Objectives and Alert Levels in the Rainy-Lake of the Woods Watershed

Phase I

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DRAFT REPORT FOR REVIEW

Submitted to:

International Rainy-Lake of the Woods Watershed Board

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Objectives and Alerts Project Team

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Contents

Executive Summary

This report summarizes the results of the first phase of a project to address the need for Water Quality Objectives and Alert Levels for the Rainy-Lake of the Woods Watershed. Water Quality Objectives are internationally agreed upon standards, whereas Alert Levels are advisory level triggers that can be brought to the attention of both governments by the International Joint Commission (IJC).

The work is required for the IJC's Rainy-Lake of the Woods Watershed Board (IRLWWB or the board) to meet its Directive (IRLWWBDirective) to recommend Water Quality Objectives for boundary waters, to establish Alert Levels 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. The report has been prepared for the IRLWWB by a project team contracted by the IJC and the board is now seeking public comments on this draft.

At the present time, Water Quality Objectives and Alert Levels exist **only for the Rainy River**. The need for Water Quality Objectives and Alert Levels is assessed here, to allow reporting on exceedances or trends in water quality and Aquatic Ecosystem Health for the **entire watershed**.

Phase I/Phase II

Phase I of the project will identify recommended parameters associated with Water Quality Objectives and Alert Levels. The individual specific guidelines (e.g. concentrations, loads or other narrative guidelines) associated with proposed Water Quality Objectives and Alert Levels will be established during Phase II.

Specifically, Phase I is tasked with:

i) providing a review on the status of water quality and Aquatic Ecosystem Health criteria relevant to priority issues in the basin;
ii) providing perspectives from stakeholders, experts and indigenous groups on indicators to assess water quality and Aquatic Ecosystem Health;
iii) proposing a prioritized list of options for Objectives and Alert Levels that are specific to boundary water hydrogeographies, together with potential metrics or indicators of aquatic ecosystem health;
iv) identifying lessons learned from other basins/boards; and
v) providing a gap analysis for relevant aspects of the project.

These tasks would focus on priority issues in the watershed and have an overarching requirement to protect Aquatic Ecosystem Health.

Priorities

Five watershed priorities identified through the review of key documents were identified as:

i) Nutrients
ii) Contaminants
iii) Climate change
iv) Aquatic Invasive Species
v) Erosion and water levels

Water Quality Objectives

With government's agreement, Water Quality Objectives 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, this report suggests that these existing Water Quality Objectives for the Rainy River be replaced by a set of boundary-segment-specific phosphorus objectives. It is recommended that there be individual phosphorus guidelines established for different boundary water segments to accommodate the fact that concentrations vary throughout the watershed. Rationale for a single Water Quality Objective for Nutrients (phosphorus) is based on the fact that phosphorus was identified as the first priority and phosphorus is the parameter that is most often exceeded in the watershed.

Alert Levels

It is proposed that the four remaining priorities will be addressed using Alert Levels. Contaminants are currently managed using a long list of substances where the most stringent guideline that is in place with any of the regulatory agencies is identified as the Alert Level for that substance. It is recommended that this long list be replaced by a shorter list of routinely monitored substances. This will allow more expedient board reporting at intervals.

With regards to Climate Change and Aquatic Invasive Species, this 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 TSS or Turbidity, but models may be required to quantify the effects of Erosion. These tools will be developed in Phase II.

Consultation

The findings of this report are based on feedback from an extensive set of consultations with experts, the public and indigenous community members. The consultation sessions included:

- Expert Workshop - March 12, 2019, International Falls, MN;
- Public Workshop - March 12, 2019, International Falls, MN;
- Open Webinar - April 3, 2019 ;
- Two Public Meetings – July 8, 2019, Kenora, ON; and
- Indigenous Learning Forum – August 21, 2019, Onigaming First Nation (Ontario).

Gap analysis

A gap analysis is provided here to identify:

i) Any limits to the establishment of specific guidelines for Water Quality Objectives and Alert Levels (Phase II).

ii) Any limits to our ability to assess the efficacy of established guidelines.

Recommendations

The primary recommendations with respect to Water Quality Objectives and Alert Levels together with aspects of proposed indicators for Aquatic Ecosystem Health are listed below and the key aspects of deriving Water Quality Objectives and Alert Levels are shown in the table at the end of this summary.

1. That the board recommend to governments that the Water Quality Objectives (WQOs) and Alert Levels (ALs) be adopted as described in Section 9 of this report.
2. That Aquatic Ecosystem Health (AEH) be assessed by one or all of the suggested approaches described in Section 3 of this 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.
3. That a process be 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.
4. That communication between rule curve or water level boards be established when water levels are shown to be associated with WQOs or ALs.
5. That 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.
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.
7. When the board recognizes that a WQO has been exceeded, it will recommend that the exceedance be assessed by both governments.
8. When the board recognizes that an AL has been triggered, it will advise that the AL be assessed by both governments.
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.
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.

The following table shows the five priorities with the potential for management using Objectives, Alert Levels and risk-based guideline together with desired outcomes.

Priority	WQO or AL	Parameter	Desired Outcome
Nutrients	Water Quality Objective To replace existing Objectives	Total phosphorus loads or concentrations. Although some reactive or filtered phosphorus fractions are sometimes monitored there are no guidelines for these fractions, and they are not routinely monitored.	Reduce nutrient status to lower productivity, improve water clarity and improve aesthetic water quality.
Contaminants	Alert Levels for reduced list of routinely monitored substances. Alert Levels may	Alkalinity Chlorophyll a Chloride	Maintain water quality within most stringent guidelines.

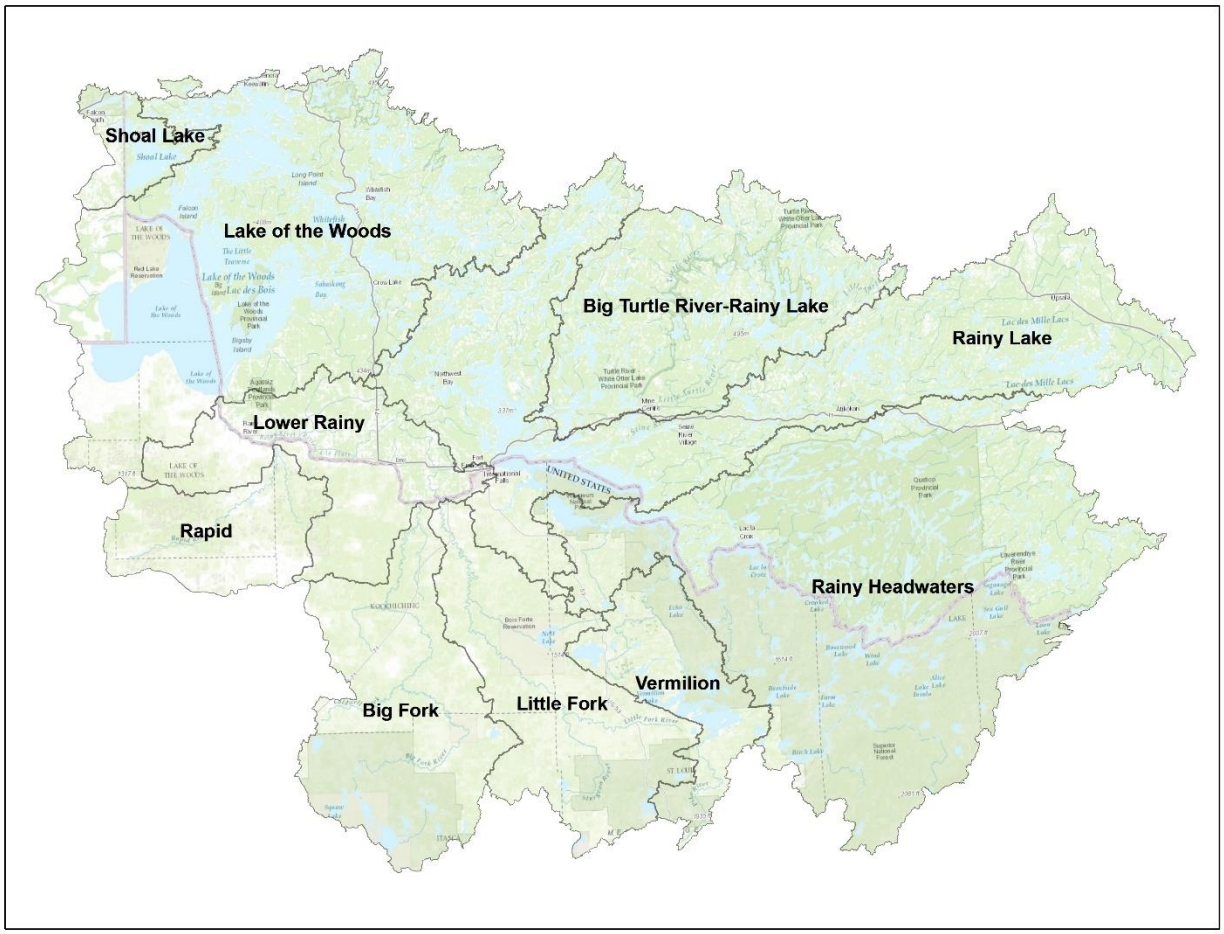
	be different between lake and river environments or specific to boundary water segments. The mechanism of adopting Alert Levels based on the most stringent guideline for any regulatory agency would apply to all boundary segments including those outside the Rainy River.	Conductivity Colour, DOC Dissolved Oxygen Hardness NH_3, NO_2, NO_3, TKN pH, Sulphate, SVS Total Phosphorus TSS, Turbidity Secchi, Temperature Aluminum, Antimony, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver, Zinc, Thallium, Titanium, Zinc	Reduce contaminants in fish and benthos.
Climate Change	Alert Level for Demonstrated Significant Risk	Indicator	Maintain risk awareness
Aquatic Invasive Species	Alert Level for Demonstrated Significant Risk	Indicator	Maintain risk awareness. Protect biodiversity. Avoid food web disruptions
Erosion	Alert Level for Demonstrated Significant Risk for non-numeric aspects such as loss of shoreline	Bank Erosion Hazard Index TSS, Turbidity, SS	Develop tools to address erosion

1. Overview

1.1 Introduction

The International Joint Commission's (IJC) Rainy-Lake of the Woods Watershed Board (the "board") was created in January 2013, amalgamating the International Rainy Lake Board of Control and the International Rainy River Water Pollution Board. While its role and geographic scope for water level management did not change, its water quality responsibilities expanded to the broader Rainy-Lake of the Woods watershed (see Figure 1). To support this, it was given a Directive to recommend Water Quality Objectives (WQOs) for boundary waters, to establish Alert Levels (ALs) in the basin to identify potential problems for boundary waters, and to report on these and trends of water quality and aquatic ecosystem health (AEH) in the watershed. In August 2017, the board made the decision to focus on this primary Directive task and, in 2018, initiated this project to address the need to develop water quality and AEH Objectives and ALs, relevant to priority issues in the basin. While some dated WQOs exist, there are no WQOs for the board's expanded mandate to include the entire Rainy-Lake of the Woods watershed. In the absence of relevant WQOs or ALs for the board, monitoring and reporting on exceedances or trends in water quality and AEH cannot be assessed in a consistent and systematic manner. This work, then, is needed for the board to meet its Directive.

Figure 1 – Rainy-Lake of the Woods Watershed



1.2 Background

In 1959, the IJC received a reference from the Canadian and U.S. federal governments for water pollution in the Rainy River and Lake of the Woods. In a 1965 report back to governments, the IJC recommended WQOs for the Rainy River (IJC, 1965). With government's agreement, WQOs were established for qualitative Objectives covering sanitary sewage, suspended solids and slime bacteria as well as quantitative Objectives for coliforms and dissolved oxygen concentrations (see Table 1). Since that time, there have been efforts to introduce additional parameters for Rainy River WQOs including bacteria, pH, TDS, ammonia, DO, polychlorinated biphenyls (PCBs), cadmium, copper, iron, lead, manganese, mercury, nickel, zinc, nitrates, pesticides, color, suspended solids, turbidity, odor, temperature, arsenic and organic compounds, but no further WQOs have been approved by governments since the 1965 list. It is important to note that these WQOs apply only to the Rainy River.

Table 1 – Existing Water Quality Objectives for the Rainy River.

Parameter	Threshold Level
Coliforms (Most probable number [MPN]) (ml)	2400/100 (Max), 1000/100 (Median)
Dissolved oxygen (DO)	The dissolved oxygen should not fall below 5 mg/L at the average monthly flow which is exceeded 95 percent of the time in the critical month, nor below 3 mg/L at the minimum daily flow that is exceeded 95 percent of the time in the critical month
Suspended solids	"…should be reduced to a point that they are not conducive to slime growths, formation of sludge islands and banks, and do not injure fish or wildlife or their habitats"
Nutrients and wood sugars	"…should be controlled to the extent that they do not promote the nuisance growths of Sphaerotilus and other slime bacteria in the river"

In 1992, a revised board Directive allowed the establishment of ALs for the Rainy River. These are advisory level triggers for dealing with water quality issues that are not covered by the International WQOs. These could be established for any parameter for which any party (i.e., Ontario, Minnesota, Environment and Climate Change Canada, US Environmental Protection Agency) has established standards or guidelines. These ALs do not need to be ratified by governments and do not specifically require monitoring. Board Directive 4b does require reporting on ALs. There is a long list of ALs currently in place for the Rainy River and these are based on the most stringent standards that are currently in place by any of the parties; the extensive list is shown in Clark and Sellers, 2014. This project examined whether this list requires updating and whether further ALs are required for other areas of the watershed's boundary waters outside of the Rainy River.

1.3 Project Approach

This project is the first phase of a larger effort to identify the relevance of priority issues to specific basin hydrogeographies, and will determine how the board should measure, evaluate and report against these priorities. This project is split into two phases and this report provides the results of Phase I, which has focused on expert and community consultation around what is meant by AEH, context setting and background review. It sets the foundations for recommending WQOs and ALs relevant to priority issues such as water quality, Aquatic Invasive Species (AIS), climate change indicators and adaptation, and

surface water contamination in the Rainy-Lake of the Woods watershed. The focus will be on established priorities that include both water quality and aspects of AEH.

Phase II will focus on the development of appropriate benchmarks, metrics or indicators for WQOs and ALs that can be used to report on AEH status and trends; in short, what should be measured, is it being measured and what should the number of criteria be. Upon completion of Phase II, the board will be provided with:

- Recommendations for WQOs, as appropriate, for specific boundary waters;
- An updated list of priority ALs for specific basin waters/locations that reflect priority issues in the basin and are minimally needed to identify potential problems for boundary waters;
- An assessment of monitoring and information adequacy / needs minimally required to support evaluation and reporting against the recommended Objectives and ALs; and
- A proposed assessment framework for ongoing evaluation and assessment of AEH in the basin.

It is important to note that some of the activities completed for Phase I progressed organically through the consultation process to touch on aspects of Phase II and, conversely, some of the items meant to be accomplished in Phase 1 would be better handled in Phase II. It is also important to note, for consideration in Phase II, that WQOs and ALs, and related issues such as frequency of data collection, analysis and reporting, should take into consideration the purpose and use of WQOs and ALs, as well as human and financial resource requirements and availability to effectively manage reporting against WQOs and ALs.

Engagement of key communities has been essential throughout Phase I to develop a shared understanding of the meanings, expectations and potential metrics for water quality and AEH in the basin. This phase has focused on building this foundation and a context for developing specific WQOs and ALs in Phase II, drawing upon the extensive amount of information and research that has been done in the past in this basin. The goals of Phase I are:

- to identify and refine the priority issues specific to the basin's hydrogeographies;
- in consultation with agencies, stakeholders and the board, develop a clear definition of what is meant by AEH in the basin;
- inventorying and assessing the status of existing water quality and AEH criteria (provincial, state, federal, indigenous, binational) relevant to the identified priorities;
- the status of and lessons learned from other watersheds / boards;
- proposing a prioritized and justified list of options for the development of WQOs and ALs as well as potential metrics or indicators for these, to be more fully developed during Phase II; and
- a gap analysis with respect to monitoring and reporting on priority WQOs and ALs.

Each of these goals were reached through a review of primary documentation, conversations with the board's Aquatic Ecosystem Health Committee and a series of consultation sessions with experts, the public and indigenous communities. These consultation sessions included:

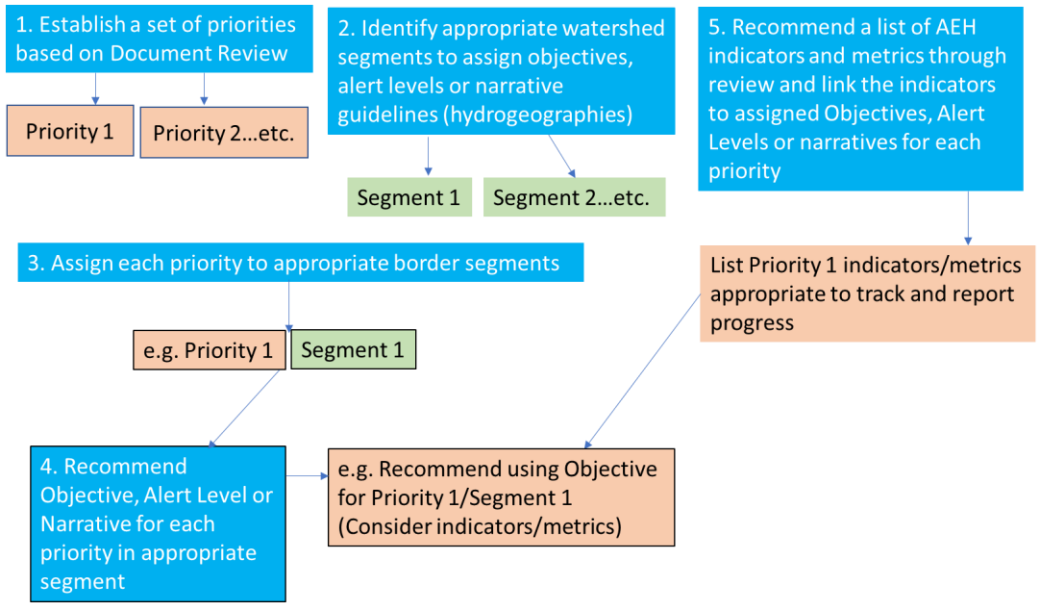
- Expert's Workshop in International Falls, MN at the Watershed Forum, on March 12, 2019;
- Public Workshop in International Falls, MN at the Watershed Forum, on March 12, 2019;
- Open Webinar on April 3, 2019;
- Two public meetings in Kenora, ON - July 8, 2019; and
- Indigenous Learning Forum in Onigaming First Nation on Aug 21, 2019.

As mentioned above, earlier WQOs (1965) and ALs (1994) have been established jointly by the IJC and the Canadian and U.S. federal governments for the Rainy River but these are outdated with respect to current priority issues. It is important to note that international WQOs and board ALs have not been established for any other parts of the watershed. WQOs and ALs should be assessed for the **entire watershed**, to allow reporting on exceedances or trends in water quality and AEH.

This project addresses the need to track AEH both within the context of the priorities but also in a broader sense since AEH is an overarching priority. The role of AEH within this process and in the watershed in general is threefold. First, the stated goal for all oversight in the watershed is to protect AEH. Second, any action in boundary waters, including the establishment of WQOs and ALs, has the underlying goal of protecting AEH. Third, AEH indicators and metrics, of which there are many, should be selected as appropriate and used to assess progress following the establishment of numerical or narrative guidelines in the form of WQOs or ALs.

Figure 2 outlines the approach the project team used to identify/refine the priorities, assign watershed segments and progress towards the recommendation of appropriate WQOs and ALs.

Figure 2 – Approach to identifying priorities, assigning watershed segments and recommending WQOs and ALs.



2.0 Document Review

2.1 Identifying Priorities

As a first step, key synthesis documents were reviewed to identify the main priorities associated with water quality and AEH for the Rainy-Lake of the Woods watershed. Information with respect to parameters that would be candidates for both WQOs and ALs were recorded together with the boundary water segments where they would apply. The review was initiated using the documents listed below with the understanding that more could be added to the list, if appropriate.

Documents were reviewed to summarize any priorities that were identified, together with the segments of the boundary waters, where these were indicated. There was also a scan to identify AEH indicators and/or definitions within each document (no definitions of AEH were found). For AEH indicators, it was noted whether these were monitored. The summary table for this review is shown in Appendix 1.

2.2 Documents Reviewed

1. Clark, Bev J. and Todd J. Sellers (2014). State of the Watershed Report, 2nd Ed. Published by the Lake of the Woods Water Sustainability Foundation.

2. International Joint Commission (2015). A Water Quality Plan of Study for the Lake of the Woods Watershed. ISBN: E95-2/19-2015E-PDF.

3. International Joint Commission (2017). A Review of International Water Quality Objectives in the Souris, Red, Rainy-Lake of the Woods and St. Croix River Watersheds: Historical Perspectives, Recent Trends and Future Directions. January 2017 unpublished report.

4. International Joint Commission (2014). Great Lakes Ecosystem Indicator Project Report: A Report of the IJC Priority Assessment of Progress towards Restoring the Great Lakes.

5. Minnesota Pollution Control Agency (2018). Preliminary Review Draft - Lake of the Woods Excess Nutrients Total Maximum Daily Load.

6a. Environment Canada's Lake of the Woods Science Initiative 2008 to 2011 report.

6b. Environment Canada's Lake of the Woods Science Initiative 2008 to 2011 – Summary report.

7. Environment Canada (2015). Results of Environment Canada's water quality monitoring and surveillance activities in the LoW watershed 2012-14, WQMS 2015.

8. Canadian Council of Ministers of the Environment (2016). Guidance Manual for Developing Nutrient Guidelines for Rivers and Streams PN 1546 ISBN 978-1-77202-022-9 PDF.

9. International Rainy and Namakan Lakes Rule Curves Study Board (2017). Managing Water Levels and Flows in the Rainy River Watershed: A Report to the International Joint Commission, Final Report.

10. International Lake of the Woods and Rainy River Watershed Task Force (2011). Bi-national Management of Lake of the Woods and Rainy River Watershed, Final Report.

11. Manitoba Water Stewardship (2011). Manitoba Water Quality Standards, Objectives and Guidelines, Water Science and Management Branch, Nov 2011.

12. International Rainy-Lake of the Woods Watershed Board (2016). First Annual Water Quality Report. Submitted to The International Joint Commission April 2016.

13. International Rainy-Lake of the Woods Watershed Board (2017). Aquatic Ecosystem Health Report, 2015 and 2016. Submitted to the International Joint Commission October 25, 2017.

14. Minnesota Pollution Control Agency (2016). Lake of the Woods Watershed Monitoring and Assessment Report.

15. IJC Directive to the International Rainy-Lake of the Woods Watershed Board, 2013.

16. IJC Sparrow Modelling.

17. International Joint Commission (1965). Pollution of the Rainy River and Lake of the Woods, 1965.

18. Rainy River Alert Levels – excerpt from IRRWPB report.

19. McDaniel, T. and T. Pascoe (2018). Presentation: Environment and Climate Change Canada - Lake of the Woods Monitoring Update.

20. Valipour et. al. (2018). Webinar - Update on Integrated Modelling.

A simple method was used to weigh priorities based on the number of times that each was listed in the reviewed documents. For example, the first priority was listed as **nutrients** and associated internal loads together with algal bloom indicators because it was mentioned in nine of the reviewed documents. It should be noted that there are many circular references in these documents, such that the priorities listed in one document may be carried forward to a subsequent document. We do not see this as an issue, simply because if a document's review has its priority list carried into a subsequent document, then this endorsement is considered more as a juried priority rather than one that is counted twice.

The key priorities noted through the documents review are shown in Table 2, together with the number of supporting documents and the number associated with their titles, as shown in the previous numbered document list. Review documents include important periodic reviews of water quality and AEH indicator data that incorporate the most up to date data into review documents. These include the State of the Basin report (Clark and Sellers, 2014) and the IJC Plan of Study (2014). Also, many more detailed reports contain data that address topics such as erosion in more detail than is covered by the documents reviewed here.

Several additional priorities listed in single documents are not considered here because they would not normally be addressed by WQOs or ALs. These may include metrics to be used as indicators of AEH. They include:

- Petroleum transport (document 2) – otherwise regulated
- Stakeholder participation (document 10) – addressed in this project
- Land development (document 10) – assessed through planning
- Monitoring (document 13) – an integral component/adequacy may be determined as a gap
- Communication (document 10) – has been addressed through consultations

Table 2 – Key priorities noted in the documents review with the number of documents where the priority was identified. Document #'s in the right column refer to the list of documents previously shown.

Priority	# Documents	Document
1. **Nutrients** including internal loads and algal blooms	9	1,2,5,6,7,10,12,13,14
2. **Contaminants**/mining including Agricultural contaminants and Contaminants of Emerging Concern	6	1,2,5,6,7,13
3. Water Levels / **Erosion**	5	1,2,9,10,20
4. **Climate Change**	5	1,5,9,10,13
5. **Aquatic Invasive Species**	5	1,2,9,10,13

2.3 Summary of Document Priorities

Nutrients

Nutrients and their effects on algal blooms have been identified as the key priority in the greatest number of reviewed documents (Table 2). The link between phosphorus loads to Lake of the Woods from point and diffuse sources, including internal loads, has been the topic of much research in the watershed, including the establishment of impaired waters in the south end of the lake with the resulting Total Maximum Daily Load (TMDL) study by the Minnesota Pollution Control Agency (MPCA) for the Minnesota portion of the lake and Environment and Climate Change Canada (ECCC) efforts to complete nutrient models to address algal blooms. There have been many exceedances noted for total phosphorus in the Rainy River and Lake of the Woods by regulatory agencies on both sides of the border (Table 3). In addition, nutrients were the most mentioned priority in the review documents. This provides rationale for a WQO for total phosphorus.

Contaminants

The list of potential contaminants to surface and ground water is extensive and grows with each year as new compounds or contaminants of emerging concern come to light. This is reflected by the long list of substances that are currently listed for ALs in the Rainy River. The AL concentrations, in this case, are listed as the most stringent of any of the parties that regulate water quality on either side of the border waters. Most of these contaminants are on this list due to agencies that monitor them elsewhere

outside the watershed in areas where there are more substances in the environment due to industrial or urban activity. As such, they are best described as potential contaminants. These are rarely monitored or analysed in the Rainy – Lake of the Woods watershed. There are some exceedances noted in Table 3.

Aquatic Invasive Species

The presence of many species is noted in reports and literature (see Table 3). Data is most often presented as presence/absence but the spread of AIS is often tracked more carefully when there is elevated risk due to invasion.

Erosion

Soil and water conservation documents contain substantial erosion data (see Reference section, Lake of the Woods Sediment & Nutrient Budget Investigation, 2013). There are aspects of the Contaminants ALs discussed above that could address erosion (TSS, Turbidity etc.) and there may be solutions to quantifying erosion through modelling. Tools to identify aspects of erosion will be developed in Phase II.

Climate Change

Climate change 'data' tend to be integral to many databases due to their impact as a stress multiplier. There are more straightforward examples such as the extension of the open water season and more complex processes showing the role that climate change plays in exacerbating algal blooms (Paterson et al. 2017). The IJC has published extensively on the impacts of Climate Change (see Appendix 4, Annex 9 – Climate Change).

Table 3. Water quality exceedances and Aquatic Invasive Species noted

Concern	Exceedance	Boundary Segment	Document	Notes
P	> Alert Levels	LoW, RR (US & CDN tributaries) Rainy Lake outlet not monitored	13, 7, 19	US and CDN data
Hg	Fish consumption	LoW, RR, Headwaters	13	
Fe	3% > 300 µg/L	RR	19	ECCC
PCB	Fish consumption	LoW, RR	13	Ontario caution
Arsenic	1 exceedance	RR	19	2014-17
Cd	2 exceedances	RR	19	2014-17
Cu	2 exceedances	RR	19	2014-17
Wastewater	none	RR		
AIS	Hybrid Cattail	Headwaters	13	IMA-TAC AIS* Subcommittee/ Board risk assessment proposal currently under review
	SW Flea	LoW, RR, Headwaters		
	Rusty Crayfish	LoW, RR, Headwaters		
	Papershell Crayfish	LoW, RR, Headwaters		
	Clearwater Crayfish			
	Rainbow Smelt	LoW, RR, headwaters		
	Zebra Mussel	RR		
	+ more			
Sediment	Metals - various exceedances of Fe2O3, Mn, TKN	LoW, RR	7, 19	ECCC
Sulphate	OK	RR	7	
Chloride	OK	RR	7	
Climate			13	Must derive metrics
Fish	Mostly good shape	LoW, RR, Headwaters	13	Refer to ON-MN Fisheries Atlas

*International Multi-Agency Arrangement Technical Advisory Committee's Aquatic Invasive Species

3.0 Aquatic Ecosystem Health

Ecosystem health is used to describe the overall condition of an ecosystem. Ecosystem condition can vary as a result of fire, flooding, drought, extinctions, invasive species, climate change, mining, overexploitation in fishing, farming or logging, chemical spills along with a plethora of known and unknown stressors.

The meaning of AEH seems easy to grasp and the concept has been referred to as embracing 'common sense' (O'Brien et al. 2016). Yet, there are few actual definitions, or a justified choice of indicators published (O'Brien et al. 2016). Many of the reviews that discuss AEH seem to read more like conversations than a rigorous examination of the topic. A common formal definition utilizes the concept of stress ecology by defining health in terms of system organization, resilience and vigor (Rapport et al. 1998). These definitions, however, are difficult to use because of the complexities involved with

measuring and evaluating the various terms. Karr (1999) notes that "much that we have concluded on the basis of theory – such as the interactions of system vigour, organization and resilience has not been empirically verified." In addition, the statistics watchdogs will insist that the various statistical protocols must be followed to ensure power in the analysis, which further complicates efforts to define AEH monitoring outcomes.

The water here is further muddied by more than a few reviews that claim that AEH is not a valid concept and, as such, cannot be seriously defended (Suter, 1993).

AEH is seen by some as a tool to communicate science to the public through an easily understandable analogy. This may sidestep the requirement for a definition. So, is it possible to go forward to identify and monitor a set of indicators that can assess AEH without referring to a formal definition? As O'Brien et al. point out, "*There is no overall agreement on what it means to have a healthy ecosystem, yet it is still necessary to have clear definitions of ecosystem health on a study-by-study basis*."

Many references, especially older ones, suggest the use of benthos or fish (Munawar et al. 1989) as indicators of AEH. These indicators, especially fish, tend to be monitored in all aquatic systems, probably because they are attributed high value from the human perspective. In these cases, AEH is defined as the ecosystem's ability to adequately support its components and the reader picks the component.

The use of indexes has been popular to try to encompass the health of more than one organism, but these indexes can themselves be criticized for failing to identify the reasons for passing or failing grades (Suter 1993). In addition, a good grade might not always be desirable, as in the case where a mesotrophic or eutrophic system might seem preferable to an oligotrophic system due to increased production or diversity. It is also difficult to incorporate changes that might be due to irreversible changes in the ecosystem. In other words, in those cases where there can be no return to baseline conditions.

In most ecosystems, there are many sets of variables that are being monitored and, in many cases, there are long-term records for these. So how do we know if any of these variables are linked to AEH? And if we imagine that they are, then what do the data say about AEH? The answer may change as time goes by. For example, someone keeping temperature records a century ago might not imagine that there are any implications to AEH hiding in his or her data. It might be collected to reflect some industrial process. Today, it would be foolish to suggest that temperature has no bearing on AEH. So, it might be enough to simply identify the way in which a certain parameter reflects AEH and go ahead to monitor it. Priorities usually come with a set of reasons why they are important because monitoring costs money and there needs to be compelling reasons to garner funds for any proposed work.

It is interesting to note that O'Brien et al. (2016) summarize many of the common AEH indicators as contaminants, climate change, habitat loss, and exotic species. These align well with the priorities noted here for the Rainy-Lake of the Woods watershed. It is important to note that these are stressors associated with AEH. If stressors are monitored, then the rationale attaching their effects to AEH have usually been pre-defined. In the end, it may not be that important to attach definitions, i.e. if the fish are failing, then the AEH is suffering.

Definitions of AEH

AEH (formal) – The ability of the ecosystem to maintain system organization, resilience and vigor.

AEH (informal) – The ability of the ecosystem to adequately support its components with an emphasis on ecosystem integrity.

AEH indicator – Any (monitored) variable that has been shown to have an effect on AEH.

Wikipedia - A healthy aquatic ecosystem is an aquatic environment that sustains its ecological structure, processes, functions, and resilience within its range of natural variability. (Adequate to take forward to Phase II).

3.1 Applicable Aquatic Ecosystem Health Indicators

There is a long list of AEH indicators that could be useful to assess AEH in the watershed. These are listed below. It is important to note, however, that any indicators that would be useful for periodic reporting by the board would need to be embedded in ongoing monitoring programs and ideally assessed and summarized at appropriate intervals. This will be further refined, including program locations, in Phase II.

Source Acronyms
AMRN - Adaptive Management for Rainy and Namakan Lake Levels
MPCA – Minnesota Pollution Control Agency
MECP – Ministry of Environment, Conservation and Parks
ECCC – Environment and Climate Change Canada
WPLMN - Watershed Pollutant Load Monitoring Network
MDNR – Minnesota Department of Natural Resources
MNRF – Ministry of Natural Resources and Forestry
TALU – Tiered Aquatic Life Uses
IBI - Invertebrate biotic index
YOY – Young of Year
VNP – Voyageurs National Park
LOW – Lake of the Woods
FCIN – Fish community index netting
USGS – United States Geological Survey

AVIANS
Indicator: Common Loon
Metrics: Nest Flooding
Priorities Addressed: Water levels/Erosion, climate change
Ongoing?
Source: AMRN
Comments: Consider impact of high flood risk rule curve on Rainy.

MAMMALS

Indicator: Muskrat
Metrics: Over winter survival
Priorities Addressed: Water levels/Erosion, climate change
Ongoing?
Source: AMRN
Comments: Incorporate traditional knowledge. Ask Voyageurs National Park about imagery analysis. Also, note the current funding is only for five years. Extrapolating data to Canadian waters might not work as well due to trapping outside VNP.

FLORA

Indicator: Wild Rice
Metrics: Success and density
Priorities Addressed: Nutrients, contaminants, water levels, climate change
Ongoing?
Source: AMRN
Comments: Rank could change based on follow up conversations with Tribes, First Nations, and possibly other experts.

Indicator: Narrow leaf and Hybrid Cattail encroachment
Priorities Addressed: Aquatic Invasive Species
Ongoing? Ongoing monitoring in VNP for five years.
Source: AMRN
Comments: Could have imagery analyzed every 3-5 years for extent on all water bodies, including Rainy River.

Indicator: Wet meadows, Shrubby swamps, Emergent plants, Submerged plants
Priorities Addressed?
Source: AMRN
Comments: Could serve as surrogate for Northern Pike spawning habitat and improvement in conditions for benthic invertebrates on reservoirs

Indicator: Emergent Plants along Rainy River
Priorities Addressed?
Source: AMRN
Comments: Could have imagery analyzed every 3-5 years for extent on all water bodies, including Rainy River. Important habitat for fish and wildlife - prioritize the upper river to maximize ability to detect effects of dam operation.

Indicator: Cyanobacteria
Metrics: taxonomy, biomass, genetics C, N, P, cyanotoxins, remote sensing
Priorities Addressed: nutrients, climate change
Ongoing: An outcome for WQOs for P, modelling and satellite sensing may be ongoing
Source: ECCC

INVERTEBRATES
Indicator: TALU
Metrics: IBI based health of aquatic macroinvertebrate community
Priorities Addressed: all
Ongoing: 10 year cycle
Source: MPCA
Comments: Based on Index of Biologic Integrity of Stream and River Biomes

FISHERIES

Indicator: TALU
Metrics: IBI based Health of Fisheries Community
Priorities Addressed: all
Ongoing: Ongoing, 10 year cycle
Source: MPCA
Comments: Based on Index of Biologic Integrity of Stream and River Biomes

Indicator: LOW/Large Lake Fisheries Atlas
Metrics: Health of Fisheries Community
Priorities Addressed: all
Ongoing: Ongoing 6 year cycle
Source: MDNR

Indicator: Rainy River Fisheries Survey
Metrics: Health of Fisheries Community
Ongoing: Ongoing 10 year cycle
Source: MDNR
Comments: Fisheries surveys of tributaries to LOW and lower 40 miles of Rainy River (ongoing 10 year cycle) start 2020

Indicator: Populations of adult gamefish,
Walleye egg survival,
Walleye spawning success,
Priorities Addressed: all
Source: AMRN

Indicator: Northern Pike Spawning Suitable Habitat – lakes (improve models of spawning habitat)
Northern Pike Larval Suitable Habitat
Northern Pike Young of Year Suitable Habitat
Priorities Addressed: all
Source: AMRN

Indicator: Whitefish Egg Survival Probability
Whitefish Spawning Success
Cisco spawning success
Priorities Addressed: all
Source: AMRN

Indicator: Rainy River Walleye spawning habitat
Rainy River Lake Sturgeon Habitat
Priorities Addressed: all
Source: AMRN

Indicator: Yellow perch spawning habitat – lakes
YOY northern pike, walleye, and yellow perch
Priorities Addressed: all
Source: AMRN
Comments: Expand FCIN netting to Canadian waters on Rainy Lake and Namakan Reservoir

CLIMATE AND WEATHER

Indicator: Atmospheric Deposition
Metrics: annual and seasonal air temperature; annual and seasonal precipitation; wind speed; PAR
Priorities Addressed: Nutrients and climate change
Ongoing: yes various
Source: Trent University, ECCC
Comments: deposition chemistry and meteorological variables could be separate metrics

Indicator: Water temperature
Metrics: Open water season average
Priorities Addressed: may include all
Ongoing: yes various
Source: ECCC, MECP, MPCA

WATER CHEMISTRY AND PHYSICAL CONDITIONS

Indicator: Pollutant Load Monitoring Network
Metrics: Dissolved Orthophosphate, Total Phosphorus, Total Kjeldahl Nitrogen, Nitrate + Nitrite Nitrogen, Total Suspended Solids
Priorities Addressed: Nutrients, contaminants, climate change
Ongoing: yes
Source: MPCA
Comments: Storm events and once per month calendar-based stream sampling

Indicator: Intensive Watershed Monitoring Concentrations
Metrics: Dissolved oxygen, Escherichia coli, Nitrate plus Nitrite – Nitrogen, Orthophosphate pH, Total Kjeldahl nitrogen, Total phosphorus, Total suspended solids, Unionized ammonia (NH3)
Priorities Addressed: Nutrients, contaminants, climate change
Ongoing: Ongoing, 10-year cycle
Source: MPCA
Comments: Lakes, streams and rivers; 8-digit HUCs

Indicator: Watershed Monitoring Concentrations
Metrics: Dissolved oxygen, Escherichia coli, Nitrate plus Nitrite – Nitrogen Orthophosphate
pH, Total Kjeldahl nitrogen, Total phosphorus, Total suspended solids, Unionized ammonia (NH3)
Priorities Addressed: Nutrients, contaminants, climate change
Source: Trent University (Contract with MPLMN)

Indicator: Intensive Watershed Lake Monitoring
Metrics: Total Phosphorus, Chl-a, Secchi Transparency, Dissolved oxygen, Escherichia coli
Nitrate plus Nitrite – Nitrogen Orthophosphate, pH, Total Kjeldahl nitrogen, Total suspended solids
Unionized ammonia (NH3)
Priorities Addressed: Nutrients, contaminants, climate change
Ongoing: 10-year cycle
Source: MPCA
Comments: Selected Lakes within 8-digit HUCs

Indicator: In-Lake Monitoring
Metrics: Chlorophyll-a, Nutrients (P, N, C), Major ions, Metals, TSS, temp, DO, conductivity
pH, TDS, Turbidity
Priorities Addressed: Nutrients, contaminants, climate change
Ongoing: uncertain to continue beyond 2019
Source: ECCC, MNRF and MECP
Comments: Lake of the Woods

Indicator: Rainy River Nutrient Monitoring
Metrics: Metals
Priorities Addressed: Nutrients, contaminants, climate change
Ongoing: yes
Source: ECCC

Indicator: LOW/Rainy River Tributaries Nutrient Budget
Metrics: Nutrients
Priorities Addressed: Nutrients, contaminants, climate change
Source: Trent University, ECCC

Indicator: MOECP Lake Partner Program
Metrics: phosphorus, Secchi, occasionally others
Priorities Addressed: Nutrients
Ongoing: yes
Source: MOECP
Comments: Many locations throughout watershed

HABITAT

Indicator: Minnesota Stream Habitat Assessment
Metrics: Surrounding Land Use, Riparian Zone Conditions, Instream Zone Conditions
Channel Morphology, Aquatic Vegetation
Priorities Addressed: water levels/erosion
Ongoing: 10-year cycle
Source: MPCA

HYDROLOGY
Indicator: Stream Flows
Metrics: discharge
Priorities Addressed: Water levels/erosion, climate change
Ongoing: yes
Source: MNDR, USGS, WPLMN

3.2 Using Demonstrated Significant Risk to Identify ALs

The concept of demonstrated significant risk should be used to define ALs for those priorities where there are no defined numerical guidelines. This applies to AIS, Climate Change and aspects of erosion. Any AEH metric which can be shown through well defended research to constitute a significant risk would represent an AL. This would include any AEH indicator or metric being studied in the watershed in addition to those associated with priorities.

There are two approaches to identifying ALs associated with risk. The first would be to sort through all programs where AEH indicators are monitored and examine each for elements of risk (examine indicators shown in the previous section.

For this approach, data analysis could be divided into the following major categories:

- Biology
- Climate and Weather
- Fluvial Morphology
- Habitat
- Hydrology
- Water Chemistry and Physical Conditions

Categories are further divided into indicators, which are further divided into specific metrics.

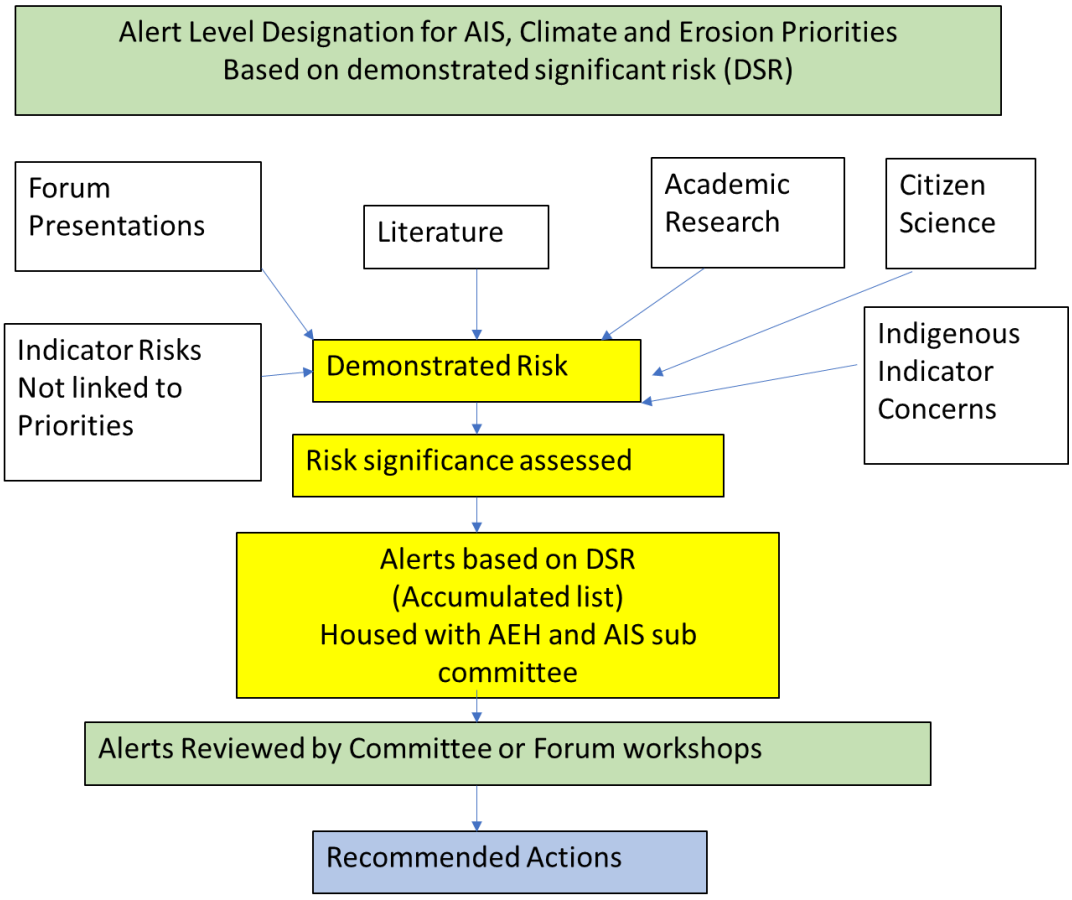
Resource agencies on both sides of the border have ongoing monitoring programs that include many, if not most, of the metrics that would be needed for start-up of an AEH program for the boundary waters. Many of the metric sites are located within boundary waters, however appropriate metrics need to be identified before gaps in the spatial coverage can be determined. Adopting existing metrics for the boundary waters AEH will likely improve sustainability of the start-up program.

This option would require a robust identification of AEH indicators to help identify risks representing ALs. In this case, any indicator that, through proper and peer reviewed research is shown to indicate a harmful effect on AEH, would constitute an AL to the board. Ideally, indicators should be monitored in an ongoing program and reported at reasonable intervals that reflect the level of risk. We understand that while comprehensive, this approach would be time consuming and likely represent a task that is beyond the board's ability to manage.

The second approach would be to identify only those metrics where there is demonstrated risk and have the AEH committee gather these into a parking lot for periodic evaluation. Each of these individual risks would represent an AL to the board. The process to identify risks could be through resource management agency reviews, via presentations each year at the Rainy-Lake of the Woods Watershed Forum, or by defensible conclusions drawn by academic institutions, citizen scientists or indigenous observers. The main driver of this process could be through structured sessions or workshops each year at the Forum, overseen by the AEHC and the AIS sub committee. Some mechanism for evaluating risk significance would be required if this was not clearly embedded in the research. The concept is shown in Figure 3.

Board preferences for the use of indicators should be developed in Phase II.

Figure 3- Concept for identifying Alert Levels associated with significant risks.



4.0 Human Health Indicators

There are several AL and AEH indicators that have implications for human health. Most contaminants in water could potentially affect human health but there are few exceedances in the watershed, and most would be a risk, only if present in drinking water. Proper treatment should eliminate these risks.

4.1 Drinking Water

As far as drinking water is concerned, there are cautions against drinking untreated surface water. In this case, the responsibility to safeguard drinking water quality relies on the proper operation of the water treatment system. Source water protection is addressed in many areas of Ontario but is not currently assessed in northwestern Ontario, where this watershed is situated.

4.2 Fish Contaminants

There are advisories for consumption of fish for several contaminants and these are specified by agencies dedicated to contaminants in fish, e.g. Guide to Eating Ontario Sportfish, https://www.ontario.ca/data/guide-eating-ontario-fish-advisory-database

4.3 Contaminants in Sediments

There are several noted exceedances for contaminants in sediments, but it is unclear how these affect human health.

4.4 Contaminants in Groundwater

Contaminants in ground water would be addressed by either Canadian or U.S. regulations depending on the location and there is, at this time, no advice with respect to ground water impacts on boundary water segments.

4.5 Algal Toxins

Algal blooms can produce harmful toxins. There is no way to ensure, or indicate through analysis, that toxins are not present during blooms because they can show up in the water at any time. Advisories against drinking or having human contact with water (when blooms are occurring) are posted by Health Units in Ontario.

In the U.S., USEPA guidance states:

Based on the latest scientific information, EPA has established recommended water concentrations, at or below which protects public health, for the cyanotoxins microcystins (8 micrograms per liter) and cylindrospermopsin (15 micrograms per liter). EPA's recommendations are protective of all age groups and are based on peer-reviewed and published science.

https://www.epa.gov/newsreleases/epa-issues-recommendations-recreational-water-quality-criteria-and-swimming-advisories

There is also extensive guidance for recreational water quality.

https://www.epa.gov/wqc/recreational-water-quality-criteria-and-methods#rec3

5.0 Approaches and Lessons Learned from Elsewhere

Two documents provide details that are relevant with respect to lessons learned from elsewhere. The first involves details within the Great Lakes Water Quality Agreement and the second is from a review of approaches used by other IJC boards outside of the Great Lakes.

5.1 The Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement (GLWQA) is a bi-national agreement that outlines specific goals towards restoring and maintaining the chemical, physical and biological integrity of the waters of the Great Lakes. https://www.canada.ca/en/environment-climate-change/services/great-lakes-protection/2012-water-quality-agreement/appendix.html

The agreement is divided into several Annexes which are general topics covering individual concerns. It is notable that these Annexes line up well with the priorities that have been noted here for the Rainy-Lake of the Woods watershed (Table 4).

Table 4 - GLWQA Annex topics alignment with Rainy-Lake of the Woods watershed priorities. Alignment areas shown by green cells.

GLWQA Annex	Rainy-Lake of the Woods watershed priority
Annex 1 - Areas of Concern	no
Annex 2 - Lakewide Management	Approach may be relevant for Lake of the Woods
Annex 3 - Chemicals of Mutual Concern	yes
Annex 4 - Nutrients	yes
Annex 5 - Discharges from Vessels	no
Annex 6 - Aquatic Invasive Species	yes
Annex 7 - Habitat and Species	Approach may be relevant for watershed
Annex 8 – Groundwater	yes
Annex 9 - Climate Change Impacts	yes
Annex 10 – Science	Describes approaches

A description of the science aspects of each Annex (where applicable) is outlined in detail in Appendix 4. These are shown verbatim directly from GLWQA documents.

A summary of important considerations derived from the GLWQA are shown for Rainy-Lake of the Woods watershed priorities in Table 5.

Table 5 - A summary of important recommendations derived from the GLWQA for Rainy-Lake of the Woods watershed priorities.

GLWQA Annex	Rainy-Lake of the Woods watershed priority
Annex 4 - Nutrients	GLWQA includes both concentration and load guidelines for each lake.
Annex 3 - Chemicals of Mutual Concern and groundwater (Annex 8)	Ambitious protocols but no guidance for establishing concentration guidelines. Groundwater mostly about identifying impacts.
Annex 9 - Climate Change Impacts	Relies heavily on the use of models.
Annex 6 - Aquatic Invasive Species	Keywords: prevention, barriers, rapid response, control, eradication, detection, spread, climate change impact risk assessment
Annex 10 - Science	AEH component to science using indicators: *The Parties shall establish and maintain comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, to anticipate emerging threats and to measure progress in relation to achievement of the General and Specific Objectives of this Agreement*

5.2 Approaches by other IJC Boards outside of the Great Lakes

A review of the approaches to using WQOs and ALs by other boards outside of the Great Lakes (Figure 4) shows that there is no consistent approach across boards. This likely reflects the imperatives for each area of boundary water. The WQOs range from one to more than 40 and ALs range from none to extensive lists. In one case, the AL is represented by a Water Quality Index (Table 6).

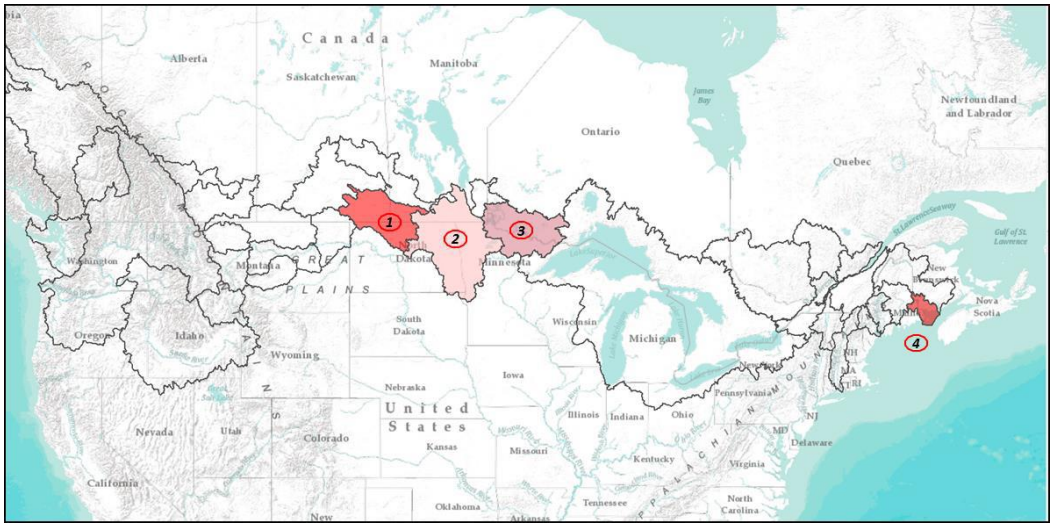


Figure 4 - Map of the transboundary region showing locations for the Souris River Watershed (1), the Red River Watershed (2), the Rainy-Lake of the Woods Watershed (3) and the St. Croix River Watershed (4).

Table 6 - Objectives and Alert Levels established by other IJC boards outside of the Great Lakes.

International Souris River Board	Objectives	More than 40
	Alert Levels	none
International Red River Board	Objectives	DO, TDS, Chloride, SO_4, E. coli
	Alert Levels	29 including pesticides (in leu of more objectives)
International Rainy-Lake of the Woods Watershed Board	Objectives	Coliform, DO, SS, nutrients and wood sugars (Rainy River only)
	Alert Levels	Extensive list – *see in State of Watershed 2nd Edition*
International St. Croix River Watershed Board	Objectives	Dissolved Oxygen
	Alert Levels	Water Quality Index (10 WQ parameters)

5.3 Summary of Lessons Learned

Lessons learned from the review of these documents include:

- The alignment of priorities between the GLWQA and the priorities identified by this project gives confidence that we are focusing on the correct set of priorities;
- Approaches used by other boards are extremely variable indicating that there is no set pattern to approaching WQOs and ALs;
- Information and guidance within these documents may be revisited for aspects of Phase II; and
- GLWQA (Annex 4) may be a good model for Rainy - Lake of the Woods.

6.0 Feedback from Consultations

Much of the focus of Phase I has been on gathering feedback from experts, the public, stakeholders and indigenous communities in order to develop an understanding of their perspectives on ecosystem objectives and expectations for water quality and AEH, as well as how they could be assessed. The sessions were spread out between March and August 2019, so the material that was presented to the groups varied somewhat, as progress was made on the project. With the Expert Workshop held first, much of what was discussed and, in some cases, distilled down to focus on key concepts, was then the material presented at the upcoming public and indigenous sessions for feedback. The consultation sessions included:

Expert Workshop - March 12, 2019, International Falls, MN

Public Workshop - March 12, 2019, International Falls, MN

Open Webinar - April 3, 2019 (several individuals requested the recording of this afterwards)

Two Public Meetings – July 8, 2019, Kenora, ON

Indigenous Learning Forum – August 21, 2019, Onigaming First Nation (Ontario)

6.1 Summary of Expert Workshop Feedback

At the Expert's Workshop, feedback was requested on the list of priorities, the relevance of the existing WQOs and ALs, updates on indicators of AEH and current monitoring programs to support all of these. There were 35 participants, representing the key resource agencies who have a mandate for water

quality in the basin. It was held during the week of the annual Watershed Forum in International Falls, MN where these experts typically gather to attend this scientific forum. For those experts unable to attend, the team contacted them directly for their input.

A complete listing of comments from the Expert's Workshop as well as a participants list can be found in Appendix 5, with a summary of the discussion presented herein. Expert advice below, which has been incorporated into this project, is underlined.

With respect to WQOs, the experts agreed that the project should consider:

- Recommending a review and revision of WQOs and ALs at a minimum every five years.
- Recommending updates and revisions to 1964 Objectives; largely, the group indicated that the existing objectives are no longer required. There was some advice to retain an oxygen objective together with advice that it also is no longer necessary.
- Recommending an Erosion and Sedimentation Objective.
- Recommending an objective to determine the effects of climate change, treating climate change as a stressor. Once the effects are determined, the board may consider an objective to mitigate those effects.
- Recommending an objective to determine the vulnerability to and effects of AIS in the boundary waters.

With respect to ALs, the experts agreed that the project should consider:

- Recommending that ALs apply to all segments of the boundary waters.
- Drafting a narrative explaining how ALs are used.
- Drafting recommendations for an updated list for ALs along with a subset of priority alerts based on availability of data (often-monitored parameters).
- Updating a list to include all the water quality Standards or Objectives for ECCC, EPA, MOECP or MPCA and identify the most stringent guideline.
- Adding sulfate to the AL list.
- Including the concept of demonstrated risk.

With respect to AEH, the experts agreed that the project should consider:

- Assessing AEH as a set of indicators which will act as an AL if any conditions relative to the indicators is shown to be deteriorating. Preferred indicators will be used in ongoing monitoring programs.
- Adding an atmospheric deposition indicator, which will use metrics from MET stations in ELA, VNP and Ely.
- Recommending land cover and fragmentation remote sensing every ten years.
- Recommending an indicator for disturbance of riparian zones (500 feet / 152 meters) along boundary waters.
- Contacting Nature Conservancy (Canada and US) to determine if Conservancy maps may be used as an indicator.

- Recommending a review of summary reports that examine load and concentration data from tributaries flowing directly to a boundary water.
- Including water temperature data in the Indicators and Metrics section.
- Basing indicators on summary reports rather than on raw data to make the reporting process easier for the board.

With respect to boundary waters segmentation, the experts agreed that the team should:

- consult with Canadian scientists and the AEHC to determine whether to add additional segments for the cold-water watersheds (Clearwater Bay and Whitefish Bay) in the northern waters of Lake of the Woods.

With respect to the Gap Analysis, the experts agreed that the team should:

- Review all boundary waters segments to determine gaps in monitoring sites.

6.2 Public Stakeholder sessions

Three public/stakeholder sessions were held during Phase I; one in International Falls, MN in March 2019 and two in Kenora, ON on July 8, 2019, linking to existing events in the basin to help maximize attendance and efficiency. An open Webinar was held on April 3, 2019 for those who could not attend the March sessions.

6.2.1 March Sessions and Webinar

The March session was held during the week of the annual Watershed Forum with 18 attending. The March session was open discussion format, following a similar format as the Expert's Workshop. A complete listing of comments from the sessions in March together with the team's response to questions as well as a participant's list for each session can be found in Appendix 5.

In the March session, the feedback tended to reflect a desire for answers to questions rather than providing feedback to specific aspects of the project. As a result, our approach to structuring the subsequent sessions was changed to focus on project specific goals. Some questions/comments from the March session include:

- Has the river's transparency improved?
- Where are nutrients coming from?
- Isn't part of the problem from the logs that were driven down the river?
- Threats and timeframe – how do these impact priorities?
- We need to know if a specific AIS are a risk prior to infestation, need a risk assessment
- Rainy Lake Property Owners Association (RLPOA) interested in being involved in monitoring down the road to monitor indicators – RLPOA and Lake of the Woods District Stewardship Association (LOWDSA) both supportive of a sampling campaign
- Supportive of more segments in headwaters – need to know if monitoring is done in these segments
- Comment made about stagnant water and need for flushing occasionally and that flow is important

- Contaminants – fish advisory regarding mercury – is this natural or man made?
- Question around sulphate liberating phosphorus – is this true? Is sulphate a contaminant or a nutrient issue?
- Can impact of a mine way upstream be detected down on Rainy Lake?

The **Webinar** was attended by 14 people and was primarily focused on answering questions of interest from the participants. Questions and answers are listed in Appendix 5.

6.2.2 Summary from July Sessions:

In July, the afternoon session was held immediately following the summer meeting of the LOWDSA and was attended by 25. The evening session the same day accommodated those who could not attend earlier - attendance was 6.

The July afternoon session was more structured, dividing participants into breakout groups to discuss what ecosystem health meant to them and to capture what they thought the outcomes should be for each of the priorities (all comments are provided below). Each breakout group was tasked with addressing one of the 5 priorities (nutrients, contaminants, climate change, AIS and erosion). In addition, they were asked to identify any indicators that they thought were important and whether these were monitored.

In the afternoon session, the four breakout groups presented the results of their conversations at the end of the workshop. Below we present the feedback received on the focused questions:

What does Aquatic Ecosystem Health mean to you?

- to be able to swim and play in the water. No blooms. Drinkable. Biodiversity in place with desire to go back to pre-human condition.
- a good balance with respect to species, dissolved oxygen and nutrients.
- biodiversity, no eutrophication, no toxins or disease in gamefish, abundance of plants, resilience to perturbation

Are there Aquatic Ecosystem Health indicators that are important to you?

- total phosphorus, turbidity, e. coli., Lake Partner Program data, measure toxicity of blooms
- informal monitoring for: wild rice, population changes in birds (pelicans and gulls), algal blooms earlier and later in the year, green rock algae earlier in the season, beaver and muskrat, fish and frog spawning, leaches
- fish health a good tool. Rusty crayfish and other animal life could be monitored by locals
- hydrocarbons should be monitored
- biomagnification of organics
- P in rainfall

What would you like to see as an outcome with respect to invasive species?

- insist that boats and float planes be washed. Tournaments may not be doing their best. More education around the dangers of species transfer (to include both residents and visitors) and why it's important to be preventative
- rusty crayfish concern, few native shellfish

What would you like to see as an outcome with respect to contaminants?

- stronger regulation and enforcement should be an outcome
- general concern for contaminants

What would you like to see as an outcome with respect to climate change?

- should be a budget for research. How does it affect Lake of the Woods? Give some thought to electric boats.
- need for quantitative measurement of climate metrics, i.e. ice out, ice thickness, precipitation, wind speed and direction

What would you like to see as an outcome with respect to erosion?

- concern in the south, Rainy River and the south shore. Human causes – logging, water levels, vegetation profile. Desired outcomes – minimal erosion, lower total phosphorus and turbidity
- impacts include flow meandering, reduced navigation, less utility for power, reduced waterfront property and harm to cultural sites. Public buy-in required, need to manage vegetation on shoreline.

What would you like to see as an outcome with respect to nutrients?

- examine the ways that these are monitored and measured

The evening session in July was attended by a small group, so most of the session included informal discussion, focused mainly on the most stringent aspect of the existing ALs. The economic importance of clean water was stressed and there was discussion around best management practices to reduce phosphorus loads. The question was again raised about the adequacy of current monitoring.

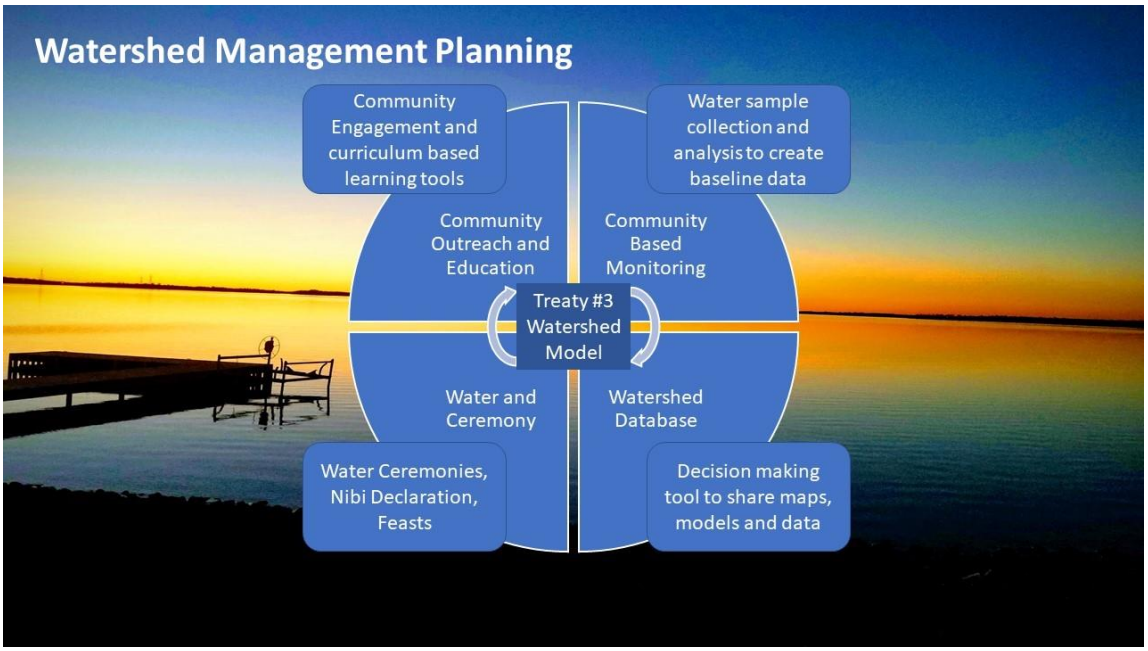
6.2.3 Summary of Feedback from Indigenous Learning Forum

Prior to the Learning Forum on August 21, 2019, the Project Coordinator attended Grand Council Treaty 3's (GCT3) Water Declaration sessions in April, 2019 to learn about this initiative to develop a treaty-wide declaration of the importance of water and the need for everyone to respect its value in decision making. It was also an opportunity to meet members of the Women's Council. In Anishinaabe culture, women are the keepers of the water and it is important to seek advice from them when working on water-related projects. As follow up to that session, the Project Coordinator met a representative of GCT3 and a member of the Women's Council (July 9, 2019) and, subsequently, two elders on August 6, 2019 to talk about the goals of this project, seek advice on protocols and agenda topics and their insight on project outcomes. Advice from the elders was to keep the final recommendations simple and brief, to incorporate the concept of respect for water in the discussions at the Learning Forum and throughout this project and in its outcomes.

The Learning Forum on Aug 21, 2019 attracted 17 participants from a variety of First Nation communities and was held in Ojibways of Onigaming First Nation near Nestor Falls, Ontario. The meeting was in the council chambers of the band administrative office that acts as the self government responsible for the day to day operations of the Ojibways of Onigaming First Nation. Elder Isobel White opened the meeting up in ceremony in order for the dialogue and meeting to commence in a good way.

An introduction to the IJC and the WQOs and ALs project goals were outlined and GCT3 also presented on their Water Declaration, Manito Aki Inakonigaawin (resource law) and the GCT3 watershed planning model (see below).

Conceptual diagram for the Treaty 3 Watershed Model.



The participants were asked to provide feedback on a number of specific questions related to aquatic ecosystem health, changes they have seen in the ecosystem and monitoring that is done. Detailed notes and a list of participants are included in Appendix 5.

The discussion focused on key questions:

What does ecosystem health mean to you?

What changes do you look for in the ecosystem that help you understand its health?

Do you measure or monitor them? How?

Feedback on these as well as suggestions with respect to potential indicators of AEH included:

- cedar die back
- range expansion of many species including magpies
- many concerns about wild rice
- fish spawning, fish deformities/growths in species on LOW (perch, crappy, pike walleye)

- colour of water has changed (murky, less clear than it used to be)
- cedar trees turning orange on LOW islands
- recent emergence of magpies
- no chokecherries this year
- brown cranes new to area
- fewer cormorants than used to be
- non-native animals impacting water quality
- reduction in waterfowl and changing routes

Several suggested questions provided by Elders prior to the Forum included: *What have we heard so far? And where does the feedback go?* These questions were answered by briefly describing what we have heard so far in previous public sessions:

- Keep it simple
- Is current monitoring adequate?
- More education for AIS
- More research (budget) for climate change (quantitative)
- Public buy-in for aspects of erosion
- Indicators: wild rice, birds, algae, beaver, muskrat, fish, frogs
- Fish health is a good tool
- Possibility for local groups to monitor

It was reported that feedback would be captured in the final report of Phase I and that key indicators would be identified and assessed for their ability to track AEH as part of the demonstrated risk approach as part of Phase II. The team worked with Grand Council Treaty 3 to provide a summary of the Learning Forum to all participants.

6.3 Observations from all Sessions

1. The many general concerns that are not within the scope of this project should be brought to the attention of the IJC. These are listed throughout Section 6 and in Appendix 5.

2. More community monitoring and data sharing would be a valued asset to the WQOs & ALs project.

3. First Nation involvement in identifying and assessing AEH indicators should be ensured. This would be described within the AL demonstrated risk process (Figure 3). This should be an aspect of outreach in Phase II.

4. Common questions/concerns heard at all sessions that require further attention:
    - How do we know that the things that are being monitored are the things that should be monitored?
    - What is the response when an AL is identified?

5. Concerns with respect to AEH in all consultation sessions should be reviewed in Phase II to see if they align with the final management goals with respect to WQOs and ALs.

7.0 Assessing Appropriate Boundary Water Segments

The most straightforward division of the watershed into boundary water segments would be to consider four segments as follows:

1. Lake of the Woods North
2. Lake of the Woods South
3. The Rainy River
4. Rainy Lake Watershed

The use of these four segments is well supported. First, these boundary water segments line up well with the MPCA's Total Maximum Daily Load (TMDL) modelling efforts (Figure 5) and second, they are generally aligned with watershed characteristics including soil types and land cover within the watershed (Figure 6). Lake of the Woods should be considered with at least two boundary water sub-segments (north and south) due to water quality differences between the two areas of the lake. Expert feedback suggested that there may be a need to further divide Lake of the Woods north and south sectors to recognize cold water systems in the northern portion of the lake. This will be accomplished with consideration of the phosphorus WQO in Phase II.

Figure 5 – Watershed showing Rainy Lake, Rainy River and direct watershed areas. From TMDL draft (MPCA).

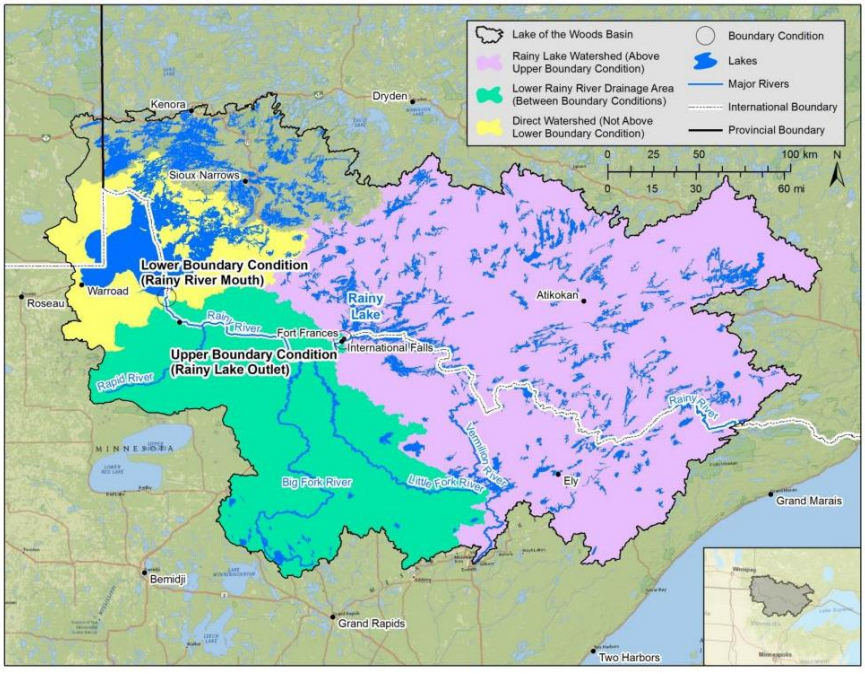
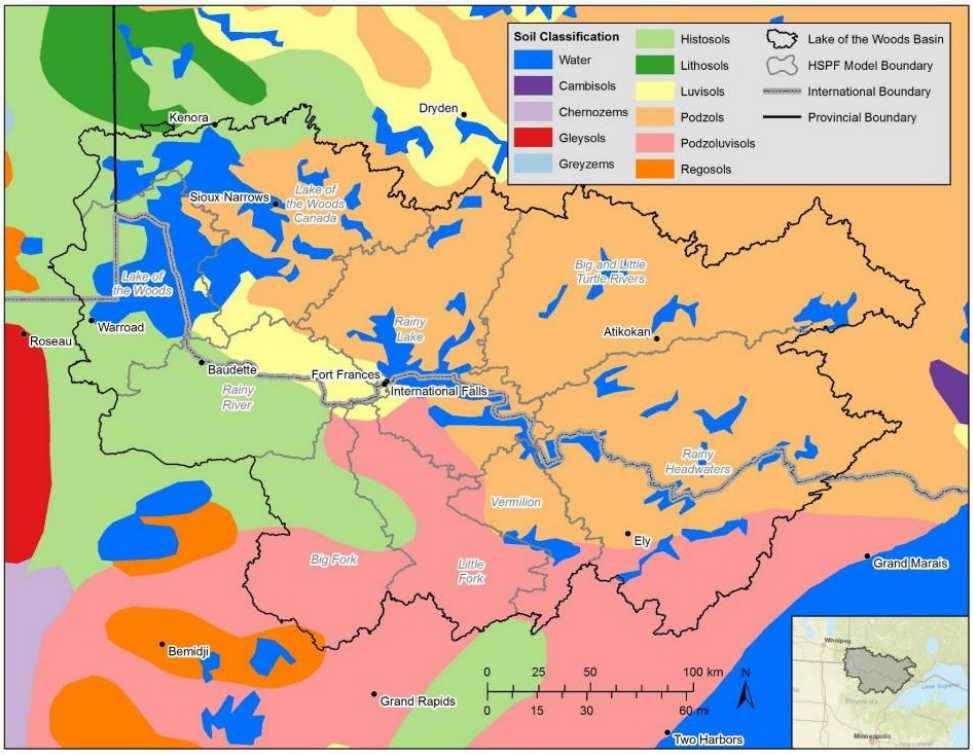


Figure 6 – Dominant Soil Classifications in the Rainy-Lake of the Woods watershed. From TMDL draft (MPCA).



Boundary water segments must be identified as having sufficient monitoring to evaluate the efficacy of any WQOs or ALs that are recommended. In this case, these four segments are currently supported by existing monitoring sites. Further segmentation of the Rainy River may be necessary due to large tributaries in this area (Figure 7). It may be possible to use the output from the SPARROW model to confirm whether there is a need to further divide the Rainy River into additional segments.

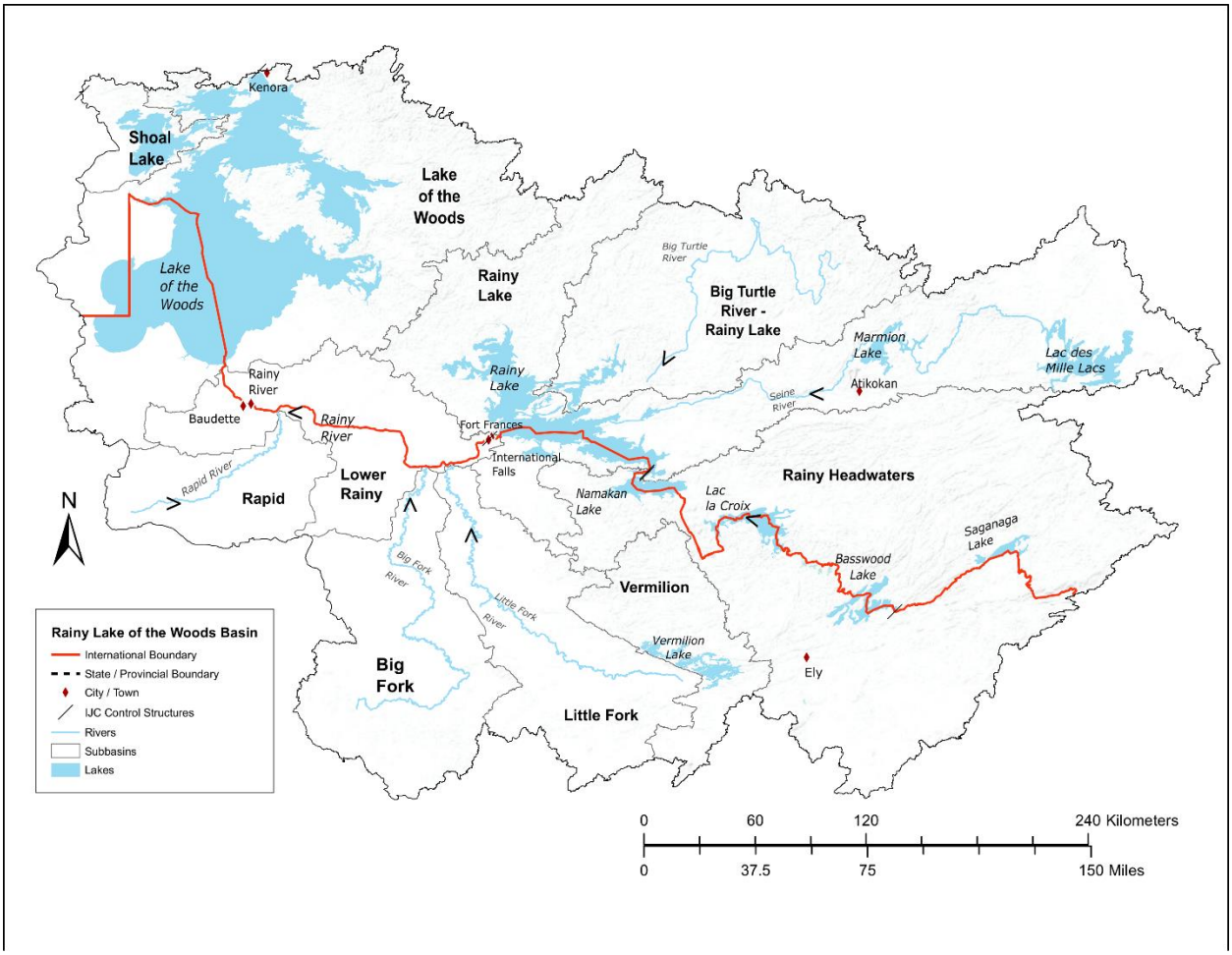
Stakeholder feedback questioned whether there was a need for additional segmentation of headwater areas. These suggestions will be considered in Phase II when guidelines for WQOs are established.

7.1 Priorities assigned to boundary water segments

Each of the five priorities were assessed with respect to the need to develop WQOs or ALs for each of the four boundary water segments. The recommended need for a single WQO for nutrients (phosphorus) would require a **set** of objectives for various segments of the boundary waters since phosphorus concentrations vary throughout the watershed. Appropriate boundary segments will be assigned in Phase II and would likely include several segments for Lake of the Woods, a segment for the Rainy River and a segment for the headwaters.

At this time, it is proposed that all ALs developed for any priorities will apply to all boundary water segments of the watershed. This eliminates the need to consider which segments should have ALs.

Figure 7 – Rainy-Lake of the Woods sub-watersheds and boundary waters.



8.0 Potential for Objectives, Alert Levels and/or Narratives to Manage Priority Issues

Two approaches to using WQOs to address priority issues were explored. The first approach would recommend WQOs only for those priorities where exceedances have been measured with ALs established for the remaining priorities. The second approach would establish WQOs for **all** priorities and an AL list for the contaminants. Following guidance from the Aquatic Ecosystem Health Committee, it was recommended that the WQOs be as straightforward as possible which, in this case, results in a set of border segment specific WQOs for phosphorus (reflecting variation throughout the watershed). All other priorities would then be addressed using ALs, with the understanding that any of these could be re-evaluated in the future for management through WQOs. In this section, we discuss the rationalization for a proposed approach to managing each of the priorities that is based on document review, expert input, feedback from public and indigenous engagement and input from the AEHC and board. Section 9 provides a set of recommendations for each priority for consideration in Phase II.

Nutrients

Nutrients, in this case phosphorus, can be addressed using a WQO. It is fortunate that much work has already been done to identify loads and concentrations of total phosphorus that will improve the beneficial uses of water in the Rainy River and south (U.S.) portions of Lake of the Woods. The TMDL process has identified the load reductions that would be necessary to remove the impaired listing for the south portion of Lake of the Woods. Impairments to water quality in the south watershed of Lake of the Woods include total phosphorus concentrations, chlorophyll a concentrations and water clarity. It is more uncertain which phosphorus concentrations could be achieved at nodes throughout the system following recommended load reductions to the Rainy River. In addition, ECCC is finalizing their modelling efforts to link phosphorous objectives to desired outcomes. This should be completed by March 2020 in time to include these results in Phase II of this project.

The AEHC recommended a combination of both load and concentration considerations for phosphorus WQOs. This will be explored in Phase II of this project.

Contaminants

Contaminants in surface and groundwater are best addressed using ALs simply because most of these are not regularly monitored and the potential list of contaminants of concern is continuously evolving. There are two potential approaches to establishing ALs. First, there could be a ghost list of 'most stringent' concentrations for every parameter for which there is a guideline by any party. This list would be auto updated and would not need to be published. In addition, the list could apply to all boundary waters and this would not involve costs or oversight to manage. The problem with this approach is that it is difficult to assess whether the guideline for any parameter is current at a given time. In addition, the list included many parameters that are not routinely monitored such that they cannot be assessed. The other approach would be to list only those parameters or AEH indicators that are routinely monitored or where exceedances have occurred. This approach yields a very short list if exceedances are examined. There are some noted exceedances for fish consumption, for metals in sediments and for the presence of AIS, but the list is small (Table 3). The list is longer for routinely monitored substances but much shorter than the existing list.

There are certain contaminants such as sulphate with concentrations that are not exceeded but should be examined closely due to concerns around future mining projects. There is no AL for sulphate in the existing AL list, but this parameter would be included in an updated AL list due to the existence of a current Minnesota guideline. It is recommended that a shortened list of ALs be developed to more closely reflect those parameters that are routinely monitored.

It is unclear how best to deal with contaminants in fish or in sediments. Contaminants in fish are currently addressed by consumption advisories. There is considerable literature available with respect to the pros and cons of remediation of sediment contaminants.

Water Levels/Erosion

Water levels are managed independently through the use of rule curves (Rainy Lake and Namakan Chain of Lakes) or control boards (Lake of the Woods). Erosion, which is partly a consequence of water level fluctuation and weather, could be managed using narrative approaches that are linked to models. Alternatively, there could be ALs established that are based on TSS or turbidity. This will be addressed in Phase II of this project.

Climate Change

It may be overly optimistic to imagine that climate change can be addressed through narrative guidelines. Ideally, any narrative guidelines would be linked to indicators that can track the severity of the change in a quantifiable way. There has recently been a great deal of background work completed by the IJC to address climate change, which is a cosmopolitan priority. The need to derive indicators is often noted as a priority.

Bernstein et al. (2017) outlined the current climate change challenge with respect to the IRLWWB:

"One aspect that may require consideration is the level of harmonization between American and Canadian science, policy, preparedness and governance for a given watershed. A discrepancy in the level of science and monitoring on either side of the border in the Rainy-Lake of the Woods watershed was identified as an example."

Currently the IJC guidance with respect to climate change (Annex 9) for the Great Lakes states:

To identify and quantify the climate change impacts on the quality of the Waters of the Great Lakes, the Parties, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, and the Public, shall:

1. *develop and improve regional scale climate models to predict climate change in the Great Lakes Watershed Ecosystem at appropriate temporal and spatial scales;*
2. *link the projected climate change outputs from the regional models to chemical, physical, biological models that are specific to the Great Lakes to better understand and predict the climate change impacts on the quality of the Waters of the Great Lakes;*
3. *enhance monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts;*

4. *develop and improve analytical tools to understand and predict the impacts, and risks to, and the vulnerabilities of, the quality of the Waters of the Great Lakes from anticipated climate change impacts; and*
5. *coordinate binational climate change science activities (including monitoring, modeling and analysis) to quantify, understand, and share information that Great Lakes resource managers need to address climate change impacts on the quality of the Waters of the Great Lakes and to achieve the objectives of this Agreement.*

In this review, many experts and regulators have suggested that climate change should be assessed as a stress multiplier with the effects noted in relation to the key priorities. As an example, if phosphorus is listed as an objective and algal blooms are an indicator used to assess the success of the objective/guideline, then climate change impacts on algal blooms would also need to be assessed since blooms have been shown to worsen without an increase in nutrients. This information, although difficult to quantify, would be useful to the IJC with respect to how conditions were changing. Trends in temperature, precipitation, etc. would provide more quantitative basis for ALs.

Many aspects of climate change could be addressed through this project's suggested use of indicators that demonstrate significant risk (discussed in Section 3.2).

Aquatic Invasive Species

Experts were concerned that the threat and risk of invasions should be identified proactively, if possible. Many aspects of AIS could be addressed through this project's suggested use of indicators that demonstrate significant risk via the AEHC and AIS sub-committee. The model is shown in Figure 3.

9.0 Recommended Water Quality Objectives and Alert Levels

Following feedback from the Expert's Workshop, the public sessions, the Learning Forum and AEHC guidance, the proposed WQOs and ALs are summarized in Table 7. These are being put forward for further consideration and refinement in Phase II of the project, where specific metrics and indicators will be deliberated and agreed upon.

Table 7 – The following table shows the five priorities with recommendations for management using Objectives, Alert Levels and risk-based guidelines.

Priority	WQO or AL	Parameter	Desired Outcome
Nutrients	Water Quality Objective To replace existing WQOs	Total phosphorus loads or concentrations. Although some reactive or filtered phosphorus fractions are sometimes monitored, there are no guidelines for these fractions, and they are not routinely monitored.	Reduce nutrient status to lower productivity, improve water clarity and improve aesthetic water quality.
Contaminants	Alert Levels for reduced list of routinely monitored substances. ALs may be different between lake and river environments or specific to boundary water segments. The mechanism of adopting ALs based on the most stringent guideline for any regulatory agency would apply to all boundary segments including those outside the Rainy River.	Alkalinity, Chlorophyll a Chloride, Conductivity Colour, DOC Dissolved Oxygen Hardness NH_3, NO_2, NO_3, TKN pH, Sulphate, SVS Total Phosphorus TSS, Turbidity Secchi, Temperature Aluminum, Antimony, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver, Zinc, Thallium, Titanium, Zinc	Maintain water quality within most stringent guidelines. Reduce contaminants in fish and benthos.
Climate Change	Alert Level for Demonstrated Significant Risk	Indicator	Maintain risk awareness
Aquatic Invasive Species	Alert Level for Demonstrated Significant Risk	Indicator	Maintain risk awareness. Protect biodiversity. Avoid food web disruptions
Erosion	Alert Level for Demonstrated Significant Risk for non-numeric aspects such as loss of shoreline	Bank Erosion Hazard Index TSS, Turbidity, SS	Develop tools to address erosion

10.0 Gap Analysis

A gap analysis is provided here to identify:

i) Any limits to the establishment of specific guidelines for WQOs and ALs (Phase II).
ii) Any limits to our ability to assess the efficacy of established guidelines.

These limits are outlined below relative to the five priorities. It should be noted that any ALs that are brought forward based on demonstrated risk may have associated gaps that cannot be identified until such time as the Al is brought forward.

Nutrients
It is uncertain whether nutrients are an issue in the headwaters. The need for a nutrient objective for the headwaters will be assessed in Phase II.

There may be existing gaps with ongoing research especially with respect to monitoring. The concern is that sufficient monitoring should be in place to track the effectiveness of phosphorus WQOs for the various boundary water segments. There are many examples of monitoring activities that are, for now, ongoing:

- The MPCA's long term water quality (load) monitoring site in the Rainy River at the Manitou Rapids streamflow gage will continue into the foreseeable future. This site is sampled year-round at least monthly, with about 30 samples per year to quantify nutrient and sediment loads from this location;
- The MPCA's special study on the Rainy River (Large River Assessment) occurred in 2016-2017 and included 9 fixed sites sampled biweekly from May to September for nutrients, sediment, and bacteria. Following the MPCA's Intensive Watershed Monitoring (IWM) Schedule, this project will be repeated at the same sites in 2026-2027. There were sites for this effort near the newer USGS flow gage just downstream of International Falls / Fort Frances, and the now idle flow gage near the Rainy River Wheeler's Point confluence. The Rainy River Large River sampling effort was done for water quality assessment purposes versus the load monitoring site at Manitou Rapids, which is event-driven, similar to the program recently started on Ontario tributaries;
- MPCA's sampling of 4 long term fixed sites on Minnesota's Lake of the Woods waters (responsible for original impairment designation in 2008); they will likely be resampled in 2022-2023, as part of the IWM process, and to help track conditions in support of the TMDL and ECCC's science initiatives;
- Ministry of the Environment Conservation and Parks - Lake Partner Program continues to monitor Total Phosphorus at several locations throughout Lake of the Woods by citizen volunteers. Numbers vary between years;
- Ministry of Natural Resources and Forestry's Broadscale Monitoring Program monitors nutrients on a rotational basis in Canadian portions of the watershed;
- Environment and Climate Change Canada - nutrient modelling to establish targets to reduce algal blooms in Lake of the Woods; and
- Trent University studies to identify loads from Ontario tributaries

Contaminants
Protocols are needed to deal with contaminants of emerging concern. These may be allocated to an AL narrative. There is very little guidance with respect to groundwater contaminants. The Great Lakes Water Quality Agreement (GLWQA) approach to groundwater contaminants suggests:

1. identify groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes;
2. analyze contaminants, including nutrients in groundwater, derived from both point and non-point sources impacting the Waters of the Great Lakes;
3. assess information gaps and science needs related to groundwater to protect the quality of the Waters of the Great Lakes; and
4. analyze other factors, such as climate change, that individually or cumulatively affect groundwater's impact on the quality of the Waters of the Great Lakes.

Contaminants in sediments are rarely managed except for extreme cases, so there are no tools other than lists of threshold concentrations. There is considerable literature available with respect to the pros and cons of remediation of sediment contamination, but remediation is not discussed here.

Contaminants in fish are managed through adaptation with few or no management tools other than consumption advisories. Emission regulations address this to some extent.

Questions arose several times through consultation as to whether the things that need to be monitored are being adequately monitored. This can be addressed further in Phase II.

Water Levels/Erosion
Requires identification of metrics or models (Phase II). See consultation section for public comments concerning erosion.

Climate Change
Approach is complex and gaps are difficult to identify since all priorities can be impacted by climate change (a stress multiplier). Indicators have not been well established. Document 10 recommends developing indicators for climate change.

Aquatic Invasive Species
Experts emphasized the need to be able to identify potential risk of invasion. The IMA-TAC AIS Sub committee/board proposal for a risk assessment remains under review.

Aquatic Ecosystem Health
If the board prefers to assess a wide variety of indicators to track ecosystem health, then a comprehensive review of indicators and metrics is required. Indicators should be prioritized. Resource agencies on both sides of the border have ongoing monitoring programs that include many, if not most, of the metrics that would be needed to assess AEH for the boundary waters. Many of the monitoring sites are located within boundary waters, however, appropriate metrics need to be identified before gaps in the spatial coverage can be determined. Adopting existing metrics for the boundary waters AEH will likely improve the utility of indicators. There are several issues that need to be addressed:

- There is a need to confirm which metrics are a component of ongoing projects;

- There is a need to identify boundary waters monitoring gaps;
- Indicators and metrics will require sorting and prioritizing in Phase II; so far, 47 potential indicators have been identified; along with over 80 potential metrics. Select a subset of the best indicators and metrics for an AEH start-up using data from currently monitored sites;
    - Develop a second subset of indicators and metrics recommended for potential future expansion of the AEH program. Appendix 2 contains a listing of additional indicators and metrics that might be considered for the boundary waters
- Given the large number of agencies involved, development of a Quality Assurance and Quality Control (QA/QC) program may be necessary to harmonize data.

It is important to note that many indicators, like macroinvertebrates, require a model to assess the data. The MPCA, and other agencies, have and continue to develop models to help with assessments. There is a need to determine if agencies can share their models.

Monitoring & Data
Sufficient monitoring in the headwaters to assess future development may be a concern.

11.0 Communication and Outreach

Throughout the project, outreach to key groups and organizations has occurred to ensure that there is ample opportunity for all parties to participate in Phase I and provide a good foundation for the discussions to come in Phase II. Table 8 summarizes the outreach activity since the beginning of the project.

Table 8 – Phase 1 Outreach Efforts

Date	Outreach	Notes
2019		
Sept. 30	Deliverable 4	Submitted to Board and AEHC
Sept. 9	AEHC	Update on project and review of Deliverable 3 with AEHC
Sept. 6	AEHC and IJC	Review of initial comments on Deliverable 3
Aug. 30	Deliverable 3	Submitted to Board, AEHC and IMA
Aug. 22	Phone discussion and response to MNO	MNO requesting opportunities to meet with O/A team and option for IJC support
Aug. 21	Indigenous Learning Forum, Onigaming First Nation	17 attendees
Aug. 20	Attendance at IMA-TAC Water Quality Subcommittee meeting	Update on O/A project and parallels with subcommittee's project regarding challenges with setting targets
Aug. 14	Attendance at IRLWWB Board meeting	Participation in O/A discussion
Aug. 14	Attendance at IRLWWB CAG meeting	Update on O/A engagement
Aug. 14	Attendance at AEHC meeting in Baudette, MN	Update on project
Aug. 13	Presentation at Resource Agency Meeting of IRLWWB in Baudette, MN	Update on project
Aug. 13	Attendance at IRLWWB Engagement Committee meeting	
Aug. 6	Meeting with Elders of GCT3	Protocols and approach for Learning Forum
July. 11	Meeting with WLC/GCT3	Discussion around integrating findings from sturgeon and/or wild rice protocol into list of indicators
July. 9	Meeting with GCT3 Women's Council	Seeking advice on planning of Learning Forum, process and protocols, items for agenda
July. 8	Two public meetings in Kenora	attendance - 30 and 7
July. 4	Social media notice of July 8	IJC and LOWDSA
July. 4	Newspaper article describing project, meetings	Kenora Enterprise and online

July. 3	Reminder email of July 8 sent to distribution list	Expert and public contacts, IMA, Board
June. 27	Email to invite FN communities of AKRC	New contact at AKRC (discussion by phone too)
June. 21	Update presentation to RLWWB	
June 18 and 19	Notice of July 8 meeting sent to distribution list	Expert and public contacts, IMA, Board
	Hold the Date email sent to communities by GCT3	
May. 14	Email to GCT3 re Learning Forum planning strategy	
May. 13	Revised overview document sent for posting on RLWWB website	Updated to include July 8 public meeting dates
May. 13	Watershed News newsletter sent - includes update on project and summer meeting dates	Sent to ~300 recipients
May. 8	Re sent email to MNO re participation in O/A	
Apr. 30	Deliverable 2	Submitted to Board
Apr. 24/25	Water Declaration workshop hosted by GCT3	Attended event to learn about value of water to First Nation communities and meet Women's Council members to discuss O/A project
Apr. 22	Meeting with MPCA	Refine description of MPCA indicators and metrics
Apr. 11	Update presentation to AEHC	
Apr. 9	Email offering link to recording of webinar	Sent to all registrants
Apr. 5	Call with PIISD-ELA	Discussion regarding options to combine events in summer 2019 and upcoming opportunities with First Nation communities and GCT3
Apr. 3	Open webinar	14 attendees
Apr. 1	Call with GCT3	Discussion regarding focus of Learning Forum, connecting with Womens' Council to plan Forum, possible dates in summer 2019
Mar. 28	Invite to April 3 webinar emailed as a reminder	Expert and public contacts, IMA, Board
Mar. 19	Invite to April 3 webinar emailed	Expert and public contacts, IMA, Board
Mar. 13	Presentation at Watershed Forum	160 attendees
Mar. 12	Public workshop	19 attendees
Mar. 12	Expert workshop	36 attendees
Mar. 5	Water Matters features O/A project	posted and sent via IJC social media
Mar. 4	Public package sent to all invitees	

Mar. 4	First Nation project overview sent to AKRC	
Feb. 28	Package sent to public RSVPs	agenda, package and report
Feb. 28	Press release announcing workshops, meetings	Sent by IJC to all media
Feb. 28	Meeting with IJC Advisors	Discussion regarding process for planning Learning Forum
Feb. 28	Email to MNO rep	Follow up to ask if any questions; interest in participation
Feb. 26	Reminder email to Public workshop invitees	
Feb. 15	Expert package sent to all non-attendees	
Feb. 14	Project overview, list of events for FN communities	Sent to all First Nation contacts by GCT3
Feb. 14	Expert package sent to all attendees	
Feb. 11	Reminder email to Expert Workshop invitees	
Feb. 5	Invitation to Public Workshop and Newsletter Ad	Sent to all stakeholder contacts, lake associations
Feb. 4	Project overview posted on IRLWWB website	
Jan. 31	Deliverable 1	Submitted to Board
Jan. 29	IRRLWWB- update presentation	
Jan. 28	Meeting with IJC, Board member, AM Task Team member	Overlap of O/A, AM and climate change initiatives
Jan. 25	IMA-TAC committee update presentation	Questions about how exceedances are managed
Jan. 21	Email to MNO rep	Follow up to ask if any questions; interest in participation
Jan. 16	Email to MNO rep	Follow up to ask if any questions; interest in participation
Jan. 16	IJC Communications Team	Plans for communicating upcoming workshops
Jan. 11	ECCC call with Dr. Bill Taylor re ECCC science	Overview of ECCC science
Jan. 9	Invite to Expert Workshop sent (Experts, IMA, Board)	Regular follow ups and reminders
Jan. 8	Call to MDNR re AEH	Indicators and Metrics
Jan. 8	Call to MOECP re AEH	Contact for Indicators and Metrics
Jan. 7	Call with GCT3	Discussion of opportunities to involve GCT3 and communities in the O/A project; outreach materials

2018		
Dec. 11	Email to MNO rep	Response to request for more detailed information
Dec. 10	AEH committee update	
Dec. 7	IMA update - presentation	question about regulatory agency input
Dec. 6	Call with MPCA re AEH & segmentation	
Dec. 5	Email to MNO rep	Introduction to project; invitation to participate
Nov. 7	Startup call with AEHC & IJC	
Nov. 4 2018	Call with MPCA re AEH	Tiered Aquatic Life Uses

12.0 Recommendations

1. That the board recommend to governments that the Water Quality Objectives (WQOs) and Alert Levels (ALs) be adopted as described in Section 9 of this report.
2. That Aquatic Ecosystem Health (AEH) be assessed by one or all of the suggested approaches described in Section 3 of this 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.
3. That a process be 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.
4. That communication between rule curve or water level boards be established when water levels are shown to be associated with WQOs or ALs.
5. That 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.
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.
7. When the board recognizes that a WQO has been exceeded, it will recommend that the exceedance be assessed by both governments.
8. When the board recognizes that an AL has been triggered, it will advise that the AL be assessed by both governments.
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.
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.

13. Next Steps and Phase II

Immediate next step is to deliver the findings of this report to all individuals who have a stake in the outcomes, including a window for public review, if deemed appropriate by the board.

Phase II Tasks

1. Identify boundary water segments that require phosphorus Water Quality Objectives and assign P concentration or load targets to achieve desired results in each segment.
2. Update the contaminants AL list to include routinely monitored substances according to the most stringent guideline determined by any regulatory agency associated with the boundary water.
3. With respect to AEH:
   If a comprehensive assessment of AEH is desired, then:
   - Refine the list of AEH indicators to include those additional indicators and metrics that might be considered for the boundary waters.
   - The MPCA, and likely other agencies, have and continue to develop models to help with assessments. There is a need to determine if agencies can share their models.
   - Develop an updated list of priority ALs for specific basin waters/locations that reflect priority issues in the basin and are minimally needed to identify potential problems for boundary waters;
   - Conduct an assessment of monitoring and information adequacy / needs minimally required to support evaluation and reporting against the recommended Objectives and ALs; and
   - Develop a proposed assessment framework for ongoing evaluation and assessment of AEH in the basin

   If the demonstrated risk approach is desired, then:
   - Establish a process whereby stakeholders/researchers and indigenous communities can bring forward ALs associated with demonstrated risk.

4. Final recommendation of Objectives and ALs, and related issues such as frequency of data collection, analysis and reporting, should take into consideration the purpose and use of Objectives and ALs, as well as human and financial resource requirements and availability to effectively manage reporting against Objectives and ALs.

5. The Gap Analysis presented in this report should be revisited in Phase II to determine whether the various identified gaps are relevant to Phase II.

6. Assess the need for further consultations associated with Phase II tasks. Concerns with respect to AEH in all consultation sessions should be reviewed in Phase II to see if they align with the final WQOs and ALs.

7. A plan to proceed should be developed to assist the board with assessing efficacy of WQOs and ALs and to provide tools to assess AEH in an ongoing basis. Capacity to ensure reporting in 5-year intervals should be addressed.

14. References

Note: References for reviewed documents are listed in Section 2 of this report.

Bernstein, A., Brown, C., Taner, M., and B. Werick (2017). Climate change guidance framework pilot project. Prepared for the International Joint Commission, Final Report October 2017.

Clark, B.J. and T.J. Sellers 2014. State of the Watershed Report, 2nd Ed. (2014). Published by the Lake of the Woods Water Sustainability Foundation, July 1, 2014, Editors Bev J. Clark and Todd J. Sellers.

International Lake of the Woods Watershed Water Quality Plan of Study Covering the Rainy-Lake of the Woods Watershed Draft for Public Review and Comment, Click or tap here to enter text.July 22, 2014 https://legacyfiles.ijc.org/tinymce/uploaded/lwbwqpos/DRAFT_LakeoftheWoodsWatershed_WQ_PlanofStudy_22July2014_FINAL.pdf

Houston Engineering Inc. (2013) Lake of the Woods Sediment & Nutrient Budget Investigation – Focusing on watershed and southern shoreline loads, Final Report, March 8, 2013 – 78pp.

IJC 1965. Report of the International Joint Commission United States and Canada on the Pollution of Rainy River and Lake of the Woods, Washington-Ottawa, February 1965.

Karr, J.R. (1999). Defining and measuring river health. Freshwater Biology 41, 221-234. Hydrobiologia 188/189: 123-135, 1989.

Munawar,M. , G. Dixon, C. I. Mayfield, T. Reynoldson and M. H. Sadar (1989). Environmental Bioassay Techniques and their Application, Hydrbiologia, 188/189 123-135.

O'Brien, A, Kallie Townsend, Robin Hale, David Sharley, Vincent Pettigrove (2016) How is ecosystem health defined and measured? A critical review of freshwater and estuarine studies. Ecological Indicators 69 (2016) 722–729.

Paterson, A.M., Kathleen M. Rühland, Crystal V. Anstey &John P. Smol, 2017.
Climate as a driver of increasing algal production in Lake of the Woods, Ontario, Canada. Lake and Reservoir Management, Volume 33, Pages 403-414

Rapport, D.J, R. Costanza and A.J. McMichael (1998). Assessing ecosystem health, TREE vol. 13, no. 10 October 1998.

Suter, G.W. (1993). A critique of ecosystem health concepts and indexes, Environmental Toxicology and Chemistry, Vol 12, pp 1533-1539.

Appendix 1 - Document Review Summary

1. State of the Basin Report, 2nd Ed., 2014. Published by the Lake of the Woods Water Sustainability Foundation, July 1, 2014, Editors Bev J. Clark and Todd J. Sellers.

Priority	Border Water Segment	AEH indicators	Monitored
Climate Change	Regional - All	Algal Blooms, water levels, temperature, ice-free days, coldwater fish, water chemistry	At present
Contaminants	All	Water chemistry, aquatic toxicity	Water chemistry
Invasive Species	All	Presence absence	partial
Nutrients	LoW, RR	Algal blooms, cold water fish	yes
Erosion	LoW, RR tributaries	Water clarity, fish recruitment, aspects of habitat	RR tributaries
Note: Algal blooms were listed as a priority but in this review, we have included algal blooms as an AEH indicator for nutrients.			

2. International Joint Commission (2015) A Water Quality Plan of Study for the Lake of the Woods Watershed. ISBN: E95-2/19-2015E-PDF.

Priority	Border Water Segment	AEH indicators	Monitored
Algal blooms	LoW		yes
AIS	All		yes
Contaminants: Sulphate, Copper Nickel, Mercury	In mining areas	Not specified but contaminants in fish and sediments could be an indicator	?
Water levels	All	Aspects of habitat	yes
Petroleum transport	All		?
Ag contaminants	All		?
CECs	LoW, RR		?
This study recommended specific projects that would answer questions about priorities. Priorities are specified including secondary concerns (last 4 priorities). No AEH indicators mentioned for individual projects. Gap would be identifying which parameters represent indicators relating to a given priority for developing WQOs. Is there an indicator for AIS risk of invasion? Can we use output from models as an Objective? One project was to report contaminants in water, sediment and fish which could be contaminant indicators.			

3. International Joint Commission (2017). A Review of International Water Quality Objectives in the Souris, Red, Rainy-Lake of the Woods and St. Croix River Watersheds: Historical Perspectives, Recent Trends and Future Directions. January 2017 unpublished report.

ISRB (Souris)	Water Quality Objectives	>40
	Alert Levels	none
IRRB (Red River)	Water Quality Objectives	DO, TDS, Chloride, SO_4, E. coli
	Alert Levels	29 including pesticides
IRLWWB (Rainy-LoW)	Water Quality Objectives (under review)	Coliform, DO, SS, Nutrients & Wood sugars
	Alert Levels (under review)	Most stringent of any parameter measured (extensive list)
SCRWB (St. Croix)	Water Quality Objectives	Dissolved Oxygen
	Alert Levels	Water quality index
Note: This is a review of the development and current status of the Objectives and Alert Levels that are in place for the four IJC reference watersheds outside of the Great Lakes Watershed. No priorities considered for R-LoW watershed		

4. Great Lakes Ecosystem Indicator Project Report A Report of the IJC Priority Assessment of Progress towards Restoring the Great Lakes. June 2014. IJC, Canada and United States.

Great Lakes watershed – AEH not tied to specific priorities	
Disturbance:	Monitored
Land cover fragmentation	Y
Shoreline Alteration Index	TBD
Riparian wetlands quality	TBD
Lake level fluctuations	Partial
Tributary physical integrity	Y
Temperature	Y
Atmospheric deposition	?
Water chemistry	Y
PBT in biota	Y
Nutrient loading	Y
AIS invasion rates and impacts	?
Riparian birds	?
Primary producer's condition	?

5. Preliminary Review Draft Lake of the Woods Excess Nutrients Total Maximum Daily Load, 2018, Minnesota Pollution Control Agency.

Priority	Border Water Segment	AEH indicators	Monitored
Water Quality	LoW and RR	Nutrient loading and concentrations, TP, Chl a, Secchi	Manitou Rapids and all U.S. tribs to the RR
Climate change Indicators and Adaption			
Ground and surface water contamination			

6a. Environment Canada's Lake of the Woods Science Initiative 2008 to 2011 and,
6b Environment Canada's Lake of the Woods Science Initiative 2008 to 2011 – Summary.

Priority (not specific)	Border Water Segment	AEH indicators	Monitored
Phosphorus	LoW, RR	Many parameters compared to existing ALs. Noted that no AL currently for sulphate	Ongoing?
Hg			Ongoing?
Sulphate			Ongoing?
pesticides			Ongoing?
Algal blooms			Ongoing?

6. Results of Environment Canada's water quality monitoring and surveillance activities in the LoW watershed 2012-14 Environment Canada, WQMS 2015.

Priority (not specific)	Border Water Segment	AEH indicators	Monitored
None specified but focus can indicate priorities plus initiatives may be based on previously assessed priorities	LoW, RR	phosphorus	Ongoing?
		nitrates	Ongoing?
		Chl a	Ongoing?
		Sulphate	Ongoing?
		chloride	Ongoing?
		Calcium	Ongoing?
		DOC/DIC	Ongoing?

8. Guidance Manual for Developing Nutrient Guidelines for Rivers and Streams
PN 1546 ISBN 978-1-77202-022-9 PDF © Canadian Council of Ministers of the Environment, 2016

Priority	Border Water Segment	AEH indicators	Monitored
Nutrient focus but not linked to any priorities in RR-LoW watershed	NA	Nutrients	no
Guidance to establishing Objectives using different approaches			

9. Managing Water Levels and Flows in the Rainy River Watershed A Report to the International Joint Commission, Final Report – June 2017, Prepared by the International Rainy and Namakan Lakes Rule Curves Study Board.

Priority	Border Water Segment	AEH indicators	Monitored
Water Levels Adaptive Management May be linked to all priorities	RR headwaters	Game fish and whitefish	Y
		Wild rice distribution	?
		Hybrid cattail distribution	?
		Muskrat abundance	?
		Loon reproductive success	?
		Benthic community health	?
		Water quality	Y
		Hg in YOY perch	Y
		Climate change	Y

10. Bi-national Management of Lake of the Woods and Rainy River Watershed Report, International Lake of the Woods and Rainy River Watershed Task Force - July 15, 2011.

Priority	Border Water Segment	AEH indicators	Monitored
Participation of Tribes, First Nations and Métis at the decision-making table	ALL		NA
Nutrient enrichment and harmful algal blooms			Y
Accelerating effect of climate change on water management		Recommends developing indicators for climate change	
Land development			Y?
Invasive species			Partial
Impacts of water regulation decision making			NA
Communication.			NA
Note: This report has a great deal that needs to be brought forward especially with respect to consultation. It is an amalgamation of several reports reviewed here.			

11. Manitoba Water Quality Standards, Objectives and Guidelines Water Science and Management Branch Manitoba Water Stewardship, Nov 2011.

Priority	Border Water Segment	AEH indicators	Monitored
No priorities for watershed but can serve as a reference for established WQOs or ALs	Manitoba	None	NA Similar to PWQOs

12. International Rainy-Lake of the Woods Watershed Board First Annual Water Quality Report. Submitted to The International Joint Commission April 2016

Priority	Border Water Segment	AEH indicators	Monitored
Phosphorus	Identifies areas where ALs have been exceeded	none	Y
	Shows spatial variation of P in all areas		Y
Useful for setting Objectives for nutrients in various watersheds. Contains ECCCs monitoring 2012-14			

13. International Rainy-Lake of the Woods Watershed Board Aquatic Ecosystem Health Report, 2015 and 2016. Submitted to the International Joint Commission October 25, 2017.

Priority	Border Water Segment	AEH indicators	Monitored
nutrients (TP)			Y
mining			Y
AIS		AIS is an indicator	Y
algal toxins			Y
Climate Change		Fish as indicator of AEH	?
Monitoring			
First attempt at identifying indicators. Notes gap in load data. No habitat measurements.			

14. Lake of the Woods Watershed Monitoring and Assessment Report, 2016 MPCA.

Priority	Border Water Segment	AEH indicators	Monitored
Nutrients and algae continued impairment in LoW	Lake of the Woods	Index of biotic integrity	Not in boundary waters except LoW
		Invertebrates	
		Plants	

15. Directive to International Rainy-Lake of the Woods Watershed Board, 2013.

16. IJC Sparrow Modelling (beta version still in development)

17. Pollution of the Rainy River and Lake of the Woods, 1965, Report of the IJC United States and Canada.

18. Rainy River Alert Levels – excerpt from IRRWPB report.

19. Presentation – McDaniel and Pascoe 2018 – ECCC Lake of the Woods Monitoring Update.

20. Update on Integrated Modelling, 2018. Valipour et al., Webinar

Document	Border Water Segment	AEH indicators	Monitored
15	For information only		
16	For information only		
17	For information only		
18	For information only		
19	Monitoring data review. Useful to note exceedances and concentrations relative to ALs LoW, RR, Pinewood R.	no	Ongoing?
20	LoW, RR	Has erosion component	Ongoing?

Appendix 2 - AEH Indicators that may be applicable to Rainy-Lake of the Woods Watershed

Additional indicators suggested by the Great Lakes Ecosystem Indicator Project Report are:

- Coastal Habitat – Shoreline Alteration Index
- Land Cover and Fragmentation Status
- Seasonal and Long-Term Fluctuations in Great Lakes Water Levels
- Tributary Physical Integrity
- Water Temperature
- Atmospheric Deposition of Chemicals of Mutual Concern
- Chemicals of Mutual Concern in Water
- Persistent, Bioaccumulating, Toxic (PBT) in Biota
- Phosphorus Loads and In-Lake Concentrations
- Aquatic Invasive Species: Invasion Rates and Impacts
- Abundance and Distribution of Fish-Eating and Colonial Nesting Birds
- Lower Food Web Productivity and Health
- Fish Species of Interest
- Harmful and Nuisance Algae

Indicator List Taken from: GREAT LAKES ECOSYSTEM INDICATOR PROJECT REPORT:

3.2.1 Coastal Habitat – Shoreline Alteration Index

Expert workgroup member: Scudder Mackey
IJC staff: Lizhu Wang
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Definition
The indicator uses Shoreline Alteration Index (SAI) as a measure of human modified shoreline length that is physically and biologically unfavorable to the Great Lakes ecosystems. The physical and biological components used to calculate the SAI can be measured using conventional high-resolution aerial photography or satellite imagery at multiple scales. The physical component is the ratio of lineal length of armored and other “man-made” shoreline relative to total lineal length of the shoreline. The biological component is the lineal length of biologically incompatible shoreline structures relative to the total lineal length of human modified shoreline.

Team Notes:

- *Disturbance Indicator*
- *Data not currently collected, but data can be derived from satellite imagery*

3.2.3 Land Cover and Fragmentation Status

Expert workgroup members: Scott Sowa, Dave Allan, Mark Nelson, Hobie Perry, Randy Swaty, Dave Ullrich
IJC staff: Lizhu Wang, Vic Serveiss
Page 17

Definition
This indicator assesses the rate and extent of change to, and the fragmentation of, natural land cover within the Great Lakes watersheds. This landscape scale indicator will inform inferences about the major proximate causes of changes and trends in other biological communities, physical habitat, and water quality indicators that are more directly reflective of the health of the Great Lakes ecosystem.

Team Notes:

- *Disturbance Indicator*
- *The MPCA and MDNR are currently working with local governments to develop metrics that, using the SAM model, can provide easy access to disturbance data for watersheds from 8 digit HUCs down to 14 digit HUCs*

3.2.4 Seasonal and Long-Term Fluctuations in Great Lakes Water Levels *(NB – LOW, Rainy and Namakan)*

Expert workgroup members: Drew Gronewold, Norm Grannemann, John Allis, Glen Benoy, Jacob Bruxer, David Fay, Mike Shantz, Al Steinman
IJC staff: Lizhu Wang, Glenn Benoy, Vic Serveiss
Page 19

Definition
This indicator tracks seasonal, inter-annual, and long-term (i.e. decadal) trends in lakewide-average water levels across each of the Great Lakes. The set of measures associated with this indicator are calculated from existing estimates of lake-wide average water levels based on gage measurements since 1918. This formal network of gages for each lake was established and has served as the basis for an internationally-coordinated set of monthly-average water level measurements. Lake-wide average water levels based on gage measurements is also available dated back to 1860, the year in which at least one gage ("master gage") was installed along the shoreline of each of the Great Lakes. The measures proposed below are based on monthly average water level records from gage data collected between 1918 and present. It is suggested to not use the data before 1918 because of the concern that glacial isostatic adjustment may bias the measures.

Metrics:

1. Long term water variability
2. Timing of seasonal water level Max and Min
3. Magnitude of seasonal rise and decline

Team Notes:

- *Most of the data for the metrics are available from LOW Secretariat, USGS and ECCC*

3.2.5 Tributary Physical Integrity

Expert workgroup member: Scudder Mackey
IJC staff: Lizhu Wang
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Definition
This indicator includes three measures. The Hydrologic Alteration (R-B Flashiness Index) quantifies the hydrologic responsiveness (i.e. flashiness) of a Great Lakes tributary to temporal changes in precipitation and runoff. The Tributary Connectivity quantifies the percent of mainstem channel length that is naturally accessible and is connected to the Great Lakes. This measure can be calculated for a single tributary or multiple tributaries. The Tributary Sediment-Turbidity quantifies changes in the magnitude and duration of turbidity referenced to a turbidity threshold. When calibrated properly, turbidity may be used as a surrogate for changes in suspended sediment load.

Metrics:

1. Hydrologic Alteration
    a. R-B Flashiness Index
2. Tributary Connectivity to receiving waters
3. Sediment -turbidity measure

3.2.6 Water Temperature

Expert workgroup members: Norm Granneman, Eric J Anderson, Jay Austin, Ed Rutherford, Chris Spence, Jia Wang, and Ram Yerubandi
IJC staff: Lizhu Wang, Glenn Benoy
Page 26

Definition
This indicator tracks the trends in water temperature and extent of winter ice cover for each of the five Great Lakes by measuring changes in duration and spatial extent of water temperature and ice cover using long term data. This indicator measures the thermal properties of the Great Lakes that affects the ecosystems' function and influences water evaporation from the lakes that affects lake's water level.

Team Notes:

- *May not be applicable to R/LOW watershed lakes, but data for tribs should be available from USGS and MPCA*

3.3.1 Atmospheric Deposition of Chemicals of Mutual Concern

Expert workgroup member: Todd Nettesheim
IJC staff: Jennifer Boehme, Antonette Arvai
Page28

Definition
This indicator will report on spatial patterns and temporal trends of concentration of chemicals of mutual concern in the atmosphere and precipitation of the Great Lakes region. The indicator will be

used to infer potential impacts of toxic chemicals from atmospheric deposition loadings on the Great Lakes aquatic ecosystem, as well as to infer the progress of various programs toward virtual elimination of toxics from the Great Lakes.

Team Notes:

- *Metrics will need to be identified if we want to use this indicator*
- *Will require continuous MET station(s)*

3.3.2 Chemicals of Mutual Concern in Water

Expert workgroup members: Michael Murray, Deborah Swackhamer, Gail Krantzberg, and Conrad DeBarros, Gary Klecka IJC staff: Jennifer Boehme
Page 29

Definition

This indicator addresses total concentrations of selected legacy toxic chemicals and chemicals of emerging concern in water that are determined at selected offshore and nearshore sites in each lake on a two-to-three-year basis. The specific chemicals of mutual concern, including legacy and emerging chemicals, will be selected by the Great Lakes Executive Committee as per Annex 3 of the GLWQA. The purpose of the indicator is to assess the magnitude and direction of trends of chemicals of mutual concern (CMCs) in Great Lakes surface water, the potential for human or ecological impacts, and progress toward virtual elimination of toxic substances in the Great Lakes watershed (Dove, 2011).
Team Notes:

- *Currently the only regular monitoring for chemicals of concern on the US side is the WICOLA/MPCA heavy metals project, with sampling every ten years*
- *If we want to do more, we would need to identify chemicals of concern*
- *Politics- likely we will be pressured by anti-mining and mining interests*

3.3.4 Persistent, Bioaccumulating, Toxic (PBT) in Biota

Expert workgroup members: Jeff Ridal, Michael Murray, Conrad deBarros, Gary Klecka
IJC staff: Vic Serveiss, Lizhu Wang
Page 34

Definition

The persistent, bioaccumulating, toxic substances (PBTs) in biota indicator is an assessment of the trends in the concentrations of PBTs in whole fish and fish-eating birds. It can be used to describe temporal and spatial trends of bioavailable contaminants in representative biota throughout the Great Lakes; to infer the impact of contaminants on the health of fish and bird populations; to infer the effectiveness of remedial actions related to the management of *critical* pollutants; and to document and describe the trends of chemicals of emerging concern.

Team Notes:

- *Data available from MN Health Dept. Currently MDNR collects samples from water bodies identified by Health Dept. Health Dept analyzes samples and publishes a report*

3.3.5 Phosphorus Loads and In-Lake Concentrations

Expert workgroup member: Joe DePinto

IJC staff: Mark Burrows, Raj Bejankiwar
Page 36

Definition
This indicator tracks the trends in phosphorus loading to each of the Great Lakes, including specification of loading to major embayments/sub-watersheds of the lakes. The loads of both total phosphorus (TP) and dissolved reactive phosphorus (DRP) should be tracked from the major watersheds of each lake. A second component of the indicator is to track the spatial and temporal trends of TP and DRP concentrations in the nearshore and offshore areas of each lake in response to the external loads.

Team Notes:

- *Loading – MPCA provides loading data for all 8-digit watersheds (and many minor watersheds within the 8 digit HUC), Status of MOECC loading study unknown at this time*
- *In-lake - Monitoring is ongoing in both Canada and the US*

3.4.1 Aquatic Invasive Species: Invasion Rates and Impacts

Expert workgroup members: Bill Taylor, Gavin Christie
IJC staff: Lizhu Wang, Mark Burrows, Vic Serveiss
Page 37

Definition
This indicator measures the rate of invasion and status and impact. The rate of invasion is the number of new aquatic invasive species (AIS) arriving in the Great Lakes since the last assessment (3 year window), a retrospective analysis to identify the likely pathway by which the species arrived, and an evaluation of the longer record to quantify any trend in the rate of invasion.
The status and impact is to measure the detrimental effects of aquatic invasive species on the Great Lakes. It specifically excludes species that are benign or perceived to be desirable species. Status measures the relative abundance of AIS to native species of equivalent trophic position, while impact measures how AIS affects the other ecosystem components

Metrics:

- Rate of Invasion – plotting cumulative numbers of invasions verses time
- Status and Impacts –

Team Notes:

- *Need to determine what AIS monitoring is going on in the watershed. AIS committee report to follow.*

3.4.2 Abundance and Distribution of Fish-Eating and Colonial Nesting Birds

Expert workgroup members: Bill Bowerman, Latice Fuentes, Pamela Martin, Robert Letcher, Doug Crump, Kim Fernie, Michael Gilbertson, James Ludwig, Shane DeSolla, Jeff Ridal
IJC staff: Glenn Benoy, Lizhu Wang
Page 39

Definition
This indicator measures ecological integrity using population measures that are tied to the health of individuals, colonies, and populations of fish-eating birds at multiple geographic scales; and links biological integrity to both chemical integrity and physical integrity, which are measurable stressors (causes) to biological integrity (effects).

Team Notes: Ongoing monitoring for Fish-Eating and Colonial Nesting Birds in the watershed except the long term monitoring of eagle nests VNP and MDNR have done some special studies in the past.

3.4.3 Lower Food Web Productivity and Health

Expert workgroup members: Bill Taylor, Jan Ciborowski, Veronique Hiriart-Baer, Ora Johannsson, Tim Johnson, Chuck Madenjian, Euan Reavie, Lars Rudstam, Hank Vanderploeg, Sue Watson
IJC staff: Lizhu Wang, Vic Serveiss
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Definition
This indicator focuses on the efficiency with which energy is transmitted from primary producers to different levels of consumers. The indicator mainly measures phytoplankton and zooplankton community structures and biomasses, benthos abundance and diversity, and prey fish abundance and diversity. These measures are selected based on their inherent importance in energy transfer and their measurability.
Metrics:

- Phytoplankton
- Zooplankton
- Mysis Biomass
- Benthos
- Prey Fishes

Team Notes:

- *Lower Food Web Productivity and Health is the foundation of the aquatic ecosystem. Using appropriate metrics we can recognize early-on changes to the ecosystem*
- *There's been a lot on this in the R/LOW work, but we need to meet with the scientists doing the work to determine if there's regular monitoring of the lower food web and which metrics are appropriate for the R/LOW*

3.4.4 Fish Species of Interest

Expert workgroup members: Gavin Christie, Roger Knight, James Boase, Chuck Bronte, Mark Ebener, Jixiang He, Kevin Kayle, Jana Lantry, Charles Madenjian, Tom Pratt
IJC staff: Lizhu Wang, Vic Serveiss
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Definition
This indicator measures status and trends in population abundance and recruitment for several key fish species that are representative of healthy fish communities in major habitats of the Great Lakes. It

includes species that support valuable fisheries in the Great Lakes and that reflect ecosystem health through their roles in the aquatic food web.

Metrics:

Measure Description
This indicator consists of standardized scoring of lake-specific adult abundance and recruitment for several fish species that represent various thermal and spatial habitats:

1. Cold water, off-shore - Lake Trout and Lake Whitefish.
2. Cool water, near shore – Walleye.
3. Cool water, near shore, rivers, and connecting channels - Lake Sturgeon.
4. Warm water, near shore – Northern Pike and/or Smallmouth Bass/Largemouth Bass.

Team Notes:

- *There's plenty of regular monitoring for fisheries (OMNR, MDNR & MPCA). We need to work with the agencies to determine appropriate metrics and define frequency of monitoring*

3.4.5 Harmful and Nuisance Algae

Expert workgroup members: Sue Watson, Greg Boyer
IJC staff: Glenn Benoy, Lizhu Wang
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Definition
Harmful algae or harmful algal blooms refer to blooms that are documented to contain toxins or are composed of species with the genetic potential to produce toxins that affect human health, livestock, pets, and other organisms. In the Great Lakes and most other freshwaters, harmful algae toxins are exclusively produced by certain species of cyanobacteria which may not always express their toxin genes to the fullest extent. Nuisance algae or nuisance algal blooms refer to a broader subset of algae and cyanobacteria species that form blooms which are nontoxic to humans but cause ecological and socioeconomic harm. Collectively, they are referred to as harmful and nuisance algae (HNA). Excessive algal blooms refer to those blooms where information on their composition and ecosystem effects is generally lacking. Most commonly, this will encompass bloom events detected by remote sensing where identification of the cyanobacterial taxa, toxicity, or ecosystem effects has not been confirmed by ground-based measurements.

Metrics:

1. *Harmful Algal Blooms* (adapted from Watson and Boyer 2014)

Severe	The occurrence of one or more observations has Microcystin-LR concentrations > 10ug/L (pelagic) or >300 ug/gram dry weight (benthic) OR The occurrence of one or more observations have chlorophyll-a > 30 ug/L for pelagic samples or >50% coverage for benthic samples, *and* dominance (> ~80%) of the biota by potentially toxic (*Microcystis, Anabaena, Planktothrix, Oscillatoria, Lyngbya*) cyanobacterial

	species.
Moderate	Toxicity or cyanobacterial abundance is observed, but the magnitude of the harmful algal bloom does not reach the threshold necessary to rate as “Severe”.
Good	Lakes do not display any significant cyanobacteria dominated blooms or Microcystin-LR concentrations < 1 ug/L or <30 ug per gram dry weight.

2. *Nuisance Algal Bloom*

Severe	The occurrence of chlorophyll-a > 30 ug/L and levels of common algal odour compounds (e.g., geosmin, 2-MIB, b-cyclocitral, decadienal) are greater than human odour threshold concentrations (Watson, 2003) or malodour or taste unacceptable to sensory screening (sniff tests or standardized Flavour Profile Analysis; e.g. Dietrich, 2004). OR The occurrence of a significant number of beach posting or closure is due to excess algal material.
Moderate	Significant nuisance algal abundance is observed, but the magnitude of the nuisance algal bloom does not reach the threshold necessary to rate as “Severe”.
Good	Lakes do not display any significant nuisance algal blooms that may impair ecosystem functions.

3. *Excessive Algal Abundance*

Severe	The occurrence of high levels of % coverage of nearshore (up to 15m depth) of nuisance algae at high risk sites and reference sites, sampled from quadrants; or % coastline with > 50% coverage or 50g dwt/m2 (Auer et al., 2010). OR The occurrence of an extensive pelagic bloom as measured by timing, intensity (average chlorophyll-a concentration), duration, aerial extent (e.g., Binding et al., 2011) using remote sensing techniques.
Moderate	Significant excessive algal abundance is observed, but the magnitude of the event does not reach the threshold necessary to be “Severe”.
Good	Lakes do not display any significant excessive algal abundance events based on proxy measurements.

3.2.2 Extent, Composition, and Quality of Coastal Wetlands (NB – Riparian wetlands)

Expert workgroup members: Don Uzarski, Dave Ulrich, Denny Albert, Patricia Chow-Fraser, Matt Cooper, Lucinda Johnson, Kurt Kowalski, Carl Ruetz, Doug Wilcox

IJC staff: Lizhu Wang, John Wilson

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Definition

This indicator tracks the trends of Great Lakes coastal wetland ecosystem health by measuring the composition and density of macroinvertebrates, fish, plants, amphibians, and birds. The Great Lakes Coastal Wetlands Consortium (GLCWC) developed indices of biological integrity (IBIs) for each of the groups in 2002 and protocols were finalized in 2008 (GLCWC, 2008). The five sub-indicators being used in the current monitoring project are existing individual SOLEC indicators. The continuation of this work addresses Objective 2.2 in the US EPA Strategic Plan of fiscal year 2014-2018. Individual IBIs are derived for each of the sub-indicators which can be used independently as a measure of Great Lakes coastal wetland ecosystem health. However, an overall view of wetland health can be derived by considering these sub-indicators in combination, because they function and indicate anthropogenic disturbance at different spatial and temporal scales and have varying resolution of detection.

Metrics: Macroinvertebrates, fish, plants, amphibians, birds, wetland area and extent

3.3.3 Contaminants in Groundwater

Expert workgroup members: Norm Granneman, Gary Bowen, Emil Frind, Dale VanStempvoort, Al Kehew, Bill Alley
IJC staff: Antonette Arvai, Lizhu Wang
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Definition
Groundwater is an important component of the hydrologic cycle and, therefore, groundwater quality is an important factor in determining the overall quality of water in the Lakes. Groundwater is important to ecosystems in the Great Lakes Region because it is, in effect, a large, subsurface reservoir from which water is released slowly to provide a reliable minimum level of water flow to streams, lakes, and wetlands. Groundwater discharge to streams generally provides good quality water that, in turn, promotes habitat for aquatic animals and sustains aquatic plants during periods of low precipitation. The major groundwater resources issues in the Great Lakes Region revolve around 1) the quantity of groundwater, 2) groundwater and surface-water interaction, 3) changes in groundwater quality as development expands, and 4) ecosystem health in relation to quantity and quality of water. This indicator includes the quality and quantity of the groundwater in the Great Lakes region, and its interaction with the surface water in the Great Lakes watershed.

Appendix 3 – Alert Levels for the Rainy River

Reference indicates that this table is available in the 2nd Edition, State of the Watershed Report.

Appendix 4 – GLWQA Annex notes

Annex 1 - Areas of Concern – not relevant

Annex 2 - Lakewide Management – shown here for consideration

The Parties shall document and coordinate these management actions through the development of Lakewide Action and Management Plans (LAMP) for each Great Lake as follows:
Lake Superior;
Lake Huron, and the St. Marys River;
Lake Erie, and the St. Clair River, Lake St. Clair, and the Detroit River;
Lake Ontario, and the Niagara River and the St. Lawrence River to the international boundary; and
Lake Michigan, for which the Government of the United States shall have sole responsibility.
The Parties shall issue a LAMP for each Great Lake every five years. When the LAMP is issued, the Parties shall provide a copy to the Commission for advice and recommendations. The Parties shall provide brief annual updates to the Public on each LAMP.

Annex 3 - Chemicals of Mutual Concern

1. identifying and assessing the occurrence, sources, transport and impact of chemicals of mutual concern, including spatial and temporal trends in the atmosphere, in aquatic biota, wildlife, water, and sediments;
2. identifying and assessing loadings of chemicals of mutual concern into the Waters of the Great Lakes from all sources including point sources, non-point sources, tributaries, and the atmosphere;
3. evaluating the effects of chemicals of mutual concern, and combinations thereof, on human health and the ecosystem, including the development and use of reproductive, physiological and biochemical measures in wildlife, fish and humans as health effect indicators;
4. maintaining biological and sediment banks to support retrospective analysis and to establish background levels for use in assessing future management actions;
5. coordinating research, monitoring, and surveillance activities as a means to provide early warning for chemicals that could become chemicals of mutual concern;
6. reviewing and prioritizing research, monitoring, and surveillance needs on an annual basis, taking into account progress made in implementing this Agreement, new developments in science, and other factors; and
7. exploring research, monitoring, and surveillance opportunities related to management at source and treatment technologies under the respective jurisdictional authorities to address chemicals of mutual concern in wastewater effluent and residuals.

Annex 4 - Nutrients

To achieve (these) Substance Objectives for phosphorus concentrations, the Parties shall develop phosphorus loading targets and allocations for each Party for each Great Lake, as required.

The Parties shall retain the following Substance Objectives on an interim basis for phosphorus concentration in the open Waters of the Great Lakes until updated:

Interim Substance Objectives for Total Phosphorus Concentration in Open Waters (ug/l) (as represented by Spring means)
Lake Superior, 5
Lake Huron, 5
Lake Michigan, 7
Lake Erie (western watershed), 15
Lake Erie (central watershed), 10
Lake Erie (eastern watershed), 10
Lake Ontario, 10

To help achieve these Substance Objectives, the Parties shall use the following phosphorus loading targets for the Waters of the Great Lakes on an interim basis until the loading targets are updated:

Interim Phosphorus Load Targets (Metric Tonnes Total P Per Year)
Lake Superior, 3400
Lake Michigan, 5600
Main Lake Huron, 2800
Georgian Bay, 600
North Channel, 520
Saginaw Bay, 440
Lake Erie, 11000
Lake Ontario, 7000

Annex 5 - Discharges from Vessels – not relevant

Annex 6 - Aquatic Invasive Species
1. ecological assessments of the effectiveness of AIS prevention programs;
2. development and evaluation of technology and methods that increase the effectiveness of control and eradication efforts;
3. development and evaluation of technology and methods that improve the ability to achieve effective barriers that prevent the spread of AIS while allowing the movement of other ecosystem components through canals and waterways;
4. development and evaluation of technology and methods, including genetic techniques, that improve the ability to detect potential AIS at low levels of abundance;
5. determination of potential AIS habitat requirements and additional factors that would affect the establishment and spread of AIS;
6. assessment of the ecosystem impacts of both established and high-risk AIS in order to inform management regarding decisions for rapid response and control programs;
7. assessment of the potential impact of climate change on the introduction, survival, establishment, and spread of AIS; and
8. Risk Assessments of species, Pathways and Vectors as determined to be appropriate by the Parties.

Annex 7 - Habitat and Species – shown here for consideration
The Parties, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, and the Public, shall conduct research and monitoring, as needed, to implement prevention measures that consider the climate change impacts and other stressors and improve the resilience of native species and habitat.

Annex 8 - Groundwater

1. identify groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes;

2. analyze contaminants, including nutrients in groundwater, derived from both point and non-point sources impacting the Waters of the Great Lakes;

3. assess information gaps and science needs related to groundwater to protect the quality of the Waters of the Great Lakes; and

4. analyze other factors, such as climate change, that individually or cumulatively affect groundwater's impact on the quality of the Waters of the Great Lakes.

Annex 9 - Climate Change Impacts

1. develop and improve regional scale climate models to predict climate change in the Great Lakes Watershed Ecosystem at appropriate temporal and spatial scales;

2. link the projected climate change outputs from the regional models to chemical, physical, biological models that are specific to the Great Lakes to better understand and predict the climate change impacts on the quality of the Waters of the Great Lakes;

3. enhance monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts;

4. develop and improve analytical tools to understand and predict the impacts, and risks to, and the vulnerabilities of, the quality of the Waters of the Great Lakes from anticipated climate change impacts; and

5. coordinate binational climate change science activities (including monitoring, modeling and analysis) to quantify, understand, and share information that Great Lakes resource managers need to address climate change impacts on the quality of the Waters of the Great Lakes and to achieve the objectives of this Agreement.

Annex 10 – Science – shown for aspects of indicator and metrics use

A. Purpose

The purpose of this Annex is to contribute to the achievement of the General and Specific Objectives of this Agreement by enhancing the coordination, integration, synthesis, and assessment of science activities. Science, including monitoring, surveillance, observation, research, and modeling, may be supplemented by other bodies of knowledge, such as traditional ecological knowledge.

B. Programs and Other Measures

The Parties, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, and the Public, shall:

1. use adaptive management as a framework for organizing science to provide and monitor the effect of science-based management options;

2. undertake monitoring and surveillance to anticipate the need for further science activities and to address emerging environmental concerns; and

3. facilitate information management and sharing to improve knowledge, accessibility and exchange of relevant Great Lakes information.

C. Science Review, Priority-Setting and Coordination

The Parties, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, and the Public, shall:

1. undertake a review of available scientific information to inform management actions and policy development. Priority issues to be addressed through this review of available scientific information shall be established on a three-year basis by the Parties in consultation with the Great Lakes Executive Committee, considering advice developed by the Commission in consultation with the Great Lakes Science Advisory Board;
2. identify science priorities, taking into account recommendations of the Commission;
3. use their best efforts to ensure that agencies that fund scientific activities orient their research programs in response to research priorities identified by the Parties; and
4. coordinate scientific efforts in support of the restoration and protection of the chemical, physical, and biological integrity of the Waters of the Great Lakes to facilitate and evaluate achievement of the General and Specific Objectives of this Agreement.

D. Ecosystem Indicators
The Parties shall establish and maintain comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, to anticipate emerging threats and to measure progress in relation to achievement of the General and Specific Objectives of this Agreement. The indicators shall be periodically reviewed and updated as necessary.

E. Lake-Specific Science and Monitoring
In addition to ongoing science and monitoring activities that are routinely carried out by the Parties and other government and non-government entities, the Parties shall implement a cooperative science and monitoring initiative for each of the Great Lakes on a five-year rotational basis. The Parties shall focus monitoring activities on the science priorities identified through the Lakewide Management Process. The Parties will coordinate these activities across government and non-government organizations.

F. Reporting
The Parties shall report on progress toward implementation of this Annex every three years through the Progress Report of the Parties.

The Parties shall also issue, every three years, a State of the Great Lakes Report to the Commission and the Public, describing watershed-wide environmental trends and lake-specific conditions using ecosystem indicators established by the Parties.

Appendix 5 – Detailed Notes and Attendee lists from Consultations

Expert Workshop – March 12

List of Attendees:

Cathy Eimers	Trent University
Cary Hernandez	MPCA
Derrick Passe	Lake County SWCD, IMA-TAC, TAC AIS
Elaine Page	Manitoba Sustainable Development, IMA-WG
Euan Reavie	UMN
Matt Gluckman	EPA, IMA-WG
Greg Chapman	MNRF, IMA-WG
Jesse Anderson	MPCA
John vandenbroeck	MNRF, TAC AIS
Kevin Peterson	MN DNR
Janette Marsh	EPA, IMA-WG
Mike Hirst	LOW SWCD, IMA-TAC, TAC AIS
Pam Tomevi	Koochiching SWCD, IMA-WG, RLWWB
Phil Talmage	MN DNR, IMA-TAC
Lee Grim	Citizen
Ryan Maki	VNP, IMA-TAC, TAC AIS
Shane Bove	Red Lake Band, IMA-WG, RLWWB
Suzanne Hanson	MPCA, IMA-WG, RLWWB
Tana McDaniel	ECCC, IMA-TAC
Todd Sellers	LOWWSF, IMA-WG, IMA-TAC, RLLWB
Tom Mosindy	Citizen, RLWWB CAG
Brenda Hann	University of Manitoba
Mike Paterson	IISD-ELA
Michael Duval	MN DNR
Amy Adrihan	MPCA, IMA-WG, RLWWB
Margi Coyle	MDNR Ecological and Water Resources
Richard Kiesling	USGS, IMA-TAC
Wes Greenwood	Trent U
Felicia Minotti	Global Affairs Canada
Kelly MacGillivray	Trent U
Tricia Mitchell	ECCC, IMA-WG
Kayla Bowe	Red Lake Band, IMA-TAC
Wayne Jenkinson	IJC
Melissa Mosley	MNRF, IMA-WG
Mohamed Mohamed	ECCC, IMA-TAC

Expert Workshop Recorder 1 – Detailed Discussion Notes

Objectives and Alert Levels Discussion

Regarding four old WQ objectives:

Discussions around minimum flow typically are linked to DO – do we update the objective, or do we turn to alert levels?

- Objectives need to be relevant to ecosystem health in the watershed – if they are exceeded, there needs to be a story behind it as to what happens when objectives get exceeded

A. The Board and the IJC already have protocols in place for addressing failing Objectives and exceedance of Alert Levels

- Important to review Objectives and Alert Levels every 5 years, because ecosystems change, are impacted by climate change, etc.

A. Recommend five- or ten-year review cycle for Objectives and Alert Levels

- Need to update narratives for objectives

A. Recommend updates for the 1964 Objectives

Rainy River Alert Levels – living list:

Do we keep alert levels as they are and do we expand to other segments in the watershed?

- With continued development in headwaters, likely important to keep alert levels

  A. Recommendation that Alert Levels apply to all Boundary Waters

- Most alert levels are not supported by monitoring – misconception by public
  A. The final report will include a narrative section explaining how Alert Levels are used
- Items of existing concern could be a subset of the long list of alerts that Board keeps their eyes on regularly; need a process for updating alerts as conditions change in watershed

  A. Narrative will explain how Alert Levels are used; Team will recommend a five or ten year update cycle

- No sulphate in alert levels

  A. Recommend development of an Alert Level for sulphate

- Could do a run of sampling to determine which alerts are still an issue or are not an issue at all then pull together a subset of alerts

  A. Recommendations for an updated list for Alert Levels along with a subset of priority alerts based on proposed Objectives and availability of data

- New compounds that currently have no Alert Level – do we need to add them?

A. If an agency (ECCC, EPA, MOECP or the MPCA) has a standard for a specific compound it would automatically be included in the list of Alert Levels

- Consensus – keep existing Alert Levels, make a subset to suggest to Board in Phase 2 for more close monitoring/what Board thinks is priority

A. Provide recommendations for an updated list for Alert Levels along with a subset of priority alerts based on proposed Objectives and availability of data

- If there is something *(the)* Board feels is important for monitoring ecosystem health that's not currently monitored by agencies, this group should identify it

A. The Board may remove or add metrics as they see fit

Erosion – could rename "sediment transport" or something else instead; can affect AEH, major habitat stressor (e.g. deposition of fish habitat), can be measured/monitored

- Start with a narrative for an objective; what gets measured in order to determine if erosion is improving/getting worse
- Erosion can be compartmentalized, separate from sedimentation

A. Erosion and Sedimentation are indicators for Fluvial Geomorphology; From a geomorphic perspective stream and lake erosion and sedimentation processes are pretty much the same, however the time scales can differ significantly with stream erosion and resulting sedimentation processes working at a much faster rate than lake processes; For that reason, two indicator categories are needed, one for lake erosion and sedimentation and another for stream erosion and sedimentation

- Instead of "climate change" and "AIS" - use different terminology to better clarify the issue
  - Recommendation for an objective to determine the effects of climate change," treating climate change as a stressor. Once the effects are determined the Board may consider an objective to mitigate those effects
- Consider an objective to determine the vulnerability to and effects of AIS in the boundary waters
- Comment made that if something is listed as a priority, then it should have an objective BUT some priorities don't have enough data to be able to develop an objective
  - Agree
- With AIS, it will be important to assess risk and determine risk of it taking hold in the ecosystem
  - Agree

Aquatic Ecosystem Health

- Need to fill out the AEH indicators table with what ongoing monitoring is happening within agencies so we have a clear idea of work ongoing
- Nolan went through table to show indicators and which priorities they address – comments:
- No IBI for boundary waters in some segments – will need those; as IBI changes for the good or the bad, this helps understand how ecosystem is doing

- EPA Ohio has done good work at looking at satellite imagery and identification of good/bad HABs – consider this model
- Where are the monitoring gaps in the boundary waters?
- Missing programs?
    - Large river IBI is in development (Nolan has); smaller upstream lakes are done
    - Flora – should cattail invasion stay as an indicator or rename it as "hybrid cattail" – move to invasive species?
    - Need to look at what models will be most beneficial
- What is of most use to the AEHC in the end? No further thoughts.
- State of the Great Lakes is a good example to use but need to be cautious of what capacity of the Board is, need to be realistic
- ELA atmospheric deposition data may be useful as well as met data from VNP

  Will include in the indicator list
- Loading data from Canadian side is lacking
- Land Cover and Fragmentation – Leif Olmanson's work; could be redone on regular basis; USGS buffer work.

  Recommend Land cover and fragmentation update every ten years
- Disturbance; Nature Conservancy maps

  Team will contact the Nature Conservancy (Canada and US) and review maps to determine how maps may be used as an indicator
- Atmospheric deposition of chemicals of mutual concern– Ely and one in park, ELA

  Team will contact appropriate agencies and researchers to determine if the data are suitable as an indicator

Hydrogeographies

- Question came up about how we are handling *(LOW)* cold water watersheds – for big picture view, the thought is that these watersheds flow into the main flow and addressing the smaller watersheds is a huge workload for AEHC (further discussion needed)

  A. Team will consult further with Canadian scientists and the AEHC

Expert Workshop Recorder 2 – Detailed Discussion Notes

Introductions

Nolan Overview of Approach.

a. Focus on what is missing in terms of the existing WQO/a and how

Bev's summary

I. WQOs are agreed-to objectives (by governments)
II. Alert Levels - triggers for alert that are the most stringent c in the region.
III. Nutrients and Contaminants - some changes?
IV. Erosion - tough to measure, modelling or narrative?
V. Climate change - as a stressor
VI. AIS - some sort of assessment, narrative?

What do we do with old objectives?

I. Bev: Do we need to get rid of them? Do we nuke them and get on with something else?
II. John V: Removing the reference to oxygen could be a problem. No impacts detected, but we wouldn't want to toss oxygen as a parameter, as we don't know what would happen in the watershed.
III. Richard K: stressed the importance of oxygen as a water quality objective, or an alert level. DO is an anti-degradation standard. Are we measuring oxygen anyway?
IV. Todd: Objectives are to be agreed on by governments and carry a weight. Alerts exercise the IJC alerting functions.

Team needs to determine if we want to recommend keeping or revise the current O_2 objective or go with an alert level

John V: what happens if something exceeds?

Question addressed at workshop

Mike P: do we not have a trigger. Worried about the timeline. If it's a water quality objective. Set of problems are clearly identified in the state of the watershed report? Importance of the 5-year timeline.

A. I think Mike is saying that Alert Levels provide the needed trigger; Needed WQ objectives are identified in the SOBR and stressed the importance of the five-year objectives and Alert Levels review

A. The team will review; See response in # 2. 4 above

Jesse: drop DO. It's not 1965, we have other threats, climate change and IAS.

A. The team will review; See response in # 2. 4 above

What do we do with the alert levels?

i. Bev: Do we need the big list for the various segments?
ii. Already exceeded? Phosphorus solids Yes, but not all of them.
3. What about lake of the woods - not exceeded in most of lake of the woods?

A. True for the northern portion (above Big Narrows).

Nolan - some of the items are not being monitored.
Todd: two stage approach. List of emerging concern. If we get shot down on new objectives, what do we do?

Bev: doesn't see a reason to move sulphate to the WQO levels, but otherwise the AL could be left as they are. Some questions about mining, what number to put on these things. Ontario doesn't have a guideline for sulphate.

1. How do we know if we never have an issue?
2. Phase 2 levels which ones do we want to pick.

A. Will be determined in Phase II

Long list isn't clean.

A. Team will be updating

One season of sampling - no PCBs? Come up with a condense list of things they would be concerned about. Probably wouldn't be.

Ryan: Alerts that we want the board to look at this year. A shorter priority list.

A. Team will be proposing a concise priority list of alert levels

Richard: Are they coming out of the agency sources? Bev: yes?

1. Do you want to ad algal toxins?
2. Estrogen mimicking compounds

A. Team agrees that toxins and estrogen mimicking compounds are a concern, however if there aren't any agency standards or objectives addressing the issue, there's not much we can do; If the toxins and estrogen mimickers are listed by any agency they will be included in the alert levels

Todd: AL subset that we would want to keep an eye on.
Richard: which ones can be exceeded.
Todd: Concern that the governments have not agreed to further objectives.
To raise the questions to governments where it may be of concern to one party or another.
Speciation issue with Phosphorus.

Not necessary to assess AEH, more important for restoration
Wayne: precluding - ecosystem health.
What do we do if we're not monitoring adequately? That's a component of the five or ten year review
Nolan: Erosion: Northern lake of the woods? Is it important?
Euan - Erosion is a stressor - continuous discharge measurements. Huge deal. Tracking erosions as part of a water quality objective. Erosion or sediment transport.
Sedimentation - issues related to erosion.

Phil Talmage - Climate change and the AIS - almost urge you as you label the priority. Some type of system change. Looking for a system change or AIS. And then it might also capture some of the other stuff. Land use changes and development.
Nolan: Amount of disturbance in the watershed. It is going to have an effect downstream. Right now is that something we should be looking at? The little fork river - worst example in the watershed. Should we be reporting on? That wasn't a boundary water - it's up to the agencies.
Climate change - as a stressor on the remaining priorities.
Jesse: doesn't see erosion and nutrients as separate boxes - nutrients are carried away by the sediments.
Janette - what did you look for when you have erosion. Category doesn't seem to discriminate between the in-stream erosion or erosion of the lakeshore?
Bev and Nolan: mostly related to lake shore erosion. Do we want to get to sediment transport, or should we also have a separate look at sedimentation?
Janette - confounding factor, local stakeholders. Civic engagements. Separate set of interests and energy and information. Sedimentation is an issue for the EPA. It's part of the traditional monitoring that EPA agencies and tribes collect data on. When we're looking at HABs correlated to seasons.
Janette - wouldn't be a model

> A. Erosion and Sedimentation are indicators for Fluvial Geomorphology; From a geomorphic perspective stream and lake erosion and sedimentation processes are pretty much the same, however the time scales can differ significantly with stream erosion and resulting sedimentation processes working at a much faster rate than lake processes; For that reason, we recommend two indicator categories, one for lake erosion and sedimentation and another for stream erosion and sedimentation.

Richard K - AIS priority and an objective - needs some other tools, or data. What is the ecological impact?
Mike Duval - DNR: Within the system are they likely to take hold. Do we have tools that work on a large scale? Understand what the relative impacts would be. Would we expect the zebra mussels to be a problem?
John V: We didn't land the erosion thing - more that needs to happen there. The alerts piece and the invasive species. What is proximal to the watershed. Risk of it coming. Has the risk increased? Get the IMA Subcommittee to report to the board to show how things are coming your way. How fast is it moving that it's coming in. Give the board the tools they need to report into the aquatic invasive species.

> A. The Team recommends an objective to determine the vulnerability and effects of AIS in the boundary waters.

Trisha - how do we account for climate change? Bev.: may change the way we deal with Climate Change.

> A. The Team recommends an objective to determine the effects of climate change," treating climate change as a stressor. Once the effects are determined the Board may consider an objective to mitigate those effects.

Margi Coyle - Land use impact on the watershed to fish community health. NPS problem.

> A. Board's Directives limit their responsibility to the boundary waters. Management of the Rainy River-LOW watershed is dependant on a continuing partnership with Canadian and US agencies and the IJC.

Public Workshop – March 12, 2019

List of Attendees

Dan Vellieux	RLPOA
Dave and Jan Imes	Citizen
Diane Schwartz-Williams	LOWDSA, CAG Koochiching County
Jason Sjoblom	Citizen, CAG
Jerry Caple	Citizen
John Spencer	Citizen
Kelly Sjerven	Rainy River Community College
Mike Hirst	SWCD
Paul Anderson	Rainy Lake Conservancy, CAG
Ron Medina	H2O Power
Erik Richards	H2OPower
Tom Mosindy	CAG
Erika Klyszejko	RLWWB
Jim Yount	CAG
Mark Gabriel	IJC
Bob Tammen	Citizen
Pat Tammen	Citizen
Dale Johnson	RLPOA

Public Workshop Recorder 1 – Detailed Discussion Notes

Q: Has the river's transparency improved? Where are nutrients coming from?

A. Discussed atmospheric deposition, legacy P in sediments; question addressed at workshop

Q: Isn't part of the problem from the logs that were driven down the river?

A. It's true the river has widened, contaminants have not just come from mill practices, but from many practices – legacy P has been declining but climate change is having an impact; question addressed at workshop

Q: Threats and timeframe – how does this impact priorities?

A. We will suggest IJC review priorities/objectives every 5-10 years

AIS – We need to know if a specific AIS are a risk prior to infestation, need a risk assessment

General Comments:

- RLPOA interested in being involved in monitoring down the road to monitor indicators – James Yount (RLPOA) and LOWDSA both supportive of a sampling campaign

  Team will pass this information on to the AEHC and IMA

- Supportive of more segments in headwaters – need to know if monitoring is done in these segments

  A. Comment seems to indicate a concern that more monitoring is needed in the headwaters; Team will address this issue in the gap analysis

- Comment made about stagnant water and need for flushing occasionally and that flow is important –

  A. Blooms can occur during low flows, but science has shown blooms can be worse in high flow years; question addressed at workshop

- Contaminants – fish advisory regarding mercury – is this natural or man made?

  A. Both; mercury can get into the water via atmosphere, via industry, via methylation (internal conditions), some can get into the system via rocks; question addressed at workshop

- Question around sulphate liberating phosphorus – is this true? Is sulphate a contaminant or a nutrient issue?

  A. If the water doesn't have enough oxygen and with high sulphate concentrations, metals bonds are released, and phosphorus is then freed up; question addressed at workshop

- Can impact of a mine way upstream be detected down on Rainy Lake

  A. It's technically likely that we might be able to detect contaminates from upstream mining operations in Rainy Lake, but unlikely that concentrations would have much of an effect on water quality. Permit requirements require mine operators to monitor discharge. WICOLA monitors certain sites for metals to watch for mine impacts on their waterbodies; question addressed at workshop

Public Workshop Recorder 2 – Detailed Discussion Notes

1. Reviewing other approaches to indices
   a. Jesse: Changes in land cover status. Something that's been used as part of the TMDL process.
   b. Richard: definitions of buffers around streams and then done these analyses. I.e. focus the analysis on the riparian or contributing information. Used to predict where they could find specific contaminants.

      A. Team will consider that disturbance of boundary waters riparian areas (500 feet / 152 meters) be included as an indicator.

Team will recommend that load and concentration data from tributaries outletting directly to a boundary water be included as an indicator.

3. What about temperature monitoring throughout the water column - changes of thermocline as a result of climate change.

   A. Team will include temp information in the in the indicators and metrics section of the report.

2. Segments Handled
   a. Tom: Do we need to split up the LOW to include some of the cold-water bays as various segments?

      A. Team will investigate this issue further.

Open Webinar – April 3, 2019

List of Attendees

Christina Hausman	VNPA
Cristina Giannetas	MOECP
Daryl Wiklund	Roseau County
Dave and Jan Imes	Citizens
Janette Marsh	USEPA
John Horner	Roseau County
Lawson Gerdes	Citizen
Madhu Malhotra	MOECP
Michael Azulay	MOECP
Mirek Tybinkowski	MOECP
Nicole Kovar	MN DNR
Tom Dougherty	RLPOA
Tom Worth	Citizen
Wayne Jenkinson	IJC

Webinar Recorder – Detailed Discussion Notes

Q. Who do alert level exceedances get reported to? What are the criteria for reporting?

A. Data are collected by agencies on both sides of border and there is a mechanism in place for compilation (IMA). Data from U.S. and Canada are pulled together for specific projects. The Watershed Board can draw on this information in the form of a report to the IJC. There isn't one large database with everyone's data on it.

Q. It is odd that this hasn't gone through Lake of the Woods watershed (line on map starts at mouth of Rainy River).

A. This project includes all of Lake of the Woods because it is a boundary water. Expanded mandate of the new board includes having alert levels for LOW and upstream of Rainy River. Original alert levels were only for Rainy River. There are not a lot of current alert level exceedances; there were more in the mid 1990s. It isn't unusual to have an exceedance; for example, with low water conditions and resultant heavy concentrations of nutrients, there can be exceedances, but this isn't necessarily reported on because it is a natural event. On occasion, the IJC has gone back to the agencies or the governments to discuss alert level exceedances.

Q. Tables show "AL", but it isn't aluminum; what is it?

A. It may have something to do with an analytical technique. The * may indicate an interim level. This table will get updated. It would be good to have a live portal to keep these values updated on an ongoing basis. Need to add in standards for Manitoba as well.

Following the webinar, it was confirmed that "AL" indicates "Aquatic Life" in the alert levels table.

Q. Regarding the climate change priority as a stress modifier, what are your thoughts on how specific we can get with this effort in identifying specific parameters related to climate change, using ancillary data (e.g. intensity of storms) where there would be a feedback to contaminants, nutrients, etc.? Rather than narratives for climate change, is there climatological data that could provide more specifics?

A. There are scientists interested in demonstrating the effects of climate change on the system, so it exists in the peer reviewed literature, but these don't have a monitoring program affiliated with them. Using some indicator of climate change to monitor ecosystem health, like monitoring # ice free days on LOW or intensity of storms (mobilizes sediment), could be useful. Annual watershed forum is a good place to consolidate the research being done on this and many other topics. Someone is going to have to review the climate change research to provide the Board with something that can be reported on – it will likely show up as a list of indicators that are thought to be the most useful, where there is associated data.

Q. Where is information on # ice free days on LOW?

A. Second edition of State of the Watershed report. This is affecting biota and physical limnology of lakes.

Q. How does this affect agriculture; don't see this kind of increased warming affecting agriculture like it affects lakes? Fishing opener doesn't seem to be affected by increased number of ice-free days.

A. Light plays a big part; a lot of light-driven processes don't change but those driven by temperature do change. Food sources are emerging according to temperature and biota are emerging according to light source, so there is a disconnect in trophic levels of lake. Regularly monitored data doesn't tend to include this kind of zooplankton research (e.g. may be a project at a university).

Q. Happy to hear that this team will try to provide information to the Board that will supply them with indicators to assess how well objectives are being met; any data found on climate change that can inform and provide specific information, not just narratives, for feedback to objective itself, is useful.

Q. Would it be possible to get a copy of slides?

A. No problem. Interim report for first deliverable of Phase 1 has been submitted. Can also send that.

Q. Has USGS data been used in this project?

A. Yes, there are a lot of data and narrative information available. This project is only concerned with the boundary waters in the entire watershed, not the whole watershed. USGS data and Water Survey of Canada data have been used. Of most use down the road will be data that have been synthesized or reported on by agencies, especially for use by the Board's reporting needs. We would like to be able to recommend to the Board what is the best source of data to review for their mandate.

Public Meetings in Kenora, ON – July 8, 2019

List of Attendees

Barry Baltessen, LOWDSA
Bonnie Baltessen, LOWDSA
J. Gosseli
Vicki Burns
Ashley Cederwall
Kiley Shebagegit, RRFN
Teika Newton, IRLWWB
Joan Richardson, LOWWSF
Jeff Kantor
Darlene Bruce
J. Hook
A. Downey
Heather Gropp, Twp. Sioux Narrows/Nestor Falls
David Malaher
Rosemary Malaher
Babotunde Akande, Grand Council Treaty 3
Will Landon
Mike Paterson, ELA
Several additional citizens (names not provided)

Jacob Boutwell, Climate Action Kenora
Mona Brown, LOWDSA
Ruth Girard, Citizen
Karen Cederwall, IRLWWB, MNO
Chief Lorraine Cobines, Niisaachewan First Nation
Ashley Cederwall

Indigenous Learning Forum – Onigaming First Nation, August 21, 2019

List of Attendees

Lucas King, Grand Council Treaty #3
Ron Allen, Nigigoonsiminikaaning First Nation
Robert KakayGeesick, Buffalo Point First Nation
Tom Anderson, Shoal Lake First Nation
Robert Parenteau, Wabigoon Lake First Nation
Miles Pitchenese, Eagle Lake First Nation
Daniel Morriseau, Eagle Lake First Nation
Isobel White, Whitefish Bay First Nation
Patricia Green, Big Grassy First Nation
Glenn Archie, Big Grassy First Nation
Marvin McDonald, Wabaseemoong First Nation
Tyson Gardner, Wabigoon Lake First Nation
Pierce Brown, Wabigoon Lake First Nation
Elaine Ross, AKRC, NWA#33 First Nation
Katherine Jack, Onigaming First Nation
Bill Arch, Onigaming First Nation
Pheonixx KakayGeesick, Buffalo Point First Nation

Detailed Discussion Notes

Individual concerns raised include:

- resident septic system effects on drinking water
- sale of water e.g. Nestle
- impacts of water levels on ecosystem
- wild rice and water levels; not being heard at LWCB table (concerns brushed aside)
- farm pesticide runoff
- human waste from cottages
- boil water advisories; First Nation water treatment inadequate
- O/A policies and monitoring encroaching on land/treaty rights
- Shoal Lake 40 reviewing policies re LWCB and how to have First Nations as part of decision making
- resource development in proximity to water
- boil water advisories - Maybe could be an alert?
- Concerns raised regarding First Nations having an equal voice, on level with IJC Commissioners; having a seat at the board table is not enough and one person cannot represent all First Nations (board seat is seen by some as a token only)
- Concerns about how individual issues are overseen by multiple agencies making coordination difficult, e.g. wild rice is impacted by both water quality and water levels.
- How do we know that the things that are being monitored are the things that should be monitored?
- What is the response when an AL is identified?
- How do we get all the communities to increase their respect for water?

- Interest in knowing if there's baseline data (have sent the SOBR and AEHC report)
- Idea floated to partner with IJC in the future to do community monitoring if something arises as an AL
- Comment made that if two governments don't agree on objectives/ALs recommended as a result of this project, that there could still be written support from GCT3
- Question asked about what next steps are if an alert level is breached – no clear answer
- Suggestion made that there be more than 3 reserved seats on the Board for indigenous members
- Comment made about community establishing a constitution around water; individual met with MOECP re water sampling and waste management, blastomycosis, wild rice
- Water protection is inherent in indigenous tradition/legacy
- Used to be able to harvest wild rice by foot, walk across to islands to harvest without canoe
- Comment made about the need to monitor historic stories and oral documentation
- GCT3 has informed IJC of Water Declaration and GCT3 is doing a water governance revision
- Wabigoon FN doing water, soil, sediment monitoring; hoping to do benthic
- Comment made about a table where all issues could be heard and addressed
- ALs could spur on partnership with Grand Council Treaty #3 and Community based monitoring. GCT3 working towards baseline data and could inform when an alert is triggered
- ALs don't trigger anything
- What weight and influence do FNs have in current IJC decision making?
    - Influence in decisions around water levels and sale of water specifically
- Do objectives and ALs supersede treaty rights? How do the two interact?
- Development of a table where all issues are heard and addressed
- Look at businesses that are being put close to the water
    - Resource development as an AL?
- FNs need equal voices in decision making
- Have FN representation increased at IRLWWB
- Oral Documentation should be considered
- Minnesota sulfate levels based on wild rice
- Data sharing agreement between GCT3 and communities could lead towards learning from each other and watching over entire territory.
- Commitment to have a similar forum for Phase II of the objectives and ALs project.