ENVIRONMENTAL
monitor
FALL 2024
APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

DATA-INFORMED RESOURCE MANAGEMENT

High Definition Stream Surveys
Informed Management in Local Waterways

Francis Scott Key Bridge Collapse
Current Monitoring in the Patapsco River

Data-Driven Decisions
Tracking Sediment during the Klamath Dam Removal

Welcome...

Welcome to the Fall 2024 edition of the Environmental Monitor, a collection of the best from our online news publications. In this issue, we highlight the role of data in informing resource managers and researchers on how best to protect and preserve natural resources.

Featuring stories from glaciologists to managers of multi-site resource monitoring programs throughout the United States, environmental professionals have worked to protect natural resources and inform management decisions. From monitoring above and below dams to studying harmful algal bloom dynamics in local water bodies, this latest edition highlights the role of environmental data-informed resource management.

Our writers sought out environmental professionals dedicated to understanding environmental resources and the diverse stressors impacting them, utilizing data to shape policies, restoration efforts, and other initiatives.

Located in Fairborn, Ohio, Fondriest Environmental is the trusted partner you can turn to for help with environmental monitoring projects. We assist in everything from planning and monitoring to systems integration, equipment calibration and training. Our specialists have years of experience integrating and deploying remote systems and working with leading suppliers such as YSI, Hach, Onset, Solinst, NexSens, and many more.

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ON THE COVER

Front: A NexSens CB-650 deployed downstream of Klamath Dam. Photo taken by Gravity Consulting. (See Pg. 56)
Back: Mohonk Lake 75% ice covered on January 17, 2024. Photo taken by David Richardson / SUNY New Paltz.

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Photo Credits (Left to Right):
Maggie Warren; Kathleen Brown; AJ Martignette

IN THE NEXT EDITION

Subscribe to read the next edition of the Environmental Monitor, focusing on *Collaborative Environmental Research*. Stories will highlight the power of collaboration amongst environmental professionals.

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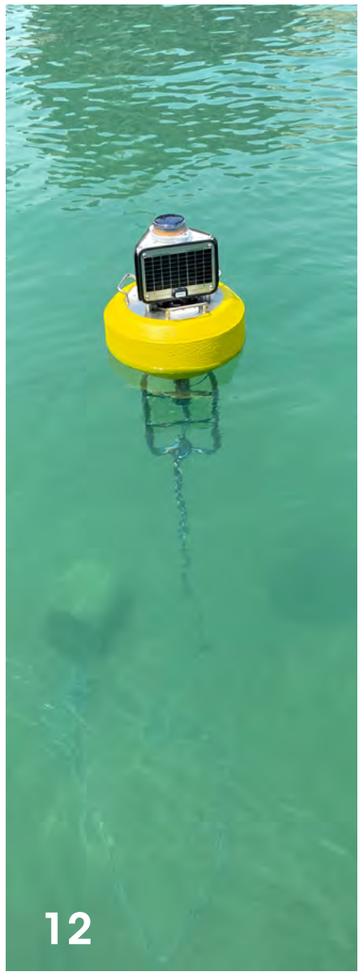


On the Web

Maui Scientists Offer Water Quality Testing in Wake of Wildfires

After weeks of battling and finally containing wildfires, the residents of Maui were faced with the arduous task of rebuilding their communities. One priority was ensuring that people impacted by the fires had access to safe drinking water, as the blazes had damaged pipes carrying water to residential and urban areas. Local scientists are leading an outreach campaign that informs residents about the safety of their drinking water.

It's a Buoy! Highlighting the New NexSens XB-200 Data Buoy

As scientists seek to better understand aquatic ecosystems, utilizing small data buoys to monitor offshore and cover more water is becoming commonplace. The new NexSens Technology XB-200 data buoy was designed for inland and coastal monitoring applications. Impact-resistant and with 200 lb. of buoyancy, the XB-200 offers a durable platform for a variety of monitoring applications.

Rebuilding Trust in Science & Protecting Resources: Thomas More University Biology Field Station

The Thomas More University Biology Field Station is managed by a team of students, faculty, and staff who facilitate ongoing restoration and monitoring programs. Molly Williams is the Station Manager of the facility and spends her days overseeing various research projects, internships, and outreach initiatives.

Searching for more quality environmental news? Find more at fondriest.com/news or scan the QR code.

REMOTE WATER QUALITY MONITORING WITH THE OKLAHOMA WATER RESOURCES BOARD

Growing up surrounded by water, whether it be rivers or streams, lakes or ponds, or right on the coast of the ocean, it can be easy to forget that clean water is a limited resource. For many, turning on the tap means potable, running water.

"You're not really thinking, 'Well this comes from a reservoir,'" explains Sarah Dexter, an Environmental Program Supervisor with the Oklahoma Water Resources Board (OWRB).

The OWRB monitors various waterbodies throughout Oklahoma, and Dexter works specifically with rivers and streams, which has placed her on several projects involving dams and stormwater monitoring.

Overall, the OWRB collects large amounts of data that allows them to support various studies, trend spotting and initiatives thanks to real-time monitoring and continuous data gathering.

Dexter explains, "We have that benefit of having our data reach a wide area of citizens. That's probably the most significant part of our work. Some of these sites, we've been sampling for 20 years or more. So there's a lot of data that we have, that can be utilized in a variety of ways."

STORMWATER MONITORING IN NORMAN, OKLAHOMA

Dexter is leading two major projects in Oklahoma, the first of which is a stormwater monitoring project for the city of Norman. The project began as a result of a Total Maximum Daily Load that was conducted in 2013 and resulted in the city being required to create a monitoring plan to identify the main sources of nutrient and sediment concentrations impacting water quality.

The city is also required to use the data gathered by the project to develop and put in place best management practices that lessen those pollutants from entering into the watershed. Dexter's role in the project is to lead the monitoring efforts year-round.

"During a rain event, the streams carry runoff, which can contain excess sediments and nutrients from the surrounding watershed, to the lake," explains Dexter.

Dexter expands, "It's what's entering into the streams, because those streams are flowing into the lake. And the lake is where people recreate, and that's where the drinking water for the city comes from—so it's a major multi-use watershed."

DAM MONITORING DOWNSTREAM

Alongside the stormwater monitoring in Norman, the OWRB has been involved in the Grand River Dam Authority's (GRDA) dissolved oxygen monitoring program since 2006. When the OWRB got involved in 2006, the division worked with the GRDA to test various release scenarios and their effectiveness on dissolved oxygen concentrations. The current strategy of monitoring water quality and preemptively mitigating dissolved oxygen declines was adopted in 2013.

Dexter serves as a contractor to the GRDA, helping to maintain equipment below the dam and collecting and correcting the data to determine whether the locations are meeting Oklahoma water quality standards.

The GRDA must meet Federal Energy Regulatory Commission (FERC) guidelines in order to maintain their operation license. The CB-450s equipped with X2-CB data loggers stationed below Kerr Dam and the X2 data loggers attached to a bridge downstream of Pensacola Dam help gather data continuously to ensure the dam is meeting these requirements.

The X2 data loggers transfer the data gathered by the system to the cloud, where Dexter and the dam operators can view the data in real-time through the WQData LIVE datacenter. The team of managers and scientists involved in the program all have access to the database, including the alarms that go off and get sent out to everyone involved when dissolved oxygen levels have dropped too low.

There are two alarms designed to go off. The first is set at a dissolved oxygen concentration above water quality standards—the goal of this alarm is to notify operators and allow them to

Photos: (Left, Middle, Bottom) Sarah Dexter, (Top) Kendall Karch

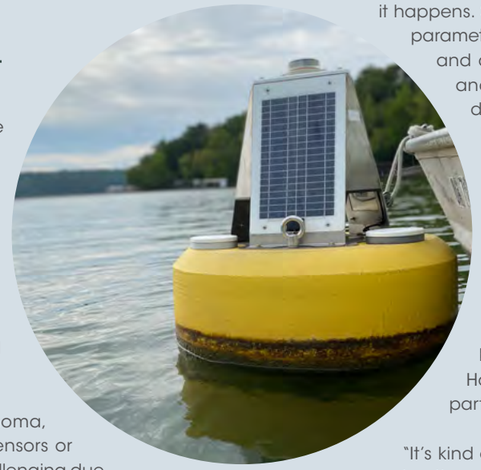
(Left) A NexSens datalogger sits on the open lid of its metal housing attached to Langley Bridge overlooking the Neosho River downstream of Pensacola Dam.
(Top) An OWRB employee measures stream height using a steel tape at Rock Creek in Norman, Oklahoma.
(Middle) An OWRB staff member pulls a multiparameter sonde out of a drag tube attached to Langley Bridge downstream of Pensacola Dam on Grand Lake.
(Bottom) Three multiparameter sondes housed in drag tubes attached to Langley Bridge downstream of Pensacola Dam are a year-round, continuous monitoring and compliance point.

An OWRB employee cleans biofouling from a multiparameter sonde permanently stationed on Langley Bridge downstream of Pensacola Dam.

proactively mitigate levels from dropping below. The second alarm occurs when dissolved oxygen falls below the standards, notifying the OWRB, GRDA and other government agencies that additional water should be released.

The alarms allow the dam operators to respond quickly to low dissolved oxygen levels. "If they're not meeting standards, then alarms get emailed to a whole bunch of people," states Dexter.

LOCAL CHALLENGES TO REAL-TIME MONITORING



The systems located near Norman have been the target of vandalism and theft on a few accounts, with solar panels being stolen or damaged, leading to equipment dying. When equipment stops working as a result of environmental damage or vandalism, Dexter has to go through the arduous process of acquiring replacement parts to ensure minimal data loss.

Since the OWRB works across Oklahoma, having to go out and troubleshoot sensors or other pieces of equipment can be challenging due to the location. The systems sounding out alarms does make identifying the need for troubleshooting easier and saves the team a great deal of time traveling to each location in order to manually collect data.

When designing each system, Dexter had to consider data needs as well as building something that would be able to withstand a challenging environment. For the GRDA project specifically, the buoys needed to be rugged and durable in the face of flood conditions while still being able to gather data.

"We use a lot of equipment from various companies and NexSens' equipment is really sturdy. We've had buoys deployed below the dam, during flood conditions, and the buoys are still there! They make it and it's reliable," states Dexter.

She continues, "[NexSens has] really good technical support. It's nice to be able to call and get someone who can actually help."

An additional two buoys are stationed in the Horse Creek arm of Grand Lake from May to October, when the system experiences lower dissolved oxygen levels. The buoys do more than simply monitor dissolved oxygen, with some being equipped to monitor algal blooms as well.

Dexter explains, "They put the NexSens buoys out there to try and see if they could catch a bloom happening before it happens. So they're looking at all these different parameters and their relationships between pH and dissolved oxygen and the chlorophyll and blue-green readings and trying to determine if they can catch something happening before it gets too bad."

One of the greatest challenges for Dexter and other scientists working for the OWRB is being unable to see the impact of the data they collect. As a non-regulatory agency, Dexter explains that it can be frustrating to collect all of the data and then be unable to act on it immediately. However, being part of the solution and part of the larger initiative is rewarding.

"It's kind of nice to be part of something where maybe there's not always a tangible solution or sometimes you can see it, like, 'Okay, this is the solution to this problem—this is how we fix it.' And sometimes it's a little frustrating, but it's nice to be able to think that what we're doing is part of a process for the greater good and communal use of the data," Dexter clarifies.

"Water is integral to everything," she states. "Being able to help improve the environment in which I'm living, my friends are living, the people of the state are living—it's nice to think that maybe we contribute to that." SB

A NexSens data buoy housing a multiparameter sonde used to help predict and identify algal blooms sits in the Fly Creek arm of Grand Lake in NE, Oklahoma.

Photos: Sarah Dexter

PROTECTING ACADIA'S WATERSHED

Acadia National Park Biological Technician Jake Van Gorder and Acadia Youth Conservation Corps Coordinator Erica Lobel returning from a monitoring visit on Eagle Lake in August 2023. During the monthly visits, park scientists collect water samples that are analyzed for nutrient and chlorophyll *a* concentrations, measure water clarity with a Secchi disk and light sensors, and record water quality (temperature, dissolved oxygen, pH, conductivity) at 1-meter depth intervals through the water column.

Long-term monitoring efforts are key to protecting Acadia National Park's natural resources. Data collected during these visits show how lakes respond to climate change, local land management, and visitor use as well as demonstrate the effectiveness of the Clean Air Act.

(See "Protecting Natural Resources: Long-Term Monitoring in Acadia National Park," Pg. 24)

NexSens XB-200

The XB-200 represents the next generation of data buoy platforms from NexSens Technology. The buoy is self-powered, featuring 28 or 56 A-Hr battery options and three integrated 15-watt solar panels for 45-watts of solar charging that are evenly spaced around the buoy. The design enables quick deployment and is well-suited for a variety of applications in both inland and coastal waters.

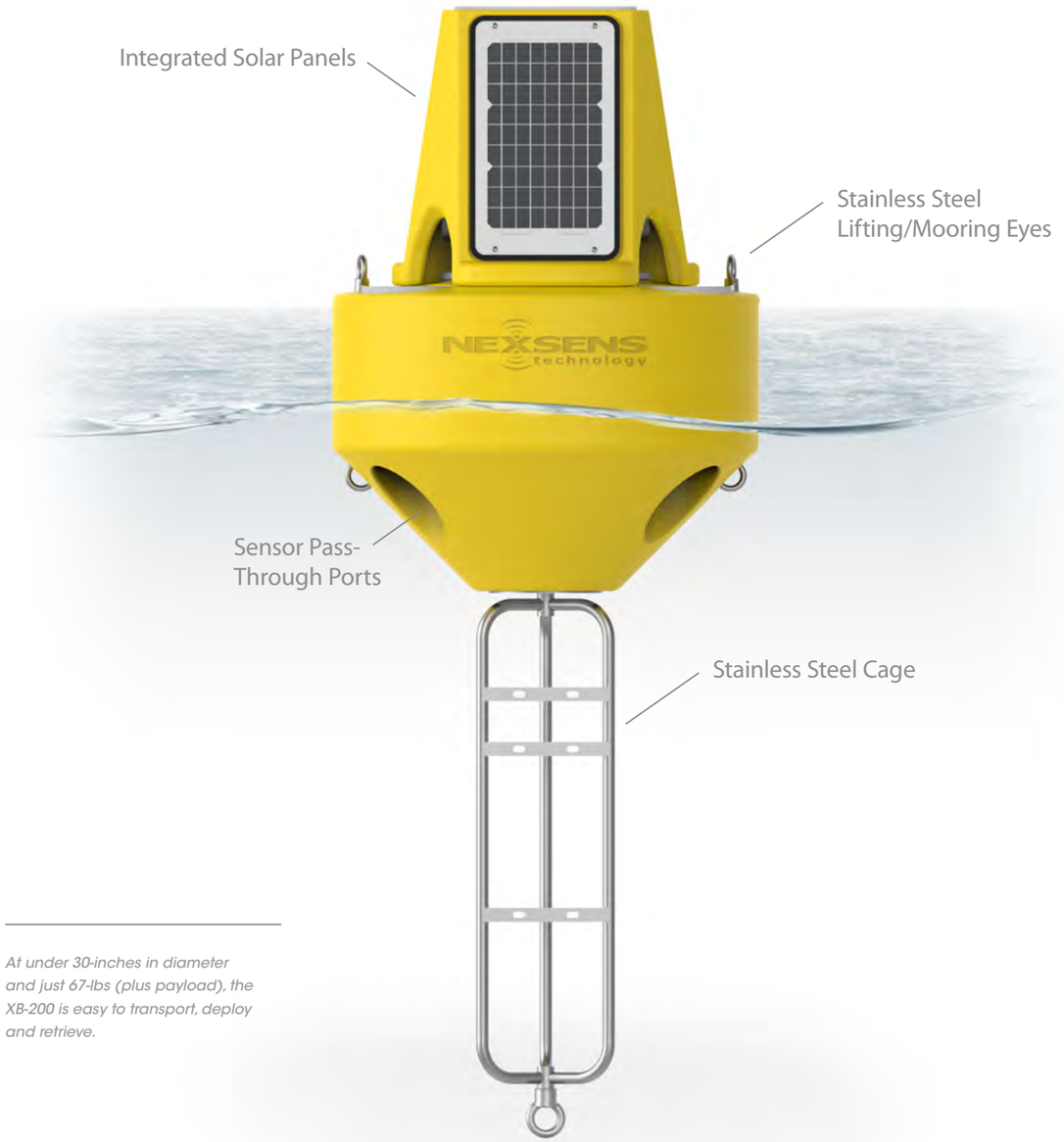
The XB-200 hull is made of UV-stabilized LLDPE plastic and filled with closed-cell polyurethane foam—the combination of which provides a lightweight, rugged monitoring platform. The hull also features three 4" pass-through ports that allow for sensors to be mounted or suspended underwater while securely routing the cable.

The X3 data logger mounts under the solar tower of the XB-200 and allows for remote, real-time data collection. When paired with the X3, communications options include Wi-Fi, 4G LTE cellular, and Iridium satellite.

The XB-200 is a popular choice for limnology research, dredge turbidity monitoring, temperature or dissolved oxygen profiling, fisheries and aquaculture monitoring, harmful algal bloom detection, and oil spill response.

XB-200 Data Buoy Features

- The closed-cell polyurethane foam-filled hull keeps the buoy afloat even if pierced or damaged
- 3rd party data loggers can be integrated and stored within the battery well
- The topside plate supports a solar marine light, weather stations, and other sensors



At under 30-inches in diameter and just 67-lbs (plus payload), the XB-200 is easy to transport, deploy and retrieve.

PROTECTING CHICAGO'S LAKEFRONT

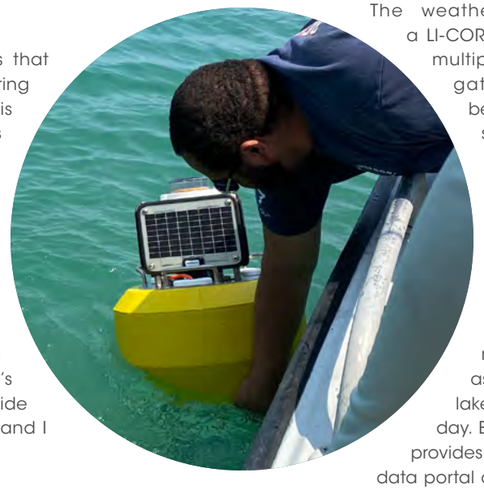
Freshwater Beach Monitoring

Thousands of people flock to the Great Lakes every year to enjoy the freshwater beaches along the coast. As an urban hub with over 2.5 million residents, beachfronts in Chicago have regular visitors as well as tourists that recreate in the bordering Lake Michigan.

According to the Chicago Park District (Park District), it is estimated that more than 100,000 residents and visitors per day use Chicago's lakefront trail during summer weekends.

Proximity to the lake is not only a recreational activity for Chicagoans, but also a part of the city's history due to its role in domestic and international shipping routes. In addition, the Lake serves as a drinking water source and as an essential climate regulator in the region that acts as a natural air conditioning effect.

Monitoring of the beaches ensures that the water is safe for recreating, ensuring that one of the lake's many services is protected. The Chicago Park District is tasked with monitoring the beaches to ensure water quality meets EPA standards and that the public can safely enjoy Chicago's beaches.



Maggie Warren took over as the water quality project manager for the Park District within the past year and was excited for her first beach season this summer. She explains, "It's rewarding to be able to work to provide this resource to Chicago's residents, and I get to enjoy it myself."

MONITORING LAKE MICHIGAN BEACHES IN CHICAGO

The Park District manages 26 miles of open lakefront for the enjoyment of residents and visitors as well as wildlife that flock to the area. A close partnership with the University of Illinois-Chicago (UIC) is a major part of what makes daily sampling possible.

Warren elaborates, "Each beach is tested daily with UIC students sampling the water at sunrise, and then taking the samples to be tested in the lab. We use the quantitative polymerase chain reaction (qPCR) methods. The results are then sent to me within three to four hours. I translate this data using the EPA's water quality recreation criteria and share the information with the public through the Park District's outreach methods."

Fortunately, the beaches aren't impacted by point-source pollution, so daily sampling focuses on finding enterococci bacteria, an indicator bacteria similar to E. coli. High levels of enterococci indicate whether the water is safe to swim in, based on the EPA's standards. Frequent sampling is critical because it allows the Park District to provide real-time information that impacts public health decisions and also facilitates trend spotting.

Additional research projects are also happening along the coast, all of which are compiled in the annual report that provides an analysis of beach conditions. In terms of real-time monitoring, Chicago currently utilizes a select number of weather stations and a data buoy to gather environmental data.

The weather stations are equipped with a LI-COR LI-200R Solar Radiation Sensor and multiparameter weather stations, which gather weather data along the beachfront. Weather data and the daily sampling results help inform beach closures and swimming restrictions whenever necessary for beach-goers' safety.

A CB-25-SVS Wave Buoy monitors conditions away from the shoreline and provides data to boaters, triathlon swimmers, and other recreational users of the lake as well as first responders who need to consider lake conditions before setting out for the day. Equipped with an X2-SDLMC, the buoy provides real-time data to the City of Chicago's data portal and the Chicago Park District website as well as Seagull.

CREATING REDUNDANCIES IN COMMUNICATION

Interpretation of the data is shared in the daily beach report as well as communicated via the Chicago Park District's flag notification system at the beaches. Data is shared via multiple methods, and the goal is to communicate effectively to everyone.

Warren explains, "Having lots of different types of means for communicating is a way for us to mitigate any potential problems that might arise. By having things be digital and also physically posted at the beaches, it makes it so that even if you're just showing up at the beach, you'll be able to be notified." She continues, "It helps to have lots of redundancies in the system just to mitigate anything that might pop up."

"[Our work] is about making sure that people are safe and able to recreate on the beaches with information easily accessible to make the best decisions for their wellbeing."

- Maggie Warren

Photos: Maggie Warren / Chicago Park District

The combination of real-time and spot sampling helps develop a complete view of conditions on the lake, allowing managers like Warren to spot trends and better prepare for the upcoming season. Having a combination of environmental data available also makes it easier to communicate with the public when advisories need to be posted to alert the public.

"[Our work] is about making sure that people are safe and able to recreate on the beaches with information easily accessible to make the best decisions for their wellbeing," says Warren.

This information gathering and sharing wouldn't be possible without the work of UIC students, as well as the real-time ease of the weather stations and data buoy. Together, Warren is given hundreds of data points to analyze during the off-season and dozens to consider throughout the day.

"It's an incredible amount of work to test all of the beaches daily, and it is something that I'm really grateful to work with such a dedicated group of people," explains Warren.

Just like many others living along the Great Lakes, Warren has found herself attached to Lake Michigan, and the work she and the Park District do helps visitors and other Chicagoans find that connection as well.

She explains, "This job has provided a greater understanding for Lake Michigan and appreciation for the Great Lakes ecosystem in general, I feel like I've gotten a much more personal relationship with the lake." SB

(Left) A CB-25-SVS buoy being deployed by rescue boat instructor Marcus Thompson at Ohio Street Beach in Lake Michigan.
(Above) CB-25-SVS buoy with Ohio Street Beach and Lake Shore Drive in the background.

RELIABLE MONITORING SYSTEMS:

HYDROELECTRIC DAM MONITORING IN WESTERN PENNSYLVANIA

Hydroelectric dams are a source of renewable energy, and many have taken the place of fossil fuel reliance across the United States. While they provide green energy to the grid, they also impact the environment above and below the dam.

In order to protect these habitats and mitigate any potential harm, hydroelectric dam operators monitor water quality conditions above and below the dam to ensure conditions meet ecosystem needs. Mahoning Creek Hydroelectric Company has a hydroelectric plant positioned in Pennsylvania managed and monitored by a team of professionals.

One of these managers is Craig Goldinger, a regional manager with Mahoning Creek Hydroelectric Company in Western Pennsylvania. More specifically, Goldinger manages All Dam Five and All Dam Six, which are hydroelectric plants on the Allegheny River, and Mahoning Creek Hydro, which is on Mahoning Dam.

Goldinger started his professional life working at a coal plant, but after the plant was shut down, he applied for a position at the hydro plant. Over the years, he moved up the ranks, eventually taking over as the regional manager. The hydro plant provides a stable field and fulfills a critical role for nearby communities.

"Electricity is a pretty basic necessity for everybody nowadays. Once you have electricity, it's hard to go without. And [. . .] you're providing a service that everybody needs in a stable and safe environment," explains Goldinger.

DAM MONITORING ON MAHONING CREEK

For Mahoning Creek Hydroelectric Company, their primary concern is employee safety, followed by environmental consideration, and finally, providing power to the grid. Environmental obligations include the continuous monitoring of the waters above and below the dam to ensure they are meeting legal requirements.

Limits are established by the U.S. Army Corps of Engineers and change based on the season and needs of the species below the dam. Dissolved oxygen (DO) and temperature are the two most important parameters for them to monitor. Both can have devastating impacts on the cold water fishery below the dam if DO falls too low or the temperature climbs.

A YSI sonde equipped with temperature, DO, and turbidity sensors measure water quality in the reservoir, stilling basin, and downstream of the dam. The sonde is connected to a NexSens data logger, which transfers the gathered data to the cloud, where it is viewable via WQData LIVE.

RELYING ON RELIABLE SYSTEMS

Goldinger spends his day communicating with each plant and checking the live data coming from each monitoring site. Outside of business hours, Goldinger continues to monitor the dams, receiving alerts via WQData LIVE when a parameter is not meeting requirements. The logged data is used to support reports demonstrating that the dam is meeting compliance standards.

He expands on the experience, "I work 24/7, 365 days a year. Whether I'm on vacation or sleeping, we have alarms set up that if anything happens I get woken up in the middle of the night, whether it's a regular alarm or an environmental alert, and then we have to go from there."

In cases where the temperature is too high, the dam must be shut off in order to allow free-flowing water that has not been influenced by the turbines, which can raise the temperature slightly. The U.S. Army Corps of Engineers use a ring jet to raise DO levels, which mixes with the lower levels below the dam, helping them meet compliance.

The hydro plants can only run if they are meeting compliance standards, and if the monitoring systems fail, then the entire plant has to shut down until levels can be restored. Additionally, if the system stops functioning for any reason, the dam has to be shut off due to operators being unable to track if the dam is compliant. Such disruptions can have a significant impact on energy availability.

"[The systems] keep us running. Especially, with the environmental restrictions that we have at Mahoning, they are a very reliable service," states Goldinger.

All of the work put in by workers at the plant hangs in the balance of the real-time systems staying operational. While Western Pennsylvania has seen the closures of many coal plants in recent years, the hydroelectric dam has stayed operational. The reliance on hydropower means a great deal to staff and locals in the region. The hydro plant provides more employment opportunities and a renewable source of power compared to coal.

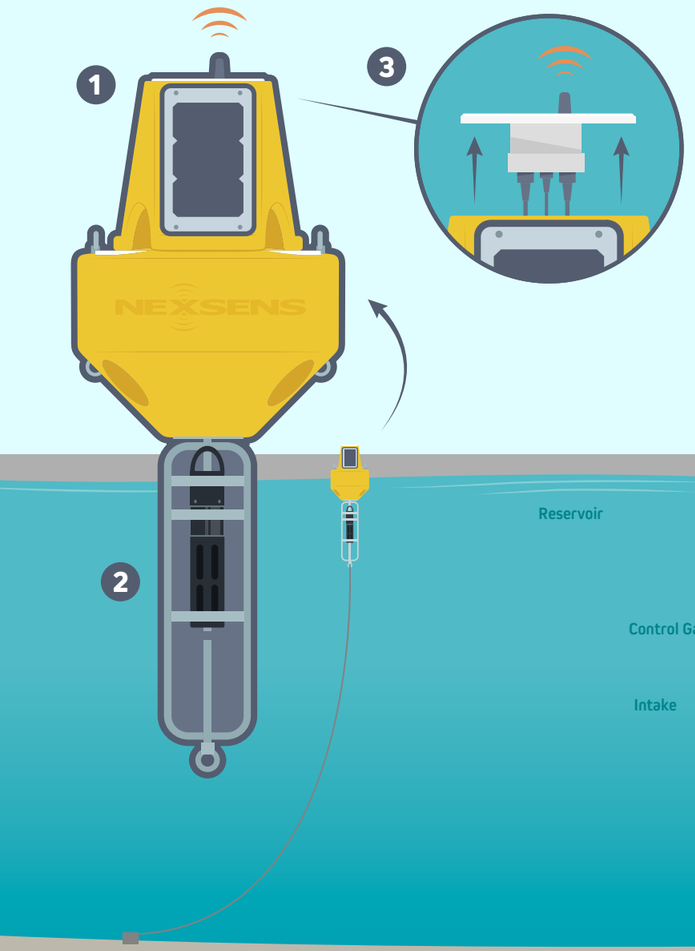
"A big part that is rewarding is that we're still providing electric to the public—clean and renewable energy—which is very important in today's climate." SB

Photos: Craig Goldinger / Mahoning Creek Hydroelectric Company

(Top Left) A NexSens water quality monitoring station located at the dam's stilling basin. (Top Right) Mahoning Dam. (Middle Left) View from the top of the dam. (Middle Right) A NexSens water quality monitoring station positioned at the intake. (Bottom Left) A NexSens water quality station downstream of the dam. (Bottom Right) View of Mahoning Creek Hydroelectric Dam from downstream.

Hydroelectric Dam Monitoring

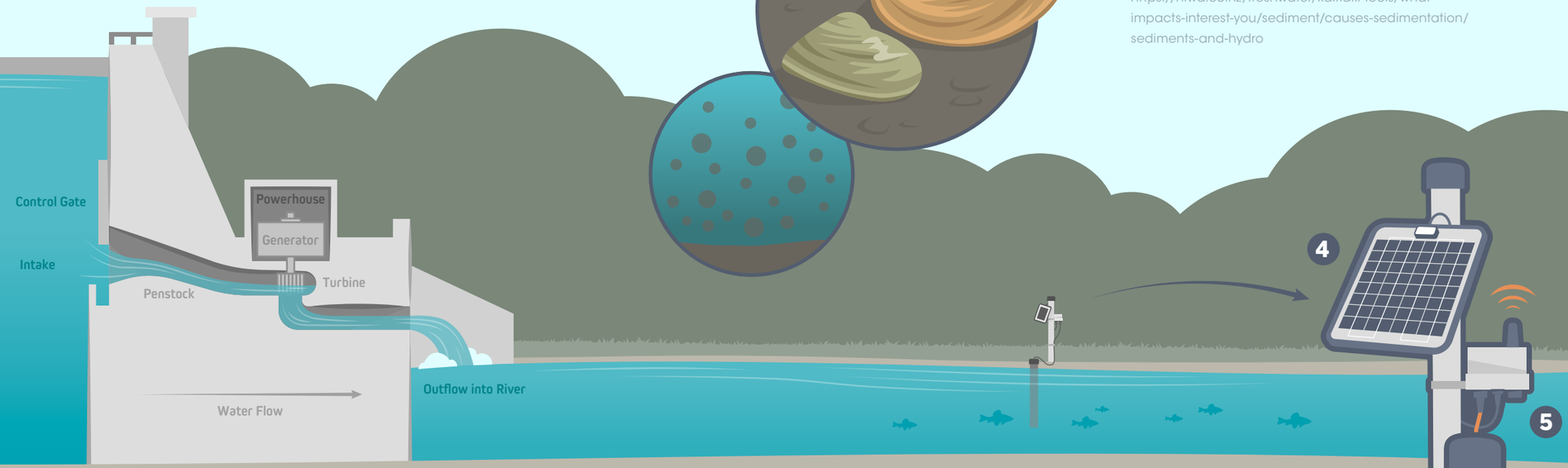
Hydroelectric dams utilize existing water resources and provide renewable energy to surrounding populations, relieving strain on non-renewable energy resources like coal and natural gas. However, environmental monitoring above and below the dam is necessary to ensure native biodiversity is maintained, even as the landscape transforms.



Why Monitor Above the Dam?

The still reservoir above the dam is prone to hypoxia, stratification, sediment build-up, and harmful algal blooms due to the lack of circulating water.

- Monitoring above the dam allows operators to manage water quality in the reservoir by timing water release and treatments.



Why Monitor Below the Dam?

Monitoring conditions below the dam informs operators of when to initiate water release from the reservoir in order to improve water quality in the river.

- The restricted flow of the river can increase the water temperature and limit dissolved oxygen availability, leading to hypoxia in the waterway.
- Sediment-rich water released from the dam could flood the waterway and bury benthic organisms in sediment and contaminants.[c]
- The transport of sediments downstream increases turbidity and decreases water clarity, impacting fish behavior and predation.[c]

Resources

[a] https://www.ferc.gov/what-ferc-does
[b] https://www.nexsens.com/systems/ferc_dissolved_oxygen_monitoring
[c] https://niwa.co.nz/freshwater/kaitiaki-tools/what-impacts-interest-you/sediment/causes-sedimentation/sediments-and-hydro

Reservoir Monitoring System

1. A buoy-based or pole-mount system equipped with water quality sensors and power supply may be deployed above the dam in order to gather real-time data at regular intervals.
2. A YSI EXO3s sonde can be used to measure dissolved oxygen, temperature, and other parameters within the reservoir.
3. A data logger, such as the NexSens X3, can be used to collect sensor measurements and send data to the cloud, allowing for remote data viewing and managers to make informed decisions.

FERC Regulations

In regard to hydroelectric plants, the Federal Energy Regulatory Commission is a regulatory agency that oversees the licensing of these projects.[a]

The licenses often include a list of regulations that dams must follow to continue operating. Requirements vary depending on the needs of the surrounding aquatic system, though some of the most common requirements center on dissolved oxygen and temperature.[b]

Downstream Monitoring System

4. A structurally stable option, such as a pole-mount system, holds a power supply, data logger, and sensors to prevent the system from moving downriver.
5. A data logger, such as the NexSens X3, can be attached to the system to collect sensor measurements downstream from the dam, making it easy to track stream health in real-time.
6. A NexSens NX250 sensor can track dissolved oxygen and water temperature, two important indicators of aquatic ecosystem health.

High Definition Stream Surveys:
Informed Management in Local Waterways

When it comes to environmental monitoring, new stream survey methodologies have revealed a great deal about water quality and streambed conditions over time. Such information can be particularly important in leading restoration initiatives and prioritizing management decisions.

Historically, stream surveys have been conducted at a single point along the stream, with data then extrapolated for miles up and downstream. However, Brett Connell, Hydrologist and Director of Sales at Trutta Environmental Solutions, started developing a more intensive stream survey format in his master's program in 2010 at the University of Tennessee.

Having grown up fishing in Lake Erie and the Maumee River, Connell chose to pursue a career initially in fisheries biology because he loved being outdoors and working in the landscape he was studying.

Jim Parham operating the High Definition Stream Survey backpack on the North Fork Wailua River on Kauai. (Brett Connell / Trutta)

"I remember sitting in a stream during my first internship with the Ohio EPA and said, 'So this could be my office?' And I was like, 'This is awesome!'"

HIGH DEFINITION STREAM SURVEYS

While Connell began developing this new way to collect stream data in college, Trutta's R&D team has spent years transforming it into the High Definition Stream Survey (HDSS) method—an approach to rapidly gather continuous, meter-resolution GIS data in a single pass for a broad range of stream corridor metrics.

By integrating GPS, video, depth, side scan sonar, and water quality sensors, water resource managers now have a continuous baseline condition inventory that reaches as far upstream and downstream from a project as needed. With each second of the video linked to a specific GPS point, data viewers are now able to identify, select, and prioritize areas of the river for multiple different water resource issues.

The results can be used to determine the most economical location and methods for mitigation, monitor restoration results, determine the extent and distribution of instream habitat, define the geomorphic condition for the stream, identify infrastructure impacts, and provide a powerful "virtual tour" experience.

USE OF HDSS IN THE FIELD

Connell manages all of the field projects for Trutta, and as the popularity of HDSS grows, so do the opportunities. One example of this success is an Abandoned Mine Land (AML) project in Hurricane Creek, Alabama, which helped identify impaired water quality conditions, current threats to the aquatic system, and specific areas for restoration.

Over 23 days, 250 continuous miles of Hurricane Creek and its tributaries were surveyed by employees of Trutta Environmental Solutions. Out of the 250 miles, 27 miles were done by kayak and the remaining 223 were by backpack.

While conducting the HDSS, Connell reported finding damage caused by stormwater issues, infrastructure issues, sedimentation from silviculture practices, trash, livestock impacts, perched culverts, and other hazards that were impacting the environment.

(Above) Map of Abandoned Mine Lands in Hurricane Creek, AL, with red dots showing water quality samples of pH between 3.2 and 4. (Jim Parham / Trutta)
(Bottom Left) High Definition Stream Survey motor boat in action on the Upper Delaware River in Pennsylvania. (Brett Connell / Trutta)
(Bottom Right) Close up of the High Definition Stream Survey backpack. (Nate Royce / Trutta)

"There's a lot of restoration being done, but there's not a lot of funding for monitoring. High Definition Stream Surveys serve as a perfect way to show how much impact you're actually having and where..."

– Brett Connell

"We saw all sorts of issues. So, while we were there documenting the abandoned mine land impacts, we saw many other types of impacts in different areas of the watershed," states Connell.

The stream surveys also revealed how the abandoned mine lands impacted the waterway, with certain areas of the creek having pH levels ranging between 3.2 and 4.0—which is considered highly acidic water.

"When we go out there, we document everything—that's the beauty of it. We're not only gathering information for stormwater or only gathering information for the Bank Erosion Hazard Index, we really broaden how much data and how many purposes that data can have for water resources," states Connell.

The data collected can help inform resource managers on how best to target restoration initiatives to meet the needs of the system and the species that reside there. The survey also provides a substantial foundation for conditions before restoration, allowing managers to see how restoration has improved conditions years down the line.

"There's a lot of restoration being done, but there's not a lot of funding for monitoring. High Definition Stream Surveys serve as a perfect way to show how much impact you're actually having and where—and so it prioritizes which types of methods are done and where so that you can spend the least amount of money and get the biggest bang for your buck," explains Connell.

Based on the success of previous projects, HDSS has the potential to shape restoration practices and protect natural resources. An upcoming project on the Wekiva River in Florida is a good example of how these stream surveys can reveal more about a system.

The project's goal is to collect data on submerged aquatic vegetation, specifically conditions that allow eelgrass to flourish. Eelgrass is important to many native Florida species, but it's been disappearing in many of the state's waterways.

"Because there's threatened and endangered species throughout this watershed that—depending on the depth of the water, the velocity of the water, the type of substrate, the type of habitat type—they'll be able to use our data to show where the most optimal habitat for these threatened and endangered species is. Or where's the most degraded habitat that needs to be improved for these species."

Connell believes that HDSS can be applied anywhere and have meaningful impacts. Ultimately, it's about collecting meaningful data in a cost-effective way that allows managers to make informed decisions about natural resource conservation and restoration.

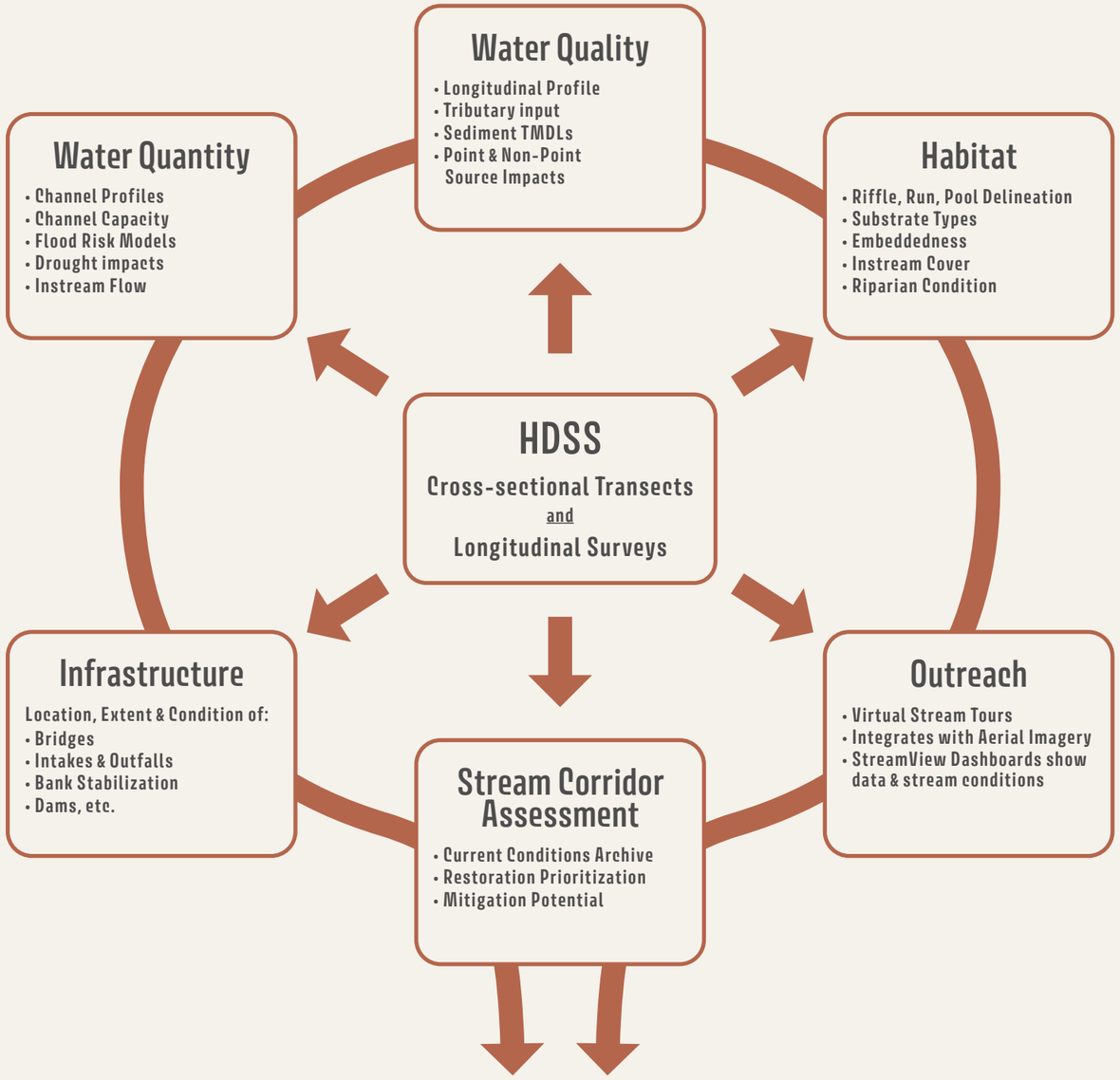
He explains, "In order to make informed management decisions, you need to know what all is going on where. And there's a lot of decisions made on our natural resources with what I believe are incomplete data sets. HDSS provides the most comprehensive, continuous, and valuable data set available." SB

"In order to make informed management decisions, you need to know what all is going on where..."

- Brett Connell

(Right) Trutta employee collecting a water quality sample during the 250 mile Hurricane Creek High Definition Stream Survey. (Brett Connell / Trutta)
(Bottom) Trutta employee waiting for power generation at Harris dam on the Tallapoosa River, AL. (Brett Connell / Trutta)

HDSS Framework



Original Graphic created by Trutta

CURRENT MONITORING AFTER THE FRANCIS SCOTT KEY BRIDGE COLLAPSE

On March 26th, according to The Baltimore Sun, a 984-foot, 112,000-ton Dali lost propulsion and collided with a support column of the Francis Scott Key Bridge, collapsing the structure. Soon after the event, search and rescue, salvage crews, and other emergency responders were mobilized.

As salvage efforts progressed in early April, NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) responded to a request for real-time tidal currents data and deployed a current monitoring buoy—CURBY (Currents Real-time BuoY)—into the Patapsco River north of the Francis Scott Key Bridge.

MONITORING CURRENTS WITH BUOYS

Designed and field tested in 2018, the CURBY is a compact, easily deployable surface buoy created by NOAA to support operational decision-making and planning for scientific coastal research and disaster response.

NOAA's CURBY measures a variety of oceanographic and meteorological parameters, including wind speed and direction, current speeds and direction, relative humidity, barometric pressure, and air and water temperature. For the Francis Scott Key Bridge response, wind and current speeds and directions were particularly vital for federal, state, and local efforts to restore marine navigation in the Patapsco River.

Robert Heitsenrether and Lorraine Heilman, of CO-OPS's Engineering Division, were part of the team that designed, constructed, and tested the CURBY buoy.

Heitsenrether explains, "Tidal current surveys conducted by NOAA's National Current Observation Program, required improved observations of near surface currents and a new surface buoy was the ideal design."

CURBY's first use dates back to 2019, when CO-OPS deployed the nascent system into the Delaware Bay and River in support of NOAA's tidal current survey led by Oceanographer Katie Kirk.

The first CURBY system consisted of a single CB-950 equipped with an Airmar 200WX weather station, Nortek Acoustic Doppler Current Profiler, Hach\Hydromet Sutron data logger, and satellite transmitter. More recent renditions of the CURBY now feature a Gill GMX560 in place of the Airmar, and an In-Situ Aquatroll 200 sensor to measure water conductivity and temperature.

NOAA's field crew, consisting of Katie Kirk, Eddie Roggenstein, Shaena Rausch, and Robert Heitsenrether, conduct final checks on the buoy ahead of its temporary deployment near the collapsed Francis Scott Key Bridge.

Photos: NOAA CO-OPS

Building on the success of the original CURBY, two additional systems were developed in 2021 to support disaster response in the Gulf of Mexico region. After this project, two more CURBY systems were developed for use in NOAA's 2022-2023 Columbia River tidal currents surveys.

Over the same time period, the original CURBY buoy was re-deployed off the coast of Savannah, GA, in order to support NOAA's Savannah River tidal currents survey. Data collected by NOAA's tidal current surveys are used to update the Nation's tidal current predictions in a given region.

"[The Columbia River], in particular, is a sandy bottom river with sand waves that reach 10 to 15 feet in height and regularly sweep through the river's bottom. Many of our typical current sensor deployment setups that we would otherwise use . . . For example, bottom mount sensors were not appropriate for our Columbia River currents survey," elaborates Heilman.

"Having the CURBY, a versatile instrument that I could put anywhere in the river where we needed a measurement, really helped ensure that our currents survey was a success. In total, we were able to deploy, retrieve, and re-deploy two CURBYs a total of six times in the river. Those were six locations that, without the CURBY, we would not have been able to get any measurements," continues Heilman.

MONITORING AFTER THE FRANCIS SCOTT KEY BRIDGE COLLAPSE

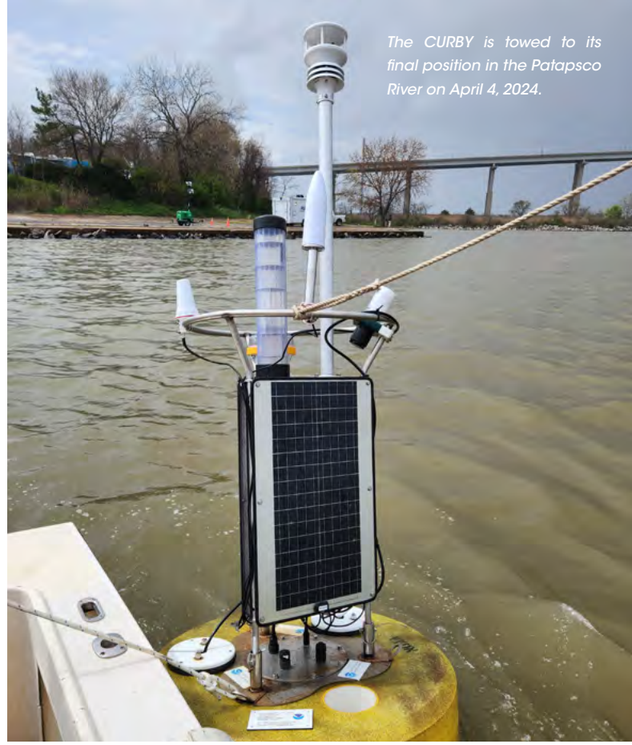
When the Francis Scott Key Bridge collapsed on March 26th, the US Coast Guard and NOAA's Office of Response and Restoration called upon CO-OPS to establish real-time currents and meteorological (e.g., wind, humidity, etc.) observations in the Patapsco River to support multiple recovery and salvage efforts. According to the CO-OPS team working on the deployment, the CURBY buoy was the ideal solution to deliver quick, accurate results.

With an already assembled CURBY system positioned at the CO-OPS Chesapeake, VA field office, NOAA was able to quickly prepare the instrument for deployment and get it deployed in Baltimore only days later.

The current and meteorological data gathered by the system in part support, dive and salvage operations, and also provide navigational support. Already having a designed and tested system to deploy was one of the main reasons CO-OPS was contacted for the project as it allowed for quick deployment.

Because the CURBY needed to be in the water within a matter of days, the CO-OPS team had to expedite a lot of the paperwork and setup, which they could usually spend weeks to months preparing. Permits and environmental compliance documents all had to be completed and approved before the system was deployed.

Deploying the buoy near Baltimore at such short-notice raised a number of logistical issues. Although compact, the CURBY is generally deployed from a vessel with lifting capability. In Baltimore, the team had limited lifting capability to offload, assemble, and prepare the buoy for deployment—making this deployment slightly more challenging than usual.



The CURBY is towed to its final position in the Patapsco River on April 4, 2024.

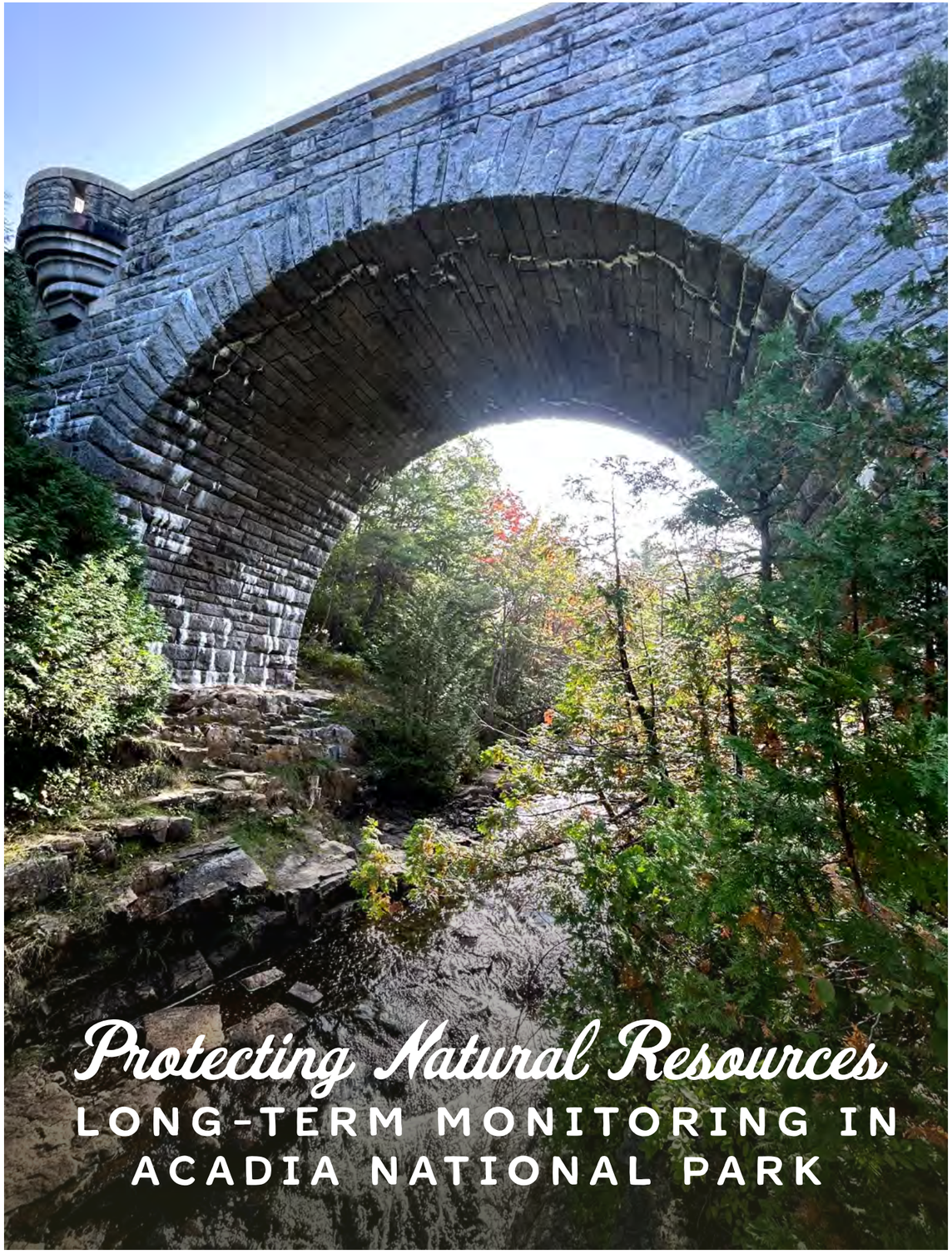
An unfamiliar launch site, boat ramp, and inclement weather conditions also presented a challenge during the buoy's deployment. Ultimately, the deployment was a success, and the CURBY was moored in its current position by NOAA's 25-foot vessel R/V Tornado.

Before the buoy was deployed, there was a great deal of discussion surrounding its ultimate location. This detail can impact how the instrumentation is programmed and the naming of the system in NOAA's database. The goal of this project was to provide real-time data to the public and recovery partners as soon as possible following the buoy's deployment.

Kirk explains, "The buoy changing locations could potentially affect how the current meter was configured, and it could affect the mooring length depending on the total water depth."

Heilman adds, "In order to actually ensure functional real-time data, we were changing a lot of parameters on the fly as the buoy was being installed. Those of us back on land also played our part in making sure the buoy was operational, and specifically making sure there was real-time data coming through."

While long-term datasets can inform and shape our current understanding of waterways, real-time monitoring can provide data critical for more short-term emergency applications as well. NOAA's CURBY buoy will remain deployed at the Francis Scott Key Bridge site while cleanup and recovery continue. SB



Protecting Natural Resources

LONG-TERM MONITORING IN ACADIA NATIONAL PARK

The United States' national parks are visited by millions of people each year, providing opportunities to experience the local beauty of the US. A core mission of the National Park Service (NPS) is to protect and preserve these unique areas since they are not totally free of pollution and the influence of climate change.

As such, national parks are the site of many environmental monitoring programs designed to assess the effects of global stressors like climate change and pollution on park resources. Acadia National Park's water and air monitoring programs are examples of this, providing a long-term data history documenting changes in air and water quality over the past four decades.

Bill Gawley, a biologist at Acadia National Park for the past 30 years, manages the park's air and water resource programs. Over his time at the park, Gawley has seen the program develop over the years, becoming more comprehensive as time goes on.

ACADIA NATIONAL PARK MONITORING EFFORTS

Acadia was created with the intention of preserving and protecting the region's natural and cultural resources. The scenic mountains, near-pristine water resources, and good air quality of Acadia are also major drivers of tourism to the national park, making protecting these resources important.

Gawley explains this responsibility, "As federal land managers, that's why we're here—to both protect the resources and also keep them accessible for the public to enjoy." He continues, "We have long-standing monitoring programs for both air and water resources that help us track our progress."

Thanks to this long-term pool of data, scientists at the national park have been able to detect the subtle changes the resources have undergone as a result of climate change and pollution, as well as how environmental policies have impacted the pollution influencing the park.

In addition to climate change, one of the most significant stressors to water resources, according to Gawley, is air pollution, particularly acid deposition in the form of acidic rain, snow, and fog. Acadia monitors both air and water conditions in order to understand how changing conditions shape the park.

Gawley expands, "We're lucky that we can monitor the stressors, like precipitation pH at our air monitoring station as well as the water quality of park lakes and streams—so we can assess both the level of pollution that's coming in, and also the effect that it is having on the water. Studies conducted in a lot of other places don't have the luxury of being able to collect both those datasets in the same location."

The NPS Air Resources Division has established a comprehensive air quality monitoring strategy across the national park system to determine the influence of air quality on human health, ecological systems, and visitor experience. Levels of four general pollutant types are tracked at Acadia's air monitoring station through participation in several national air quality monitoring programs.

Photos: (Left) Kathleen Brown / NPS; (Right) Judy Hazen Connery / NPS

Gaseous pollutants like ozone are present in both remote and urban areas and can have harmful effects on both human and ecosystem health. Ozone and its precursor gases are continuously monitored at Acadia in collaboration with the Maine Department of Environmental Protection (MDEP), who use the data to track compliance with national air quality standards and provide forecasts and advisories when ozone reaches unhealthy levels.

Atmospheric deposition is measured by analyzing weekly precipitation samples for concentrations of acidic compounds and mercury, both of which can affect terrestrial and aquatic systems and their inhabitants. Particles in the air affect human respiratory health and degrade visibility. Collaborative particulate monitoring with MDEP provides information on both issues.

"The MDEP monitors levels of fine particles affecting human health, and issues forecasts and advisories similar to those provided for ozone. The Park Service is especially interested in understanding the effects of particulate levels on visibility because over 3 million people come to the park every year wanting to be able to clearly see all these spectacular views and resources," states Gawley.

(Left) Duck Brook flows beneath the historic Duck Brook Carriage Road Bridge, one of 17 stone-faced bridges on the carriage road system financed by John D. Rockefeller Jr. Each bridge is unique in design, spanning streams, waterfalls, roads, and cliff sides.
(Right) Acadia NP Resource Management Lead Rebecca Cole-Will and Air-Water Program Manager Bill Gawley prepare to install the NexSens SDL500 datalogger in the Jordan Pond high-resolution monitoring buoy.

MULTIFACETED MONITORING

In addition to the year-round, continuous air quality monitoring occurring in the park, Gawley coordinates and implements water quality and quantity monitoring in Acadia's lakes and streams.

Eleven lakes and eleven streams are monitored monthly from May through October using protocols developed by the Northeast Temperate Network (NETN), one of the 32 networks in the NPS Inventory and Monitoring Program. Additionally, a high-resolution monitoring buoy has been deployed for the past ten years in Jordan Pond, one of Acadia's most iconic aquatic resources.

As the primary author of NETN's water monitoring protocol, Gawley spends part of his time working to support monitoring efforts at eight other parks—located from New Jersey to Vermont— in the NETN. Locally, Gawley works closely with those who live and work on the surrounding lands to understand and protect Acadia's water resources.

Gawley explains, "Acadia is a very fragmented park—it's not just one contiguous area. There are a lot of private inholdings because it was largely established through donated land. It's kind of a mosaic, in some ways, of private and federally owned land. There's a lot of stakeholders and there's a lot of neighbors."

Six lakes in the park are sources of municipal drinking water for nearby communities, and their water quality is considered to be so pristine that the municipal water companies have been granted filtration waivers by the U. S. Environmental Protection Agency (EPA). These lakes require enhanced stewardship and protection, and park efforts, in tandem with those of the water companies, have been very effective toward achieving that goal.

The park has many trails, carriage roads, boat launch ramps, and other infrastructure that border water resources, and park staff and contractors performing maintenance and construction activities must exercise caution to avoid unintended impacts.

"We've got a responsibility to take care of our own backyard and to look after our neighbors. So we work carefully in the planning of construction and rehabilitation projects to make sure that best management practices are followed to protect the resources and often employ monitoring plans to measure their effectiveness," elaborates Gawley.

Acadia has been monitoring its air and water resources for decades—gathering data that has supported research focusing on the influence of climate change and other environmental stressors on relatively isolated water bodies that are less affected by residential development and other high-impact adjacent land uses.

"The long baseline data history is very attractive for people that already recognize the trends of some of our water quality parameters, and they want to focus on a very specific research question. We encourage and facilitate a lot of that research, and it, in turn, helps us solve a lot of our park management problems," states Gawley.

Upper Hadlock Pond in Acadia National Park.

Photos: Kathleen Brown / NPS

(Top) Acadia National Park's Eagle Lake after first snowfall of the season. (Bottom) Acadia NP Biological Technician Jake Van Gorder collects a water quality data profile using a YSI EXO1 sonde during a monthly lake monitoring visit.

ENVIRONMENTAL CONCERNS IN ACADIA NATIONAL PARK

Since the 1980s, most of Acadia's lakes have experienced declines in water transparency, and a looming threat of harmful algal blooms occurring elsewhere in the region has made resource managers wary. Most of the transparency changes have been attributed to increases in dissolved organic carbon in the water, which can cause the browning of the water and reduce transparency.

Virtually all of Acadia's historic water quality data were collected during monthly, or in some cases annual monitoring events, providing only "snapshots" of conditions during those specific visits.

Park resource managers and cooperating researchers were eager for higher resolution data to fill in the gaps on the range of variability between the discrete monitoring visits and how water quality responded to storms and other high-intensity, episodic events. By 2013, planning was underway for the deployment of a buoy system to support continuous lake water monitoring.

Jordan Pond was chosen as the monitoring site due to its exceptional clarity and relatively low algal productivity. The low-ionic strength water allowed the detection of trace levels of chemical constituents and small incremental changes. Jordan Pond is also the deepest lake in the park, providing good spatial data for lake stratification studies.

"We thought, with Jordan Pond being such a clear lake and being able to detect such small changes, that it would be good to really look at the daily cycling of dissolved organic matter in the lake," Gawley expands.

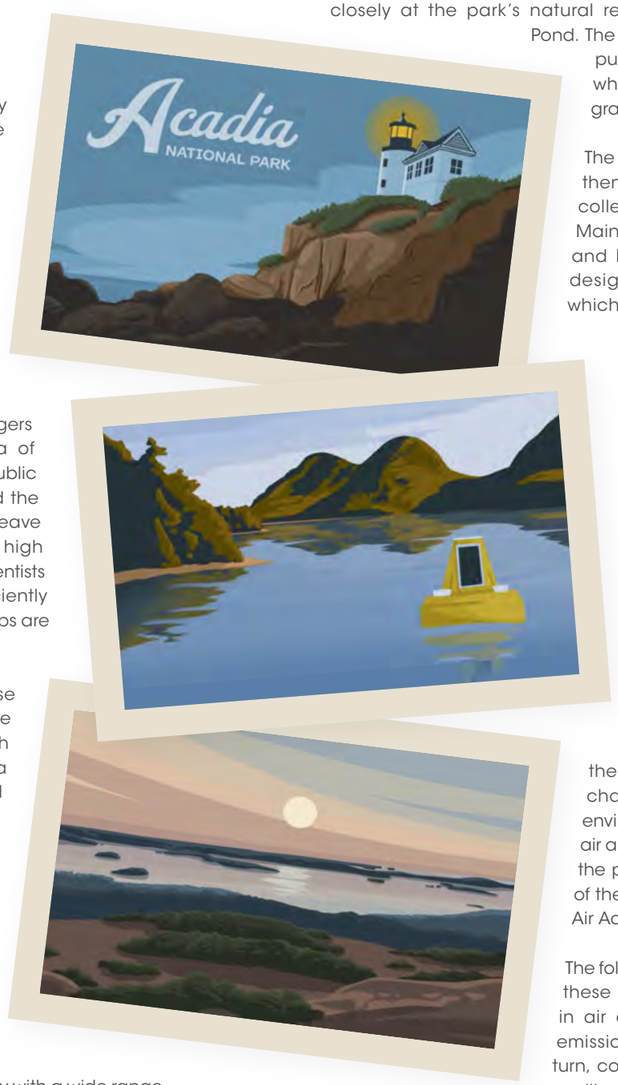
In order to monitor the conditions connected to browning and other water quality changes, a NexSens data buoy equipped with a YSI EXO2 sonde is deployed on the lake. The sonde monitors fluorescent dissolved organic matter as a surrogate for dissolved organic carbon, dissolved oxygen, temperature, specific conductance, pH, and total algae (chlorophyll *a* and phycocyanin).

Data from the buoy sensors are transmitted by radio signal to a base station at the Jordan Pond House, a park concession restaurant at the south end of the lake. The base station also receives data from a weather station located on the restaurant roof, which helps tie various meteorological events to changes in the lake. The combined sensors help link the cause and effect of changes in lake conditions, including algal productivity—something that Gawley explains to be of growing concern.

He elaborates, "We've been pretty isolated from having harmful algal blooms (HABs) this far north in Maine, but in the past several years they seem to be occurring a little more frequently, and in lakes that have been considered less susceptible to them." He continues, "We're a little concerned that this might be an issue that we're going to have to deal with more in the near future."

A MONITORING PROGRAM SPONSORED BY FRIENDS

Acadia is one of the most highly visited national parks, and the high traffic introduces unique challenges and opportunities to the staff there. While many park resources are isolated from a lot of manmade influences, the park relies heavily on the stewardship of visitors and local residents to help keep the park and its resources pristine.



The high visitation presents rangers and scientists with a plethora of opportunities to educate the public about the park's resources and the importance of practices like "Leave No Trace." At the same time, high traffic can make it difficult for scientists to reach the resources to efficiently monitor the lake when boat ramps are blocked or parking lots are full.

Still, Gawley explains that these complications allow for more opportunities to connect with the public, saying, "We get a chance to provide some good outreach and messaging while we're questioned by visitors as we're preparing to head out for a monitoring trip. It often takes a few extra minutes of our time, but it's all for good results."

While the park has a long history of conducting their own monitoring activities, the key to the program's success is through working collaboratively with a wide range of local, state, and federal groups and academic institutions.

Gawley summarizes, "There are an awful lot of people looking for the same answers we are, and we're far more effective when we work together—we're all on the same team."

Friends of Acadia has been a key partner in sponsoring the development of the Jordan Pond monitoring system and the upkeep of the natural resources.

Gawley elaborates, "Friends of Acadia has a long history of fundraising and advocacy efforts for us, and they've contributed millions of dollars over the years to different park projects like carriage road restoration, trail restoration, and the Island Explorer bus system."

The group also began the "Wild Acadia" initiative to look more closely at the park's natural resources, including Jordan Pond. The initial proposal included the purchase of the NexSens buoy, which was paid in part by a grant from Canon, USA.

The team of scientists at Acadia then relied on the expertise of colleagues at the University of Maine Climate Change Institute and NexSens engineers to help design and deploy the buoy, which has been gathering data for almost a decade.

"We've been able to get a good, steady data capture. And we've been fortunate enough to start to see what's happening in those time spans in between our monitoring visits and get a better idea of the really subtle changes that are happening in the lake," states Gawley.

The long-term monitoring programs in Acadia also allow researchers within and outside of the park to assess how policy changes have influenced the environment. For example, many air and water monitoring efforts in the park began around the time of the establishment of the Clean Air Act (CAA).

The following decades of data from these efforts show improvements in air quality resulting from CAA emission reductions that have, in turn, contributed to improved water quality.

Those observations reveal just how impactful the legislation has been—Gawley explains, "It's a good story to tell, and it provides a little bit of hope for the future. We're in an era when there's not always a lot of good news being communicated." SB

Illustration: Emma Jones / Fondriest Environmental

Porters must carry the ice cores down from the drill site after the drilling is finished. (Photo Credit: Lonnie Thompson)

Collecting Data at the Top of the World

HOW SCIENTISTS RETRIEVE GLACIAL ICE CORES

A helicopter touches down in the small town of Sicuani, Peru, at an elevation of 11,644 feet. Earlier that day, a boxcar brought fuel, drills, food, and other equipment for a glacial expedition. The year is 1979, and glaciologist Lonnie Thompson is preparing to lead a team to the Quelccaya ice cap in hopes of becoming the first scientists to drill an ice core sample from this glacier.

The only problem? The glacier is located at 19,000 feet in one of the most remote areas of the world. The helicopter takes off from the town, but the thin atmosphere at that elevation does not allow it to safely touch down on the ice–due to the aircraft's weight, and it becomes unstable when the air is less dense. With six tons of equipment needing to be transported and nothing but the backs of scientists to transport it, Thompson is forced to call off the expedition.

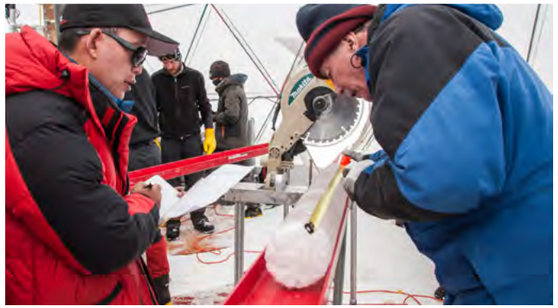
With limited funding, little support from other scientists, and uncertainty about the equipment needed to retrieve the ice cores, the prospect of drilling in this part of the world looked grim. However, four years later, Thompson again found himself on the Quelccaya ice cap, this time with a lightweight, solar-powered drill, having retrieved the first-ever ice cores from a tropical glacier.

EXPANDING THE FRONTIERS OF GLACIOLOGY

Up until the late 1970s, all of the focus on glacial research took place in the polar regions, primarily in Greenland and Antarctica. The relative ease of access and geographic locations made these glaciers an obvious choice to look into Earth's history. Yet, being located at the extreme latitudinal ends of the planet meant these glaciers did not capture the entire picture.

However, glaciers in tropical and subtropical regions provided an opportunity to peer into the past of Earth's climate to a much greater extent. Different factors impacting glaciers in those regions, such as El Niños and monsoons, would provide new insight into glacial movement and the past climate of those regions. Knowing that there was a host of discoveries to be made, Thompson became inspired to push the boundaries of his scientific expeditions.

Thompson and his team developed and used the first solar-powered ice-core drill on top of the Quelccaya Glacier in Peru 1983. (Right) Thompson (right) and a colleague processing an ice core from the Guliya ice cap in the Western Kunlun Mountains, Tibet.



"It was important to understand both natural variability, what causes climate change in those regions, but then also the human-caused climate changes that are impacting the lives of people living in those regions now," says Thompson, who is now a distinguished university professor and scholar at Ohio State University (OSU). "How do they behave? How do they behave relative to polar glaciers? More focused on glaciological questions."

After the initial setback in 1979 to reaching the Quelccaya ice cap, Thompson and his team at OSU took it upon themselves to improve the equipment needed to gather data at these altitudes. To reduce the need for heavy generators and fuel, they installed solar panels on the drills, hoping to eliminate the excess weight. During this time, solar power was still a new concept, but tests on top of an OSU campus parking garage showed that solar generated enough power to drill through ice.

Despite questions about the reliability of solar panels in the early 1980s, they proved capable enough–and light enough–to open up a new frontier in glacial research. Thompson and his team could now expand their research to glaciers around the world that had previously been untouched by science.

Since the first ascent in Peru, Thompson has gone on expeditions to China, Russia, Tanzania, Italy, Bolivia, and Indonesia, all in the pursuit of understanding how the global climate changes.

"To me, what makes these records so unique is the fact that ice cores are probably–no, they are, the best recorders of our past," Thompson says.

LOGISTICAL CHALLENGES IN GLACIAL EXPEDITIONS AND COLLECTING ICE CORES

Despite the advances in technology that made tropical glacial expeditions possible, traveling to some of the most remote areas on the planet to gather scientific data still poses a myriad of logistical challenges. However, the challenges associated with drilling and transporting ice cores have not stopped Thompson and his team from gathering information from glaciers around the world.

"Every mountain is a challenge. And you look at it and you have to figure out, 'okay, how can you accomplish this?" says Thompson.

From using sherpas and local people to help carry the equipment up mountains to loading ice core samples on the back of yaks guided by Tibetan whistlers in the Himalayas, innovation was key in ensuring that the samples would be transported safely from many different parts of the world. Thompson often had to work closely with locals and the government where he was drilling to ensure that the cumbersome but delicate ice cores remained intact.

Nearly all of the ice cores Thompson has drilled end up back on the OSU campus. Therefore, the process of preserving and transporting the ice cores is always one of the early problems that must be addressed.

Photos: Lonnie Thompson

While the mountaintops were cold enough for ice, the surrounding areas would melt the ice. The cores had to be inserted into temperature-controlled boxes, which were then carefully transported down the mountains.

Almost immediately after descending the mountain, a freezer needed to be found for the samples until they were transported to a freezer truck and a city where aircraft could be arranged to fly the frozen cores back to the United States. In total, the process of drilling, storing, and transporting frozen ice cores until they arrive back at OSU could take weeks or months.

"The logistics, they never go like you thought it would," begins Thompson. "So you have to have a good team of people so you can innovate when a problem arises so that you can preserve the core and still get the core back in good shape for analysis. Yeah, it's a process."

WHAT ICE CORES TELL SCIENTISTS

The challenges in gathering ice cores from tropical glaciers are huge, but what Thompson was learning about the climate system from his expeditions is what drove him to keep going back. Ice cores give a tremendous history of Earth's climate as they capture information such as temperature, gases, particulate matter, and more that was in the atmosphere through time.

Ice cores are composed of layers, representing the yearly snowfall that is compacted and layered on top of each other as the glacier grows. These layers contain dust particles, chemical aerosols, microbes, isotopes, volcanic ash, black carbon from fires, and pollen. Thompson explains that these particles are often visible in the ice cores and can tell scientists when volcanoes erupted, among other natural phenomena.

Moreover, according to NASA, tiny bubbles of air get trapped as the ice compacts, acting as "tiny bubbles of the atmosphere." Measuring the chemical makeup of these air bubbles reveals what concentration of these gases was in our atmosphere thousands of years ago. Using these methods, scientists can understand how levels of certain gases, such as greenhouse gases, have changed over time.

Thompson was the first scientist to collect ice cores from the tropics to analyze Earth's past atmosphere. As he analyzed this data and the isotopic composition of the ice early on, Thompson became one of the first scientists to raise alarm about human-caused climate change. The increased levels of greenhouse gases in the ice from the past century far exceeded the natural variations he observed over the previous thousands of years.

"And so you can really see how big an impact humans are having today, relative to the natural history of this planet. So they're just wonderful recorders, wherever it is cold enough to preserve an undisturbed record," Thompson says.

The initial purpose of his expeditions was to learn how tropical glaciers behaved compared to polar glaciers, but repeated expeditions over decades revealed more about the changes happening to Earth's climate. Having visited the Quelcayya ice cap many times in his career, he was able to photographically capture the melting of glaciers and used the data gathered from ice core analysis to show that Earth's current warming is outside of natural variability.

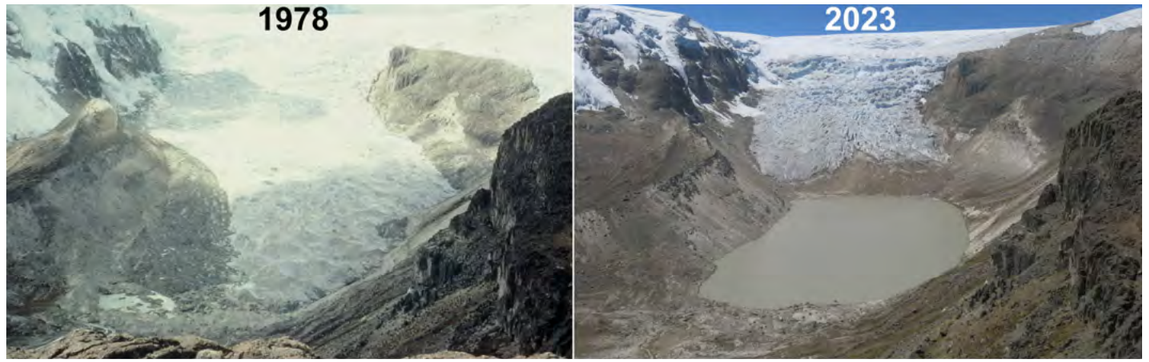
"Another part of the story, which we realized later on, is that they're disappearing," says Thomson. "Glacial records are not going to be there in the future."

Ice cores show atmospheric trends that go back hundreds of thousands of years, and comparing those to current records allows scientists to gauge how humans have impacted Earth's natural cycles. Despite the nature of his discoveries being entrenched in politics and skepticism at times, Thompson knows that the glaciers don't lie.

"If you stick with the data, and you go with the data–in the end, you win," says Thompson. "This is about science, geology, physics and chemistry. It doesn't care what you think, or anyone else thinks." SN

The retreat of the Qori Kalis Glacier is documented in photos taken in the exact spot 45 years apart.

Qori Kalis Glacier, Peru



45 Years Later

COMBATING WATER INSECURITY IN SASKATCHEWAN WITH REAL-TIME DATA

"The technology we use and research we do, is immediately used and usable, which is a rare gift for a researcher."

- Helen Baulch

The prairies of Saskatchewan can be described as one of the least water-secure parts of Canada, making water quality monitoring essential for informed resource management in a region already facing water insecurity. While natural physical properties worsen some of the poor water quality conditions in the region, others are connected to land use.

Having grown up spending summers on the shores of Lake Huron, Helen Baulch, professor at the School of Environment and Sustainability at the University of Saskatchewan, has always been dedicated to the protection of water resources.

Looking back fondly at her childhood playing along the shore, Baulch also recalls the invasion of quagga mussels during her teenage years and watching the lake change as a result. Baulch focused on ecological studies and limnology, where she gained experience working with lakes.

"I was really lucky to have a lot of exposure to limnology as a discipline early on," explains Baulch. Now a professor working on water quality, she notes, "The technology we use and research we do, is immediately used and usable, which is a rare gift for a researcher."

USING DATA TO INFORM TREATMENT PLANTS AND COMBAT WATER INSECURITY IN SASKATCHEWAN

With real-time monitoring systems in place, water treatment operators can better respond to changing conditions, and resource managers can also better understand conditions in the target water body. Much of Baulch's work focuses on Buffalo Pound Lake and how to use environmental data to support water treatment in a lake that has issues of blooms and elevated organic carbon.

Baulch expands, saying, "We can safely treat that water. A key goal is understanding changes in source water quality, and adapting to those changes." She adds, "I really enjoy trying to move into the solution space on water quality issues. We work to identify the most effective changes we can make in land and water management. That means thinking about water treatment, but also about managing flows and agricultural nutrient management specific to this region."

Baulch splits her time between teaching classes, conducting research, and communicating findings with the government and water treatment facilities. The schedule is demanding, but each element is essential—including communicating with stakeholders to improve water quality.

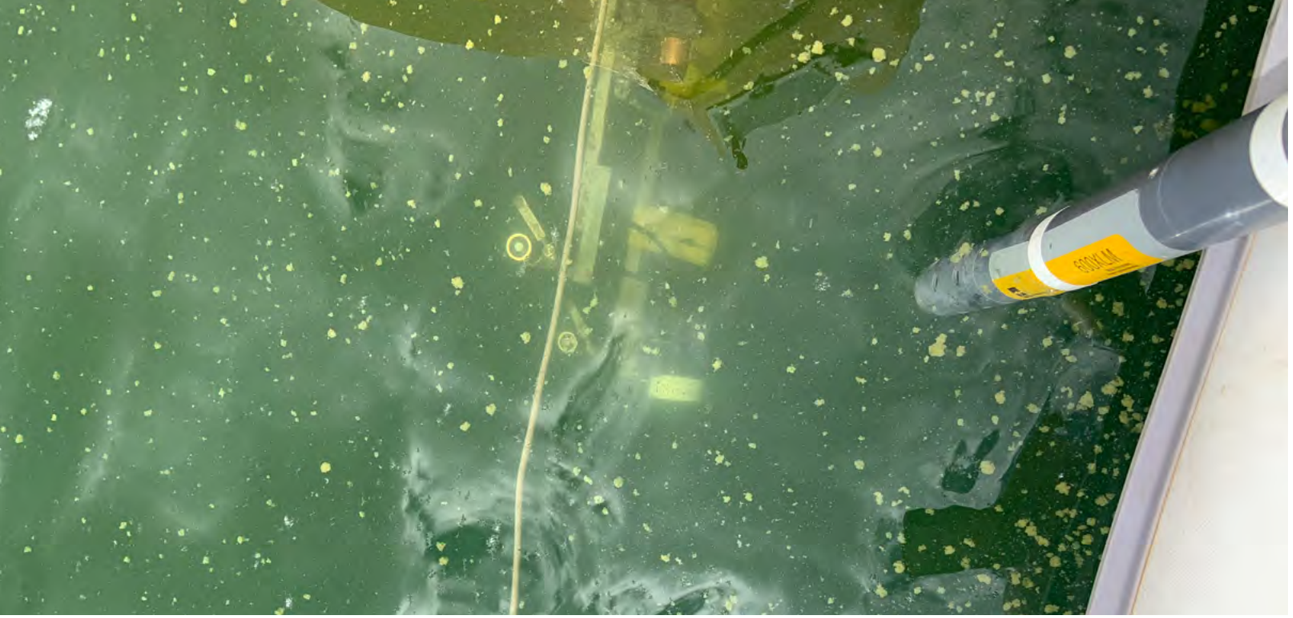
Photos: Katy Nugent / Global Institute for Water Security

"Working to advance water quality really involves a lot of dialogue and outreach, which can be politically sensitive, and also can be hard to squeeze into a busy schedule, though I try to make it a priority," states Baulch.

While water quality issues are common in Saskatchewan, much like they are in many other parts of the world, there is a benefit to capacity building between researchers and institutions. According to Baulch, the most immediate use of the data collected is by the treatment plant, supporting the use of Buffalo Pound Lake as a water supply for two cities.

She explains, "There are dozens of other water utilities in the region that have similar issues, and there just isn't capacity to have scientists at each location to help. So that's a deeper question I have about how we increase our capacity to build this type of partnership elsewhere."

(Above) Buffalo Pound Lake scum.
(Right) A close-up view of the monitoring equipment attached to Superbuoy on a foggy day.



One example of this partnership is the Global Water Futures Observatories (GWFO), of which Buffalo Pound Lake is a station. Operated under the Canada Foundation for Innovation and its Major Sciences Initiative sponsorship, 64 instrumented river basins, lakes, streams, and wetlands, 15 deployable measurement systems, and 18 water laboratories all gather data and contribute to a larger network of data.

BUFFALO POUND LAKE

Buffalo Pound Lake is very shallow and, therefore, stratifies periodically. Combined with high nutrient loads and organic carbon, this can create challenges for water treatment. To work around this, Baulch explains that monitoring with real-time data can give operators data when they need it.

Working with managers also helps researchers better understand the lake. Baulch elaborates, "Some key eureka moments have come from talking with the plant about the lake, the data, and issues they were having."

For Buffalo Pound Lake, new insights about the seasonality of buoyant cyanobacteria and impacts of thermal stratification have come from these two-way conversations, with immediate benefits to water treatment.

Researching and understanding the physical and chemical properties of the lake has helped manage both cyanobacteria and disinfectant byproducts associated with dissolved organic matter. Since Buffalo Pound Lake is a reservoir, monitoring the lake can also help inform flow management, particularly when considering water quality.

Baulch begins, "The balance between flow from upstream reservoir versus the local catchment has an impact on water quality. We're trying to understand that more deeply, and hopefully help lake managers start to integrate water quality in their decision making around flows."

"That's a really tricky one. Because like all reservoirs, there are a lot of objectives associated with its management. We're in very early days of dialogue with government on what we see in terms of the analysis we've done so far, and what might be helpful for water treatment," she continues.

THE CONVENIENCE OF REAL-TIME SYSTEMS

The systems deployed on Buffalo Pound Lake have changed the way the treatment plant treats water, particularly in cases of poor water quality. A total of four systems are used to support open water and under-ice deployments, collecting data at ten-minute intervals.

The summer buoys, a CB-950 affectionately named Superbuoy and an older MB-200 named Big Buoy, monitor conditions, focusing particularly on algal blooms. Temperature sensors have been some of the most important sensors for water treatment plants, and they are key to diagnosing stratification. While stratification is often brief in the lake, multi-day, extreme events have occurred that require changes in treatment plant operations.

The buoys are also equipped with YSI sensors, where phycocyanin, turbidity, pH, and oxygen measurements lend important scientific and operational insights. The buoys are also equipped with three LI-COR light sensors, a LI-190 placed above the water and two LI-192 deployed under the water to measure light attenuation. All of the sensors help Baulch and her colleagues understand drivers and impacts of ecological change in this dynamic system.

Exciting new technology on their new Superbuoy includes a CO_2 sensor and a camera system, which has helped observe scums and understand drivers of buoyant cyanobacteria, which have been a concern to the water treatment plant.

Photos: Katy Nugent / Global Institute for Water Security

Data is recorded and streamed live, updating as often as every hour, creating a fundamental tool used by both researchers and water treatment plant partners to assist in the early detection of reservoir changes, which supports adaptation of the treatment processes.

While the status of the lake as a water intake source has protected it from vandalism thus far, some environmental factors make monitoring the lake year-round difficult. Buffalo Pound Lake is also very productive, so biofouling can easily affect sensors, although wipers and frequent maintenance ensure good-quality data in summer when algal biomass is high.

In winter, ice conditions could destroy a buoy hull, so they shift to under-ice installations, deploying sensors about 1.5m below the ice—to keep the equipment safely below the thick accumulations of ice that can occur.

Investment from the water treatment plant that relies on the data has helped support these sensor-based monitoring efforts in Buffalo Pound Lake, as has the scientific and logistical support of the government and research funding.

Because the lake is shallow and always mixing, changes in water quality can be sudden and dynamic. The continuous stream of data supplied by the buoys helps connect data points between less frequent sampling as well as the state of the lake leading up to, during, and after algal blooms.

The data collected by the systems is pushed to the WQData LIVE web portal, which allows Baulch to view real-time lake conditions from the comfort of her office. Immediate data availability has shaped how resource and plant managers operate.

Baulch explains, "You just have the pulse of the lake when the buoys are active. You sit down at your desk before you check your email and can look at the oxygen curves from the last day and it's just interesting to get to know the lake to that level and see 'Oh, it's cloudy today'—or even the impacts of smoke on light and seeing that coming through in the oxygen curves."

Beyond the science, she emphasizes, "The operators also know when they need to change their decisions–so that provides an immediate benefit to the streamed data."

The convenience of the systems also makes data collection easy when time is a limited resource and conditions may be unsafe for research teams. According to Baulch, the durability and reliability of the buoys, particularly in source water monitoring and water treatment applications, have been game-changing due to WQData LIVE's alarm system and the ability to troubleshoot while staying online.

One thing that has stayed the same over the years has been the investment from the industry and other stakeholders. Baulch elaborates, "I really enjoy working with a really diverse team, who are all interested in issues of water security and sustainability. It's rewarding to contribute to things we need to work on for water security: training people, teaching, and working on solutions and adaptations to the issues we're facing." SB

(Left Page) YSI (6-Series Sonde), beside the PAR sensors deployed just under the surface.
(Right Page) Superbuoy (a CB-950) deployed on Buffalo Pound Lake on a clear day.

CLIMATE CHANGE AND MICROPLASTICS
MONITORING LAKE CHAMPLAIN

Most people go to Lake Champlain for its exceptional views and thrilling boating, but it's also home to a wide variety of interesting aquatic research projects. From studying microplastics to thermal dynamics of the lake, Timothy Mihuc, director of the Lake Champlain Research Institute (LCRI) at the State University of New York at Plattsburgh (SUNY Plattsburgh), has spent his career studying aquatic ecosystems.

As an aquatic biologist, he's the main investigator on Lake Champlain's research studies while also managing their grants, employees, and buoy research.

Over the years, LCRI has received a number of environmental grants that aid monitoring efforts. With those funds, the organization has bought multiple NexSens buoys for their research in Lake Champlain and the nearby rivers.

"It's very interesting to be out on the boat with people and have them pull this buoy up on their smartphone," states Mihuc.

He continues, "It's fascinating to work with technology that basically, even 15 or 20 years ago, wasn't really around, the ability to do that stuff didn't exist."

Data from the long-term monitoring project helps highlight the influence of road salt on rising salinity levels in Lake Champlain as well as supporting other research initiatives.

While these levels are relatively low, they have doubled in recent years, compared to historical levels. Due to sodium and chloride being inert, the only way for them to rise is through the contributions of watersheds, roads, and rivers.

Although the salinity levels aren't currently a problem in Lake Champlain, it's important to identify the drivers of salinization as the Great Lakes and other basins are suffering due to rising chloride concentrations.

LCRI buoy deployed on Lake Champlain in 2023.

FINDING AND STUDYING MICROPLASTICS

One of LCRI's newest research projects stems from finding microplastics in Lake Champlain. LCRI is exploring the distribution of microplastics throughout the lake, tributaries, and beaches.

While net sampling, nurdles–small plastic pellets used to make most plastic products–were detected in the water column.

According to Mihuc, the presence of microplastics in the lake is particularly concerning because Lake Champlain is considered to be a very clean lake. Beyond that, Lake Champlain is a recreational lake known for its beauty and up until recently, was presumably untouched by microplastic contamination.

"To know that there's plastic floating around in Lake Champlain–that's probably been there for years and that you only detect if you sample water and then look at it–it was slightly disconcerting to know that that stuff's floating around in the lake."

Mihuc's research seeks to answer very simply, "Do we have plastics? If so, how are they distributed and where are they and where are the problems?"

After finding the microplastics in the lake, their study began this summer to try and characterize the microplastics currently found in Lake Champlain and, if they can, figure out the sources of the plastics. Using standard net sampling for the water and grid samples for beaches, the team will count all samples and then divide them into categories.

After characterizing and numerating the plastics, LCRI will look at plastic distribution in the lake to test what type of plastic they are. This information will help identify the origin of the microplastics, which can influence the health of aquatic life, possibly compromising the stability of the food chain.

Mihuc stresses, "It's [microplastics] right there with the plankton, so it's right there where things could get into the food web."

STUDYING PLANKTONIC COMMUNITIES

Studying the lake can be hard work, but as a researcher, Mihuc finds working with students to be one of the most rewarding parts of it all.

He explains, "The most fun thing about my job is getting to explore scientific questions, answer those questions or address them and then have students involved in that process."

One of these research projects includes long-term plankton research on Lake Champlain's planktonic communities. Mihuc has done a lot of work with plankton over the years and has just started including them in the long-term studies of the thermal structure of the lake.

Photos: Tim Mihuc / Lake Champlain Research Institute

More specifically, LCRI is looking at the biological communities associated with the thermal structure and the biota responding to those changes.

"I've always been interested in aquatic communities, anything really, from invertebrates to fish, to other organisms," states Mihuc.

He expands, "I have a current graduate student working on the impact of invasive species on vertical structure in the biota. And so we're looking at the vertical structure of the biota relative to the thermal structure, and then how that's changing when a new species comes into the food web or into the system. And there are some interesting patterns going on there in terms of invasive species causing change among the native, natural communities."

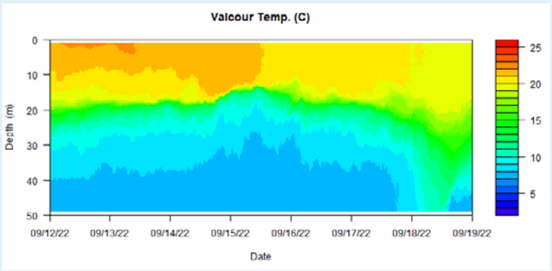
Invasive species in Lake Champlain include zebra mussels, alewives, and two recent planktonic invaders: the spiny water flea and the fishhook water flea. The intrusion of non-native species can disrupt the ecological chain, creating food scarcity for native zooplankton or the introduction of new predators.

THERMAL DYNAMIC DATA COLLECTION

Mihuc's research requires a lot of data over a long period of time. LCRI currently uses up to three NexSens CB-450 data buoys on Lake Champlain, which provides versatile monitoring and includes the addition of a thermistor chain. They also use Lufft WS502 weather stations on the buoy and land-based systems.

Mihuc states, "We can get our data live in real-time, which is, really, really amazing. We can see what's going on in the lake and make a decision whether we need to go out and sample using that real-time, live data. We also make that data available to the public."

He continues, "Boaters want to use it because there's a weather station on the buoy. Fishermen want to use it because we're measuring the water temperatures throughout the water column."



(Photo) Plankton net sampling on Lake Champlain.
(Graph) Sept 19, 2022 | 7 day plot of thermal regime at Valcour Buoy.

Thanks to the funding of several grants, LCRI recently bought a new NexSens CB-450 data buoy and upgraded their instrumentation to include an ADCP and wave sensor.

One of LCRI's newer thermal structure research initiatives includes examining storm and wind-driven events which can alter the thermal structure. The main operation is a 50-meter site with a NexSens TS210 temperature string all the way to the bottom.

Data from the thermistor is logged every 15 minutes. With years' worth of temperature data, these massive datasets can help LCRI compare patterns in the lake system to examine how thermal regimes are changing and how that relates to storm events.

Due to climate change, the continental Northeast has seen a dramatic increase in storm events, both in severity and frequency.

Essentially, the warmer waters are getting pushed deeper by these storm events which impacts the lake's thermal structure. During the summer, a normally stratified lake would be warm at the top and then cooler at the bottom. The biota orient themselves to the changes in temperature, and some need to be at the top, some at the bottom and some in the middle.

If the regimes are disrupted, the biota will have a difficult time responding and won't be able to migrate to their preferred habitat temperature anymore. The thermal patterns Mihuc is studying have large consequences to how the entire lake system functions.

The goal of the project is to help LCRI highlight the impacts of climate change, specifically the influence of weather events, on Lake Champlain. The collected data will be used to inform local officials and environmental groups to actually start making decisions.

Mihuc explains, "I think at this point, we're trying to figure out what's going on. And then the hope is to fix it. With respect to the climate change issue, it's clearly an issue that needs to happen worldwide, not just locally."

He continues, "Essentially, it's a human caused problem. So, we have data that will show what the impacts are on Lake Champlain, which will support the idea that maybe we should do the things we need to do to address climate change."

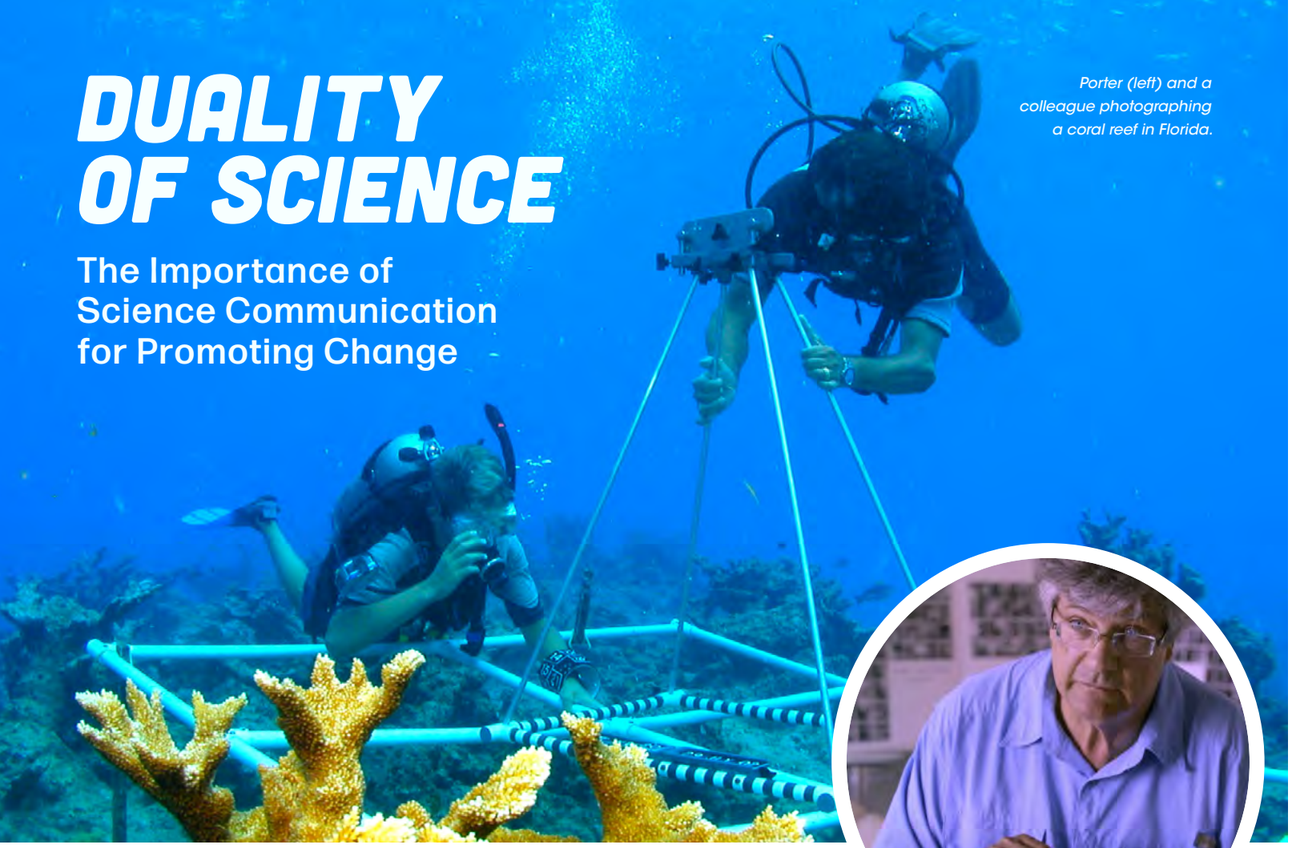
Climate change isn't the only problem that needs awareness; the rising salinity levels come from salting roads, the microplastics come from plastic waste, and invasive species usually invade by boat. Lake Champlain is one of many lakes facing these challenges and the data LCRI collects has the potential to shape research and management of other water bodies. EL

Photos: Tim Mihuc / Lake Champlain Research Institute

Installation of a NexSens buoy on Lake Champlain in 2024.

DUALITY OF SCIENCE

The Importance of Science Communication for Promoting Change



Porter (left) and a colleague photographing a coral reef in Florida.

It is no secret that in today's world, most scientists do not stick exclusively to science–they must be educators, communicators, and advocates. The looming threats facing the planet's climate and the growing distrust in science by the public have forced scientists to expand and improve their capacity for science communication to the world.

From repeatedly testifying before the US Congress to winning an Emmy as the Chief Scientific Advisor for an award-winning nature documentary, marine ecologist James W. Porter has been thrust into the public eye. Hailed as a "superstar scientist" by the Smithsonian Tropical Research Institute, Porter has used a lifetime studying coral reefs to bring the issues facing these havens of biodiversity to the forefront of conservation discussions.

After falling in love with marine ecology at Yale University, Porter began his career with the Smithsonian measuring coral growth and is now a faculty member in Ecology at the University of Georgia. His research around Florida found widespread declining health and coral bleaching, and he became one of the first scientists to bring awareness to this problem.

(Circle) Porter being interviewed for the film Chasing Coral, in which he was Chief Scientific Advisor.
(Right Page) Porter testifying before the Congressional Committee on Science, Space, and Technology in 2019.

He explains, "You start small, and you get large as the universe draws you more and more into your discipline."

Porter attributes much of his success in promoting coral conservation to effective scientific communication.

THE EARLY DAYS OF CORAL RESEARCH

In 1991, Porter presented results from six monitoring stations showing that coral reefs around Florida were declining. Despite sharing the collected data and stark before and after pictures, his findings received little initial press coverage, and he found himself criticized by other scientists who were not convinced by the small sample.

However, Porter kept sharing his findings, bringing them to lawmakers and eventually getting a Floridian Congressman to push for expanded coral reef monitoring within the Florida Keys National Marine Sanctuary. After five more years of study, this time at 140 stations, Porter and his team again concluded that the health of coral reefs in Florida and around the world was in jeopardy.

"The reason that it didn't matter whether you look in a small area or a large area for these phenomena, [is that] this was a global threat of climate change," says Porter. "It wasn't [that] a wayward vessel ran up onto a reef and, 'Oh dear, that reef has been destroyed.' No, human beings ran up against the planet, and oh, the whole planet is being destroyed."

With his passion for conservation and unwavering commitment to sharing his findings, Porter found himself a public figure for his knowledge on coral reefs. Porter claims that his use of imagery, simplification, and context when explaining the need to protect corals allows him to be an effective teacher for a wide range of audiences.

INFLUENCING THE PUBLIC THROUGH SCIENCE

His advocacy and public expertise on corals led to Porter testifying before Congress in 2019 about the global loss of diversity and the declining health of coral reefs. Congress has since signed the UN High Seas Treaty, which aims to protect at least 30% of the ocean by 2030.

Porter prepared for his speech by focusing on simplifying the topics he would be presenting without losing the facts and emphasizing the importance of corals in a context that spoke to the political goals of Congress. By explaining the economic benefits, medical uses, biodiversity, and climate resilience to be gained from conserving coral, Porter brought his research out of the lab and into the specter of public policymaking.

Understanding what your audience will tune in to is key to grabbing their attention, explains Porter. With Congress, he highlighted that in Hawai'i and Florida, reefs generate $60 billion annually. Moreover, the complex chemical makeup of corals can be used to produce new medications, such as a new drug that protects elderly patients from having a second heart attack.

"While the content of what you're saying is important, it's the context in which you put that information that allows people that are not in your discipline to remember it," says Porter. "So what I did when I spoke all three times to Congress, I prepared by simplifying the statements as much as I could, by telling congressmen and women, not just, 'what do you need to know?' but, 'why do you want to know this?'"

Outside the halls of the Capitol building, Porter has shared his coral research through film. A year before his Congressional testimony, he won an Emmy for advising the film, *Chasing Coral*, which highlights the devastating impacts of coral bleaching from rising ocean temperatures.

The documentary has been on Netflix since 2017, garnering hundreds of thousands of views. It has also been shown at festivals and community screenings around the world.

WORKING THROUGH THE DIFFICULTIES OF SCIENCE COMMUNICATION

Unlike other professors and researchers who lock themselves away in labs, prioritizing research over public outreach, Porter has continuously advocated the importance of communicating scientific research to the public. Porter recognizes the difficulties that come from sharing scientific research and results that are often very complex but believes that scientists sharing their work with the world is essential to creating change.

Photos: (Left) Craig Quirolo, (Circle) Jeff Orlowski / Director of Chasing Coral, (Right) James W. Porter

"Both the glory and the excitement of science is not just in its certainty, but in its uncertainty. So one of the challenges of science communication is to deal with uncertainty."

- James W. Porter

While the scientific process is detail-oriented and relies on the repetition of results to make conclusions, it is also still inherently uncertain. Porter believes that the lack of finality that comes with scientific hypotheses is a difficult but crucial aspect of science that must be emphasized.

Porter explains, "Both the glory and the excitement of science is not just in its certainty, but in its uncertainty." He continues, "So one of the challenges of science communication is to deal with uncertainty."

Porter explains that acknowledging this uncertainty while simultaneously instilling the value and impact of scientific evidence is what makes an effective science communicator.

"Science does not allow for fake news, even though it does allow you to change your story as the facts change," says Porter.

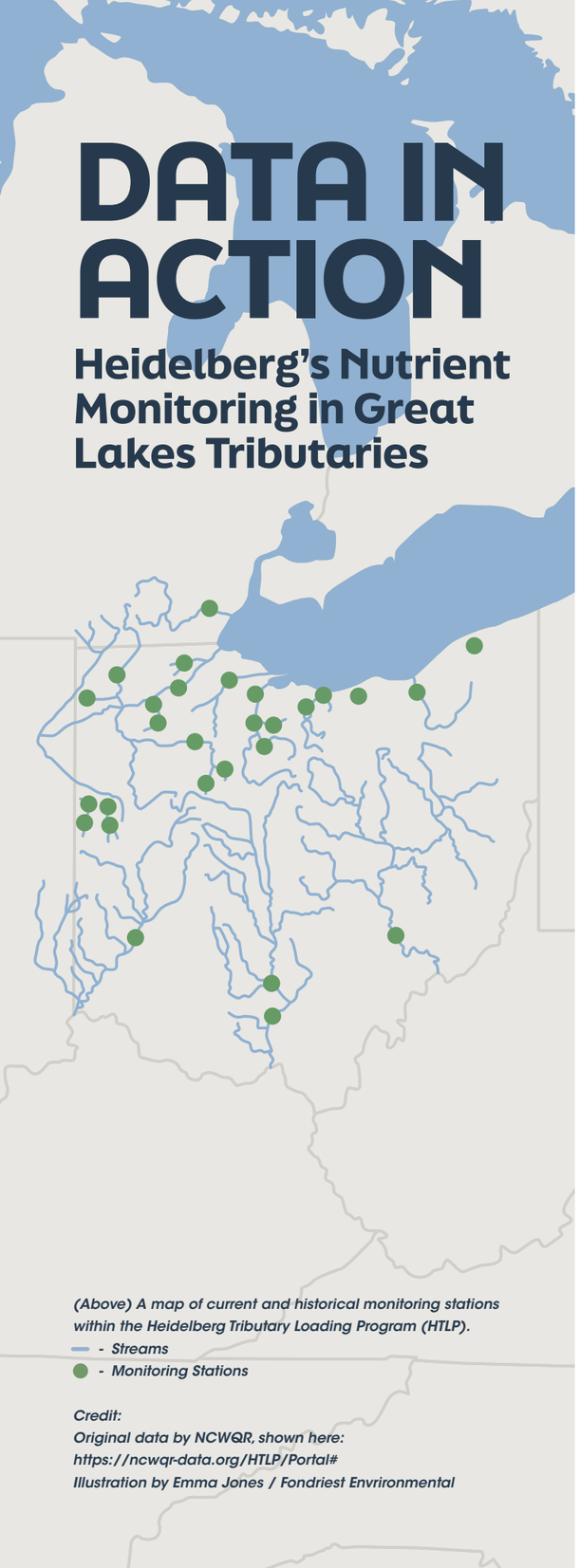
With the environmental threats facing the planet, the need for science to be accessible to the public is paramount. Porter believes that the new generation of scientists must recognize the importance of their work, communicate productively, and remain optimistic.

While Porter recognizes that coral reefs are still suffering globally, he is also hopeful for the future. Between investigating heat shock-resistant proteins in corals to discovering deepwater areas less affected by warming ocean temperatures, he believes that corals can recover.

"We're not at the point yet, where we are going to destroy our future," says Porter. "There are so many advances in our knowledge, engineering, science, [and] ecology. And what we need to do is just share our joy, share our passion, and share our knowledge about the right way to do things." SN

DATA IN ACTION

Heidelberg's Nutrient Monitoring in Great Lakes Tributaries



(Above) A map of current and historical monitoring stations within the Heidelberg Tributary Loading Program (HTLP).
- Streams
- Monitoring Stations

Credit:
Original data by NCWQR, shown here:
https://ncwqr-data.org/HTLP/Portal#
Illustration by Emma Jones / Fondriest Envrironmental

In the early hours of the morning, when most people have yet to hit snooze for the first time, water sampling sites across Ohio are awake and actively collecting nutrient data. The samplers are active at noon, eight in the evening and four in the morning, but very few people would know or even think about the equipment.

Included in those few is Jakob Boehler, field manager for the National Center for Water Quality Research (NCWQR) at Heidelberg University. For Boehler, these systems booting up every day represents valuable data points that will be used to educate the public, influence environmental policies and support future research.

"There are 20 of these samplers going off across the state of Ohio and Southeast Michigan. Most people don't realize it or think about it, but I think about it just about every day," explains Boehler.

Having grown up surrounded by nature, Boehler wanted to find a job wherein he could spend his days working in the outdoors and protecting it.

"I've always had a really strong passion for being outdoors and in the woods, on the river, in the river fishing, flipping over rocks, looking for bugs—I did that a lot as a kid. So, water in general and being outdoors was a big part of my life, and I wanted to try to turn what I liked to do into a career," states Boehler.

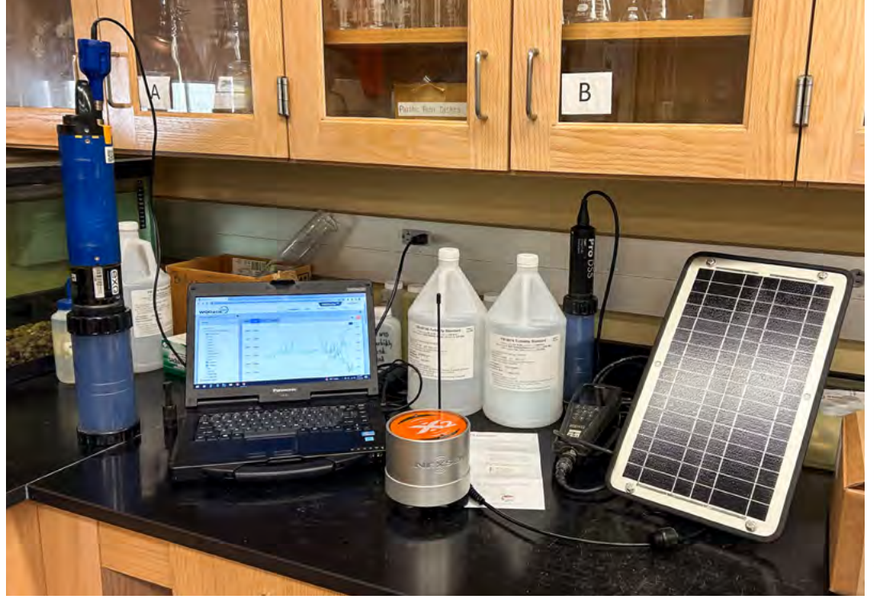
His passion for the environment and increasing public understanding is what drove him to pursue a career at Heidelberg and working with a variety of jobs connected to the NCWQR, like the Sandusky River Watershed Coalition and H2Ohio. "I am always trying to learn how to better educate the public about what we do water quality wise throughout the region," states Boehler.

GATHERING WATER QUALITY DATA OVER TIME

Research conducted at the NCWQR focuses primarily on quantifying the amount of nutrients entering Ohio's streams and rivers, which serve as tributaries for the Great Lakes and Ohio River. These nutrient-rich influxes can lead to algal blooms and similar issues like eutrophication in the Great Lakes. In order to monitor this movement, Heidelberg has set up a series of 23 water sampling sites along the various streams connected to the Great Lakes.

Known as the Heidelberg Tributary Loading Program (HTLP), each of these stations house an automated ISCO sampler and a little over half of them are equipped with a YSI EXO 3 Sonde or TriOS NICO UV Nitrate Sensor. Data is gathered every 10 minutes and then logged and transferred to the cloud with the NexSens X2 Data Logger. The real-time technology of the X2 saves time in the field and transfers the logged data into an online database, WQData LIVE.

For many years, the program ran entirely off of the sampler data, which was taken, collected and assessed over several days, meaning that more common parameters like dissolved oxygen, turbidity, conductivity, pH and temperature were unable to be studied in a meaningful capacity.



Photos: Austin Nainiger / NCWQR

Left) The workbench at the NCWQR is set up for preparing an X2 logger for deployment with an EXO 3 sonde, both of which will be powered by the solar panel in the picture. The WQDataLive portal is open on the laptop with graphs of current nutrient and water quality data from a different sampling location.
(Right) Boehler is working on setting up a NexSens X2 data logger for field deployment at an H2Ohio wetland in Seneca County, Ohio. This site will have two NexSens X2 loggers set up with sondes that will allow the research team to assess changes in water quality and nutrient levels upstream and downstream of a wetland in the floodplain of Wolf Creek.

With funding from the Great Lakes Observing System (GLOS), the introduction of the sondes and X2 data logger allowed the NCWQR to gather more data and build a more comprehensive view of the rivers in the network.

The sondes also serve as a backup to the samplers. Boehler explains, "Let's say we have an issue with one of our samplers, or something didn't get analyzed, we can fill in those gaps based off of the turbidity data." He continues, "In general, it really does help provide me, as the field manager, access for troubleshooting the stations—we're able to see what's going on with the sites in real-time."

At each site, water is bypassed away from the stream by a pump into a small building that houses a receiving tank equipped with an ISCO sampler that samples the water flowing through the tank three times a day: noon, eight in the evening and four in the morning.

Water is also pumped out of the tank, ensuring a continuous flow for the samplers. Successfully collected samples are analyzed for several different forms of nitrogen and phosphorus, as well as silica, fluoride, chloride, and several others, totaling around 14 parameters.

Sites equipped with an EXO sonde and data logger benefit from easier troubleshooting and the notifying of issues before data is lost. Boehler explains as an example that conductivity suddenly dropping to near zero would indicate that there is no water in the tank, allowing him to travel to the site to correct the problem. Without the sondes, a blockage would likely only be discovered when the team goes to the station to collect samples.

The sites are paired with USGS stream flow sites which allow the program to calculate loads of compounds entering a river by combining the concentrations of the compound collected by the samplers and the flow data from USGS.

The monitoring program has been ongoing for the last 50 years and has been instrumental in research surrounding nutrient cycling through rivers and streams. Heidelberg was also one of the first places focusing on nutrient movement through freshwaters, so continuing the program is important.

Boehler says that such long-term sets are valuable but unfortunately rare as funding for projects is often limited. He continues, "This long term monitoring has been going on for 50 plus years, which is really important and significant. It's—as far as we know—the largest dataset of its kind in the world and the data collected is not just used here in the US."

EMPOWERING THE PUBLIC WITH REAL-TIME DATA

The main focus of the lab is to track nutrient pollution in the Great Lakes and Ohio River tributaries. Data gathered by the HTLP is used to predict summer algal blooms in Lake Erie. Understanding the movement and concentration of nutrients is important, as the high amounts of phosphorus and nitrogen that enter the lakes may lead to harmful algal blooms (HABs) and dead zones. These blooms can be composed of cyanobacteria, a toxic type of blue-green algae known to cause several health issues in humans.

Having grown up around water, Boehler spends his days maintaining their sampling network, educating the public, and talking about water quality.

"Just seeing people light up like 'Oh, you know, I get this now.' Or, 'I didn't know that there were all of these bugs and fish living in the creek'—that kind of thing. And just helping them better understand water quality and see that they're starting to get passionate about it too—and excited about it! That's very rewarding," he explains.

Boehler continues, "Knowing that the work that I do makes a difference in the community to help people better understand water quality, what's going on in their local streams, and helping to drive policy decisions. He continues, "Knowing that I'm not just making data for the sake of making data—we like to know that it's getting used—is important and rewarding." SB

(Top) Upper Scioto River sampling site in Kenton, OH. This site does not have a building, so the X2 data logger and sondes, located down in the river, are powered by the solar panel. (Bottom) Illustrated example of an HTLP Station.

Photos: Austin Nainiger / NCWQR; Illustration: Emma Jones / Fondriest Environmental

Monitoring nutrient levels also helps reveal where changes can be made in environmental policy. "Based off of our data, it looks like 80-85% of the nutrients getting out there are coming from agricultural practices. So we need to try to work with [farmers] to address these issues and see what they can do to help reduce that amount," explains Boehler.

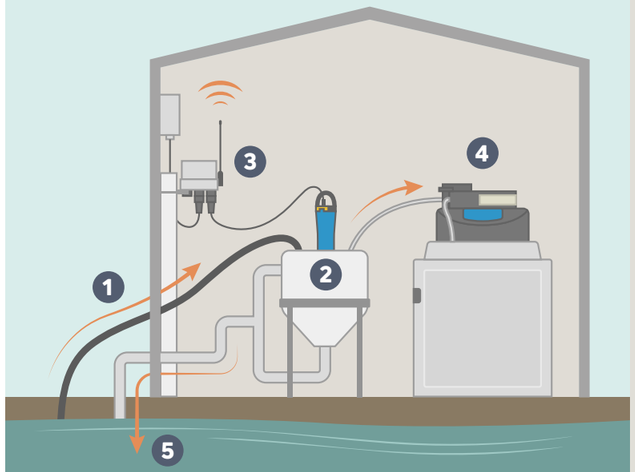
Along with others in the lab, Boehler documents findings from the HTLP to communicate data to state agencies. Since the data from the program is used locally and abroad, it has a place on the annual state budget because the Ohio EPA relies on the data to make decisions regarding what can and can't happen to rivers and streams in order to protect the environment and human health. As such, the data collected must be good quality.

While quality data is the first step, making the information available to the public is equally important. Heidelberg partnered with GLOS to share nutrient and water quality data collected by the HTLP on GLOS's Seagull platform. The public can access the data through the Seagull platform, and the researchers and administrators can see a more detailed view of the network through WQData LIVE.

Accessibility goes beyond simply being viewable online—making data comprehendible is also a large part of the NCWQR's work. Part of the challenges surrounding the program are on the data-gathering side of things with troubleshooting, creating solutions, and conducting fieldwork—others lie on the public side.

"Even though our data is freely available, we don't necessarily want people to just download it and make their own assumptions about it. We want to help educate people to understand what the data really means, so that they're using it properly," states Boehler.

HTLP Station



1. Water intake from river to tank
2. EXO2 Sonde collects data from water in tank
3. X-Series Data Logger collects real-time data from the EXO2 Sonde and transmits it to the web
4. ISCO Sampler collects water samples from the tank three times a day
5. Water drains back out of the building to the river

PROTECTING THE CALOOSAHATCHEE ESTUARY

MARINE WATER QUALITY SYSTEMS IN SOUTHWEST FLORIDA

The southwest coast of Florida is home to an incredible array of natural wonders, from the Florida Everglades to the Pine Island Sound Aquatic Preserve and the many miles of coastline in between. Yet there is also a high density of urbanization in this region, stretching from Fort Myers to Cape Coral and down to Marco Island, with an estimated population of 1.4 million, much within coastal watersheds, according to the Lee County Economic Development Office.

Many inland rivers that run through this area of the state drain into the Gulf of Mexico. One of these is the Caloosahatchee River, which forms an estuary just past Cape Coral out towards Pine and Sanibel Islands. Once an isolated river, the Army Corp of Engineers connected it to Lake Okeechobee in 1947 for use in flood control.

Now, water that has been polluted by runoff from nearby farms and other human stressors around the lake, which has a watershed of over 4,000 square miles, is sent down the river and into the gulf. This increase in the flow of inland freshwater has caused problems with the load of the river system and is believed to be at the root of deteriorating water quality around the Caloosahatchee Estuary, according to local scientists.

"It's gone into a manmade system where it didn't used to be connected [...] until the Army Corps connected them," says A.J. Martignette, a Laboratory Manager at the Sanibel-Captiva Conservation Foundation (SCCF). "Now it's a managed system and there's been lots of issues with the demand of that system."

Photos: AJ Martignette / SCCF

This water system supplies residents with freshwater, is used in agricultural practices, and has major effects on the ecosystems surrounding the Caloosahatchee Estuary and River. With so many factors contributing to the health of these aquatic ecosystems along the southwest coast of Florida, understanding these factors and working to protect their waters is of the utmost importance to SCCF.

USING MARINE WATER QUALITY DATA TO CONSERVE THE CALOOSAHATCHEE ESTUARY

SCCF was founded in 1967 as a land trust and now undertakes projects ranging from wildlife management and habitat restoration to environmental education and water quality monitoring.

Martignette has been with SCCF since 2004, and in 2007 took over the then brand-new River, Estuary and Coastal Observing Network, more commonly referred to as the RECON project, which collects data on water quality via eight sites stationed throughout the Caloosahatchee Estuary and River.

Created to "understand the dynamic and changing conditions in the Caloosahatchee," RECON uses NexSens Technology equipment to aid their research. Some of the data is used to inform the Army Corp of Engineers, which controls water flow out of Lake Okeechobee, about water management decisions. However, SCCF is also involved in many conservation projects on Sanibel Island and the surrounding waters, which can all pull data from RECON.

The RECON project is 16 years old, and despite only being given an estimate of seven years from the manufacturer, SCCF was able to keep its network of original sensors running for 14 years because of a "steadfast maintenance program." However, in 2021 SCCF was informed that no more replacement parts would be made for their equipment, and the search began for a new manufacturer.

"We needed to upgrade," states Martignette. "At that point, we went with the NexSens X2 data loggers," he continues.

When deciding between sensors from other manufacturers and NexSens Technology, Martignette explains that NexSens offering to program the data loggers to the specific needs of SCCF before shipping them out was the selling point.

(Left) Moore Haven RECON station.
(Right) Gulf of Mexico RECON station. In addition to the standard water quality sensors, this site is also equipped with meteorological sensors.

With RECON, SCCF is able to monitor water quality conditions such as water transparency and light intensity, changes in salinity, dissolved organic matter levels, temperature, hypoxic conditions, and more.

However, this is not Martignette's first experience with NexSens. He used a previous data logger, the G2 EXO, during past water quality monitoring for SCCF. These G2 loggers are still used in the original wildlife refuge site where monitoring occurred. SCCF also previously used standard X2s at sites measuring water stage and flow for the city of Sanibel.

Moreover, before switching RECON entirely to the X2 platform, SCCF placed X2 data loggers just outside Lake Okeechobee in the Caloosahatchee River. These were used for a separate project in collaboration with the University of Florida (UF) looking at blue-green algae blooms.

Using the real-time capabilities of the X2 data logger and sensors, along with a monthly discrete sampling of phytoplankton, SCCF sends collected data to researchers at UF, who use computer modeling to predict algal blooms and understand their precursors. With this modeling, Martignette hopes their data can help manage and mitigate blooms.

"With this real-time system, if we see a big bloom in chlorophyll, we can go out before that sample and actually get there and get a physical sample and see what's been in the water," says Martignette. "So that's really a great example of how this system is so beneficial compared to a sensor that you put out, get the data, and download it once a month."

Meanwhile, the coastal RECON project has NexSens systems placed in the Caloosahatchee Estuary, providing essential data to SCCF scientists along with conditions updates for the public. X2 data loggers are useful in marine environments, often deployed on piers or offshore, and SCCF had several options to fit their needs when upgrading the RECON system.

The timing was perfect for the project overhaul, as NexSens had recently come out with the X2-SDLMC Submersible Data Logger. This data logger allowed SCCF to keep using the standard connectors, with enhanced protection from marine conditions.

RECON uses this rugged data logger attached with sensors such as the Seabird HydroCAT CTD, the Seabird ECO Triplet fluorometer, and solar panels, all mounted on a pole in the shallow Caloosahatchee estuary and river mouth waters. In the upper river sites, an additional single-channel ECO is attached to standard X2s, powered by an SP-15 power pack.

With this setup, Martignette and others at SCCF are confident that the data loggers can withstand salty conditions, floods, wave action and more while continuing to collect and transmit data to the WQData LIVE portal.

"With this real-time system, if we see a big bloom in chlorophyll, we go to the site and collect a water sample, bring it back to the lab, and determine what species are making up the bloom."

- A.J. Martignette

THE IMPACT OF RECONS SYSTEMS ON MARINE ECOSYSTEMS

The Caloosahatchee River watershed covers 1,400 miles along with the additional 4,400 miles of watershed from Lake Okeechobee. SCCF believes this incredible amount of area for polluted freshwater runoff from farms and urbanized landscapes to enter the waterways has contributed to habitat destruction and loss of wildlife in the estuary.

The RECON system is used by dozens of scientists at SCCF's Marine Lab for specific projects across Sanibel Island, the Caloosahatchee Estuary, and other freshwater sampling sites in southwest Florida. Projects include red tide sampling, oyster restoration, nutrient management and a live database reporting water conditions.

Along with scientific uses, the data from RECON's NexSens equipment informs anglers about water quality conditions, helping them determine where to fish and what may be causing a slow day. Moreover, boaters can get specific weather data via sensors connected to the data loggers, reporting winds, temperature, cloud cover, precipitation, and water level.

The success of the RECON project and its popularity with the public is evidenced by the investment made to update the water quality sensor system with NexSens Technology equipment. With NexSens, SCCF continues to use its RECON program to protect the beautiful and indispensable Caloosahatchee Estuary, surrounding water, and islands.

The data collected from continual monitoring bolsters SCCF's public advocacy for conservation, engaging both citizens and elected officials about the importance of conserving southwest Florida's marine ecosystems.

With such a vast network of water quality monitoring sites, paired with diverse research projects, SCCF needs equipment that can keep up with the demanding work of conservation. NexSens Technology takes the worry out of equipment sourcing and upkeep, offering complete environmental monitoring systems and backend support.

"The great thing about NexSens versus our old system is it's a complete package," says Martignette. "You put it out there and it works."

Without worrying about the quality of their equipment, SCCF can focus on working to protect and preserve the surrounding aquatic systems and the communities that rely on them. SN

(Top) Moore Haven RECON station, with NexSens X2 datalogger and SP15 power pack.
(Bottom) Marine Lab Manager AJ Martignette and Research Assistant Sierra Greene installing the Moore Haven RECON station.

Photos: AJ Martignette / SCCF

Monitoring site setup with stilling well for EXO2 sonde at Lost River Blue Hole.

APPLIED RESEARCH AND INNOVATIVE SOLUTIONS:

CREATING **CHNGES** AT WESTERN KENTUCKY UNIVERSITY

Long-standing environmental monitoring programs have the power to support a large number of research initiatives and policy changes—however, actually starting these networks can prove challenging. Not only is starting the program difficult, but keeping things operational for decades to come has also been challenging for environmental professionals hoping to make an impact with applied research.

Jason Polk, Professor of Environmental Geoscience and Director of the Center for Human GeoEnvironmental Studies (CHNGES) at Western Kentucky University, is all too familiar with this process. With a background in paleoclimate research, karst environments, and reconstruction of the environment, Polk knows how important environmental monitoring is to understanding human and societal impacts as well as various environmental issues.

After completing his Ph.D., Polk started CHNGES and got more involved in emerging issues with water resources, groundwater, and karst environments where there are caves, sinkholes, springs, and underground rivers. In addition to his research, Polk teaches classes on these topics, serves on various policy-making boards, and oversees the CHNGES monitoring network.

He explains, "I do a lot of different things—and that's really where the strength of it all is—trying to be able to put together the pieces to really fully address some of these geoenvironmental issues."

He continues, "The coolest things I do now are the applied research projects, where we can come up with these really interesting and really innovative solutions to address things like groundwater quality issues, flooding issues, carbon transport, climate change, environmental impacts, environmental justice, and vulnerability issues."

THE REACH OF APPLIED RESEARCH

All of Polk's work revolves around these components and allows him to work on projects across the world in various fields of study. Still, the projects are all connected by applied research. As the Director of CHNGES, Polk builds monitoring networks alongside the local community to meet their needs and develop sustainable solutions.

He expands, "I can study glaciers in Iceland, I can study caves in Belize, I can study, you know, groundwater right here in Kentucky, we've done work with ag communities and impacts in Vietnam—it's been really interesting and neat to be able to do work in all these different countries in these areas and see that linkage and that thread of applied research."

A major component of Polk's work involves educating students and giving them the opportunity to experience the full scope of applied research. Students hoping to enter the field get the chance to work with communities, partners, agencies, industries, and stakeholders. The purpose of training students with real scenarios and communities is the ability to develop and teach model practices.

Not only are the students and Polk playing an active role in the success of these programs, but they are also facilitating the implementation of these initiatives. After studying a problem and researching solutions, applied researchers actually have the opportunity to use their work.

Photos: Jason Polk / WKU CHNGES

"Instead of just sitting on a shelf somewhere, we actually get to help make changes in these places where there's real issues through the research, through the community development, through the work—and then see that also translate into policy, or into regulation, or into just improved conditions for the people that live there," states Polk.

THE INFLUENCE OF APPLIED RESEARCH

In order to effectively utilize data, Polk's efforts go beyond his own work—extending to his students. For that reason, student training is Polk's top priority. This training includes anticipating student needs as they go out and try to tackle real-world environmental issues, excellent field and lab work experience, and a background of data processing knowledge.

In addition to student experience, Polk spends a lot of his time working with clients and the communities in order to ensure they understand and support initiatives.

Polk explains, "We work with the drivers of what we're doing. They are the first ones that we engage with, they drive the need and give us clarity and understanding of what our mission is to best support them."

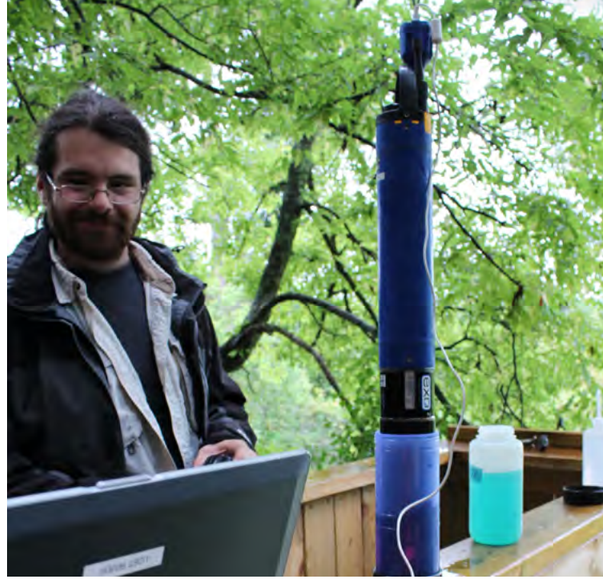
He continues, "[What] we really want to know is: What do you need? What is the thing that you're trying to achieve? What's the problem that you have that you're trying to address? From there we can really drive our applied research to focus on that outcome."

The third variable is the longevity of the project, considering budgeting, system maintenance needs, long-term data usage and reliability, and ensuring that networks are comprised of the essential pieces with backing from interest groups. According to Polk, this step is where the creativity element comes in, and all steps are taken with the ultimate goal of sustainability.

ENVIRONMENTAL MONITORING SOLUTIONS FOR BOWLING GREEN

One example of this is the system Polk helped construct for the city of Bowling Green. This network presented a unique challenge for Polk as it is a complex groundwater system in a fast-growing environment where the rural meets urban. Such complex systems require unique and targeted solutions that can take a long time to develop.

"We don't go out and set up a monitoring network overnight and spend a million dollars because those two things are both really difficult to do," states Polk.



(Top) WKU CHNGES Graduate Student Bo Schaefer calibrating an EXO2 Sonde at Lost River Rise.
(Middle) Shreya Pandey calibrates an EXO2 Sonde at the Church Karst Window monitoring site.
(Bottom) Ben Hauschild and Allison Francis download data for QC from an EXO2 Sonde at the Carver Well Cave site.

Instead, the networks are initiated with a single comprehensive system and upgraded to include newer equipment or additional monitoring sites in order to meet data needs. In the case of Bowling Green, the initial site was a YSI EXO2 deployed in 2013, followed by upgrades or additions each year for the last decade.

Because the city has such unique environmental conditions, multiple stations can be used to collect data that paints a more comprehensive picture of conditions. As of the end of 2023, the Bowling Green network is comprised of ten YSI EXO2s, seven NexSens X2 data loggers, and a NexSens CB-150 data buoy.

Data are collected every 10 minutes and available remotely through the WQData LIVE datacenter. Most of the systems monitor pH, dissolved oxygen, specific conductivity, and turbidity, though other probes have been deployed for additional research projects.

In some cases, a system is needed in areas where a permanent system has yet to be deployed. Planning for this, the city sponsored the purchase of a mobile system that can be deployed in case of a contamination issue outside of regularly monitored areas.

Polk elaborates, "Thinking about how we tie these together, so that we can continue to do research, and we can have experience—we can use these data for all different types of things! It's also great to have sort of instantaneous real time water quality data to monitor contamination issues, or flooding issues, or whatever the case may be."

PLANNING FOR THE FUTURE

For the past 10 years, Polk and the city of Bowling Green have continued to invest time and resources into the network—not only in the form of equipment spending but also in supporting the education of generations of future environmental professionals.

A lot of the project planning research Polk engages in requires him to think about how these networks will serve communities in the future. The projects that Polk has started in his professional career have continued to grow and develop to meet future needs and have pushed him to be innovative and creative in new ways. However, the implementation of all of these ideas is a race against the clock.

He elaborates, "It's an evolution of your career because you start these types of careers when you finish up your Ph.D. wondering if you have enough ideas, like how will I cope with new cool ideas that will sustain the next three, four decades? And then a couple of years into it, you switch and say, like, how am I going to have enough time to do all the things I have ideas for, and then they just keep coming."

(Top) Adam Shelley and Trayson Lawler deploying an EXO2 Sonde at the Carver Well Cave monitoring site in Bowling Green, Kentucky. (Middle) WKU CHNGES Graduate Student Dan Nedvidek deploying a sonde to monitor at the National Corvette Museum sinkhole project. (Bottom) Modified NexSens buoy setup for an EXO1 sonde deployed at the Barren River monitoring site.

Photos: Jason Polk / WKU CHNGES

The goal of the Bowling Green initiative is to create an extensive real-time monitoring network using the best technology. The network should also serve different purposes and can be leveraged to get funds and grants, engage students, and help solve problems. Data from the system is public-facing, with the intention of being available for student research, resource managers, and any resident interested in learning more about local conditions.

Moving forward, Polk hopes to get ahead of some of the regulatory changes happening and develop a more timeless network—a model system for future professionals to refer back to. In the case of his role as a professor at Western Kentucky, this includes providing opportunities for his students to grow and develop.

"I love the fact that it's already happened several places. I've had several students who've moved into positions or transitioned into careers as consultants or with city, county, or state government, and have immediately taken these skills and been able to use them and translate them into helping those communities start the same type of network and monitoring and water quality data collection," states Polk.

The future of the network also has to consider the role of the community in shaping monitoring efforts. Public outreach is foundational to keeping the public informed of the project and receiving feedback that can guide future developments. Polk has been able to serve his community for many years thanks to great partnerships and has seen the impact of his work.

Polk explains, "The most rewarding thing about what I get to do here is to see all the effort equal the outcomes [. . .] This sort of growing network translates into the main things that are meaningful for me. It helps protect my community that I live in, the water here, and the people that live here—it helps make things safe."

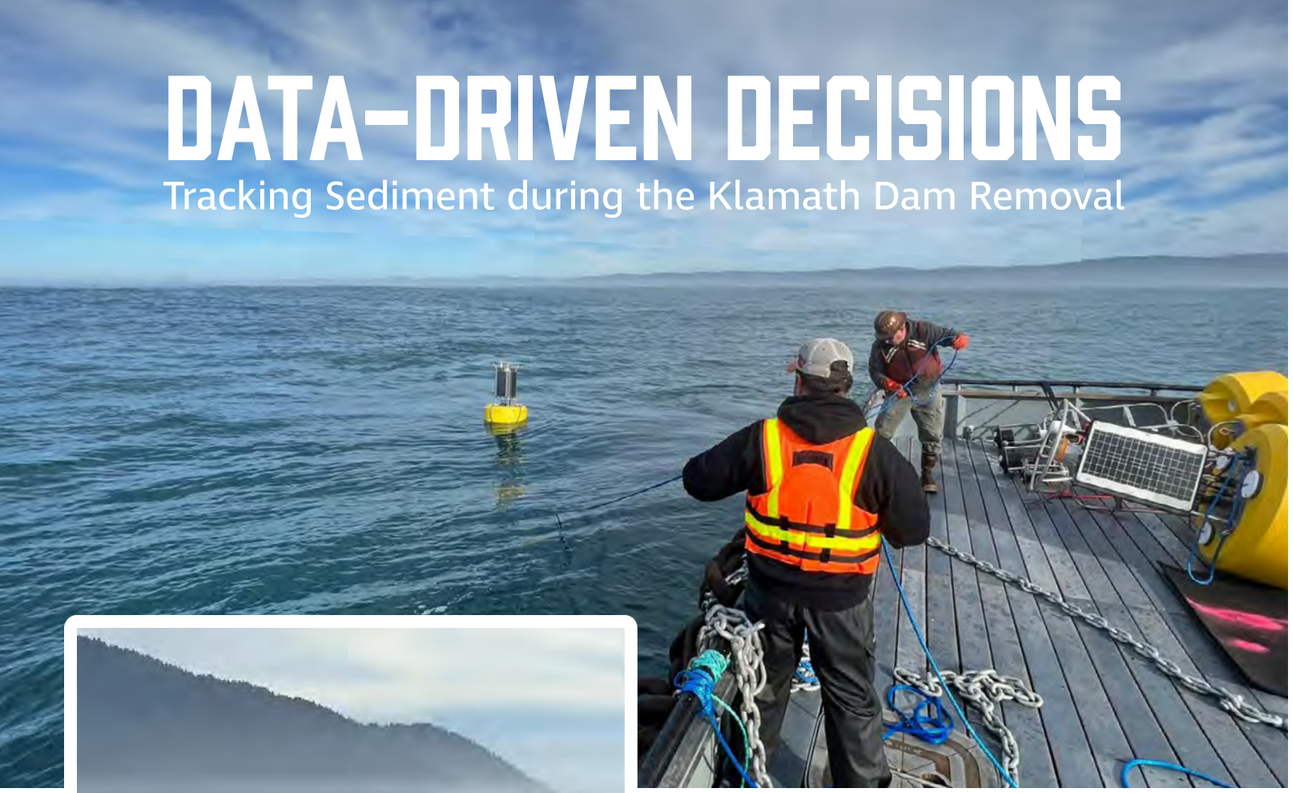
By extension, seeing his students be able to make the same difference outside of school has highlighted the importance of applied research and sharing that knowledge with future generations.

He concludes, "Once you see these possibilities, you also then get to see the rewards once you take advantage of them. So, for me, the reward every day is really just being able to know that all of the technology is being used in as many capacities as possible to help everybody at all levels—professional, community, student, stakeholder—and training those who will steward its use in the future. I think that's the ultimate goal, you really can't ask for more." SB

(Left) Checking the status of an EXO2 at Lost River Blue Hole. (Right) Flooded conditions at the stilling well and platform setup housing the real-time monitoring setup at the Lost River Rise spring in Bowling Green, Kentucky.

DATA-DRIVEN DECISIONS

Tracking Sediment during the Klamath Dam Removal



The largest dam removal in US. history, the deconstruction of the Klamath Dam is slated to begin this summer. The project includes four dams along the Klamath River with the first and smallest dam, Copco #2, scheduled for removal first. As each of the dams are torn down, scientists and consultants will keep a close eye on the state of the Klamath River downstream to assess the impact of undamming the river.

Shawn Hinz, managing partner and environmental toxicologist with Gravity Consulting, has been involved with the Klamath Dam project for over a decade. Hinz was a part of these earlier steps, representing the academic stakeholder position as a graduate student sitting on a board of other stakeholders. Even though the decision to finally remove the dam came recently, advocacy groups have been pushing to undam the river for far longer.

WHY REMOVE THE KLAMATH DAM

When the dam was built in the early 1900s, it was designed to generate hydroelectric power, support irrigation, and provide flood control. However, the damming of the Klamath River led to the destruction of the natural environment and heavily impeded fish migration. Namely, salmon in the area declined as the fish could no longer swim up and downstream for spawning.

The salmon impacted by the dam held important cultural significance for the tribes residing along the river, and these groups have been leaders in advocating for the removal of the dams. Local sport fishermen are also invested in the removal as it will establish a new fishery in the region as the salmon will now be capable of running up and down the expanse of the river.

Photos: Gravity Consulting; Diagram: Emma Jones / Fondriest Environmental

Another reason for the removal is the massive algal blooms that occur late in the summer. The water above the dam is very still, which not only allows harmful algal blooms to occur but also deteriorates water quality. These events can lead to low dissolved oxygen levels as well as other issues that can become detrimental to human and fish health. Undamming the river will open these areas back up for movement, preventing the formation of blooms and regulating water quality.

The beneficial uses of the dams have become obsolete with low power generation and few farmers relying on the source for irrigation. Hinz explains, "There's lots of stakeholders, but the necessity to remove just outweighed the benefits of keeping them."

HOW THE KLAMATH DAM REMOVAL WILL IMPACT THE ENVIRONMENT

The size of the project sets a new precedent for dam removals as well as being significant in the way of data collection. Soft sediments currently deposited between the dams are expected to move downstream as removal occurs. The sediment volume that is likely to be transported has never been seen before, so scientists like Hinz are tasked with monitoring such variables to provide more data to develop an understanding of the impacts.

In addition to the high volume, the sediment is very soft and mobile, and while there is a fair amount of research on managing this type of sediment, none reflect the expected quantities. Over the past few years, vegetative assessments have been conducted in order to see what species are compatible with the sediment. These surveys will allow the Klamath River Renewal Corporation—the group in charge of the removal project—to stabilize the river with vegetative slopes following the removal.

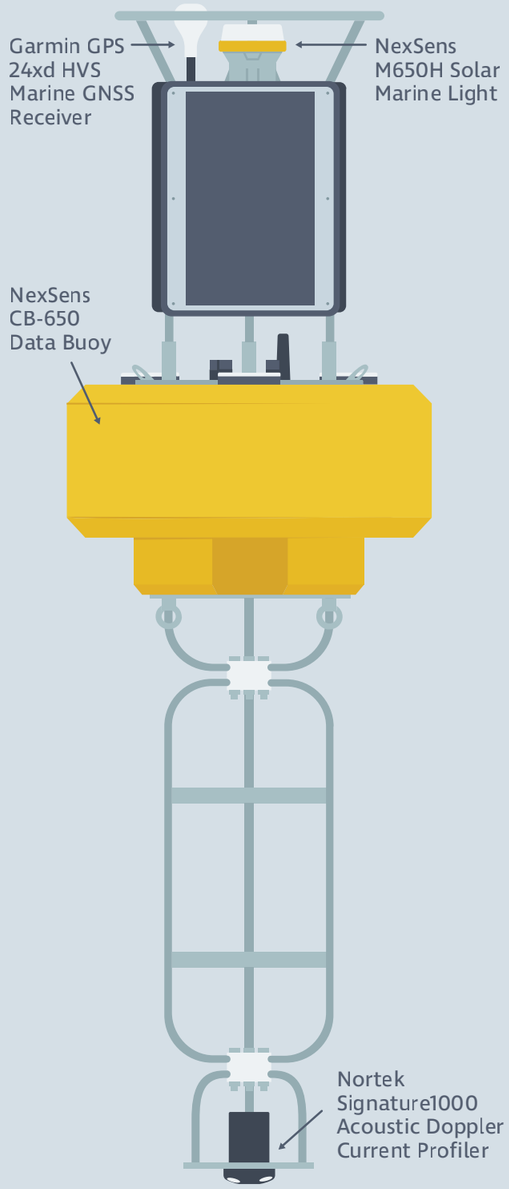
While nothing quite compares in terms of scale, there have been similar, smaller projects. Hinz recalls the Elwha Dam in Washington, another large-scale dam removal. A significant amount of sediment was transported when the structure was removed, and the sediment traveled to where the river met the ocean, leading to short-term impacts on the beach and the estuarine zone there.

In the case of the Elwha River, the transport actually restored the delta where the river meets the Strait of Juan de Fuca and rebuilt the beach and lagoon area that had been deprived of flowing sediment while the dam was in place. The Klamath Dam will have much higher sediment outputs, making predicting the impacts much more difficult.

Hinz explains, "The Klamath River Dam project is expected to increase the sediment load by 24-55% over the current Klamath River discharge of 5.83 million tons annually."

(Left Page, Top) A NexSens CB-650 being deployed downstream of Klamath Dam.
(Left Page, Bottom) A NexSens CB-650 deployed downstream of Klamath Dam.

KLAMATH DAM MONITORING SYSTEM



(Both Photos) Core sampling for environmental chemistry in the Klamath Reservoirs.

It is possible that the increased sediment could have negative impacts on the environment. Crescent City, which is located downstream of the dam, is concerned about the potential burial of benthic species and blocked harbors. Hinz adds on that sedimentation in the water column could also impact the fish and submerged aquatic vegetation communities.

DAM REMOVAL MONITORING

While these potential impacts may seem extreme, it's important to consider them as possibilities. Even further, these concerns are what make monitoring the removal process important. The project is scheduled to begin this summer, and developing an existing profile of the sediment data prior to removal is essential to identifying the impacts.

In order to gather the background data, Hinz deployed nine NexSens CB-650 data buoys equipped with X2 data loggers and select sensors that measure sediment in the water. One of Hinz's main goals with every project he is involved in is to meet the growing need for more data.

He elaborates, "There seems to be an industry trend that everyone wants more data."

While it is easy to ask for more data, there is often a gap in understanding how to get that data. This is where Gravity fits into jobs like the Klamath Dam removal.

"What I do often is work between the consultant who needs the data, and the technology we use to collect that data," states Hinz.

Remote sediment monitoring introduces unique challenges. Monitoring sedimentation is complicated and requires an acoustic Doppler radar capable of documenting backscatter. Gravity has equipped all nine CB-650s with the Nortek Signature1000 Doppler Current Profiler to measure this parameter. The unique fifth beam in the Signature 1000 creates a more precise and high-resolution echogram, or a picture of the acoustic properties of the water.

The instrument offers a remote solution to monitoring suspended sediment in the water column and riverbed. However, it also demands significant power and memory, making the CB-650 and NexSens X2 data loggers essential to gathering the necessary data.

The buoys were deployed before the first dam was removed to gather background sediment data, and they will remain in the river for the next three years while the dam is taken down. "We'll be watching continuously for changes in sediment and sedimentation over that whole period," states Hinz.

While sedimentation is expected and unavoidable to a degree, the project's goal is to limit transport and erosion. Closely monitoring conditions will allow the Klamath River Renewal Corporation to modify deconstruction and assess the success of the vegetative slopes that are planned.

The fine-grain sediments are highly mobile, so it is hard to predict what will happen.

Hinz explains, "I think the reason we're putting so many systems out is to try and come up with a better understanding of what these sentiments will do." He continues, "Now, there's lots of questions. Are they going to settle? Are they going to stay in the area? Will it be transported offshore immediately?"

While some models have been conducted, it's hard to know for certain that the sedimentation will behave one way or another. The data buoys will help gather data continuously to reveal the impacts of the removal in real-time.

Hinz explains, "Everyone wants more data—of course. We're scientists! Of course we want more data."

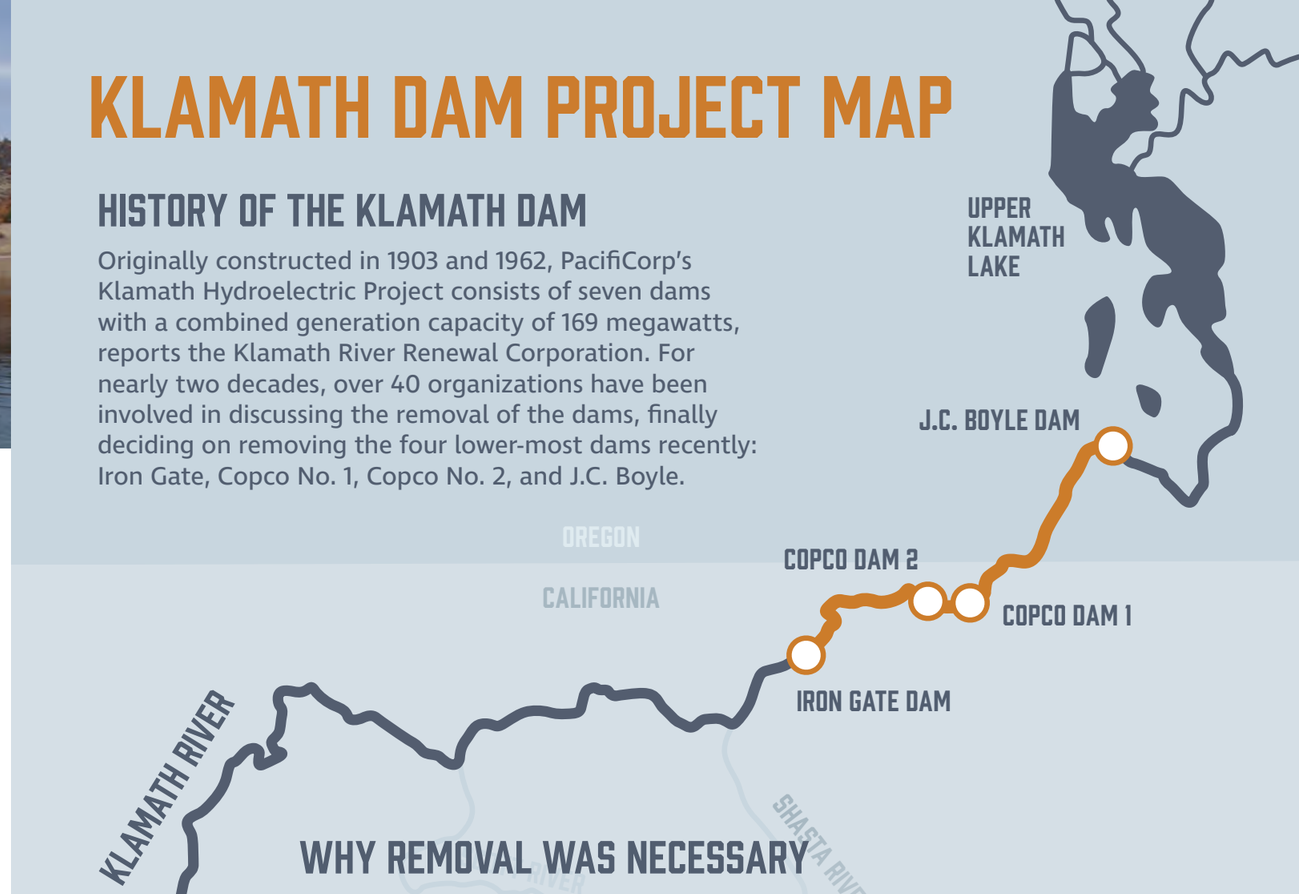
This project will help develop a deeper understanding of sediment behavior as well as the impacts of dam removals as data is gathered consistently over the next three years. These observations will be supported by thousands of data points that help construct more precise predictions for similar projects as well as provide greater insight into the Klamath Dam removal project as they remove the other three dams. SB

Photos: Gravity Consulting; Infographic: Emma Jones / Fondriest Environmental

KLAMATH DAM PROJECT MAP

HISTORY OF THE KLAMATH DAM

Originally constructed in 1903 and 1962, PacifiCorp's Klamath Hydroelectric Project consists of seven dams with a combined generation capacity of 169 megawatts, reports the Klamath River Renewal Corporation. For nearly two decades, over 40 organizations have been involved in discussing the removal of the dams, finally deciding on removing the four lower-most dams recently: Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle.



WHY REMOVAL WAS NECESSARY

Removal of the dams is a key issue for tribes, and Tribal leadership has played a major role in leading removal efforts. When the river was dammed up, salmon migration patterns were disrupted, impacting a vital food source. Additionally, fishing in the river suffered losses due to declining water quality.

DAM REMOVAL RISKS

While removal of the dams was necessary, the KRRC and other involved partners were aware that the removal would impact the Klamath River during removal. There was a risk of benthic organisms being buried under the sediment, and river levels would rise and drop as the dams were torn down.

MONITORING EFFORTS

Before beginning the project, studies were done to develop a better understanding of vegetation and how the influx of sediment and water from the dam removal would impact the ecosystem downstream. In order to monitor conditions during removal, a series of CB-650 buoys equipped with a Nortek Signature1000 Doppler Current Profiler to monitor sediment movement.

RESOURCES

Klamath River Renewal Corporation - https://klamathrenewal.org/the-project/

WQData LIVE Mobile App

Data When and Where You Need It

While working with data and visuals on a desktop computer is sometimes preferred, and the NexSens datacenter provides a powerful desktop interface for project management and data processing, the new WQData LIVE Mobile app now offers this capability on smartphones and tablets.

With the convenience of project data and site visuals anywhere and at any time, the new mobile app is especially useful for scientists on the go. Real-time data, time-series graphs and statistics are quickly displayed and push notifications keep project personnel informed of alert conditions anywhere.

Other app features include a message board for project collaboration, alarm management, data sharing and customized dashboards.

Download on the App Store

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Getting Started

1. Connect Sensors to the Data Logger

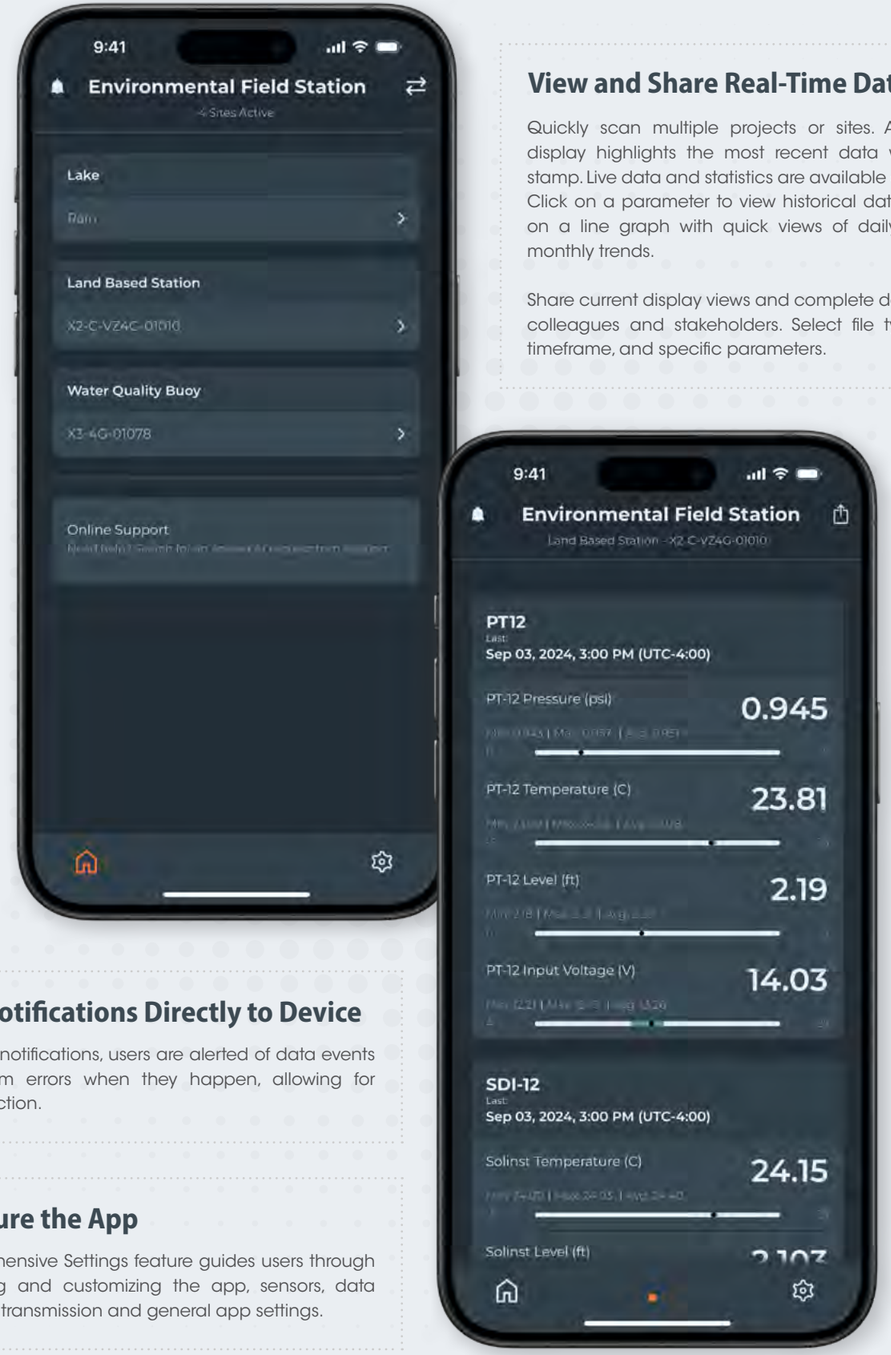
2. Power the Data Logger

3. Scan QR Code within the app

4. Complete Setup & View Data

Easily Manage Projects and Devices

Dashboards can be easily customized to suit project needs. Easily change project and system settings, as well as edit and add alerts, devices, collaborators, admins, and more personalization options.



View and Share Real-Time Data

Quickly scan multiple projects or sites. An overview display highlights the most recent data with a time stamp. Live data and statistics are available at a glance. Click on a parameter to view historical data displayed on a line graph with quick views of daily, weekly or monthly trends.

Share current display views and complete data files with colleagues and stakeholders. Select file type, format, timeframe, and specific parameters.

Push Notifications Directly to Device

With push notifications, users are alerted of data events and system errors when they happen, allowing for decisive action.

Configure the App

A comprehensive Settings feature guides users through configuring and customizing the app, sensors, data collection, transmission and general app settings.

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