Nutrient Loading on the Winnipeg River

The Benefits and Challenges of High-Frequency Data

Presented by Thomas Saleh

For the Real-Time Monitoring Workshop, November 7-8, 2023, in St. John’s, NL

Project Collaborators:

IISD Experimental Lakes Area: Joey Simoes, Madeline Stanley, Pauline Gerrard

Aquatic Life Ltd.: Connor Riach, Jeff Simpson, Steven Simpson

Aquatic Life Ltd.

RBC Tech for Nature

IISD Experimental Lakes Area

Project Summary

Lower Winnipeg River Basin (LWRB) Adaptive Monitoring Program

"The Adaptive Monitoring on the Winnipeg River project is a collaboration between [the International Institute for Sustainable Development] and Aquatic Life® to explore the use of high-frequency sensors that deliver data in near real-time via satellites and mobile data networks to better understand freshwater"
(International Institute for Sustainable Development and Aquatic Life® Ltd., 2022)

Right: Installation at a dock in Pinawa, showing the AquaHive™ data logger / transceiver and solar panel

High Frequency Data

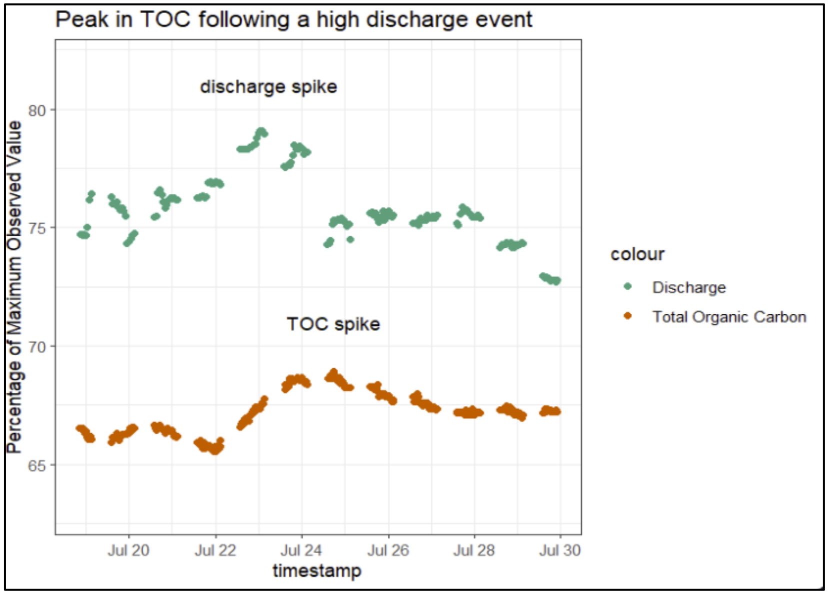


Figure 1. (Above) Total Organic Carbon concentrations increase after a peak discharge event.

Site: Powerview-Pine Falls, Manitoba

Data Sources:

TOC data: IISD-ELA & Aquatic Life® Ltd. (s::can spectro::lyser V3)

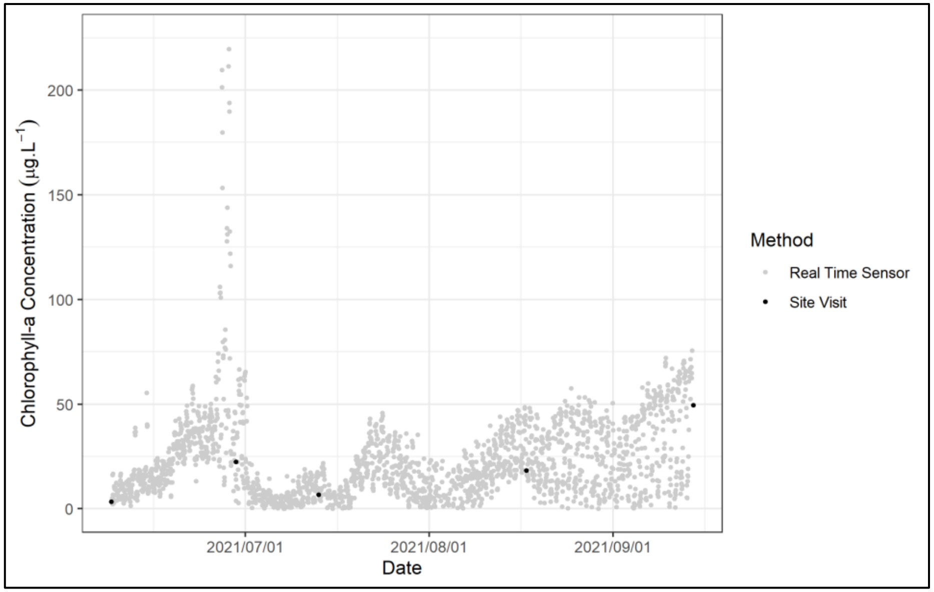
Discharge data: Manitoba Hydro, unpublished data, 2023

Figure 2. (Below) Chlorophyll-a concentration recorded with AquaHive real time sensor and site visits on Lake 227 at the IISD-ELA in 2021.

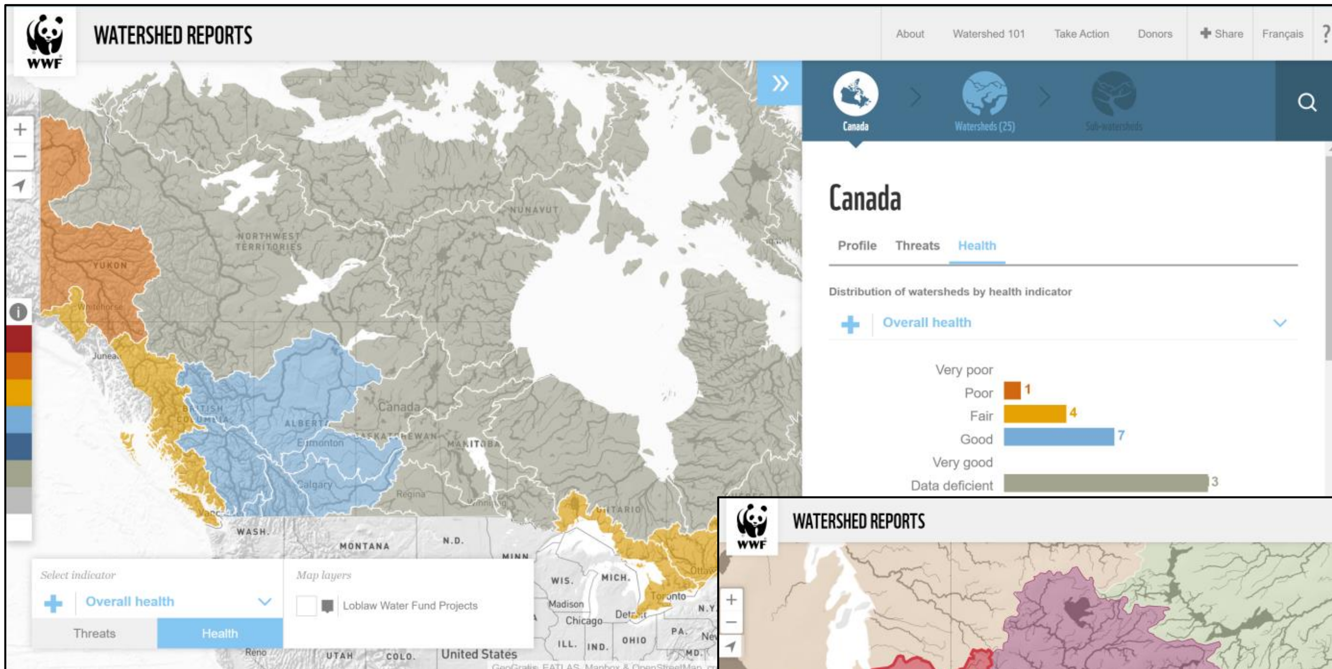
Site: Lake 227, IISD Experimental Lakes Area, Ontario

Data Source: IISD Experimental Lakes Area (Method: US EPA, 1997)

Figure Source: Saleh and Stanley, 2023



Canada's Watersheds: Health & Data Gaps



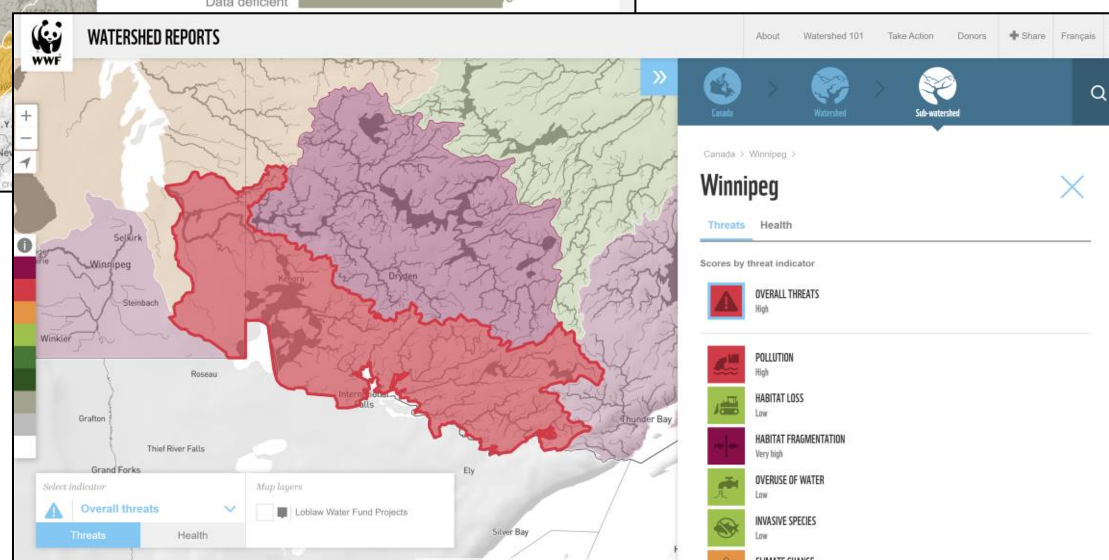


Figure 4. (Top) WWF classifies more than half of Canada's watersheds as "data deficient".
Figure 5. (Right) The Lower Winnipeg River faces Many threats, including pollution.
Source: WWF Canada, n.d.

Monitoring the Lower Winnipeg & Whitemouth Rivers

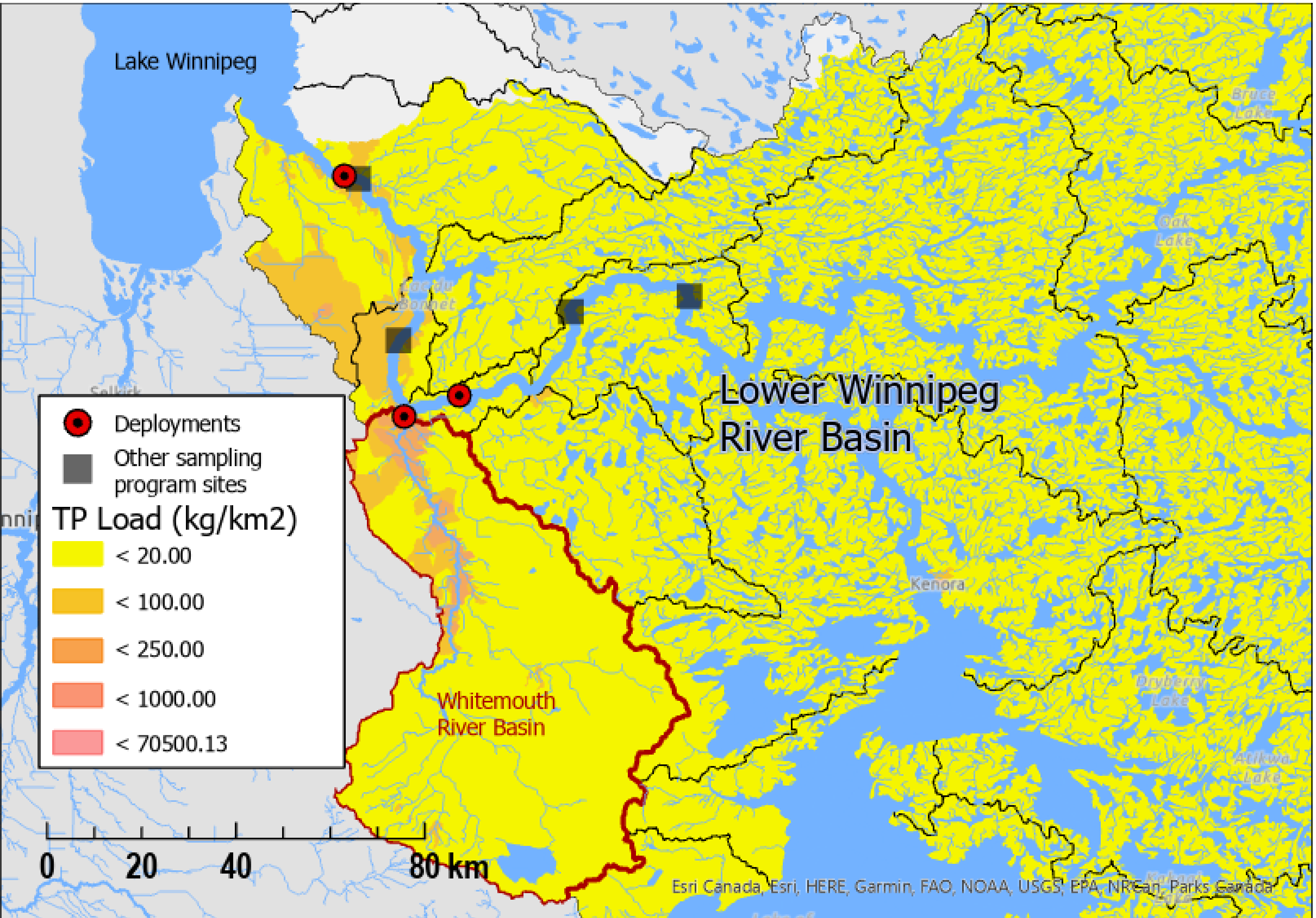
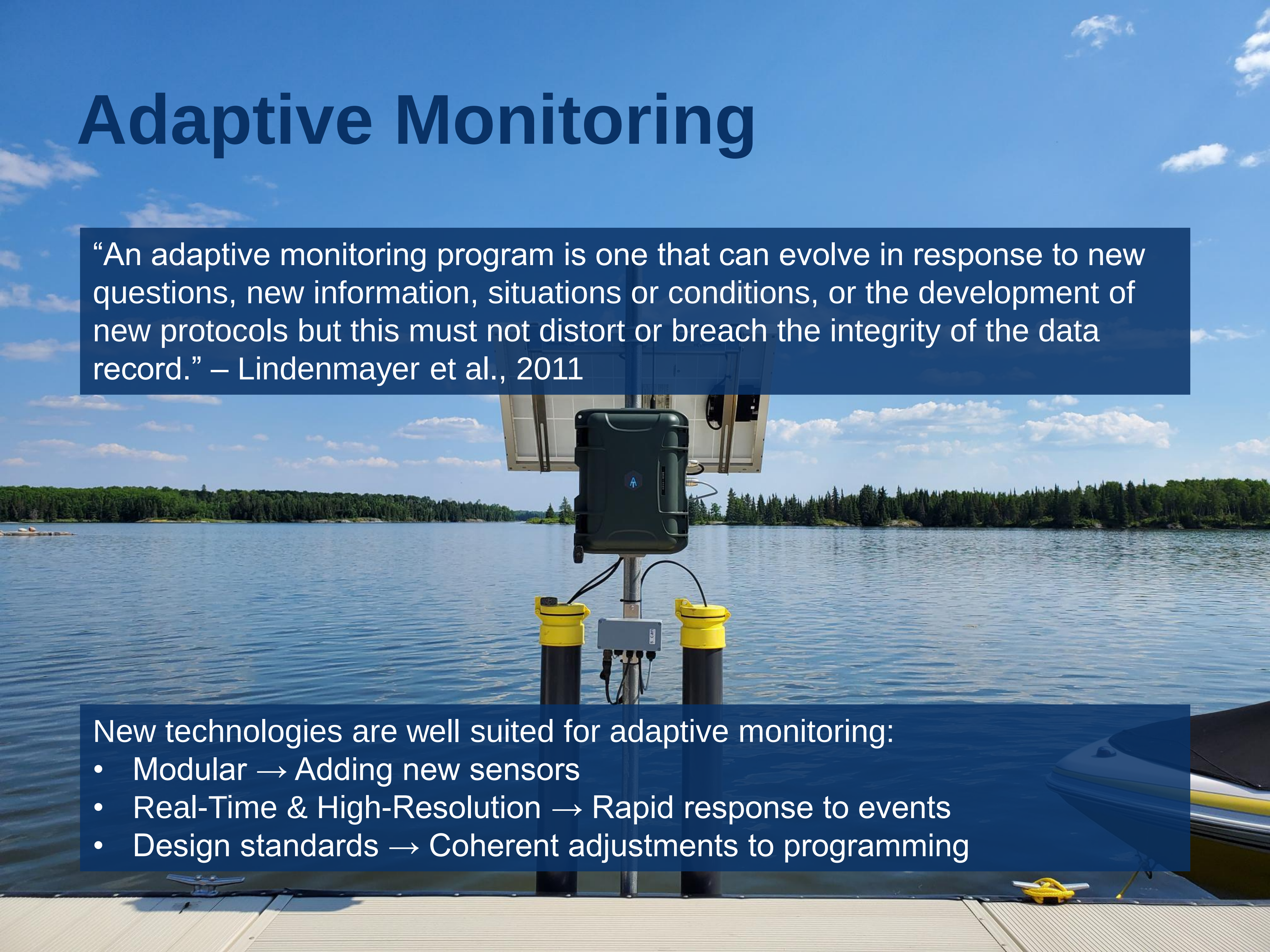


Figure 3. Monitoring sites situated on the Winnipeg and Whitemouth Rivers. The Whitemouth River has some of the highest modeled Phosphorus loading in the entire Winnipeg River Basin. *Sources: Robertson et al., 2019*



Adaptive Monitoring

"An adaptive monitoring program is one that can evolve in response to new questions, new information, situations or conditions, or the development of new protocols but this must not distort or breach the integrity of the data record." – Lindenmayer et al., 2011

New technologies are well suited for adaptive monitoring:

- Modular → Adding new sensors
- Real-Time & High-Resolution → Rapid response to events
- Design standards → Coherent adjustments to programming

Deploying In-Situ Sensors - AquaHive

- Site & parameter selection
- Rigging and power
- Calibration & lab analysis
- A little simpler on a lake than on a river…

Research Question

1. How can high-frequency water quality stations contribute to a shared understanding of the Winnipeg River and influence water management on the River?

2. **How does changing the frequency of monitoring from quarterly or monthly to hourly improve our understanding of chemical or biological parameters in the Winnipeg River?**

3. After one season, will there be sufficient data to train a data-driven model to generate near-term forecasts of river water quality?

4. Can we isolate the spectral response of phosphorus and nitrogen in Manitoba's surface waters?

Right: Sensor rigging at the Pinawa site

Hypothesis

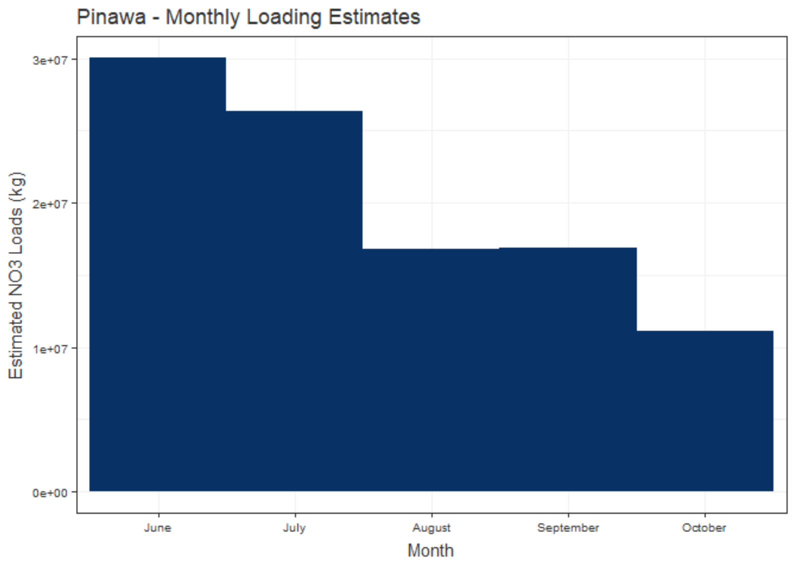
Higher sampling rates will yield significantly different and more precise annual nutrient loading estimates for the Whitemouth and Lower Winnipeg River.

There is a threshold between hourly and bi-weekly frequency at which the information loss.

Analysis (Part 1)

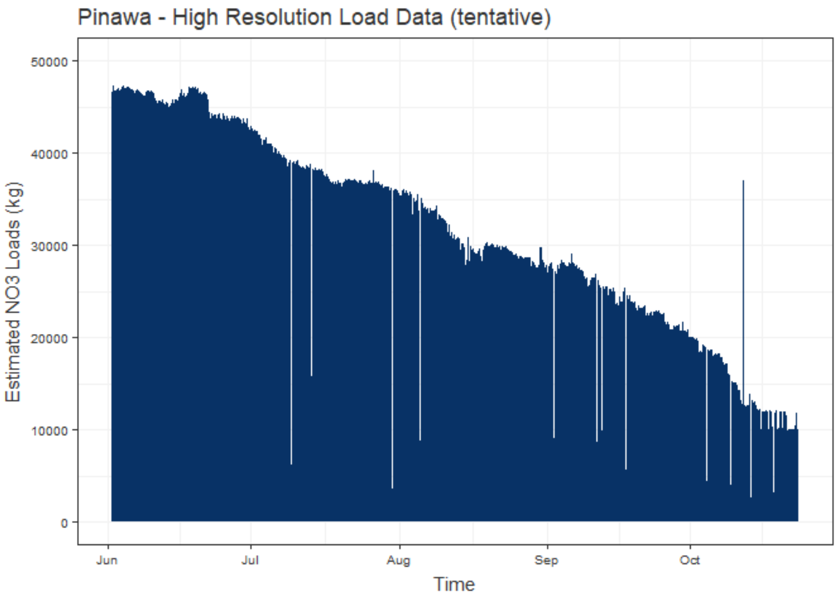
Conventional Sampling Data

1. Monthly Averaging
2. Seasonal Linear Models



Telemetered Data

3. Integration of hourly data



Analysis (Part 2)

Determining Optimal Applications & Sampling Rates

All three calculation methods will be applied to datasets of varying resolutions to determine the impact of incremental changes in observation frequency to the information loss function.

We will also compare events and sites to identify the most impactful applications.

Next Steps

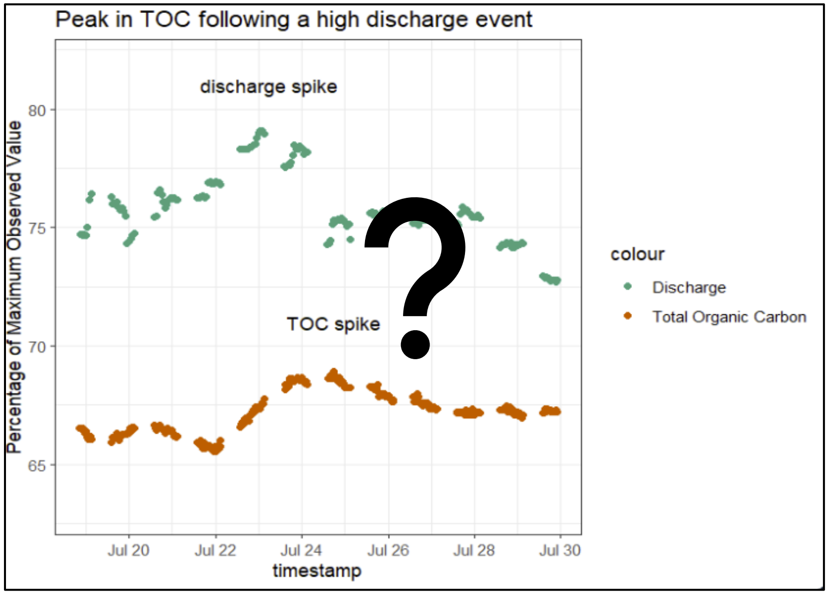


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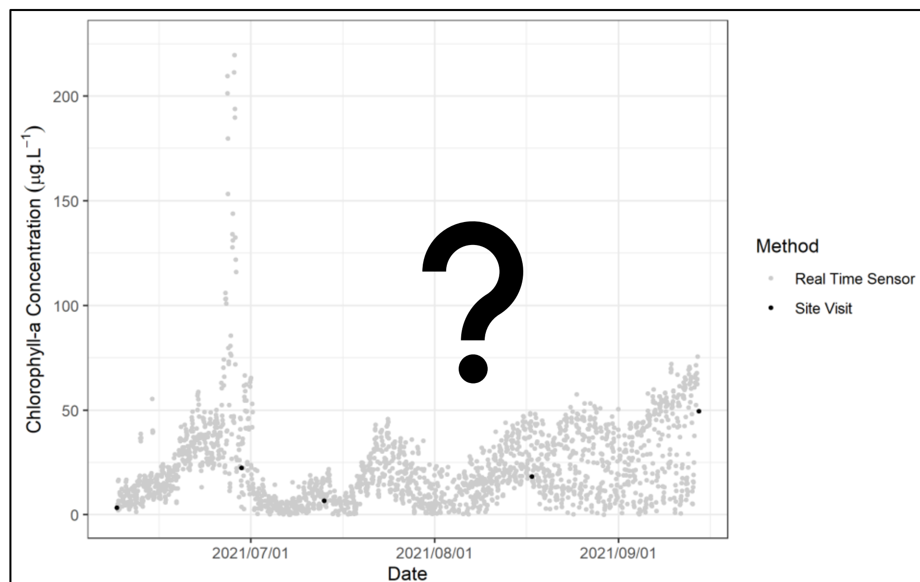
Figure Source: Saleh and Stanley, 2023 (forthcoming)



Community Engagement & Open Data

Data from this project will be available on Lake Winnipeg DataStream for public use

Figure 9. A sign at a launch point Pinawa explaining our work

Applications

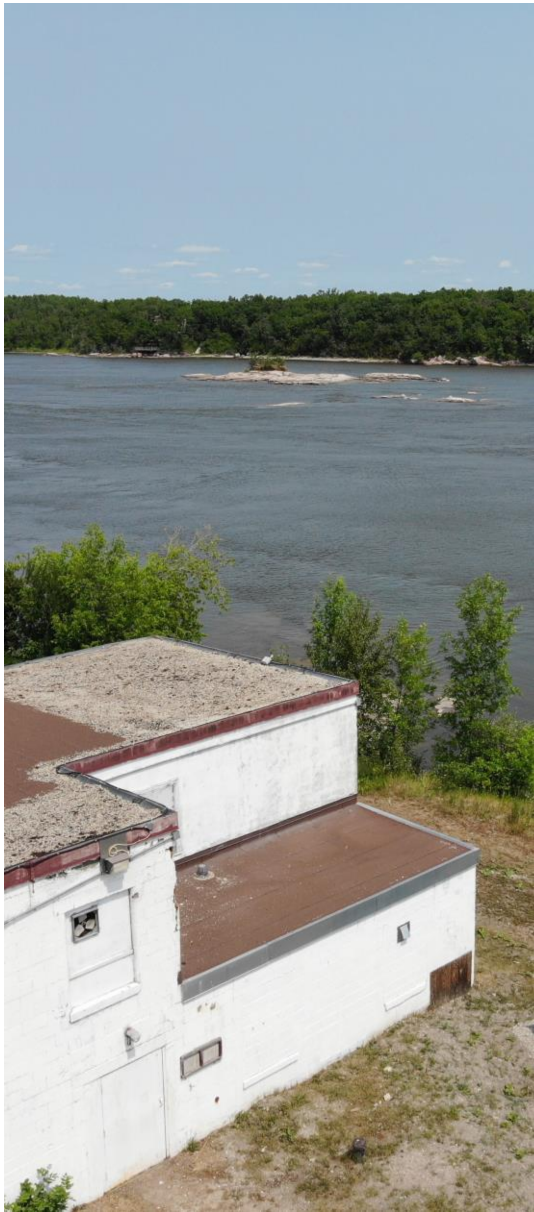
Benefits of real-time nutrient monitoring:

- decision-ready data within actionable timeframes
- more precise aggregate loading data
- insights into short-lived nutrient loading events
- a deepened understanding of site-specific loading patterns
- adaptive inquiry and monitoring methods
- public engagement opportunities

Future Research Questions

- What is the degree of site-specificity to spectral phosphorus measurement and how can calibration costs be optimized?
- How might we scale real-time, high-frequency water quality monitoring to affect better policy and practice?

Right: The Powerview-Pine Falls Water Treatment Plant overlooking the Winnipeg River



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