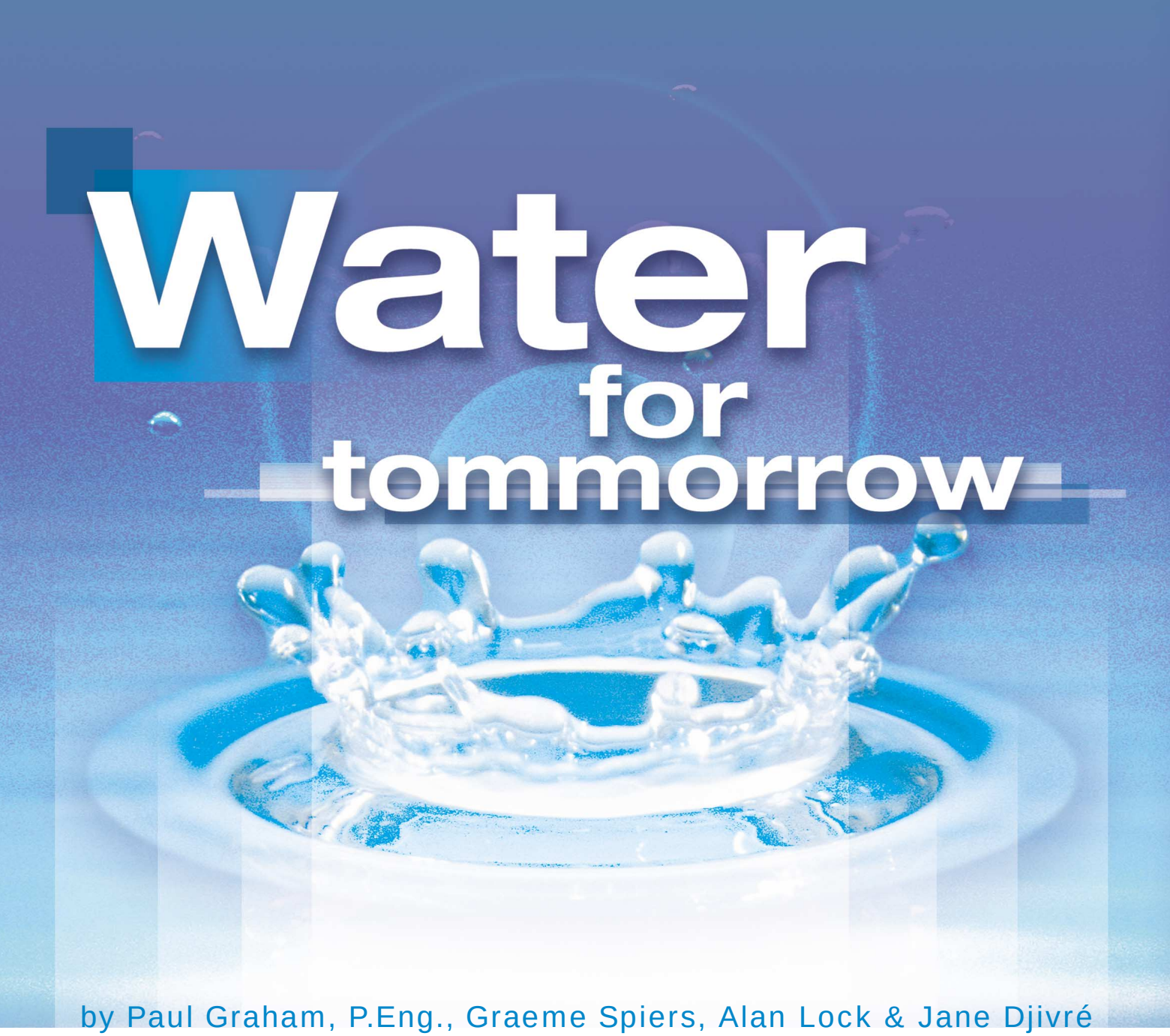


by Paul Graham, P.Eng., Graeme Spiers, Alan Lock & Jane Djivré

Probing the health of the Ramsey Lake Watershed

In the post-Walkerton era in Ontario, municipalities are required to ensure the long-term safety and viability of their water sources. Ramsey Lake in Sudbury has a history of contamination that presents an enormous challenge for the city –and an opportunity to develop leading edge–water monitoring programs.

Ramsey Lake, the centre of the most important watershed in the City of Greater Sudbury, is demonstrating the significance of industrial and transportation contamination management.

The lake provides the drinking water reservoir for more than 50,000 Sudbury citizens. Over the last century, this watershed has been subjected to myriad environmental assaults: acidic and metal-laden smelter emissions, leakage from septic systems of lakeside homes, dissolved organic acid-rich detritus and runoff from local sawmills. It has been polluted by fertilizer-rich runoff from golf courses and lawns, and by contaminated runoff from regional transportation networks.

The result is a unique "living laboratory"–a survivor of extreme environmental insult with an accumulation of 50 to 60 cm of metal and organic-rich sediment in

its depths, which must be managed to provide a continuing source of potable water for the city. The lake's contamination is further compounded by the stressors of climate change, which are modifying the planet's weather patterns.

Municipalities muscle up

In this post-Walkerton era, regulations now require municipalities to be more proactive about the testing of not only their main water reservoirs, but also the monitoring of the health of their groundwater sources.

Ramsey Lake, surrounded by the community it serves, is a critical surface water model for Ontario. Successes of the current program of monitoring Ramsey Lake will provide an opportunity to guide the implementation of similar remote monitoring programs for other important bodies of water throughout the province, with data feeds to centralized, water-quality processing and display centres.

Sudbury is facing the impact of climate change. Computer modeling predicts northern Ontario will experience a mean annual temperature rise of 2 to 4 degrees over the next 50 years.

Ramsey Lake provides a unique challenge, responsibility and opportunity to study the effects of multiple stressors on a threatened or "perturbed" aquatic system, with significance beyond northern Ontario.

The lake is an ideal location to test and develop equipment because of its close proximity to Laurentian University, community interest in the increased monitoring density of Ramsey Lake, and the benefits from understanding contaminant throughflow within this important drinking-water reservoir.

The long-term and real-time data from chemical and physical measurements of both inputs to, and exports from, the watershed will help us to understand complex changes in water chemistry. Such changes come in response to multiple stressors provided by industrial emission history, urban-runoff events, and predicted climatic extremes. Results from this project will provide insight into critical issues linking environmental and human health in the region.

Improved methodologies–and results

The goal of the Probing the Health of Ramsey research project is to improve our ability to detect, measure, quantify, collect, analyze and display key data from the Ramsey Lake watershed. This goal is being achieved by installing an automated "toolchest" of monitoring and sampling units–not only on the lake itself, but also on the input sources to this important water body. These monitoring units will allow the development of an understanding of events on time scales not possible by conventional labour-intensive monitoring. The data will allow development of the dynamic predictive models crucial for planning and effective resource management. There is also the potential to couple water chemistry models with hydrologic models to develop metal transport models.

This project is supported in part by the City of Greater Sudbury, and comprises part of the city's strategy to improve the health of critical regions that feed into Ramsey Lake and other water bodies. The study is significant because it provides the beginnings of a strategy for watershed protection planning through a comprehensive understanding of groundwater and its characteristics. The city's goal through this and other initiatives is to maintain Ramsey Lake as a sustainable water supply.

However, since it is an urban supply within a limited watershed precipitation capture zone, keeping the lake and its sources in balance is a task that requires an intimate understanding of the dynamic nature of the flows. The monitoring project will be an invaluable tool to facilitate this process and encourage ongoing analysis and communication.

Since more water feeds into Ramsey Lake via groundwater flows than surface flows, the watershed information this study provides is valuable to the environmentalist as much as the city engineer. The information collected will help to ensure the future security of municipal groundwater supplies; it will generate many large datasets that, when integrated, will create a visual framework measuring the total health of the water and its sources. The study will help to identify potential sources of contamination and better explain what kind of risks they pose to the system.

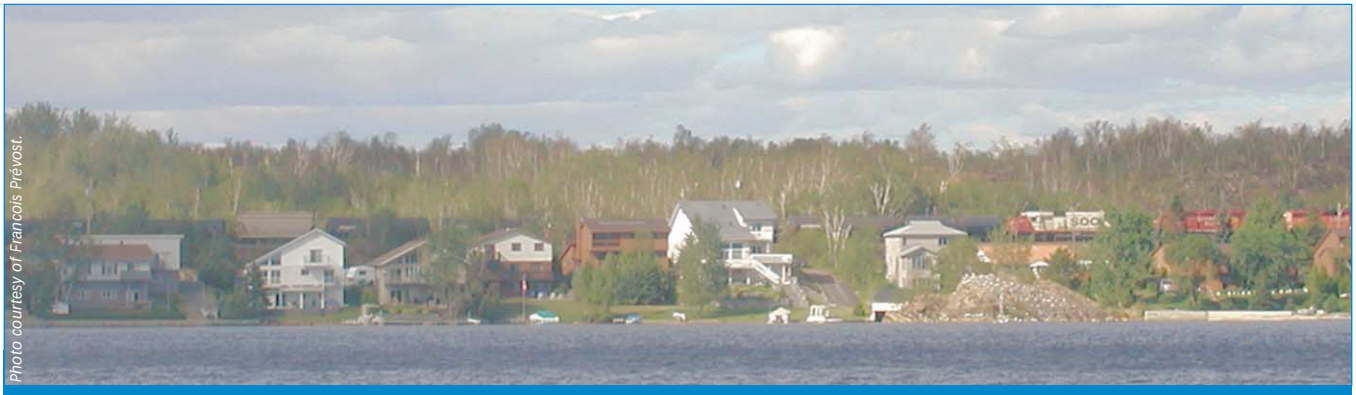
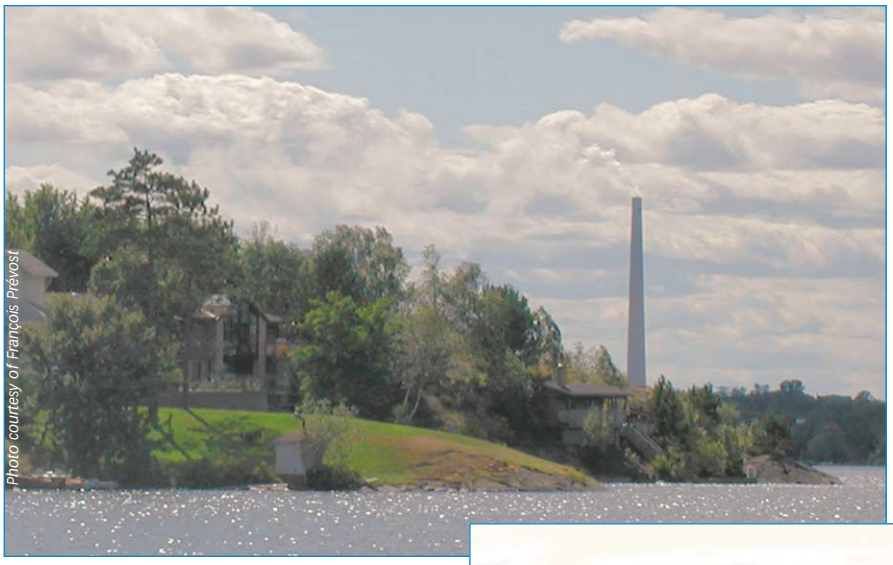


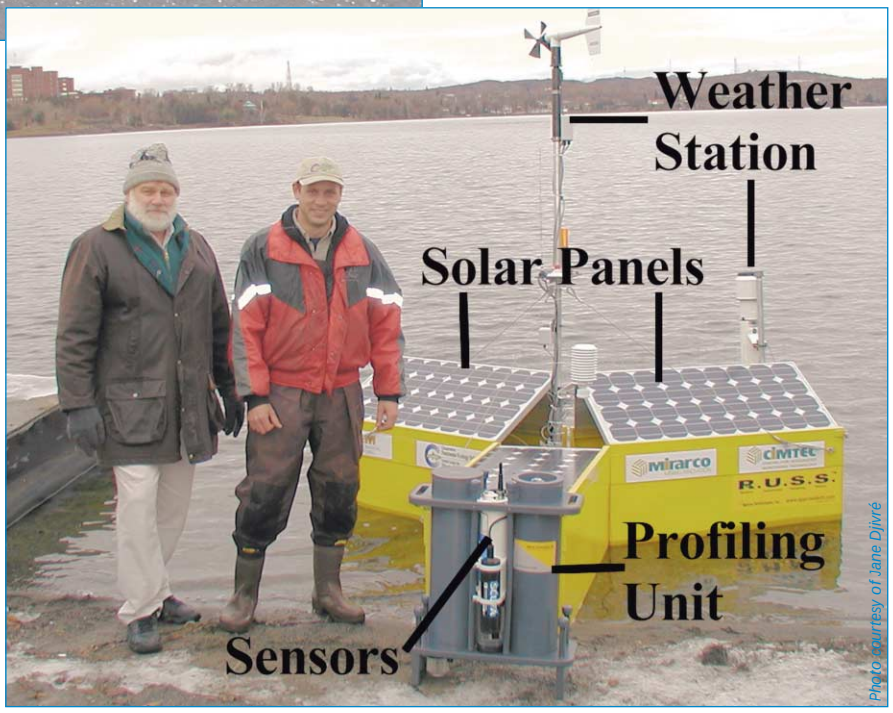
Photo courtesy of Francois Prévost.

The Ramsey Lake shoreline has sections with both dense residential and transportation infrastructure within metres of the shoreline. Note the CP freight in the background.



(Left) Ramsey Lake shoreline with fertilized lawns extending to the waterline. The 371-metre Superstack of the INCO smelting complex in the background is approximately 5 km from Ramsey Lake.

(Bottom) Graeme Spiers (left) and Alan Lock officially launch the Ramsey Lake monitoring station in November 2002. The monitoring station comprises the profiling unit and weather station, moored and collecting data for transmission to the CEM facility for processing and display.



Planning and policies

There are several main benefits to the city. Gaining a better understanding of the health of Ramsey Lake and its watershed will facilitate spill response planning and decision making related to the water supply system. The project opens opportunities to create more effective watershed protection policies in the capture zones. Long-term data monitoring will ensure there is an ongoing, comprehensive database to evaluate the success of any measures taken to improve the health of the system. An improved understanding will aid in planning to protect the source of groundwater upwelling into the lake from subsurface springs.

Ultimately, this study could help city staff develop policies that would become part of the official watershed protection plan. Such policies could include land-use constraints and measures to minimize threats and risks to regional watersheds.

High-tech study

The Centre for Environmental Monitoring (CEM), MIRARCO, at Laurentian University is one research group partnering with Sudbury to investigate Ramsey Lake. The research initiative is also funded in part by Ontario Innovation Trust, Canada Foundation for Innovation, and the European Space Agency. CEM has installed new technology to obtain high-resolution vertical chemical and biological characterization of water quality parameters. This technology is expected to demonstrate significant time and cost savings in obtaining time-relevant data, as dynamic testing reduces the need for manual, frequent and sometimes unnecessary testing, and continual data streams offer greater certainty of actual in-lake conditions, critical for protection of human health.

At the core of this technology is a remote underwater sampling system (RUSS) linked to a dynamic profiler. The profiler, moving up and down the water column using a variable, buoyancy-control system, carries a suite of sensors to measure chemical and physical parameters. Vertical movement of the profiler, and data acquisition and retrieval are remotely controlled by CEM using an embedded computerized controller on a buoy platform. The computer system is linked to the CEM facility by telemetry.

RUSS goes 24/7

The RUSS technology will be used to monitor suites of chemical and biological parameters simultaneously, using a single-sensor package recording data at user-programmed depths. The measured parameters may include some or all of: dissolved oxygen, pH, conductivity, temperature, oxidation potential, turbidity, chlorophyll, dissolved chloride, light attenuation and

total dissolved gases. Dissolved metal-specific sensors may be added as the monitoring program develops. Sensors integrated into the buoy system include conventional meteorological parameters such as wind speed and direction, barometric pressure, air temperature, relative humidity, and surface-light intensity.

The system will be further developed to allow monitoring of turbidity plumes from either lake-bottom spring or stream sources identified by more conventional, infrequent sampling programs. Results of the dynamic measurements of the turbidity plumes can be integrated with time-of-travel models for predictive assessment.

In addition, the effects of watershed events, such as rainfall and disturbances due to such activities as construction, can be monitored remotely by CEM, 24 hours a day, seven days a week throughout the entire water column.

The RUSS system, coupled with models and data visualization tools, is currently teamed with conventional field and laboratory water quality, meteorological, and flow sensors to create a "canary in a coal mine" approach to monitoring. The approach allows for broad-spectrum sensitivity to chemical and, potentially, biological agents.

The monitoring system currently uses a series of key measurement parameters to measure and allow predictions of the lake response to a variety of perturbation effects. RUSS will allow CEM to use resultant data as an early warning system, and also to validate and verify management models for Ramsey Lake.

The system is linked to a virtual reality laboratory (VRL) located at Laurentian University and managed by MIRARCO. The VRL can integrate large datasets and visualize them in immersive 3D. This is becoming a choice communication tool to demonstrate data quickly to key decision makers and councillors, facilitating the policy-planning process. The VRL can aid the city's water resource engineers as a tool to demonstrate data and study trends in a highly captivating, numerically dynamic model, superior in utility to other "snapshot-in-time" methods.

Water dynamics revealed

This CEM project will answer questions about diurnal, seasonal, and annual dynamics of water temperature, dissolved oxygen, turbidity, pH, oxidation/reduction potential, nutrient levels, and dissolved metal content.

The results from the monitoring program will lead to an improved understanding of the real health of the water resource, providing an immediate feedback signal that will enable the prediction of controls necessary to keep the water safe. Data from the RUSS system will be studied in conjunction with data and samples collected from the streams, municipal storm water systems, surface and lake bottom springs that feed Ramsey Lake. These water sources will also eventually have dynamic monitoring systems installed to provide a complete picture of the hydrological and hydrochemical dynamics of the watershed.

Instant messaging alerts

Through this project, CEM engages in high-detail testing, capable of signaling warnings to city resource engineers and researchers should data parameter control limits be breached. This environmental "instant messaging" is invaluable, especially to those who must quickly respond to any irregularities in the system. The monitoring toolkit better enables compliance to the new testing standards, as CEM has the capability to coordinate E-coli testing, with plans in the near future to shift to a dynamic monitoring system.

CEM also performs live, dynamic chlorophyll testing. High chlorophyll levels signify algal blooms that could produce microtoxins that can potentially find their way into a water supply. Ongoing monitoring can signal to treatment plants details of elevated biological activity, thereby initiating corrective action early and minimizing any health risks.

The monitoring systems tested and modified on Ramsey Lake will later be installed in remote areas where regular human access is difficult and costly. There is, for example, growing concern about how climate change may affect northern lake ecosystems that are host to cold-water fish populations. Knowledge of the seasonal dynamics of such lakes has been sparse to non-existent.

With its proximity to Laurentian University, Ramsey Lake is an ideal location to test and develop equipment that will safeguard the health of the drinking water in the community, and eventually in other communities in Ontario.

This environmental "instant messaging" is invaluable, especially to those who must quickly respond to any irregularities in the system.

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