Real-Time Water Quality Monitoring:

Benefits for decision making

IISD-ELA REPORT

Thomas Saleh
Madeline Stanley

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International Institute for Sustainable Development

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Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: iisd.org
Twitter: @IISD_news

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Tel: +1 (204) 958-7700 ext. 735
Website: www.iisd.org/ela
Twitter: @IISD_ELA

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Executive Summary

Due to worsening threats from climate change, pollution, and habitat fragmentation, there is an urgent need for data on watersheds to make effective decisions to protect their health. Water quality monitoring programs across Canada, which are seeking to meet this data need, have access to an expanding array of tools and technologies. In particular, automated systems for high-frequency and networked water quality monitoring have the potential to enhance data-driven decision making by offering larger volumes of data in near real time. However, these systems also come with their own sets of limitations and can introduce new technical, financial, and labour requirements. To deepen our understanding of these potential opportunities and limitations, the International Institute for Sustainable Development's Experimental Lakes Area and Aquatic Life Ltd. are exploring the use of networked systems to enable remote, real-time water quality monitoring in the Winnipeg River basin as part of the Adaptive Monitoring project. Drawing on a review of supporting literature and two case studies from our work in the Winnipeg River basin, this report explores the potential benefits and costs of introducing automated sensor systems to a monitoring initiative, with a particular focus on networked instruments producing real-time data.

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1.0 Introduction

Canada holds 20% of the world's fresh water, and yet we have limited knowledge on the health of—and risks to—these freshwater ecosystems, despite federal, provincial, industry, and community-based monitoring efforts. For example, World Wildlife Fund Canada noted that 100 of 167 sub-watersheds in Canada lacked sufficient data to assess the overall health[1] of these ecosystems (Paquette et al., 2020). Such limitations are especially concerning in the face of pollution, climate change, and other threats, which are increasingly putting freshwater ecosystems, their surrounding communities, and biota at risk (McCandless, 2017; Paquette et al., 2020) and limiting our collective capacity for responsible freshwater decision making. In other words, "without accurate, intensive and long-term data acquisition, the state of the world's water resources cannot be adequately assessed, effective preservation and remediation programs cannot be run, and program success cannot be properly evaluated" (Glasgow et al., 2004, p. 2). One of the top objectives identified through public and stakeholder consultations for the creation of the Canada Water Agency was that "data and information are available to support informed decision-making at all levels" (Environment and Climate Change Canada [ECCC], 2021b, p. 8). Advances in monitoring technologies will play a critical role in meeting this objective as innovations in networked electronic sensor systems allow organizations to transmit data from the environment back to our computers and make sense of it in real time (Environment and Climate Change, n.d.; Gunn & Stanley, 2018).

"Until we have a coordinated approach, including a standardized, widespread and consistent national monitoring system, we will be unable to make the evidence-based decisions that our watersheds, and the wildlife and people who depend on them, need."

—PAQUETTE ET AL., 2020, P. 6

As part of the Adaptive Monitoring Project, IISD-ELA and Aquatic Life® are exploring the use of near real-time, higher-frequency data collected from networked sensors to monitor freshwater systems and fill knowledge gaps in the Winnipeg River basin. This project builds on a Discussion Sheet Series[2] that highlighted ecological and socio-economic characteristics of the lower Winnipeg River basin. In the series, it was noted that data limitations, caused by differing water quality sampling methods and frequencies between monitoring programs and over time, constrained the analysis and interpretation of conditions between sites on the river (Stanley et al., 2021). The data available was also insufficient to identify the specific sources of nutrients and other contaminants in the watershed (Stanley et al., 2021). The following sections explore some of the benefits and

[1] WWF Canada Health Indicators: hydrology, water quality, benthic invertebrates, and fish (Paquette et al., 2020).

[2] See https://www.iisd.org/projects/lower-winnipeg-river-basin-opportunity-improve-health-our-waters

requirements of introducing real-time systems into a monitoring program for effective decision making. The latter portion of this report presents two specific examples of networked sensor deployments in the Winnipeg River watershed that highlight the value of real-time data and alerts for industrial and community decision making, rapid response, and environmental research.

2.0 Water Monitoring

Water quality and quantity monitoring is undertaken by various non-governmental organizations and federal, provincial, Indigenous, industry, and local community groups, which each focus on different priority areas. These areas can include flooding, droughts, drinking water, pollution, and aquatic invasive species, among others (ECCC, 2021b). In some cases, monitoring is driven by regulations, such as provincial standards and guidelines for drinking water quality (ECCC, 2021a) or the federal Fisheries Act (RSC 1985, c. F-14). It can also be motivated by economic activities, such as fisheries, farming, or parks and recreation (Puzyreva et al., 2021). The program objectives are what determine how water quality is defined, which parameters are measured, how frequently, and at which locations (Behmel et al., 2016; Stantec Consulting Ltd., 2005). These different aspects are also weighed against one another to optimize the quality of the data collected within the program's resource constraints—such as budget, availability of experienced personnel, or travel logistics (Canadian Council of Ministers of the Environment [CCME], 2015). Priorities may also shift over time, since "existing monitoring programs may have been established many years ago and may need to evolve to respond to new information requirements and funding pressures" (CCME, 2015, p. 1). These changes can include budget constraints, climatic changes, or new pollutants, among others.

While each monitoring program should be optimized to meet its own objectives, monitoring groups may find value in communicating with others to discuss sampling methods and practices. When sites are managed by different organizations (e.g., across different governments, industries, and community groups), sampling frequency or methods may vary (Behmel et al., 2016). This presents a barrier to those seeking to combine and analyze different datasets. Communication between monitoring groups is encouraged to ensure that the data collected is compatible across programs and to maximize the value of the combined dataset for a wider audience of watershed stewards (Stanley et al., 2021). In particular, if it is to meaningfully impact ecosystem and community health in a watershed, water quality information needs to be translated into management decisions.

2.1 Data to Decisions: Decision making and management

Communities, public officials, and industry sometimes rely on water monitoring data to inform their decisions and policies concerning activities undertaken in associated watersheds. For example, authorities may use monitoring programs to assess, locate, and mitigate sources of pollution from pesticides or other contaminants (Campanale et al., 2021). When designing land-use policies and zoning bylaws, local governments will often take water quality data, such as nutrient loads and turbidity, into consideration (Manitoba Water Stewardship [MWS], 2010b, 2014). Water quality and quantity can also be measured by industrial and non-governmental users with an eye to informing water treatment requirements (Knick International, n.d.; Staben et al., 2015), infrastructure needs assessments (Borden & Roy, 2015), conservation measures (McCarty et al., 2008), fishing (SOLitude Lake Management, n.d.), and irrigation practices (Gunn & Stanley, 2018; MWS, 2010b). In other words, monitoring programs are designed to meet certain objectives, and the specifics of each program (e.g., parameters, site location, and frequency) vary accordingly.

In an example drawn from the Whitemud River watershed in Manitoba, residents chose to prioritize ecosystem services, as well as water quality and quantity for agriculture. For this reason, indicators related to ecosystem health (e.g., dissolved oxygen, total phosphorus) and irrigation (e.g., herbicide concentrations) figured prominently in the watershed's water quality monitoring program (MWS, 2010b). In this case, water management focused on factors related to land use, such as nutrient loading and soil erosion. The information collected therefore allowed watershed managers and inhabitants to identify early signs of issues related to nutrient loading and fecal contaminants and to consider potential best practices for mitigating these issues (MWS, 2010a, 2010b).

Once the objectives of a monitoring program have been decided on, numerous factors can impact the effectiveness of the program in meeting those objectives. Many of these factors relate to the suitability of the program design. These factors include but are not limited to parameter selection, site selection, sampling or observation schedule, etc. Program design can also extend to include adaptability—allowing for changes according to unanticipated circumstances or discoveries while maintaining the coherence of the dataset (Lindenmayer et al., 2011). Other considerations include the type and quality of the instruments used, institutional knowledge and the availability of technical specialists, and access to resources, such as external labs or pre-existing data for the aquatic system (Bartram, 1996; Behmel et al., 2016; Mäkelä & Meybeck, 1996). Further, the spatial and temporal resolution of data collection is essential to determining whether the data collected will be sufficient to describe the systems of interest (CCME, 2015; Chen et al., 2012). These are just a few of the factors that shape the accuracy, reliability, and suitability of a monitoring program to meet its objectives.

Having designed and launched a monitoring program, the effectiveness of the program in informing decision-makers depends on data management practices to ensure the quality and continued availability of the resulting datasets (Behmel et al., 2016; Borden & Roy, 2015). In particular, good data quality is achieved when the data are controlled for errors, when they are easily accessible (e.g., by removing technical barriers and implementing open data principles), and when methods are standardized and well documented for users. As science and technology progress, methods may change and improve, altering comparison and interpretation between years. Clear documentation and metadata, along with robust industry standards, are essential to properly account for these changes and to develop trustworthy, transparent, and usable datasets for all stakeholders (Bartram, 1996; Borden & Roy, 2015; Cyr-Gagnon & Rodriguez, 2018). In addition, data governance and data structure may also impact a monitoring program's performance (Cyr-Gagnon & Rodriguez, 2018). For instance, security measures might be adopted to ensure that the data is protected from loss or unwanted access (Salam, 2019). While the following sections will focus on the use of real-time monitoring systems, these systems are most valuable when they are deployed in the service of a well-designed program with clearly defined objectives and sound data management practices.

2.2 High-Frequency, Real-Time Monitoring

Although the effectiveness of a monitoring program cannot be reduced to any single factor, there are some significant aspects of water quality monitoring that can be dramatically improved with the deployment of two noteworthy technologies. First in-situ data loggers are designed to collect the observations of numerous parameters at a single location with a high frequency, thereby improving the **temporal resolution** and volume of data available, especially at remote sites. This temporal resolution can be crucial to tracing, modelling, or even forecasting the behaviour of a water body, since water quality can vary in a matter of minutes (e.g., in the case of a river) (Clark et al., 2001). This can also be important when identifying the extent, timing, and even the source of a contamination event. Indeed, for decision-makers, it is often useful to know with some specificity when and where a particular event of interest has occurred. Secondly, some in-situ systems can be equipped with a transceiver to transmit and receive data via a cellular or satellite network, allowing for the **timely delivery** of data to researchers or decision-makers, which can be critical to effective action. If decision-makers are to respond to an active water quality issue, such as a chemical spill or a harmful algal bloom, they need rapid access to recent and relevant water quality data (Glasgow et al., 2004). In these emergency situations, the delays associated with field collection (e.g., steps for sample collection, analysis, interpretation, and communication) or even non-networked automated systems may not allow for a timely response to contain and mitigate the environmental impacts. Networked monitoring systems are designed to overcome this delay between data collection and decision making by offering data transmissions in near real time.

One of the greatest benefits of networked in-situ monitoring systems is the opportunity to provide alerts or notifications. Decision-makers can be notified almost immediately when any water quality issues are identified, allowing rapid response. Real-time systems might be installed around known wastewater outflow sites to alert water regulators of potential contamination events (Carducci et al., 2020; Mosley & Hipsey, 2012). Alert systems can also be used to monitor a highly valuable water body, ensuring water quality for community health and safety or for meeting industrial standards (Gunn & Stanley, 2018).

2.2.1 Benefits

Alert systems are only one of the potential applications of these high-frequency data collection and near-real-time networking technologies. Indeed, there are many possible ways in which networked in-situ systems can enhance a monitoring program, some of which are listed below.

- More data at a lower cost
  - While sensor equipment has upfront purchase and installation costs, the cost per measurement quickly diminishes over time (Adu-Manu et al., 2017; Burke & Allenby, n.d.; Lambrou et al., 2014).
  - While not a replacement, automated sensor networks reduce costs associated with resources and personnel time for travel, collection, and analysis (Adu-Manu et al., 2017; Burke & Allenby, n.d.; Lambrou et al., 2014).
  - Frequent data collection can be achieved, even in relatively inaccessible sites (Adu-Manu et al., 2017).
- Fewer knowledge barriers
  - Data can be integrated into an approachable user interface (known as Model Interfacing) (Benedetti et al., 2013).
  - Immediate visualization can support interpretation without the need for statistical or visualization skills (Glasgow et al., 2004).
  - Automated data collection reduces the need for specific, on-site technical expertise (Adu-Manu et al., 2017).
- Rapid response
  - With real-time data, decision-makers can become aware of issues in time to respond to them (Lambrou et al., 2014; Tango et al., 2019).
  - Automated alert systems can be used at high-risk sites to notify decision-makers of potentially unsafe conditions or sudden changes in water quality (Glasgow et al., 2004; Gunn & Stanley, 2018).
  - Frequent data collection and timely access allow changes in water quality to be studied shortly after a major event occurs (Rode et al., 2016).
- Adaptive monitoring
  - Fast access to high-resolution data enables watershed monitoring programs to adapt their monitoring strategy to the observed behaviour of the system, thereby maximizing the significance and impact of the data collected (Chen et al., 2012; Mosley & Hipsey, 2012; Wigmosta & Burges, 1997).
  - Management of the monitoring network is required to be systematic, allowing for more efficient and adaptive monitoring (Chen et al., 2012).

2.2.2 Limitations

The benefits of real-time monitoring are numerous, and they tend to be greater as the volume of data desired increases. At the same time, real-time monitoring is not a stand-alone solution, since the **range of observable parameters is limited** to those that can be measured with deployable electronic sensors. Additionally, real-time monitoring can present **technical barriers**, such as identifying and correcting for sensor issues, programming data transmission, automating management and quality control on large datasets, and more advanced modelling and visualization software requirements, which may not apply to the same extent under conventional monitoring approaches. To be clear, real-time monitoring systems come with a new set of requirements and limitations, which may add to the logistical cost and complexity of a monitoring program. Below are some examples of such requirements and potential limitations of in-situ, real-time monitoring systems.

- Sensor maintenance costs
  - Automated sensors are susceptible to drift and physical disturbances (such as damage and biofouling) when deployed for extended periods (Adu-Manu et al., 2017).
  - Regular supervision of the data, as well as periodic inspection and maintenance of the deployed equipment, is typically required.
- Networking costs and risks
  - Networking fees can be significant, depending on the service used and the volume and frequency of data transmissions (Borden & Roy, 2015).
  - Internet data transfers may require specialized knowledge of cybersecurity practices to ensure data is not lost (Adu-Manu et al., 2017).
- Data storage and management
  - Large volumes of data require the technical capacity for data storage and quality control, which may extend beyond the technical capacity of the pre-existing monitoring program (Adu-Manu et al., 2017; Rode et al., 2016).
  - Processing and storing large volumes of data may also require the purchase or extension of data storage and processing systems (Adu-Manu et al., 2017; Borden & Roy, 2015; Rode et al., 2016).
- Technological limitations
  - While sensor technologies are continuously improving, they are constrained to a subset of measurable parameters (e.g., temperature, pH, conductivity, dissolved oxygen, turbidity) (Adu-Manu et al., 2017). Many other parameters are only observable through manual sampling.
  - In-person site visits can provide insight into possible events or conditions that might influence the interpretation of data collected. In comparison, automated systems offer far less contextual information.

To summarize, while networked sensors can significantly improve the amount and range of data available, they also present several constraints that may not exist with conventional monitoring. Significant investments and foresight are required to ensure that the data produced is useful and valid (the common modelling refrain, "garbage in – garbage out," remains as applicable to sensor networks as to any other data source). As such, even though networked systems can sometimes replace manual sampling entirely, real-time monitoring is perhaps more often coupled with more conventional approaches.

These limitations notwithstanding, the timeliness of networked monitoring systems opens new possibilities for monitoring programs and is rapidly being adopted by many organizations. It provides information like "alerts" in near real-time for decision making, along with immediate insight into the dynamics of freshwater systems. These benefits do not imply that it is the optimal solution for all monitoring objectives or that it would generally supplant more conventional monitoring, only that it may present a significant improvement for some. On the one hand, if a monitoring program involves frequent and repeated on-site measurements of a select range of parameters, the timeliness of data is important, and the financial and data management capacity of the institution exceeds its scientific capacity, such a program may opt to widely deploy networked instrumentation. On the other hand, in cases for which the scale and resolution of the data required are minimal, the water body is readily accessible, and financial resources or technological expertise are limited, conventional approaches may still be preferred. In general, the potential benefits and requirements, including but not limited to those presented in this report, should be weighed in the unique context of each program.

Table 1. Potential benefits and limitations of real-time monitoring

Benefits	Limitations
More data at a lower cost Once equipment is purchased and installed, the cost per observation is small relative to conventional sampling methods.	**Sensor maintenance costs** Automated systems are susceptible to drift and errors resulting in maintenance and supervision costs.
Fewer knowledge barriers Data analyses and visualizations can be automated and optimized for decision making.	**Networking costs and risks** Data transmission fees can be costly, and security measures may be required.
Rapid response Data is available to decision-makers and researchers shortly after an event.	**Data storage and management** Large volumes of data may require additional computing power, data storage, and technical expertise.
Adaptive monitoring Systematic and rapid data collection allows for more responsive monitoring practices.	**Technological limitations** Not all parameters and relevant information are available through remote observation.

3.0 Real-Time Monitoring in Practice

As discussed, integrated real-time sensors can alert decision-makers, communities, and industrial operators as soon as issues occur. This can be particularly beneficial when the health of the community relies on trustworthy data and rapid response times, as in the case of drinking water (Lambrou et al., 2014). As of February 13, 2023, there were 26 active Manitoba boil water advisories for public water systems (PWSs) in the Winnipeg River basin, including 12 short-term, six medium-term, and eight long-term advisories, with the longest advisory ongoing since April 5, 2004 (Government of Manitoba, 2022, 2023). Additionally, many of the PWSs in the basin did not comply with provincial standards for turbidity (0.1 to 1.0 NTU) (Manitoba Water Stewardship & Manitoba Health, 2011), protozoa (Giardia and Cryptosporidium, 99.9% removal), and the disinfection products trihalomethanes (100 µg/L) and haloacetic acids (80 µg/L) (Manitoba Conservation and Climate, & Manitoba Health Seniors and Active Living, 2020), based on 2016–2018 provincial reporting (Manitoba Environment, Climate and Parks, 2020). Early notice of changes in water quality at an intake may enable water treatment operators to adapt their treatment methods and meet standards more consistently.

Real-time monitoring can also offer support for environmental alerts when conditions are not safe for aquatic life, recreation, or consumption. For example, water bodies that are at risk of contamination by a point source can be monitored for contaminants or for surrogate parameters that may accompany an effluent violation, prompting a treatment response or a swim ban (Carducci et al., 2020). There is a growing case for deploying sensor networks to monitor and manage the impacts of non-point-source pollution, such as nutrients leaching from watersheds with high agricultural activity (Davis et al., 2021; Zia et al., 2013). Such monitoring programs could help to inform environmental alerts or notices concerning swimming, ecosystem health, or wildlife consumption. In addition, new technologies enabling real-time data visualization and modelling or broad access to large volumes of scientific data have the potential to reach a broader audience and further scientific literacy and public interest in freshwater sciences (Smyth et al., 2018).

3.1 Deployment at Powerview: Pine Falls Drinking Water Treatment Facility, Manitoba

The town of Powerview-Pine Falls, Manitoba, is located on the northwest section of the Winnipeg River before it discharges into Lake Winnipeg. According to the 2016 census, the town supports a population of 1,316 (Statistics Canada, 2017). The drinking water for the town is sourced from the Winnipeg River and treated through the local treatment plant owned and operated by the town, with 672 m^3 of storage capacity and an estimated 100,000 m^3 treated per year (Manitoba Public Utilities Board, 2019; Town of Powerview-Pine Falls, 2021). The water is currently treated with a coagulation/flocculation process and sand filtration and is disinfected with chlorine. Additional ultraviolet treatment for Cryptosporidium and Giardia was installed in 2017. Water is collected and analyzed regularly for bacteria (E. coli and total coliform; bi-weekly), chlorine levels (daily), turbidity (daily), trihalomethane (four times per year), and chemistry and metals (annually). All parameters were in compliance during 2020, except trihalomethane, which was slightly above the health standard of 0.10mg/L (Town of Powerview Pine Falls, 2021).

In 2021, Aquatic Life® and IISD-ELA installed a s::can spectro::lyser v2 connected to a cellular data network platform at the raw water intake of the water treatment facility (in the low-pressure flow line after pre-filtration). The sensor equipment was set to measure flow, pressure, pH, temperature, oxidation-reduction potential, and a spectral fingerprint to derive total organic carbon, dissolved organic carbon, turbidity, nitrate nitrogen, and total phosphorus. Raw water quality is measured daily by the treatment facility operators, but this new technology enables data recording every two minutes. This is significant since important factors like turbidity and total organic carbon can change dramatically in a matter of hours. Higher-frequency data may therefore improve facility operators' capacity to make rapid adjustments to treatment methods.

Aquatic Life® and IISD-ELA plan to work with the treatment plant operations team on this deployment to determine the benefits of high-frequency data for drinking water treatment. For instance, the chemical composition of the water after pre-filtration may help operators to adjust inflow and/or limit the production of trihalomethanes and other harmful by-products of chlorine-based disinfection (MWS & Manitoba Health, 2011). These disinfection by-products form when water with high organic matter is chlorinated (Manitoba Conservation and Climate & Manitoba Health Seniors and Active Living, 2020). Thus, real-time information on turbidity, total organic carbon, and other contaminants could allow operators to make more targeted adjustments to the water treatment process and optimize the safety of the treated water for consumers.

High-frequency, real-time data is also essential for developing and implementing alert systems. With the data resolution offered by networked sensors, water system engineers can achieve a higher level of precision when looking for possible relationships between inflow and outflow conditions (Hobson et al., 2010). Certain correlations or threshold contaminant levels may emerge from these analyses to inform operations procedures (Gheibi et al., 2022; Raciti et al., 2012). If important thresholds are identified, an alert system can be introduced to a facility's Supervisory Control and Data Acquisition system along with any associated response protocols, allowing operators to make data-driven decisions in real-time (Shadevish et al., 2008).

3.2 Deployment on Lake 227, IISD-ELA

In Canada and around the world, a major environmental concern is the excess release of nutrients into waterways, causing eutrophication and harmful algal blooms (Winter et al., 2011). Algal blooms can be toxic to humans, requiring advisories to be issued in recreational water bodies (Rashidi et al., 2021). They can also lead to ecological issues, such as fish kills and cascading trophic effects (Landsberg, 2002). In light of the range and severity of issues caused by these blooms, watershed managers will often model water conditions (e.g., using climate and hydrological data) to inform their environmental alert systems (Ahn et al., 2021). Real-time monitoring may supplement or offer an alternative to such practices, either by detecting the formation of harmful algal blooms or by collecting data for bloom forecasting.

The IISD-ELA operates a long-term (1969–present) eutrophication experiment on Lake 227, a boreal lake in northwestern Ontario, Canada. Over its duration, the long-term experiment has evaluated the relative importance of carbon, nitrogen, and phosphorus loads to the development of algal blooms[3] that occur seasonally each year. During the open water season (May through October) of 2020 and 2021, a sensor (AquaTroll 600) and a telemetry platform (AquaHive) were installed near the centre of the lake, measuring a suite of parameters at 1 metre below the water surface (Figure 1). Initially, the platform recorded and transmitted hourly water temperature, chlorophyll-a concentration, and phycocyanin (a pigment unique to cyanobacteria/blue-green algae) concentration. In 2022, IISD-ELA added sensors to record dissolved oxygen, depth, pH and oxidation-reduction potential.

Figure 1. AquaHive and sensor installation on Lake 227 at the IISD-ELA in 2020.

Source: IISD-ELA.

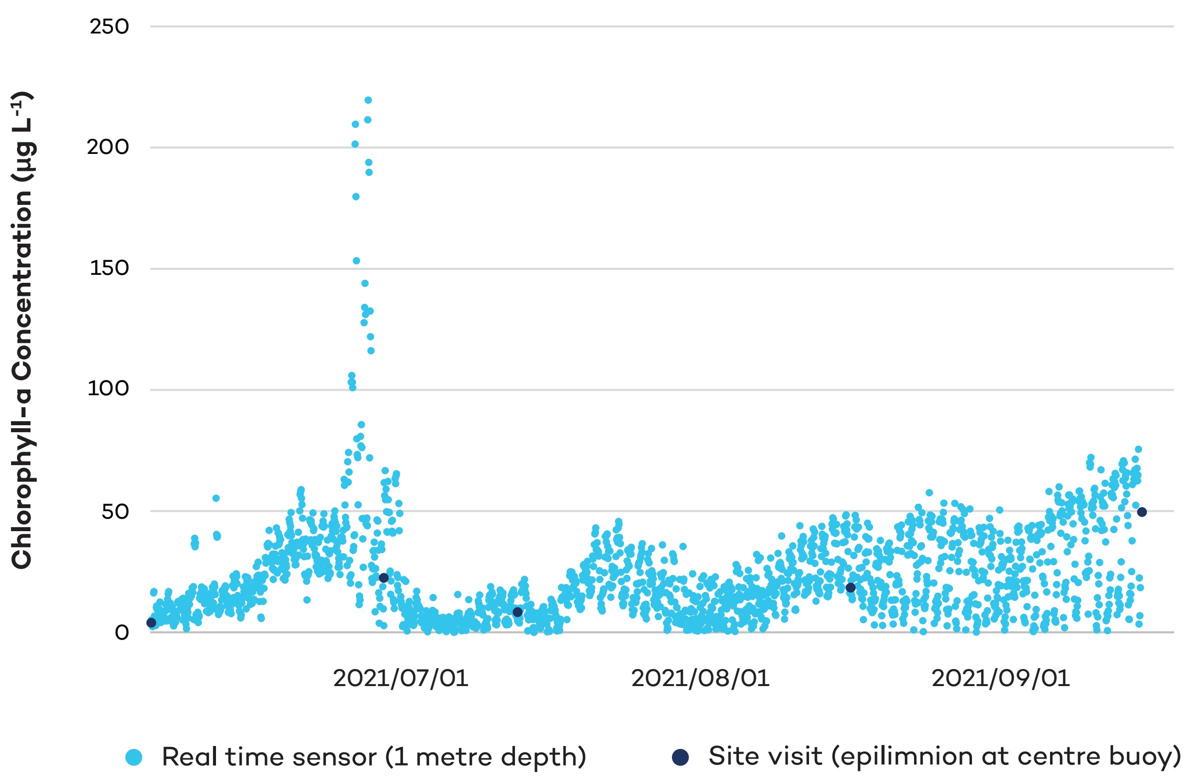
This system has allowed researchers to track the fluctuations of key parameters, including estimates of algal and cyanobacterial biomass (via pigment concentrations) in the lake in near real

[3] https://www.iisd.org/ela/research/current-research/harmful-algal-blooms/

time. For this experiment, the high-resolution data is particularly valuable for filling data gaps between scheduled bi-weekly site visits (Figure 2) that did not fully capture seasonal dynamics and led to challenges in detecting long-term trends. Further, the addition of high-intensity data on dissolved oxygen can allow for estimates of ecosystem productivity. Our research team is also interested in adding sensors to measure dissolved carbon dioxide concentration, which undergoes large diel variation and may limit algal growth rates and bloom development but is otherwise difficult to sample using conventional means.

High-frequency monitoring can also help to mitigate the spatial patchiness of phenomena like algal blooms (i.e., by averaging over a large sample size), and finer time resolutions can offer insights on a broader range of potential nutrient forcing processes, such as terrestrial–aquatic links during flood events (Marcé et al., 2016). These are only a few examples of the many possibilities offered by automated, higher-frequency data collection systems for environmental monitoring and freshwater science.

Figure 2. Chlorophyll-a concentration recorded at 1 metre from the water surface



Note: Recorded using a multiparameter sonde (In-Situ Aqua TROLL) connected to a networked AquaHive system and site visits on Lake 227 at the IISD-ELA in 2021. Near real-time sensor data was drift calibrated with the site visit data, and all values <0 were removed. Site visit chlorophyll-a analysis methods are described by Arar (1997).

4.0 Moving Monitoring Forward

Real-time monitoring has the potential to dramatically improve the effectiveness of many water quality monitoring programs. The examples outlined in this report demonstrate that robust real-time monitoring systems can open new avenues for water management and scientific inquiry by scaling-up data volume and resolution and by delivering nearly immediate information via alerts or modelling interfaces.

The value of real-time data for decision making has been well established in certain industries, such as water asset management, but is still being explored and tested in the context of watershed monitoring. Indeed, in the current landscape, real-time monitoring may not be the optimal solution for all water quality monitoring programs. There can be significant factors related to cost, field conditions, and technical knowledge that may lead a monitoring program to favour more conventional monitoring methods. This holds especially true if the need for higher data resolution, real-time data access, and remote sampling is minimal.

However, there is a way forward for accelerating the deployment of real-time monitoring technology. When it comes to monitoring water quality in watersheds, widespread adoption of real-time data will require networked instruments that are designed to adapt to the objectives of different monitoring groups at local or regional scales. It will also depend on the affordability of these technologies and their capacity for accommodating the material and technical resources available to different monitoring groups. Scaling this technology beyond its currently sporadic and siloed applications will require communication across monitoring groups as well, which can be facilitated by regional or national authorities through resources such as data repositories, institutional networks, targeted funding, and standards for publishing real-time data. In other words, a combination of adaptability to individual programs' needs along with a broadening of data infrastructure will help to ensure that the benefits of real-time monitoring are reliable and widely accessible in the future.

In the meantime, there is already a compelling case for decision-makers to implement real-time monitoring programs for their watersheds. Watershed organizations, provincial and municipal governments, and federal agencies may also benefit from promoting the use of real-time monitoring, as needed, to gather higher volumes of readily available and cross-compatible water quality data. While there may be challenges or limitations to implementation in some cases, the benefits of real-time monitoring are in many ways unparalleled by conventional methods, allowing watershed managers to make rapid and effective decisions to protect fresh water and build trust with communities.

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