making waves

INNOVATIVE WATER TREATMENT TECHNOLOGY born in a home garage

Using *game tech* to explore real watersheds in virtual worlds

DNA in a drop of water

Everyday Albertans investigate their own questions using cutting-edge tools

The stories and change makers of Alberta Innovates' Water Innovation Program | Fall 2022

making waves

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For more information on these stories or the programs we offer to support water innovation please contact:

Vicki Lightbown
Director, Water Innovation Program
vicki.lightbown@albertainnovates.ca

The Environmental Services Division of our applied research subsidiary, InnoTech Alberta, develops and validates processes and technologies that enable more efficient, effective and economical environmental monitoring and management.

For more information on environmental applied research services please contact:

Bonnie Drozdowski
Director, Environmental Services
bonnie.drozdowski@innotechalberta.ca

Content: Kate Broadley and Kristy Burke, Fuse Consulting Ltd.

Design: Jennifer Windsor

ALBERTA INNOVATES

Advancing water solutions in a growing and changing province

THERE IS NO QUESTION that water is a fundamental part of our communities, our environment and all aspects of our economy. Here at Alberta Innovates we recognize the critical value of water to Alberta. Water can be found in all aspects of our programming, whether it's water startups receiving advice from our Technology Development Advisors, communities engaging with water management experts at Innotech Alberta, our applied research subsidiary or the water impacts being considered as we search for net-zero energy pathway solutions in Alberta.

Alberta's population continues to grow with a current five-year growth rate of 4.8 per cent. Our economy is expanding and shifting with surging energy prices and new investment in petrochemicals, agriculture and digital technologies. Coupled with a changing climate, this growth will put new and unexpected pressures on Alberta's water resources. The Water Innovation Program, Alberta Innovates' main water-related program, provides funding and support to projects that will help us respond to and get ahead of these ongoing and emerging water issues. The program has nearly a 20-year history of informing practices/policies and advancing technology throughout the province. The breadth of support is wide-ranging from modeling efforts that inform alternative approaches to reservoir management along the South Saskatchewan River Basin to development of effective oil sands tailings dewatering technologies.

The Water Innovation Program has experienced a few name changes and reorganizations since first established in 2004, but its core purpose has remained the same, to develop the knowledge and technologies that are needed to meet the goals of Alberta's Water for Life Strategy: 1) safe, secure drinking water; 2) healthy aquatic ecosystems; and 3) reliable, quality water supplies for a sustainable economy.

I am excited to share this publication, *Making Waves*. We hope it will raise awareness of the amazing work being done to advance water solutions in our province and inspire the next great idea. Happy reading.

Vicki Lightbown
Director, Water Innovation Program
Alberta Innovates

Water infrastructure for the win

THIS SPRING, THE CONSULTING ENGINEERS OF ALBERTA recognized a study sponsored by Alberta Innovates and Alberta Environment and Parks with an Award of Excellence for a collaborative study on the potential impact of climate change on municipal drinking water facilities. Understanding how climate change can impact our drinking water infrastructure is key to ensuring Albertans have a safe supply of water—now and into the future. Conducted by Associated Engineering, this high-level assessment looked at the historic vulnerability of 48 drinking water facilities across Alberta and the risk of future extreme streamflow events caused by climate change. The study identified potential gaps and vulnerabilities in drinking water infrastructure and provided information that supports the development of climate resilient communities. •

Water innovation webinar series

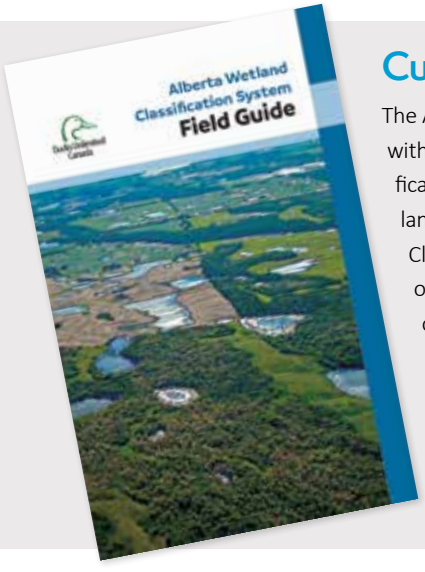
Did you know Alberta Innovates hosts an ongoing Water Innovation Webinar series? These informative webcasts are an opportunity to share ideas and outcomes from projects funded through the Water Innovation Program and to highlight other important water initiatives within the province. Recordings of completed webinars are available on the Inventures Unbound online event portal. •

https://inventurescanada.com/inventures-unbound/

Restoring river riparian

RESEARCHERS AT THE University of Lethbridge worked with Alberta Environment and Parks to develop and implement "functional flows" in the South Saskatchewan River Basin, successfully restoring riparian woodlands along the Oldman and Waterton Rivers. Functional flows are deliberate patterns created through river dam operations. They are applied in high-flow years to create healthier, more resilient river ecosystems that can withstand dry and low-flow years. Additional success in applying functional flows has been observed in the Twin Valley Dam Project along the Little Bow River and along the Red Deer River. •

Final report: https://albertainnovates.ca/app/uploads/2022/06/WIP-HAE-2341-N-Expanding-Functional-Flows-Final-Report-10Dec2019.pdf



Cutting out the guess work on wetland classification

The Alberta Wetland Classification System Field Guide, produced by Ducks Unlimited Canada with support from Alberta Innovates, is taking some of the guesswork out of wetland classification in Alberta. Being able to accurately identify and classify wetlands can lead to better land-use decisions. However, many land users may not be familiar with the Alberta Wetland Classification System, or how to implement it in the field. Chalked full of detailed fact sheets, over 250 images and a vegetation identification guide, this new-and-easy to use resource offers an accessible and highly visual solution. Its clear and effective design was recently recognized by being shortlisted for a 2022 Alberta Emerald Award in the Water category. Individuals interested in classifying wetlands can have all their classification questions answered by purchasing a hardcopy or downloading the field guide from Ducks Unlimited National Boreal Program website. •

https://boreal.ducks.ca/alberta-wetland-classification-system-field-guide/

Making a splash at AI Week

In May, Martha White, Alberta Machine Intelligence Institute fellow and associate professor at the University of Alberta, delivered a keynote presentation for AI (Artificial Intelligence) Week 2022 in Edmonton. This four-day event connected industry leaders and AI researchers to explore the exciting economic applications of AI. Drawing from her experience as one of the lead researchers on the project Optimizing the Treatment of Drinking Water Using Reinforcement Learning, Martha spoke to the challenges of being a leader in reinforcement learning, an emerging field of AI. •

To learn more about Martha's research: https://webdocs.cs.ualberta.ca/~whitem/

Untangling the complexities of water allocation in Alberta

THE ALBERTA WATER NEXUS PROJECT, led by the Alberta WaterPortal Society, is connecting water-use decision makers to online simulation tools that help explore the interconnectedness of water use in Alberta. The initial development was completed in 2016 and resulted in an online simulation tool that uses the Bow River Basin to demonstrate how allocating water to different uses, and under different environmental conditions, potentially impacts its availability for energy production, agricultural production and community use. Subsequent phases of development helped refine and update the tool, which is available on a mobile friendly website through the Alberta WaterPortal Society.

New ecotoolkit for natural infrastructure systems

A MUNICIPAL ECOTOOLKIT, developed by the Miistakis Institute, is helping Alberta municipalities manage and maintain their natural infrastructure systems. The natural assets that comprise these systems—such as wetlands, trees, rivers and riparian areas—contribute to a range of natural functions that benefit our communities. Whether it's mitigating flood risk through riparian vegetation or naturally filtering water through surrounding wetlands, natural infrastructures offer Albertans some diverse advantages. The Municipal EcoToolKit (www.ecotoolkit.ca) is an accessible collection of advice and resources that focuses on five key areas: protection, planning, practices, perceptions and persuasion. Its goal is to generate broader awareness among Albertan municipalities in maintaining their natural infrastructure systems, and to encourage creativity and collaboration. •

Swirltex puts a spin on innovation

SOMETIMES INNOVATION CAN HAPPEN in unlikely places. For Peter Christou, president and founder of Swirltex Inc., that place was in his garage in Edmonton.

It was there that Christou derived a new and effective way to filter wastewater that produces cleaner water and requires significantly less energy than conventional treatments.

Initially, Christou was exploring ways to treat the wastewater created by Alberta's oil and gas industry. He was experimenting with membranes to more efficiently separate oil from water and during the process, he discovered a novel way to efficiently filter out oil and other contaminants, benefitting a much broader scope of industries and sectors.

Membrane filtration is a technique used to remove unwanted particles from water. It's an effective way to treat wastewater by filtering out potentially dangerous agents like bacteria or biological contaminants. The clean, usable water is forced through the membrane and the unwanted materials flow through the centre inside. Unfortunately, the buildup of contaminants on the inside of a traditional membrane requires frequent cleaning or membrane replacements. The Swirltex technology developed by Christou keeps filtration membranes free of debris, requiring significantly less energy than conventional treatments.

Christou's solution was twofold. First, he infused the liquids entering the tubular membranes with gas microbubbles. The bubbles bind to contaminants like a life jacket, making them float. Second, he applied a vortex to the liquid stream as it flowed through the tube. He found the swirling water forced the floating contaminants to the centre of the tube, while the cleaner water was pushed towards the membrane wall. The result was ultra-filtered water.

The potential for Christou's discovery to advance wastewater treatment processes is significant. However, moving a new technology to an operational product doesn't happen overnight. It requires testing, refinement and validation to prove its value and effectiveness before it can be fully implemented. The process also requires money.

In 2017, Alberta Innovates' Water Innovation program contributed nearly half a million dollars to Swirltex. The funds supported the design, pilot and demonstration of the Swirltex Lagoon Unit, a portable wastewater treatment system that evolved from Christou's innovative membrane technology.

Initially, the unit was used to treat municipal wastewater lagoons in the Towns of Ponoka and Crossfield. Like many rural communities in Alberta, these towns struggle to maintain their wastewater treatment systems. Aging infrastructure, growing populations and increased industrial activity make it difficult and expensive to get wastewater to regulatory standards. The Swirltex Lagoon Unit offered a solution by enhancing existing treatment systems rather than replacing them.

The team setting up the pump so it can begin suctioning water to feed the Swirltex unit

Today, Swirltex's proprietary technology is being used to meet a diverse range of client needs. Industries like Alberta's oil and gas sector can use the Swirltex system to efficiently produce higher volumes of clean water than conventional treatment systems. The food industry—including dairies, breweries and food processors—also has the potential to benefit from Swirltex through reduced biological contaminants and wastewater surcharges. The Swirltex story demonstrates how targeted investments help ideas grow into real, on-the-ground solutions, and how innovative technologies contribute to sustainability across Alberta. •

Portable water testing labs provide rural communities with safer water

TESTING DRINKING WATER for bacteria and contaminants is important to keeping citizens safe. However, rural and remote communities often lack the resources or facilities needed for standard water-quality testing, requiring samples to be sent to larger urban areas. A new portable microbial water testing lab, developed by Alberta-based startup Roshan Waters Solutions, is providing rural communities with an on-site solution, and empowering them to take control of their water testing needs.

Roshan Water Solutions' patented VeloCens™ technology was an idea born from the academic work of co-founders Amirreza Sohrabi and Parmiss Mojir Shaibani. Both completed their PhDs in materials engineering at the University of Alberta and studied various water monitoring and treatment methods. Mojir Shaibani's work was the impetus behind their business. She worked as part of a program directly aimed at helping rural and remote communities that struggled to find fast and efficient water testing solutions and learned first-hand the standard testing methods used in more populated regions were not a good fit for rural areas.

Relying on urban centres to conduct water quality testing puts rural and remote communities in a tricky position. Samples have about a 12-hour shelf life and often must be shipped hundreds of kilometres away for processing. Additionally, the turnaround time to get test results can take 24 to 36 hours. This creates an alarming window of time in which thousands of individuals are vulnerable to the risk of consuming water that's been contaminated by dangerous microorganisms like E. coli.

"When something happens to our water supply," said Mojir Shaibani, "we need to be able to make public safety decisions right away. Having quick and reliable testing is essential to ensuring water is safe."

The solution Mojir Shaibani explored during her studies was a portable bacteria sensor unit. When she and Sohrabi realized the potential for this technology to protect human health, they were inspired to make it available to the people who needed it. This became the foundation for Roshan Water Solutions' patented VeloCens™ technology, a portable microbiological water testing lab.

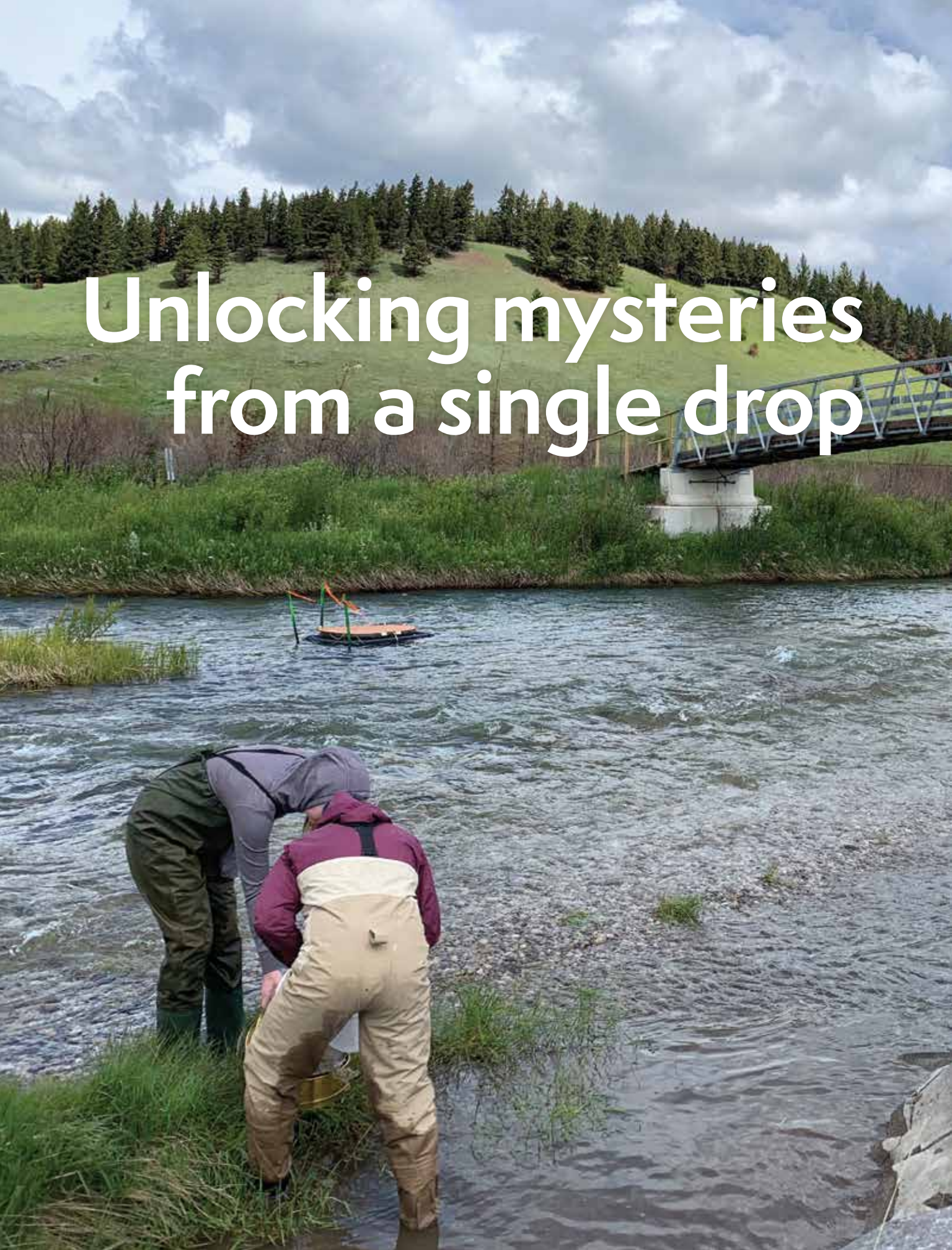
At its core, VeloCens™ technology supports real-time decision-making. It uses innovative nanotechnology to test water for E.coli and Total coliforms on-site and with results available in just one hour. It's simple to use and according to Sohrabi and Mojir Shaibani, can be used by anyone and anywhere.

Adapting to their user's needs has helped Roshan Water Solutions continue to strengthen their water monitoring products. In addition to their portable testing unit, they've also developed a mobile application that uses QR codes to keep a digital record of the collection and transfer of each sample. This reduces errors in documenting samples and provides a cloud-based data centre where users can track samples and monitor results and trends, a feature that was not previously available in the water monitoring industry.

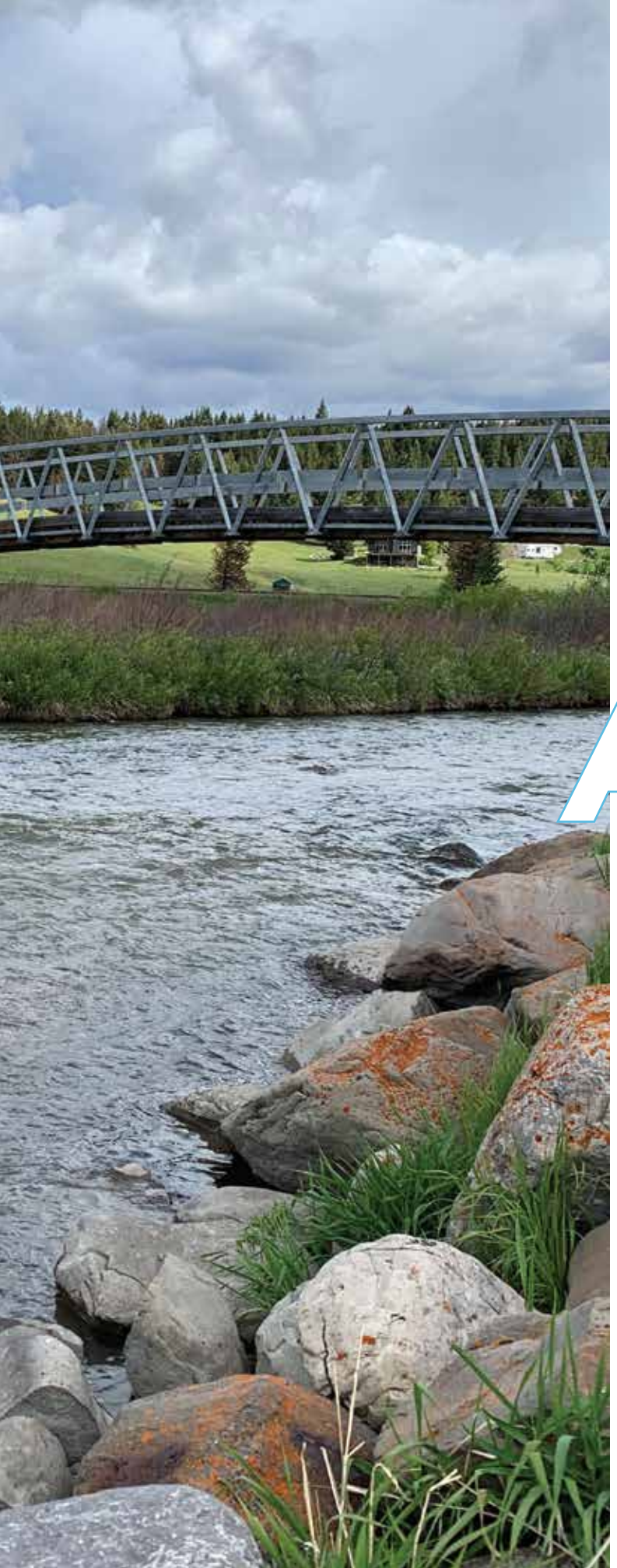
Since its humble beginnings as a startup of two in 2017, Roshan Water Solutions has grown into an exciting small business with several employees and manufacturing contractors. Sohrabi said the support from Alberta Innovates was invaluable to helping them navigate the transition to the business world, connecting them with knowledgeable mentors who helped them develop their business skill set.

Today, they are close to commercializing products that will protect water quality for potentially thousands of people, and they remain motivated to explore new and innovative ways to keep water safe. •

A VeloCens™ portable water testing device



Unlocking mysteries from a single drop



Cutting-edge sampling takes water monitoring to the next level and puts it in the hands of everyday Albertans

ANYTHING THAT LIVES in water leaves pieces of itself behind. Fragments of plants break off into the current. Fish leave trails of poop in their wake. Fur washes off a paddling beaver. A snail sheds mucus into the surrounding water. A drop of water contains a record of history—one told by the traces of tissue that living things leave behind.

These cells adrift in the water column contain genetic material (DNA), and scientists are increasingly looking to these traces as a rich source of data. Using sensitive detection methods, environmental DNA—or eDNA—can indicate what species were recently present in the ecosystem. This is helpful for a wide range of applications, from monitoring for indicators of water-borne pathogens to detecting elusive invasive species or species at risk.

Water, water, everywhere, but not enough samples

During warm summer months, many Albertans seek relaxation at the province's lakes and rivers. But a brush with parasites can put a serious damper on the fun. Preventing water-borne disease is a key research interest for Patrick Hanington, an associate professor at the University of Alberta's School of Public Health. His team aims to better understand microbial biological hazards present in our waterways, such as swimmer's itch, fecal bacteria and blue-green algae. eDNA has been a valuable tool for this research, enabling the tracking of microbes over space and time. But while his group has sophisticated tools at their disposal, getting sufficient samples to the lab is a significant hurdle.

"It's really difficult for individual researchers like my group and I to go and get samples," said Hanington, "and you need to have a certain frequency of sampling in order to get reliable information."

Microbe populations can change quickly over time. A change in weather or water flow can dramatically impact the progression of an algae bloom or bacteria contamination. To understand whether a lake is safe to swim in or if a drinking source is contaminated, multiple samples need to be taken over time. To understand patterns at the provincial scale, sampling must be replicated across many distant waterbodies. This is a challenge for eDNA as samples must be processed within about 24 hours of collection. Collecting thousands of samples and driving them back to a centralized lab quickly becomes impossible.

Fortunately, researchers like Hanington are not the only ones interested in better monitoring. Many community members take keen interest in their local watersheds. Their motivations range from ensuring safe recreation and drinking water, to preventing the spread of invasive species, to conserving species at risk. While individuals and organizations conduct regular water sampling across the province, these groups often lack access to tools that could enable the collection of more informative data—like eDNA. If community members wanted to sample eDNA, they would need to somehow transport those samples to a university or other well-equipped institution. But what if there was a way to bring the lab to them? And what if, while pursuing their own questions, they could collect data on key microbial hazards, all from the same water sample?

"We envisioned that one way to expand the scope and scale of some of this water sampling was to involve community partners," stated Hanington.

Putting high-tech tools in community members' hands

Community-based monitoring is not new, but typically involves relatively simple data collection. Where more advanced techniques are used, community members tend to lose the flexibility to pursue their own questions as they must operate under strict research protocols. eDNA is special in this regard. A single water sample has the power to answer many different questions, like what fish are present in the lake, or whether the lake has harmful levels of fecal bacteria. And because the DNA from multiple species can all be analyzed at the same time, an analysis performed by a community partner can be just as useful to Hanington and his team as one they collected themselves—even if they're interested in different species. Supported by Alberta Innovates, Hanington leads a program to enable province-wide water monitoring by empowering community partners to sample eDNA.

Measuring eDNA involves a process known as qPCR (quantitative Polymerase Chain Reaction). First, the water is passed through a filter that catches any eDNA present in the sample. The filtered contents are then "washed" through a series of special buffer solutions, to purify and preserve the DNA. The purified DNA is then ready for analysis with a qPCR machine.

A change in weather or water flow can dramatically impact the progression of an algae bloom or bacteria contamination. To understand whether a lake is safe to swim in or if a drinking source is contaminated, multiple samples need to be taken over time. To understand patterns at the provincial scale, sampling must be replicated across many distant waterbodies.

qPCR involves the use of special enzymes that make duplicate copies of select sequences of DNA. If even a single strand of the target DNA is present in the sample, the enzymes will rapidly duplicate it into millions or even billions of copies for easy detection. The number of copies produced indicates the quantity of the DNA sequence present in the original sample. qPCR is a powerful tool capable of detecting the tiniest traces of DNA, but it requires the careful preparation and purification of the samples while they are still fresh. To make this possible, Hanington's team needed to train community members to properly collect and prepare samples on-site and, if interested, quantify the eDNA themselves using a portable qPCR machine.

"Part of our focus has been to understand how we can tweak the training to make sure they're getting the best data they possibly can," said Hanington. "People who get introduced to this technique, they have no idea of the small scale that they're working at until they start doing it. You're working with clear liquid that's less than a drop of rain, basically."

Once community partners are up and running, they have a great range of

A portable backpack sampling unit enables collection of water samples from even the most remote locations.

flexibility. The qPCR kits are portable and efficient, with partners able to collect and analyze a sample within a few hours. As the program has expanded, participants across the province are reliably collecting and quantifying eDNA out of their homes, their garages or even the back of their car. In the past year, almost 6,000 samples have been analyzed—an impossible feat for even a dedicated team of graduate students.

The program's longest-running community partner, the Baptiste Lakes Stewardship Society, has used eDNA to narrow down drivers of blue-green algae blooms in their lakes.

"At first we thought it was sewage problems, but we ascertained that's not the biggest issue," recalled society president Dennis Irving. "The DNA monitoring has helped us narrow it down to some of the hotspot areas, and we will be doing some more testing this summer."

Hanington believes the freedom of community members to pursue their own research interests is key to the program's success.

"We have questions we want to answer, but we're not restricting the community partners to our targets. It allows us to tailor projects to their needs," stated Hanington.

Community partners extracting DNA from water samples that they collected from around Baptiste and Island Lake

Expanding the scope of official water monitoring programs

Beyond small-scale community partners, the program has fostered government partnerships, spurred by the COVID-19 pandemic. In 2020, some official monitoring programs were paused to limit travel and close contacts. University field research was also limited.

"We actually thought to ourselves, it's really a perfect system for a situation like this, where there's restricted sampling and it's difficult for the traditional programs to work. If we have community partners who are already at these lakes collecting samples, there can be a lot less interaction between people," said Hanington.

Hanington's team partnered with Alberta Health to collect samples for their beach monitoring program by leveraging community volunteer networks. In the years since, the partnership has evolved into an effective pipeline for sample collection, involving the Alberta Lake Management Society's LakeWatch volunteers. Beyond fostering lasting partnerships between the Government of Alberta and community partners, the beach monitoring program provided a unique scientific opportunity to validate community partner data.

"The program allowed us to have samples collected that were the exact same sample that was used as part of the official beach monitoring program," said Hanington. "We could take the gold standard test done through the government testing facility, and compare that to our community partner qPCR data, all from the exact same water sample."

What they found was energizing: 86 per cent of the time, data generated by the community partner is within 10 per cent of the gold standard. While expert monitoring programs are essential, the trial demonstrated community-based monitoring can generate reliable data and expand first-line surveillance over a much greater area.

"If a community member gets a positive, it allows you to target that location or region with the official program," added Hanington.

Supporting conservation through invasive species detection

Alongside public health, eDNA-based tools can also support conservation. Early detection of invasive species enables intervention before they spread out of control. Whirling disease—caused by an invasive parasite that infects trout, whitefish and salmon—is a key concern in the southwest region of the province.

"In 2016, when whirling disease was detected in Johnson Lake, Alberta Innovates put us in touch with some of the people in Alberta Environment and Parks. We ended up working with them to design a qPCR test that could be used for environmental samples," said Hanington.

As the provincial program has rolled back, Hanington has helped interested community partners take over the whirling disease monitoring. These partners in southern Alberta are now testing for whirling disease, zebra mussels and Chinese mystery snails.

"Invasive species and species at risk, such as bull trout, have really emerged as targets of interest with the groups we're working with. And it's really pulled us towards true eDNA-based monitoring where rather than looking for the organism in the water, you're looking for DNA it has shed into the water," stated Hanington.

Inspiring the next generation of Alberta's water stewards

One of the most exciting outcomes to emerge from the program has been the involvement of Alberta students. During a teacher's networking event, Alberta Innovates suggested that Inside Education, a natural resources education non-profit, connect with Hanington.

"Inside Education had worked with Alberta Innovates previously on lots of different projects," recalled Kathryn Wagner, project manager for Inside Education. "We focus on bringing meaningful environmental education to Alberta classrooms and enriching the curriculum. Taking it the step beyond: what's cool, what's innovative, what's happening on the ground?"

Intrigued by the work of Hanington's team, Wagner took a group of teachers to tour Hanington's lab.

"Inside Education had worked with Alberta Innovates previously on lots of different projects," recalled Kathryn Wagner, project manager for Inside Education. "We focus on bringing meaningful environmental education to Alberta classrooms and enriching the curriculum. Taking it the step beyond: what's cool, what's innovative, what's happening on the ground?"

"He mentioned that a limiting factor is collecting water samples and getting the breadth of samples needed to answer key research questions," said Wagner. "And I thought, 'Oh, we're out with students all the time! We work with schools all across the province.' I thought, 'I wonder if there's a way to connect what we're doing.'"

To test the feasibility of student involvement, Hanington brought a qPCR testing system to the 2016 Navigate Youth Water Leadership Summit in Canmore. Students in attendance were invited to extract DNA from water samples they had collected near their schools and analyze them for targets like cyanobacteria and fecal indicators.

"It really showed the proof of principle, that within a one-hour training session, we could talk to them about it and they could extract DNA and run a qPCR sample, and 20 minutes after the session is over the data is done," recalled Hanington. "It's quite easy and with even one person who knows what they're doing, you can have the program run really smoothly."

"We were just trying to test the waters—pun intended—to see how effective it was to teach students and have them extract the DNA," recalled Wagner. "We had all the students bring water from their local water bodies to the summit in Canmore. They would say things like, 'Oh wait, we can figure out what's living in here?'"

This began a partnership between Hanington's team and Inside Education to bring qPCR into the classroom. Participating schools would conduct water sampling and analyze their samples in the classroom, empowering students to investigate questions about their local watersheds. The program has since evolved into a lending library, where trained teachers can request access to a qPCR system through Inside Education.

Wagner remarked on the power of engaging students in the scientific community: "Knowledge transfer to young people—to let them know there's really great work being done, that there's good people working on it and sharing those stories that resonate broadly—schools are an awesome conduit for that. We often say, 'Oh hey, you're the future generation of leaders,' but they're the leaders now. We just need to engage with them."

Next steps

For Hanington, new partners continue to join the community-based monitoring program. Currently, between 40–50 partners are participating. The school qPCR program is also set to expand when students return in the fall. In Hanington's view, a key factor in the program's success has been the strength of its partnerships.

"An awesome dimension of working with Alberta Innovates is that they're so good at seeing the connection between the different projects they support—and even projects that they're not able to support—and be able to link everyone together," said Hanington.

As the program evolves and more partners engage, community members across the province are finding new opportunities to steward their local lakes, streams and rivers.

"It's been pretty rewarding to have a partnership with Dr. Hanington. I think lots of the other lakes around here are jealous of us because we established that partnership," joked community partner Dennis Irving. "He's been just ace—and very patient in training us." •

BRINGING THE LAB OUTSIDE:

Alberta's aquatic mesocosm test facilities

SCIENTISTS AT INNOTECH ALBERTA have created a valuable bridge between the natural world and the laboratory, contributing to better reclamation and design of end-pit lakes for Alberta's oil sands industry. Their solution is to use mesocosms, an outdoor system of contained structures that allow researchers to replicate many real-world conditions in controlled experiments.

When a mine reaches end of life, the land it operated on must be reclaimed to a usable state. End-pit lakes—a common landform created when surface mining pits are backfilled with mining by-products and then topped off with water—are part of a reclamation plan. There are stringent requirements for getting end-pit lakes approved and understanding how they will impact their surrounding ecosystem is critical to their design. This includes choosing fill materials that are best suited to the reclamation goals and the lake's intended end use.

However, testing different fill materials in a real end-pit lake can pose risks to the environment, and small-scale laboratory experiments lack the seasonal conditions of the real world. So how do scientists get the data needed to design the best end-pit lakes possible? The answer may lie somewhere in between—in mesocosms.

Mesocosms provide researchers with a simplified model of a real ecosystem. They also provide a way to test the impact of a range of water chemistry conditions on different species over time. This can help planners understand the impact of Alberta's complex freeze-thaw cycle and determine the appropriate percentage of tailings and other materials to include in end-pit lakes.

> The large below-ground mesocosms are the only ones in the world capable of supporting research during the winter.

Brian Eaton, Manager of the Environmental Impacts division at InnoTech Alberta, described the mesocosms as a tool to manage the risks associated with oil sands end-pit lakes.

"We use the mesocosms to look at different tailings and other oil sands by-products that could potentially be found in end-pit lakes," he said. "Then we investigate what those materials do in terms of biological systems and their potential impact on the environment. They allow us to do controlled and replicated experiments that model a natural system."

Built in 2016 in partnership with Canada's Oil Sands Innovation Alliance (COSIA), the InnoTech Alberta aquatic mesocosms currently consist of sixteen above-ground polyethylene tanks (5,000 litres) and 30 below-ground, double-walled tanks (15,000 litres). The large below-ground mesocosms are the only ones in the world capable of supporting research during the winter. This allows researchers to observe how water and living organisms are impacted by the freeze-thaw cycles that naturally occur throughout Alberta's colder months.

The facilities, located near Vegreville, Alberta, also include a variety of instruments and equipment to support numerous sampling and monitoring systems.

InnoTech Alberta's mesocosm test facilities are accessible to a variety of sectors and offer a variety of access models. Trained staff are available to support organizations from the study design stages through to the testing and monitoring stages. Alternatively, if available, companies may rent the facilities and manage their experiments independently. InnoTech Alberta will also customize split designs where both parties collaboratively design and manage the experiments. •

Guiding the way to safer water reuse

PROVIDING ALBERTANS with safe and abundant water is challenging. Climate change, population growth, aging infrastructure and urbanization create a multitude of pressures on municipal water systems. Reusing urban stormwater and rainwater is an area of growing interest to address these challenges, but water reuse comes with a host of public health considerations, such as the potential impact of residual microbes on human health. Recent work by Norman Neumann, a professor in the school of public health at the University of Alberta is helping to manage the risks associated with reusing urban stormwater and rainwater, informing Alberta's new Public Health Guidelines for Water Reuse and Stormwater Use and contributing to healthier, more sustainable communities.

Understanding the potential hazards of reusing water is important to determining how it needs to be treated to be safe. Systems designed to capture and redistribute stormwater and rainwater need to ensure the risks of the public getting sick are low. Neumann's work looked specifically at the microbial risks of reusing stormwater and rainwater and explored innovative ways to assess and reduce these risks to the public.

"The concern with microbes," said Neumann, "is their ability to amplify and replicate their effects. All we need is for one person to get sick and then they infect others, who then infect others, and so on."

However, determining the acceptable level of microbes in reused water is not always easy. What the water will be used for, where it came from and the amount of expected human exposure are all important risk considerations. Neumann and colleagues used a quantitative risk assessment approach to examine a variety of water reuse scenarios and to identify microbial targets appropriate for the water end use.

The diverse water reuse scenarios Neumann examined identified some innovative risk reduction strategies. For example, stormwater used for irrigating recreational fields have less stringent microbial targets than stormwater used for toilet and urinal flushing. This is because when combined with management strategies like watering at night, the likelihood of human exposure to water reused for recreational irrigation is much lower than the likelihood of being exposed to reused water in your home.

Neumann's work has the potential for significant impact. Previously, Alberta had no clear guidelines or standards in place to ensure water reuse was being done safely.

"When we started looking at this, there were standards being developed in other parts of the world," said Neumann. "But how do you decide which regulation you follow? Many jurisdictions have conflicting guidelines and definitions of what safe water even is, and often have very different water sources and demands than we have in Alberta."

Neumann believes that with clear guidelines, comes the potential for greater innovation. It provides developers and municipalities with a framework that supports building better infrastructure and more sustainable communities, giving them the confidence they need to invest in new and innovative water reuse systems.

"When it comes to building sustainable, safe water systems, we need to consider our future needs," said Neumann. "The solutions and programs we implement today will impact our communities 20 years from now. The Water Innovation Program transpires multiple points of innovation—not just technology innovation, but policy and regulation innovation as well." •

> "The solutions and programs we implement today will impact our communities 20 years from now. The Water Innovation Program transpires multiple points of innovation—not just technology innovation, but policy and regulation innovation as well." *— Norman Neumann*

Simulating a glimpse into future water supply

ON THE EASTERN SLOPES OF THE Rocky Mountains, snow clings to the high mountaintops—but it won't remain there. In fact, after entering rivers as meltwater, some of this snow will go on to water crops hundreds of kilometres away on the plains of Southern Alberta. It's a natural system Albertans rely on everyday. And now, thanks to cutting-edge research, communities will be able to understand potential future changes to this water supply. Some will even have the chance to visualize these changes through virtual simulations.

In a new project supported by Alberta Innovates, University of Lethbridge professor Chris Hopkinson along with partners at the University of Waterloo, Government of Alberta and MacHydro are studying how future landcover trends will impact Alberta's water supply. With climate change, forestry, wildfire and insect outbreaks all affecting forest cover on the Eastern Slopes, it is critical to better understand how vegetation and snowpacks interact.

"We are trying to take a more holistic approach to the challenge of water resources and understand how some of the less obvious changes like vegetation change are impacting snowpack," said Hopkinson. "For example, if you take away the forest, more snow might accumulate because less of it is lost from the canopy, but then again it melts more quickly,"

Hopkinson and his team are using a combination of remote sensing and satellite data with on-the-ground sensors to track vegetation and snow cover patterns over time. Using sophisticated hydrological models, the team will simulate how landscape factors have influenced water supply to Alberta's major drainages over the last 40 years. With a better understanding of the past, the team can also project how water supply may change in the future.

"What if we were in a year where we had both a moisture deficit in the Prairies and a low snowpack year? With climate change, there's a good chance we're going to see more years like that in the future," added Hopkinson.

Beyond research and water management, the project provides a unique opportunity for education. Using their detailed imaging data, Hopkinson's team are working with Calgary-based Fluid Planet to develop digital game environments that replicate real life mountain headwaters, starting with Alberta's Castle region. It's a tool that's destined to be a hit in high schools.

"We know it's not easy to get all high school students out to the headwaters. So how do we create that immersive experience? Imagine, in the virtual environment they could start at the Westcastle Field Station and go on a guided interpretive hike. As they move through and explore the environment, they learn more about the environment."

Hopkinson and his partners at Fluid Planet and Inside Education plan to embed scenarios, like changing snowpack, weather or water levels, to help students understand what's important to the landscape and how things are changing.

"It isn't a replacement for being out in the real world with all of the sounds, smells and sensations. But we hope this will be a valuable tool for the students who can't get out there." •

A glimpse of the virtual environment created by Fluid Planet using imaging data from Hopkinson's team

A bank of reverse osmosis filters in a desalination plant

Machine learning for optimizing reverse osmosis

NEW TECHNOLOGY DEVELOPED by the Alberta-based startup, Synauta, is revolutionizing the way desalination and wastewater plants operate. Their patented machine learning algorithm is helping optimize reverse osmosis water treatment systems across the globe, with the potential to save the global industry more than 12 million tonnes in carbon dioxide emissions every year.

Mike Dixon, CEO and founder of Synauta, describes reverse osmosis as the 'heart of the desalination process'. It uses high pressure pumps to force salt water across a semi-permeable membrane, filtering out salt and other impurities. It's a technique used in water reuse plants across Alberta, helping the oil and gas, mining and food and beverage industries treat wastewater.

Operating a reverse osmosis system, however, is a complex and expensive task. From planning and maintenance to energy and chemical consumption, operators are challenged to meet water production and environmental targets while keeping expenses low. Managing these systems manually is often further complicated by a lack of available personnel, complex calculations and over or under cleaning membranes.

Synauta's solution is a machine learning algorithm for reverse osmosis that optimizes both energy and chemical use. It integrates with existing control software so plant operators can easily and reliably manage and optimize variations and trends in water conditions while adapting to fluctuations in feedwater. Ultimately, this technology minimizes energy use, contributes to a lower environmental footprint and lowers operating costs.

Machine learning also has the potential to solve problems unique to many remote and Indigenous communities. Operators in these areas may lack the training required to run desalination or wastewater treatment plants, or have limited capacity to do manual optimization work. Synauta's technology can support remote monitoring and determine optimal energy use for a plant in minutes. Its unique algorithm reduces energy consumption by up to 15 per cent and saves up to 25 per cent in the costly chemicals required for cleaning reverse osmosis membranes.

Synauta's products and services have a strong market in Canada and abroad. The company, which was recently acquired by Gradiant International Holdings, is doubling their team in Canada this year and their machine learning for reverse osmosis has been deployed with customers in Singapore, the Middle East, Australia, Spain, Chile, Africa and California. •

Water Innovation Program investments and outputs

FROM JUNE 2015 TO MARCH 2022:

38 ONGOING PROJECTS

NEWLY APPROVED IN 2021/22

45 COMPLETED PROJECTS

$31,861,494
ALBERTA INNOVATES **INVESTMENT**

$114,050,122
TOTAL PROJECT VALUE

2.6:1
INVESTMENT LEVERAGED

A WATER NETWORK OF **>160** COLLABORATORS

16 NEW POLICIES OR PRACTICES INFLUENCED

29 FIELD PILOTS

>350 HIGHLY QUALIFIED PERSONNEL SUPPORTED

19 NEW PRODUCTS AND SERVICES CREATED