments to strategies for both the rule curves and operation of the Lake of the Woods Control Board. It is here that a noticeable gap occurs in the creation and development of equitable space for Indigenous Knowledge systems, cultural protocols, and governance. Two common issues can

UNDRIP (United Nations, 2008) calls for the free, prior, and informed consent of Indigenous peoples prior to the approval of projects affecting their lands.

UNDRIP Article 25 (United Nations, 2008)

Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationships with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.

UNDRIP Article 26 (United Nations, 2008)

1. Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.
2. Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use as well as those which they have otherwise acquired.
3. States shall give legal recognition and protection to these lands, territories and resources. Such recognition shall be conducted with due respect to the customs, traditions and land tenure systems of the Indigenous peoples concerned.

be seen in this regard. First, Indigenous Nations as rights holders in the Rainy – Lake of the Woods Basin are often regarded as stakeholders and input, knowledge systems and governance mechanisms are taken under advisement as there has not to date been equitable space created for the two systems to work together. Secondly, as discussed in Water Regulation and Water Management, this is often where Indigenous engagement occurs. However, the decisions in these tiers do not directly impact the core essence of Water Governance, so how can Indigenous Nations truly be engaged as rights holders in a manner that creates space in respect of the inherent jurisdiction and treaty relationships of both Canada and the United States when a mandate has already been set in Water Governance.

Pathways Forward

In the case of the Rainy-Lake of the Woods Basin, the acknowledgement of a major gap in Water Governance is not to say there has not been efforts, activities, progress, and relationships built along the way. It is just to say, the work in the basin and the structures in which decision-making occurs has a long way to go towards creating equitable space to respect Indigenous Knowledge systems, cultural protocols, and governance to truly be in a place of braiding both Western and Indigenous systems. The first step forward has already been taken — the acknowledgement of this gap. It is a gap that precludes the opportunity to have increased knowledge and capacity in the basin for better decision-making and protection moving into the future, especially as government agencies and organizations are continually faced with decreasing resources and increasing need. The need is demonstrated through increases in resource development and a need to understand climate change and associated cumulative impacts.

The second step is furthering our understanding of the present context through expanding our understanding and acknowledgement of the past. Chapter 2 of this report aims to start the conversation with understanding of the Indigenous Nations in the basin and the governance structures, systems and activities that are present. For example, a common misconception of Treaties is that they afford special rights. In reality, what makes the rights special is the essence that they predate colonial contact (Thompson, 2020) and that Treaty #3 was signed in order to share the land between the Anishinaabe and the Crown as brothers (Grand Council Treaty #3, n.d.). Acknowledging and understanding the past, is a process that will be ongoing and is strongly recommended to understand how we got to the current state. Research or discussion questions that can start this process in relation to Water Governance include (questions are aimed to be a starting point and are not exhaustive in nature):

- What does it mean to be a Treaty Partner and uphold a Treaty Relationship in the International Rainy-Lake of the Woods Basin?
- How do the predated Indigenous Treaties and the Boundary Waters Treaty work together?

- What are the past grievances and historical concerns that have to be acknowledged to move forward?
- What mechanisms are currently in place to create equitable space for Indigenous Knowledge systems, cultural protocols, and governance and what still needs to be created?
- How do Indigenous Nations in the basin view Water Governance, Regulation and Management?
- What is the vision and process to water protection in the Rainy-Lake of the Woods Basin that is respectful of all Nations and jurisdictions in the basin?

The ideologies of Water Governance, Regulation and Management in many ways can be counter intuitive to Indigenous Knowledge systems that recognize the agency and life that water has (Craft & King, 2021). Recognizing the spirit of water and ensuring its central role to decision-making can provide a mechanism for better decision-making and creation of space for the future. This understanding must be brought forward and guided by the Indigenous Nations residing in the Rainy-Lake of the Woods Basin and will take considerable work together to reach a shared understanding of governance in relation to water. Ongoing discussions and relationship-building will be needed with increased understanding of mechanisms available to western organizations (i.e., UNDRIP) to undertake and create new mechanisms where gaps are found. Once there is a common understanding, the pathway forward can include shared vision, governance and decision-making protocols that are respectful of all Nations in the basin and creates the equitable space for both western and Indigenous Knowledge systems, cultural protocols, and governance. This will provide the foundation for increased knowledge, resource and data sharing, better decision-making and ultimately the sustainability of a basin to share relationships and opportunities with future generations.

CHAPTER 2 - ANISHINAABE NATION OF TREATY #3, MÉTIS NATION OF ONTARIO, AND US TRIBES

Anishinaabe Nation of Treaty #3

> After three years of negotiations, a sacred relationship was entered and the territory was agreed to be shared between the Nations as "brothers".

Treaty #3 is significant for many reasons. It is the third of the numbered Treaties, and was signed October 3, 1873 between the Crown and the Anishinaabe (Grand Council Treaty #3, n.d.), originally meant to be the first post-confederation treaty. However, the Anishinaabe would not cede lands, as it is understood in the Anishinaabe worldview that one does not own land and therefore it cannot be surrendered (Garrett, n.d.). The land is a gift from the Creator for the Anishinaabe to care for. Interest in the territory was heightened as the need for the British to develop the Canadian confederation including a transcontinental railway and without such treaty, the Anishinaabe would not allow for settlement (Garrett, n.d.). After three years of negotiations, a sacred relationship was entered and the territory was agreed to be shared between the Nations as "brothers" (Grand Council Treaty #3, n.d.). In this context of the international watershed described throughout this report, the context and understanding in which we view Treaty #3 is very important, as much of the understanding is drawn from Crown interpretation (Luby, 2010) without recognition of the oral traditions and Anishinaabe interpretations such as the Paypom Treaty and knowledge held in the Nation.

Today, the Anishinaabe Nation in Treaty #3 is comprised of 28 First Nations over 55,000 square miles spanning from west of Thunder Bay to north of Sioux Lookout, along the international border and into Manitoba (Figure 4) with an approximate population of 25,000. The following Anishinaabe Communities are located within the Treaty #3 Territory:

- Animke Wa Zhing
- Anishinabeg of Naongashing
- Asubspeeschoseewagong Netum Anishinabek
- Big Grassy River First Nation
- Buffalo Point
- Couchiching
- Izkatewizaagegan #39
- Lac Des Mille Lacs
- Lac La Croix
- Lac Seul
- Migisi Sahgaigan (Eagle Lake)
- Mitaanjigamiing
- Naicatchewenin
- Naotkamegwanning
- Nigigoonsiminikaaning
- Niisaachewan
- Northwest Angle #33
- Obashkaandagaang
- Ojibways of Onigaming
- Rainy River First Nations
- Sagkeeng
- Saugeen
- Seine River
- Shoal Lake #40
- Wabaseemoong
- Wabauskang
- Wabigoon Lake Ojiibway Nation
- Wauzhushk Onigum Nation

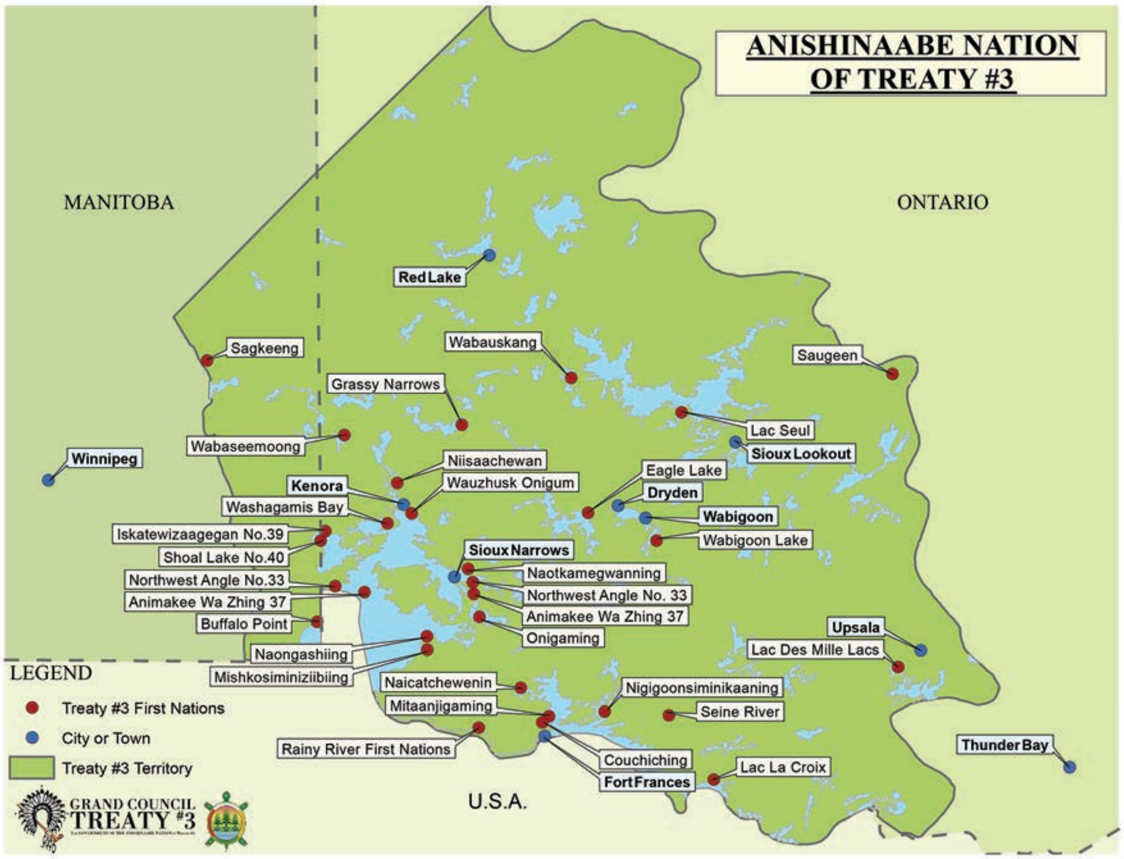


Figure 4 – Anishinaabe Nation in Treaty #3.

Governance Structure

Grand Council Treaty #3 (GCT3) is comprised of 28 Anishinaabe communities throughout the Territory. GCT3 is the Traditional Government of the Anishinaabe Nation in Treaty #3, tasked with the mandate of protection, preservation, and enhancement of inherent and treaty rights. The Chiefs of the Anishinaabe communities are the members of the Grand Council Treaty #3 Chiefs in Assembly, who work together for the benefit of the nation to fulfil the mandate of Grand Council Treaty #3 and advance the unique interests of the Anishinaabe Nation and its people.

Chiefs and citizens of Treaty #3 gather to discuss the business of the Nation and pass resolutions providing Grand Council Treaty #3 with mandate and direction. National Assemblies occur in the spring and fall, as October signifies the signing of the treaty. The leadership is exercised at assemblies through decision-making, participating on Councils and Committees, and through the election of an Ogichidaa(kwe) (Grand Chief) to act on behalf and represent the Grand Council in the political and administrative functions. The Ogichidaa(kwe) serve four-year terms after which a traditional selection process is held during the Fall National Assembly, where candidates are nominated through the offering of tobacco, and have the opportunity to speak to all leadership in attendance (Chiefs and Councils) before the selection process takes place. Assemblies also incorporate each of the Treaty #3 councils and committees to ensure input and guidance from the Nation in relation to all decision-making and flow of information being shared as updates on past resolutions and emerging issues are discussed. In order to provide clear guidance, resolutions are passed through consensus resulting in the mandate to be undertaken by the Ogichidaa(kwe) and the technical staff at Grand Council. The governance of the Nation and Grand Council Treaty #3 is through the four-direction governance model (Figure 5) the framework ensures regional decision-making throughout the nation. The below committees and councils advise the Nation in order to move forward.

Chiefs Committees:

- Kiiwetinong (North) – Social Committee
- Waabanong (East) – Environmental Committee
- Shaawanong (South) – Cultural Committee
- Ningabii'onong (West) – Economic Committee

Advisory Councils:

- Gitiziminan (Elders Council)
- Gaagiidoo-Ikwewag (Women's Council)
- Oshkiniigig (Youth Council)
- Mamawichi-Gabowitaa-Ininiwag (Men's Council)
- LGBTQ2S Council

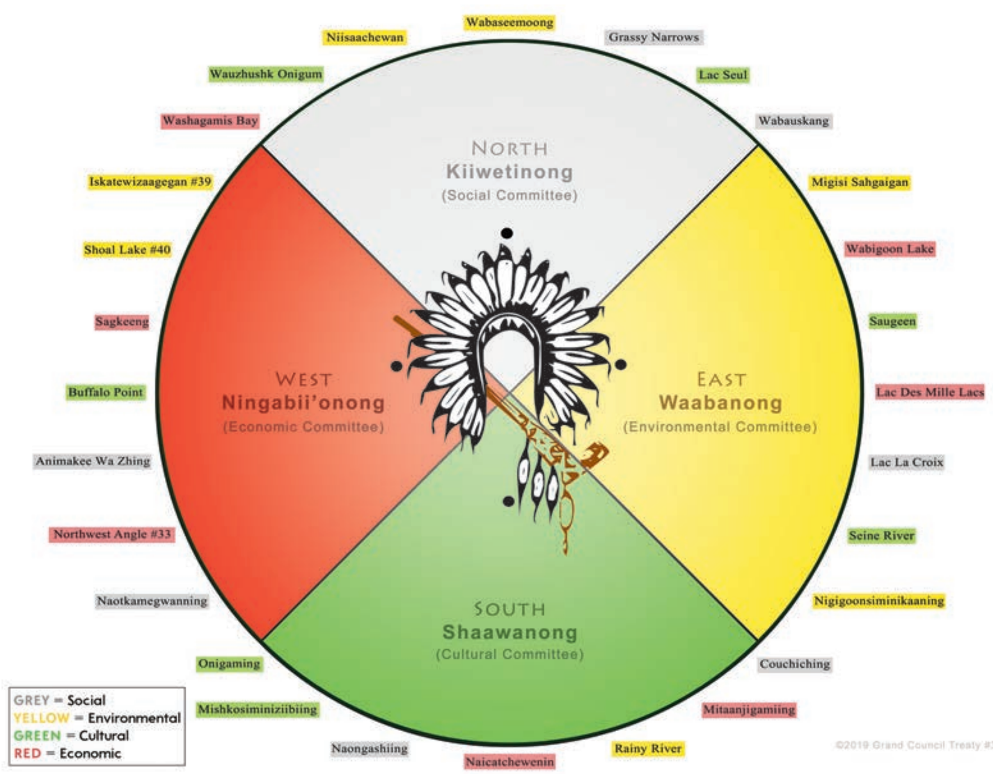


Figure 5 – Four-direction governance model of Treaty #3.

Anishinaabe Law - Manito Aki Inaakonigaawin

Officially written and ratified by the Anishinaabe Nation in Treaty #3 in 1997, the elders in the Nation brought the written law of Manito Aki Inakonigaawin through ceremony, where the spirits approved the law and requested the Nation to adopt it as the temporal law of the Nation (Territorial Planning Unit, 2021). Each community then assented to the law through the process of Band Council Resolutions and then development of consultation protocols in each community and the Nation. This was a significant process as it was an opportunity to have written record of the law (Territorial Planning Unit, 2021). However, the authoritative version of the law lives in ceremony and the oral understandings of the Anishinaabe Nation in Treaty #3.

As an inherent law to the Anishinaabe since time immemorial, the law outlines the pre-existing jurisdiction that continues to be exercised in the Nation and is engraved in the Anishinaabe way of life. The responsibilities outlined by Manito Aki Inaakonigaawin are to last forever, in spirit, in breath and in all of life, for all of eternity across creation (Territorial Planning Unit, 2021). The spirit and intent of the law signifies the duty to ensure the lands and water of the Treaty #3 Territory are respected and protected for future generations and ensure decision-making throughout Treaty #3 respects the jurisdiction of the Nation, lands and water (Territorial Planning Unit, 2021), and in post-colonial times, can act as a mechanism for joint decision-making as treaty partners between the Crown and Anishinaabe. The law governs relationship with the land and creation by ensuring (Territorial Planning Unit, 2021):

- respecting the lands and waters
- giving offerings to spirits and Creator when you benefit from Mother Earth's gifts such as hunting, fishing or transportation
- knowing the rights of the Anishinaabe Nation in Treaty #3
- understanding the responsibilities as a steward of the land

As an inherent law to the Anishinaabe since time immemorial, the law outlines the pre-existing jurisdiction that continues to be exercised in the nation and is engraved in the Anishinaabe way of life.

In the relationship between the Crown and the Anishinaabe Nation in Treaty #3, Manito Aki Inakonigaawin states that all resource development is done in honor of Anishinaabe rights and respect of the land and future generations (Territorial Planning Unit, 2021); the Manito Aki Inakonigaawin outlines a framework of consent of the Anishinaabe Nation in Treaty #3. This framework of consent is the foundation in understanding that all decision-making in Treaty #3 is to be done in respect of the relationship as outlined by Treaty #3, and that in order to move projects or decision-making processes forward a consensus process is necessary to go through between the Nations (Crown and Anishinaabe). Through this process, proponents who enter the Territory do not just respect Federal or Provincial legislation but are required to understand, respect, and adhere to the authorizations and processes outlined by the Anishinaabe Nation in Treaty #3 (Territorial Planning Unit, 2021). These processes ensure the rights of Treaty #3 communities, and the Nation as a whole, are respected and the best possible decision-making occurs in order to fulfill responsibilities to the lands and waters for future generations.

Treaty #3 Nibi (water) Declaration

Ratified in 2019, the Nibi Declaration of Treaty #3 voices the relationship with water (nibi) and jurisdictional responsibility that all Anishinaabe citizens have within the Treaty #3 territory. It affirms the responsibilities and relationships that others living within the territory should have with the water and ensures that the spirit of Nibi is central to decision-making and water governance (Craft & King, 2021).

Ratified in 2019, the Nibi Declaration of Treaty #3 voices the relationship with water (nibi) and jurisdictional responsibility that all Anishinaabe citizens have within the Treaty #3 territory.

> *This Nibi Declaration is about respect, love, and our sacred relationship with nibi and the life that it brings. It is based on Gitiizii m-inaanik teachings about nibi, aki/lands, other elements (including air and wind) and all of creation. This knowledge will be preserved and shared through the declaration with our youth and future generations. Anishinaabe-Ikwewag have a sacred responsibility to nibi and should be included in all decision-making around nibi. This declaration will guide us in our relationship with nibi so we can take action individually, in our communities and as a nation to help ensure healthy, living nibi for all of creation. —Treaty #3 Women's Council 2018 purpose of the Treaty #3 Nibi Declaration*

The key pillars of the development of the Treaty #3 Nibi Declaration are community-driven engagement and ceremony. This process driven by women, in ceremony, mirrored that of the Treaty #3 Law Making process with the help of Gitiiii m-inaanik (elders) and the Nation as a whole (Craft & King, 2021). To start this process, a partnership between the Treaty #3 Women's Council, Grand Council Treaty #3 Territorial Planning Unit and the research organization Decolonizing Water was formed in order to bring forward the relationship of the Anishinaabe Nation of Treaty #3 and nibi through the Declaration. Advice of elders, knowledge keepers and the Nation were brought forward in drafting the Nibi Declaration to then be brought to the Nation through four regional engagement sessions. The regional aspect of these sessions honors and respects the four-direction governance model of Treaty #3. As the process progressed forward to National forum, Treaty #3 Assembly and ratification, the Declaration was brought to ceremony at each key milestone from advice of Treaty #3 elders. In this way, the declaration is responsive to the water and its desire to be engaged with through the principles of the declaration (Craft & King, 2021).

The Nibi Declaration reflects the voice and the relationship of the Anishinaabe Nation to nibi and ensures that this is foundational to decision-making and water governance in the Treaty #3 Territory.

The Declaration supports Manito Aki Inakonigaawin (Treaty #3 Great Earth Law) bringing forward Nibi Principles to decision-making and planning for the nation as an embodiment of nationhood, sovereignty, and Anishinaabe

NIBI DECLARATION
PRINCIPLES

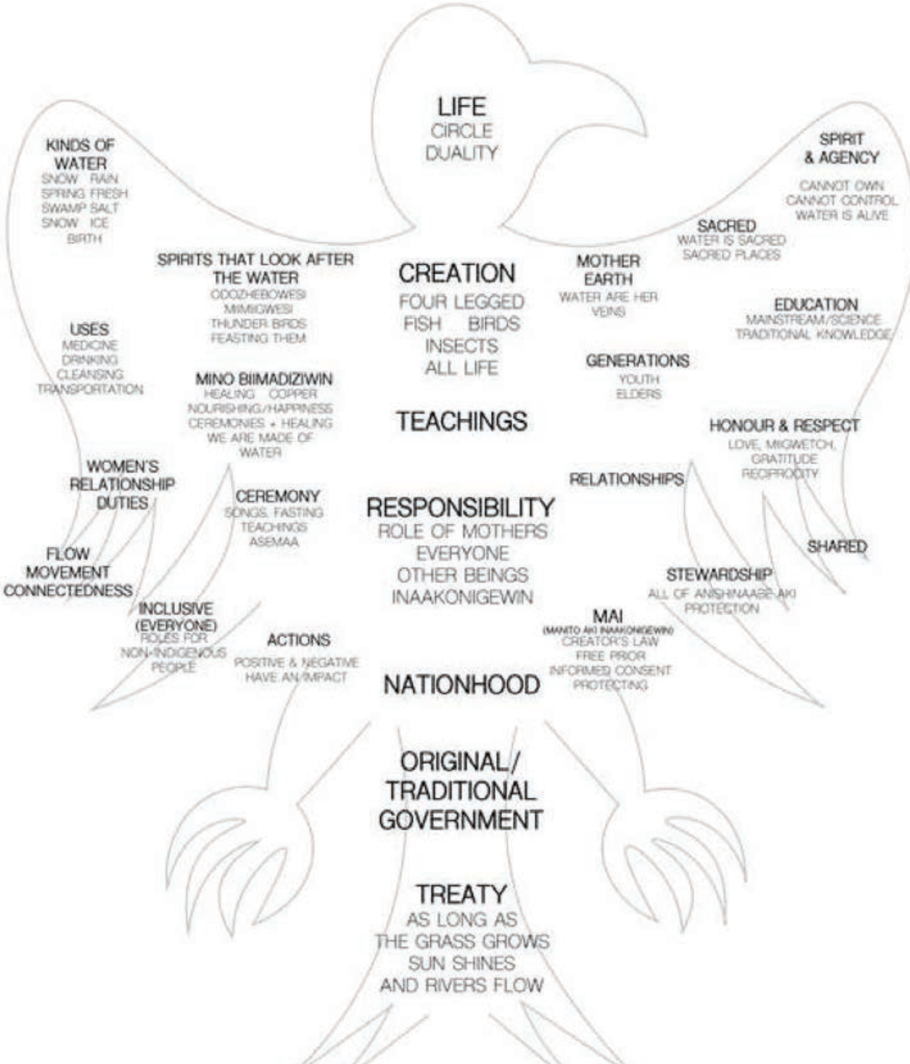


Figure 6 – Water principles of the Anishinaabe in Treaty #3.

jurisdiction as it relates to the environment and water (Craft & King, 2021). The importance of ceremony and language to the assertion of these responsibilities and relations to water can be better understood as a result of the Nibi Declaration and the sacred connection women have with Nibi (Craft & King, 2021), as they are carriers of birth water and have the ability to bring life into the world.

The Nibi Declaration reaffirms that Anishinaabe do not view water as a resource to be exploited, owned, consumed, or commodified. In a similar fashion to what is mentioned with the Treaty, land and water cannot be owned or privatized (Garrett, n.d.), it is a gift, for all generations to care for. Nibi is rather, a living entity with its own agency and ability to govern itself through its relationship with Mother Earth. This relationship and governance between Mother Earth and Nibi can alternatively be recognized in some cases as natural infrastructure and the agency of water can be seen through moments of uncontrolled flooding and events that overwhelm any human engineered infrastructure in place for control. From here, relationships with nibi become central to the responsibilities to protect and plan as water connects us all whether it be through the gift of life, our human composition or the environment and watersheds around us. Every person has a relationship with water, the Nibi Declaration outlines the process of recognizing and respecting that relationship, and nurturing the relationship though the teachings, ceremonies, and principles (Craft & King, 2021). Nibi has a spirit, nibi is life, nibi is sacred, we honour and respect and love nibi (Grand Council Treaty #3, 2019). Everyone is connected through the water, as we move forward together connected by nibi, the Declaration will provide clarity on the responsibilities, relationships, and partnerships necessary in order to protect nibi for future generations and all of creation (Figure 7).

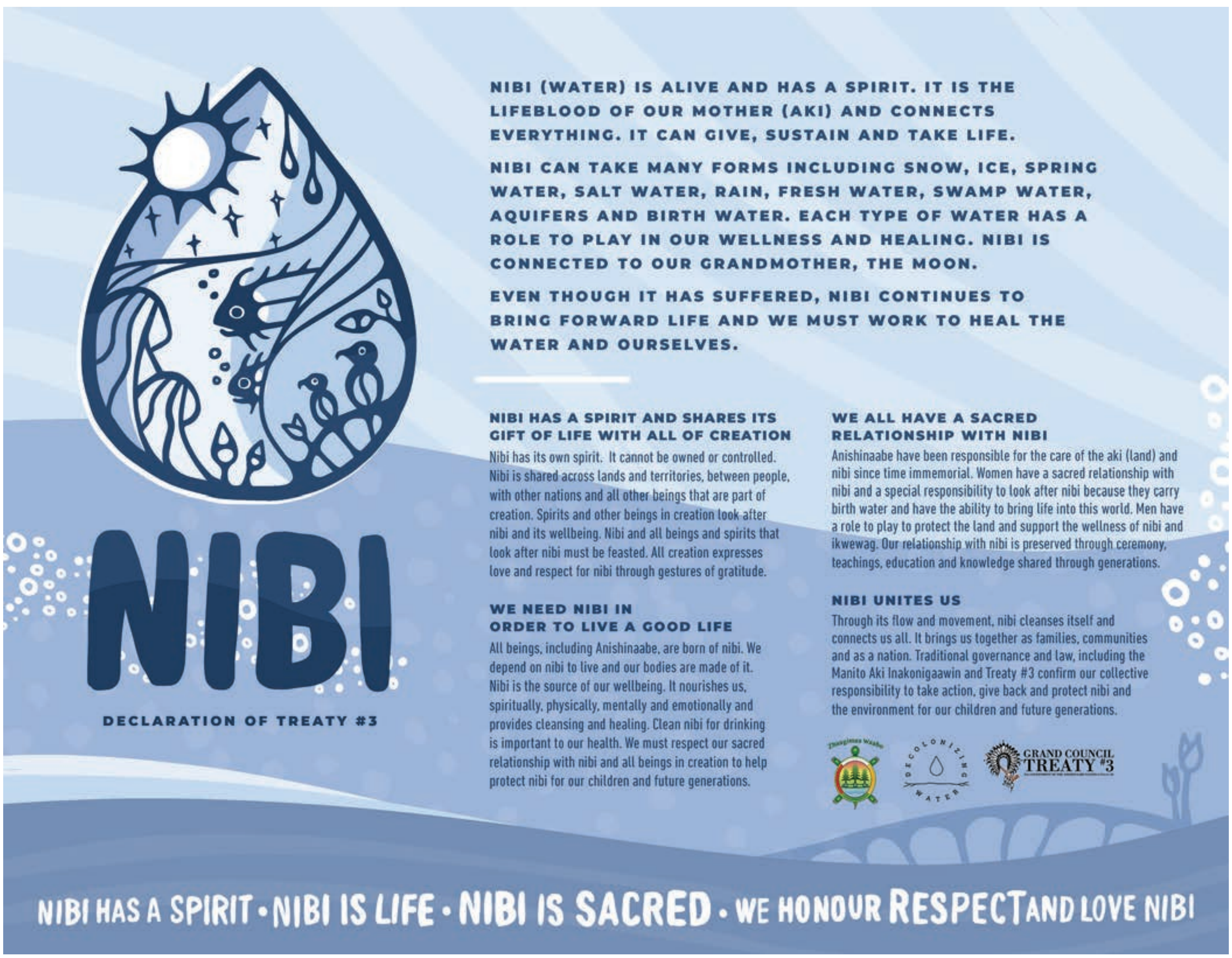


Figure 7 – Treaty #3 Nibi Declaration.

Watershed Management Planning

With the foundation and vision through the Treaty #3 Nibi Declaration and Manito Aki Inakonigaawin, the Anishinaabe Nation in Treaty #3 has taken on the process of watershed management planning. The planning process, rooted in Anishinaabe law and through guidance of Treaty #3 elders, is an exercise of nationhood (Craft & King, 2021) that ensures the four-direction governance model of the Nation is respected and guides the protection and preservation of the water in Treaty #3 for future generations. The draft Treaty #3 Watershed Management plan includes four pillars (Territorial Planning Unit - Grand Council Treaty #3, n.d.):

- Governance
- Ceremony
- Community Based Monitoring
- Outreach/Education

Each of the four pillars of the watershed management planning model are interconnected, supporting each other, and creating a holistic pathway forward (Craft & King, 2021), in order to fulfil the responsibilities as demonstrated in the Treaty #3 Nibi Declaration. This style of planning guides the understanding of the past and present and helps map out future implications of resource development through community driven processes (Craft & King, 2021). It is adherent to the Nation and a fluid process that provides a foundation for cohesive and coordinated approaches to protection that is absent through current water governance in Canada (Renzetti & Dupont, 2017).

Each of the four pillars of the watershed management planning model are interconnected, supporting each other and creating a holistic pathway forward, in order to fulfil the responsibilities as demonstrated in the Treaty #3 Nibi Declaration.

Community based monitoring (CBM) in Treaty #3 has two core aspects, the first being environmental monitoring and the second data governance. Environmental monitoring is taken on through the Territorial Planning Unit's coordinator, working with each community to be out on the water with Treaty #3 youth collecting water samples with YSI monitors. The results each season are shared back to the community and contribute to the long-term baseline data collection across the Treaty #3 Territory. In recent years, the monitoring program has evolved and built on the foundation of training from the International Institute of Sustainable Development – Experimental Lakes Area (IISD-ELA) to also include Canadian Aquatic Biomonitoring Network (C.A.B.I.N) training for benthic invertebrates. Treaty #3 youth who attend the training can take these skills to future opportunities and continue to support the expansion of CBM in Treaty #3 to include fish sampling and invasive species monitoring, such as the zebra mussel early detection program. All the monitoring that does occur is guided by Treaty #3 elders to ensure specific locations and indicators are included. The second portion of monitoring is the data analysis, storage and sharing. This is done through the development of a Treaty #3 Geospatial Database that provides a free and secure database to each Treaty #3 community and a mechanism to share data across the Territory. This data portal will become the hub of information across the watershed and Treaty #3 to ensure all information across multiple jurisdictions is included in both a public-facing side and secure internal Treaty #3 side. Opportunities are upcoming in 2022 for training and orientation on the Treaty #3 Geoportal once complete.

Northwestern Ontario Métis Community–Métis Nation of Ontario

The Métis Nation is comprised of descendants of people born of relations between First Nations and European people, having mixed ancestry and the intermarriage of the mixed ancestry resulted in the new Indigenous people called the Métis (MNO, 2021a). The Métis are a distinct Indigenous people with a unique history, culture, language, and Territory. Settlements of Métis peoples emerged as part of the fur trade along waterways and watersheds, and in Ontario these settlements were connected to larger regional communities (MNO, 2021a).

The NWOMC has a unique history and geography as well as distinct rights, interests, and claims.

The Northwestern Ontario Métis Community (NWOMC) is represented at the local and regional levels by the Regional Councillor for the Northwestern Ontario Métis Community - Region 1 and by the Atikokan Métis Council, Kenora Métis Council, Northwest Métis Council, and the Sunset Country Métis Council (the "NWOMC Councils") as community councils at the local levels, and at the Provincial level by the Regional Councillor. Together, they work collaboratively to represent the rights and claims of the NWOMC as a part of the Métis Nation of Ontario's (MNO) overall governance structure. The Provisional Council of the Métis Nation (PCMNO) is the governance structure of the Ontario Métis Nation. At the provincial and regional level elections are done every 4 years, and at the community council level elections are every 3–4 years based upon their bylaws.

As a part of their elected responsibilities within MNO, they also represent the interests and aspirations of all MNO citizens living throughout the NWOMC's traditional territory. Where required, they work collaboratively with other regional rights-bearing communities represented by the MNO.

The NWOMC has a unique history and geography as well as distinct rights, interests, and claims. For example, they are the only Métis community to collectively adhere to one of the historic treaties signed with First Nations. In addition, given their unique location in what was the historic Northwest, they have extensive historic and ongoing kinship and relationship connections to the Manitoba Métis Community and the Métis Nation as a whole.

The Rainy-Lake of the Woods watershed is located in the traditional territory of Region 1 of the Métis Nation of Ontario including Lake of the Woods/Lac Seul and Rainy Lake/Rainy River as seen in Figure 8.

The Northwestern Ontario Métis Community has credibly asserted and established claims to Métis and treaty rights throughout its traditional territory. Ontario currently accommodates Métis harvesting rights through the Framework Agreement on Métis Harvesting within the Rainy Lake/

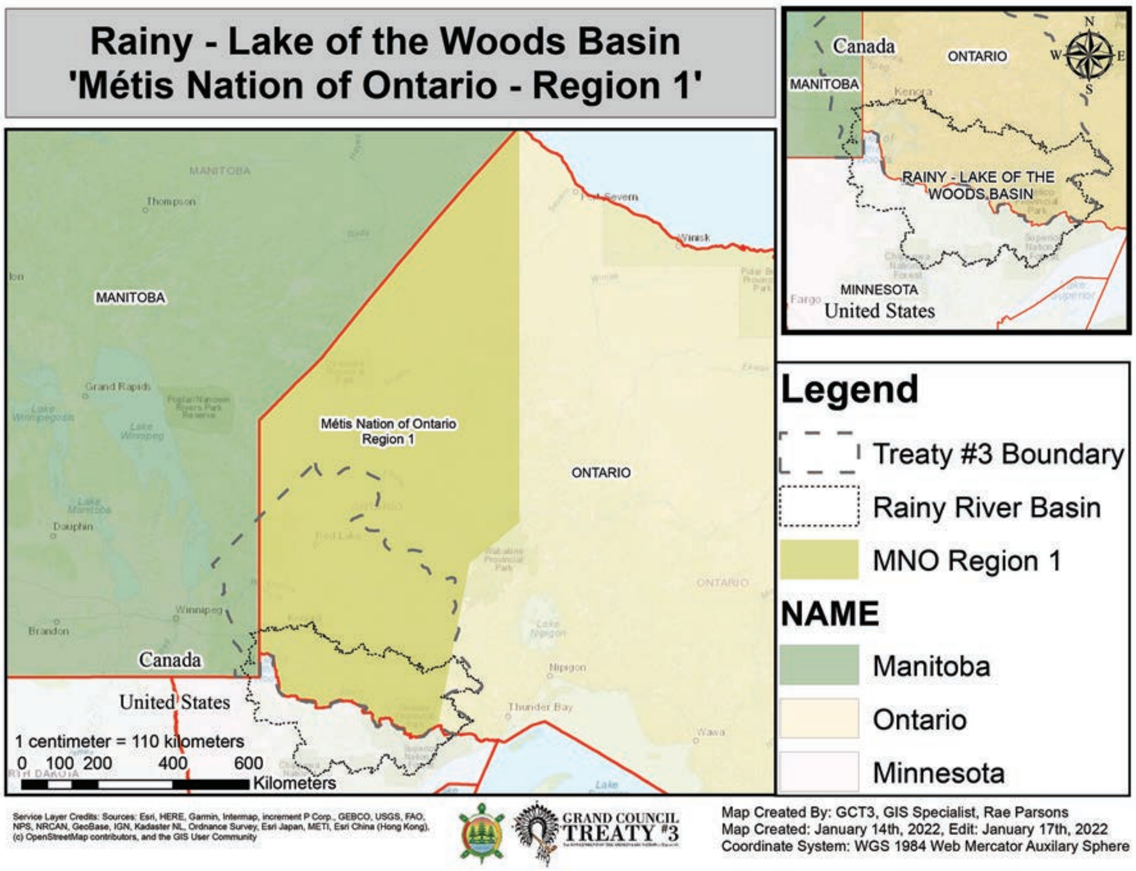


Figure 8 – Regions of the Métis Nation of Ontario.

Rainy River/Lac Seul Harvesting Area, identified in Schedule C to that Agreement. In addition, the "Halfbreed Adhesion to Treaty #3" was signed on behalf of the "Halfbreeds of Rainy Lake and Rainy River" in September 1875. This Adhesion recognized that beneficiaries of the Adhesion enjoyed the same rights under Treaty #3 as First Nations, including harvesting rights throughout the Treaty #3 territory. Today, the NWOMC represents many of the descendants of the original beneficiaries of the Adhesion who still live in the Treaty #3 territory, and they constitute a modern-day Métis community, along with other Métis who lived in the region prior to effective control but were not beneficiaries of the Adhesion, who have section 35 Aboriginal rights that are not treaty rights.

Self-Government

The Métis Nation of Ontario and the Government of Canada came to agreement on the Métis Government Recognition and Self Government agreement on June 27, 2019, (MNO, 2021e), where for the first time it was recognized the Métis communities hold inherent right to self-government and self-determination as protected by sections 25 and 35 of the Constitution Act, 1982 (Government of Canada & Métis Nation Ontario, 2019). The purpose of this agreement is to support and advance the inherent right to self-determination of the Métis that is recognized in section 35 of the Constitution Act, 1982 (Government of Canada & Métis

Nation Ontario, 2019). This provides consistency with the United Nations Declaration on the Rights of Indigenous Peoples and charts a path forward for reconciliation between the MNO and the Government of Canada. In recognition of the local Indigenous rights for self-government, The Northwestern Métis Community (MNO) and the Government of Canada signed The Agreement for Advancing Reconciliation with the Northwestern Métis Community on December 11, 2017.

MNO Consultation Protocol – Treaty #3 Lake of the Woods/Lac Seul and Rainy Lake/Rainy River (Region 1)

As a result of Section 35 of the Canadian Constitution Act, 1982, the Crown and, in the case of the International Rainy-Lake of the Woods Basin, has the legal duty to consult, and where possible accommodate with Indigenous peoples when the crown anticipates conduct that may adversely affect an "aboriginal" or treaty rights. From the duty as outlined in Section 35, the Métis Nation of Ontario has developed nine regional consultation protocols, with one being for Region 1 concerning the Rainy-Lake of the Woods Basin.

Unlike funded First Nations and Tribes, the Métis lack adequate funding or capacity to fully be engaged or involved.

The consultation protocols are inclusive of all Métis organizations in the basin, including the Sunset Country Métis Council, Kenora Métis Council, Dryden Métis Council and Atikokan Métis Council in order to come together to provide a mechanism for the Crown to fulfil its legal duty to consult (MNO, 2011). The Consultation protocol outlines a process for the Crown to abide by when the duty to consult is triggered in Region 1 of the MNO, this will protect the rights and way of life of the MNO (MNO, 2011). The framework outlines the development of consultation committees, communication and dispute resolution in relation to consultation and resource development in the region and provides the clarity and framework necessary for Canada, Ontario or the International Joint Commission to effectively work with the Métis Nation of Ontario.

In Region One, the local/regional protocols for communication requires that all contact or information go through the Regional Councillor who works together with the elected community council leadership and Métis citizens to advocate and negotiate on behalf of our Northwestern Ontario Métis Community. MNO Lands and Resources Branch provides some support. Unlike funded First Nations and Tribes, the Métis lack adequate funding or capacity to fully be engaged or involved. These are the lands and waters of our ancestors that are vital to our continued Métis Way of Life.

Harvesting

In 2004, the Métis Nation of Ontario was the first Métis Government to negotiate an agreement with the province in relation to harvesting rights (MNO, 2021c). This preliminary agreement recognized the MNO's harvester card system and, in 2018, this agreement was amended to further recognize Métis rights in the province as outlined in Section 35 of the Constitution of Canada. The current 2018 agreement outlines a pathway forward towards reconciliation and data sharing between Ontario and the MNO. The MNO harvester's policy is asserted through this agreement with Ontario to ensure inclusion of Métis law and traditions around harvesting that includes conservation, sustainability, safety, and responsibility (MNO, 2018). The key elements of the agreement are (MNO, 2018):

- Recognition of MNO Harvesting Policy, Harvesters Cards and Harvesting Areas
- MNO Harvesters Card Holders will be treated the same as First Nations Harvesters
- The "Cap" on the number of MNO Harvesters Cards is removed
- Verification of Additional Métis Root Ancestors and Family Lines
- The Agreement sets out key subject matters for future negotiations
- Sharing information on the Métis Harvest with NDMNRF
- Commercial Rights and Licenses of MNO Citizens are not impacted by the agreement
- Regional Métis communities may engage MNRF on Specific Harvesting Issues
- The Agreement does not limit the recognition of Métis Harvesting rights in the future

Way of Life Framework

The way of life framework, as developed by the MNO, is the documentation of traditional knowledge acquired through living on the land (MNO, 2020) and the relationship built with the land and water over time. This framework encompasses all ways of life, including:

- Biological
- Ecological
- Economic
- Social
- Cultural
- Spiritual

The way of life framework, as developed by the MNO, is the documentation of traditional knowledge acquired through living on the land and the relationship built with the land and water over time.

This way of life contributes to the collective knowledge of the community and acknowledges the oral traditions of Indigenous peoples across Canada. The intergenerational knowledge is transferred orally through stories, songs and living on the land (MNO, 2020), with the goal of ensuring preservation of traditional knowledge from past generations for the future. In 2009, Georgian Bay traditional territory completed a land use study, completing interviews with elders, hunter, trappers, and fisheries to document the way of life of the Métis Nation of Ontario (MNO, 2020), with future work and studies on their way.

Community-Based Water Quality Monitoring Program

Currently the MNO is developing the Métis Guardians Environmental Monitoring program. This program will respect the relationship and reliance on the land and water of the Métis for water, food, medicine, and livelihood (MNO, 2021d). Under this program, the MNO has undertaken the development of a water quality monitoring program, that has engaged over 50 members of MNO in training and monitoring of the ongoing impacts and effects of pollution and climate change to water in the province (MNO, 2021d).

US Tribes

Red Lake Band of Chippewa

> **The Tribal Council ensures the protection, preservation, and maintenance of rights of the nation to ensure all members and future generations will have access to the resources in order to live as sovereign people.**

The Red Lake Band of Chippewa Indians encompasses over 840,000 acres of land and water across Northern Minnesota (Figure 9), where all land is held in common for the benefit of membership (Red Lake DNR, n.d.-a). The Red Lake Nation is a lineage of Ojibwe people who are an independent Nation. The Tribal Council ensures the protection, preservation, and maintenance of rights of the nation to ensure all members and future generations will have access to the resources in order to live as sovereign people (Red Lake Nation, n.d.-a). The reservation land falls into two categories based on the ownership and location, the diminished reservation that is a block around the Upper and Lower Red Lake is the majority of the land and then the ceded territories located at the Northwest Angle which are only accessible through Manitoba, Canada (National Wildlife Federation, 2006). The reservation is home to roughly three quarters of the population where the primary sources of livelihood include hunting, fishing, and harvesting and large industries being commercial fisheries and logging (Red Lake DNR, n.d.-a).

Governance Structure

The uniqueness of Red Lake is exemplified as the lands are held in common. This is often then referred to as a closed community, where the Tribal Government has full sovereignty over the reservation only subject to the federal government (Red Lake Nation, n.d.-b). In this case, laws are made by the Tribal Council and enforced by council and federal courts. In 1918, Red Lake established the Red Lake General Council Constitution, an 11-member tribal council that consists of three officers, and eight council members, two of which are from each community (Red Lake Nation, n.d.-b). Serving as advisory to the tribal council, the seven hereditary chiefs, descendants of those who negotiated the land agreement, serve in this capacity for life.

Programs

Fisheries

The Red Lake Fisheries program is responsible for the management of reservation fish stocks on both upper and lower Red Lake, 135 smaller lakes and 55 miles of rivers and streams that includes trout, bass, walleye,

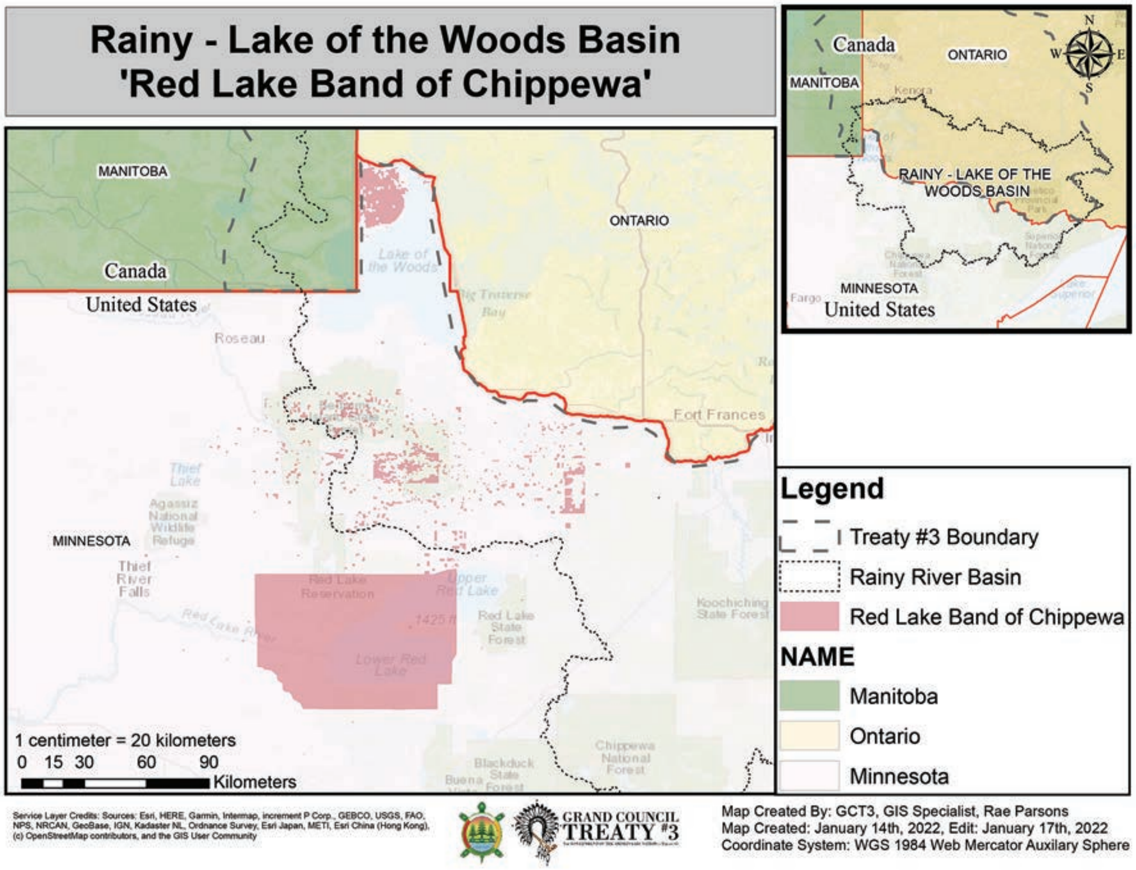


Figure 9 – Red Lake Band of Chippewa Territory.

and perch (Red Lake DNR, n.d.-b). The goal of the program is to monitor the health and harvest of fish stocks of Red lakes, as the area is home to the oldest commercial fishery in the United States (established in 1917). To ensure the ongoing fishery, a joint Red Lake band and Minnesota and Bureau of Indian Affairs restoration effort was established. The joint effort produced a plan to recover the walleye populations that still today thrive throughout the area, sharing an example of joint collaboration and efforts for the benefit of fisheries and water resources in the basin (Red Lake DNR, n.d.-b). Non-tribal members are able to purchase tribal fishing licenses to fish in the areas that are stocked. In another joint effort with multiple agencies, the Red Lake Band is currently working on a re-introduction of lake sturgeon and has stocked around 90 000 lake sturgeon since 2007 (Red Lake DNR, n.d.-b).

Water Resources

In a similar fashion to the fisheries program, the water resources program was established in 1989 in order to monitor the red lake nation's streams, rivers, lakes and groundwater (Red Lake DNR, n.d.-c). The program monitors surface water quality in lakes, wetlands and rivers and streams across upper and lower red lake. The monitoring program includes data collection for nutrients, bacteria, and biological data for all the tribal lands all the way to the Northwest Angle (Red Lake DNR, n.d.-c). Current projects in the water resources program are:

- Water Quality Standards Development
- Water Quality Monitoring
- Lake of the Woods Monitoring
- Contaminants in Fish Study (mercury)
- Invasive Species Prevention

1854 Treaty Authority

Tribes have been asserting the right to hunt, fish and gather in ceded territories of Minnesota since 1970. This followed the creation of the 1854 Treaty Authority in order to protect and implement the rights of Indigenous peoples in off-reservation areas (Thompson, 2020). The 1854 Treaty Authority (Figure 10) area includes:

- Grand Portage Band of Lake Superior Chippewa
- Bois Forte Band of Chippewa
- Fond du Lac Band of Lake Superior Chippewa

In earlier treaties, ceded lands were not incorporated. In later years, land was

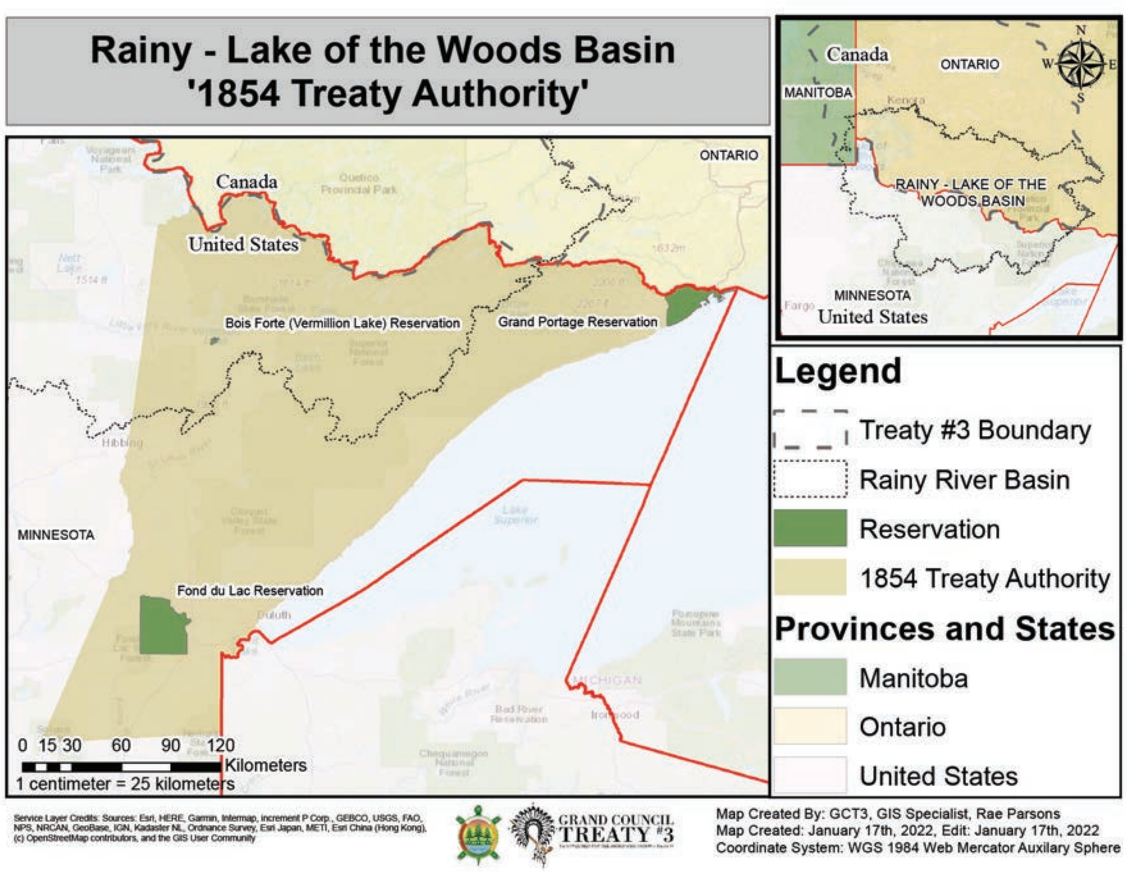


Figure 10 – 1854 Treaty Authority Territory.

ceded through treaties signed between the Chippewa and the United States (Thompson, 2020). However, these treaties ensured the retention of tribal rights to hunt, fish and gather. In 1854, land was ceded in the Minnesota's arrowhead region that is roughly half million acres over six counties of Minnesota. This Treaty also established reservations in Minnesota, Wisconsin and Michigan stemming from the aftermath of the Sandy Lake Tragedy (Thompson, 2020). Chippewa Nations have continued to lead traditional lifestyles since the signing of these treaties in co-existence of non-Indigenous peoples throughout the United States. However, due the continued erosion of rights, the Treaty Authority works to ensure continued respect and access to these rights for the Nations within the 1854 Treaty area. Today, the 1854 Treaty Authority mission is to provide an inter-tribal natural resources program to ensure security of rights to tribes of the United States (1854 Treaty Authority, n.d.-a) through the provision of programs to protect, preserve and enhance the rights of the Grand Portage, Bois Forte Bands of Lake Superior and Fond du Lac Band of Lake Superior Chippewa.

... due the continued erosion of rights the Treaty Authority works to ensure continued respect and access to these rights for the Nations within the 1854 Treaty area.

Governance Structure

The 1854 Treaty Authority is governed by a ten-member board of directors that consists of elected officials of Bois Forte and Grand Portage Tribal Councils (1854 Treaty Authority, n.d.-a). This board meets on a bimonthly manner to set and establish policy and provide mandate for the 15 employees in the administrative division of the organization.

Programs

Fisheries

The fisheries program does spring and fall walleye assessments, trawling surveys and lake sturgeon monitoring projects. The walleye assessments in spring include spawning surveys by use of electrofishing boats to collect data and determine population estimates in the areas (1854 Treaty Authority, n.d.-b). As the fall rolls in, the same process is undertaken in order to determine how strong of a year class it was. Trawling surveys have shown increases in ruffe and other invasive species (1854 Treaty Authority, n.d.-b) since 2016 (after discontinuation in 2005).

Invasive Species Monitoring

Research is continuing in determination of impacts and extent of invasive species throughout the area. In recent years, the 1854 Treaty Authority has developed further understanding on the impacts of spiny waterflea and rusty crayfish. In order to do this, enclosures and exclosures were set up to further understand the impacts of rusty crayfish on wild rice production (1854 Treaty Authority, n.d.-c) in a published report on potential impacts of rusty crayfish on wild rice in ceded territory. Partnerships are also established for control and public awareness programming to ensure reduction of spread of invasive species through the ceded territories (1854 Treaty Authority, n.d.-c).

How can Indigenous Knowledge systems improve our understanding of nutrients and algae?

Overview

Algal blooms continue to be a concern in many areas of the basin and in Lake of the Woods (LoW) in particular. Blooms were continuing in 2021, extending to the north portion of the lake (Figure 11).

There has been a great deal of progress with respect to understanding and managing nutrients and their impact on algal blooms since 2014. In all cases the research has focused on phosphorus (P) which is the primary nutrient that controls the growth of algae in the basin. All measurements presented here are as total phosphorus (TP).

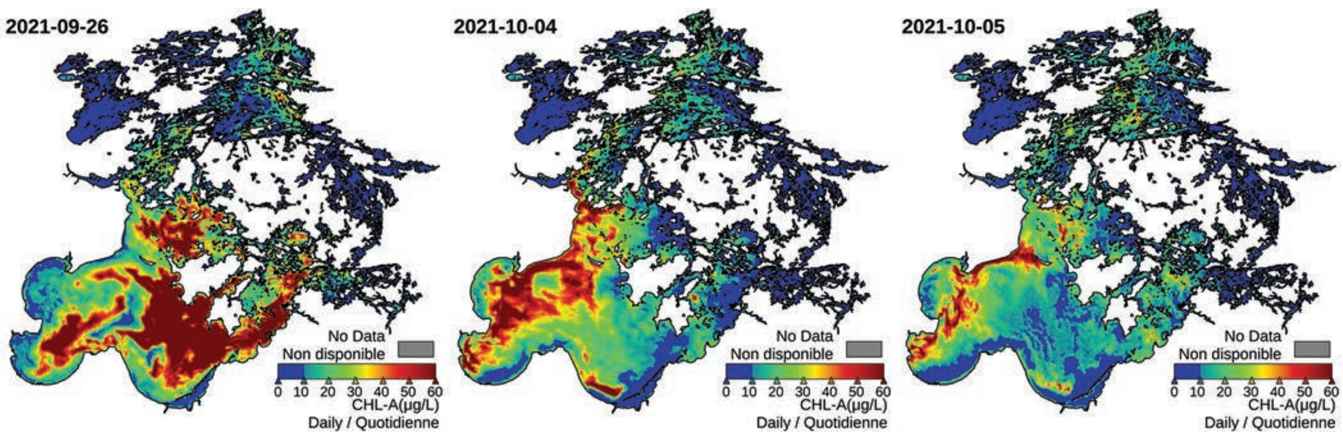


Figure 11 – Chlorophyll concentrations on three dates in 2021 in Lake of the Woods (EOLake-Watch, Caren Binding ECCC).

What mechanisms are needed to expand Lake Partner Program to work with Indigenous Nations? Or include data from Indigenous Nations at their choosing?

The Ministry of Environment, Conservation and Park's (MECP) Lake Partner Program (LPP) continues to provide the tools for volunteers to monitor TP at more than 130 locations throughout the basin and these data are presented online with an interactive map.

https://www.ontario.ca/environment-and-energy/map-lake-partner

The highly precise Lake Partner data (2 Standard Deviations = +/- 0.7 µg/L) are used here to show trends in TP concentrations throughout the watershed where long-term data are available.

Several studies and reports have now included quantitative estimates of TP internal loads for the first time. These estimates are outlined and compared here in the section describing nutrients in *The South Basin of LoW*.

Finally, this chapter includes a review of several new tools including the use of satellites to assess the severity of algal blooms throughout LoW and the use of sediment fingerprinting to identify sources of suspended solids resulting from erosion in tributaries.

Key Nutrient Studies

This section describes three major watershed studies devoted to nutrients. These are:

1. IJC Objectives and Alerts project (IJC O&A) — a whole watershed study which examines other objectives in addition to nutrients.
2. ECCC Lake of the Woods Science Program (2016–2020) and Ecosystem Objective and Phosphorus Reduction Scenario development which pertains to the Rainy River and LoW.
3. Minnesota TMDL study which focuses on the Rainy River and the south basin of LoW.

Navigation buoy leaves a track in a dense algal bloom. (Jesse Anderson)

IJC Objectives and Alerts Project

This report summarizes the results of the first phase (2019) of a project to address the need for Water Quality Objectives (WQOs) and Alert Levels (ALs) for the **boundary waters** in the R-LoW Watershed. WQOs are internationally agreed-upon standards, whereas ALs are advisory level triggers that can be brought to the attention of both governments by the IJC.

This work is required for the IJC's IRLWWB to meet its Directive to recommend WQOs for boundary waters, to establish ALs in the basin, to identify potential problems for boundary waters, and to report on these and trends in water quality and aquatic ecosystem health in the basin. At the present time, WQOs and ALs exist **only for the Rainy River**. The need for WQOs and ALs was assessed to allow reporting on exceedances or trends in water quality and aquatic ecosystem health for the **entire watershed**.

Phase I of the project, now complete, identified the recommended parameters associated with WQOs and ALs. The individual specific guidelines (e.g., concentrations, loads or other narrative guidelines) associated with proposed WQOs and ALs will be established during Phase 2.

https://ijc.org/sites/default/files/2019-10/WQO_AL_Draft_Report_Oct15.pdf

Phase 1 provided:

1. A review of the status of water quality and aquatic ecosystem health criteria relevant to priority issues in the basin.
2. Perspectives from stakeholders, experts, and Indigenous groups on indicators to assess water quality and aquatic ecosystem health.
3. A prioritized list of options for WQOs and ALs that are specific to boundary water hydrogeographies, together with potential metrics or indicators of aquatic ecosystem health.
4. A summary of lessons learned from other basins/boards.
5. A gap analysis for relevant aspects of the project.

These tasks focused on priority issues in the watershed and had an overarching requirement to protect aquatic ecosystem health. Five watershed priorities identified through the review of key documents were identified as **nutrients, contaminants, climate change, aquatic invasive species, and erosion/water levels.**

What relational mechanism are available to understand some water quality objectives of Indigenous Nations?

Replacing 1965 Water Quality Objectives — With agreement of governments, WQOs were established in 1965 for qualitative parameters covering sanitary sewage, suspended solids and slime bacteria as well as quantitative objectives for coliforms and dissolved oxygen concentrations. Given the extensive cleanup of the Rainy River since the 1960s and the fact that these are no longer issues of concern, the phase 1 report suggests that existing WQOs for the Rainy River be replaced by a set of boundary segment-specific phosphorus objectives. The rationale for having only one WQO for nutrients (phosphorus) is because phosphorus was identified as the first priority and phosphorus is the only parameter that often exceeds guidelines in the watershed. Concentrations above 20 µg/L for lakes and above 30 µg/L for streams and rivers are considered as exceedances based on the most stringent guideline for any jurisdiction in the boundary waters. No other parameters were considered as requiring objectives. It is recommended that there be individual phosphorus guidelines established for different boundary water segments to accommodate the fact that concentrations vary significantly throughout the watershed.

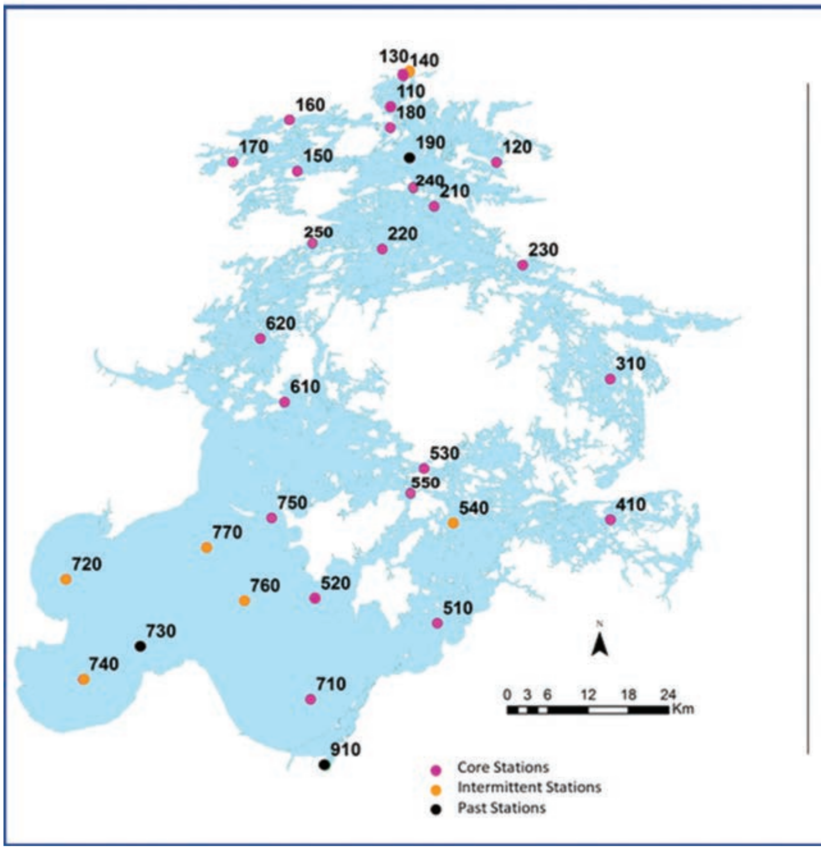
Alert Levels — It was proposed that the four remaining priorities **(contaminants, climate change, aquatic invasive species, and erosion/ water levels)** be addressed using ALs. Contaminants are currently managed using a long list of substances where the most stringent guideline that is in place by any of the regulatory agencies is identified as the AL for that substance. It was recommended that the existing long list be replaced by a shorter list of routinely monitored substances. This will allow more expedient board reporting at intervals. For climate change and aquatic invasive species, the report recommends the use of aquatic ecosystem health indicators that can be used to identify significant risks. These risks would represent Alert Levels to the board. Erosion can be addressed by several of the substances on the contaminants short list such as total suspended solids (TSS) or turbidity, but models may be required to quantify the effects of erosion. Tools to address and quantify the effects of erosion are currently being developed and these are outlined in this report and will be examined in phase 2 of the O&As study.

Moving forward, how can Indigenous Knowledge shape selection of key areas for monitoring?

ECCC Lake of the Woods Science Program (2016-2020) and Ecosystem Objective and Phosphorus Reduction Scenario Development

Environment and Climate Change Canada's Lake of the Woods Science Program (2016-2020) focused on four themes including: enhanced monitoring of Lake of the Woods, Rainy River and select tributaries in Canada; nutrient and algae research; development of tools to identify and monitor algae blooms using remote sensing, and development of integrated watershed and lake-based models to assess lake responses to nutrient reductions. Empirical data and these integrated models were used to develop phosphorus-load-response curves for open-water TP and Chl-*a* concentrations for various sectors of the lake to estimate what level of phosphorus load reductions would be required to achieve desired water quality improvements (ECCC 2021a).

The models could also be used to determine what actions are needed to reduce phosphorus loads and the results that can be expected from different levels of action. ECCC collected lakewide TP data in 2015–2019, summarized in Figure 12.



2015-2019		
Stn	TP June	TP Sept
110	19	33
120	19	27
130	15	23
140	16	22
150	13	20
160	15	19
170	12	21
180	15	28
190	15	
210	18	30
220	19	23
230	13	30
240	16	20
250	17	33
310	11	11
410	16	31
510	27	42
520	19	27
530	19	38
540	23	34
550	25	39
610	15	32
620	12	34
710	16	33
720	18	25
730		33
740	18	29
750	18	30
760	16	
770	20	25

Figure 12 – ECCC sample locations 2015– 019 shown with past and intermittent stations. Station TP means shown are means of all surface and integrated samples. Blue cells in table are <20 µg/L, green 20-30, and orange >30. Units are µg/L.

ECCC's stated overview of its Ecosystem Objective and Phosphorus Reduction Scenario Development is as follows:

> *Using an Ecosystem Approach, a number of options for future potential desirable water quality and ecosystem health conditions were identified and computer models were used to determine the level of phosphorus reduction that would be needed to achieve each. The key steps of this approach include describing potential desired ecosystem conditions for the lake (i.e., Lake Ecosystem*

Objectives), identifying ecosystem indicators to determine when each ecosystem objective has been achieved (i.e., Ecosystem Response Indicators), and applying computer models to determine the level of phosphorus reduction required to meet the objectives (i.e., Scenario Reductions). This resulted in three phosphorus reduction scenarios.

The first scenario relied solely on natural reductions in the internal load (see Internal Loading further in this section). The other two scenarios examined 20% and 30% reductions in TP loading. The 20% reduction best satisfies the projects proposed desired Ecosystem Objectives, which were to:

1. Maintain the diversity of trophic status (lake productivity) for different areas of the lake.
2. Maintain levels of algae below those constituting a nuisance and/or harmful condition.
3. Minimize the extent of hypoxia (low oxygen events) in the southern basin to protect aquatic life and maintain a healthy aquatic ecosystem.

The projected effects of the three different scenarios were presented in a narrative sense as improved conditions, etc. and as concentrations achieved by each scenario at locations throughout the lake.

The projected effects of the three different scenarios were presented in a narrative sense as improved conditions, etc. and as concentrations achieved by each scenario at locations throughout the lake. Threshold indicators and load-response curves were provided for TP and Chl-*a* in supplementary information including a public-friendly fact sheet that shows projected concentrations of TP and Chl-*a* in different areas of the lake. The proposed thresholds indicators presented by ECCC are shown in Table 1.

ECCC also proposed to evaluate the remote sensing tool, bloom severity index (Binding et al., 2021), as a potential ecosystem response indicator (Table 1), that would be used to determine whether the ecosystem objective of maintaining algae blooms below those constituting a nuisance and/or harmful condition has been achieved. At the time of this report, tool development to link model scenarios to bloom severity has not yet been demonstrated. This relationship is being examined, combining knowledge from remote sensing, modeling and the confounding roles of climate and internal loading.

Early in 2021, ECCC held public engagements on its proposed Ecosystem Objectives and Phosphorus Reduction Scenarios. An online platform (https://www.placespeak.com/lakeofthewoods) was used to present information in the form of public-friendly material to support soliciting comments on key questions and support virtual events. In addition, LOWWSF organized a series of town-hall style webinars to provide opportunities for the public to connect directly with ECCC policy and science experts. Due to COVID restrictions, ECCC was not able to engage fully with Indigenous communities and is working to identify opportunities to do this. At the public engagements, ECCC outlined the expected responses of the lake to three TP load reduction scenarios (5 per cent, 20 per cent, and 30 per cent). The

A process can be undertaken to develop the process of a joint phosphorous reduction plan between Indigenous Nations and ECCC.

Table 1 – ECCC proposed lake ecosystem objectives and threshold levels (after ECCC 2021a).

Proposed Lake Ecosystem Objective	Proposed Ecosystem Response Indicator	Indicator Threshold
Maintain the diversity of trophic status (lake productivity) for different areas of the lake	1. Total Phosphorus (TP)*	South basin ≤30 µg/L Central-North ≤20 µg/L Isolated Bays ≤15 µg/L
	2. Chlorophyll a (Chl-*a*)*	South basin ≤10 µg/L Central-North ≤10 µg/L Isolated Bays ≤7 µg/L
Maintain levels of algae below those constituting a nuisance and/or harmful condition.	Bloom Severity Index*	No threshold for bloom severity index proposed – additional research needed
Minimize the extent of hypoxia events in the southern basin to protect aquatic life and maintain a healthy aquatic ecosystem	Science insufficient to select an indicator at this time. *Hypoxic Factor[1] was assessed as a potential indicator but was deemed not appropriate because it lacked sensitivity to changes in phosphorus. Hypoxic Factor is recommended as an important measure to continue to assess with other potential indicators as data and models improve*	

* Indicators as average concentration or index values for the June-October period to capture when blooms occur in Lake of the Woods

[1] Hypoxic Factor estimates the extent and duration of hypoxia as the number of days that it occurs for a given area and is based on: Gertrud K. Nurnberg (2002). Quantification of Oxygen Depletion in Lakes and Reservoirs with the Hypoxic Factor. Lake and Reservoir Management 18(4):298-305. DOI: 10.1080/07438140209353936

scenarios focused on overall load to the lake and not specific source load targets. The 20 and 30 per cent scenarios included the 5 per cent natural flushing. The ECCC scenarios are not in addition to the 17.3 percent load reduction in the Minnesota TMDL. Rather, they are somewhat parallel but with some differences in scope. The ECCC scenarios incorporate TP loads to the entire lake, including those in the Minnesota study that considered only loads to the southern basin of Lake of the Woods. During these engagements, the main points heard from participants, summarized by LOWWSF (https://lowwsf.com/eccc-p-what-we-heard), were:

- Consensus on the 20% phosphorus reduction scenario as it met most objectives, was aligned with Minnesota's target (17.3%), and was considered achievable.
- Binational targets should be set; achieving them is a shared responsibility of all levels of government, individuals, and industry in both countries.
- There is a strong desire to "get on with it" and take steps to reduce phosphorus loads based on best available knowledge and without further delay.
- Needed is a collaborative approach – Some asserted strongly that targets, monitoring, and reporting on progress should be coordinated by the IJC.
- Adaptive management is supported – called for was a commitment

from governments to a systematic and sustained monitoring program to support adaptive management.

- Scenarios were too high-level and lacking information from a management standpoint that could inform actions. Desired are details of where the Canadian sources of phosphorus are, how much they should be reduced (source targets), and where or if there are any practical actions that can be taken.
- Perception that federal and provincial governments in Canada are lagging behind the U.S. on this issue and that Minnesota's study is further along to the level of identifying sources and assigning specific targets and starting actions.
- Consensus that there is enough information to act without further delay to reduce phosphorus pollution.

LoW continues to host nuisance algal blooms and several initiatives have been developed to determine the nutrient reductions (if any), primarily from the Rainy River, that are required to maintain water quality in the south basin of LoW.

Minnesota Total Maximum Daily Loads

LoW continues to host nuisance algal blooms and several initiatives have been developed to determine the nutrient reductions (if any), primarily from the Rainy River, that are required to maintain water quality in the south basin of LoW. Two of these initiatives are whole watershed studies with a component dedicated to the south basin of LoW. These are described in the previous sections for the IJC Objectives and Alerts project and the ECCC Lake of the Woods Science Program (2016-2020) and Ecosystem Objective and Phosphorus Reduction Scenario Development. The MPCA TMDL Study (MPCA, 2021) has its scope set to the south basin of LoW and the Rainy River. The TMDL provides a comprehensive measurement of loads from various sources together with the reductions (Table 2) that would be required to meet favourable water quality conditions in the south basin of LoW. These are illustrated as percent of the total load (at the source) in Figure 13.

Table 2 – TMDL recommended reductions that would be required to meet favourable water quality conditions in the south basin of LoW.

	Total Load** kg/yr	CAN/US %	Proposed Reduction
Point Source Wastewater	**89,189**	50/50	48.7%
Includes LoW point source	62		61.8%
Includes RR point source	88,838		49.1%
Includes stormwater	289		0.0%
Total Watershed Load	**796,763**	35/65	15.5%
Includes RR drainage*	344,839	38/62	
Includes LoW HUCS	28,688	34/66	25.2%
Includes lakeshed	17,112	86/14	
Includes septic systems	722	57/43	43.1%
Includes shoreline erosion	72,000	/100	16.0%
Includes atmos. dep.	51,407	54/46	
Includes internal load	281,995	35/65	25.0%
Total	**885,952**	**37/63**	**17.3%*** **

* Rainy Lake discharge is 148,302 with with a CDN/US of 70/30%
** Total load is at source
*** Reduction of total load at LoW

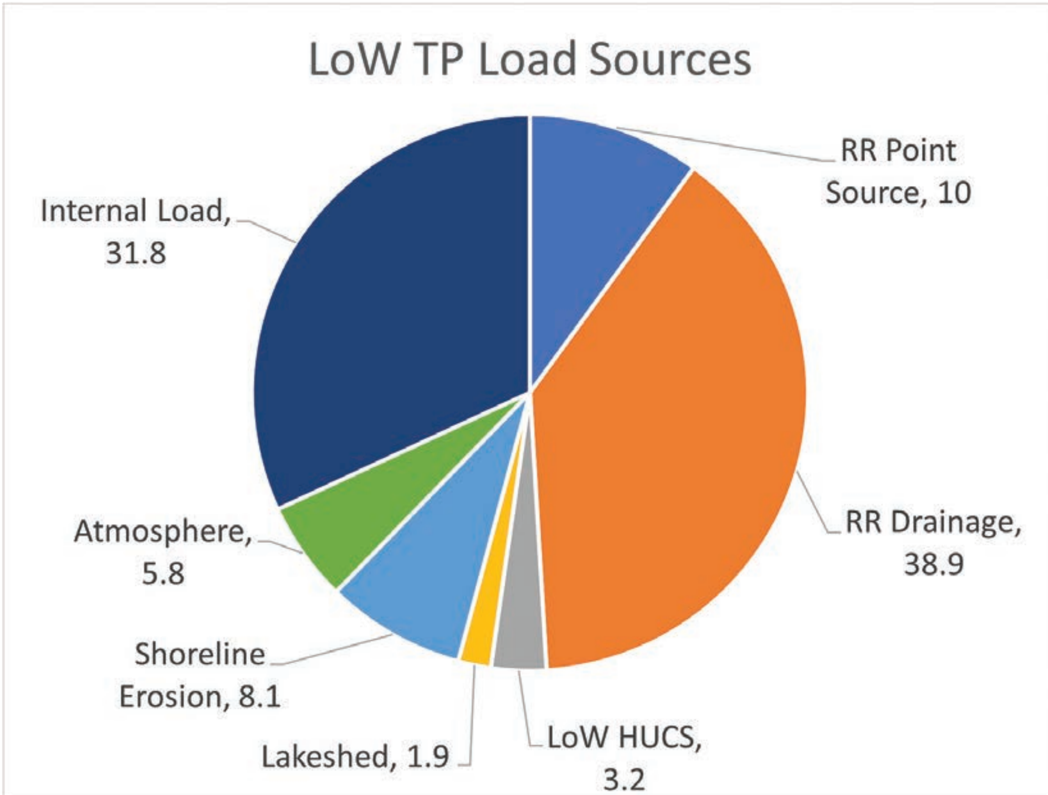


Figure 13 – Percent of total loads to LoW from various sources (for portion of the watershed included in the TMDL).

The EPA approved Minnesota's two Total Phosphorus TMDLs for the Minnesota jurisdiction of the LoW (Lake of the Woods Main; Lake of the Woods – 4 Mile Bay), which were addressed by a single loading capacity study (MPCA, 2021). This meets the requirements of Section 303(d) of the Clean Water Act implementing regulations at 40 C.F.R. Part 130. and address impairments to Aquatic Recreation Beneficial Use.

It is worth noting that there is general agreement with respect to the magnitude of loads between several recent load studies, although many of the model components are not directly comparable. Table 3 shows comparable load estimates derived from the TMDL, ECCC's modelling and the original Hargan et al., (2011) LoW TP budget. The understanding of TP loads and required reductions seems to be converging.

The Rainy River Headwaters

Minnesota's Watershed approach is summarized at this location: https://www.pca.state.mn.us/water/watershed-approach-restoring-and-protecting-water-quality.

Extensive monitoring of headwater aquatic life and aquatic recreation indicators in the Rainy River Headwaters is summarized by Mielke (2017) in the MPCA *Rainy River-Headwaters Watershed Monitoring and Assessment*

Aerial view of heavy algal bloom on Kabetogama Lake (Lee Grim)

Table 3 – Comparable load estimates derived from the TMDL, ECCC's modelling for proposed whole basin scenarios, and the original Hargan et al., (2011) LoW TP budget.

	TMDL		ECCC	Hargan et al.
Data range utilized	*2005 to 2014*		*2016 to 2018*	*up to 2008*
Target receiver	*South Basin LoW*		*LoW*	*LoW*
Load estimate	***(MT)***		***(MT)***	***(MT)***
Waste Load	89.2*		60.8**	98.7***
Local watershed	17.1			81
Septics	0.7		9.36	18
Tributaries	373.5 (inc. RR)		123	130
Atmosphere	51.4		70.2	95
Erosion	72		70.2	no est.
Internal load	282		219.3	no est.
Rainy River			395	568
Current Load	**886**		**877**	**762**
Proposed reductions	162.5 at source (18.3%) 141.1 at lake (17.3%)		175.4 (20% scenario)	no est.
Target TP concentration (µg/L)	State Standard South basin ≤30		Proposed indicators South basin ≤30 Central-North ≤20 Isolated Bays ≤15	no est.
Source of reductions	Rainy River		whole watershed but primarily the Rainy River	no est.
Notes	* Includes Abitibi load ~43.5 MT		** No Abitibi load (mill closed)	***Includes Abitibi load ~47.2 MT

Report (https://www.pca.state.mn.us/sites/default/files/wq-ws3-09030001b.pdf). The report noted that all monitored lakes met eutrophication standards for protecting cool and warm-water or lake trout lakes in the Northern Lakes and Forest Ecoregion, except for Blueberry Lake near Ely which missed standards a result of natural conditions. Shallow Lake Kabetogama supports recreational use but is susceptible to algal blooms and is nearing eutrophic conditions. Otherwise, good to excellent water quality indicated mesotrophic to oligotrophic conditions.

Concentrations of phosphorus, Chl-*a* and Secchi transparencies were at expected levels given the area's dominant forest and wetlands, limited lakeshore development, and high percentage of protected lands.

Sixty-four (of 408) stream reaches were assessed for aquatic life, with 12 of those assessed for aquatic recreation. Of the 64 assessed streams, 62 fully supported aquatic life and 11 fully supported aquatic recreation. None of the stream reaches were classified as limited resource waters.

The Mielke (2017) report noted that Voyageurs National Park's (VNP) larger lakes have seen an improvement in water quality with a reduction in Chl-*a* concentrations since about 2000. This is a result of a change in water level management that allowed a more natural water regime (Christensen and Maki, 2015). Water levels in these lakes are controlled by two dams at the Namakan Lake outlet at Kettle Falls. Lake levels are regulated by Rule Curves under the auspices of the IJC.

What are the current and historical concerns of Indigenous Nations in regard to water level management?

There are a handful of streams assessed and classified as Exceptional, with very high-quality biological communities identified on Table 59 on page 246 of the Mielke (2017) report.

Lake Partner Program (LPP) (MECP) data can be used to examine variations in present day TP concentrations from place to place in the headwaters on the Ontario side (Figure 14). Here we used the most recent data (the last five years) for those areas where there are long-term records and the best available data for those areas where there are data only for a shorter record. Sites were divided into trophic status compartments, assigning colours to the site markers to show the range in TP concentration. Water with less than 20 µg/L phosphorus are shown with a blue marker. This is water that the Ontario Provincial Water Quality Objectives (PWQOs) indicate should be at reduced risk of nuisance algal blooms. Water with 20–30 µg/L is shown with a green marker. These concentrations are within guidelines for rivers but too high for lakes according to the PWQOs. These concentrations are also within Minnesota's water quality standards for aquatic recreation (excluding those

The International Dam between Namakan Lake and Rainy Lake at Kettle Falls (Lee Grim) for lake trout lakes which is <12 μg/L TP). Finally, the concentrations over 30 μg/L are shown in red but there is only one of these and this is in Black Bay which receives the Rat Root system. Most areas have TP concentrations below 20 μg/L. This is acceptable water quality according to the PWQOs. There are a few locations where concentrations are between 20 and 30 μg/L, indicating increased potential for algal blooms, and in fact some of these headwater areas do have algal blooms from time to time.

The water quality of the headwaters that contribute to the Rainy River is acceptable being mostly below 20 μg/L. It is important to note that these TP concentrations are naturally higher than those measured elsewhere on the Canadian Shield where concentrations are closer to 10 μg/L. Because the concentrations in the Rainy headwaters are in the 10–20 μg/L range, the potential to support algal blooms is somewhat higher but still considered to be at a reduced risk of nuisance algal blooms.

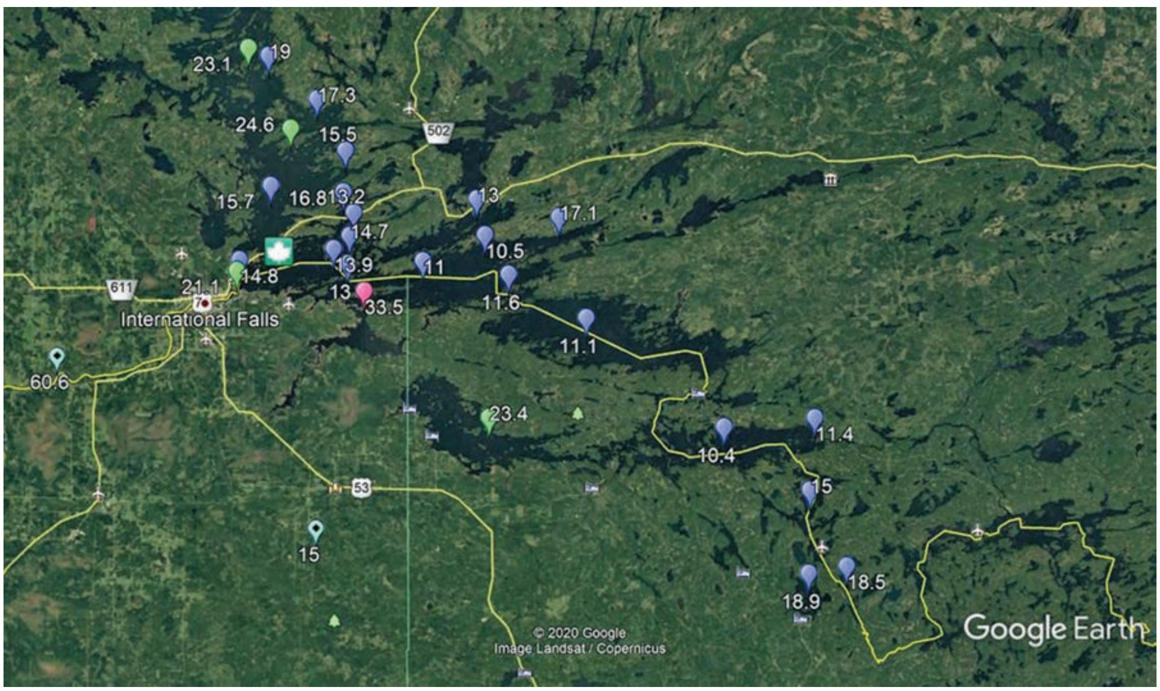


Figure 14 — Phosphorus concentrations in the headwaters to the Rainy River measured by Lake Partner Program volunteers. Most measurements are below 20 μg/L indicating water quality within the PWQOs and Minnesota's water quality standards for aquatic recreation (30 μg/L).

Excellent long-term records of TP concentrations exist for Rainy Lake in the LPP database. Much is owed to the volunteers who collect the samples at these sites. Trends through time are not evident but variability in many locations in Rainy Lake is spanning all trophic levels from oligotrophic to eutrophic (Figure 15 a-d). In addition, VNP has collected TP and Chl-*a* data monthly on Rainy Lake and Namakan Reservoir lakes since 2001. Their long-term lake chemistry monitoring reports have been summarized and are accessible from: https://www.nps.gov/im/glkn/voya.htm

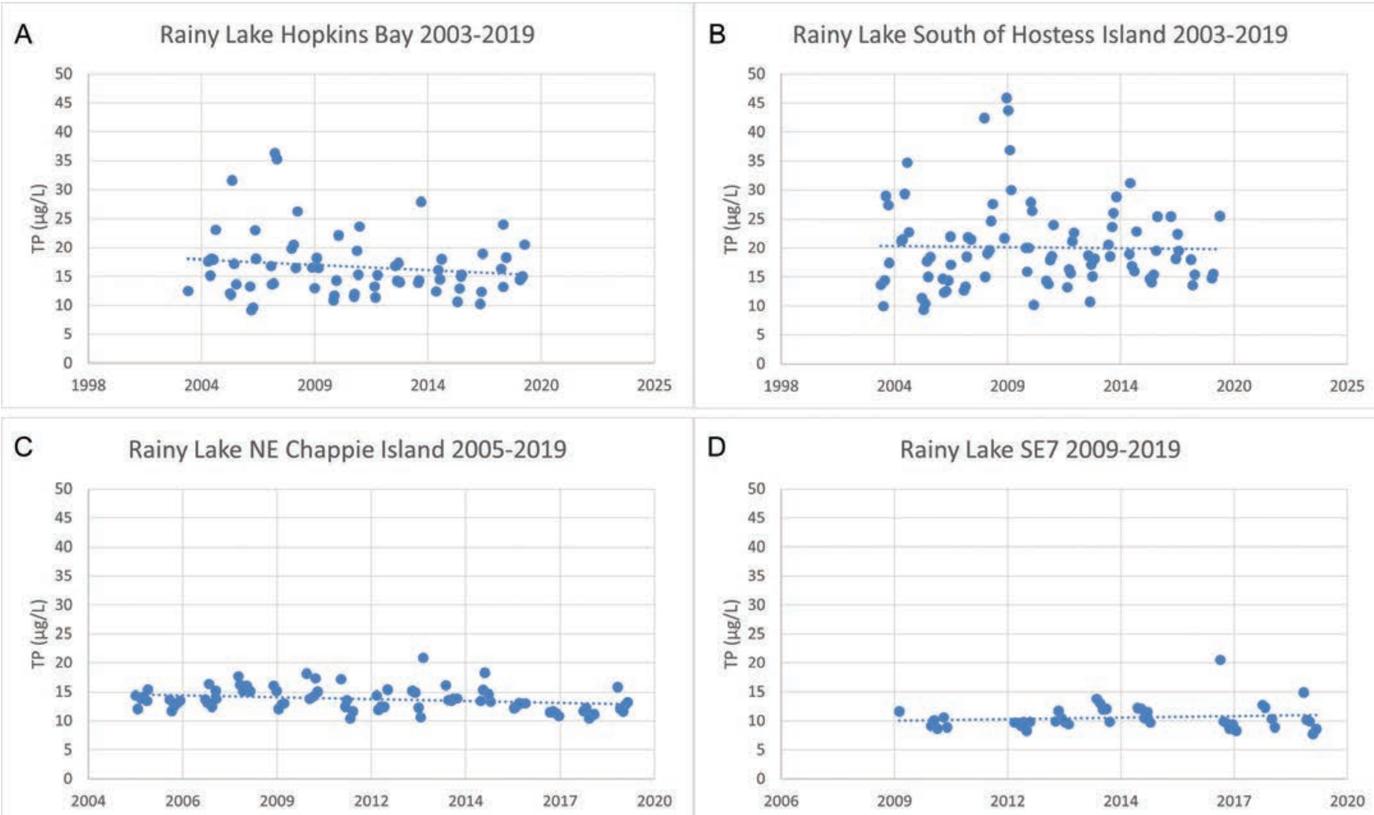


Figure 15 – Long term TP concentrations for 4 locations in Rainy Lake (LPP data). A: South of Hostess Is. (484531, 931605), B: Hopkins Bay (484407, 931058), C: NE Chappie Is. (484100 925845) and D: Rainy Lake SE7 (483333 924843).

There is an enormous amount of data collected by the MPCA for the headwaters of the Rainy River.

https://webapp.pca.state.mn.us/wqd/surface-water

It would be difficult to summarize this volume of data. Here we show TP data for a station in Rainy Lake 2 miles SE of Island View in a part of Rainy Lake close to the outflow, 48.635928, -93.293247 (Figure 16). Data collected between 2004 and 2015 show TP concentrations between ~3–13 µg/L indicating oligotrophic to mesotrophic conditions with no evidence of trends within the observed range. This agrees generally with the LPP data for Rainy Lake at SE7.

The Ontario Broadscale monitoring program has collected comprehensive data for many inland lakes in the headwaters over two sample cycles. These cannot be used for trend analysis but are useful to characterize water quality in these lakes. The data are shown in Appendix 3.

With respect to TP, the water quality of the Rainy River headwaters remains excellent with no appreciable change since 2014 although there is considerable seasonal variability in TP concentrations at many sites. Algal blooms occur in some areas.

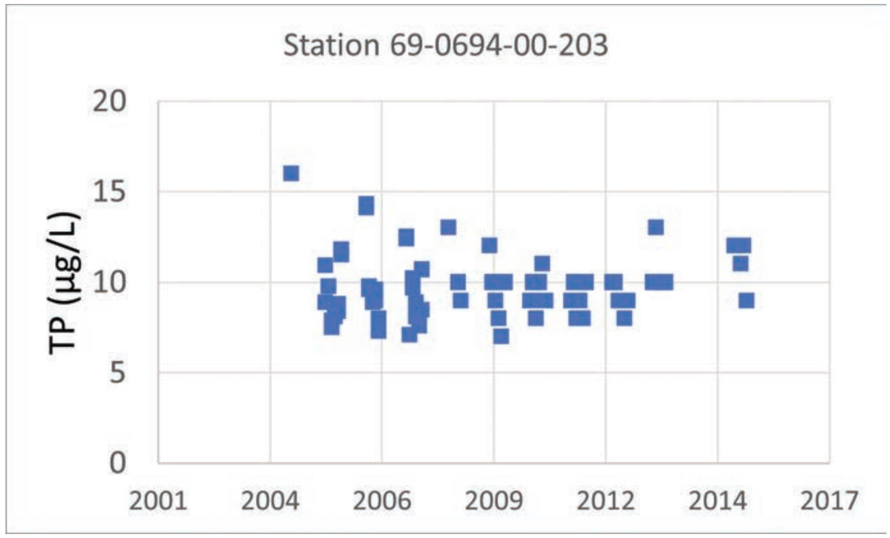


Figure 16 — MPCA TP data for a station in Rainy Lake 2 miles SE of Island View in a part of Rainy Lake close to the outflow, 48.635928, -93.293247.

The Rainy River

The focus of attention with respect to phosphorus loading to LoW has been to examine loads from the Rainy River. This is because the only substantial and realistically controllable sources of P to LoW enter via the Rainy River. It is difficult to describe mean concentrations of any parameter in a river environment due to diurnal and seasonal variations which are not captured by monitoring program sample intervals especially if sample intervals miss the high flow events caused by storms.

How does the unilateral permitting of resource development impact the nutrient loading in the basin?

ECCC collected TP data at four sites on the Rainy River in 2015–2019. See (Table 4). Average results are lower than those measured by MPCA in the Rainy River where results are presented as flow-weighted average concentrations.

Table 4 – TP concentrations measured by ECCC in transects at four sites in the Rainy River in 2015–2019.

Site ID	Latitude	Longitude	n	Mean TP (µg/L)
FF 1	48.59317	-93.4549	100	12
FF 2	48.59265	-93.4549	79	13
FF 3	48.59228	-93.4549	76	16
MR1	48.63325	-93.9187	100	20
MR2	48.63268	-93.9187	79	20
MR3	48.63205	-93.9186	76	21
LS 1	48.64973	-94.1754	101	21
LS 2	48.64902	-94.1755	81	22
LS 3	48.64817	-94.1755	76	22
911 A	48.8224	-94.6995	123	20
911 C	48.8221	-94.7021	82	23
911 E	48.8217	-94.7045	91	22

By converting the ECCC TP data collection dates to Julian day it shows that many of the higher concentrations occur in the spring when flows are high (Figure 17). This may explain why the **non**-flow-weighted concentrations (FWCs) measured by ECCC are lower than the FWCs presented by the MPCA (further below in Table 5).

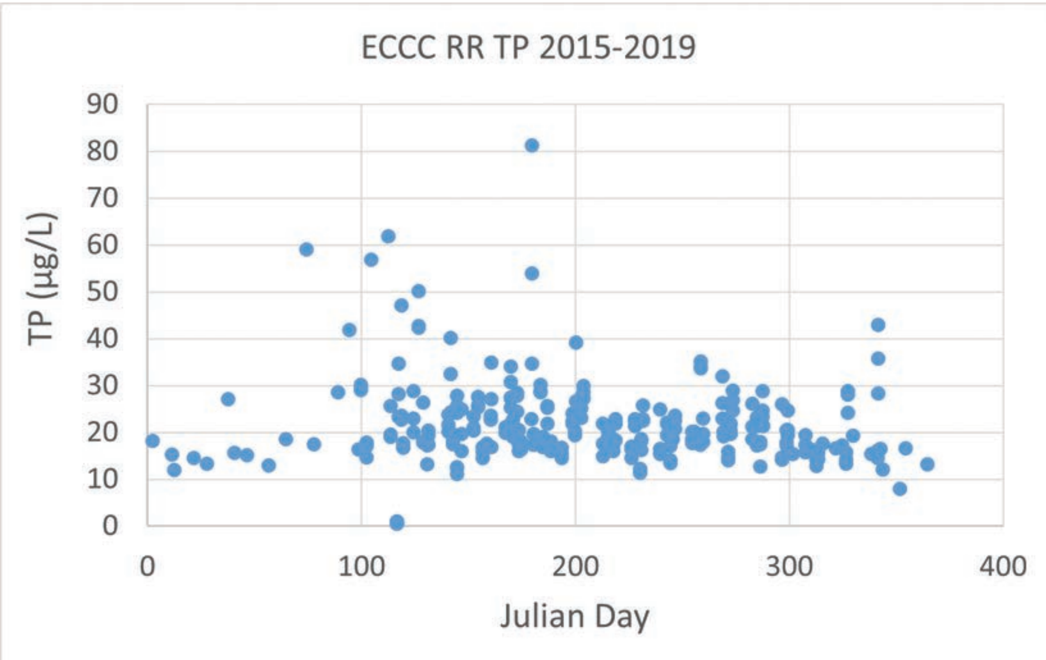


Figure 17 — ECCC Rainy River TP data collected near the mouth of the river with dates converted to Julian day.

Minnesota measured TP concentrations in the Rainy River are remarkably consistent around ~ 30–35 ug/L (excluding a few spring days during very high flows). Data and analyses can be explored using the MPCA data viewer: https://public.tableau.com/app/profile/mpca.data.services/viz/WatershedPollutantLoadMonitoringNetworkWPLMNDataViewer/WPLMNBrowser

Flow-weighted annual average TP concentrations from 2010 to 2019 are shown in Table 5.

Data from https://webapp.pca.state.mn.us/surface-water/station/05133500

The Minnesota Pollution Control Agency (MPCA) annual average FWM concentration based on several datasets collected at Manitou Rapids (05133500) is 33 µg/L. This number represents the most defensible mean

Table 5 — Flow-weighted annual average TP concentrations at Manitou Rapids 2010 to 2019 (µg/L).

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
40	30	30	30	30	30	30	30	40	30
Data from https://webapp.pca.state.mn.us/surface-water/station/05133500									

The Rainy River at Manitou Rapids. (Lee Grim)

concentration for the Rainy River with the understanding that there are occasional annual excursions to 40 µg/L.

In a 2014 report (Christopherson), *Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites*, long-term TP data are summarized for 2 sites on the Rainy River. MPCA milestone sample sites at International Falls (RA 83) and Baudette (RA 12) show respective 2000 to 2010 means of 20 and 30 µg/L. TP concentrations declined significantly between 1953 and 1995 with no trends noted since then. Concentration means in recent years are 20 µg/L at International Falls increasing downstream to 30 µg/L at Baudette (https://www.pca.state.mn.us/sites/default/files/wq-s1-71.pdf).

Are there Oral Histories of Indigenous Nations that can provide support or historical context of algal blooms in the basin?

The data from routine MPCA monitoring stations and ECCC monitoring stations within the Rainy River itself, show concentrations that are around 20 µg/L or lower (https://webapp.pca.state.mn.us/surface-water/search).

However, these ~20 µg/L concentrations are generally not representative of the annual average values which would include elevated concentrations that follow storm events or times when particulates provided by the large inflows on the U.S. side of the river are high.

Tributary TP concentrations collected by MOECP (2014–2017) are shown in Figure 18. For Rainy River tributaries (La Vallee, Sturgeon, Pinewood), these data represent higher concentrations than are usually measured in the main channel of the Rainy River. The PWQO for phosphorus in rivers is 30 µg/L and this concentration is exceeded at many locations in the Canadian inflows to the Rainy River.

Trent University researchers (Eimers et al., 2018–2021) have been conducting detailed seasonal observations of TP export and runoff characteristics in tributaries throughout the basin (Table 6; Figure 19) including the tributaries to the Rainy River. This research describes spatial and seasonal patterns in climate, hydrology and total phosphorus (TP) for tributaries in the Canadian portion of the R-LoW Basin between 2017 and 2020. The contribution of spring melt and winter chemistry to annual nutrient export is compared across sites and between the years. Details regarding this research will be presented at the 2022 Rainy-Lake of the Woods Watershed Forum and in various papers that are in preparation for publication at the time of this current SOBR.

MPCA TP concentrations in the Little and Big Fork rivers and Rapid River are all > 40 µg/L. These data include storm-targeted samples so these are

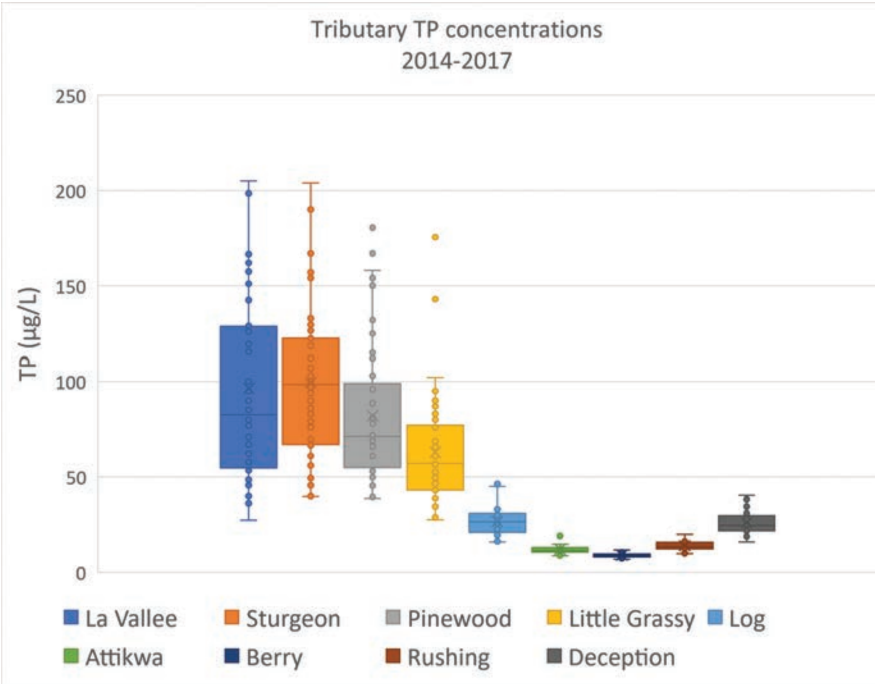


Figure 18 – TP concentrations measured in Canadian tributaries to the Rainy River and Lake of the Woods.

Table 6 — Tributary and basin land area for tributaries studied by Trent University (1 = Shield, 2 = Agassiz. Big Fork and Little Fork Rivers in MN are a blend of both zones)

Tributary	Basin area (ha)
[1]Atikokan R. (ON)	346
[1]Pickerel R. (ON)	170
[1]Seine R. (ON)	5897
[1]Turtle R. (ON)	4739
[1]Trout R. (ON)	251
[1]Berry Cr. (ON)	790
[2]La Vallee R. (ON)	104
[2]Everett Cr. (ON)	37
[2]Sturgeon R. (ON)	169
[2]Pinewood R. (ON)	233
[2]Little Grassy R. (ON)	154
[1,2]Big Fork R. (MN)	3853
[1,2]Little Fork R. (MN)	4384

accurate estimates. Flow-weighted mean TP concentration for the Big Fork River at Big Falls for 2007–2019 is 47 µg/L (Minnesota WPLMN Data Viewer). For reference, flow weighted TP concentrations in Rainy River tributaries on the Canadian side (e.g., Sturgeon, Lavallee, Pinewood) are also well above 40 µg/L. Peak measured concentrations are 300 – 400 µg/L during spring

For reference, flow weighted TP concentrations in Rainy River tributaries on the Canadian side (e.g., Sturgeon, Lavallee, Pinewood) are also well above 40 µg/L. Peak measured concentrations are 300 – 400 µg/L during spring melt

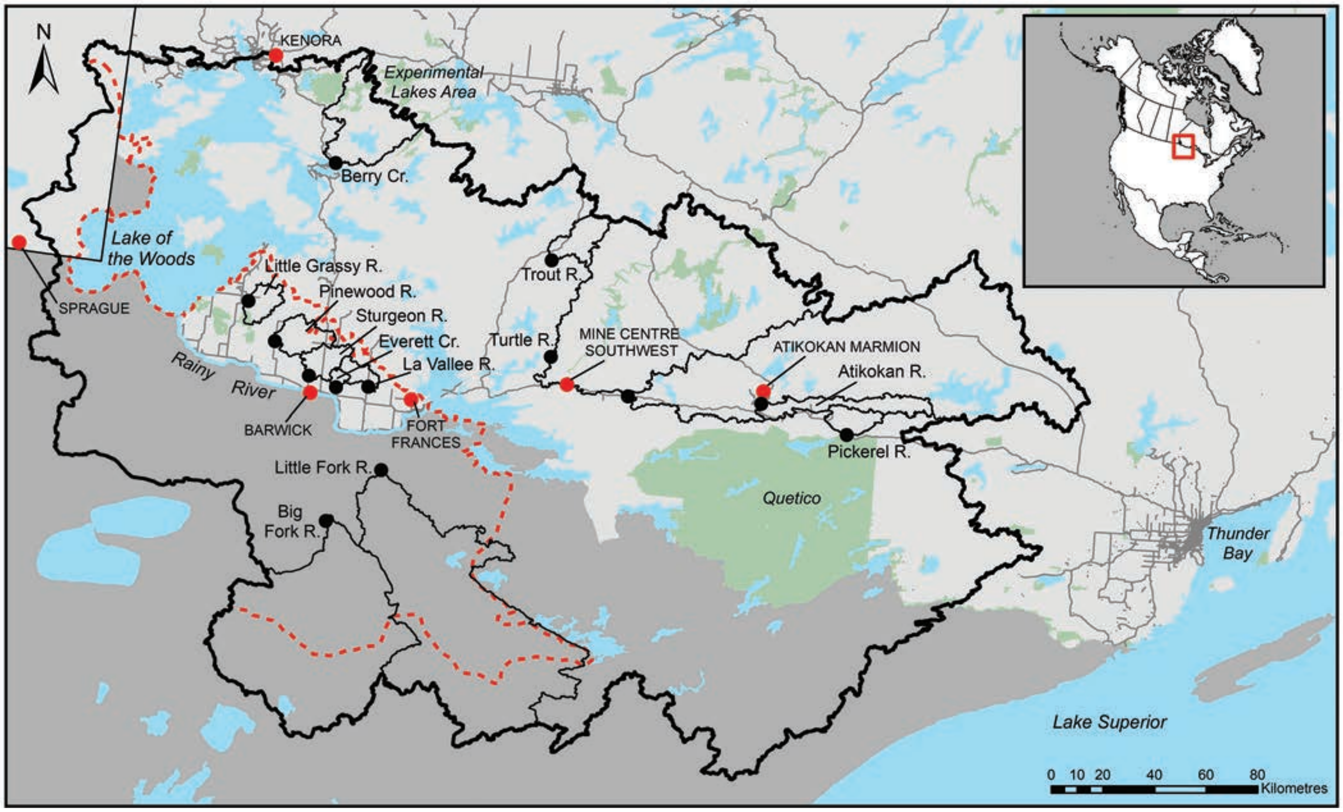


Figure 19 – Tributaries studied by Trent University 2018-2021 in Canadian (light grey) and U.S. (dark grey) portions of the Rainy-LoW watershed. Also shown are discharge stations (black circles), along with their respective contributing areas, and climate stations (red circles). The boundary between the two major geozones – Shield and Agassiz – is indicated by the stippled red line (Eimers et al., 2018-2021).

melt (Eimers, pers. comm.). These very high concentrations also occur under low flow/stagnant conditions when redox processes are likely causing release from riverbed sediment. Notably, water level controls in the Rainy River system may contribute to stagnant conditions in the influent tributaries and unintentionally create the conditions for redox release of TP.

Total phosphorus concentrations increase in the Rainy River as you move downstream from Rainy Lake toward the inlet to the LoW. This is due to the contribution of TP by major tributaries from Canada and the US.

It is important to note that water quality considerations for the Rainy River are more focused on loads than on concentrations. This is the case with recent TMDL studies in the south portion of LoW. The goal is to reduce loads to a level where the water quality in the south end of LoW will no longer be impaired. The actual concentrations that these load reductions will produce will also vary with inflow characteristics and weather. You can read more about the TMDL study in the following section concerning the south portion of LoW.

MPCA 2020 Rainy River Study

This recent study shows that with respect to ecological metrics, the Rainy River continues to improve and is now considered to be in excellent condition (www.pca.state.mn.us/rainy-river-study).

The 2020 Rainy River Study does not go into detail with respect to phosphorus concentrations in the Rainy River, but it mentions that phosphorus concentrations in the tributaries feeding the Rainy River are among the lowest in Minnesota. Higher concentrations in the Little Fork River are attributed to sediment loading and this is flagged as a potential problem for LoW downstream.

The study infers ecosystem health due to the numbers and diversity of aquatic insects.

Long Sault Rapids on the Rainy River, Franz Jevne State Park, MN. (Lee Grim)

Lake of the Woods

There have been monitoring efforts by several agencies to collect TP data (among many other parameters) in LoW. TP data collected by ECCC between 2015 and 2019 are shown in Figure 12 with data plotted in Appendix 2. A further examination of these data can be found below in sections devoted to the north and south portions of the lake. ECCC returned to LoW in September 2021 to collect data at previous sample locations including the outflow at Kenora.

Monitoring in the Canadian section of the lake has been completed in recent years by NDMNRF/MECP through the broadscale monitoring program and through outlet monitoring. It is unclear how many water quality sample cycles have been completed for LoW. Outlet monitoring was discontinued by NDMNRF/MECP in October 2018.

TP concentrations in the Rainy River declined significantly between 1953 and 1995 with no trends noted since then. Current TP concentrations have a flow weighted mean of 33 µg/L.

MECP-Lake Partner Program citizen monitoring continues at many stations throughout the lake.

The MPCA has completed extensive monitoring in the Rainy River and portions of southern LoW. MPCA intensive monitoring of southern LoW was completed in 2010.

The South Portion of Lake of the Woods

ECCC TP data for the stations monitored in the south portion of the lake can be seen above in Figure 12 with detailed plots for selected stations in Appendix 2. Average concentrations of pooled, mixed layer and surface samples collected between 2015 and 2019 show a June mean of nine stations in the south basin of 19.3 µg/L with a mean of 33.2 µg/L for the September data.

The MECP-LPP program continues to collect TP data at many locations in the south basin of LoW although the large areas in Big Traverse that lie within the U.S. are not sampled. Many locations have a range in concentrations between 20 and 30 µg/L. This is not surprising given the volumes of water entering the lake from the Rainy River that are above 30 µg/L. Much of this water works its way up the central portion of the lake towards the north and outflows at Kenora.

Intermittent data sets and wide seasonal variation make it difficult to assign an average or typical TP concentration to the south basin of LoW. It is necessary, however, for us to have a reasonable approximation to support and assess the progress of various nutrient reduction strategies that are currently focusing on the south basin. LPP data originally had a long-term record at Frenchman's Rock which has been discontinued. It showed a wide range in seasonal concentration (20-100 µg/L) that increased towards late summer and fall (Figure 20).

It is difficult to describe average TP concentrations for the south portion of LoW due to high spatial and temporal variability in the measured concentrations. There are however general observations that can be made based on a large amount of data. Spatial and temporal variation includes concentrations ranging between 20 and 90 µg/L.

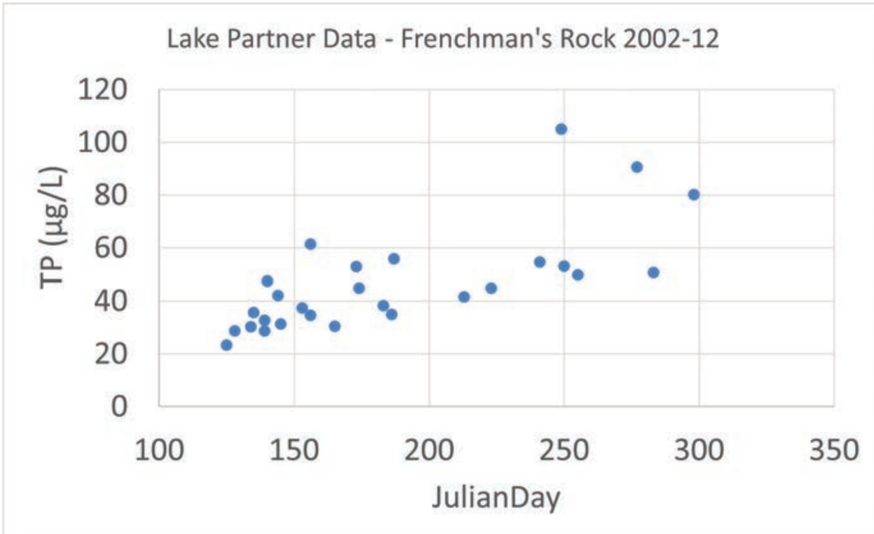


Figure 20 – Seasonal P concentrations at Frenchman's Rock (LPP data).

The most recent MPCA data (2010) from a station near the centre of Big Traverse shows a similar seasonal pattern (Figure 21).

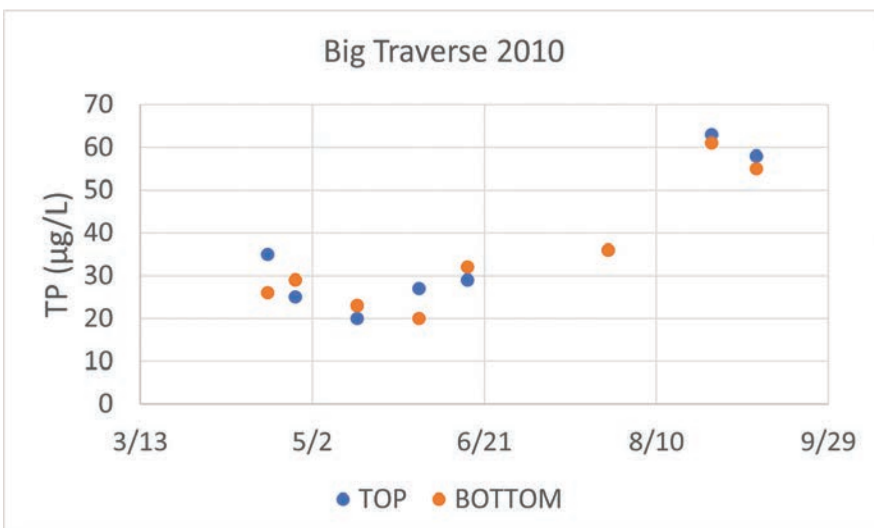


Figure 21 – MPCA Big Traverse seasonal TP data in 2010

These datasets highlight the importance of including seasonal ranges in any discussions around average conditions. The fact that concentrations are highest at times when conditions are otherwise favourable for algal blooms should be a consideration. This acknowledges the fact that it is more difficult to organize late summer and fall collections by volunteers.

This same pattern is shown using 60 day rolling means of empirical data from the TMDL study in Minnesota (their Appendix F). Seasonal range is <30 to >50 µg/L (Figure 22). Note this is a rolling mean which will not indicate the highest or lowest individual values.

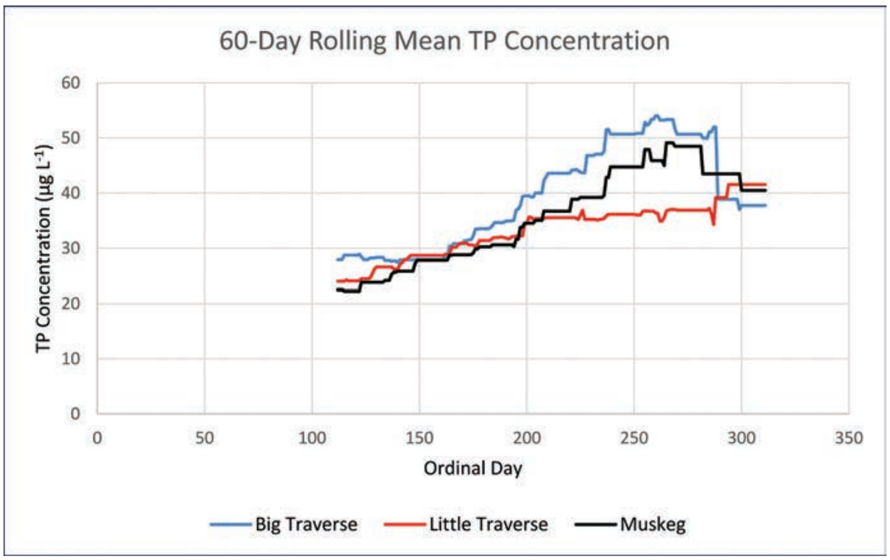


Figure 22 – 60 day rolling means of empirical data from the TMDL study in Minnesota (Appendix F).

It is important to consider TP concentrations at seasonal times when algae blooms occur, for assessing effectiveness of remedial strategies

These data stress the importance of examining the TP concentrations in the lake at those times when algal blooms are most likely to occur. In this case, the "open-water seasonal average" cited by ECCC and used in its model calibration likely is not representative of the conditions when it is favourable for algal blooms.

See section below titled ***Watershed P Concentration Summary*** for more information about the spatial variation in TP concentration throughout LoW.

Internal Loading

Internal loading is a process whereby lake sediments can contribute phosphorus to the overlying water and thereby potentially exacerbate algal blooms. It has been recognised for many decades that internal loads can be influenced by factors including anoxia, temperature, sediment P concentration and the presence of certain elements like iron. While we understand the conditions that contribute to higher or lower sediment P release rates, we cannot easily identify the conditions that apply to a given body of water because these conditions are difficult to quantify. This is especially true for LoW where the area involved is huge, sediment water interface anoxia may be evanescent and where P concentrations in the sediment have been historically augmented by nutrient pollution from the Rainy River. It is important to know the actual load from sediments if there is any hope of developing models that will predict in-situ P concentrations so that budgets can be developed to support management decisions.

Dr. Eimers (Trent University) has additional evidence to suggest that internal loading that occurs in the tributaries can contribute to exceptionally high TP concentrations (e.g., > 300 µg/L) in the late summer.

That pool of phosphorus is declining. The lake is on a trajectory to meet some new steady state.
Edlund et al., 2017

In 2015, Edlund published a popular literature article titled *Unlocking Lake of the Woods*, based on their studies at the St. Croix Watershed Research Station. They found that, unlike other water bodies that they studied, there was not much phosphorus in the sediment. Instead, the phosphorus was being stirred up on the bottom and entering the water, where it is consumed by algae. When the algae die it settles to the bottom where the phosphorus that it contained can once again be mixed into the water column. The upside is that the phosphorus is slowly being flushed out of the lake as algae, and the available supply is dwindling. Water stays in the lake for about a year, which means a slow but steady process.

In 2017, Edlund, et al. constructed a historical phosphorus budget for southern LoW using sediment cores from seven bays. Historical monitoring showed that external P loads have decreased since the 1950s while sediment P continues to increase since the mid-20th century.

Two mass-balance models were used to explore historical P loading scenarios and in-lake dynamics. A one-box model predicted that pre-settlement external loads were slightly less than modern loads. A dynamic model showed that water column P was higher in the 1950s–1970s than today. This indicates that the lake is sensitive to external loads because P losses from burial and outflow are high, and that the lake is moving towards a new steady state with respect to water column P and size of the active sediment P pool with its legacy effects now minimal. Key observations (Edlund et al., 2017) include:

1. Water column P was significantly higher in the past, particularly in the 1950s–1970s than it is today.
2. The lake is very responsive to changes in external loads. Model results show the lake quickly became more eutrophic as nutrient loading ramped up following settlement, but also show that water column P levels quickly fell as external loads were reduced after the 1970s. No long-term trend in outflow volume and P loss at Kenora was noted that might account for this drop in water column P.
3. The responsiveness of the lake is a consequence of rapid and large burial and outflow fluxes that remove P from the lake.

4. With rapid reduction of external loads after the 1970s and current external loads remaining relatively constant for the last decade, LoW has both rapidly depleted any legacy pool of sediment P and has or will soon reach a new steady state with respect to water column P and the size of its active pool of sediment P.

Quantifying internal loads

The 2017 Minnesota TMDL report shows that internal loading is an important portion of the P budget.

The TMDL study determined internal load based on a detailed (summer) monthly mass balance which considered known and expected change in P from external flows, in-lake transport and outflow. Using two separate models to estimate P concentrations in the south portion of LoW they were able to determine that unexplained residuals between the two models would be internal loading plus resuspension and settling of particle bound P. These estimates include only the summer months.

The TMDL study (their Appendix F) summarized the quantitative P loading estimated by recent studies as shown in Table 7. Here we have added estimates published by Environment and Climate Change Canada (ECCC).

The TMDL report points out that many questions remain, but the investigations have arrived at converging quantitative estimates of internal loading.

Estimates of TP loads to the south portion of LoW have now been completed in detail with estimates of required reductions necessary to protect multiple uses. In addition, researcher's ability to both quantify internal loads and make predictions about future loads have improved.

Table 7 — Quantitative internal P loading estimated by recent studies.

Study	Mean annual internal load (t/yr)	Notes
TMDL	282	Study area only
TMDL	220	Big Traverse only
Edlund (2017)	250*	Entire LoW
James (2017)	241-364	Big Traverse only
ECCC	228, 219, 217 for 2016,2017, and 2018 respectively	Entire LoW
*Based on 2.5 % of active sediment pool of 10,000 tons available each year		

Quantifying Future Changes in Internal Loads

The Science Museum of Minnesota's St. Croix Watershed Research Station (SCWRS) estimates that, with continued decreases in watershed loading, the internal load will decrease approximately one percent per year (based on Edlund et al., 2017).

In ECCC's modelling efforts to link P concentrations to in-lake processes, one of their scenarios involves a reduction in TP based on future decreases in internal loads alone. These were estimated to be 1% per year over 20 years with a net reduction of 44 MT.

MPCA's TMDL study estimates that the proposed reduction from internal loads should be 70 MT over a restoration period of 25 years (based on Edlund et al., 2017).

Although the current conditions in the south portion of LoW have been well described, it is difficult to assess trends in TP concentrations over time using empirical data. This is because datasets are fractured.

Models can predict future scenarios, but much will depend on the degree to which internal loads contribute to mixed layer TP concentrations.

The North Portion of Lake of the Woods

ECCC data

ECCC mean TP data collected between 2015 and 2019 are shown in Figure 12 with data plotted in Appendix 2. Mean, pooled, mixed layer and surface TP samples collected between 2015 and 2019 ranged from ~28 µg/L in areas in the south-central area to 19 µg/L near the outflow at Kenora. Isolated areas to the east and west of the central flow showed lower concentrations. See LPP data in Figure 23 below.

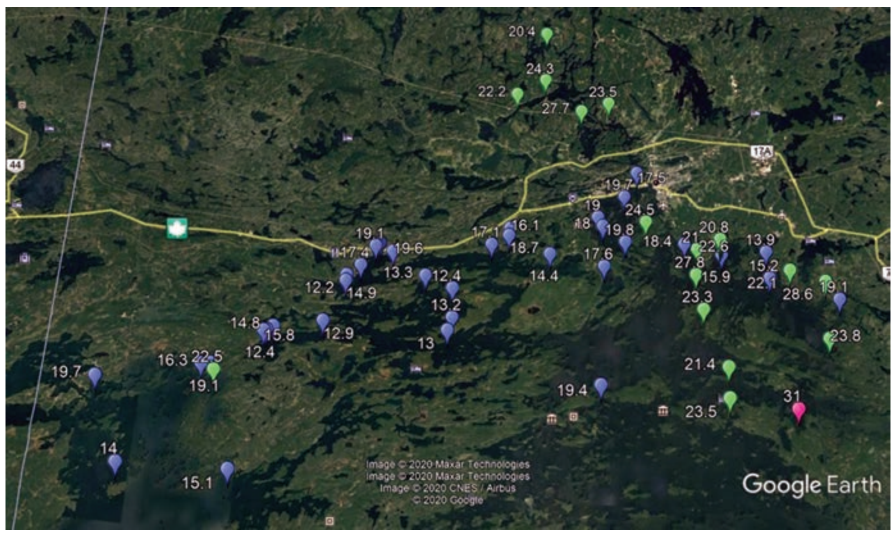


Figure 23 – Phosphorus concentrations in the north portion of Lake of the Woods. Most concentrations are below 20 µg/L (the blue markers).

LPP data

Lake Partner Program data for the northern area of LoW are shown in Figure 23. Most of the measurements in the north end of the lake are below 20 µg/L, indicating acceptable water quality according to Ontario's PWQOs. Water below 20 µg/L should not experience nuisance algal blooms although there are some species that can bloom at low TP concentrations.

Water originating from the south has resulted in concentrations in central areas that are over 20 µg/L (the green markers) and these exit the lake into the Winnipeg River at concentrations between 20 and 30 µg/L. These concentrations are once again acceptable for river environments since the PWQO for phosphorus in rivers is 30 µg/L (the green markers at the top of Figure 23). It is also clear that isolated bays in areas connected to the north

Water originating from the south has resulted in concentrations in central areas that are over 20 µg/L (the green markers) and these exit the lake into the Winnipeg River at concentrations between 20 and 30 µg/L.

end of the lake have lower phosphorus concentrations. These are the blue markers in the top left areas of Figure 23.

An excellent long-term data record from the Lake Partner Program at a station near Coney Island in the north central portion of the lake (494440, 943140) indicates that there has not been any significant change in TP concentrations since 2014 (Figure 24). Long-term trends are difficult to interpret due to higher variability in the earlier data. Concentrations have been stable with a slight decline since around 2008. Seasonal variations in P concentrations at Coney Island are shown in Figure 25 with all dates set to Julian Day. Data at this site collected since 2014 (the orange markers) show

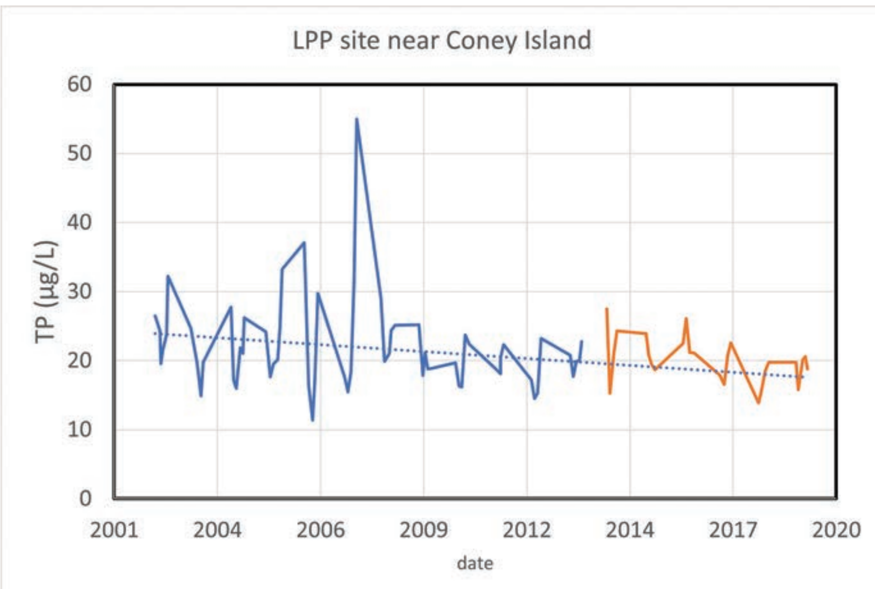


Figure 24 – Long- term data record from the Lake Partner Program at Coney Island. Orange data indicates samples collected since 2014. Long-term trends are difficult to interpret due to higher variability in the earlier data.

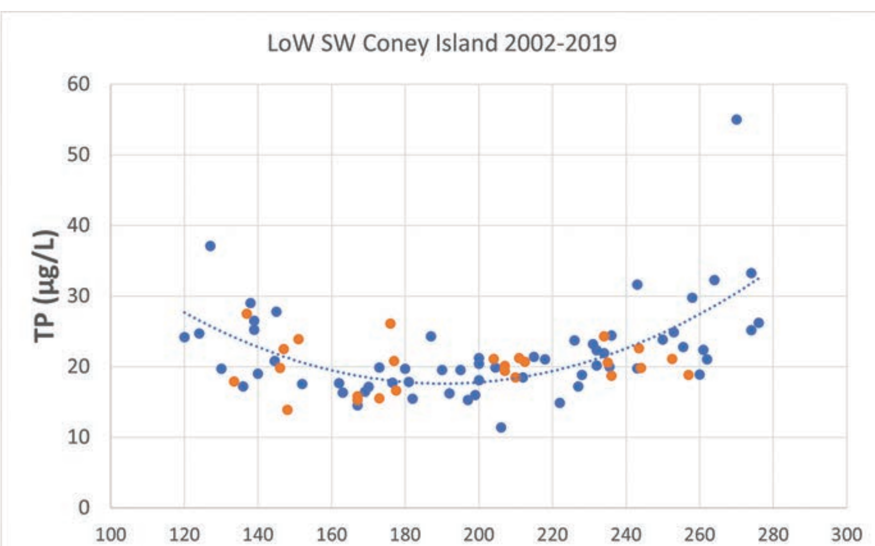


Figure 25 – Data at Coney Island (494440, 943140) collected since 2002. X axis is date converted to Julian Day. Orange data is since 2014.

An excellent long-term data record from the Lake Partner Program at a station near Coney Island in the north central portion of the lake (494440, 943140) indicates that there has not been any significant change in TP concentrations since 2014.

less seasonally elevated concentrations in the spring and fall than in the past but it is important to note that there are fewer late season samples in the recent years. These data demonstrate that a strong seasonal pattern exists in the north-central portion of LoW.

Lake of the Woods TP Concentration Summary

Both seasonal and between-year variations in TP concentrations coupled with extreme observed spatial variation make it difficult to describe average conditions in any one area of LoW. Still, we have a great deal of empirical data as outlined in previous sections to help us derive estimates. A very useful dataset collected by the OMNRF Lake of the Woods Fisheries Assessment Unit (FAU) contains from 28-86 observations for many sites throughout LoW. FAU data collection began in the mid-1980s and continued to 2018 with data collected on a sector rotational basis over several years. Sample locations for these are shown in Figure 26.

Both seasonal and between-year variations in TP concentrations coupled with extreme observed spatial variation make it difficult to describe average conditions in any one area of LoW.

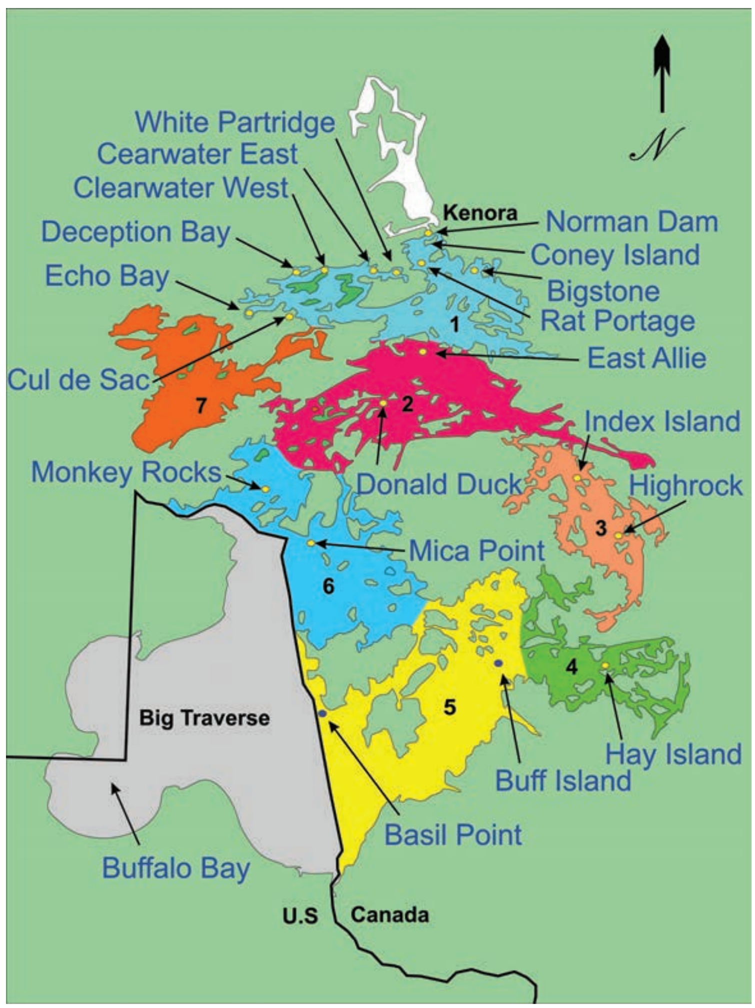


Figure 26 — Sample locations for Fisheries Assessment Unit monitoring data including 1 site using MPCA data (Buffalo Bay) and 1 site using LPP data (Coney Island). Assessment Sectors are shown in different colours.

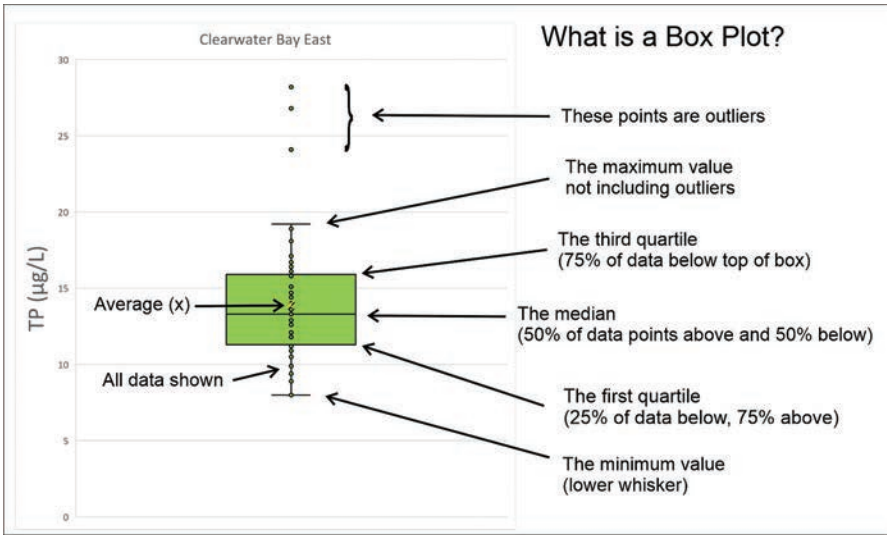


Figure 27 – The elements of a boxplot. Note that maximum values are denoted by the top of the high whisker unless values are more than 1.5 times the inter quartile range (25-75%). In this case the top of the whisker is at that location and all point above are identified as outliers. This does not mean that the values are not true values.

Box plots (see example explanation of box plot elements in Figure 27) can be used to summarize TP concentrations for sites throughout Lake of the Woods (Figure 28). Median and mean values are around 30 µg/L (or above) in the south sites and concentrations decrease to 20 µg/L or slightly above for the sites towards the outflow at the Norman Dam (mean 23 µg/L). Box plots for sites in the isolated bays in the northwest areas of the lake are shown in Figure 29 with most data below 20 µg/L with notable numbers of

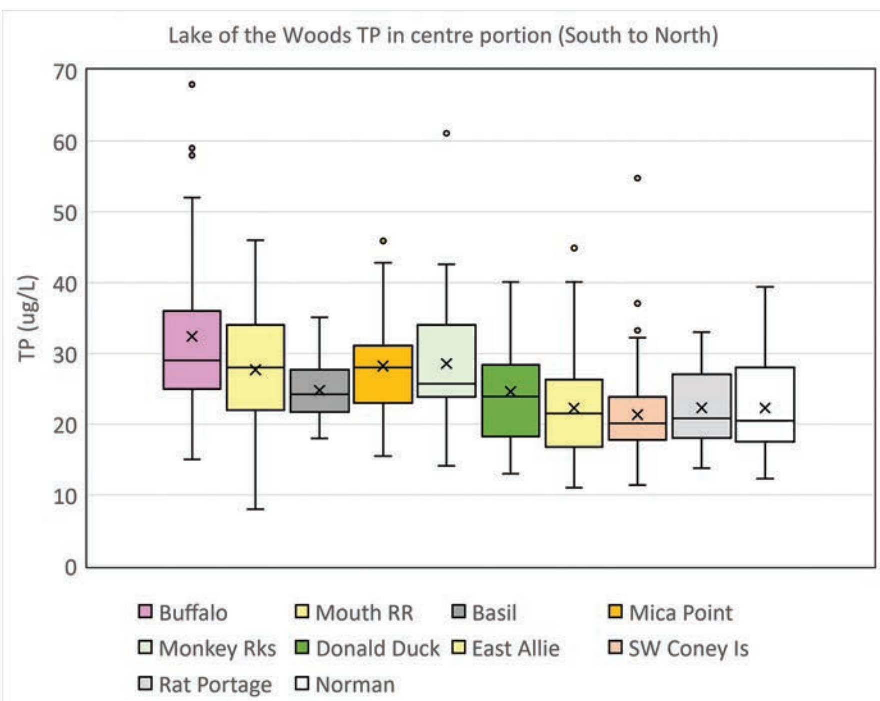


Figure 28 – Box plots for TP datasets spanning the south (left) to north (right) centre lake sample locations. Data were collected by the LoW Fisheries Assessment Unit with approx 28 to 88 observations over the span of the data record up to 2017. This plot includes data from the Lake Partner Program at Coney Island and from MPCA data at Buffalo Bay.

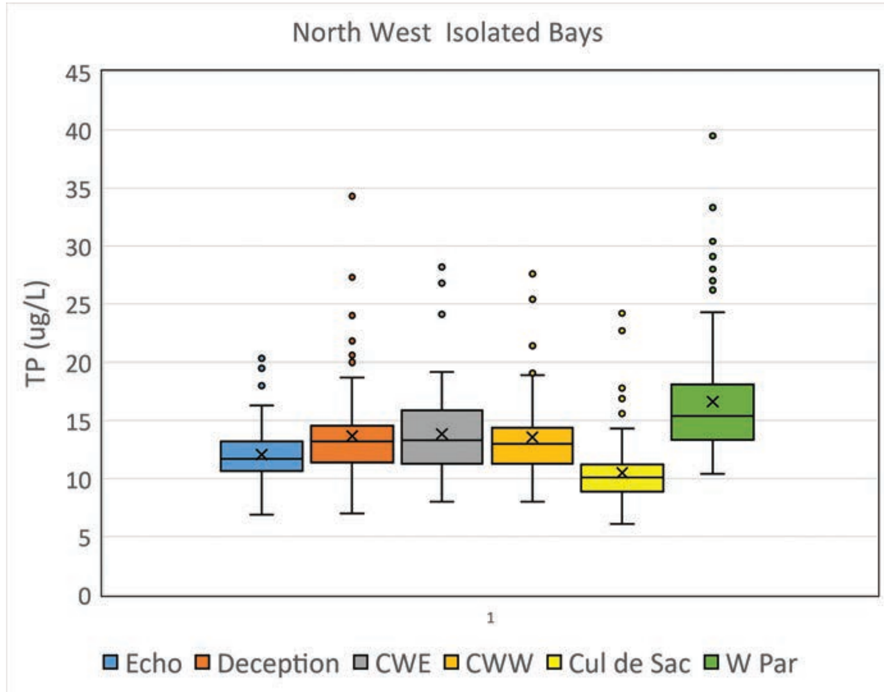


Figure 29 – Box plots for the TP datasets collected in the more isolated North West portions of LoW. Most observations are within the PWQO of 20 µg/L.

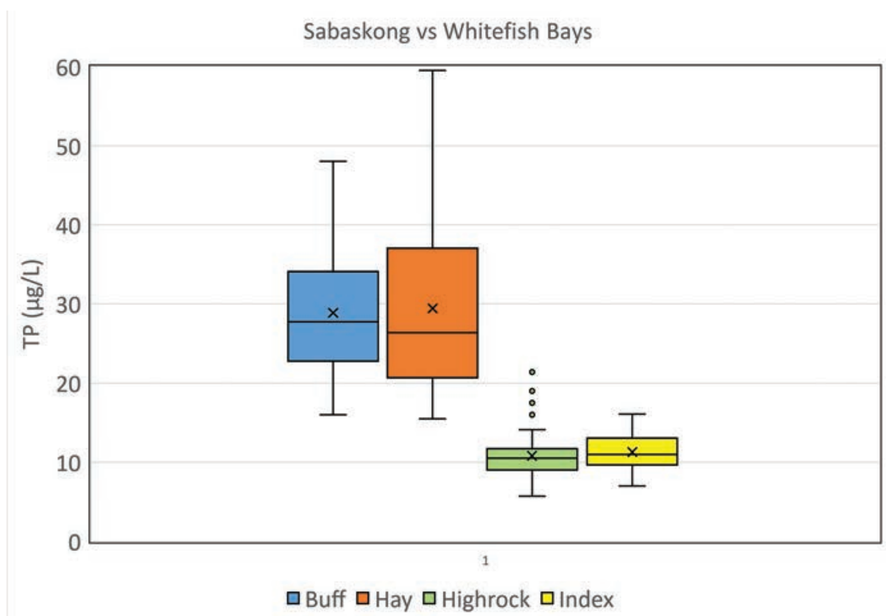


Figure 30 – Box plots showing the range in TP concentrations observed at two locations in LoW. Buff and Hay sample locations are in Sabaskong Bay and Highrock and Index locations are in Whitefish Bay (see Figure 26).

high outlier data points. Plots comparing two sites in Sabaskong Bay with two sites in Whitefish Bay are shown in Figure 30, illustrating difference in TP between waters influenced and separated from loadings from the flow of the Rainy River and Big Traverse.

Action and Tools Development

Recently developed tools include Minnesota's TMDL TP load reduction targets for sources to the Rainy River and LoW, and ECCC's proposed potential reductions scenarios. For the latter, next steps could eventually include proposed reductions to support in-lake processes that should improve bloom severity, the effectiveness of which could be monitored using satellite technology.

In Minnesota, the approach to restoring and protecting water quality has a 10-year adaptive management cycle. Major watershed monitoring years are shown at:

https://www.pca.state.mn.us/water/watershed-approach-restoring-and-protecting-water-quality

with for example, follow up monitoring and assessment of Lake of the Woods is scheduled for 2023, and Lower Rainy and Rainy Lake in 2028.

In Minnesota, actions resulting from TMDLs include revisions to permits for point sources and development of Watershed Restoration and Protection Strategies (WRAPS) for diffuse non-point sources, and then funded actions to implement WRAPS, typically with a combination of local landowner and local, state, and federal governments' funds. For example, for the recently approved LoW phosphorus TMDL, all of the 19 permitted point sources currently meet the TMDL goals.

For non-point sources, Minnesota has completed draft WRAPS (entering public consultation December 31, 2021) for the Lower Rainy, Rapid, and Rainy Lake watersheds. https://www.pca.state.mn.us/water/watershed-restoration-and-protection-strategy-status.

Other recent examples include completion of the Big Fork River Watershed WRAPS in 2017 and spending for implementation projects over 2018-2020 totaled at least $4.4 million. https://www.pca.state.mn.us/water/spending-watershed-implementation-projects

The MPCA has an excellent source for information on any watershed in the State, including water quality assessment data, tracking actions taken, and spending on projects – for further information, see: https://www.pca.state.mn.us/water/watersheds.

Satellite Technology

Satellite images can now be used to determine the extent and intensity of algal blooms and these can be combined to give a measure of bloom severity. These measures, produced operationally by ECCC's EOLakeWatch (Binding et al., 2021), are reported on a daily basis and compiled both as

Sentinel-2 satellite image of algal blooms in Lake of the Woods, October 4, 2021

It's appropriate to say we have some "good news" to report. Satellite data from ECCC suggest declining trends in algal bloom extent and severity, TP concentrations in LoW are stable or slightly declining at long-term monitoring sites, and current TP concentrations in Rainy River are very stable presently, after significant reductions following improvement in wastewater treatment from the late 1970s through the 1990s. Jesse Anderson.

growing season average and maximum indices. These data can be used to examine changes that may be tied to weather, biogeophysical processes, or to phosphorus concentrations.

The maximum size of the bloom each year is shown in Figure 31 as percent of the total lake area. Extent is defined by areas having more than 10 µg/L chlorophyll which is a photosynthetic pigment used as an indicator of phytoplankton biomass. These data (Figure 31) show large areas of LoW (50-80%) are affected each year by blooms with 2019 being a noticeably lower year (35%).

Plotting the maximum bloom intensity (Figure 32) gives us an idea about how green things can get because intensity is based on average chlorophyll concentrations. Intensity varies but it seems lower in more recent years and higher in the past, especially in 2003 and 2004.

By multiplying bloom extent (km^2) by bloom intensity (µg/L chlorophyll), it is possible to derive an index of severity (Figure 33) with units of µg/L km^2. The severity scale can be based on maximum or average conditions. Presentation here is based on maximum data and thus relates to the worst conditions noted for each year. In this case the severity of the worst blooms seems to be decreasing since a peak in 2004. It is also possible to plot average conditions throughout the growing season if those data would be more relevant. Satellite data, indices, products, and annual bloom summary reports are available from ECCC's EOLakeWatch website:

https://www.canada.ca/en/environment-climate-change/services/water-overview/satellite-earth-observations-lake-monitoring.html

It has been well demonstrated that climate change plays a role in bloom dynamics which makes it difficult to predict bloom characteristics using TP alone. However, lower trophic status (lower P) should have a positive effect on algal bloom severity both under maximum and average conditions.

Algal bloom, Coney Island, Lake of the Woods

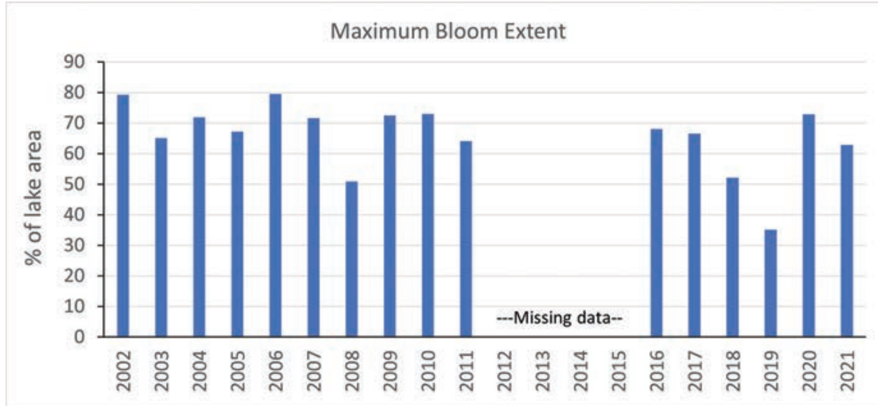


Figure 31 – Satellite data showing maximum bloom extent across Lake of the Woods (2002-2021) as a percent of lake area (ECCC EOLakeWatch).

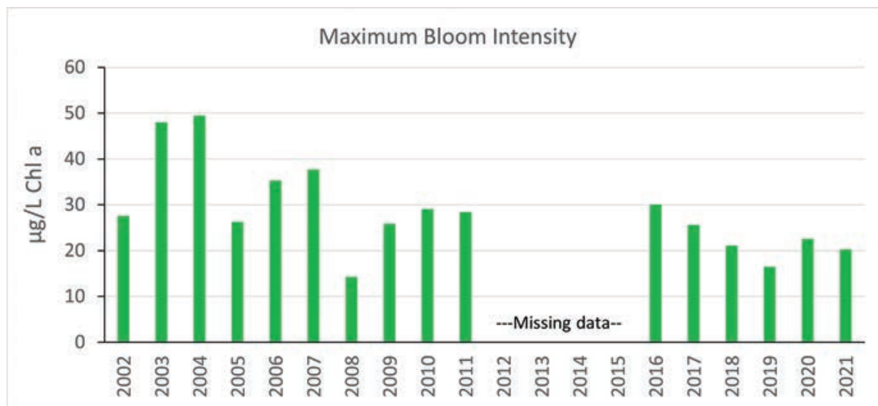


Figure 32 – Satellite data showing maximum bloom intensity on Lake of the Woods (2002-2021) as µg/L chlorophyll (ECCC EOLakeWatch).

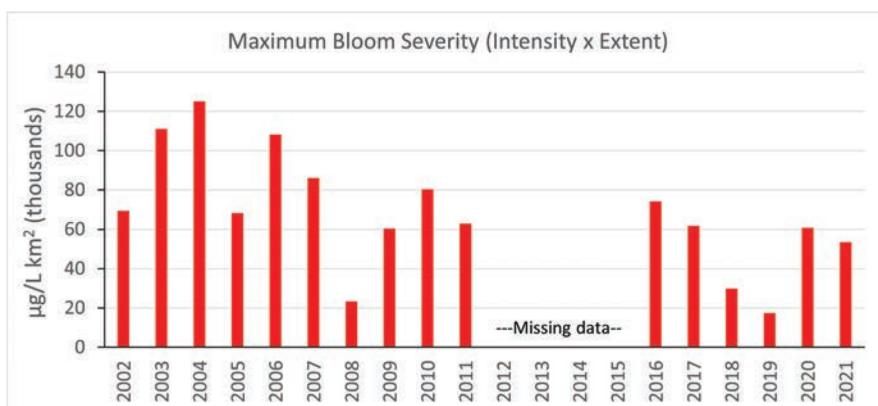


Figure 33 – Satellite data showing maximum bloom severity on Lake of the Woods (2002-2021) calculated by multiplying bloom extent (km²) by bloom intensity (µg/L chlorophyll). Units are x103 µg/L km² (ECCC EOLakeWatch).

IJC Objectives and Alerts Study Findings

The IJC Objectives & Alerts Study (Clark et al., 2019) found very few contaminant exceedances except for phosphorus in Lake of the Woods and Rainy River segments (Table 8). Most other contaminant exceedances were in the Rainy River. Mercury contamination in fish is a basin-wide problem.

Table 8 — Contaminant exceedances identified by the IJC O&A Study.

Concern	Exceedance	Boundary Segment	Document
Phosphorus	> Alert Levels	LoW, RR (US & CDN tributaries) Rainy Lake outlet not monitored	**, ***, *
Hg	Fish consumption	LoW, RR, Headwaters	**
Fe	3% > 300 µg/L	Rainy River	*
PCB	Fish consumption	LoW, Rainy River	**
Arsenic	1 exceedance	Rainy River	*
Cd	2 exceedances	Rainy River	*
Cu	2 exceedances	Rainy River	*
Sediment	Metals - various exceedances of Fe_2O_3, Mn, TKN	LoW, Rainy River	***, *

* LoW Monitoring Update 2014-17 McDaniel and Pascoe (2018)
** IRLWWB Aquatic Ecosystem Health Report (2017)
*** EC WQMS (2015) Results of EC's water quality monitoring program 2012-14

MPCA Rainy River Study

The MPCA Rainy River Study (2020) found that all segments of the river supported standards for aquatic life and aquatic recreation. More information is required with respect to the segment between the Little Fork River and the Rapid River. All segments fail the standards for consumption due to mercury (MPCA 2020).

The IRLWWB notes:

Contaminants concerns exist related to:

- Areas listed as Federal Contaminated Sites (in Canada)
- Areas that may have legacy contamination from historic mining activity
- Areas that demonstrate atmospheric contamination of lakes and fish by mercury
- Areas that receive point-source discharges from industry and municipalities
- Areas that are affected by emerging potential for industrial activities, especially mining, to increase once again in the basin

(IRLWWB, n.d.)

Mercury in Fish

Minnesota has a state-wide TMDL for mercury (Hg), which was last revised in 2020. The TMDL lists lakes impaired for Hg – mostly for fish tissue but also for some water exceedances. Impaired lakes are included in their Appendix A and these include lakes that have been added or removed from impairment, e.g., Gunflint Lake was removed in the last revision (https://www.pca.state.mn.us/water/statewide-mercury-tmdl).

The Ontario guide ***Eating Ontario Fish*** lists consumption restrictions (e.g., meals per month) for many fish species based on contaminant groupings (last updated in 2018). Guide users can search by lake or use an interactive map. There are consumption restrictions listed for many lakes especially for Hg (https://www.ontario.ca/page/eating-ontario-fish-2017-18).

In 2021, Brigham et al. reported on wet mercury deposition in four Voyageurs

National Park lakes. They reported that although anthropogenic mercury releases to the environment have been substantially lowered in the United States and Canada since 1990, concerns remain for contamination in fish from remote lakes and rivers where atmospheric deposition is the predominant source of mercury. Their findings were based on one of the longest known multimedia data sets for mercury in atmospheric deposition. Aqueous total mercury (THgaq), methylmercury (MeHgaq), and sulfate were measured in epilimnetic water samples from four lakes in Voyageurs National Park (VNP), and total mercury (THg) in aquatic biota was measured in the same lakes from 2001–2018.

Wet Hg deposition at two regional Minnesota Mercury Deposition Network sites decreased by an average of 22 percent from 1998–2018 with much of the decreases prior to 2009, and relatively flat trends since then. In the four VNP lakes, epilimnetic MeHgaq concentrations declined by an average of 44 percent and THgaq by an average of 27 percent. For the three lakes with long-term biomonitoring, temporal patterns in biotic THg concentrations were similar to patterns in MeHgaq concentrations but biotic THg concentrations declined with statistical significance in only one lake.

Epilimnetic MeHgaq may be responding both to a decline in atmospheric Hg deposition as well as a decline in sulfate deposition, which is an important driver of mercury methylation in the environment. Results from this study suggest that regional-to continental-scale decreases in both mercury and sulfate emissions have benefitted aquatic resources, even with global increases in mercury emissions.

Blanchfield et al. (2021) showed experimental evidence for relatively rapid reductions in mercury contamination in fish following decreases in mercury loading:

> *"Thereafter, isotopic additions were stopped, resulting in an approximately 100% reduction in Hg loading to the lake. The concentration of labelled MeHg quickly decreased by up to 91% in lower trophic level organisms, initiating rapid decreases of 38–76% of MeHg concentration in large-bodied fish populations in eight years. Although Hg loading from watersheds may not decline in step with lowering deposition rates, this experiment clearly demonstrates that any reduction in Hg loadings to lakes, whether from direct deposition or runoff, will have immediate benefits to fish consumers."*

Water levels in many of the large lake in the basin are actively managed and studies of these lakes suggest that the water level management can influence the methylmercury contamination of food webs, including bioaccumulation in fish tissues. A discussion of these effects and the role of various water level metrics is provided by Larson et al. (2021).

What are the historical current impacts of mercury in fish to Indigenous Nations as fish harvest and consumption are part of a traditional way of life and sustenance?

Indigenous Nation health implications through consumption of fish and deterioration of access to treaty right to fish

The IRLWWB notes:

In Canada, the major contribution of atmospheric mercury until the 1980s was the chloralkali industry but all chloralkali plants are now closed in Ontario. The resulting decline in emissions combined with reductions from mining and smelting industries throughout the 1990s has resulted in an overall decline in the amount of mercury emitted to the atmosphere from human sources.

In 2011, Canada emitted under 3.7 tonnes of mercury, 27% of which was attributed to electricity generation and 26% to incineration. Ontario was responsible for 27% of the total Canadian emissions. U.S. mercury emissions are also declining (from approximately 250 tons/yr in 1990 to 100 tons/yr in 2005).

Despite these reductions in North American emissions the deposition of mercury may continue to increase due to increases in global emissions which may delay recovery in mercury contamination in the biota. Studies in Minnesota and elsewhere in the Great Lakes basin have shown decreasing trends in mercury in fish between the 1980s and the mid-1990s after which the trend of mercury in fish tissue begins to rise once again. One explanation for this is that although regional emissions of mercury have declined considerably over the past 30 years, these have been offset by recent increases in the global emissions of mercury.

(IRLWWB, n.d.)

Steep Rock Mine pit filled with water near Atikokan, Ontario. The Seine River was diverted to get to the iron ore below it. (Lee Grim)

How are mines permitted by Indigenous Nations? What are the cumulative impacts of continued mine development in the basin?

The IRLWWB notes:

Historically, mines have released dredged and stored suspended sediments into nearby waterways. For example, the Steep Rock Mine near Atikokan operated from 1944-1979, and was at the time one of the largest iron ore mines, involving many water diversions and disturbances to the natural drainage. In 1951, a particularly high volume spring freshet resulted in the mine releasing its stored sediments into the nearby Seine River.

Historically in the Lake of the Woods watershed there were many gold mining sites and processing operations. Environment Canada (2014) noted that several of its sediment monitoring sites (where sediment concentrations of arsenic and barium were higher than expected) were adjacent to historic gold mines.

In Minnesota, there are effects from leaching metals from sulfide waste rock stockpiles at the historic Dunka taconite mine near Babbitt, and contaminants enter Birch Lake which is near to the Boundary Waters Canoe Area Wilderness.

(IRLWWB, n.d.)

Mining Concerns

The Citizen's Advisory Group (CAG) has concerns about mining activities and future proposed activities in the basin. Large scale mining operations have begun since 2014. The New Gold Rainy River mine commenced processing ore on September 14, 2017. Commercial production followed in October 2017. Development of the underground mine began in the second half of 2018. The mine occupies approximately 6,050 hectares with approximately 17,240 hectares surrounding the mine site, including patented mining rights and/or surface rights and unpatented claims. This large mine is at Emo, approximately 20 km north of the Rainy River.

The CAG has recommended that the IRLWWB consider developing a funding proposal to the IJC through the International Watersheds Initiative to map mining activities in the basin.

In 2021, officials with the U.S. Forest Service took a decisive step toward long-term protection of the Boundary Waters Canoe Area Wilderness. The agency announced it is seeking to block mining on federal lands upstream of the wilderness. If approved, the move would put 223,000 acres off limits, including sites where Chilean mining company Antofagasta PLC is planning its Twin Metals mine.

https://queticosuperior.org/blog/mining-ban-upstream-of-boundary-waters-back-in-consideration/

Transport of Hazardous Materials

The IRLWWB conducted a review to assess whether appropriate plans are in place to respond to an environmental emergency in a binationlally coordinated manner. This was undertaken in response to concerns raised by the IRLWWB's Community Advisory Group of increased transport of hazardous materials such as petrochemicals by rail in the region. A draft report, *Review of Environmental Emergency Planning, Preparedness and Response in the Boundary Waters of the Rainy-Lake of the Woods Drainage Basin 2019*, was submitted to the IJC for consideration. In March 2019, on the IJC's recommendation, the draft report was posted to the Board website for a 30-day public review period. It was also distributed directly to basin municipalities for comment. The final review report, including recommendations was submitted to the the IJC in 2021. Report findings and recommendations are as follows:

Finding 1 — There are plans and procedures in place at all levels of government in both Canada and the US to respond to environmental emergency situations in the Rainy-Lake of the Woods drainage basin, including a binational mechanism to ensure coordination and support across the international boundary.

Finding 2 — Based on a review of the Canada-U.S. Joint Inland Pollution Contingency Plan it is evident that plans can become dated, and this could reduce their effectiveness in times of emergency.

Recommendation: EPA and ECCC should be strongly encouraged to follow through on their planned review of the Canada-U.S. Joint Inland Pollution Contingency Plan, and to put in place a schedule for regular ongoing review and revision into the future.

How do emergency events impact rights of the Indigenous Nations?

Finding 3 — Based on a review of the 2017 release of sulfuric acid from PCA Boise Paper in the Rainy River it is evident that there is lack of clarity and potentially lack of effectiveness associated with processes in place to alert cross-border communities of a spill occurrence, which could pose a hazard to human health and impede effective emergency response. In this context, state and provincial agencies, as well as federal agencies, play an important role.

Recommendation: Federal, provincial and state agencies should engage with other relevant entities to clarify and ensure effective functioning of emergency notification processes.

2014 flood year, high water under bridge at Ranier 7/14/2014 (Lee Grim)

Research since 2014

Indigenous Knowledge systems lend a holistic view to mother earth, how can this be included to better understand the changing climate?

Most ecological studies will contain a statement allowing that ongoing climate change has the potential to change their conclusions. In many cases climate change is directly implicated as a driver of the results. For example, Paterson et al. (2017) used spectrally inferred chlorophyll a (Chl-*a*) concentrations in lake sediment cores, as a measure of past changes in aquatic primary production. Beginning in the late 1970s to early 1980s, inferred Chl-*a* increased at five impacted sites in the north end of LoW that experience cyanobacterial blooms in late summer and autumn. In contrast, no change in Chl-*a* was observed at an oligotrophic reference site with much lower cyanobacteria biomass. At the impact sites, Chl-*a* generally showed no significant relationship to long-term trends in diatom-inferred total phosphorus concentrations, but was significantly and positively correlated to climatic variables, including mean annual air temperature at all sites and total annual precipitation at four sites. They suggested that climate change may exacerbate algal blooms in LoW. They also found that the effects of climate change on aquatic production may be enhanced at sites with higher nutrient concentrations, likely due to positive feedback between cyanobacteria biomass, water temperature and nutrient availability. They caution that the impact of climate change should be considered carefully in future management initiatives.

ECCC EOLakeWatch, Sentinel 2 - MSI image acquired on April 22, 2020, over Lake of the Woods.

A comparison of historical nutrient dynamics and sediment records of algal production in the south basin showed a counterintuitive increase in production after external P loads decreased, suggesting other drivers may regulate modern limnoecology, including seasonality of P loading, shifting nutrient limitation, and climate warming (Edlund et al., 2017).

The Rainy-Namakan Lakes Rule Curve Study Board noted in 2017 that future climate change could substantially affect water levels in the basin regardless of the Rule Curve in use, since levels in both lakes cannot be controlled under extremely high or low inflows.

Climate concerns can include:

Human health, access to traditional lands, medicines, foods, economies, education movements of animals and uptake of invasive species that impact access to assert rights.

ECCC (2021b) notes that climate change is expected to exacerbate the harmful algal problem. Increases in air and water temperatures, longer ice-free periods, more intense rain events at earlier times of the year, changes in wind patterns and conditions favourable to internal loadings are just some examples of how the climate is influencing water quality in the lake. In the future, climate change is expected to result in greater P loads resulting from more variable and extreme weather events. Warmer water temperatures could also lead to a shift towards more frequent toxin-producing algae such as *Microcystis* (ECCC 2021b).

There have been recent attempts to describe climate change phenomena in greater detail and attribute the effects to specific shifts in weather patterns. Although not specific to the R-LoW basin, in *Winter Weather Whiplash: Impacts of Meteorological Events Misaligned with Natural and Human Systems in Seasonally Snow-Covered Regions*, Casson et al. (2019) described phenomena of ecosystem impacts connected to changes in "misaligned" meteorological patterns, evocative of some events in our basin in recent years, such early fall ice storms, unprecedented 2019 fall rains and flooding, and extreme drought conditions in summer 2021.

Casson et al. (2019) investigated "winter weather whiplash" events, which are characterized by weather conditions swinging from frozen to unfrozen (or vice versa). They note that these events have consequences for ecosystems and communities, especially when they occur at unusual times of the year. Impacts include tree damage, flooding, electrical outages, and crop damage. They present a series of case studies to explore the impacts of these events and analyze long-term data to demonstrate how they could be detected from weather data. This publication may provide insights into potential climate change effects in our basin.

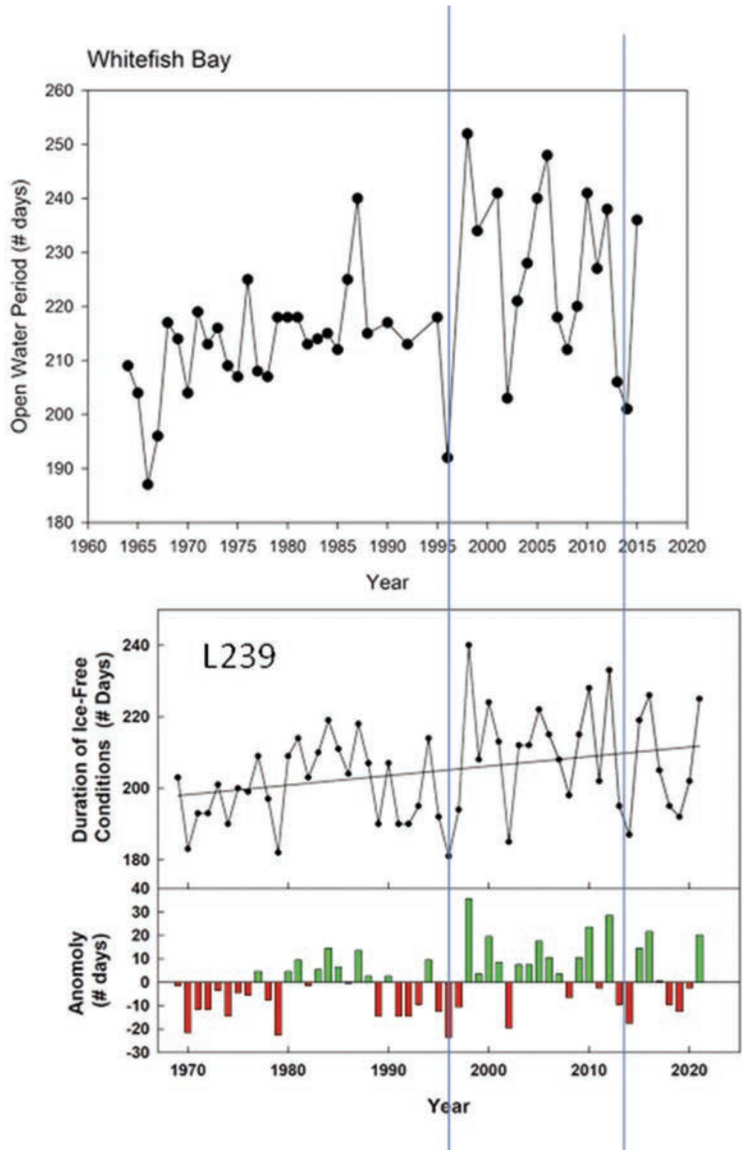


Figure 34 — Duration of open water season on Whitefish Bay (LoW) between 1969 and 2016 (top) and Lake 239 at ELA (bottom) between 1969 and 2021

In the previous SOBR (2nd Edition) we showed an increase in the number of ice-free days on Whitefish Bay in LoW. It is unclear whether this record has been continued. However, examining the ice-free data from the long-term record on Lake 239 at the IISD-Experimental Lakes Area, there is a clear correspondence between the Whitefish Bay record and the L239 record especially after the 1990s. The L239 record indicates a continuing trend towards longer ice-free periods (Figure 34). The L239 figure is shown with a linear regression line for illustration purposes, but a better trend test (Mann Kendall Sens slope) shows a trend whereby the ice-free season increases by 0.297 days each year. This means that at ELA there is about 2 more days of open water now than there was when we first looked at this in 2014.

International Joint Commission

The IJC's International Watersheds Initiative (IWI) is examining climate change as one of its strategic initiatives. One initiative has been the development of a Climate Change Guidance Framework (CCGF). The CCGF recommends planning guidance methods that can be used by IJC control, watershed, and pilot watershed boards. The purpose of the framework is to provide

Ice out on Rainy Lake (Lee Grim)

responsible systems with the ability to maintain ecosystems, economic and social benefits, and impacts within preferred ranges relative to water levels and flow management in the face of future change and uncertainties. The framework provides clear guidance to the boards for addressing climate change using the best available science and rightsholders input. This framework is an iterative document, updated as climate change knowledge is improved. For further information on the IJC CCGF, see: https://ijc.org/en/what/climate/framework.

Implications of Adaptive Management to Climate Change

The IJC Adaptive Management Committee (AMC) was established in June 2020 following a recommendation in the Rainy and Namakan Lakes Rule Curve review report of 2017 that indicated a need for adaptive management to ensure the new rule curves (ratified in the 2018 Supplementary Order) continue to perform as expected.

Its overall objective is to consider information collected by resource agencies and others during the interim that may indicate the effect that changes to the 2018 rule curves have on water levels and flows, and the impacts these have on the affected interests in the boundary waters of the Rainy River basin, and make recommendations to the IRLWWB.

The AMC is also responsible for overseeing the Board's implementation of the IJC's Climate Change Guidance Framework, an adaptive management protocol for Boards to assess and respond to known and anticipated climate change impacts.

Invasive species including spiny water fleas, zebra mussels, rainbow smelt, rusty crayfish, flowering rush and hybrid cattails

In 2015, the Ontario provincial government introduced the Invasive Species Act (2015), which explicitly regulates the prevention and management of invasive species in Ontario. Sixteen species are prohibited under this Act, meaning it is illegal to import, possess, transport, or release these species anywhere in Ontario. Four additional species are restricted, meaning it is illegal to bring them into provincial parks or conservation reserves and illegal to import or release them anywhere in Ontario. See: https://www.ontario.ca/laws/statute/s15022.

How do AIS impact the access to asserting Indigenous rights? How can Indigenous Knowledge systems lend historical information to the movement of species?

Minnesota maintains its own list of infested waters. Additions since the 2014 SOBR, include zebra mussels: Rainy Lake (2021), Lake of the Woods (2019), Big Fork River (2019) downstream of Dora Lake, Dora Lake (2017) and spiny water fleas in Lake Vermilion (2015) near Tower, MN. Spiny water fleas are widespread throughout the boundary waters, including Lake of the Woods, Rainy River, Rainy Lake, and many others in the headwaters and have been listed for many years, predating the 2015-2021 period covered by this SOBR report. For more and most up-to-date information, see: https://www.dnr.state.mn.us/invasives/ais/infested.html.

In September 2021, the Minnesota Department of Natural Resources confirmed the presence of zebra mussel larvae in Black Bay of Rainy Lake, near International Falls. Four of five MNDNR water samples taken in July of 2021 contained zebra mussel larvae, suggesting a reproducing zebra mussel population in Rainy Lake. These samples followed up on a July 2020 unconfirmed public report of a single adult zebra mussel, see: https://www.dnr.state.mn.us/news/2021/09/01/zebra-mussel-larvae-confirmed-rainy-lake-st-louis-county.

The MPCA Rainy River assessment indicated that many introduced and invasive fish species are known to exist within the basin, including:

- *Osmerus mordax* (rainbow smelt)
- *Salmo trutta* (brown trout)
- *Salvelinus fontinalis* (brook trout)
- *Lepomis gulosus* (warmouth) and
- *Micropterus dolomieu* (smallmouth bass)

Many of the fish species were either introduced during historical stocking efforts or likely transported by recreational users. Other introduced plants and organisms include,

- *Potamogeton crispus* (curly-leaf pondweed)
- *Heterosporis* (a parasite of fish)
- *Lythrum salicaria* (purple loosestrife)
- *Bythotrephes longimanus* (spiny water flea)

The IRLWWB Aquatic Ecosystem Health Report, 2015 and 2016, lists several AIS in the basin (Table 9). No further updates regarding invasive species were included in the IRLWWB – Sixth Annual Report, April 2018-March 2019.

Table 9 — Aquatic Invasive Species noted in the IRLWWB Aquatic Ecosystem Health Report, 2015 and 2016 (2017)

AIS	Boundary Segment
Hybrid Cattail	Headwaters
Bythotrephes	LoW, RR, Headwaters
Rusty Crayfish	LoW, RR, Headwaters
Papershell Crayfish	LoW, RR, Headwaters
Clearwater Crayfish	Birch and Basswood lakes
Rainbow Smelt	LoW, RR, headwaters
Zebra Mussels	Sand L, Dora L., Big Fork R. Veligers in S. Basin LoW near Warroad

These lists are not aligned with the list of invaders that have been prioritized for risk assessment by the International Joint Commission (for the fulfillment of Interagency Agreement Number 1042-201734) with respect to the R-LoW basin. This project titled AIS Risk Assessment for Rainy – Lake of the Woods Watershed. Phase I (2019), now completed (Bell and Vellequette, 2021), provides a coarse scale analysis regarding AIS risks in the basin. The first phase of this project initiated a broad-scale qualitative assessment of the relative AIS to the Rainy-LoW basin including:

- a binational list of AIS of concern to local waters
- identification of gaps in knowledge
- focus on areas in need of risk prevention

Based on proximity, ease of transport or introduction, and known impact to R-LoW or other impacted ecosystems, the ten species prioritized to perform risk evaluations on first are:

- *Bythotrephes longimanus* (spiny waterflea)
- *Faxonius rusticus* (rusty crayfish)
- *Neogobius melanostomus* (round goby)
- *Dreissena polymorpha* (zebra mussel)
- *Bithynia tentaculata* (mud bithynia, faucet snail)
- *Potamopyrgus antipodarum* (New Zealand mudsnail)
- *Butomus umbellatus* (flowering rush)
- *Nitellopsis obtusa* (starry stonewort)
- *Myriophyllum spicatum* (Eurasian watermilfoil)
- *Phragmites australis australis* (common reed)

Indigenous Nations' monitoring data can be incorporated to address gaps and capacity to better inform AIS planning

Spiny water fleas are tiny (1/4-5/8") crustacean zooplankton. They threaten aquatic ecosystems by competing with native fish for food. The Minnesota Department of Natural Resources has designated the following water bodies as infested: Lake of the Woods, Rainy Lake, Rainy River, Namakan Lake, Kabetogama Lake, Sand Point Lake, Crane Lake, and Little Vermilion Lake. The infested waters designation triggers specific Invasive Species Laws which can be found in the most current Minnesota DNR Fishing Regulations. Recent research (Hansen et al., 2020) showed decreased walleye growth in MN lakes infested with spiny water flea and/or zebra mussel.

Rusty crayfish — Native to the Ohio River drainage, rusty crayfish have invaded lakes in Wisconsin, Minnesota and Ontario in recent years. They were found in Sand Point Lake in 2006. Rusty crayfish are more aggressive than native crayfish and can eliminate native crayfish and aquatic plants, causing great change to the aquatic ecosystem of invaded lakes. Rusty crayfish are found throughout LoW and were first reported in LoW in the 1960s. Specimens collected in Long Bay, Sioux Narrows in 1963 were described by Crocker, and Barr (1968).

Zebra mussels, photo David Britton, US FWS

Zebra mussels — Recent confirmations of presence and continued spread of zebra mussels in the basin should be a concern.

Zebra mussels have invaded several headwaters upstream in the R-LoW basin and infested hundreds of lakes nearby, outside the basin. Zebra mussels were first confirmed in 2013 in the R-LoW basin in Sand Lake and the closely connected Little Sand Lake and Rice Lake in Itasca County, Minnesota. In late 2017, the Minnesota Department of Natural Resources confirmed the presence of zebra mussels downstream of the initial 2013 invasion, in Dora Lake and the upper reaches of the Big Fork River, which ultimately flows to the Rainy River. Most recently (2021) zebra mussel larvae (veligers) were confirmed in Black Bay of Rainy Lake, suggesting a reproducing population in Rainy Lake (MNDNR 2021), although adults have not been found. Zebra mussels have been confirmed in other waterbodies in the R-LoW basin headwaters.

Equally concerning are the confirmations by MNDNR in 2019, 2020, and 2021 of zebra mussel larvae at sites in the southern portion of LoW. Although the numbers in 2021 were lower than in previous years, the comparative significance is difficult to assess and to date, there has been no confirmation of adults or a reproductive colony in the lake (Nicole Kovar, MNDNR, pers. comm.)

Voyageurs National Park — Exotic species, such as the spiny water flea and rusty crayfish, are threats to the aquatic ecosystems of regional lakes including those in Voyageurs National Park (VNP). As of 2018, spiny water fleas have invaded multiple lakes in the region, including the large lakes within VNP. Rusty crayfish have invaded at least one lake in VNP and many other lakes in the region.

The MNDNR works to prevent AIS in Minnesota. Koochiching and St. Louis counties have state funded AIS prevention programs. They both work to prevent AIS throughout their counties, and they work with the MNDNR and VNP to prevent AIS within VNP.

Each county in MN receives funding to work on AIS. Below are links to information on local aquatic invasive species aid and tools that support Minnesota counties in AIS prevention:

- https://www.dnr.state.mn.us/invasives/ais/prevention/index.html
- https://www.revenue.state.mn.us/aquatic-invasive-species-prevention-aid

CHAPTER 7 - WATER LEVELS, EROSION AND FLOODING

Water Levels Overview

The Rainy-Lake of the Woods basin includes the international boundary between Minnesota and Ontario, where water flows from the Great Lakes basin divide, west through the chain lakes to Namakan Lake, Rainy Lake, the Rainy River and LoW. From the LoW outflow at Kenora it enters the upper reaches of the Winnipeg River which flows to Lake Winnipeg.

Aerial view of Kenora and LoW outflow (Lee Grim)

The IJC formed the IRLWWB to assist with binational coordination of water quality efforts for the entire boundary watershed and to coordinate the management of the water levels and flows on Rainy and Namakan lakes and the Rainy River in accordance with the IJC's orders. Water levels and flows are controlled as prescribed by rule curves which maintain seasonal water levels between the highest or lowest water levels that will provide the best water usage for a wide variety of stakeholders.

Levels on Lake of the Woods are managed by the (Canadian) Lake of the Woods Control Board, between lower and upper elevations (1056 and 1061 feet above sea level) set by the 1925 Lake of the Woods Convention and Protocol. The International Lake of the Woods Control Board, appointed by the two national governments approves the actions of the Canadian LWCB whenever the level of LoW falls below or rises above these prescribed extreme elevations. Further information on the role and mandate of these boards are available at: Lake of the Woods Control Board https://www.lwcb.ca/ and International Lake of the Woods Control Board https://www.ijc.org/en/watersheds/lake-of-the-woods.

Rainy Lake and Namakan Lake

The outlets of Rainy and Namakan lakes have been controlled by dams for more than 100 years. Formal rules to control water levels have been in place since 1949, under Orders and Supplementary Orders of the IJC, updated periodically. The rule curves assessed in the 2017 study had been in place since 2000 and were updated in 2018.

In the 2014 SOBR, we reported on the Rainy and Namakan Lakes Rule Curves Study which was underway at the time, to assess whether the 2000 Rule curves remained appropriate. The final report, *Managing Water Levels and Flows in the Rainy River Basin*, was completed and submitted to the IJC in 2017.

This comprehensive study considered the findings of many individual studies that assessed the effects of water levels on:

- shoreline properties
- hydroelectricity generation
- the natural environment
- cultural and archeological sites
- boating and tourism
- water quality

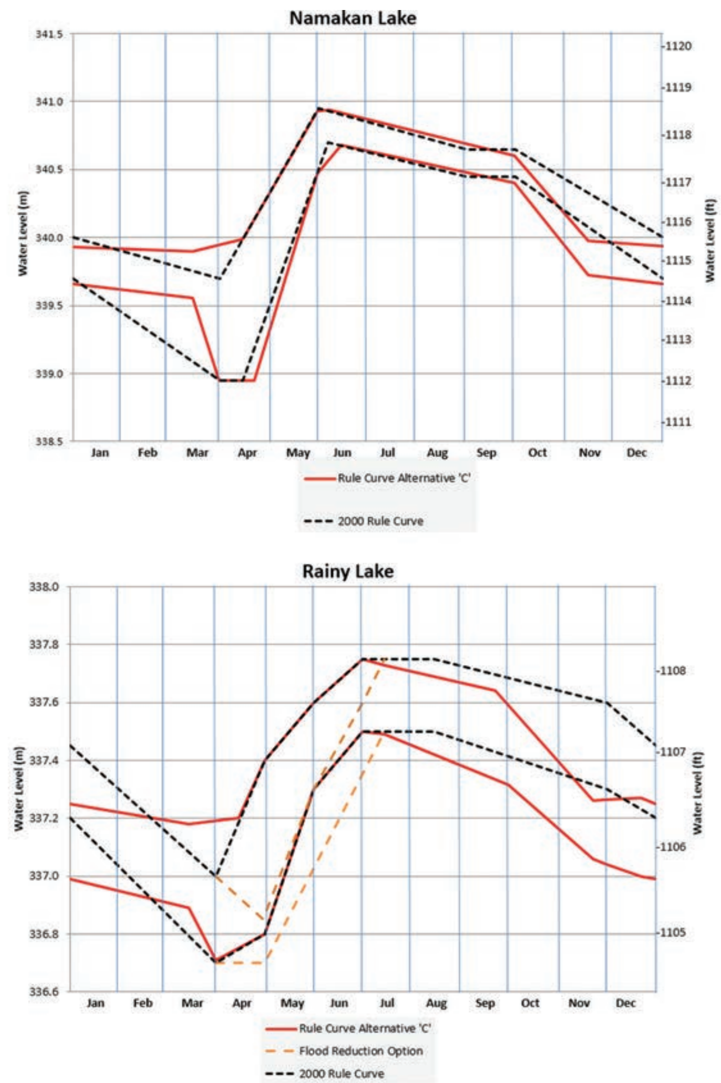


Figure 35 — IJC 2018 Rule Curves for Namakan and Rainy lakes.

The Rule Curve Review Study Board found that the 2000 rule curves performed as expected with positive outcomes compared to the 1970 rule curves which they replaced. Positive outcomes included that trophic state indices (Chl-*a*) indicated that Sand Point, Namakan, and Rainy Lakes remained oligotrophic, and trophic state has decreased for Kabetogama Lake and Black Bay, and there had been no decline in lake ecosystem health since the implementation of the revised water-level management plan (Christensen and Maki, 2015)

Negative outcomes identified included a reduced potential for hydroelectricity production and increased flooding due to decreased storage ahead of the spring freshet. In addition, the steady water levels produced by the 2000 Rule Curves have provided excellent conditions to promote the growth of invasive cattails.

The Rule Curve Review Study Board and the ECCC modelers who created the Integrated Ecosystem Response Model for the Rainy – Namakan System tested prospective rule curves with hydrologic input datasets based on various climate scenarios before recommending the alternative that became the IJC's 2018 Rule Curves for this system (Figure 35).

Alternative Rule Curves were evaluated to reduce flooding (especially on Rainy Lake) and to improve ecological outcomes compared to the 2000 Rule Curves. The Study Board recommended the use of Alternative C (Figure 35) among other potential changes to reduce flooding in Rainy Lake and to reduce over winter drawdown to allow broad ecological benefits. These changes were not major but provide incremental refinements and were ratified in the IJC Supplementary Order for regulation of levels on Rainy and Namakan Lakes; 2018.

How is equitable space created for Indigenous governance in water regulation?

Details of the recommendations made by the Rule Curve Review Study Board are as follows:

1. Adopt Rule Curve Alternative C.
2. Promote flexible operation to improve outcomes.
3. Provide the Water Levels Committee (WLC)with Terms of Reference.
4. Empower the WLC to direct targets outside of the Rule Curve range.
5. Examine practical operational approaches to benefitting Rainy River interests.
6. Review data monitoring sources to support inflow forecasting by the WLC.
7. Formalize pre-spring engagement by the WLC.
8. Investigate adaptive management.
9. Advise governments about Rainy outlet modification.
10. Examine approaches for developing and sustaining improved relationships and communications. with First Nations, Métis and Tribes on water issues.

In establishing the 2018 Supplementary Order, the IJC adopted Alternative C for the Rainy Lake Rule Curve to help reduce flood peaks for high flood risk years, and accepted the other recommendations, except for Recommendation 4 above. Recommendation 4 was rejected in favour of the IJC retaining control over approving excursions outside of the Rule Curves. Most of the other recommendations are being implemented, including the establishment of an Adaptive Management Committee by the IRLWWB.

Ongoing work on water level regulation

Manoomin (wild rice)

In 2018, the IJC reported that manoomin has been struggling in Rainy Lake due to the damming and the water management regime and also due to aspects of climate change and the prevalence of invasive cattails. There were infrequent successful harvests leading up to 2018. Harvests of wild rice in Ontario have declined over 150,000 pounds on Rainy Lake, and over 1 million pounds on LoW since the 1970s, to less than 100,000 pounds in total.

https://www.ijc.org/en/climate-change-and-dams-present-challenges-wild-rice-rainy-lake

Dam operators seek to maintain water levels in Rainy Lake and Namakan Lakes within the rule curves, with oversight by the IJC's IRLWWB. Hybrid cattails have taken advantage of the regulated and consistent water levels. The cattails grow in thick mats, outcompeting native plants. Muskrats are a major natural control source for the cattails but were rarely surviving the winter due to winter water level draw down under the historic rule curve regulations prior to the 2000, and very similar 2018 Rule Curve Orders.

The IJC has been interested in improving conditions for wild rice in the Rainy Lake system. They have been working with regional First Nations, funding wild rice studies in the Rainy-Namakan basin. The Seine River First Nation used IJC funding to determine the best water conditions for rice growth. They were able to determine ideal water depth and timing for wild rice stands, concluding that the submerged stage and floating leaf stages are the most sensitive periods. A later study looked at the severity of impacts of the hybrid cattail, revealing that hundreds of hectares of wild rice stands had been taken over. Research found that by cutting the cattails beneath the water surface, these invasive plants would be killed, and any wild rice seeds still in the bed would germinate and regrow.

In 2018, Treaty #3 hosted a forum to discuss the development of a Wild Rice Communication protocol. Currently, this work is looking at the mapping of control structures to better understand the impacts to ricing areas in the Treaty #3 Territory.

One of the goals of new rule curves that went into effect in August 2018, is to improve wild rice survival and harvest rates. Changes to drawdown timing, which reduce the winter drawdown period substantially, should help more muskrats to survive the winter months, which should help control the invasive cattail problem. First Nations that are part of Treaty # 3 and NWOMC have commenced conversations on wild rice protocols, including an IWI project to begin mapping control structures and their relation to wild rice areas to better understand the water level impacts on wild rice.

A bed of wild rice in Kathio State Park in Minnesota (Brett Whaley)

Climate change can produce more frequent and severe storms. These storms can push the wild rice over or knock rice grains off the plants before they can be harvested. Storms can lead to more turbid water that hinders germination and plant development, according to Peter David, wildlife biologist with the Great Lakes Indian Fish and Wildlife Commission. Floods during the floating leaf stage can cause losses from a fungal disease known as brown spot.

Sturgeon Protocol for Managing Rainy River Flows

A protocol for protecting the sturgeon spawn in the Rainy River is now part of the considerations in operating the dam at the outflow of Rainy Lake. In spring 2013, dam operations led to a rapid drop in flows and levels in the Rainy River below the dam, leading to egg loss from air exposure. Following a review of this event, the Water Levels Committee (WLC) of the IRLWWB created a collaborative arrangement, known as the "Sturgeon Protocol", to include consideration of sturgeon spawning needs in management decisions on flows, to avoid dewatering of eggs. The Sturgeon Protocol is a collaborative approach of the WLC, with Ontario NDMNRF, Minnesota DNR, dam operators (Packaging Corporation of America and H2O Power), the Rainy River First Nations and its sturgeon hatchery, and others. Under the protocol, water temperature is monitored and when it reaches 12°C for two consecutive days, procedures are triggered to confirm that sturgeon spawning is occurring, assess whether changes in outflows are likely to negatively impact eggs, and consider needs of sturgeon spawning in flow decisions by the WLC. If deemed necessary, the WLC may direct dam operators to a specified outflow to avoid dewatering of eggs. This is subject to considerations of safety and adherence to the IJC Orders which take precedence, as the WLC does not have authority to direct flows when the level of Rainy Lake is outside the Rule Curve band.

Since the establishment of this Sturgeon Protocol, several flow changes have been undertaken to maintain stable and appropriate flows for the benefit of sturgeon spawning.

Drought

Recently (2021) the Winnipeg River basin experienced an unusual period of prolonged dry conditions. Regulated and natural river discharges across the basin were well below normal as are water levels in all major lakes (see photos below). The development of dry conditions began in 2020 with precipitation on an annual basis being below normal through the 12-month period ending June 30, 2021.

Photos showing low flow conditions in Big Fork River at Big Falls on August 12, 2021 (left) and high flow at the same location in July 2014 (right) (Lee Grim).

For the U.S. portion of the basin, there are many resources that can provide information on stream flow and drought metrics. The USGS National Water Dashboard (Waterwatch) https://dashboard.waterdata.usgs.gov/app/nwd/?aoi=default provides:

- Streamflow by basin, last 7-day average, for each of the gages in basin. Lowest flows (lowest on record for these days) in the Rainy and around Sauk Basin. Most of northern half of MN is much below normal.
- Streamflow by basin by streamflow percentile, and current streamflow compared to other historical, statewide drought years.
- Selected streamflow hydrographs from long-term gages showing the recent low flows in context of historical record and droughts of 1934, 1977 & 1988 at selected long-record gages including 05127500 Basswood River at Winton (89 years of record) and 05133500 Rainy River at Manitou Rapids (91 years of record).

Monthly hydrologic conditions reports and real-time stream flow data for Minnesota's watershed basins are available from:

- https://www.dnr.state.mn.us/current_conditions/hydro_conditions.html
- https://www.dnr.state.mn.us/waters/csg
- http://waterwatch.usgs.gov/new/index.php?m=real&r=mn&w=map
- https://water.weather.gov/ahps/region.php?state=mn

There is also information available through the Lake of the Woods Control Board (https://www.lwcb.ca/) and with the Water Survey of Canada (https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/monitoring/survey.html).

Thirteen Treaty #3 First Nations on Lake of the Woods, Shoal Lake, Winnipeg River, with a total of 45 separate reserves, filed flooding claims with Ontario and Canada.

Flooding

Indigenous Flood claims

Thirteen Treaty #3 First Nations on Lake of the Woods, Shoal Lake, Winnipeg River, with a total of 45 separate reserves, filed flooding claims with Ontario and Canada. Ontario accepted the claims in 2007, and Canada accepted them in 2009. One flooding claim has been settled (Rainy River First Nations).

The remaining twelve First Nations are:

- Anishinabe of Wauzhushk Onigum (Rat Portage)
- Anishinaabeg of Naongashiing (Big Island)
- Mishkosiminiziibiing (Big Grassy River)
- Naotkamegwanning (Whitefish Bay)
- Northwest Angle 33
- Animakee Wa Zhing 37 (Northwest Angle 37)
- Washagamis Bay (formerly Obashkaandagaang)

- Niisaachewan Anishinaabe Nation (formerly Ochiichagwe'babigo'ining or 'Dalles')
- Ojibways of Onigaming
- Shoal Lake 40
- Iskatewizaagegan 39 (Shoal Lake 39)
- Buffalo Point

Updates on claims accepted for negotiation, research, assessment and settlement agreements can be accessed at: https://www.ontario.ca/page/current-land-claims#section-11.

In addition to the First Nation communities that are asserting impacts from flooding, the Northwestern Ontario Métis Community (on behalf of the historic Métis communities and their modern-day descendants) are also in negotiations with both Ontario and Canada over impacts to lands and rights caused by flooding.

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Rainy Lake First Nations

Five First Nations (Couchiching, Mitaanjigamiing, Naicatchewenin, Nigigoonsiminikaaning, and Seine River) submitted claims to Canada and Ontario, alleging unauthorized and uncompensated flooding of their reserve lands on Rainy Lake following construction of the dam at Fort Frances. Ontario accepted the claims for negotiation in 2003. Negotiations with Canada and Mitaanjigamiing, Naicatchewenin, Nigigoonsiminikaaning, and Seine River First Nations have been proceeding since 2009. Negotiations with Canada and Couchiching First Nation began in 2013. Surveying of flooding easements on the reserves and drafting of settlement and easement agreements is proceeding.

Groundwater

The SOBR Editorial Committee has identified groundwater information as a potential gap. For the Lake of the Woods direct watershed, the MPCA (2016) reported that there was only one current MPCA Ambient Groundwater Monitoring well in the Lake of the Woods local watershed and not enough data yet to see trends in water quality. Since then, limited groundwater quality data are now available for a few more sites. Available data for the few well sites in the Minnesota portion of the entire basin can be accessed from the MPCA Ambient Groundwater Monitoring program at: https://mpca.maps.arcgis.com/apps/webappviewer/index.html?id=6675cad8bb8f4f3ead043008977f282e.

ECCC will provide results of their groundwater studies in a future issue of the Journal of Great Lakes Research. These studies indicate that dissolved P in shallow groundwater along the shores of LoW are 30 ± 20 µg/L, suggesting that groundwater discharge to the streams in the Rainy River basin may be at least partially responsible for the 20-30 µg/L TP concentrations measured in the streams. Their studies have shown that groundwater is generally the dominant source of baseflow in streams. Groundwater contributes ~2.7 to 12 metric tonnes of P to shorelines of LoW by groundwater seepage each year, which is ~ 0.3 to 2% of the load from external sources to the lake. At both developed (cottage/urban) and undeveloped sites, P (dissolved) concentrations in shallow groundwater along the shores of LoW were 30 ± 20 µg/L.

Erosion

Rainy River - Rainy Lake Watershed

Mielke (2020) notes that: "Water quality is impacted by the high sediment load in the form of excessive turbidity. The fine sediments are ultimately deposited into the slower, low gradient portions of streams in the Rat Root River drainage, Rat Root Lake, and Rainy Lake. Natural vegetative buffers along shorelines, a key protection strategy to maintain high quality lakes, should be encouraged to prevent overland runoff and reduce erosion potential." (The Rainy River – Rainy Lake Watershed Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-09030003b.pdf).

What are the historical and present concerns and impacts of Indigenous Nations as it relates to shoreline erosion including loss of land and destruction of burial sites?

The Rat Root River, Minnesota (Lee Grim)

Lake of the Woods Shoreline Erosion

The MPCA, in its P budget estimates for the Lake of the Woods TMDL, concluded that 8.8% of the total budget was from erosion, equivalent to 72 t (Table 10). The TMDL targets an 11.5 t/yr reduction in this load.

ECCC, in its P budget estimates, concluded that 8% of the total budget was from erosion (Figure 36), estimated as 70.2 MT, roughly similar to the estimates derived by the MPCA in its TMDL.

Table 10 — MPCA derived P loading from various sources showing shoreline erosion as contributing 8.8% to the total load.

Source	kg/yr	% of total
Tributary Loading	319,381	39.1
Internal Load	281,995	34.6
Shoreline Erosion	72,000	8.8
Industrial Wastewater	63,943	7.8
Atmospheric Deposition	51,407	6.3
Lakeshed Loading	17,112	2.1
Domestic Wastewater	8,066	1
Industrial Stormwater	798	0.1
Subsurface Treatment Systems	722	0.1
Construction Stormwater	389	0.04

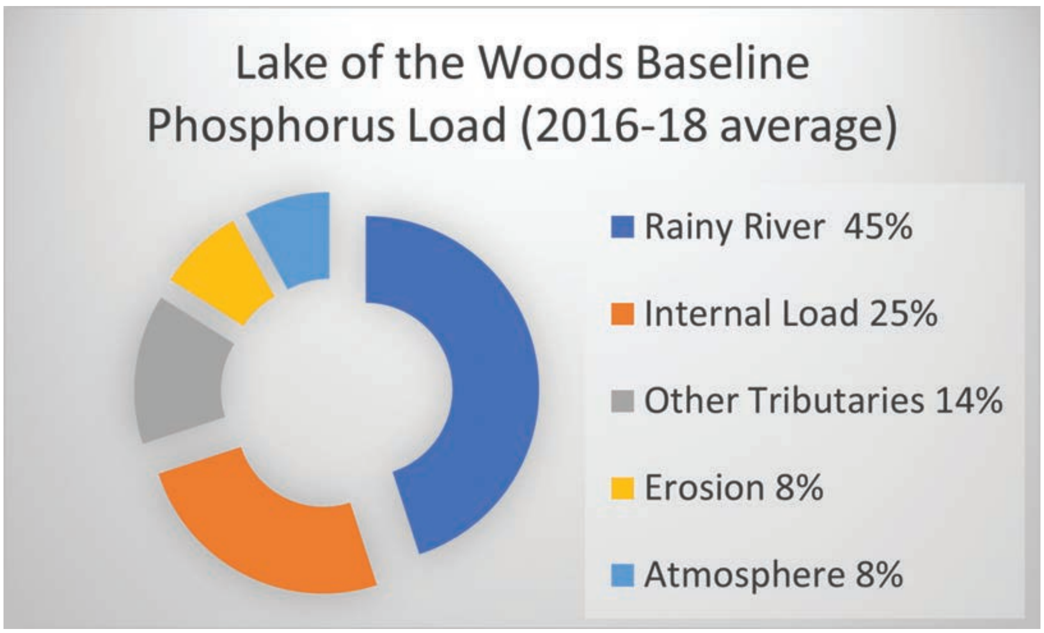

Figure 36 — ECCC phosphorus load estimates from various sources to LoW.

Erosion Tools

Sediment Fingerprinting

In fall of 2019, the USGS, MPCA, and Koochiching and North St. Louis Soil and Water Conservation Districts began a sediment fingerprinting study in the Little Fork River watershed to address a 105 mile stretch of the river that is impaired by turbidity.

The sediment fingerprinting process is an analysis of sediment that can attribute the particles' source to different locations in the watershed. Sediment properties are matched to their source fingerprints. Determining the erosion sites and deposit locations of sediment is important in developing strategies to reduce sediment loads to water bodies that have been impaired by turbidity.

While it has been established that there is an excess of sediment present in the Little Fork River, it is unknown how to proceed to reduce it to acceptable levels. Identifying sediment sources is the first step in targeting sediment-laden stream reaches for remediation projects.

Staff collecting sediment fingerprinting samples.

Over the course of the past ten years, about 120 miles of main stem, and major tributaries, have been identified for Total Suspended Sediment (TSS) impairments in the Little Fork (LF). TSS modeling in the system as well as traditional field-based source assessments were not adequate for addressing these impairment issues. In 2017, other options were explored for developing a plan to identify where the sediment was coming from and suggest field level projects to address it. US Geological Survey began exploring the idea of sediment fingerprinting for the 1800 sq. mile Little Fork system. A major sediment project was developed for the system, including three County Soil and Water Districts (Koochiching, North St. Louis, and Itasca Counties).

Flood Vulnerability Studies led by Indigenous Nations can provide information about erosion impacts and risks to Indigenous Nations and can also provide a larger understanding of land loss and change across the Rainy-Lake of the Woods Basin.

In April 2021, eight passive samplers were installed in the Little Fork, five in the main stem, and three in Willow, Valley, and Sturgeon tributaries. A plan was developed to build a "bank" of upland samples, randomly selected through a GIS exercise, including young and old forested soil samples, wetlands, roads, and agriculture settings. There are 75–100 upland soil sampling sites.

In the summer of 2021, the project continued to wait for rain to move sediment into the samplers in stream (see low flow photos).

Left – Low flows: Sturgeon spawning rapids on LFR looking south from MN Highway 217 bridge at the town of Littlefork, MN. Right – Confluence of the Littlefork River with the Rainy River (upper right) on 7/16/2021 taken from bridge on MN Highway 11 looking north. (Lee Grim)

The Lake of the Woods TMDL calls for a 30% plus reduction of P out of the Little Fork system. This sediment fingerprinting study will help with understanding the TSS/P relationship and should inform projects to reduce pollutants to implement the LoW TMDL.

Lake of the Woods Wind-Wave Modeling Report

In 2017 the US Army Corps of Engineers, St. Paul District, produced a report that provides tools to assess shoreline erosion primarily at the U.S. south shore of LoW (USACE 2017).

> *The purpose of this project is to provide local stakeholders with estimates of wind setup and wave parameters along the southern shoreline of the Lake of the Woods for use in assessment and design of shoreline erosion mitigation, water quality practices, and flood risk management measures. These local stakeholders include, but are not limited to, the Lake of the Woods County Soil and Water Conservation Service, the Roseau County Soil and Water Conservation District, the Minnesota Pollution Control Agency, and the Minnesota Department of Natural Resources.*

2014 was a devastating year for erosion on the southern shore of LoW.

2014 was a devastating year for erosion on the southern shore of LoW. Exceptionally high water of long duration, coupled with strong winds, led to substantial property damage and extensive erosion along the southern shore of LoW. Lake levels exceeded the top of the Normal Operating Range for 66 days (June 17 to August 22) peaking on July 24 at 323.79 m (1062.3 ft) above sea level, which was 32 cm (12.6 in.) above the top of the Normal Operating Range. This was the highest level since the 1950 flood (DeWolfe et al., 2015).

Although the recent past years of drought are probably more on people's minds, over $750,000 were received in MN State disaster funding to protect property from shoreline erosion from the 2014 high water event.

Erosion on south shore of Lake of the Woods (Todd Sellers).

Lake of the Woods has a significant muskellunge fishery. The vast majority of musky caught by anglers are released (Todd Sellers)

Walleye Under Pressure

In 2017, MNDNR and NDMNRF published the Fifth Edition of the Ontario–Minnesota Boundary Waters Fisheries Atlas (MNDNR and OMNRF, 2017). Conclusions indicate that there is evidence of over-harvest of walleye in Lake of the Woods (LoW) Sector 1 North, and Sector 2 Central (Figure 37). In the North Sector, declines in walleye biomass and fishing quality are expected if harvest reduction is not implemented. In the Central Sector, close monitoring is indicated.

What is the process to jointly manage and permit fishing in the basin between Crowns and Indigenous Nations?

With respect to other fish, northern pike are likely doing well in northern and central sectors, musky maintain a strong fishery with most fish released but with few data. Smallmouth bass annual harvest is well below targets. In Sector 3 (Whitefish Bay) lake trout regulated harvest size restrictions maintain an abundance of large-bodied lake trout but harvest levels may prevent the population from reaching its full potential to support trophy angling opportunities.

Todd Sellers and Nolan Baratono net a nice walleye (Bev Clark)

In a separate study, NDMNRF similarly showed that the LoW walleye fishery is not sustainable. In a presentation at the 2021 International Rainy-Lake of the Woods Wateshed Forum (IRLWWF), Steve Bobrowicz reported that monitoring by NDMNRF's Biodiversity and Monitoring Section indicated that the walleye population in Ontario waters (of LoW) is experiencing high fishing mortality and low biomass of mature fish (Figure 38), suggesting that the current fishery is unsustainable. NDMNRF has established a stakeholder Advisory Council to assist it in developing a management plan for the recreational walleye fishery. The plan is being developed using a structured decision-making process with 10 meetings of the Advisory

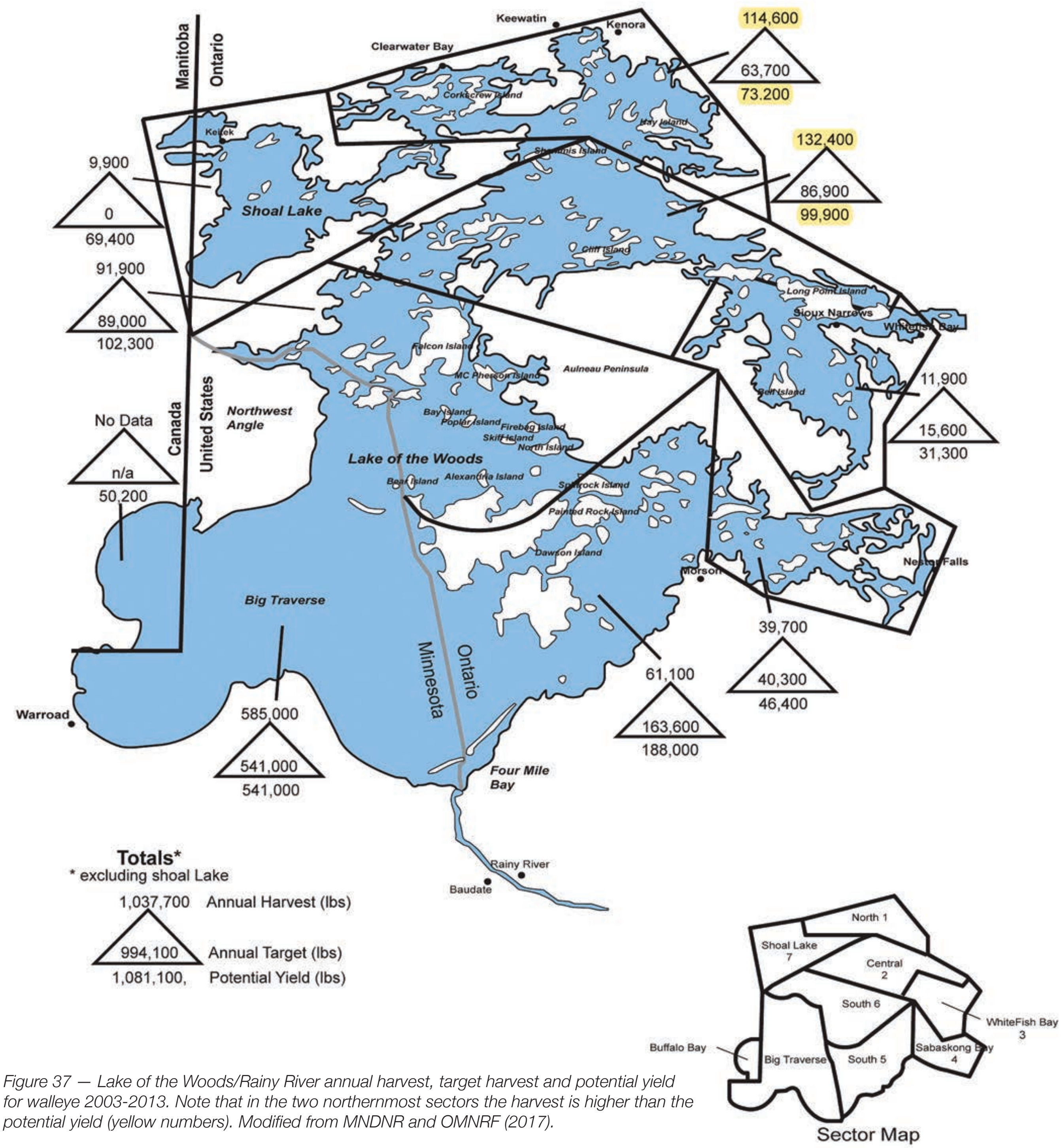

Figure 37 — Lake of the Woods/Rainy River annual harvest, target harvest and potential yield for walleye 2003-2013. Note that in the two northernmost sectors the harvest is higher than the potential yield (yellow numbers). Modified from MNDNR and OMNRF (2017).

Council between January and October 2021. Additional consultation with stakeholders is expected in early 2022. The council consists of 21 people including local anglers, members of the tourism industry and Indigenous communities. COVID-19 has impacted the group's ability to meet, and little was accomplished during the summer of 2020. Once the recommendations are completed, they must go for a minimum of 30 day posting to the official Environmental Registry for review. Posting will include the Draft Plan document as well as a short summary of the project. The Crown has a Duty to Consult with Indigenous communities such that a draft plan document will be directly sent to 13 First Nations groups including: Grand Council Treaty #3, Anishinaabeg of Kabapikotawangag Resource Council, and Region One Métis Nation of Ontario. NDMNRF will discuss appropriate approaches to consultation with these groups after which the proposal should go forward for implementation in early 2023.

Changes to the recreational fishing regulations are an expected outcome of this process; however, it is premature to anticipate what those changes might be at the current stage of planning.

Changes to recreational fishing regulations for Lake of the Woods are expected from the current review; however it is premature to anticipate what those changes might be.

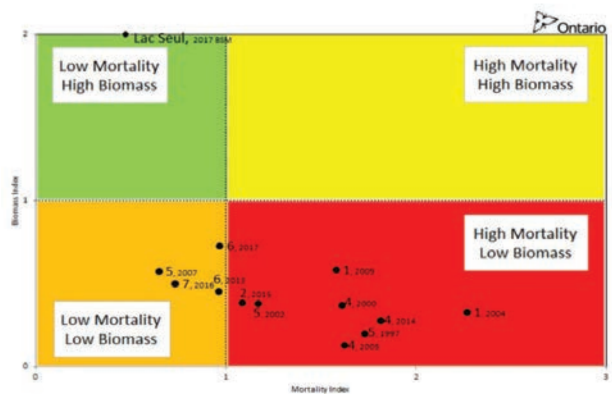

Figure 38 — Showing Lake of the Woods Assessment data with Sector and year assessed, indicating high mortality and low biomass for walleye populations.

Managing Fisheries in Ontario

Managing fisheries in Ontario is directed by the Ontario Provincial Fish Strategy. This is an exhaustive and comprehensive plan, see: https://www.ontario.ca/page/ontarios-provincial-fish-strategy.

More regional fish management strategies are addressed using guidelines that are specific to individual fisheries management zones (FMZs). The LoW basin is in Zone 5. Regional considerations for fisheries management in Zone 5 can be viewed here: https://www.ontario.ca/page/fisheries-management-plan-fisheries-management-zone-5#section-11

Broadscale Monitoring

The LoW Fisheries Assessment Unit in Kenora ON collected its last set of water samples in 2017. Since then, fisheries monitoring in LoW has been replaced with the Broadscale Monitoring Program (BsM). In 2008, NDMNRF moved toward a broader landscape scale approach to managing fisheries by establishing 20 Fisheries Management Zones (FMZs) as the primary units for planning, management, and monitoring of fisheries in Ontario.

The BsM will sample LoW completely in one year (scheduled to occur in August 2021) rather than using the previous sector-by-sector sampling scheme on a rotational basis. This will provide a more cohesive point-in-time snapshot of the whole lake. Sampling uses the North American Large Mesh Gillnetting Standard which should address the status of many species within the lake. Every five years, there will be three open-water nettings and one winter netting plus creel surveys. Creel reporting (2017–2018) was presented at the 2018 International Rainy-Lake of the Woods Watershed Forum (IRLWWF). Reporting on the 2021 monitoring may be available by summer 2022.

Shore lunch (Bev Clark)

The BsM Program samples lakes throughout the basin on a rotating basis. Information was presented at the 2018 IRLWWF showing the lakes that have been sampled in the first two cycles of the program (2008–2012 and 2013–2017) with the third cycle in 2018–2023. Available data are included in Appendix 3.

Broad-scale monitoring bulletins are available to summarize the information collected on each lake in the program. Lake bulletins can be found on NDMNRF's Fish ON-Line website. State of the Resources Reports will be produced for the BsM program to summarize information for each FMZ, and indicate the status of Ontario's fisheries. The data from BsM is used in the development and review of FMZ fisheries management plans, and the BsM results are reported in the documentation for those planning exercises.

For over 30 years DNR and the Ontario Ministry of Natural Resources and Forestry have been working cooperatively on shared resource management.

Managing Fisheries in Minnesota

Minnesota has published a comprehensive fisheries management plan to address fisheries goals specifically for LoW. It notes:

> *Since the early 1980s annual monitoring has been conducted on large lakes throughout the state of Minnesota. The data and information collected from these surveys allows for sound science to inform management decisions. For over 30 years DNR and the Ontario Ministry of Natural Resources and Forestry have been working cooperatively on shared resource management. It is in this forum where target harvest and management direction are shared with our counterparts in Ontario. https://files.dnr.state.mn.us/areas/fisheries/baudette/lothw_mplan.pdf?20201201.*

VNP has ongoing work on coldwater fish habitat (a report summarizing this work is in peer review for a US National Park Service Report Series). There is a threat to this habitat and the US Fish and Wildlife Service, US National Park Service, and others are monitoring it.

New since the 2014 SOBR, MNDNR has changed harvest regulation for northern pike statewide, now with three harvest zones in Minnesota each with different management objectives for northern pike. However, as noted above, Lake of the Woods has its own plan and regulations, aimed at supporting trophy fishing opportunities for northern pike.

MPCA Rainy River Study

An information sheet summarizing the current state of the Rainy River (Anderson and Kennedy, 2020) indicates that scientists monitored 13 stations for fish and found the populations to be in excellent condition in terms of numbers and species. They found 42 species overall in the Rainy River, with ten of those considered sensitive to pollution, including sturgeon, longnose dace, and smallmouth bass. The fish community in the Rainy River from International Falls to Baudette is considered to be in excellent condition and a world class fishery for walleye and sturgeon (once extinct in the main river).

An information sheet summarizing the current state of the Rainy River (Anderson and Kennedy, 2020) indicates that scientists monitored 13 stations for fish and found the populations to be in excellent condition in terms of numbers and species.

In a more detailed report, Mielke 2020 observed that the presence of relatively sensitive fish species and the mixture of tolerant species indicated fair to good water quality. The report notes that:

"The Rainy River Basin does not have any endangered or threatened species under US federal law, but the watershed does have six fish species listed by the state of Minnesota as being of special concern (MNDNR 2013). These species include:

- *Ichthyomyzon fossor* (northern brook lamprey)
- *Acipenser fulvescens* (lake sturgeon)
- *Coregonus zenithicus* (shortjaw cisco)
- *Couesius plumbeus* (lake chub)
- *Lepomis gulosus* (warmouth)
- *Lepomis peltastes* (northern longear sunfish)."

Internationally Shared Fish Stocks

Several fish populations are managed as shared stocks on the international border. These are species-specific and are observed through joint research. Primary areas are LoW, Rainy River, and the South arm of Rainy Lake. Ontario FMZ 5 considers other shared stocks, including those in Namakan Lake, Sand Point Lake, Little Vermilion Lake, Loon Lake, Lac La Croix, and numerous lakes in Quetico Provincial Park. Support for this shared stock work is provided by the ON/MN Fish Atlas as described earlier. It is important to clarify that the Atlas does not meet Ontario's current requirements for a fisheries management plan; but the Atlas is used as a source of information.

Indigenous Fishing and Harvesting Rights

Treaty 3 Inherent and Treaty Right to Fish

Treaty #3 members have both inherent and treaty rights to harvesting and fishing. They can harvest fish or wildlife for personal consumption, or for social or ceremonial purposes, and are not required to hold the otherwise applicable Ontario license. Treaty #3 members will not be subject to enforcement action, except in certain circumstances including:

- hunting and fishing in an unsafe manner

- harvesting fish and wildlife for commercial purposes (where a commercial harvesting right has not been recognized by a Court and no license is held)
- taking fish and wildlife that puts conservation objectives at risks
- hunting or fishing on privately owned or occupied land without permission of the landowner

Métis Rights to Fish

Métis have aboriginal rights to harvest and fish that are affirmed and protected by the Constitution Act 1982. In 2018, a framework agreement was established that ensures that Metis Nation of Ontario (MNO) Harvester Card Holders received equitable treatment when exercising this right.

> *On April 30, 2018, MNO President Margaret Froh and Ontario's Minister of Natural Resources and Forestry Nathalie Des Rosiers signed a new framework agreement on Métis harvesting in Ontario. The Agreement requires the NDMNRF treat MNO Harvesters Card holders in the same way as First Nations harvesters for the purposes of enforcement. This means that valid MNO Harvesters Card holders who are harvesting in compliance with the MNO Harvesting Policy and within their identified MNO Harvesting Area will just need to show their card to NDMNRF enforcement staff, in the same way that First Nations show their "status Indian" cards. This provides certainty to MNO Harvesters Card Holders as to how they will be treated by the NDMNRF and ensures equal respect for Métis harvesting rights. MNO Harvester Card holders will need to respect all applicable safety and conservation restrictions. https://www.Métisnation.org/news/harvesting-agreement.*

Métis have aboriginal rights to harvest and fish that are affirmed and protected by the Constitution Act 1982.

In a 2009 Report, Water and Health in the Lake of the Woods and Rainy River Basins, Oblak provided an excellent overview of interconnections between both natural biota and human contaminants and human health in the basin. The report takes a watershed approach to identifying water and health related issues in boundary waters. It outlines some key water quality and quantity issues, provides a brief overview of each, and identifies how each relates to human health. Information gaps are listed with suggestions for next steps in addressing these gaps as well as suggesting other initiatives. The report lists key government agencies which deal with water and health issues, with information on available databases. In this SOBR, key issues of human health are discussed, where there is information since the 2009 Oblak report and the previous SOBR (2014).

Drinking Water

Work to end long-term boil water advisories and provide clean water in 37 First Nation communities across Ontario is set to begin soon, with 12 projects in northwestern Ontario communities.

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The Kenora and Kiiwetinoong districts have the largest concentrations of long-term boil water advisories across the country. As of March 19, 2021, Indigenous Services Canada reports there are still 58 long-term drinking water advisories in effect in 38 communities in Canada.

The Minnesota Department of Health is the authority for drinking water in the US portion of the basin. Areas that are proposed for upgraded drinking water infrastructure in Minnesota are added to the Project Priority List and priority is ranked based on public health protection, adequate water supply and financial need ("Minnesota Drinking Water Revolving Fund Project Priority List - EH: Minnesota Department of Health" n.d.). Upon review of the Project Priority List, no US Tribe in the basin is listed, however further study is needed to evaluate the true state of drinking water supply of US Tribes in the R-LoW Basin.

In northwestern Ontario, funding has been approved for local projects including:

- Anishinaabeg of Naongashiing First Nation — Sewage lagoon
- Couchiching First Nation — Storm-water management infrastructure upgrades
- Grassy Narrows First Nation — Replacement of sewage pumping stations
- Mishkeegogamang Ojibway Nation — Water treatment plant upgrades
- Iskatewizaagegan #39 Independent First Nation — Water distribution, fire protection

- Naotkamewanning First Nation — Wastewater plant replacement
- Northwest Angle 33 First Nation — Water treatment plant upgrades
- Washagamis Bay First Nation — Replace existing distribution water main
- Ochiichagwe'Babigo'Ining Ojibway Nation — Wastewater collection, treatment
- Ojibways of Onigaming First Nation — Water treatment plant upgrades
- Shoal Lake #40 First Nation — Subsurface septic system rehabilitation
- Wabigoon Lake Ojibway Nation — Water treatment plant rehabilitation

The Rainy River First Nations' Water Treatment Plant is currently (2021) unable to meet the demands for water. The reservoirs are low. There is a boil water advisory before consumption and people are asked to limit their water usage. This advisory is in effect as of June 14, 2021, and the community will be advised once it has been lifted.

Shoal Lake 40

Shoal Lake No. 40 First Nation is home to 306 people. The First Nation has built a new centralized water treatment plant and distribution system in partnership with Indigenous Services Canada. The community's water treatment systems have been under long-term drinking water advisories since 1998. After more than two decades without clean drinking water, in 2021, Shoal Lake 40 celebrated the opening of a water treatment facility and the end of water advisories for the community.

The opening of the all-season Freedom Road in June 2019 provided the community with access to the Trans-Canada highway and was essential to bringing construction goods and equipment to the community for construction of the new plant.

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Winnipeg Aqueduct

Completed in 1918, the Shoal Lake Aqueduct continues to supply water to the City of Winnipeg. The intake and the initial sections of the aqueduct are located on reserve land belonging to Shoal Lake Band 40. Maintenance of good water quality continues to be a concern for Indigenous communities, seasonal residents, and the City of Winnipeg. There are ongoing concerns, particularly of Shoal Lake Band 39, whose reserve adjoins Band 40 in the vicinity of the aqueduct inlet, about rights of access and compensation from the City of Winnipeg for use of water to which it claims ownership.

Mercury

Human health impacts of mercury pollution are of concern to communities in the R-LoW basin, particularly considering problems with mercury in neighboring communities adjacent and or downstream to this watershed. Fish harvest and consumption are part of a lifelong traditional way of life for many Indigenous peoples, who now suffer from the negative health impacts of mercury contamination throughout the region.

Work is currently underway to address historic mercury contamination in the English and Wabigoon Rivers near Grassy Narrows First Nation and Wabaseemoong Independent Nations.

Cyanobacterial Toxins

Harmful cyanobacteria blooms (CyanoHABs), which are common in the R-LoW basin, can produce toxins that may be hazardous to human health. Case studies, anecdotal reports, and data from laboratory animal research suggest that cyanobacterial toxins can cause a wide range of human health effects. However, few studies have definitively explored the links between cyanoHabs and human health, world-wide. Case studies and reports of health effects from exposure via drinking water, recreational contact, and epidemiological studies, are reviewed in WHO (2020a; 2020b).

Humans can be exposed to cyanobacterial toxins by drinking untreated water that contains the toxins, swimming in water that contains high concentrations of cyanobacterial cells or breathing air that contains cyanobacterial cells or toxins. Adverse health effects associated with exposure to cyanobacterial toxins include stomach and intestinal illness, trouble breathing, allergic responses, skin irritation, liver damage, and neurotoxic reactions. Explanations with regard to various toxin groups are shown in Appendix 4. Cyanobacterial toxins have been implicated in animal deaths (e.g., dogs, livestock etc.). Cyanobacterial toxins have been linked incidence of human disease in many countries, however there are no reports of fatalities (WHO 2020a) in North America and the only reported case of suspected human poisoning by the cyano-neurotoxin anatoxin-a, widely reported in the popular press, has been discounted (WHO 2020b).

The IRLWWB notes:

Elevated Microcystin-LR concentrations in LoW have been reported during the summer months by many researchers. As a general rule, it is advisable to avoid drinking and body contact with water during times when algal blooms are occurring. Water samples cannot be used to assess the safety of the water for drinking since toxins can appear at any time. https://ijc.org/en/rlwwb/watershed/faq

In Lake of the Woods, there is evidence that cyanobacterial toxins have increased in recent decades. Zastepa et al. (2017) showed microcystin congener concentrations in sediment cores from Hay Bay, LoW (Figure 39). Microcystins were below detection limits prior to 2000 and highest in the upper sections of the core (approximate year 2010) leading Zastepa et al. (2017) to suggest that this was possibly due to changes in climate and reorganization of algal and cyanobacterial communities due to recent warming as reported by Rühland et al. (2010).

In another study, Pilon et al. (2019) showed results of sedimentary DNA - Microcystis specific 16S rDNA gene copy numbers over time in LoW and compared trends to the post-1980 rise in *Cyclotella* relative to *Aulacoseira* suggesting that rises in cyanobacteria in recent decades were indicative of warming (Rühland et al. 2010).

Researchers at VNP and collaborators have published several papers on cyanotoxins since the 2014 SOBR. Seth McWhorter completed a master's thesis on testing for cyanotoxins in fish samples from Lake Kabetogama (paper in prep). VNP completed the first season (2021) of a three-year study with USGS of possible lake-level fluctuation influence on algal toxins in blooms in Lake Kabetogama. Cyanotoxin mixture models were tested by Christensen et al. (2021) for Kabetogama bloom metrics in 2016—2017.

Blastomycosis

Blastomycosis (commonly known as "blasto") is a disease caused by the soil-born, thermally-dimorphic fungi (*Blastomyces dermatitidis* and/or *Blastomyces gilchristii*). Blastomyces species are endemic to the R-LoW basin, and other areas including the Ohio and Mississippi River basins, and some areas of the Great Lakes – St. Lawrence basin.

Blastomycosis is a substantial health threat in the R-LoW basin, with elevated but regionally varying incidence in Ontario, Minnesota, and Manitoba. The impacts of blasto on the lives of those who live in or visit the R-LoW basin can be substantial, resulting in serious illnesses and death in dogs, humans, and occasionally other mammals.

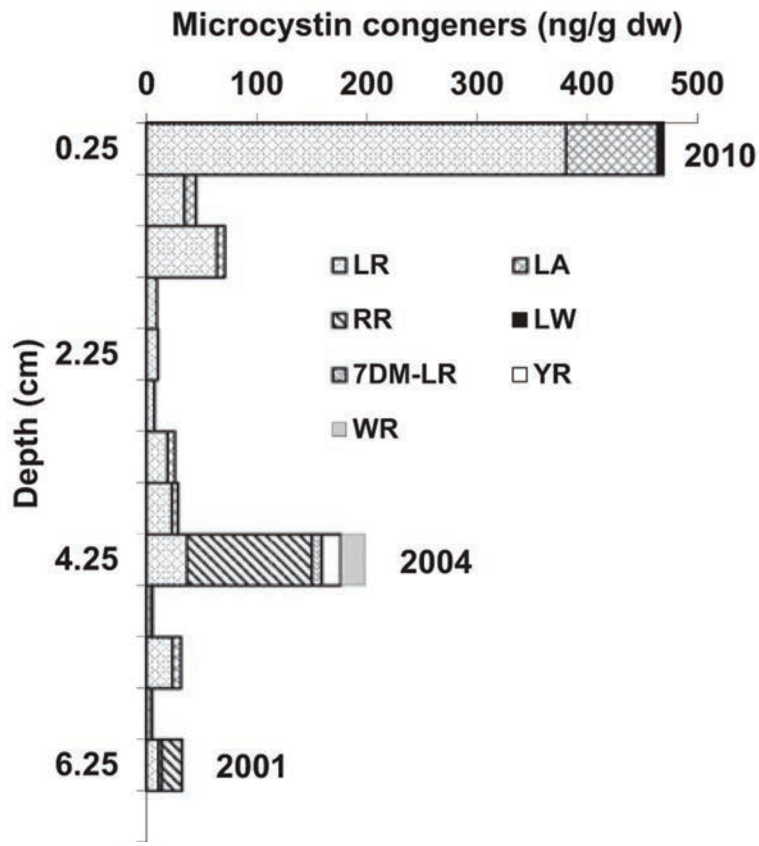

Figure 39 — Microcystin congener concentrations on sediment particles in the top 6.25 cm of a 40cm long core from Hay Island, LoW. Measurements were below the limit of detection in deeper sediment intervals (>6.25 cm) (Zastepa et al., 2017).

Soil is the only known reservoir for *Blastomyces* spp. with moist, slightly acidic soils enriched with decaying organic matter being implicated (Schwartz 2018). Epidemiologically, incidence of human and canid infection by this pathogen is associated with proximity to the waterways in our basin.

The primary mode of infection is inhalation of spores, released when infected soils are disturbed, although in rare cases infection can occur through direct skin-puncture contact. As such, infection is sporadic but there have also been several outbreaks in the R-LoW region with suspected sources of contact.

Blasto "awareness" is important because delays in diagnosis and initiation of treatment are critical factors in unfavourable outcomes. This is particularly important for people (and their dogs) that visit the region in the summer and return home to other regions where the medical and veterinary communities' index of suspicion may be low.

Blasto in Humans

Blasto has a long incubation period, ranging from 21 to 106 days, with a median of 43 days (Klein et al., 1986; and others). Disease presentation and diagnosis typically occurs in the fall or early winter, suggesting exposure during summer.

Blasto in humans typically presents as a pulmonary infection in about 70% of cases. Blasto can also present as skin lesions, ocular, genitourinary or other organ and bone tumors, central nervous system involvement, or generally disseminated through the body. Pulmonary infection can be mild to severe, with approximately 6–15% (Schwartz 2018; Schwartz et al., 2016) of human cases developing acute respiratory disease syndrome (ARDS), for which fatality rates can be at least 40% or higher (Schwartz et al., 2016). Although treatable with powerful antifungal drugs, the overall human mortality rates are normally reported to range from 6.3% (Crampton et al., 2002) to 10% (Schwartz, 2018; Ireland et al., 2020). However, in a review of hospital cases in northwestern Ontario (Dalcin and Ahmed 2015) calculated mortality at nearly twice that (20.3%).

Blasto in Dogs

In dogs, incidence of blasto is in the order of 8–10 times higher than humans (Schwartz 2018), possibly related to time outdoors, proximity to soil, and activities that may increase exposure risk such as digging, sniffing the ground, etc. Sporting / retriever breeds are most likely to be affected. In addition to pulmonary involvement, ocular disease is much more common, occurring in up to half of cases (Schwartz 2018). Blasto is fatal in up to 25 percent of dog cases.

Detailed statistics for blasto in dogs are not available for Ontario. Anecdotally, just about every dog owner who lives either permanently or seasonally in the Kenora region has had experience with or knows someone who has experience with Blasto infection in their dogs. In Minnesota, there were 1951 reported cases of blasto in animals between 1999 and 2020, with 96% of these being dogs (MDH, n.d.).

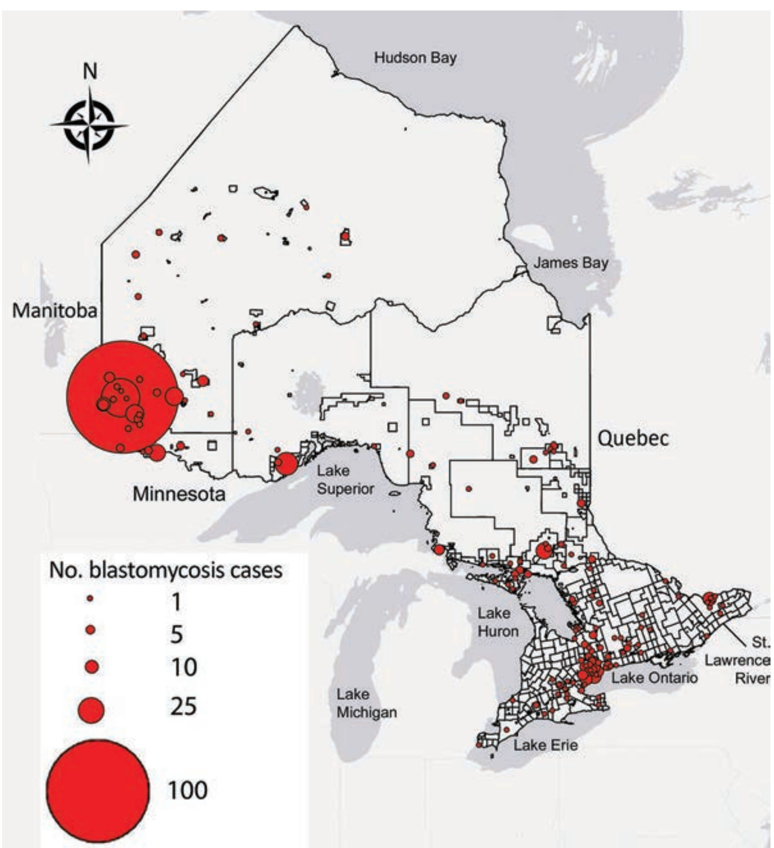

Figure 40 — Geographic distribution of blastomycosis cases in Ontario, 1995–2015. Size of dot is proportional to number of cases at a given location (Brown et al., 2018)

Incidence of Blasto

In the northwestern health unit region of Ontario, the incidence of blasto disease in humans is 12.6 times higher than any other region in the province, with over half of the provincial cases (Brown et al., 2018) and 42% of hospitalizations despite having only 0.6% of the Ontario population (Litvinjenko and Lunny 2017). Yearly average hospitalization rates in the northwestern district are 35 per 100,000 population with a slight increasing trend, driven by significant peaks in 2009 and 2013 (Litvinjenko and Lunny 2017). The reasons for these peaks in infection incidence are not known.

Within the northwestern health unit district, there are significant "hotspots" around Kenora and Rainy River, ON (Figure 40; Brown et al., 2018). The

Kenora region is considered hyperendemic, accounting for most of the cases in the northwest region. Yearly hospitalization rates average 57.9 per 100,000 population and during an outbreak in the late 1990s has been as high as 117.2 / 100,000 for residents withing the Kenora catchment and 404.9 per 100,000 people living outside the boundaries of Kenora on First Nations reserves (Litvinjenko and Lunny 2017).
For comparison, in neighbouring Manitoba, the laboratory confirmed current incidence rate was 1.7 per 100,000 population, with an average over 2002–2016 of 1.2 per 100,000 population (Government of Manitoba 2019). This may be overestimated in comparison because residents of the Ontario NWHU may be referred to Winnipeg for diagnosis and treatment and many Manitoba residents travel to NWO to seasonal residences and may have acquired infections there.

Minnesota Department of Health collects detailed reporting and tracking information on blasto diagnoses and probable location where exposure may have occurred. There were 833 reported human cases of blasto over 1999-2020, concentrated in the northern part of the State and with St. Louis County in the R-LoW basin being an apparent hotspot, having the highest occurrence and highest probable exposure location (Figure 41).

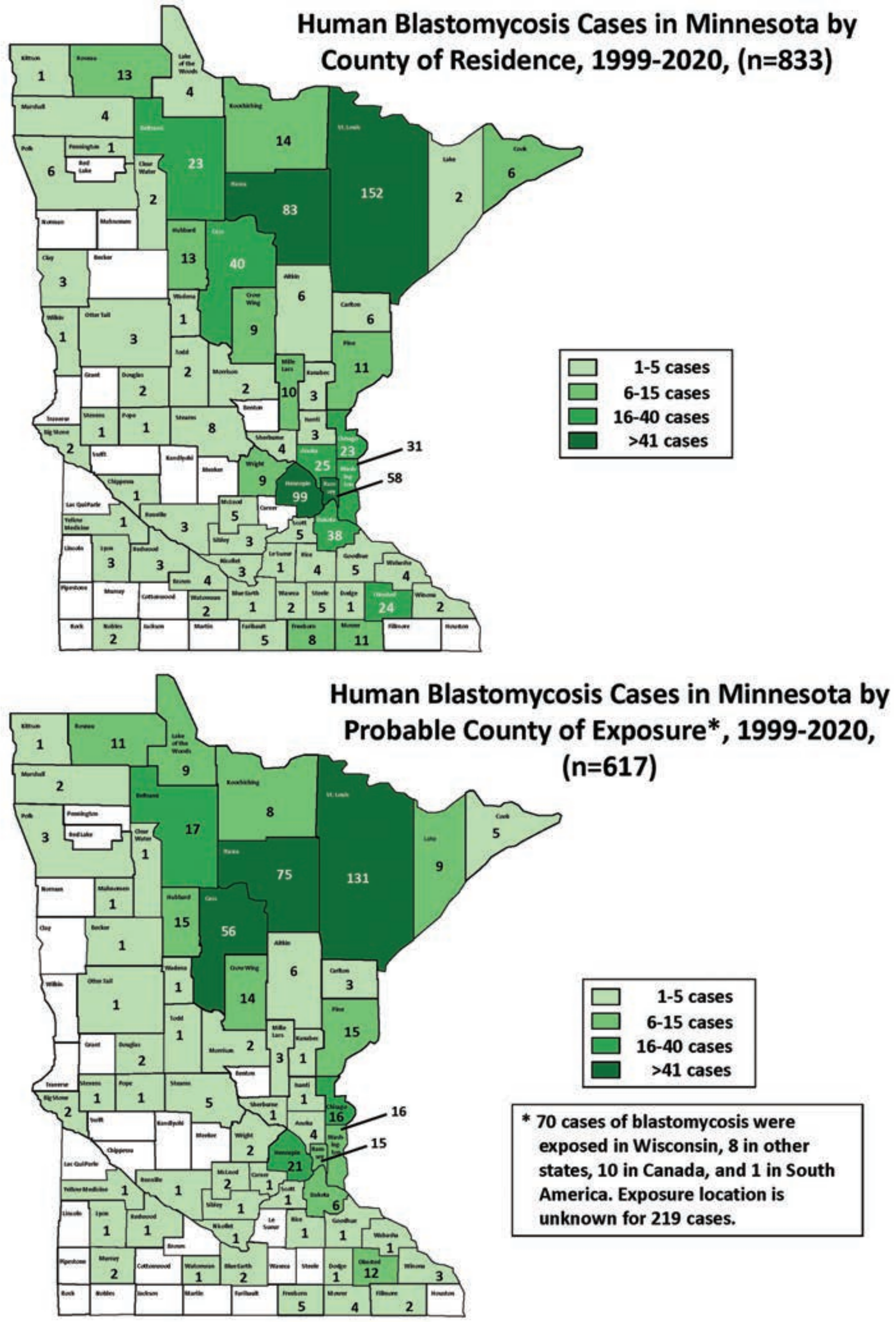

Figure 41 — Human cases of blastomycosis in Minnesota by residence and probable exposure locations (MDH, n.d.)

Is Blasto Increasing?

There is some evidence that suggests that Blasto infections have increased in humans (Brown et al., 2018; MDH n.d.) and in dogs (MDH n.d.) although this is not certain.

In Ontario, blasto diagnoses increased six to seven-fold between the late 1990s and early 2000s but have remained elevated since (Figure 42: Brown et al., 2018 with data extended in this report). However, it is not known whether the increases observed are real, or artefacts of increased public and clinical awareness and better reporting requirements. Blasto was not a reportable disease between 1989 and 2018, so historical incidence can only be reconstructed from retrospective reviews of hospitalization diagnostic records.

The Minnesota Department of Health and the Board of Animal Health have tracked Blasto for many years as a reportable disease. According to the Minnesota Department of Health, in recent years, Blasto has increased in both humans (Figure 43) and animals, 96% of which are dogs (Figure 44). Some of this increase may be attributable to increased public awareness and clinical surveillance, and in the case of animals, initiation of direct reporting from laboratories in 2016 (MDH n.d.).

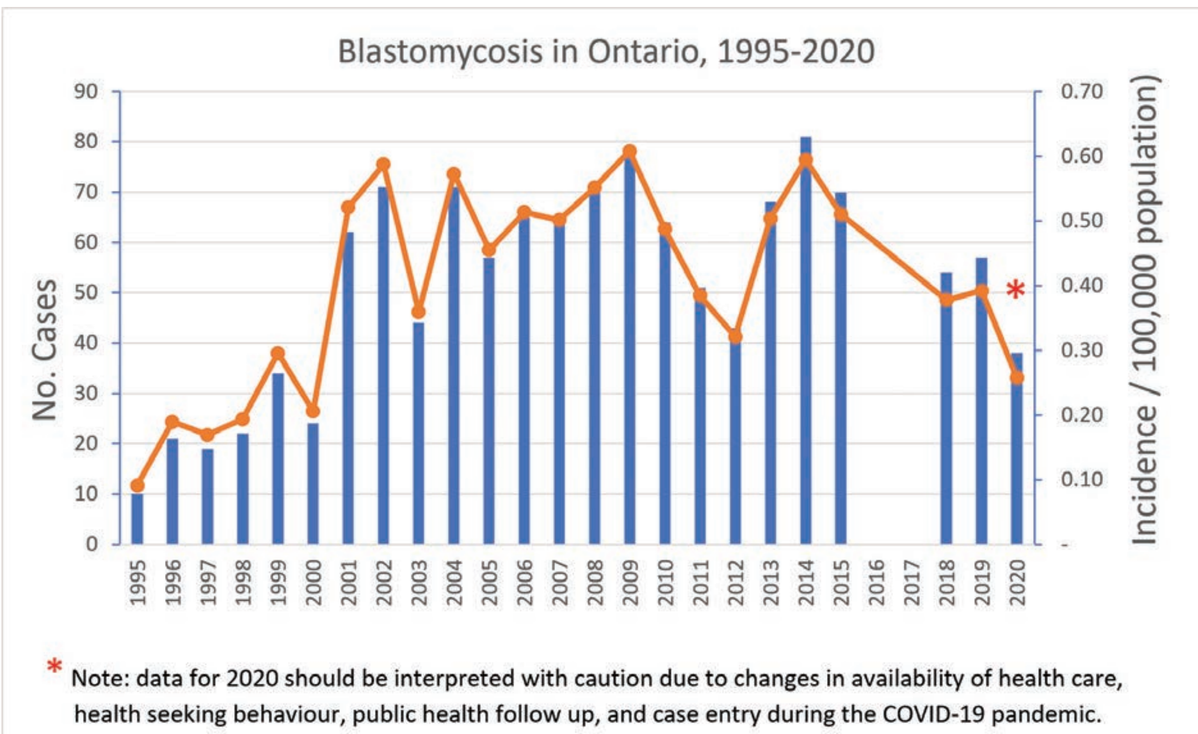

Figure 42 — The number of cases (bars) and annual incidence (line) of microbiology laboratory–confirmed blastomycosis in Ontario, Canada, 1995–2015 (from Brown et al., 2018) and 2018-2020 (added this report). Incidence was calculated using population denominators from Statistics Canada and for 2018-20, Public Health Ontario Monthly Infectious Diseases Surveillance Reports.

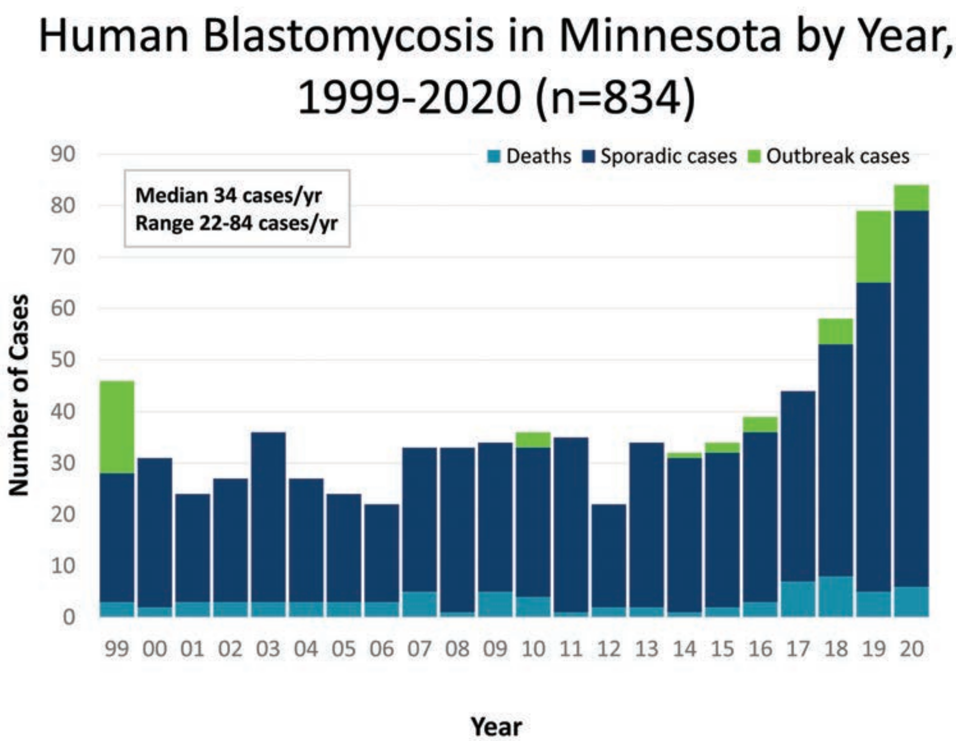

Figure 43 — Cases of blastomycosis in humans in Minnesota 1999-2020 (MDH, n.d.)

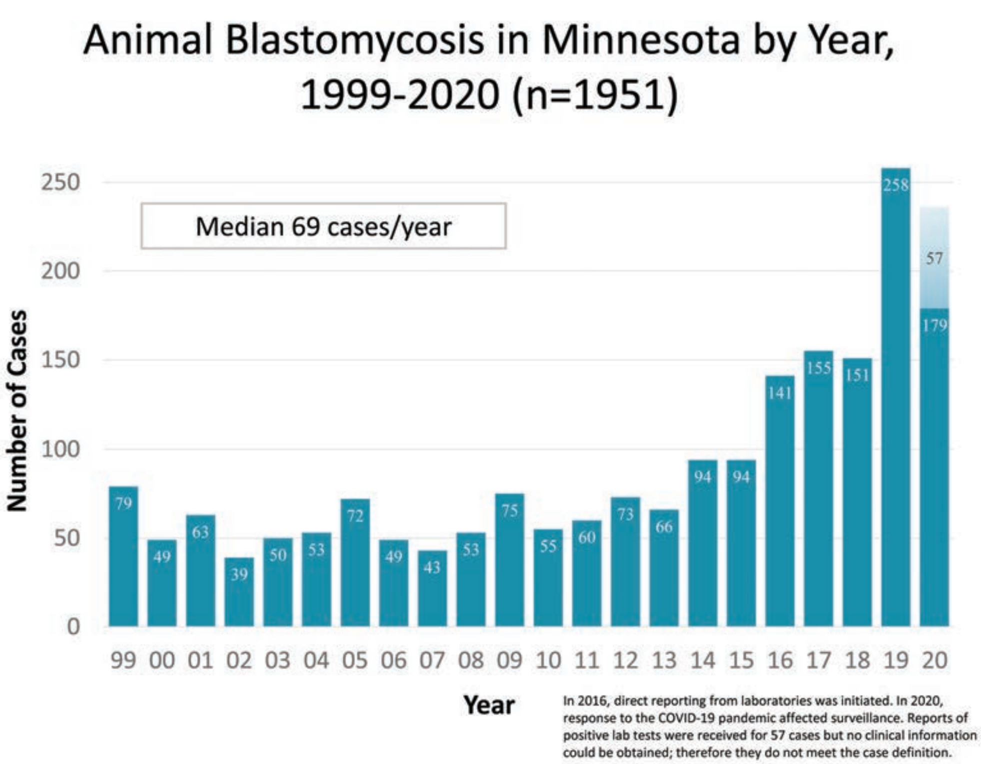

Figure 44 — Cases of blastomycosis in animals (96% dogs) by year 1999-2020 (MDH, n.d.)

CHAPTER 10 - MONITORING IN THE BASIN

The IRLWWB notes:

In the Rainy-Lake of the Woods basin, there has been widespread collection of data by the Ontario Ministries of Environment and Natural Resources (OMOE/OMNR) and by the Minnesota Pollution Control Agency (MPCA). Areas upstream of the Lower Rainy River have been monitored by Voyageurs National Park (VNP) and by MPCA and in many areas by citizen monitoring groups.

Much of this data collection has been through routine monitoring whereby samples are collected and analyzed for the same substances in the same locations either annually or on a rotating basis. Other data have been collected in connection with special studies that are limited in scope and these are often directed by universities or through non-governmental organizations to answer specific questions about local ecosystem health – for example, using satellite images to track the spread and severity of algal blooms between years. The result is that a great deal of data exists and much of this information is being combined to answer compelling questions that remain about water quality throughout the basin.

(IRLWWB, n.d.)

Editors' note: In addition to efforts noted above, additional widespread data collection has been completed by both ECCC's Water Quality Monitoring Division and the Watershed Hydrology and Ecology Research Division since 2008 to inform on nutrients, water quality and harmful algal blooms. Remote sensing of algal bloom severity is reported on from 2002 to present by ECCC's EOLakeWatch.

A vast amount of chemical and biological data are required to support the findings presented in this report. These data are required to address the major concerns but are needed as well to fulfill an impressive number of research initiatives that are ongoing in the basin. This emphasizes the fact that there are two basic kinds of monitoring data. The first is core monitoring that is essentially ongoing data collection at permanently established sample locations. These data can be used to support any number of scientific investigations through time. The second type of monitoring is project-specific monitoring that involves addressing specific questions in more localized areas. The differentiation between the two monitoring types is often blurred as long-term sample locations are discontinued or as project-specific sample locations turn into long-term monitoring program sample sites. It is therefore difficult to describe an essential core monitoring program that will satisfy the needs of multiple agencies and allow data to be shared between agencies through the adoption of standard sample collection protocols.

A major requirement for the future is to establish a core monitoring program that can coordinate and sustain monitoring at key locations throughout LoW and its basin. Elements of a core monitoring program have previously been assembled and this project should be moved forward for recognition by the various agencies responsible for monitoring. Needed is a multi-nationally agreed-upon approach to harmonize monitoring methodologies amongst the various federal, provincial and state agencies/organizations and Indigenous Nations conducting routine long-term monitoring. In addition, harmonization of research/monitoring activities to support stated bi-national objectives for the basin as a whole, given its high degree of interconnectedness, is required.

One notable gap is the need for more data assessment considering that many agencies house considerable data with no routine assessment provided.

Sentinel-2 satellite image of algal blooms in Lake of the Woods, October 4, 2021 (Dr. Caren Binding, ECCC EOLakeWatch)

CHAPTER 11 - ONGOING WORK TO ADDRESS CONCERNS

There is a significant amount of ongoing work conducted in the basin to address current concerns. Ongoing work to address the current list of concerns are listed in Table 11, and it is important to note that this is not a comprehensive list. Readers should look at the proceedings reports of the International Rainy-Lake of the Woods Watershed Forum from past years, to get a feeling for the broad scope of research that has been ongoing in the basin (https://www.lowwsf.com/forum-proceedings). A selection of these presentations that relate to the major concerns are listed in Appendix 1.

For a comprehensive list of ongoing projects in Minnesota see: https://www.pca.state.mn.us/water/healthier-watersheds

https://www.pca.state.mn.us/water/spending-watershed-implementation-projects.

Table 11 — Selected, current projects underway to address the list of concerns identified in this report.

Concern	Project	Agency
Nutrients	TMDL complete. Next steps implementation and assessment	MPCA
	Assessment of nutrient reductions to achieve satisfactory in-lake conditions based on satellite determinations of algal bloom severity- ongoing	ECCC
	TP measurements at numerous locations throughout the watershed	MECP LPP, ECCC, MPCA, VNP, Citizen monitors
	Fisheries and water quality monitoring on a rotational basis	Broadscale monitoring program, MN DNR
Contaminants	IWI mining mapping proposal	IRLWWB
AIS	Risk assessment phase 1 completed	IRLWWB
	Provincial and state education with respect to AIS	
Erosion	Sediment fingerprinting, ongoing	Koochiching soil and water
Fisheries	Ontario/Minnesota and shared waters fisheries assessment, ongoing	ON/MN
	Fisheries and water quality monitoring on a rotational basis	Broadscale monitoring program, MN DNR
Climate Change	Satellite monitoring of algal blooms include effects of climate change	ECCC
	Extensive stream monitoring efforts capture effects of climate change	USGS
	Climate change guidance framework	IJC

Lake of the Woods (Nancy Dunnel)

CHAPTER 12 - GAPS AND EMERGING CONCERNS

We are getting to the point where many science gaps have been effectively filled. Emerging concerns should remain much lower than those noted for more-developed watersheds. Potential gaps include:

- the IRLWWB Citizens Advisory Group maintains concerns around mining in the watershed, such that the need for developing an inventory of mining activities should be considered a gap
- there does not seem to be a data source in Canadian waters for AIS (a gap)
- the threat of Typha expansion and negative impacts to fisheries, wildlife, diversity, wild rice might also be considered a major gap and concern
- groundwater information remains sparse and may constitute a gap with respect to some studies, but it is unclear how groundwater gaps relate to the current list of concerns
- the lack of information available for the assessment of rule curve impacts on Rainy River was highlighted as a major data gap (IRLWWB – Sixth Annual Report, April 2018-March 2019)
- there is a need for more regular data assessment considering that many agencies collect and house considerable data with no regular assessment or interpretation provided
- equitable space for the respect of Indigenous Knowledge systems, cultural protocols and governance in decision-making and planning within the basin

Any previous recommendations that have not been addressed would be considered as an outstanding gap, and are listed in Table 12.

Sustainability

It is important to develop a sustainability plan for the R-LoW Basin, with multi-nationally agreed objectives, targets, and actions. A multi-national framework to oversee the plan will be required. Many of the pieces are now in place but some, such as a core monitoring program, still need to be developed.

It is important to develop a sustainability plan for the R-LoW Basin, with multi-nationally agreed objectives, targets, and actions. A multi-national framework to oversee the plan will be required. Many of the pieces are now in place but some, such as a core monitoring program, still need to be developed.

The IJC Lake of the Woods Water Quality Plan of Study (2015) provides the model with the key pillars of a sustainability plan, which include:

- Nutrient management to combat harmful algal blooms
- Aquatic Invasive Species prevention and response
- Surface and Groundwater contamination risk mitigation
- Systematic monitoring across the basin

The IJC established a watershed board (IRLWWB) for the R-Low Basin, with the support of the provinces, state, and the national governments. The watershed board has multinational participation of government agencies, First Nations, Métis, US Tribes and public members, with mechanisms to engage public and industrial stakeholders more broadly. With fine tuning and mechanisms of change in Water Governance, the board could provide the foundation of an inclusive framework for collaboration on management, and watershed solutions in the Rainy-Lake of the Woods Basin.

Governance

The established water governance structures in the basin do not fully acknowledge or incorporate Indigenous rights, knowledge, or worldviews. Considerable work is needed to advance towards the development and creation of equitable space to respect Indigenous Knowledge, cultural protocols, and governance. The creation of equitable space will guide the work in the basin to form a future multi-jurisdictional approach that allows for joint decision-making, shared vision, and ultimately better protection of the water. Progress in this area requires acknowledgement of the past, further understanding of current approaches and systems, as well as building on the existing governance framework to improve holistic watershed planning that will address the gaps outlined in this report and move forward to better protection and relationship with the water.

The established water governance structures in the basin do not fully acknowledge or incorporate Indigenous rights, knowledge, or worldviews.

At the end of the day, it can be said that the core values between the multiple Nations of the basin are similar, it is just the lenses, through which they are viewed, that differ. The protection and preservation of the water is at the root of every Nation, government, organization, community, and person, in order to be able to share the experiences and ways of life that have been grown accustomed to in the basin with future generations.

Moving forward the first step is to acknowledge the gap and then the past and to build on the relationships and understanding currently existing in the basin to work together to serve the water. This will chart a path forward to holistic watershed planning and protection that plays into water quality agreements, objectives, baseline monitoring, etc.

CHAPTER 13 - SUMMARY OF PREVIOUS RECOMMENDATIONS

There have been many successful responses to previous recommendations, especially if examined within the context of the first state of the basin report in 2009. The intensity and quality of research devoted to concerns within the basin since that time have been remarkable.

A list of previous recommendations produced by key reports is shown in Table 12. Recommendations that have been followed or acted upon are shown by cells highlighted in green.

Table 12 — Recommendations provided by previous review documents. Green cells indicate that progress with respect to the recommendation has been made. Yellow cells identify monitoring recommendations since core monitoring programs are not in place.

	SOBR First Edition - 2009
SOBR1-1	enhance meteorological monitoring
SOBR1-2	improve spatial coverage for the collection of deposition chemistry
SOBR1-3	improve bathymetric maps and water circulation/internal water movement data
SOBR1-4	collect further data on internal loading and release rates of nutrients from lake sediments
SOBR1-5	quantify tributary nutrient loads to the Rainy River and LoW
SOBR1-6	quantify non-point source anthropogenic contributions of nutrients
SOBR1-7	improve the spatial distribution of water quality monitoring sites with continued discussion regarding the location and sampling frequency of core monitoring sites
SOBR1-8	integrate GIS base layers from U.S. and Canadian watersheds
SOBR1-9	improve understanding of algal abundance and composition, and algal toxins in LoW
	SOBR 2nd Edition - 2014
SOBR2-1	continued support for the IJC, Rainy-LoW Watershed Board governance model
SOBR2-2	ensure continued communication
SOBR2-3	secure funding for monitoring and research
SOBR2-4	fill information gaps for each of the listed basin concerns
SOBR2-5	assess adequacy of current monitoring programs.
SOBR2-6	assess the need for International Water Quality Objectives
	IJC Plan of Study - 2014
Pos-1	coordinated Implementation of a tiered monitoring program for the LoW Basin
PoS-2	review of data collection programs and monitoring in the headwaters regions of the basin
Pos-3	assessment of monitoring networks for meteorological conditions and atmospheric deposition of nutrients and contaminants
PoS-4	development of regional climate models for the basin and improved public education and engagement on the issue of climate change
Pos-5	development of a LoW basin geospatial mapping framework
PoS-6	collection of ecosystem information and discussions of ecosystem health with Indigenous communities
Pos-7	enhancement of the IRLWWB website as a public communications tool
PoS-8	mass-balance models for phosphorus and nitrogen: towards an understanding of the sources and sinks of nutrients in the LoW Basin
Pos-9	application of water quality models at watershed and basin-wide scales to apportion nutrient sources and run scenarios
PoS-10	improved understanding of internal loads and hypoxia in LoW
Pos-11	application of the Phosphorus-Ferrous Conceptual Model to Lake of the Woods

PoS-12	assessment of nutrient subsidies from shorelines due to erosion from high water levels in lakes and high flows in rivers
Pos-13	development of predictive models of algal blooms based on hydrological forcing, wind dynamics and water circulation
PoS-14	application of satellite imagery and remote sensing tools to map and characterize water quality and algal blooms in LoW with application to other transboundary lakes
PoS-15	development of aquatic food web models focusing on how zooplankton communities and trophic structure affect production of harmful algal blooms
PoS-16	taxonomic characterization of algal communities and algal toxins
PoS-17	public health and animal welfare risks including public alerting mechanisms
PoS-18	binational aquatic invasive species management team for the LoW basin and development of a binational prevention strategy
PoS-19	rapid evaluation and implementation of options to manage recent Zebra Mussel infestation in headwaters areas in Minnesota
PoS-20	ecological impact of the spiny waterflea in infested boundary lakes
PoS-21	develop and implement adaptive control measures for hybrid cattail and rusty crayfish.
PoS-22	comprehensive Assessment of Potential Invasion Risks to and within the LoW basin
PoS-23	water quality risk assessment for Zebra Mussels and Quagga Mussels
PoS-24	climate risk assessment for aquatic invasive species
PoS-25	assessment Report on Contaminants in Water, Aquatic Sediment, and Fish
PoS-26	spatial Survey of Contaminants of Emerging Concern
PoS-27	assess vulnerability of border waters to contamination from mining, agriculture, and petroleum transport
PoS-28	annual mining effects science workshop
PoS-29	determine the most appropriate working relationship between the IMA Work Group and the IRLWWB
PoS-30	feasibility of establishing a binational agreement on water quality and ecosystem health of the LoW Basin
PoS-31	pilot project to adapt Minnesota's watershed assessment process to Ontario waters
PoS-32	feasibility of establishing a funding program for NGOs to promote stewardship
PoS-33	binational water quality management for the LoW basin
	Rainy Namakan Rule Curve Review 2017
RNRC-1	adopt Rule Curve Alternative C
RNRC-2	promote flexible operation to improve outcomes
RNRC-3	provide the Water Levels Committee (WLC)with terms of reference
RNRC-4	empower the WLC to direct targets outside of the Rule Curve range
RNRC-5	examine practical operational approaches to benefitting Rainy River interests
RNRC-6	review data monitoring sources to support inflow forecasting by the WLC
RNRC-7	formalize pre-spring engagement by the WLC
RNRC-8	investigate adaptive management
RNRC-9	advise governments about Rainy outlet modification
RNRC-10	examine approaches for developing and sustaining improved relationships and communications with First Nations, Métis and Tribes on water issues

	Objectives and Alerts (phase 1) - 2019
	Recommendations' adoption pending completion of phase 2
OA-1	the board to recommend to governments that the Water Quality Objectives (WQOs) and Alert Levels (ALs) be adopted as described in Section 9 of the report
OA-2	Aquatic Ecosystem Health (AEH) should be assessed by one or all of the suggested approaches described in Section 3 of the report. Some guidance is required to identify the preferred approach to using AEH indicators to identify ALs for AIS, climate change, erosion and other associated risks that may not be aligned with the key priorities.
OA-3	Put a process in place to ensure that stakeholders and Indigenous communities' concerns are addressed. This could be accomplished with the ability to bring forward Alerts associated with demonstrated risk.
OA-4	Communication between rule curve or water level boards be established when water levels are shown to be associated with WQOs or ALs.
OA-5	The need for and efficacy of established WQOs and ALs be reviewed at a 5-year interval. The principles of adaptive management should be used in the course of these reviews.
OA-6	The board should determine how and why the information associated with WQOs and ALs is to be used and determine its capacity to manage and report on findings.
OA-7	When the board recognizes that a WQO has been exceeded, it will recommend that the exceedance be assessed by both governments.
OA-8	When the board recognizes that an AL has been triggered, it will advise that the AL be assessed by both governments.
OA-9	Concerns with respect to AEH indicators in all consultation sessions should be reviewed in Phase II to ensure that they align with the final WQOs and ALs.
OA-10	Advice from Indigenous elders was to keep the final recommendations simple and brief, to incorporate the concept of respect for water in the discussions throughout this project and in its outcomes.

Recommendations Going Forward

Governance

1. Research into the historical impacts to and grievances with Indigenous Nations.

2. Further understand the responsibilities of Treaty Partnerships and Relationships.

3. Further understand the relationship of Indigenous Treaties with the Boundary Waters Treaty.

4. Research the vision and process to water protection in the Rainy-Lake of the Woods Basin that is respectful of all Nations and jurisdictions in the basin.

5. Indigenous Engagement to understand how each nation looks to be included in decision-making and governance and how Indigenous Nations view Water Governance, Regulation and Management.

6. Development of understanding of western mechanisms and how they impact the Boundary Waters Treaty (UNDRIP, FPIC, Truth and

Reconciliation Commission, etc.). What mechanisms need to be created?

7. Establish table of Indigenous Nations in the basin.
8. Establishment of a shared vision or agreement for the basin inclusive of Indigenous Nations.
9. Explore what frameworks of co-management can be applied to the R-LoW Basin?
10. Explore what mechanisms are available for data sharing across the basin and inclusion of Indigenous Nation monitoring data in all below categories?

Nutrients and algal blooms

1. Core monitoring program should be established to monitor effects of nutrient reduction strategies.
2. Relationship between nutrients and satellite derived bloom intensity should be formed.
3. Explore the relevance of nitrogen limitation.

Core monitoring program should be established to monitor effects of nutrient reduction strategies.

Climate change

1. Continue to recognize and advocate for reduced emissions of greenhouse gasses.

Contaminants

1. Develop a watershed mining activity map.
2. Continue and expand public awareness of mercury contamination in fish.

Aquatic invasive species

1. Complete phase 2 of risk assessment.
2. Harmonize AIS prevention efforts (regulations and Best Management Practices) in the full watershed.

Water levels/erosion

1. Develop tools to address the effects of drought.
2. Explore need for better understanding with respect to groundwater (little is known).
3. Explore the effects of lake volume on algal blooms.

Fish & fisheries

1. Continued support for ON/MN Fish Atlas.

Other

1. Consider sustainability in management decisions.
2. Examine aspects of changing human activity in the basin.
3. Continue to improve multinational governance models.
4. Continue to embrace the concept of adaptive management.
5. Establish core monitoring requirements.
6. Encourage summaries and synthesis for existing data.

Coring on Lake of the Woods

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APPENDIX 1 — LIST OF SELECTED FORUM PRESENTATIONS BY TOPIC (2014-2021)

Key presentations are listed below by previously established priority concerns. Forum proceedings are available at https://www.lowwsf.com/watershed-forum

Nutrients and Algae

2014

A historical phosphorus budget for Lake of the Woods: Biogeochemical and diatom records in the southern basin, 2014. Edlund, M.B., Reavie, E.D., Schottler, S., Hougardy, D., Wattrus, N., Baratono, N. Paterson, A.M., Engstrom, D.R.

2015

Paleolimnology of the southern basin of Lake of the Woods, Part 1: the sedimentary record. Euan D. Reavie, Mark B. Edlund, Norman A. Andresen, Daniel R. Engstrom.

A historical phosphorus budget for Lake of the Woods: legacy loads still affect the southern basin. M.B. Edlund, E.D. Reavie, S. Schottler, N. Baratono, A.M. Paterson, D.R. Engstrom.

Diffusive phosphorus flux and sediment characteristics in Big Traverse, Lake of the Woods: update on 2014 research. William F. James.

Phosphorus sources for the Rainy River / Lake of the Woods watershed. Christopher D. Lupo and Julie A. Blackburn.

Recent and historic phytoplankton and cyanobacteria changes in Lake of the Woods. Hedy J. Kling, Sue Watson, Claire Reis (Herbert), Michael P. Stainton, Gregory McCullough.

2016

Harmful algal blooms in Minnesota: A review of recent incidents, research findings, and questions that need to be answered. Steve Heiskary and Jesse Anderson.

Understanding cyanobacterial toxins - we've come a long way. Brian Kotak, Susan Watson and Hedy Kling.

Using molecular tools to understand and predict cyanobacterial harmful algal bloom toxicity in Kabetogama Lake, Voyageurs National Park, Minnesota. Erin A. Stelzer, Victoria G. Christensen, Donna S. Francy, and Ryan P. Maki.

Developing a spectral inference model to measure trends in cyanobacterial pigments in lake sediments. Hadley, K.R., Paterson, A.M., Michelutti, N., Karst-Riddoch, T., Watson, S.B., Gregory-Eaves, Zastepa, A., Smol, J.P., and Hutchinson, N.

High-frequency monitoring of stratification and sediment re-suspension in Lake of the Woods. Heathcote, A.J., Edlund, M.B., Engstrom, D.R., Hernandez, C.

Diffusive Phosphorus Flux in Big Traverse, Lake of the Woods. William F. James.

Assessing long-term nutrient and primary production trends in embayments containing Lake Trout in Lake of the Woods, Ontario. Clare Nelligan, Adam Jeziorski, Kathleen M. Rühland, Andrew M. Paterson, and John P. Smol.

Lake of The Woods Total Maximum Daily Load Study: A progress report Hernandez C., Hirst M., Kramer, G.

2017

Algal toxins in Lake Kabetogama, Voyageurs National Park. Victoria Christensen, Erin Stelzer, and Ryan Maki.

Historical phosphorus dynamics in Lake of the Woods: Does legacy phosphorus still affect the southern basin?

Edlund, M.B., Schottler, S., Reavie, E.D., Engstrom, D.R., Baratono, N., Leavitt, P., Heathcote, A.J., Wilson, B., Paterson, A.M.

Lake of the Woods Total Maximum Daily Load Study: A progress report. Cary Hernandez, Mike Hirst, Geoff Kramer.

2018

Algal blooms, toxin production, and potential effects on ecosystem health, Kabetogama Lake, USA. Victoria G. Christensen, Ryan P. Maki, Erin A. Stelzer, and Jaime F. LeDuc.

Remote sensing indices for enhanced monitoring of algal blooms on Lake of the Woods. Binding, C. E., Zeng, and Narayanan, A.

Harmful Algal Blooms in Lake of the Woods. Arthur Zastepa.

ECCC's Lake of the Woods Integrated Modelling. Reza Valipour, Isaac Wong, Craig McCrimmon, Jun Zhao, Felix Ouellet, Paul Klawunn and Ram Yerubandi.

Lake of The Woods Total Maximum Daily Load Study: A progress report. Cary Hernandez, Mike Hirst, Geoff Kramer.

2019

Cyanobacterial and harmful algal blooms in Lake of the Woods. Arthur Zastepa.

Algal bloom remote sensing on Lake of the Woods; update on 2018 conditions and in situ validation efforts. Caren E. Binding, Zeng, C., and Pizzolato, L.

Trent University Watershed Loading Study Part One: Characterizing the hydrology of the Lake of the Woods watershed. Wes Greenwood and Catherine Eimers.

Trent University Watershed Loading Study Part Two: Updated estimates of tributary loading: importance of storm events and year-round measurements. Catherine Eimers and Wes Greenwood.

ECCC's Lake of the Woods integrated modelling – lake and watershed. Reza Valipour, Craig McCrimmon, Ram Yerubandi, Jun Zhao, Phil Fong.

Linking science to management solutions: How sediment records and paleolimnology are informing lake management in the basin. Mark Edlund, Burge, D.R.L., Heathcote, A.J., Ramstack Hobbs, J.M., Bowe, S., Reavie, E.D., Oakes, D.A., Hernandez, C., Anderson, J.P.

2020

Lake of The Woods Total Maximum Daily Load Study: A progress report. Cary Hernandez, G. Kramer, J. Blackburn.

Algal toxin exposures on Reserved Federal Lands and Trust Species. Z. Laughrey et al. (Victoria Christensen).

Harmful Algal Blooms Update. Janette Marsh and Wendy Drake.

An integrated modelling and monitoring framework for assessing nutrient dynamics and algal blooms in Lake of the Woods. Ram Yerubandi.

Phosphorus loading in the LOW watershed: tributaries and atmospheric deposition. Catherine Eimers.

Spatiotemporal diversity of phytoplankton structure and function in Lake of the Woods: Insights into bloom formation and toxin production. A. Zastepa.

An overview of ECCC's progress in satellite remote sensing of algal blooms on Lake of the Woods. Caren Binding.

Application of CanSWAT watershed modelling for Lake of the Woods. Craig McCrimmon.

2021

Environment & Climate Change Canada ECCC Policy: Proposed Objectives and Scenarios to reduce harmful algae in Lake of the Woods. Daniel Rokitnickiwojcik ECCC.

Spatio-temporal trends in hydroclimatic conditions for the Rainy River-Lake of the Woods watershed: implications for nutrient export. Wes Greenwood, Catherine Eimers, and Andrew Williams.

Then and now: Updating the nutrient budget for the Canadian Rainy- Lake of the Woods basin. Andrew Williams and Catherine Eimers.

Multi-year simulations, Under ICE dynamics and Climate Change Scenarios: outcomes from observations and the application of a coupled watershed-lake model of Lake of the Woods. Reza Valipour, Phil Fong, Rajesh Shrestha, Jun Zhao and Craig McCrimmon.

Minnesota Lake of the Woods Phosphorus TMDL Update. Cary Hernandez.

Cyanotoxins in fish at Voyageurs National Park. Seth McWhorter.

Invasive species

2014

Long term monitoring in Minnesota lakes — Interactions between Bythotrephes longimanus and native zooplankton communities. 2014. Hirsch, Jodie K.

2015

Spread, control and effect of exotic cattails on wild rice in the Rainy Namakan. John Kabatay, Peter Ferguson Lee and O'Niell Tedrow.

2016

Influences of water depth on wild rice (Zizania sp.) growth, development, and density. O'Niell Tedrow, Peter Ferguson Lee, Kristi Dysievick, and John Kabatay.

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Testing for potential impacts of Orconectes rusticus (rusty crayfish) on wild rice in Dumbell Lake, MN. Kelsey Wenner and Tyler Kaspar.

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Restoration of hybrid cattail dominated wetlands in Voyageurs National Park. Bryce Olson, Claire Kissane, Steve Windels.

Hotspots of Bythotrephes (Spiny Water Fleas) in Lake of the Woods: Where? When? Why? Brenda Hann

Rusty crayfish (Orconectes rusticus) monitoring and control in the Rainy Basin. Sonja Smerud, Darren Lilja, and Derrick Passe.

2019

Status of zebra mussel spread in the Big Fork River, Minnesota, USA. Michael Duval and Rich Rezanka.

2020

Hybrid cattail removal and wetland restoration in Voyageurs National Park: A project update. Reid Plumb.

2021

Impacts of invasive spiny water fleas and zebra mussels on first-year growth of walleye and yellow perch in Minnesota's large lakes. Gretchen Hansen, Tyler Ahrenstorff, Bethany Bethke, Josh Dumke, Jodie Hirsch, Katya Kovalenko, Jamie LeDuc, Ryan Maki, Heidi Rantala, Tyler Wagner.

Do Spiny Water Flea Push Walleye, Sauger, and Yellow Perch Out of the Pelagic Zone? Bethany Bethke, Gretchen Hansen, Heidi Rantala, Tyler Ahrenstorff, Holly Wellard-Kelly, Katya Kovalenko, Josh Dumke, Ryan Maki, Jodie Hirsch, Valerie Brady, Jaime LeDuc.

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Risk Assessment Tool for Aquatic Invasive Species to the Rainy-Lake of the Woods Basin. Amanda Bell (USGS, IJC-IMA Project).

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Potential environmental impacts of the Twin Metals Mine 2014. Baker, Lawrence A.

Potential Risks of Underground Nickel/Copper Mines in the Kawishiwi Watershed. Myers, Tom

2016

Mine-Impacted-Water Threats from the St Louis River Watershed to the Lake of the Woods. Tom Myers.

2017

Mitigating the contaminated source of traditional foods with an uncontaminated river system. Peter Ferguson Lee, Kristi Dysievick, and John Kabatay.

2018

Mitigating the contaminated source of traditional foods with an uncontaminated river system. Peter Ferguson Lee, Kristi Dysievick, and John Kabatay.

Phosphorus and mercury reduction as a result of plant upgrades at NKASD. Cyndy Strand.

Lake of the Woods Monitoring Updates from ECCC: pre-mining metal concentrations in Lake of the Woods and Rainy River. Tana McDaniel and Tim Pascoe.

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2019

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The effect of changes in atmospheric deposition on mercury accumulation by zooplankton and fish: the METAALICUS project. Paterson, M.J., P.J. Blanchfield, L.E. Hrenchuk, H.H. Hintelmann.

2020

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2014

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Influencing ecological properties using water level management. James H. Larson, David F. Staples, Ryan P. Maki, Jon M. Vallazza, Brent C. Knights, Kevin E. Peterson, Brian R. Gray.

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Simulating flooding impacts on the Rainy and Namakan chain of lakes to compare rule curve performance. Mike Shantz. Environment Canada, Burlington, ON.

Effects of water management regime of Rainy Namakan system on wild rice production. O'Niell Tedrow , Peter Ferguson Lee, John Kabatay.

Correlating turbidity, depth, and upstream dam releases with wild rice (Zizania palustris) production in the Seine River, Northwestern Ontario. Stephanie Reid, Peter Ferguson Lee.

Using corrected benchmark elevations and high-resolution bathymetry to address water-level management in Rainy Lake and Namakan Reservoir. J. R. Ziegeweid, R. J. Silliker, B.K. Densmore. U.S. Geological Survey Minnesota Water Science Center; Mounds View, MN 55112.

Model predictive control strategies for implementing rule curves for the Namakan Reservoir / Rainy Lake watershed. Jeffrey C. Kantor.

Trophic state in Voyageurs National Park lakes before and after implementation of a revised water level management plan. V.G. Christensen and Ryan P. Maki.

Beaver lodge site selection in large lake environments. Steve K. Windels, Joshua B. Smith, Jerrold L. Belant, Brian E. McLaren.

Estimating the effect of water-level fluctuations on the reproductive success of common loons. Steve Windels, Steve Gutreuter, and Ryan Maki.

2D modeling of the impacts of water level regulation on vegetation: the cases of wild rice and cattail. Marianne Bachand, Sylvain Martin, Julien Hénault-Richard, Olivier Champoux, Patrice Fortin, Jean Morin.

Potential role of sediment resuspension on nutrient dynamics in Lake of the Woods. Reza Valipour, Ian Droppo, Johann Biberhofer, Jun Zhao, and Yuanrong Pan.

2016

The Study of the International Rainy and Namakan Lakes Rule Curves Begins. Matt DeWolfe, Col. Daniel Koprowski, Syed Moin, Larry Kallemeyn, Erika Klyszejko, Pam Tomevi, Scott Jutila, Jean Morin, Bill Werick.

Defining the Best Rule Curve for the Environment. Jean Morin Marianne Bachand & Sylvain Martin.

Modeling the impact of water level regulation on spawning habitat of lake sturgeon in the Rainy River. Marianne Bachand, Sylvain Martin, Olivier Champoux, Jean Morin.

Multivariable Control of Lake Levels and Stream Flows in the Namakan Reservoir/Rainy Lake Watershed. Jeffrey C. Kantor.

2017

Making the decision about the 2000 Rule Curves. Bill Werick. International Rainy Namakan Rule Curve Study Board.

An environmental Rule Curve for the Rainy-Namakan system. Jean Morin, Marianne Bachand, Guillaume Guénard, Sylvain Martin & Bill Werick.

Estimating inflows and forecasting ice-out for adaptive management of the Rainy Lake and Namakan Reservoir. Jeffrey C. Kantor.

Do the past Rules Curves improve the conditions for the spawning of lake whitefish in Rainy Lake and Namakan Reservoir? Marianne Bachand, Sylvain Martin and Jean Morin.

2021

Little Fork River Sediment – decoding sources with sediment fingerprinting to help guide management. Anna Baker and Faith Fitzpatrick.

Water regulation, wild rice, and the ongoing production of settler colonialism on Rainy Lake. Johann Strube.

Climate Change

2015

Modeling the effects of past climate change on boreal lakes. Daniel R. Engstrom, Mark B. Edlund, James E. Almendinger, Xing Fang, Joan Elias, Ulf Gafvert, David VanderMeulen.

2016

A multi-disciplinary examination of the effects of climate change in the deciduous-boreal forest ecotone of northern Minnesota and northwestern Ontario. N. Baratono, A. Paterson, K. Rühland, M. Edlund, L. Frelich, W. Herb, P. Jacobson, T. McDaniel, S. Malick, T. Pascoe, E. Reavie, M. Seeley and S. Windels.

Recent and long-term climate change in northwest Ontario: assessment of past changes from lake sediments. Brian Cumming.

Using predictive modeling to assess lake ecosystem responses to stressor gradients. Richard Kiesling and Erik Smith.

The effects of climate change on small boreal lakes of the Canadian Shield. Scott N. Higgins, P. Blanchfield, C. Emmerton, M. Guzzo, M. Paterson, M. Rennie, and Ken Sandilands.

Fisheries

2015

Hydraulic and eco-hydraulic conditions of critical spawning habitats in the upper Rainy River under the 2000 Rule Curve. J.W. Muirhead and W.K. Annable.

Studies of the upper Rainy River food web and variations in spawning critical habitats in relation to flow. Adrienne

Smith, Karen Smokorowski, Jerome Marty, Evan Timusk, Michael Power.

Habitat use within a juvenile nursery hole by adult and juvenile lake sturgeon in the Namakan River. Jim Burchfield, Cameron Trembath, Brian McLaren.

2017

Bass population status in Lake of the Woods, Ontario: Kenora Bass International monitoring program 1993-2015. Christopher Martin.

2018

The Ontario – Minnesota Boundary Waters Fisheries Atlas: Fisheries management and collaboration on shared border waters Kevin E. Peterson.

Biological Reference Point Framework. Blair Wasylenko.

Fish stock status – Lake of the Woods in Ontario. Victoria Danco.

Status and management of the fishery – Lake of the Woods in Minnesota. Phil Talmage.

Fish and fishery monitoring in Rainy-Lake of the Woods Watershed. Kim Armstrong.

MN DNR update on the current status of fish stocks in Rainy Lake and the Namakan Reservoir. Ben Vondra.

Sampling techniques for juvenile Lake Sturgeon in the lower Rainy River: Past, present, and future. Brett Nelson.

Modelling the effect of juvenile population density on recruitment of lake sturgeon in the Namakan Chain of Lakes. Jim Burchfield and Brian McLaren.

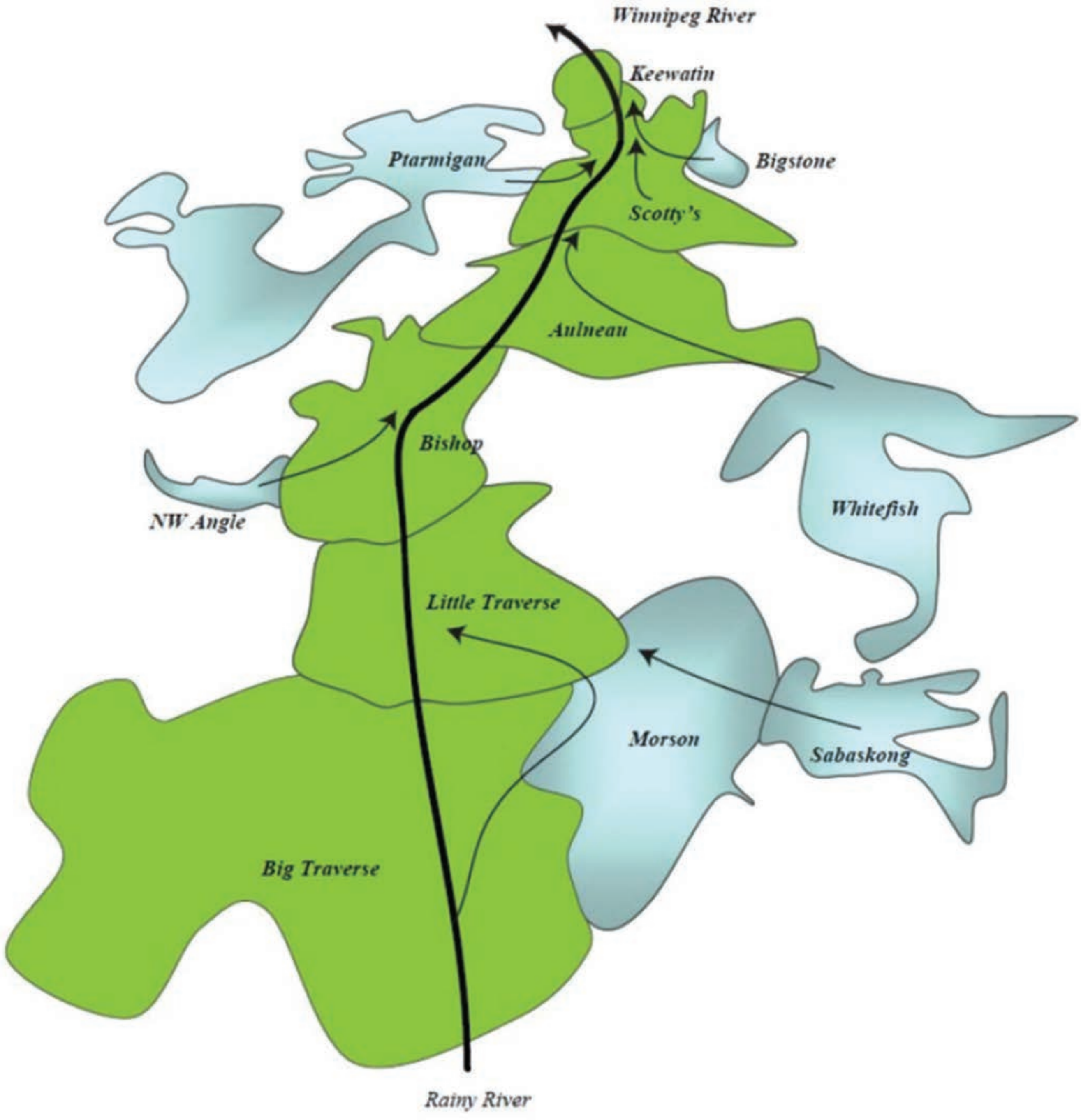
2021

Lake of the Woods fisheries management council's walleye sportfishing exercise. Steve Bobrowicz Ontario Ministry of Natural Resources and Forestry.

Emerging concerns

2015

Removal of contaminants of emerging concern in sewage. Craig Murray.



Lake of the Woods basins and flows schematic (David Malaher)

APPENDIX 2 — ECCC TP DATA PLOTS BY LAKE ZONE

The following data plots are organized from North to South by Lake Zone per naming convention used by Environment and Climate Change Canada in its lake TP load-response modeling. Please refer to the figure below for locating the lake plots for regions of the lake.

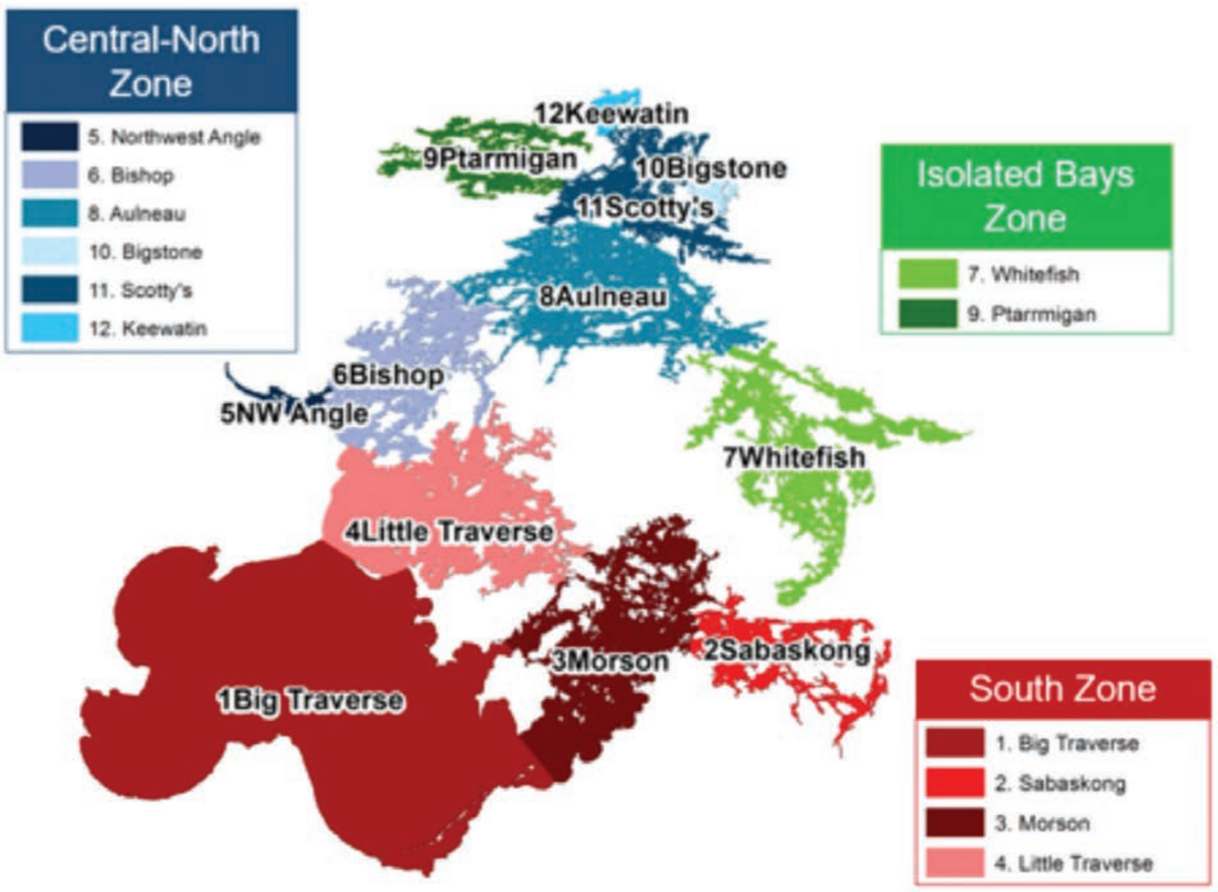
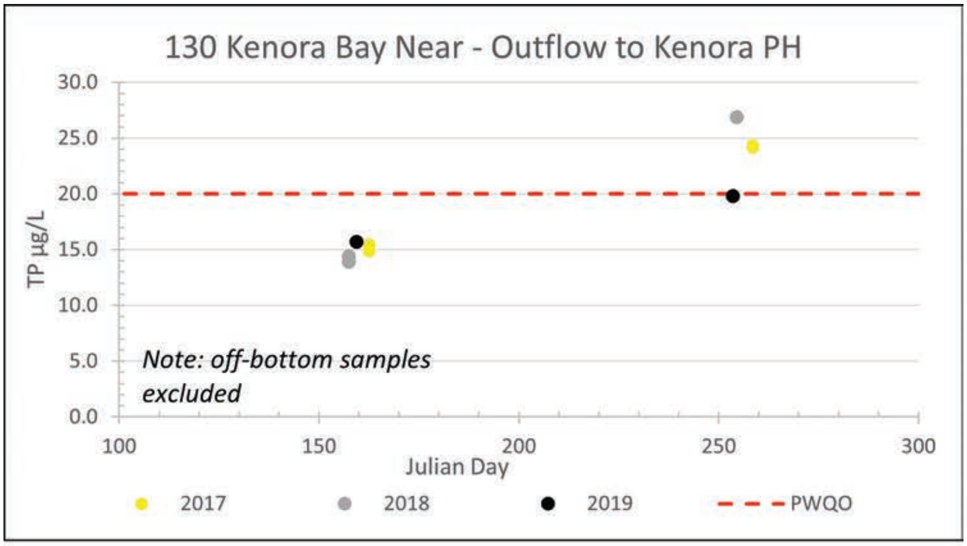
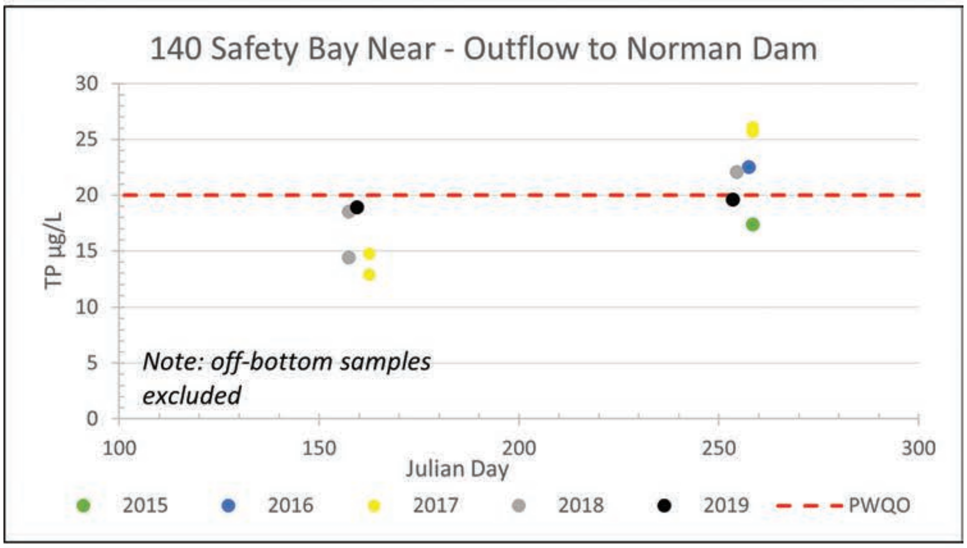
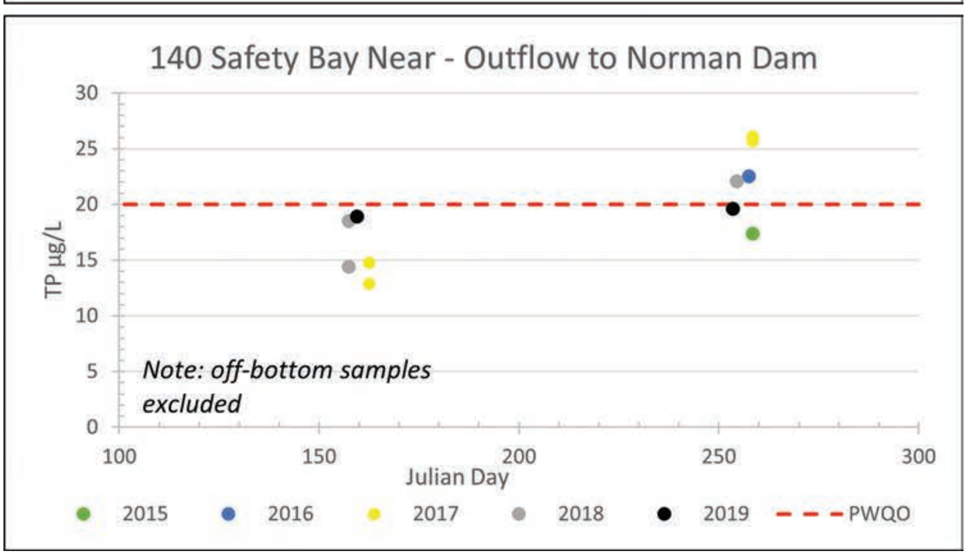


Figure 45 — Lake zone partitioning used by ECCC in its lake modeling, ECCC Factsheet "Proposed Ecosystem Objectives and Phosphorus Reduction Scenarios to Manage Algal Blooms in Lake of the Woods", February 2020

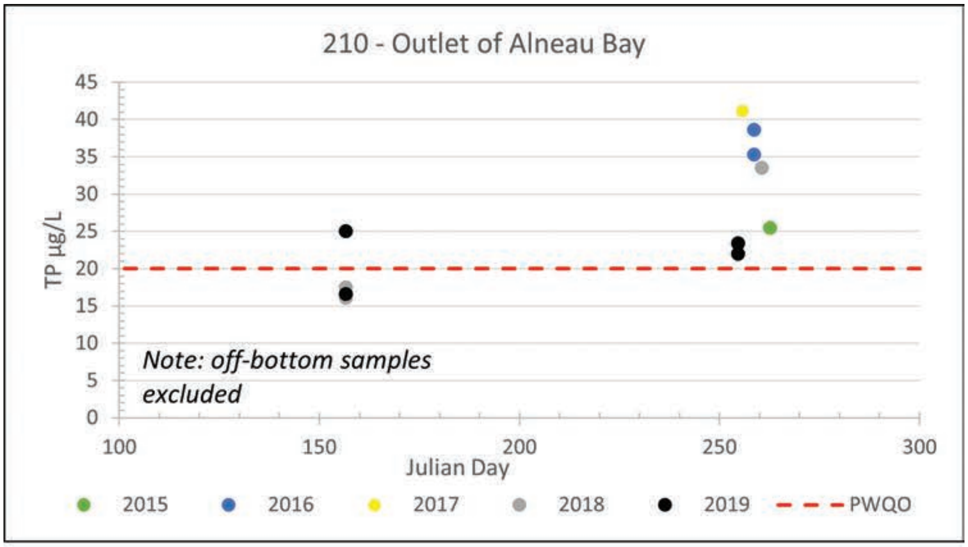
North Central Zone “Keewatin Bay”

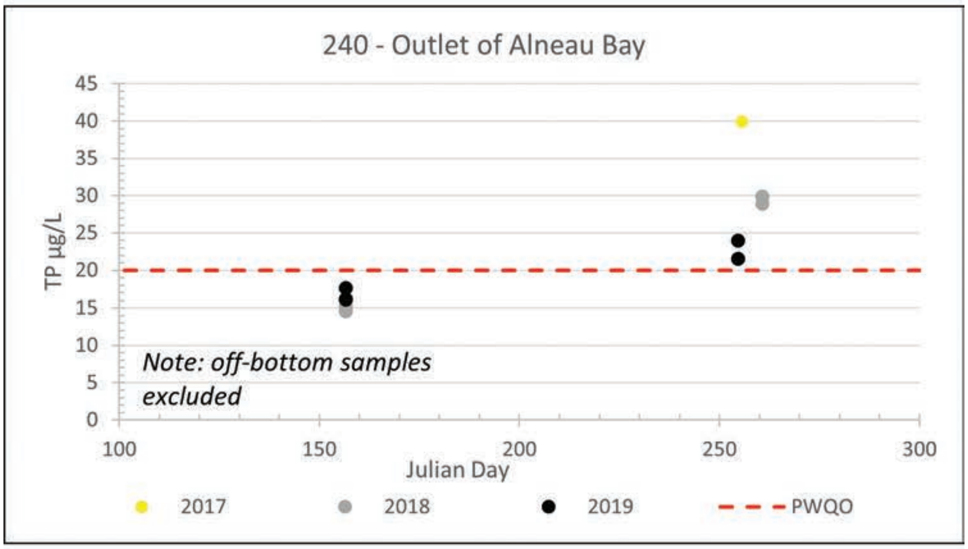


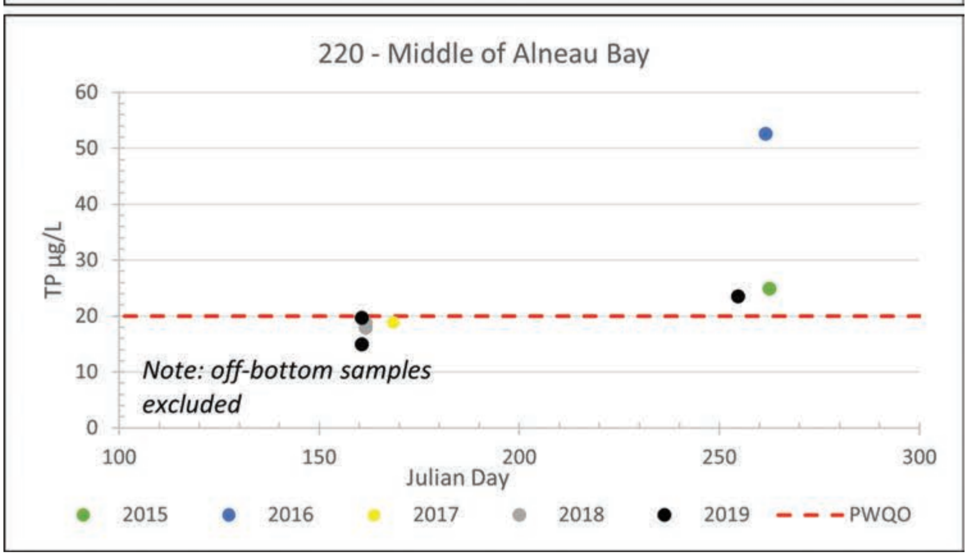




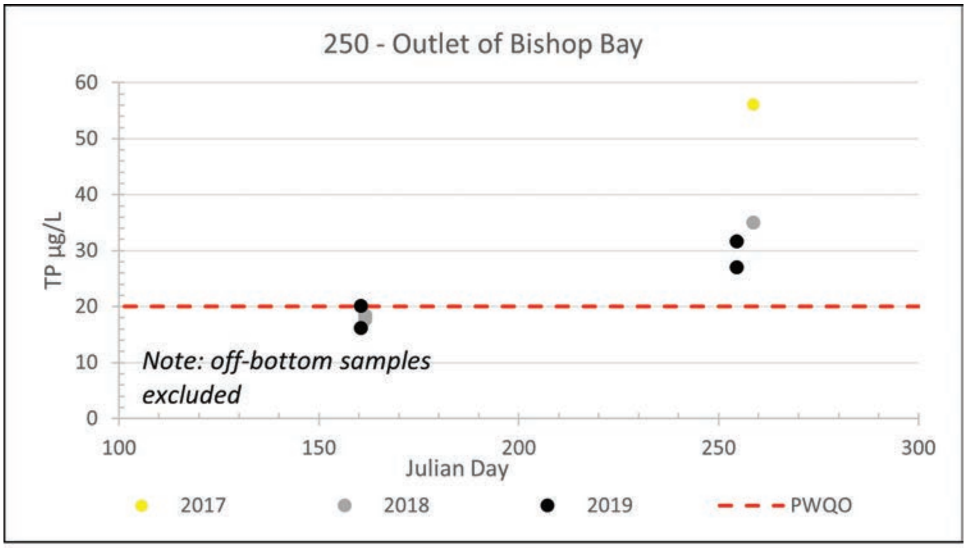
North Central Zone “Alneau Bay”

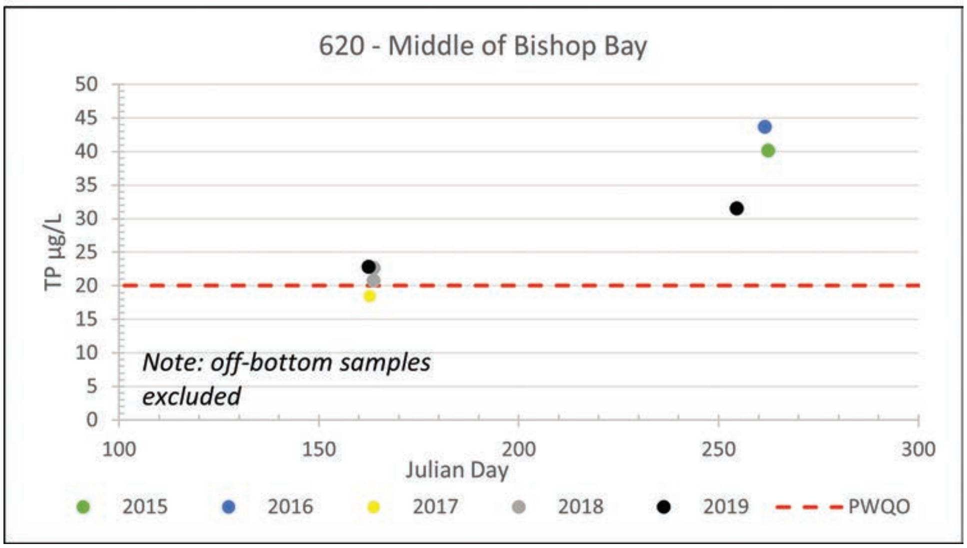




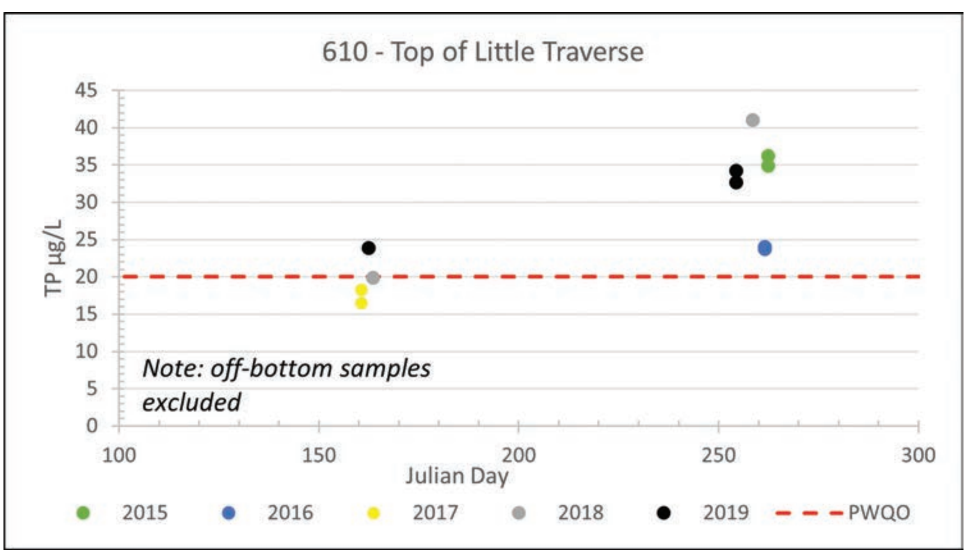


North Central Zone "Bishop Bay"



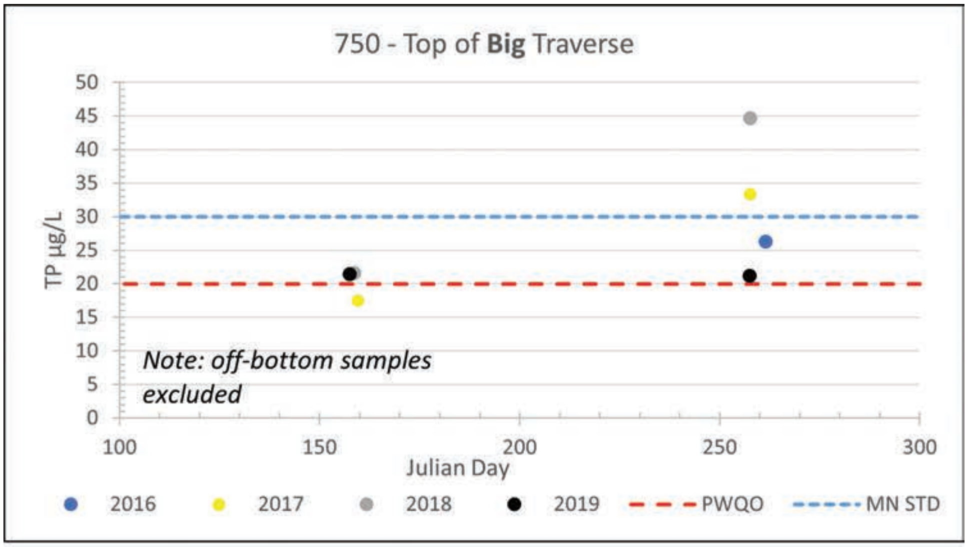


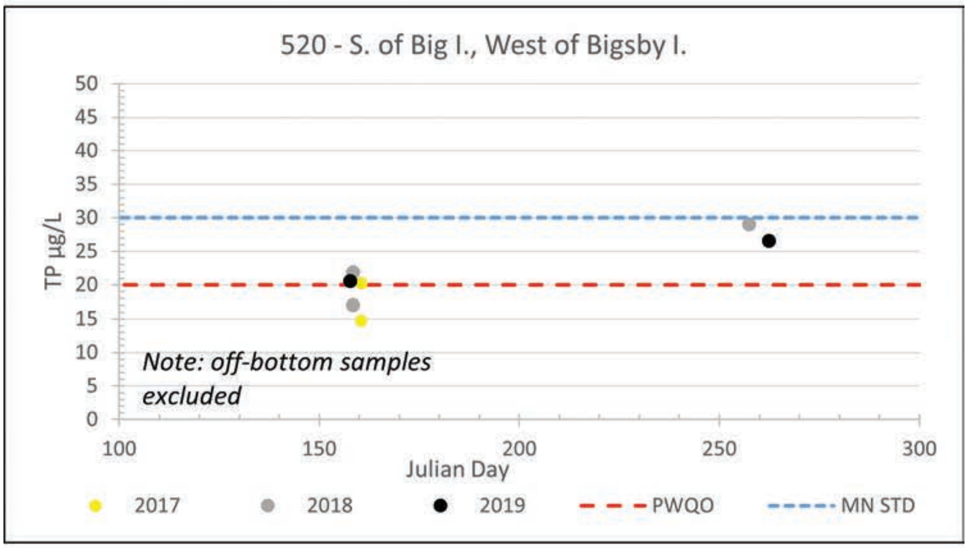
South Zone "Little Traverse"

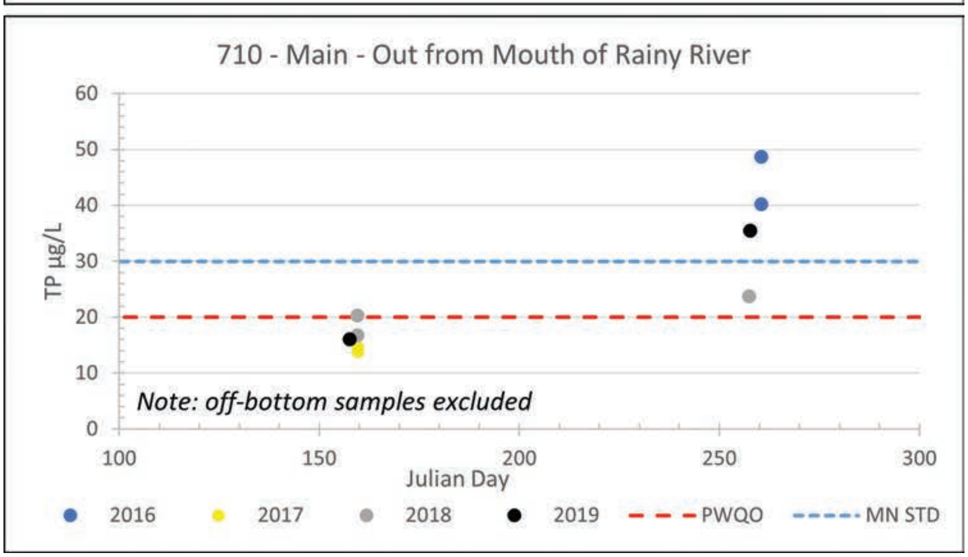


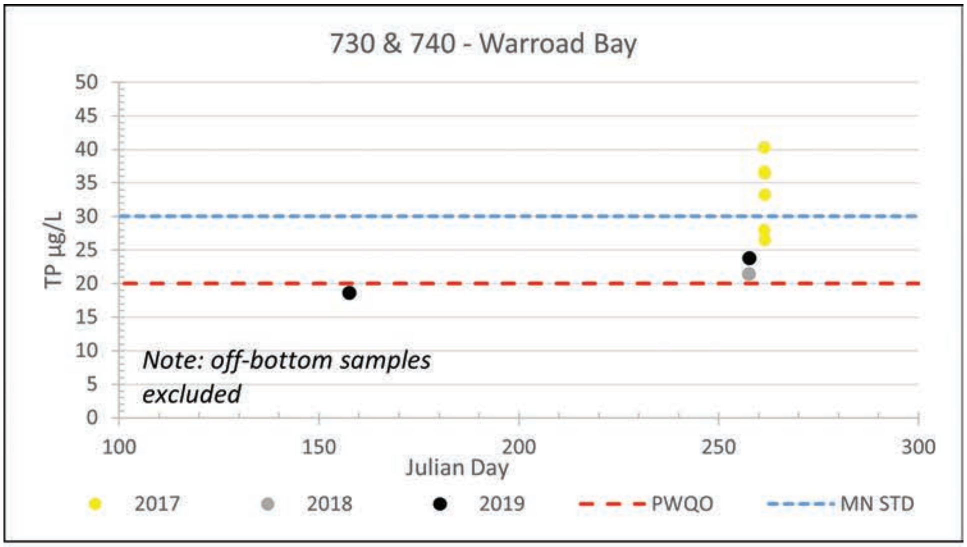
Note: No other sites in the Little Traverse zone

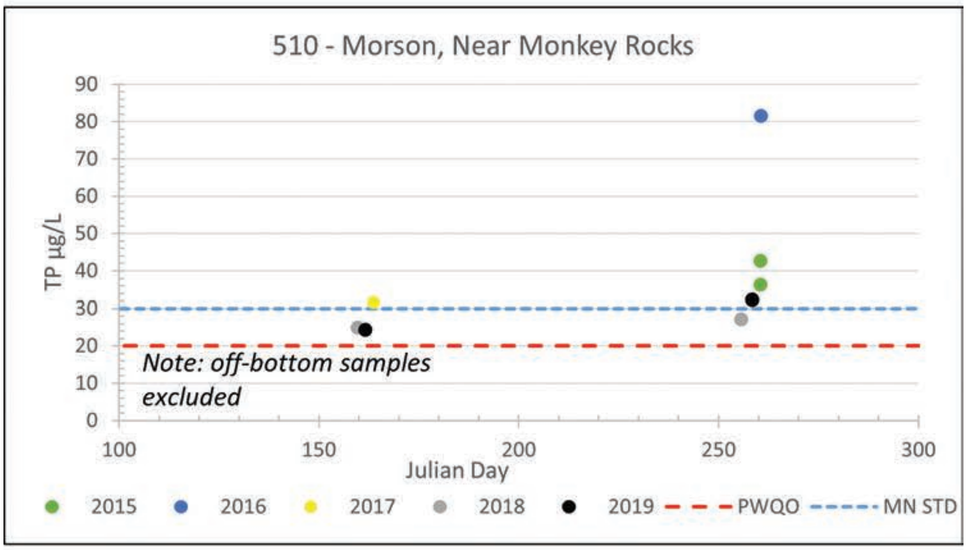
South Zone “Big Traverse”

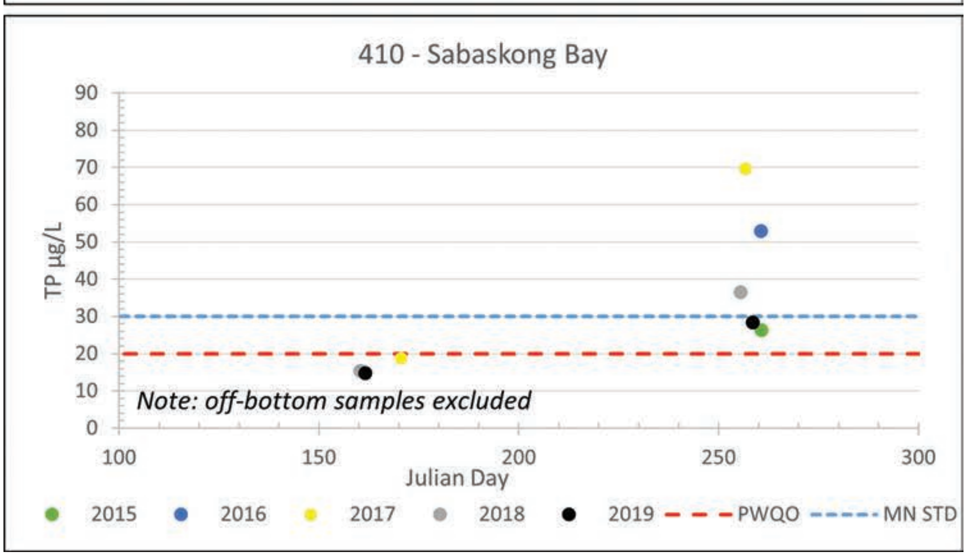







730 & 740 - Warroad Bay
TP µg/L
Julian Day
Note: off-bottom samples excluded
2017
2018
2019
PWQO
MN STD


510 - Morson, Near Monkey Rocks
TP µg/L
Julian Day
Note: off-bottom samples excluded
2015
2016
2017
2018
2019
PWQO
MN STD


410 - Sabaskong Bay
TP µg/L
Julian Day
Note: off-bottom samples excluded
2015
2016
2017
2018
2019
PWQO
MN STD

APPENDIX 3 — BROADSCALE MONITORING DATA – INLAND LAKES

Two cycles 2008-2012 and 2013-2017

	mg/L	mg/L	mg/L	TCU	uS/cm	mg/L	µg/L	µg/L	µg/L	µg/L		µg/L	m	mg/L	mg/L
Andy L.	49.62996	-94.08113													
5/10/2008	29.3	11.5	9.3	20.4	98.0	8.1	45	14	4	380	7.5	7.8	4.5	0.4	2.4
5/25/2016	28.6	10.8	10.3	21.1	106.0	9.0	50	22	2	423	7.2	9.9	3.3	0.6	2.4
Atikwa L.	49.49371	-93.53738													
5/10/2008	14.7	5.7	0.3	14.2	37.2	5.9		8	12	266	7.2	6.3	4.5	0.8	2.2
5/25/2016	12.0	4.5	0.3	28.1	34.7	7.5	40	14	2	365	6.8	7.9	2.6	0.9	1.6
Bad Vermilion	48.7038	-92.683													
5/10/2008	31.2	9.6	4.3	13.0	83.4	5.2	42	30	6	292	7.6	8.3	3.9	0.6	2.7
5/24/2016	30.3	10.0	4.5	19.4	86.8	5.8	30	12	2	327	7.2	9.4	2.8	0.6	2.3
Base L.	49.81915	-94.12424													
5/10/2007	5.3	1.6	0.2	28.8	17.0	7.1	68	10	2	320	6.8	6.8	3.5	0.7	1.5
Beaverhouse	48.54666	-92.07906													
5/10/2006	6.6	2.6	0.3	20.4	23.8	5.1		10	80	314	6.9	4.8	5.6	0.8	2.9
5/17/2008	7.6	2.2	0.2	15.8	24.2	5.5		6	102	217	6.8	5.1	4.2	0.8	2.4
5/17/2016	6.8	2.2	0.2	17.3	24.7	5.6		12	84	262	6.7	4.3	4.3	0.8	2.5
Bending L.	49.34819	-92.16096													
5/10/2007	5.7	2.4	0.7	57.6	21.2	8.0	124	6	62	320	6.8	5.9	2.5	1.8	1.9
Berry L.	49.4794	-93.9713													
5/17/2009	11.0	3.1	0.4	21.8	31.4	4.9	60	22	1	288	7.0	8.7	1.9	0.8	2.3
5/25/2016	10.1	3.1	0.4	17.1	31.5	5.2	40	4	2	254	6.7	6.4	2.5	0.5	2.4
Big Sandy L.	49.80873	-92.36737													
5/20/2009	65.2	20.8	2.3	24.6	136.0	7.2	76	14	42	313	7.8	14.9	2.7	1.1	2.8
Black L.	49.53878	-94.08465													
5/10/2008	8.1	3.3	6.3	84.6	47.2	14.1	417	8	40	484	6.8	15.2	1.8	2.0	1.7
Black Sturgeon L.s	49.82874	-94.29966													
5/10/2008	14.7	4.8	3.6	27.2	50.3	7.2	91	17	19	354	7.2	12.5	2.8	1.0	2.6
5/17/2009	31.4	9.4	7.3	76.4	104.8	15.7	200	68	20	754	14.2	28.2	1.8	2.2	3.9
Blindfold L.	49.66388	-94.22729													
5/10/2008	13.3	4.3	5.4	35.0	52.2	8.5	167	22	2	421	7.1	15.4	2.2	0.9	2.0
5/25/2016	11.5	3.8	5.4	32.2	52.3	8.2	90	24	2	393	6.8	11.6		0.8	1.8
Bluffpoint L.	49.17543	-93.41962													
5/10/2004	19.6	7.4	0.3	13.2	46.8	6.4		8	2	326	7.1	7.5	4.2	0.1	2.0
5/24/2016	15.7	5.9	0.7	21.3	43.0	7.2		8	2	353	6.9	6.5	3.7	0.6	2.0
Burditt L.	48.98899	-93.74712													
5/10/2004	38.1	12.9	0.6	10.2	84.6	5.7		2	2	308	7.3	7.3	5.0	0.9	3.1
Butler L.	49.6934	-92.6797													
5/17/2009	57.9	16.8	0.3	29.0	117.0	8.9	100	24	1	442	7.7	14.6	1.6	0.9	0.8
5/16/2016	56.3	16.0	0.3	30.6	115.0	10.7	90	26	4	443	7.5	10.9	2.2	1.2	0.9
Calder L.	48.94619	-93.53293													
5/10/2004	5.6	2.1	0.3	57.8	21.6	11.0	246	10	20	468	6.4	12.9	1.9	1.0	1.6
Calm L.	48.748	-92.06039													
5/10/2008	16.7	6.6	1.6	59.4	47.0	10.4	213	8	80	345	7.2	9.6	3.6	2.4	2.2
Captain Tom L.	48.4781	-92.3129													
5/10/2006	6.2	2.6	0.3	120.0	22.6	15.6	563	26	68	615	6.6	17.8	1.2	2.6	1.3
5/19/2015	6.9	2.1	0.3	119.0	23.7	13.9	700	16	74	634	6.5	21.7	1.5	1.6	0.8
Caviar L.	49.37166	-93.74161													
5/10/2011	22.7	8.2	0.4	22.2	52.2	5.7		8	4	295	7.4	7.7	4.5	0.7	2.4
5/25/2016	27.0	9.1	0.4	14.2	64.2	6.2		8	2	318	7.0	10.2	3.0	0.8	2.1
Cedartree L.	49.30145	-93.86742													
5/10/2011	55.2	18.8	0.9	18.2	115.0	4.4		6	2	254	7.8	6.9	5.2	2.0	3.4
Cirrus L.	48.61213	-91.9907													
5/10/2006	5.6	2.1	0.3	31.0	21.2	6.2		6	138	372	6.8	5.2	4.5	1.0	2.5
Clearwater West L.	48.97045	-92.02329													
5/10/2008	7.3	2.5	0.2	10.8	21.4	2.2		4	36	158	7.0	5.2	8.5	0.4	2.5
Crook L.	49.0647	-92.13353													
5/22/2015	7.0	1.7	0.8	6.7	20.1	3.9	70	4	2	237	6.8	5.6	4.1	0.9	1.0
Dibble L.	49.19826	-92.02488													
5/10/2007	7.9	3.0	0.2	18.6	22.4	3.6		8	2	198	7.0	4.5	4.8	1.4	2.4
Dinorwic L.	49.6205	-92.5668													
5/17/2009	31.5	10.2	3.2	79.1	79.5	9.5	420	28	44	370	7.4	19.6	0.9	2.3	1.3
5/16/2016	29.3	9.7	2.9	70.8	75.6	10.2	380	24	20	400	7.2	11.6	1.0	2.0	1.4
Dogpaw L.	48.93506	-93.89095													
5/10/2008	31.0	11.2	0.6	9.4	67.4	5.8		18	2	259	7.5	7.0	4.9	0.6	2.9
5/25/2016	29.1	9.7	0.4	13.7	68.4	6.7	30	6	2	304	7.2	7.7	2.7	0.8	2.2
Dogtooth L.	48.29872	-92.37451													
5/10/2008	9.5	3.1	4.9	15.8	43.0	5.8		12	2	332	7.0	8.2	4.0	0.5	2.3
Dore L.	49.64134	-92.83727													
5/10/2011	23.1	7.8	2.8	37.4	58.8	9.3		6	2	378	7.4	10.3	4.0	0.6	1.9
5/15/2013	24.2	6.7	2.2	26.3	60.6	8.8	70	6	2	393	7.3	13.2	2.8	0.2	1.4
Dovetail L.	48.87186	-92.05276													
5/10/2008	3.2	1.6	0.0	49.8	14.8	9.0	204	14	64	318	6.4	9.4	3.3	1.2	0.1
Dryberry L.	49.52487	-93.85152													
5/10/2008	9.1	3.1	0.0	5.8	27.4	3.6		2	44	159	6.9	4.5	7.5	0.4	0.1
5/25/2016	10.7	2.9	0.3	6.8	29.8	3.8		6	18	217	6.7	5.1	4.2	0.4	2.6
Eagle L.	49.6979	-93.2222													
5/17/2009	44.8	13.0	6.5	93.3	138.0	20.6	250	78	6	1086	21.4	41.8	3.6	2.4	5.7
5/18/2016	45.4	13.7	7.4	62.4	144.2	19.6	130	74	6	1038	20.5	34.4	3.4	1.6	6.2
Eltrut L.	48.99499	-92.42203													
5/17/2008	8.1	2.3	0.3	62.3	22.3	8.3	220	22	30	352	6.8	11.9	1.0	1.9	1.3
5/10/2011	7.5	2.6	0.3	47.2	22.8	6.7	155	16	12	302	6.9	10.1	2.7	1.5	1.9

	ALKTI mg/L	Ca mg/L	Cli mg/L	Col TCU	Cond uS/cm	DOC mg/L	Fe µg/L	NNH µg/L	NO2+3 µg/L	TKN µg/L	pH	TP µg/L	SECCHI m	SiO3 mg/L	SO4 mg/L
Entwine L.	49.14555	-92.71424													
5/10/2011	6.8	2.6	0.2	26.0	22.0	5.9		6	110	251	6.9	4.9	5.1	0.9	2.0
Factor L.	48.70312	-92.06666													
5/10/2008	9.9	4.1	0.0	9.2	35.2	4.3		16	6	240	7.1	7.2	6.0	0.5	0.1
5/22/2015	11.2	3.6	1.7	7.9	37.7	4.3		8	16	230	7.0	5.0	5.2	0.5	2.6
Godson L.	49.60462	-92.75984													
5/10/2011	23.4	9.2	4.9	62.0	66.4	11.5	133	10	8	434	7.4	11.4	2.0	2.1	1.6
5/15/2013	21.7	7.0	3.1	44.6	60.8	11.4	150	16	2	491	7.2	18.3	1.8	3.2	0.9
Grey Trout L.	49.00594	-92.07375													
5/10/2008	6.3	2.2	0.3	7.2	19.4	2.5		14	4	224	7.0	8.9	5.4	0.7	2.0
5/22/2015	6.7	1.9	0.3	5.7	20.0	3.3	40	2	2	257	6.7	11.3	4.1	1.3	1.6
Gullwing L.	49.53478	-92.62387													
5/10/2011	55.9	20.0	0.5	37.4	112.0	8.8	43	2	2	335	7.8	10.2	3.5	0.4	2.6
Hartman L.	49.75181	-92.45062													
5/20/2009	67.8	11.5	12.8	16.0	114.0	5.9	53	18	2	400	7.6	10.8	3.0	0.7	2.3
5/23/2014	34.3	11.2	12.6	18.6	118.0	5.6	50	12	2	313	7.4	10.1	2.8	1.0	1.9
Hartman Lake	49.74941	-92.45084													
5/21/2019	36.9	12.0	15.1	9.2	133.0	4.9	20	30	2	354	7.6	10.6	3.5	0.4	2.1
Hawk L.	49.78524	-93.99241													
5/10/2008	9.5	3.2	2.1	7.8	36.2	3.9		6	104	210	7.0	3.5	7.5	0.6	3.1
Heron L.	48.92356	-92.67252													
5/17/2008	6.4	2.0	0.6	42.1	22.9	8.7	190	28	56	354	6.7	12.5	1.5	1.5	1.4
James L.	49.14971	-93.06445													
5/10/2004	20.2	8.3	0.2	23.6	48.6	7.4	43	18	12	372	7.1	7.3	2.5	1.2	2.1
Kaiashkons L.	49.04736	-93.39763													
5/10/2004	28.0	11.2	0.6	7.8	78.8	3.8		2	44	201	7.1	5.1	5.0	0.4	8.3
5/24/2016	27.3	10.6	0.5	10.2	79.0	4.2		6	26	242	7.1	5.4	4.5	0.4	7.0
Kakagi L.	49.22603	-93.89557													
5/10/2011	60.9	20.8	1.2	11.0	129.0	2.7		2	2	169	7.9	5.4	6.5	1.6	4.2
5/25/2016	59.4	18.0	1.1	2.3	131.0	4.3		10	2	208	7.6	5.6	5.3	1.8	3.8
Katimiagamak L.	49.12173	-93.71167													
5/10/2004	44.7	16.9	0.4	9.0	97.6	4.2		6	6	236	7.3	5.3	5.0	1.7	3.2
Lac la Croix	48.36896	-92.10253													
5/17/2008	15.1	4.6	0.8	51.0	41.8	9.2	120	14	50	344	7.1	9.9	1.3	2.0	2.5
LoW sector 1	49.32857	-94.50117													
5/18/2015	50.5	13.3	2.3	31.6	117.5	10.3	30	30	78	578	7.3	22.0	2.0	2.1	4.0
LoW sector 2	49.32857	-94.50117													
5/18/2015	46.0	12.2	1.9	27.4	106.0	9.2	20	20	74	460	7.2	19.1	3.5	1.8	3.5
LoW sector 5	49.32857	-94.50117													
5/18/2013	41.3	11.3	2.7	53.8	105.0	9.6	200	36	128	443	7.2	31.4	1.3	2.1	5.1
Lawrence L.	49.26497	-93.38034													
5/10/2004	8.3	3.1	0.5	27.8	28.8	8.6		2	94	305	6.6	4.7	3.0	1.1	2.2
5/24/2016	9.1	3.2	0.4	28.1	29.3	7.9	40	6	62	329	6.7	6.0	2.6	1.0	1.8
Lilac L.	48.29872	-92.37451													
5/10/2008	13.1	3.7	0.3	21.0	32.8	5.6		22	2	344	7.2	12.1	3.8	0.3	2.2
5/17/2008	12.2	3.0	0.2	25.6	32.9	6.3	70	22	4	313	7.1	11.0	2.1	0.6	1.8
Little Kishkutena L.	48.99581	-93.80381													
5/10/2004	26.5	10.1	0.5	38.8	61.0	9.2	163	18	2	490	7.0	13.6	2.5	0.9	1.9
Little Turtle L.	48.79809	-92.71316													
5/10/2011	9.0	3.1	0.5	57.2	26.4	7.7	203	16	12	348	7.0	13.0	2.4	1.7	1.9
5/24/2016	8.5	2.7	0.4	60.3	25.7	7.9	220	14	2	361	6.7	12.4	1.2	1.6	1.4
Long L.	49.4623	-92.36409													
5/10/2011	33.8	13.0	0.5	15.0	74.6	4.3		2	2	221	7.6	5.7	5.5	1.2	3.2
5/14/2015	35.5	11.3	0.4	8.8	76.1	4.0		8	2	228	7.5	7.8	5.0	1.4	2.6
Longbow L.	49.72042	-94.30719													
5/10/2008	26.2	8.0	19.4	25.4	127.0	9.0	80	18	4	424	7.4	12.6	3.1	0.6	2.7
Loonhaunt L.	49.01611	-93.50616													
5/10/2004	16.8	6.1	0.4	19.0	48.2	6.1		8	14	309	6.9	7.2	3.6	0.7	4.6
5/15/2013	20.0	6.1	0.3	17.0	51.5	5.8	30	12	2	297	7.2	8.6	3.4	0.8	3.8
Lower Manitou L.	49.83166	-92.74416													
5/10/2004	27.8	10.2	1.1	10.4	67.4	4.8		4	32	263	7.1	5.7	5.9	0.9	2.9
5/15/2013	28.7	9.4	0.9	10.8	68.6	5.8		6	42	243	7.4	6.2	5.0	1.0	2.3
Lower Stewart L.	49.80168	-93.75899													
5/17/2009	8.5	3.3	7.9	56.6	57.2	8.7	180	16	76	319	6.9	6.9	2.0	1.7	2.0
Lowry L.	48.94762	-92.78809													
5/17/2008	9.3	2.4	1.2	78.5	28.7	11.0	440	34	68	479	6.8	24.1	1.5	1.4	1.0
Manion L.	48.91587	-92.32181													
5/10/2008	8.6	3.1	0.5	42.8	26.0	7.2	66	10	6	311	7.0	9.7	3.3	1.7	2.2
5/17/2008	9.3	2.8	0.5	37.2	27.7	7.0	90	26	10	308	6.9	10.5	1.5	2.3	1.7
5/17/2016	9.1	2.8	0.5	38.2	28.0	7.2	90	18	2	291	6.7	7.5	2.1	1.9	1.8
McCaulay L.	48.70908	-91.98959													
5/17/2008	10.0	3.7	0.7	31.7	32.8	6.8	40	4	122	265	6.9	8.1	3.8	1.3	2.5
Mickle L.	49.75776	-92.25405													
5/17/2009	14.9	4.2	0.2	75.6	35.9	9.2	220	22	18	381	7.1	19.4	1.2	1.9	1.3
Mount L.	49.01115	-92.19358													
5/10/2008	8.3	3.2	0.8	31.4	26.8	5.3		6	86	276	7.0	7.3	5.0	2.3	2.3
5/17/2008	9.6	2.9	0.8	29.7	29.2	5.7	40	12	102	218	6.9	6.7	4.0	2.4	1.9
5/17/2016	8.4	2.9	0.8	30.7	29.2	5.2	40	18	2	324	6.6	5.7	2.5	2.2	1.9
Mud L.	49.4194	-99.09584													
5/19/2009	13.5	4.3	0.3	12.8	34.6	4.4	53	8	2	346	7.1	7.3	4.5	0.9	2.2

	ALKTI mg/L	Ca mg/L	Cli mg/L	Col TCU	Cond uS/cm	DOC mg/L	Fe µg/L	NNH µg/L	NO2+3 µg/L	TKN µg/L	pH	TP µg/L	SECCHI m	SiO3 mg/L	SO4 mg/L
Namakan L.	48.45589	-92.56932													
5/17/2008	16.4	5.0	1.3	52.3	47.9	9.8	110	16	68	383	7.1	10.9	1.8	2.1	2.8
Off L.	48.90001	-93.82357													
5/10/2004	61.9	18.5	2.5	46.8	136.0	13.7	66	12	2	599	7.3	13.2	2.6	2.1	2.8
5/24/2016	65.1	17.9	1.9	61.4	139.0	15.9	80	24	2	633	7.5	13.2	2.3	0.8	1.6
Old Man L.	45.53124	-94.11355													
5/10/2007	9.6	3.1	0.5	32.0	27.2	6.3	58	12	6	304	7.0	7.8	2.8	0.9	2.2
Otukamamoan L.	48.90515	-92.85164													
5/10/2011	8.0	3.3	1.7	36.0	30.8	8.3		6	84	340	6.9	7.0	4.7	0.9	2.1
5/24/2016	7.4	3.1	1.6	35.2	30.8	8.1	70	16	32	362	6.6	9.3	2.8	0.9	1.6
Pettit L.	48.94874	-92.2863													
5/10/2006	8.7	3.2	0.6	30.8	27.0	5.6		14	10	249	7.0	7.6	4.2	1.9	2.4
Pickerel L.	49.78966	-94.87346													
5/10/2007	11.9	3.8	0.7	17.4	34.2	6.8	48	8	2	337	7.1	9.2	3.7	0.3	2.0
Pipestone L.	49.06095	-93.56566													
5/10/2004	37.9	13.5	0.6	12.2	84.0	6.0		8	2	333	7.2	7.3	3.5	1.2	3.3
Populus L.	49.52428	-93.60826													
5/10/2008	31.8	13.2	0.3	22.2	70.0	8.1		8	2	339	7.6	6.6	4.0	1.4	2.3
5/15/2013	31.2	11.0	0.2	29.9	68.1	8.8	40	14	2	366	7.4	8.0	2.7	1.5	2.0
Porcus L.	49.72547	-93.84707													
5/10/2008	7.5	2.5	0.2	16.8	23.6	4.2		2	40	238	7.0	3.5	7.0	0.5	2.8
Priam L.	49.35405	-93.3583													
5/10/2004	9.4	3.5	0.3	41.6	28.4	9.9	155	10	2	389	6.7	8.2	2.5	1.4	1.8
5/17/2009	9.8	3.0	0.2	57.1	27.7	9.4	200	28	28	395	6.9	9.7	2.1	1.9	1.4
5/25/2016	9.4	3.0	0.3	46.7	27.6	9.4	110	4	2	432	6.7	9.3	2.1	1.4	1.8
Rainy Lake - 1	48.72662	-93.13074													
5/23/2018	19.4	6.4	1.6	50.1	51.4	9.4	130	54	14	476	6.9	32.0	1.3	2.1	2.1
Rainy Lake - 2	48.72662	-93.13074													
5/23/2018	10.7	3.3	0.9	48.7	31.6	8.1	180	30	34	383	6.8	25.8	2.1	1.7	1.4
Rainy Lake - 3	48.72662	-93.13074													
5/23/2018	26.0	8.2	1.0	16.3	62.8	6.6	30	28	2	369	7.1	25.0	3.9	0.7	2.2
Rock L.	49.6209	-92.5665													
5/17/2009	61.3	18.0	0.9	22.2	128.0	6.0	110	28	1	390	7.8	17.7	1.4	2.0	1.4
5/16/2016	61.6	19.1	0.9	23.0	129.0	8.7	150	34	2	394	7.6	15.5	1.5	1.1	1.6
Rowan L.	49.31954	-93.53518													
5/10/2004	19.2	6.8	0.5	16.2	48.6	7.2		6	2	304	7.0	7.2	3.0	0.8	2.5
5/24/2016	16.5	5.6	0.3	22.4	43.1	7.4	30	16	2	345	7.0	8.8	2.3	1.0	2.0
Rutter L.	49.07204	-92.20367													
5/22/2015	7.0	2.0	0.4	17.7	22.1	5.2	60	4	2	252	6.8	6.8	3.6	1.3	1.1
Sandbeach L.	48.94269	-92.20707													
5/10/2008	8.8	3.8	0.5	50.2	30.0	7.2	62	2	168	249	6.9	4.6	2.8	3.3	2.7
5/17/2008	8.2	3.6	0.5	57.8	31.2	7.5	70	4	188	223	6.9	10.6	2.0	4.0	2.3
5/17/2016	9.1	3.4	0.5	58.5	31.3	7.5	80	4	16	387	6.7	4.1	2.3	3.4	2.2
Scattergood L.	49.29802	-92.72852													
5/15/2013	10.5	3.5	3.0	40.3	40.2	9.3	70	8	70	324	6.9	7.0	2.5	1.7	1.4
Schistose L.	49.1599	-93.615													
5/10/2004	56.0	19.6	0.5	14.4	122.0	6.1		8	2	318	7.6	5.5	3.8	2.2	4.6
5/24/2016	52.7	17.0	0.3	14.5	119.0	7.3		16	2	325	7.5	5.7	3.1	2.2	4.0
Secret L.	49.07862	-92.14228													
5/22/2015	6.0	1.6	0.4	6.5	19.1	3.1	50	2	2	198	6.8	6.9	5.2	1.3	1.4
Shoal L.	49.54181	-95.03													
5/17/2009	69.4	19.3	1.4	14.6	147.0	7.4		16	6	409	7.8	15.6	3.5	3.5	2.9
Silver L.	49.52683	-94.12013													
5/17/2009	12.2	3.6	0.5	8.5	35.9	3.2		2	116	158	7.0	4.5	5.0	0.6	2.9
South Crook L.	49.04835	-92.13205													
5/26/2015	4.9	1.4	1.6	6.3	19.9	2.7	60	12	2	240	6.6	7.0	8.7	0.1	1.4
S.Wapageisi L.	49.25354	-92.38386													
5/17/2008	6.7	2.2	0.2	32.7	19.8	6.8	130	20	28	281	6.7	6.9	2.0	1.1	1.4
Stormy L.	49.38502	-92.30037													
5/10/2007	33.1	12.3	0.4	15.6	73.6	4.9		4	2	236	7.6	5.6	6.0	1.3	3.0
5/14/2015	34.7	10.9	0.4	9.2	74.6	4.3		6	2	239	7.5	8.0	4.5	1.4	2.1
Tadpole L.	49.47214	-93.2957													
5/10/2004	6.2	2.2	0.2	18.2	20.0	6.3		4	2	266	6.6	5.5	3.2	0.6	2.0
5/17/2009	7.9	2.1	0.2	25.6	22.2	6.3	40	18	6	286	6.9	6.0	3.1	0.9	1.6
5/25/2016	6.5	2.2	0.2	23.0	22.0	6.6	30	4	2	311	6.6	5.9	2.4	0.7	1.7
Thompson L.	48.37714	-92.30243													
5/10/2006	12.2	3.5	0.3	19.4	33.8	5.1		14	2	347	7.3	8.9	3.8	0.3	2.8
Thunder L.	49.77345	-92.66061													
5/10/2006	44.8	13.9	4.2	27.6	107.0	6.4		8	22	274	7.7	8.7	4.5	1.4	3.3
5/17/2009	44.9	13.3	4.4	25.3	112.0	6.4	40	30	12	301	7.7	12.1	3.1	1.6	2.5
5/16/2016	42.4	12.9	4.4	23.2	111.0	7.8	50	26	24	313	7.3	9.9	3.5	1.4	2.7
Trap L.	49.6573	-92.7866													
5/17/2009	57.7	16.4	6.5	30.5	140.0	8.9	80	16	1	424	7.7	13.2	2.5	0.9	1.1
5/16/2016	55.6	15.1	6.2	34.6	135.0	11.4	90	44	2	465	7.4	12.8	2.4	1.1	1.1
Turtle L.	48.94648	-91.98953													
5/10/2008	4.6	2.0	0.0	26.6	17.8	5.8	76	12	64	211	6.7	4.8	4.1	1.8	0.1
Unnamed L.	49.47258	-93.88457													
5/10/2008	14.7	5.6	0.3	64.0	39.0	12.4	238	14	18	520	7.1	12.9	2.5	1.4	2.0
Upper Manitou L.	49.40542	-92.78494													
5/10/2004	35.1	12.2	0.8	8.4	80.0	4.3		2	2	226	7.3	7.1	4.9	1.1	3.1
5/15/2013	36.8	10.3	0.6	5.8	80.2	4.8		6	2	246	7.5	6.5	6.0	1.2	2.5

	ALKTI mg/L	Ca mg/L	Cli mg/L	Col TCU	Cond uS/cm	DOC mg/L	Fe µg/L	NNH µg/L	NO2+3 µg/L	TKN µg/L	pH	TP µg/L	SECCHI m	SiO3 mg/L	SO4 mg/L
Vista L.	49.06844	-93.07416													
5/10/2004	24.5	10.0	0.6	14.4	60.0	5.9		10	10	316	7.1	6.4	3.8	0.9	3.2
5/15/2013	25.7	7.9	0.3	12.8	61.0	6.2		10	18	293	7.4	6.6	4.0	0.8	2.5
Wabigoon L.	49.7592	-92.8566													
5/17/2009	41.0	12.4	3.2	80.4	97.0	7.8	810	28	8	397	7.6	37.7	0.8	1.2	1.6
5/18/2016	40.9	12.5	4.0	60.1	101.0	9.4	470	22	2	427	7.2	20.4	1.0	1.0	1.4
Wapageisi L.	49.33455	-92.3543													
5/10/2007	17.0	7.4	0.3	15.6	41.6	5.1		12	2	258	7.4	6.2	4.2	0.8	2.4
5/17/2008	13.6	4.9	0.2	25.6	33.2	5.5	70	20	1	260	7.0	6.9	2.6	1.2	1.7
5/17/2016	15.9	6.0	0.2	15.1	41.4	5.3		20	2	298	6.9	8.1	3.0	0.8	1.9
Wasaw L.	48.74659	-93.56124													
5/10/2004	30.0	9.2	1.6	113.0	74.6	19.2	172	30	24	729	7.0	26.3	1.5	2.3	2.4
WE66-23, L.	49.3205	-92.0598													
5/17/2008	4.7	1.7	0.4	94.8	18.3	10.3	380	12	34	338	6.5	10.1	1.2	2.7	1.1
5/18/2016	3.8	1.8	0.4	87.2	18.9	10.4	340	18	10	380	6.3	7.8	1.8	2.5	1.3
West Jackfish L.	48.93444	-93.67166													
5/10/2004	11.6	3.7	0.4	33.6	33.8	10.0	126	24	4	535	6.7	17.9	2.0	0.4	2.3
5/15/2013	12.1	3.2	0.3	41.1	33.2	9.6	140	18	4	463	7.0	19.2	2.1	1.8	1.3
Whitefish L.	49.79596	-95.02512													
5/10/2007		3.0	0.2	22.4	26.2	6.8	134	12	44	309	6.9	5.7	3.0	0.7	1.9
5/17/2009	10.3	3.1	0.2	36.2	27.8	7.9	210	28	34	363	7.0	8.2	1.6	1.1	1.3
5/16/2016	10.2	3.1	0.2	22.8	29.6	8.0	120	24	2	335	6.8	7.5	2.8	0.8	1.4
Whitewater L.	49.53478	-92.62387													
5/10/2006	52.9	18.5	0.3	6.6	105.0	3.4		14	2	314	7.8	8.4	4.0	0.6	1.8
Windermere L.	49.79953	-93.82124													
5/10/2008	8.9	3.2	0.0	13.6	41.6	4.3		10	22	220	7.0	4.7	5.0	0.8	0.1
Winnange L.	49.71922	-93.74192													
5/10/2008	8.8	3.1	2.1	6.4	34.0	3.3		3	39	178	7.0	4.5	6.9	0.6	3.1
5/15/2013	9.8	2.7	1.5	6.3	34.9	3.6		4	66	177	6.9	3.7	8.2	0.5	2.5
Wolseley L.	48.434	-92.0859													
5/17/2008	8.4	2.4	0.2	38.3	26.8	8.0	110	20	66	352	6.9	10.4	2.0	0.8	2.0
5/17/2016	7.4	2.3	0.2	41.4	27.3	8.8	100	18	64	388	6.7	8.1	3.5	0.8	2.1
Z05_Cy2_03 L.	49.03836	-92.30437													
5/18/2017	11.2	3.6	0.3	41.2	31.3	9.0	380	36	8	495	7.0	12.2	2.3	0.5	1.9

APPENDIX 4 — CYANOTOXINS

Following table shows a list of specific cyanotoxins and the genus/species of alga that produce the toxins. This from: https://www.epa.gov/cyanohabs/learn-about-cyanobacteria-and-cyanotoxins.

Microcystins (hepatotoxin)
Dolichospermum (previously Anabaena)
Fischerella
Gloeotrichia
Nodularia
Nostoc
Oscillatoria
Microcystis
Planktothrix

Cylindrospermopsin (liver and kidney)
Raphidiopsis (previously Cylindrospermopsis)
raciborskii (C. raciborskii)
Aphanizomenon
Umezakia natans
Dolichospermum
Lyngbya wollei
Rhaphidiopsis

Anatoxins(neurotoxins)
Chrysosporum (Aphanizomenon) ovalisporum
Cuspidothrix
Raphidiopsis (previously Cylindrospermopsis)
Cylindrospermum
Dolichospermum
Microcystis
Oscillatoria
Planktothrix
Phormidium
Dolichospermum (previously Anabaena)
A. lemmermannii Raphidiopsis mediterranea
Tychonema
Woronichinia

Saxitoxins (paralytic shellfish toxin)
Aphanizomenon flos–aquae
Dolichospermum (previously Anabaena) circinalis
Lyngbya wollei
Planktothrix spp
Brazilian isolate of Raphidiopsis raciborskii

Principal groups of cyanobacterial toxins, their acute toxicities, structures and known producers.

From https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2984099/

Table 2. Principal groups of cyanobacterial toxins, their acute toxicities, structures and known producers.

Toxins (LD50 - acute toxicityA)	Structure (number of variants)	Activity	Toxigenic genera
Hepatotoxins			
Microcystins (25 to ~ 1000)	Cyclic heptapeptides (71)	Hepatotoxic, protein phosphatase inhibition, membrane integrity and conductance disruption, tumour promoters	*Microcystis*[BCD], *Anabaena*[BCD], *Nostoc*[BC], *Planktothrix*[BCD], *Anabaenopsis*[B], *Hapalosiphon*[BC]
Nodularins (30 to 50)	Cyclic pentapeptides (9)	Hepatotoxic, protein phosphatase inhibition, membrane integrity and conductance disruption, tumour promoters, carcinogenic	*Nodularia*[BCD]
Cylindrospermopsins (200 to 2100)	Guanidine alkaloids (3)	Necrotic injury to liver (also to kidneys, spleen, lungs, intestine), protein synthesis inhibitor, genotoxic	*Cylindrospermopsis*[BC], *Aphanizomenon*[BC], *Anabaena*[C], *Raphidiopsis*[BC], *Umezakia*[B]
Neurotoxins			
Anatoxin-a (250)	Tropane-related alkaloids (5)	Postsynaptic, depolarising neuromuscular blockers	*Aphanizomenon*[B], *Anabaena*[BCD], *Raphidiopsis*[BC], *Oscillatoria*[BC], *Planktothrix*[BC], *Cylindrospermum*[B]
Anatoxin-a(S) (40)	Guanidine methyl phosphate ester (1)	Acetylcholinesterase inhibitor	*Anabaena*[BC]
Saxitoxins (10 to 30)	Carbamate alkaloids (20)	Sodium channel blockers	*Aphanizomenon*[BC], *Anabaena*[BC], *Planktothrix*[BC], *Cylindrospermopsis*[BC], *Lyngbya*[BC]
Dermatotoxins (irritants) and cytotoxins			
Lyngbyatoxin-a	Alkaloid (1)	Inflammatory agent, protein kinase C aktivator	*Lyngbya*[B], *Schizotrix*[B], *Oscillatoria*[B]
Aplysiatoxin	Alkaloids (2)	Inflammatory agents, protein kinase C aktivators	*Lyngbya*[B], *Schizotrix*[B], *Oscillatoria*[B]
Endotoxins (irritants)			
Lipopolysaccharides	Lipopoly-saccharides	Inflammatory agents, gastrointestinal irritants	All cyanobacteria?

[A] acute toxicity in mouse bioassay (i.p. exposure, LD50 - µg/kg body weight); [B] toxin identified in natural population with dominant genera; [C] toxin identified in non-axenic monocyanobacterial culture (not bacteria free); [D] toxin identified in axenic monocyanobacterial culture (cyanobacteria free). (Compiled from Codd *et al.*, 2005a; Codd *et al.*, 2005b).