Lake Huron's Phosphorus Contributions

WORKSHOP SUMMARY | SEPTEMBER 2020

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Erb Family Foundation

WATER CENTER
UNIVERSITY OF MICHIGAN

LAKE HURON'S PHOSPHORUS CONTRIBUTIONS

Workshop Summary | September 2020

About this report:

This report summarizes the group discussions and priorities that emerged from a workshop hosted by the University of Michigan Water Center and the University of Waterloo's Water Institute with guidance from U.S. and Canadian representatives of the Great Lakes Water Quality Agreement Annex 4 Committee. The workshop was held in Windsor, Ontario in December 2019. Its purpose was to explore recent findings about phosphorus loadings from Lake Huron to the St. Clair River and identify next steps for priority research areas.

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For more information on this project, please go to:
myumi.ch/detroit-river

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Cover photo: Aerial view of the Blue Water Bridge, taken from above Sarnia, ON, looking west towards Port Huron, MI. Courtesy of Silverchemist of Wikimedia Commons.

Graphic design: Fatimah Bolhassan, Graham Sustainability Institute

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INTRODUCTION

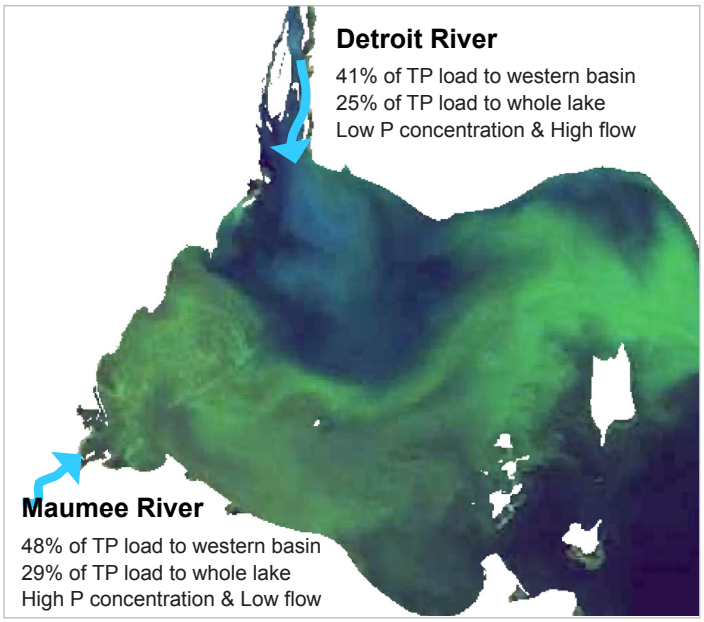

Figure 1. Image of the Western Lake Erie Basin in September 2015. The algal bloom originating from the mouth of the Maumee River is diluted and pushed away by the high volume of water with low phosphorus concentration entering from the Detroit River.

Western Basin Harmful Algal Blooms

- Driven by Maumee River Loads
- Diluted/deflected by Detroit River flow

Central Basin Dead Zone

- Driven by all Western and Central Basin loads
- Dominated by Detroit and Maumee Rivers

The rivers flowing into Lake Erie carry phosphorus and other nutrients that can lead to harmful algal blooms in its western basin and hypoxia (low oxygen levels) in its central basin. Despite past nutrient management efforts and successes, algal blooms and hypoxia that impact drinking water, tourism, swimming, and fishing have become more extensive in recent years.

In 2012, the U.S. and Canada signed a revised Great Lakes Water Quality Agreement, which included Annex 4 governing the implementation of actions to manage phosphorus and other nutrients. In 2016, the binational committee overseeing Annex 4 adopted new phosphorus loading targets and action plans to meet those targets. The plans were released in 2018.

The 2016 phosphorus loading targets reflect the different ways that the various sources (tributaries such as the Maumee River and Detroit River) affect different parts of Lake Erie. For example, nutrients delivered from the Maumee River are largely responsible for western basin algal blooms, while the Detroit and Maumee rivers combined have a significant impact on central basin hypoxia (Scavia et al. 2014, 2016).

In May 2019, a team from the University of Michigan reported results from a three-year project (Scavia et al. 2019a, b) focused on increasing the understanding of phosphorus loads from the Detroit River watershed. The team's mass balance findings agreed with other studies (Burniston et al. 2018) that showed the load to Lake Erie from the Detroit River is higher than previously estimated (Maccoux et al. 2016). The findings also showed that the relative contribution from Lake Huron is much more significant than previously understood.

The University of Michigan team and colleagues from the University of Waterloo worked with U.S. and Canadian representatives of the Great Lakes Water Quality Agreement Annex 4 team to facilitate a workshop where these findings and other relevant knowledge could be discussed. The workshop was held in Windsor, Ontario in December 2019. Its purpose was to explore recent findings about phosphorus loadings from Lake Huron to the St. Clair River and identify next steps for priority research areas.

BINATIONAL PHOSPHORUS LOAD REDUCTION TARGETS		
Lake Ecosystem Objectives Great Lakes Water Quality Agreement Annex 4, Section B	**Western Basin of Lake Erie**	**Central Basin of Lake Erie**
Minimize the extent of hypoxic zones in the Waters of the Great Lakes associated with excessive phosphorus loading, with particular emphasis on Lake Erie Maintain algal species consistent with healthy aquatic ecosystems in the nearshore Waters of the Great Lakes	40 percent reduction in total phosphorus entering the Western Basin and Central Basin of Lake Erie – from the United States and from Canada — to achieve 6000 MT Central Basin load 40 percent reduction in spring total and soluble reactive phosphorus loads from the following watersheds where localized algae is a problem: • Thames River - Canada • Maumee River - US • River Raisin - US • Portage River - US • Toussaint Creek - US • Leamington Tributaries – Canada	• Sandusky River - US • Huron River, OH – US
Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the Waters of the Great Lakes	0 percent reduction in spring total and soluble reactive phosphorus loads from the Maumee River (U.S.)	N/A
"Recommended Binational Phosphorus Targets." EPA, Environmental Protection Agency, 22 Oct. 2018, www.epa.gov/glwqa/recommended-binational-phosphorus-targets. Accessed 5.21.20.		

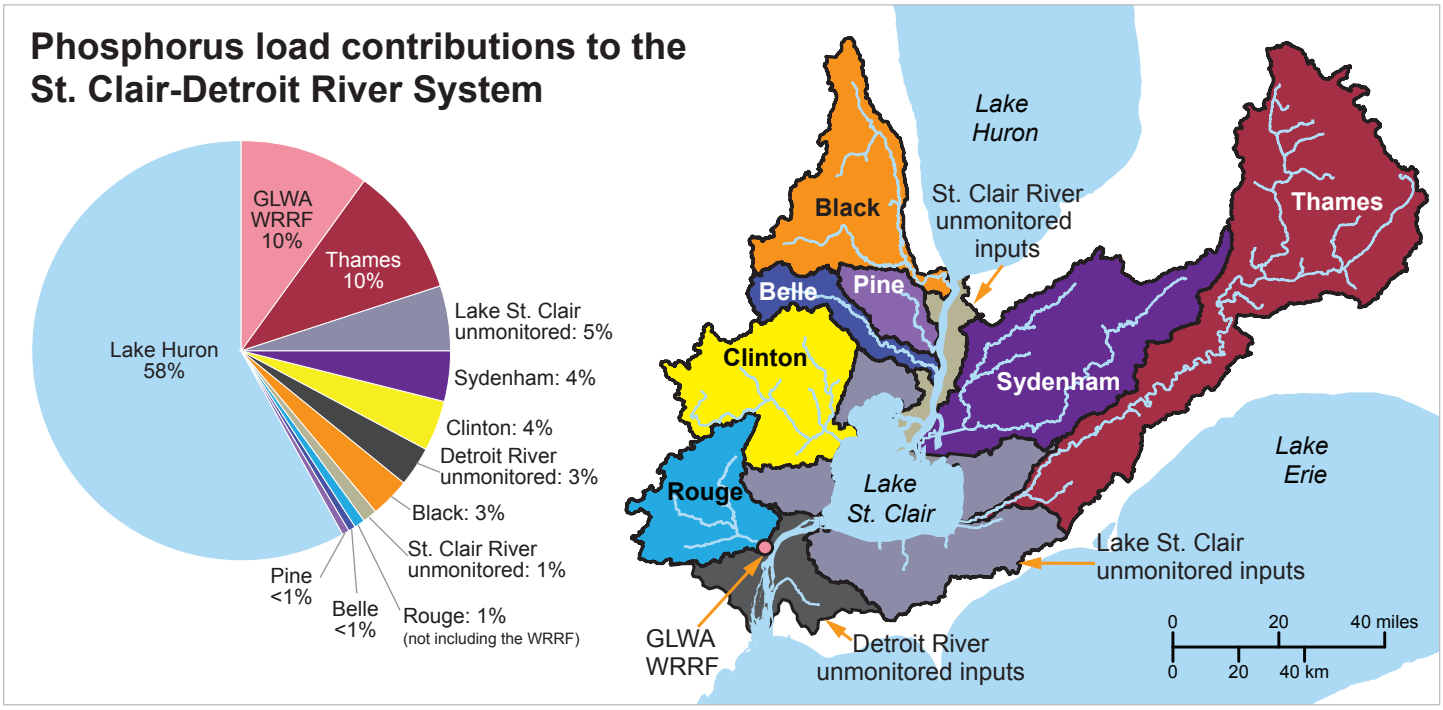

Figure 2. The pie chart shows the relative amounts of phosphorus that come from different parts of watershed. Colors in the pie chart correspond to the map at right. The University of Michigan team found that approximately 58 percent of the phosphorus entering Lake Erie from the Detroit River came from Lake Huron. By contrast, when setting the nutrient reduction targets, the Parties understood the Lake Huron to be contributing approximately 15 percent (Maccoux et al. 2016). To learn more about the University of Michigan project, visit: myumi.ch/detroit-river

WORKSHOP APPROACH

At the workshop, the organizers sought to establish a common framework for understanding Lake Huron's phosphorus contributions to Lake Erie. The participants learned about Lake Huron nearshore and shoreline processes, and their impact on phosphorus loads to the lake. They also identified, clarified, and prioritized key policy questions and information gaps about Lake Huron's phosphorus contributions to Lake Erie, and developed recommendations for monitoring, modelling, and research to address them.

The workshop was framed around four key policy questions identified by the Great Lakes Water Quality Agreement Annex 4 Committee. These questions were generated during the fall of 2019 after considering new findings emerging from agency research and from the University of Michigan, as well as the needs of the Annex 4 adaptive management process:

1. What is our best estimate of Lake Huron's phosphorus contribution (load and concentration of total phosphorus (TP)) to the St. Clair River?
2. How are phosphorus loads processed as they move through the St. Clair-Detroit River System (e.g., influence of shipping channel and other biophysical characteristics)?
3. What are the sources and drivers of Lake Huron's phosphorus loads (e.g., shoreline erosion, lake bottom sediments, run-off)? And what other factors influence phosphorus loads (seasonal dynamics, storm events, water levels,etc.)?
4. How does the Lake Huron phosphorus contribution affect Lake Erie and how will it affect the lake's response to phosphorus reductions within the watershed?

Workshop participants were primarily U.S. and Canadian state, provincial, and federal agency personnel with expertise in, or responsibility for, monitoring, modeling, or research activities related to Lake Huron or Great Lakes nutrient loading. A few academic and private-sector scientists were also included. (See Appendix One for a list of workshop participants.) While recognizing that the purpose of the workshop was to understand Lake Huron's contributions to Lake Erie, participants were also aware that circumstances specific to Lake Huron, or regions within it, could also be informed by monitoring, modeling, and research ideas emerging from the workshop. The first day consisted of presentations providing background information. The second day focused on processing that information through breakout group discussions related to the four questions identified above, and priority-setting activities for the resulting outputs conducted in a closing plenary session.

DAY 1: CONTEXT SETTING

Sandra George *(Environment and Climate Change Canada)*, the lead speaker, reminded participants that the Annex 4 process is iterative and that the Parties are committed to an adaptive approach. Policy and management decisions are informed by new science and knowledge. She articulated the focal questions that the Annex 4 team generated during the fall of 2019 after considering new findings emerging from agency research and from the University of Michigan. She also outlined the adaptive management process timeline whereby agency personnel would review new information through 2022 to inform the Domestic Action Plan review in 2023.

Don Scavia *(University of Michigan)* provided insights from recent work organized around the questions posed by the Annex 4 team. He noted that the University of Michigan mass balance work confirmed new agency research that previous estimates of the Detroit River load to Lake Erie were low. This work also demonstrated a significant and growing unmeasured contribution from Lake Huron that appears to have accelerated around 2010. He used ECCC's continuous turbidity measurements at the Point Edward sampling station to show that several high-turbidity events were missed by the phosphorus sampling protocol over the past three years (Figure 3). Because it is challenging to measure loads at the inlet of the St. Clair River, especially its spatial variability, Don suggested similar turbidity measurements might be a surrogate for phosphorus in the future.

The University of Michigan team showed that increases in storm events and ice-free days parallel the growing unmeasured load from Lake Huron, and suggested that high turbidity measured at Point Edward is most likely due to suspended solids transported from the Ontario side. However, more recent work by this team on Lake Huron circulation demonstrated some seasonality in currents that originated on the Canadian or U.S. side of the lake, and that important uncertainties exist as to whether these events can be predicted from wind, wave, and currents, and whether we can differentiate between resuspension and erosion being responsible for the turbidity.

Don also showed work done to determine whether Lake St. Clair is a phosphorus source or sink. The results point to, on average, 20 percent of the TP input retained annually, but that the lake is not likely a dissolved reactive phosphorus sink. It is also unclear whether Lake St. Clair will continue to be a sink over time.

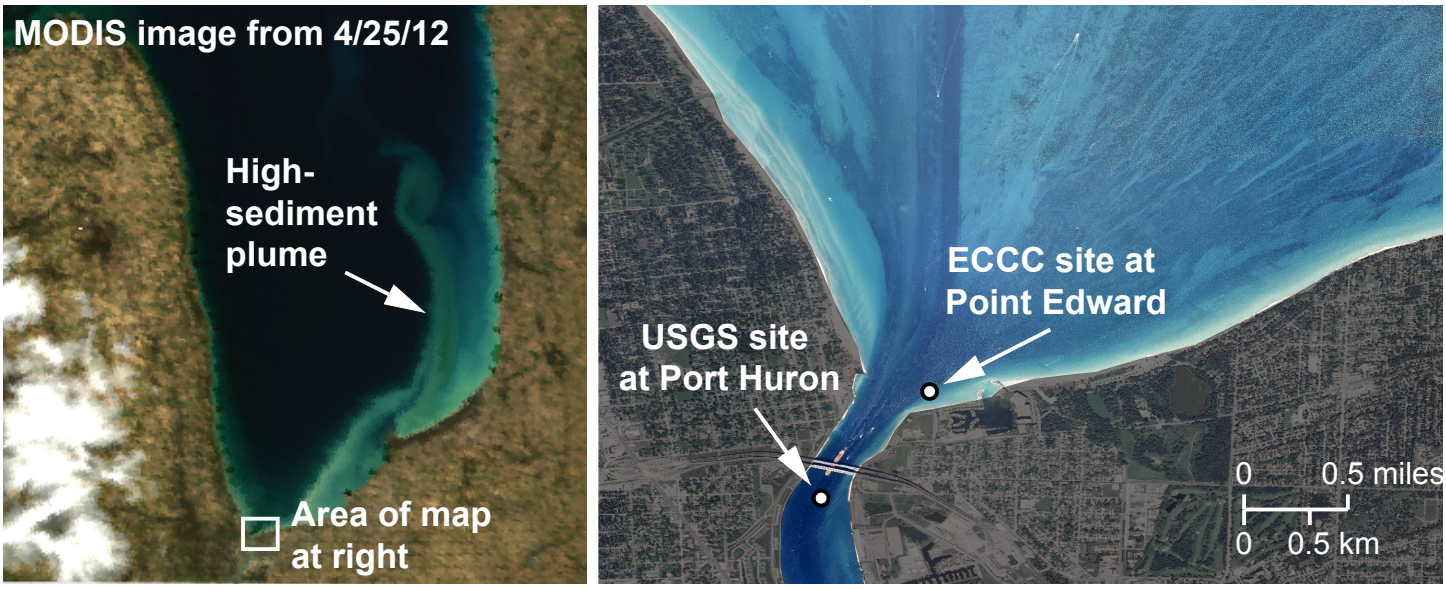

Figure 3. *Left:* True-color satellite image showing a high-sediment resuspension event. *Right:* Monitoring stations around the Bluewater Bridge at the head of the St. Clair River. Only data from the Environment and Climate Change Canada (ECCC) site at Point Edward showed these events, but the sampling there is not frequent enough to capture them all.

Craig Stow *(NOAA's Great Lakes Environmental Research Laboratory)* provided information about Saginaw Bay based on extensive work from the mid-2000s. He noted that Saginaw Bay phosphorus concentrations are currently stable, that nutrient inputs have declined due to management actions, and that there has been an increase in phosphorus retained in the bay due to invasive mussels. Together, these factors suggest a reduction in phosphorus exported from Saginaw Bay to Lake Huron.

Brad Hill *(Environment and Climate Change Canada)* provided a detailed overview of the ECCC's upstream/downstream monitoring program that has been ongoing since 1987 for monitoring chemicals entering the system below the Bluewater Bridge. While originally set up to monitor inputs from Chemical Valley, this work is also providing insights into Lake Huron phosphorus. However, the sampling is not continuous or event-based.

Todd Howell *(Ontario Ministry of Environment, Conservation and Parks)* provided an overview of work that characterized the very nearshore area in southeast Lake Huron. This area is oligotrophic except for limited areas such as the plumes from large river mouths, areas immediately adjacent to small rivers/drains, and wadeable areas of the shoreline—essentially the places people are most likely to be present. Otherwise, the biological response of the nearshore area most closely resembles that of an oligotrophic lake.

Ted Briggs *(Ontario MECP)* presented a programmatic overview of the Healthy Lake Huron program, which incorporates six sub-watersheds—five with various water quality challenges and one reference watershed in the Bruce Peninsula. Healthy Lake Huron is the most recent provincial response to persistent nearshore challenges due to algal growth and E. coli shutting beaches and otherwise impacting the public. He described the many BMPs that have been implemented, and the key take-away was that there is an extant assessment framework that allows them to follow water quality trends in response to management actions—regardless of the program in place. He emphasized that it is, unfortunately, challenging to detect and attribute improvements in water quality to management actions.

Pete Zuzec *(Zuzec Inc.)* wrapped up the situational presentations by providing an overview of his climate-related work that looks at climate impacts on physical processes in the lake which will, in turn, likely impact phosphorus loading. He anticipates that reduced ice-cover will continue to increase wave energy reaching the shoreline, leading to increased shore erosion and resuspension, especially in winter. Sediment transport rates will increase, but it is not clear by how much or in what direction this will take.

On the second day, participants broke into four groups to address the four questions raised by the Annex 4 Committee. Each group considered research, monitoring, and modeling needs associated with its question.

DAY 2: PRIORITIES FOR RESEARCH, MONITORING, AND MODELING

GROUP 1: CHARACTERIZING LAKE HURON PHOSPHORUS LOADS TO THE ST. CLAIR RIVER

Research

- The most significant question is how labile is the sediment-bound phosphorus entering the St. Clair River from Lake Huron? If it is relatively unavailable biologically, then the load may not have a significant impact on Lake Erie. If however it is substantially bioavailable, currently and/or over time, then a better understanding of its spatial and temporal patterns at the outlet of Lake Huron are needed to inform a more robust monitoring and assessment program.
- If this research shows the phosphorus to be bioavailable, then a field campaign can be used to determine 1) if turbidity is a good surrogate for phosphorus across temporal and spatial scales, 2) what are the temporal and spatial patterns of resuspension/erosion events, and 3) if resuspension events can be characterized through drone deployment?

Monitoring

- If it is important to understand the source(s) of the sediment load, e.g., resuspended from the lakebed, eroded from the shoreline, or entering from the watershed, then higher resolution monitoring up into the watershed will be needed.
- A more refined understanding could also be achieved through some monitoring changes, e.g., USACE is considering adding capacity to measure sediment at its gauge at the inlet of the St. Clair River.
- The river gauge at Fort Wayne could collect some additional parameters. However, differences in water quality across the river channel need to be considered in determining a monitoring strategy for the St. Clair and Detroit Rivers.
- Can existing data inform the next Lake Huron Cooperative Science and Monitoring Initiative (CSMI) field year to assess the biochemical properties of the suspended sediment?

Modeling

- Is it possible/effective to model Lake Huron phosphorus, e.g., mass balance model, as a surrogate, or augmentation, to monitoring the outlet from Lake Huron?

GROUP 2: ADDRESSING THE SOURCES AND DRIVERS OF LAKE HURON'S PHOSPHORUS LOAD

Research

- Because potential management action will have to be tied to specific sites and linked to site characteristics (silt, sand, clay-plain) and sources (agriculture, urban), we need to quantify the relative contributions of various sources of phosphorus that constitute Lake Huron's load to the St. Clair River, including watershed contributions, shoreline erosion, and lakebed sediment resuspension, to best guide management.
- Can data collection be standardized to make meta-analyses possible?

Monitoring

- Need to characterize and monitor land use, and understand the location of phosphorus sources in the watershed.
- Need to know loads from tributaries to calibrate models and assess how much load reduction is possible.
- Need to characterize phosphorus in the water column after a suspension event to determine variables such as: amounts coming from the land or resuspended from substrates, physical and chemical variability, seasonality and U.S. / Canada differences.

Modeling

- Determine if existing hydrological model(s) have sufficient resolution and skill to help determine particle movement.
- We need a lake ecosystem model to help determine phosphorus fate.

GROUP 3: PHOSPHORUS PROCESSING IN THE ST CLAIR-DETROIT RIVER SYSTEM

This group focused on three topics

- Separating and characterizing channel vs. tributary sources of phosphorus and sediment.
- Better characterizing the ecological and biogeochemical processing of phosphorus.
- Determining how seasonal changes and storms affect Lake St. Clair as a phosphorus sink or source.

Research

- Increase understanding of the biogeochemical processing of phosphorus, and how phosphorus transformations affect retention and mobilization, to better understand in-stream processes.
- Does phosphorus availability vary seasonally and geographically?
- Characterize sediment spatial differences, e.g., phosphorus content, particle size, organic/inorganic, and biogeochemical/ isotope/ genetic signatures, to help identify sediment sources and transport, and whether phosphorus bioavailability differs depending on the source.
- Increase understanding of other parameters, e.g., mercury distribution, to help understand phosphorus sources and transport.

Monitoring

- Take advantage of monitoring data from drinking water intake to help understand storms and other transport events that may not be captured by monthly monitoring.
- USACE is in the process of mapping sediments in the St. Clair delta, including taking sediment cores to better understand historical deposition. This is an opportunity for others to add additional analyses with cores, such as phosphorus or algal parameters, or coupling core data with sediment trap data.

Modeling:

- Review all relevant existing hydrodynamic and ecological models to determine if they are sufficient to cover the required spatial and process. If not, additional development will be needed.
- Biogeochemical process models could be improved, and there may be ways to link models for a specific purpose.

GROUP 4: HOW LAKE HURON PHOSPHORUS LOADS INFLUENCE LAKE ERIE AND THE POTENTIAL LAKE ERIE RESPONSE TO NUTRIENT REDUCTIONS

Research

- We need to better understand the impact of Detroit River loads to various Lake Erie basins. The current understanding is that Detroit River inputs do not contribute significantly to the western basin HABs, but have a greater effect on central basin hypoxia. However, to what extent do Detroit River inputs influence cladophora in the eastern basin? What is the potential role of Maumee inputs on Cladophora?

Monitoring

- Need to determine if monitoring activities throughout the St Clair-Detroit River System are adequate for understanding how forms of phosphorus may evolve downstream from Lake Huron.

Modeling

- Need a mass balance for all important forms of phosphorus (e.g., TP, DRP) in Lake Huron and Lake Erie.

CROSS-CUTTING PRIORITIES

During the discussions of the breakout group reports, recorders noted key ideas and messages, and reorganized them under the following headings: Overarching, Research, Monitoring, and Modeling. Participants were each given stickers and asked to allocate them to what they perceive as the highest priority items. A summary of items follows of those that received the most votes (stickers) overall, with at least three people voting for a listed item. Participants could provide more than one vote per item to give added emphasis to its importance.

Research - The new findings of potential additional phosphorus from Lake Huron are based on identification and tracking of sediment resuspension events, movements of Lake Huron water toward its outlet, and presumed relationships among turbidity, suspended sediment, and phosphorus. However, direct measurements of that additional load, especially its bioavailability, have not been made. Therefore, among the highest priorities are to characterize phosphorus in the water column before, during, and after resuspension events to determine:

- If there is a difference in phosphorus content between background levels and the events;
- The phosphorus content and lability of that material; and
- If it is eroded shoreline or resuspended sediment.

If the bioavailability is substantial, then it will be important to better understand the seasonality of those inputs, and to sort Canadian and U.S. contributions.

Monitoring - Most participants believed there is a need for enhanced monitoring of the St. Clair-Detroit River system, especially in the connecting channel. So, while general enhancements, such as increasing the temporal and spatial frequencies of existing programs, are obvious and strongly supported, other enhancements and refinements could best be defined based on the following research and modeling efforts. It was also emphasized that effective progress across all of the issues, questions, and approaches requires additional levels of cooperation across countries, among agencies, and with the academic and private sector communities.

Data mining - While recent efforts to amass existing federal, provincial, and state monitoring data have proven to be useful for constructing initial mass balances for the system, there exists large stores of research data that can add value in interpreting those results. For example, exploring sediment trap archives (ECCC) for the St. Clair and Detroit rivers would help to understand the significance of the mass balance work by providing mass and phosphorus content estimates of the suspended sediment load. Other efforts exploiting drinking water data could be fruitful.

Modeling - While the additional research and data mining will provide important new information at various scales, models are required to scale up and integrate those findings to scales relevant for informing potential management action. Some key questions include:

- What is the role of Detroit River inputs on the western, central, and eastern basins;
- How much of Lake Huron's resuspended sediment makes it to the St. Clair river and what is the frequency of occurrence of relative sources (e.g., Michigan vs. Ontario);
- What is the physical and biogeochemical fate of phosphorus entering the system from Lake Huron;
- What is the frequency and relative significance of sediment resuspension vs. shoreline erosion;
- How might any of these processes change under future management actions and climate change.

Many more questions are likely.

Some of these questions can be addressed by mass balance models that are either based on existing data supplemented with additional short-term monitoring, or based on the more substantial intensive monitoring enhancements of the CSMI. Other questions will rely on modest- to high-resolution hydrodynamic and ecosystem models that can, for example, track particles at lake scale, and simulate biogeochemical changes in phosphorus as various loads travel through Lake St. Clair and the connecting channels.

While model development and enhancement is likely needed to address existing, new, and emerging questions as the GLWQA adaptive management process unfolds, it is important to start with an inventory of existing agency, academic, and private sector models of Lake Huron, the Huron-Erie connecting channels, Lake St. Clair, and Lake Erie. This will identify capacities, needs, and opportunities.

SUMMARY AND CONCLUSION

Across the breakout groups and in plenary sessions, participants emphasized that effective progress across all of the issues, questions, and approaches requires additional levels of cooperation across countries, among agencies, and with the academic and private sector communities. While such cooperation is common in the Great Lakes region, it will be important to identify and expand on partnerships, especially to improve monitoring of this physically complex system.

Participants also noted that Lake Huron itself does not have an excessive nutrient problem except in very specific areas, such as the wadable nearshore, the mouths of rivers, and the vicinity of shoreline communities. The vast majority of the open lake is, in fact, suffering from nutrient deficiency that challenges various interests around the lake. Thus, it is important that any discussions related to mitigating the potential impact of the Lake Huron load on Lake Erie include both Lake Huron and Lake Erie stakeholders.

Finally, the workshop recognized the significant challenge in communicating uncertainty about what is known and not known. This includes communicating concepts such as the relationship among loads, concentrations, and flow to decision makers and the public to help them understand why we believe the phosphorus being delivered by the Detroit River does not impact the western basin but instead affects the central and likely eastern basins.

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APPENDIX TWO: PRIORITIZING NEXT STEPS

This table outlines high priority next steps for research, modeling and monitoring as identified by workshop participants during a final voting exercise.

CATEGORY	ITEM	TOTAL VOTES
Monitoring, Overarching	Identify and expand on partnerships to improve monitoring; binational collaboration	18
Research	Data mining - Explore sediment trap archive (ECCC) to understand mass balance(?) and phosphorus content of suspended sediment in the St Clair and Detroit Rivers. Also access St Clair River and other drinking water data.	18
Monitoring, Research	Characterize P in the water column after suspension event (physical and chemical); determine load-substrate fractions; include seasonality, and understanding Cdn and US contributions. Possible innovation: drone monitoring with water grabs.	16
Research	Understand phosphorus content and lability of suspended sediment during events to determine if it is eroded bluff or re-suspended sediment. Determine if there is a difference in phosphorus content between events and background.	15
Research	Further clarify the role of Detroit River inputs on Lake Erie eutrophication specific to western, central and eastern basins.	13
Modeling, Overarching	Mass Balance of the Lake Huron-Erie system: using existing data with some supplement data developed by additional short-term monitoring. Note: this will help understand contributions such as from net pens.	10
Research	Sediment budget, contribution from watershed, shoreline (where coming from) and how much? When thinking about questions such as: how much phosphorus is eroding from shore now and can be anticipated in the future? How is the phosphorus characterized, e.g., lability? We need to determine: what is the appropriate modelling framework to help with these questions? How to best couple watershed and lake models, integrate our understanding of phosphorus reductions and fishery impacts.	8
Monitoring, Research	Characterize and monitor land use management	7
Research	What is the nutrient impact at watershed scale: Can we characterize sub-watershed impact on downstream water quality with enough resolution to focus on BMPs and actions? What is the contribution of in-stream processing to watershed load?	7
Modeling	Inventory of all existing Lake Huron models to identify capacities and opportunities: look at what different agencies have (e.g., USGS, NOAA, USACE, fed, prov and state, universities), Upper Great Lakes study	7
Modeling, Overarching	Mass Balance of the Lake Huron-Erie system; using existing data only	5
Modeling, Overarching	Mass Balance of the Lake Huron-Erie system; supplement with a comprehensive data set: Link substrate and sediment movement to and in hydrodynamic models; particle tracking at lake scale; where sediment coming from and going; reverse particle tracking. Also lake ecosystem models to determine P fate. Water modelling at scale.	5

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