Advancing Science and Technology for Freshwater Ecosystem Protection
We are proud to report that the Jefferson Project’s historic purpose — to become the global model for sustained ecosystem understanding and protection — is now being realized. In the coming year we will deploy new technology, release the much-anticipated Mobile Weather App, expand our lake monitoring, and conduct a new series of experiments including several conducted at the lake. We continue to expand research and application of the Jefferson Project, integrate our efforts, and serve as a model for other lakes.

As a highlight, the Jefferson Project has received increased attention as the New York State Governor’s Office has announced a new initiative to understand and control harmful algal blooms (HABs). Among the 12 focal lakes identified, Lake George will serve as the “control lake,” since it is the only one that has not yet experienced a harmful algal bloom. The research that we are conducting on Lake George offers a wide range of insights and actions that other lakes can use to help predict and prevent HABs.

There’s never been a more critical time to focus on freshwater ecosystem protection. We hope you’ll join us.

Harry Kolar
Associate Director
IBM Research

Rick Relyea
Director
Rensselaer Polytechnic Institute

Eric Siy
Associate Director
The FUND for Lake George
Lake Threats and Solutions

Like many lakes around the world, Lake George faces threats from human activities. These threats include pollution from road salt (primarily sodium chloride), introductions of invasive species, and inputs of excess nutrients. Our goal is to assess these threats — alone and in combination — to understand their impacts on overall water quality and potential mitigation strategies. To do this, the project combines ecosystem monitoring, experimenting, and modeling.

Road Salt

In the past several decades, we’ve seen a dramatic increase in the use of road salt. However, little research tracks how much of this salt makes its way into water bodies, or its effect on aquatic organisms and overall water quality.

For the past 38 years, Rensselaer researchers have monitored salt concentrations, finding that chloride concentrations remain relatively low, despite tripling in the deep waters of Lake George. However, streams carrying water to the lake can have salt concentrations up to 100 times higher than normal during peak snowmelt events. Our computer models show how salt moves into the lake — documenting which roads and regions of the watershed contribute the most salt. This helps us predict the future impact of different salt-reduction strategies.

Experiments by Rensselaer researchers testing the impacts of salt pollution on aquatic organisms have focused on the most common form of road salt, sodium chloride, and alternatives promoted as environmentally safer than sodium chloride. Our results suggest that the current elevated concentration of chloride in the deep waters of Lake George does not pose an immediate threat to the algae, plants, and animals. Closer to shore, however, as well as in tributaries and soils, this may not be the case — requiring further research.

With much higher concentrations, we can expect decreases in the lake’s zooplankton and increases in algae, causing a decline in water clarity. Additional experiments at Rensselaer show that rainbow trout are stunted in high salt environments, while developing tadpoles change sex from female to male. However, some species, such as invasive Asian clams, are quite tolerant to elevated salt concentrations. The salt alternatives we’ve tested all come with tradeoffs as research results show that magnesium chloride and calcium chloride can be even more lethal than sodium chloride, while salt additives like beet juice or distillation by-products can decompose and act as fertilizers in the lake — contributing to algae growth.

Road Salt — What’s Next:
Future work is focused on adding data from GPS-equipped salt trucks of The FUND’s Road Salt Reduction Initiative to our salt computer model to better understand salt inputs around the watershed and to predict the impacts of different salt-reduction methods and amounts. Continued salt monitoring in the lake and its tributaries will be aided by the installation of additional tributary monitoring stations, which allows us to understand the dynamics of salt inputs particularly during snowmelt and rain events. Experiments will continue to explore how salt pollution interacts with other impacts — including excess nutrients and invasive species — and how this impacts human uses of the lake.
Invasive Species

The introduction of non-native species is a growing threat and non-native species that cause economic, aesthetic, or recreational harm are classified as an invasive species. Currently, Lake George has 20 non-native species with five of them classified as invasive: Eurasian milfoil, curly-leaf pondweed, zebra mussels, Asian clams, and spiny water fleas.

Researchers at Rensselaer monitor plants and animals in Lake George, allowing us to understand the current distribution and abundance of native and invasive species. Our invasive-species experiments have focused on zebra mussels, which are well-studied, and Asian clams, which are not well-studied. Asian clams have made a relatively recent appearance in lakes around North America, and scientists consequently know little about their impact on food webs and water quality. Both invaders filter water and eat floating algae, thereby increasing water clarity and potentially upsetting the ecological balance. However, the clams favor the growth of algae attached to the bottom of the lake. Experiments on the non-native banded mystery snail, suggests it has become the dominant snail in Lake George because it is a superior competitor for attached algae with a strong shell that provides protection against many predators. Given that the banded mystery snail is altering the lake's food web, it may need to be classified as an invasive species.

Excess Nutrients

Fertilizers and improperly treated sewage can bring excess nutrients into lakes that support algae growth and turn crystal-clear water opaque, leading to decreased tourism and declining real estate values. With increased fertility, excess nutrients such as phosphates also can cause algal blooms, which can produce toxins that are harmful to people and their pets.

In monitoring the deep waters of Lake George over time, Rensselaer researchers have detected a 74% increase in orthophosphate, which represents a small absolute increase in concentrations from 0.7 to 1.2 micrograms (millionths of a gram) per liter. Orthophosphate is a form of phosphorus that is absorbed by algae and promotes its growth. The direct cause of the increase in orthophosphate is unknown, although phosphates typically arrive via stream runoff that carries nutrients from lawn and farm fertilizers as well as nutrients from outdated septic systems and wastewater treatment plants.

Increased orthophosphate is associated with an increase in Chlorophyll a, which is an indirect measure of floating algae in the lake. Our Smart Sensor Network has detected that the greatest concentrations of floating algae are quite deep in the lake, highlighting the need to monitor both surface and bottom algae. Our long-term monitoring in the deep waters over 38 years shows that Chlorophyll a has increased 34 percent, which represents a small absolute increase in concentrations from 1.3 to 1.7 micrograms per liter. These data are consistent with experiments showing that the growth of Lake George algae is strongly limited by nutrient availability. These changes are a concern because continued increases in floating algae would eventually lead to declines in water clarity. Fortunately, this small increase in the deep-water algae of Lake George has not yet caused a detectable decline in deep-water clarity.

Excess Nutrients — What’s Next:

Two-dimensional food-web models are helping us understand and predict how changes in lake nutrients will lead to changes in algal abundance and species composition over time. Rensselaer researchers shifted our monitoring efforts from the deep to shallow water in 2017, putting the focus where changes are being observed. We will continue monitoring the shallow water sites in 2018 to quantify the abundance of nutrients, algae, invertebrate animals, and fish to better understand how inputs of excess nutrients alter food webs, which in turn drive overall water quality. This is especially important as measures are implemented to upgrade wastewater treatment systems and control stormwater runoff, leading to a reduction in nutrient inputs.

Invasive Species — What’s Next:

Our goal is to use monitoring data on invasive species to better predict their distribution and abundance in Lake George and other lakes in the region. Using Artificial Intelligence techniques, we will identify the habitat variables that are associated with the presence of an invasive species and then predict how the species will spread throughout a lake as guidance toward developing better monitoring of invasives and more effective controls.
The evolution of the Jefferson Project has introduced market opportunities to develop new instruments and equipment. To address a technology gap on existing commercial profilers, the Rensselaer Center for Automation Technologies and Systems (CATS), in collaboration with IBM Research, designed and built a new generation of vertical profilers. The floating sensor platforms monitor conditions from the surface of the lake to the bottom in the five deepest basins with more adaptable, superior hardware and software that collect higher-quality lake data for our experiments and computer models.

To link cause and effect, experiments must be conducted under conditions that, while controlled, reflect the real world. During the past three years, Rensselaer researchers have conducted experiments in the highly controlled laboratory environment, and in large outdoor tanks of water that more closely mimic a natural aquatic environment. In the coming year, we will develop in-lake experiments — large bags of water suspended from floating platforms — to offer a richer realistic environment for select experiments. In each bag, conditions will be manipulated in a controlled manner to explore the impact of known lake threats like road salt and nutrients. In collaboration with IBM Research, sensors will automate data collection — including temperature, pH, salinity, and dissolved oxygen — and will be integrated with the Smart Sensor Network so that we can compare changes in the mesocosms to changes in the lake. These experimental results will directly inform our food-web models.

IBM Research is advancing a suite of computer models that depict weather, runoff, and circulation of water and pollutants in Lake George. Our current weather model offers unprecedented resolution and a longer forecasting period. A new land surface model accurately depicts the interplay of the land surrounding Lake George with the atmosphere, and is supported by new soil sensors within the watershed. In parallel, research continues on improving the salt model, which helps us better understand how salt moves within the watershed. This is aided by the increasing availability of salt application data as more salt trucks are fitted with new instrumentation, an initiative led by The FUND. A new capability of the particle tracking model traces particles backward in time to origination points using our advanced circulation and stream models. We have expanded our efforts to model important nutrients such as nitrogen and phosphorous in conjunction with the expanded water quality monitoring program.

To predict how future changes — such as road salt inputs, excess nutrients, and invasive species — will affect the lake, IBM Research is developing a “scenario engine.” The scenario engine draws on data from our sensors, long-term surveys of water chemistry and food webs, experiments, and computer models to predict future changes in water quality. With this capability, we can ask how human activities and proposed mitigation efforts will affect the lake and the surrounding watershed. We anticipate this capability will be essential to ensuring the protection of Lake George and other lakes around the world by providing guidance to decision makers regarding a wide range of “what if” scenarios.
Expanded Smart Sensor Network

The Jefferson Project Smart Sensor Network — which uses four types of sensor platforms to track parameters related to chemical, physical, and biological quantities within the lake — has been expanded with the addition of enhanced vertical profilers and new stream monitoring stations. The sensor platforms consist of multiple sensors and additional smart technology computational elements from IBM Research that allow the sensors to perceive their surroundings, communicate with other sensors, and adapt to changing environmental conditions. As a result, we’re able to anticipate and capture higher quality data around unusual events, like storms.

Jefferson Project by the Numbers:

Between the sensors and models, we are collecting enough data to fill up 5,250 16GB mobile phones annually — that’s 14 mobile phones daily.

- **51** sensor platforms
- **500+** sensors
- **9** terabytes of data/year from sensors
- **300+** million measurements to date
- **73+** terabytes of data/year generated by computer models

jeffersonproject.rpi.edu