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CONTENTS

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FEATURES

- 6 How can we strengthen the environmental industry workforce? – **Editorial comment**
- 8 Helping the water sector chart a path through the rough waters of public relations
- 10 Hamilton's Woodward Avenue WWTP gets new raw sewage pumping station
- 16 Improved vapour barriers allows for safer brownfields development
- 20 Belleville tests wastewater odour suppressant
- 21 Alberta town secures funding for major stormwater project
- 41 The important role of high capacity water filters in eDNA sampling of surface water
- 58 Hamilton Region wins AWWA drinking water quality award
- 59 B.C. District switches out lake drinking water source over rise in algal blooms
- 60 WWF report warns of data gaps in 60% of Canada's sub-watersheds
- 62 University of Guelph to track wastewater for foodborne illnesses and COVID-19

CONSULTANTS' FORUM

- 22 Applying multi-criteria decision making for wastewater treatment process selection
- 28 The project delivery process has suddenly become much more complicated
- 30 Why keeping a notebook can help young engineers become reliable and promotable
- 32 Considering all the impacts of the pandemic on the consulting industry and client relations
- 34 OSPE working to welcome next generation of women engineers with open arms
- 36 What is environmentally conscious building?
- 38 Environmental sector jobs to see growth in spite of pandemic, report says

OPERATORS' FORUM

- 44 Evaluating the business case for using wastewater digestate
- 46 Intake filter recycles waste heat to prevent WWTP equipment from freezing
- 49 Chemical feed flowmeters must be extremely accurate
- 50 The Internet of Things is transforming wastewater collection system maintenance
- 54 Unidirectional distribution system flushing improves White Rock's water quality

DEPARTMENTS

- 56 Product Showcase
- 58 Environmental News
- 59 Professional Cards
- 62 Ad Index



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How can we strengthen the environmental industry workforce?

According to ECO Canada's recent report *"From Recession to Recovery: Environmental Jobs and Hiring Trends in the Decade Ahead"*, environmental employment demand is projected to persevere in the years following COVID-19, while other markets may face longer recoveries.

This is indeed good news for those who want to join this industry, but how can we make it possible for everyone to have a fair chance to work in the environmental, water and wastewater sectors?

In 2018, the Water Environment Federation (WEF) recognized that diversity and inclusion in the water workforce was an important and timely issue needing its attention. In August 2019, it established the Workforce Diversity and Inclusion Task Force, which has since developed a suggested program of short- and long-term projects that WEF could undertake to address this issue.

SHORT-TERM STRATEGIES

- Start a conversation on diversity, equity and inclusion in the water industry through different media channels.
- Celebrate and create incentives to encourage companies to undergo diversity, equity and inclusion training (i.e., unconscious bias, diversity, equity and inclusion basics, inclusion, sensitivity training).
- Create a mission-based "Industry for Everyone" campaign, seeking out and highlighting non-traditional water professionals to tell their stories.

LONG-TERM STRATEGIES

- Develop bold partnerships with external partners and industry giants to leverage their access to underrepresented/underserved communities.
- Facilitate a network for underrepresented/underserved operators to communicate best practices, mentor and engage others.
- Create a skills database for the water industry that is searchable by career opportunities, skills, experiences, career paths and job descriptions.
- Create a "Water Bootcamp" training program for mid-level, non-engineer professionals, who are not currently in water or who are new to water.

Engineering groups outside of the environment and water sectors are also tackling the issue of underrepresentation and have formed strategies to welcome new labour participants.

Over the last five years, the Ontario Society of Professional Engineers (OSPE), has focused on engineering's gender gap, highlighting the fact that the number of women working in engineering in the province has

increased by only 2% over the last decade. A figure that OSPE calls "dismal".

OSPE views "engineering's culture of exclusion" as a threat to the future of engineering and far behind other regulated professions. To tackle this problem, it recently launched a new campaign called "Engineering for Change" that encourages employers to voice their support for a diverse and inclusive workforce.

An encouraging sign of progress did occur two years ago at Concordia University, when for the first time in Canada, a faculty of engineering was named after a woman: the Gina Cody School of Engineering and Computer Science. Cody, who grew up in Iran, donated \$15 million to the school and was the first woman in Concordia's history to be awarded a PhD in building engineering.

Another area that appears to be underrepresented by women is in technical sales positions. I asked current Ontario Pollution Control Equipment Association President Linda Cooke-Weaver what she thinks contributes to this.

"I honestly think it is because there are so few women as mentors. Paving our way in a male dominated field is not easy," she said.

Cooke-Weaver said that ironically, her career only advanced when a company she was working for dismantled its Canadian organization and the American team took over.

"My new team saw me no differently than anyone else and I did not see the barriers working with them that I saw here in Canada," said Cooke-Weaver. "Opportunities were open to all, and consequently I was given many that I never received, prior to the dismantling of that firm's Canadian organization."

Cooke-Weaver added that: "I always encourage young women to accept the fact that we are different and that it is okay to be different. Use it positively, not negatively. We see the world differently and because we do, we need to believe in ourselves. Eventually others will see us and we will persevere."

Throughout our 32-year history, ES&E Magazine has supported associations with many of their initiatives, and we stand ready to help work towards a stronger and more diverse workplace as best we can. ■



Steve Davey is the editor and publisher of ES&E Magazine. Please email any comments you may have to steve@esemag.com

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(Left to right) James Campbell, Halifax Water, Amy Barrilleaux, Madison Water Utility and James MacAdam, City of Tucson Water.

HELPING THE WATER SECTOR CHART A PATH THROUGH THE ROUGH WATERS OF PUBLIC RELATIONS

By **David Nesseth**

Three municipal experts in navigating the minefield of public opinion on difficult water issues such as lead and per- and polyfluoroalkyl substances swapped success stories during a recent virtual summit organized by the American Water Works Association.

Representing the cities of Halifax, Nova Scotia, Madison, Wisconsin, and Tucson, Arizona, the public relations veterans explored avenues around transparency when water problems are discovered, the delicate art of insistence, and the tug-of-war that exists in the press and social media world. Especially when public fear and safety are involved in issues that are often too scientifically complex for general public dialogue.

For James Campbell, communications and public relations manager for Halifax Water, it was a long journey with the media following a phone call from a *Toronto Star* reporter in March 2018, looking to acquire some raw water data.

Campbell explained that he and his team knew that when it came to something as publicly volatile as lead service

lines, it would be better to sit down with the reporter and work through the complex data, which was ripe for misguided, often negative inferences based on a one-size-fits-all approach.

“Lead service line replacement is a bit of a mish-mash across Canada, and there’s different ways of doing it,” Campbell said during his presentation. “There’s different flushing directions and all number of parameters, so we actually wanted to educate the reporter on how we do that.”

Despite the reporter’s strong initial reluctance to not be given free rein with the data, Halifax Water’s team remained “politely insistent”. Thus began a year-long discussion with the reporter and his colleagues that gave fuller context to the data and illustrated some of the utility’s proactive efforts for years in advance to address challenges around lead.

The *Toronto Star* article went live in November 2019 and “really kind of took the country by storm,” Campbell recalled. While it still painted a “rather grim” picture of lead in Canada, Campbell said it turned out to be “as much of a good story

as it could be” when it comes to something that presents such significant risk to human health as lead in drinking water, and particularly in the case of schools.

“The moral of the story for us was to have a program in place for years in advance, to evolving the program, and pushing that information out to your customers and the media,” Campbell explained. “And when something good or bad happens, you’re already covered.”

NAVIGATING PFAS IN THE PUBLIC SPHERE

In what has become one of the quintessential risk-communication challenges for the present-day water industry, per- and polyfluoroalkyl substances are an emerging concern that every water utility will have to address for the public at some point. Learning that “every compound had at least 20 letters in its name” did not make the public messaging process any easier for Amy Barrilleaux, public information officer at Madison Water Utility.

“When the public sees these words, it’s scary, and they just want to check out,” said Barrilleaux, noting that the utility eventually decided to use the blanket term “perfluorinated compounds”.

In 2017, the City of Madison first detected what have commonly become known as “forever chemicals”, many of which are still commonly used in product manufacturing. Initially, the city found nothing, but soon decided to use lower reporting limits to understand the fuller scope of any potential problem. Their team discovered PFAS in two wells located by an airbase and a landfill. Both wells had levels below the United States Environmental Protection Agency (EPA) thresholds, which meant the city had no obligation to convey the discovery to residents. This began a process for Madison officials in terms of what to do next because people were in fact consuming these chemicals through their drinking water, if only in trace amounts. How transparent did they want to be?

“If this comes from another source that’s not us and people ask, ‘why didn’t you tell us?’, there’s never a good answer to that question,” Barrilleaux explained during her presentation. “We didn’t think you’d care; we thought you might freak out; we didn’t think you needed to know”;

if someone needs to ask you that question, you've already lost their trust and it's really hard to get it back," she added.

Barrilleaux said that erring on the side of transparency is the role of communications for a public utility, daunting as it may be. That is important, as is making complex data accessible as the go-to source for water information.

Firstly, the utility created a basic webpage about PFAS that could help people better understand any possible health advisories. Next, the utility began to work with elected officials to ensure they were aware of and understood the issues. Then, they began to hold public meetings to address questions head on. Part of that process was to begin to practically demonstrate for people something as seemingly abstract as parts per trillion.

In the absence of federal guidelines at the time, some states were starting to take action against PFAS by creating their own standards. New Hampshire and Vermont, for instance, had regulated some of the compounds at levels that would have made one of the wells in Madison non-compliant, recalled Barrilleaux.

"That was the landscape of PFAS, with a patchwork of regulations and no federal regulation," said Barrilleaux, who noted that the well in question, despite being at just 20 parts per trillion, had to be shut down to quell public fears and regain some trust. "When you look hard for PFAS, you're going to find it," she added.

"This is a slow-moving crisis."

'NOT AGGRESSIVE, BUT ASSERTIVE'

For James MacAdam, superintendent of public information and conservation at Tucson Water, the utility had already been working for decades to rebuild trust eroded by past pollution from a local airbase. In the 1950s, the industrial solvent trichlorethylene (TCE) was routinely dumped down drains and infiltrated the water supply. The result was a spike in cancer rates, substantial remediation, and an eventual \$35 million settlement with south Tucson residents in 1989.

With this backdrop, in the fall of 2018 the utility faced a new daunting headline in the *Arizona Daily Star*, which read "Tucson Water mistakenly sent contaminated water to thousands of residents".

The utility had been looking for PFAS in water since 2009 and had even shut down some of its more than 200 wells prior to the story breaking. When the story first circulated, the utility was in the process of systematically comparing its well data against newly-lowered perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) thresholds at the EPA. It discovered PFAS and, to make matters worse, determined that it had been monitoring water from the incorrect pipe.

"Between the history of water contamination in our community, and the journalist involved, our attempt to be proactive with the media kind of backfired.

And it's the beauty of Facebook, where you can take the headline, never read the story and forward it along to anyone you want to," MacAdam said.

MacAdam recalls a conflation of issues with the media's reporting of the PFAS discovery and the mis-located sampling point. The result was fear and confusion, he said.

The approach from the utility was to become even more aggressive from an operational standpoint. Although it had already begun its PFAS response, "it was accelerated by this crisis," said MacAdam, who stressed that Tucson's standards soon joined the most stringent in the country.

From a communications standpoint, the Tucson utility became more "assertive" following the media blitz, said MacAdam, who added fact sheets to its social media pages to clarify some inconsistencies and refute particular claims published in the local newspaper.

"We're very clear and upfront with them about what we're trying to say, and what we're not trying to say," explains MacAdam. "It's an even greater level of transparency with the media, to say, 'look we don't want to say this, because people will misconstrue it as this.' And that's a skill and practice we're all working on." ■

David Nesseth is a writer with Environmental Science & Engineering Magazine. Email: editor@esemag.com



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HAMILTON'S WOODWARD AVENUE WWTP GETS NEW RAW SEWAGE PUMP STATION

By **Bryan Orchard**

The 45-kilometre long shoreline of Hamilton Harbour on Lake Ontario has been at the heart of its surrounding communities for many centuries. Once a pristine source of fresh fish and a place of leisure for the local population, industrialization and the growth of the City of Hamilton have had a detrimental effect on the life of the harbour. By the middle of the twentieth century, decades of toxic sediment, stormwater runoff, habitat loss, water quality deterioration and other factors had caused severe damage to the Hamilton Harbour ecosystem.

In 1987, the International Joint Commission, the organization overseeing the Canada-United States Great Lakes Water Quality Agreement, identified the 500 km² Hamilton Harbour as one of 43 “areas of concern”. Being on a list of locations where environmental degradation seriously impaired the use and environmental health of the Great Lakes was a wake-up call for the city. Over the past few years, significant environmental engineering programs have been implemented, the largest being the multiphase Clean Harbour program.

WASTEWATER TREATMENT PROJECT

In 2008, the city completed the Woodward Avenue Wastewater Treatment Plant (WWTP) Service Area Environmental Study Report, to determine a plan for upgrades to the plant. This recommended investment to manage wet weather flows, provide treatment capacity, and meet treatment objectives defined by the Hamilton Harbour Remedial Action Plan, the Ministry of the Environment, Conservation and Parks and the *Canadian Environmental Protection Act*.

Located near the southeast corner of the harbour, the Woodward Avenue WWTP is the largest wastewater treatment plant in the Hamilton Harbour watershed and amongst the largest in



The new raw sewage pumping station at Woodward Avenue. Courtesy of Reimar Construction

Ontario. The harbour also contains one of the largest toxic sediment sites on the Canadian side of the Great Lakes. Because the plant is the largest single source of water flowing into Hamilton Harbour, the quality of its effluent has a direct and powerful impact on water quality and environmental health. The Woodward upgrade project is a multi-phase, multi-year process, that includes a number of sub-projects, each of which has its own specification and timelines.

Costing \$340 million, upgrades include elevating the plant's final treatment process from secondary to tertiary levels. This increases the processing of the plant's treated wastewater and will allow the plant to reach strict discharge limits described by the Hamilton Harbour Remedial Action Plan for phosphorus, ammonia and suspended solids.

A significant sub-project is the construction of a new raw sewage pumping station and collection system con-

trol to support wet weather and flooding control initiatives. Having an effective pumping station capable of handling current and projected flows is essential to the functioning of the WWTP and the prevention of overflows into the harbour. Construction on the upgrade began in May 2017 and is projected to be completed by July 2021.

WOODWARD AVENUE PUMPING STATION

Now approaching 60 years of age, the existing WWTP has a rated average capacity of 409 million litres per day (MLD) and peak rated capacity of 614 MLD. If this is exceeded, the excess water, being a mix of industrial and domestic waste and runoff from the land, is discharged into the harbour.

To comply with the long-term projected processing requirements, the plant will have a maximum receiving capacity...
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ity of 1,700 MLD. In order to meet this requirement, considerable effort had to be put into designing a highly efficient pumping station, containing pumps with a proven track record in handling high volumes of untreated wastewater.

After due consideration of the various pump options available, Maple Reinders, contractors for the pump station, together with the City of Hamilton selected KSB Pumps Inc.

The design of the existing pump house at Woodward Avenue is rather unusual in that it is a circular construction, containing a circular split wet well located inside a circular dry well. Here, 12 KSB Sewatec K700-950 G1 VGW vertical dry pit solid handling pump sets are installed. The pump house has a total elevation of 81 m above sea level, and at almost 30 m, the subterranean wet well is much deeper than its predecessor. This larger and deeper wet well prevents system flooding and provides increased system storage.

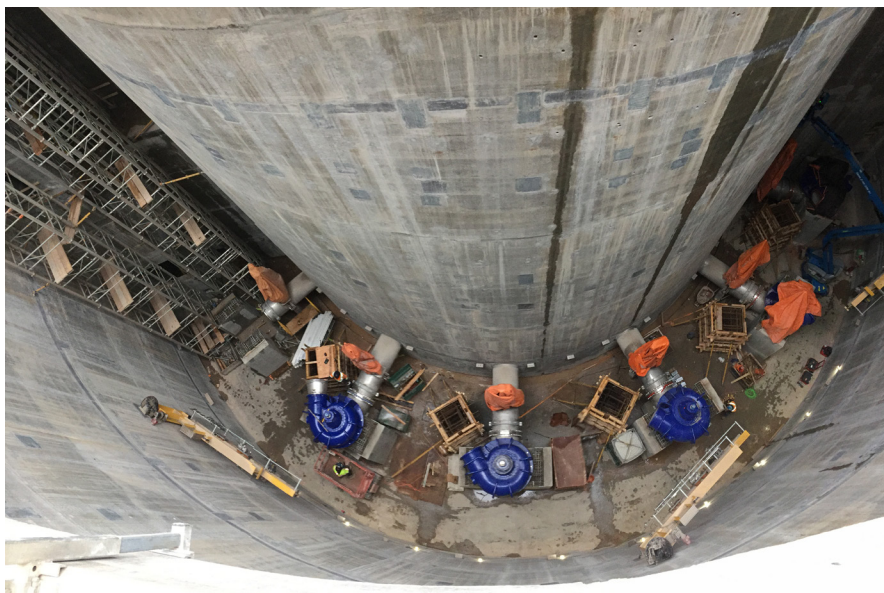
There are several benefits of the wet well inside the dry well configuration. Firstly, dry well pumps, as opposed to wet well pumps, enable easy access to all pump parts for in situ maintenance and repair. When components need to be removed from the dry well, they can be easily craned to the surface. The split wet well design, with six pumps allocated to either side, allows one side to be taken off stream for cleaning, without there being any adverse impact on the efficiency of the pump house.

THE CHALLENGE

With the pump house being of a rather unconventional design, KSB had to address a number of design challenges imposed on the configuration of the pump mountings. Formulating a layout for the pumps around the exterior of the wet well was the first issue to contend with. The answer was differing installation angles of pressure for the connection piece/inlet pipe. This in turn meant coming up with mountings peculiar to the configuration.

For this, KSB provided a tailor-made volute casing for each pump with an integrated mounting flange foot. This allows the pumps to be anchored directly to the cast-in-place foundation blocks.

In order to handle the optimum flow



The pumping station contains a circular split wet well located inside a circular dry well where 12 KSB Sewatec K700-950 G1 VGW vertical dry pit solid handling pump sets are installed.

Courtesy of Reimar Construction

of wastewater through the plant, 10 pumps would be required for full-time availability, and a further two for standby demands. In addition, the pumps had to be collectively capable of handling up to 23,600 l/s and a potential solids content size of 190 mm.

The third significant issue to address was varying flows. At times when the effluent level is low, cavitation has to be avoided. When storm conditions arise, high flows have to be accommodated. By installing four variable frequency drives, all the pumps automatically respond to the incoming flow. Finally, the pumps had to deliver high levels of efficiency.

Being able to handle large solids and control flow velocity gives the treatment plant the opportunity to drain the interceptors for cleaning through the manipulation and control of the interceptor. On the existing plant it is not possible to lower the level in the wet well to control the velocity in the interceptors. Thus, when storms occur, extra inflow and increased velocity result in the interceptors losing the ability to contain accumulated sediment and this passes directly to the headworks, creating an overload condition. With the new pump house design, it will be possible to drain the interceptors as necessary and remove the extra grit load to the plant.

THE PUMPS

All of the vertically mounted Sewatec pumps are supplied with a 15 m long carbon fibre drive shaft, 700 hp motor, split mechanical seal, long 1050 mm x 750 mm radius suction elbow and vibration monitoring system. The smooth-finish reducing suction elbows contain a 200 mm clean out port.

The motors are at an elevated level in the dry well so they cannot be affected by the possibility of flooding from the wet well. Whilst the pump is designed to operate in a dry environment, there is an external clean water flushing line for the mechanical seal. The provision of redundant seal technology adds an extra layer of protection that prevents wastewater getting out of the pump. With a variety of impeller options and mounting methods, the Sewatec pump can transport raw wastewater, as well as thicker mediums such as biosolids/sludge.

“This contract required a combination of high pumping efficiency, good NPSH performance and the ability to deal with solid materials in the un-screened wastewater and storm runoff,” says Marcus Henderson, KSB Pumps Canada regional sales manager. Each of the pumps contains an 898 mm non-clog multi-vane radial flow K design impeller, giving a
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The first of the pumps being installed and anchored to their mountings. Courtesy of KSB Canada.

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The dry-installed pump is fitted with variable-frequency drives, IE4 motors and the optimized hydraulic system yields high efficiency, thereby helping to reduce energy consumption and minimize operating costs. The brief required a hydraulic efficiency of 86%, with KSB guaranteeing 86.97% at the design duty condition. But when submitted to witness testing conditions at the KSB factory in Halle, Germany, the pumps delivered 89.1%, some 2.1 percentage points more efficient than KSB guaranteed, according to Henderson.

For the mechanical seals, KSB worked with a local seal supplier on a special configuration to accommodate the pump installation and shaft. Split mechanical seals were selected and positioned above the bearing housing, thereby allowing them to be accessed and replaced in situ. The dry well design gives the advantage of allowing easy access to both the seals and the bearings for maintenance.

By spring of 2020, construction of the dry and wet wells, including the cast-in-place foundation blocks for the pumps, had been completed and work on the service areas at, and above, ground level were underway. The first of the pumps had been craned into position and anchored to the mountings. Complete installation of the pumps, drives and shafts is expected in early 2021. ■

Bryan Orchard is a technical author and journalist.
For more information visit, www.ksb.com or email:
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REINVENTING THE CHEMICAL DOSING SYSTEM

The **DICE Dosing Module**, by Meunier Technologies, integrates all the necessary discharge components required for a typical chemical dosing system.

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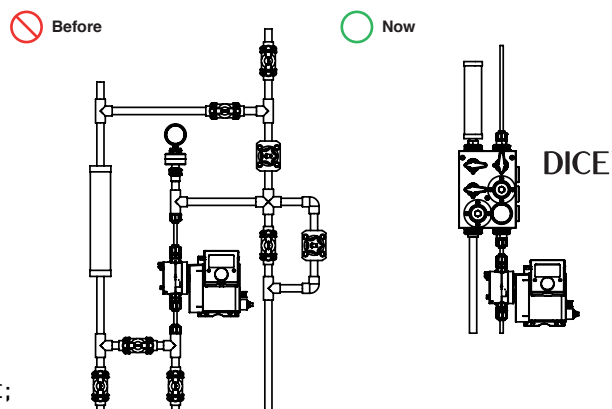
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Technological innovation most often begins with old elements that are fitted for a new purpose. The earliest contaminant vapour barriers were adapted from the waterproofing industry, using high-density polyethylene (HDPE) sheets placed together and sealed with construction tape.

IMPROVING VAPOUR BARRIERS AND INSTALLATION PRACTICES ALLOWS SAFER DEVELOPMENT

By **Hieu Nguyen**

Barriers are commonly used to protect human health by preventing contaminant vapours from entering an occupied space. These volatile organic compounds (VOCs) become airborne by being spilled or leaked into the subsurface and subsequently partitioned into the soil, liquid and vapour phases. In the vapour phase, accumulated VOCs can diffuse into a building's interior through cracks, utility penetrations, sumps or structural weaknesses in a building's foundation. Vapours can even pass through concrete, as it is naturally porous.

The need for vapour barriers emerged

in the early 2000s when regulatory agencies began to embrace risk-based corrective action (RBCA). RBCA was a paradigm shift in the environmental industry, allowing the development of cleanup goals by assessing potential exposure pathways based on current or future property use. In practice, this means that a property with future planned use as a residence will require that VOCs be mitigated to more stringent levels than an outdoor park, based on the duration of potential human exposure to the contaminants.

The shift from uniformly stringent to RBCA-cleanup levels allowed more

soil and groundwater contamination to remain in place, ushering in the development of former industrial properties known as brownfields. As more brownfields began to be developed, and as an increasing number of buildings were built atop known or suspected contaminant vapour plumes, the growing risk of vapour intrusion became a reality that needed to be addressed.

THE ADAPTATION OF WATER VAPOUR BARRIER SYSTEMS

Technological innovation most often begins with old elements that are fitted for

a new purpose. The earliest contaminant vapour barriers were adapted from the waterproofing industry, using high-density polyethylene (HDPE) sheets placed together and sealed with construction tape.

Besides being difficult to install, it was also later realized that the adhesive in the tape being used for attaching the sheets dissolved after contact with chlorinated solvents, benzene and other VOCs. Moreover, the thin HDPE sheets were prone to rapid gas diffusion. Over time, this approach became widely considered as inappropriate for protection against vapour intrusion.

By the mid-2000s, latex asphalt sprays, adopted from the waterproofing industry, came into prominent use as contaminant vapour barriers. These "booting" sprays employed styrene-butadiene rubber (SBR), often applied onto the dirt or a scrim mesh below a new concrete slab or around pipe penetrations.

SBR sprays were meant to seal out water and did so accordingly. However, as SBR is a hydrophobic material, it is also

excellent at sorbing organic contaminants. As a result, over time the VOCs would sorb into the SBR boot and eventually break through, rendering the approach ineffective.

To come up with a better option, scientists worked with a materials supplier to create and launch a composite vapour barrier system that uses HDPE as an outer protective layer for the SBR spray-applied core. These forward-thinkers also developed the first testing methods to demonstrate a level of effectiveness in preventing vapour intrusion, adapting protocols used for personal protective equipment (PPE) testing. At its launch, this composite vapour barrier system, comprising two HDPE sheets sandwiching a spray-applied SBR core, was the best available technology.

Limitations remained in adapting the old waterproofing materials for vapour intrusion, as the SBR material that repels water also sorbs and accumulates VOCs. Contaminant vapour sorption can ultimately lead to breakthrough into an

indoor air space, especially over long periods of exposure at high concentrations. Similarly, while the HDPE protective sheets slowed this process, they failed to offer complete protection, as VOCs could also diffuse into and through the HDPE layers.

INNOVATIONS IN CONTAMINANT VAPOUR BARRIER SYSTEM MATERIALS

In 2015, researchers began evaluating the latest advances in material science to see how they could be used to substantially improve contaminant vapour barrier performance. This research has resulted in two major recent innovations in the building blocks used for contaminant vapour barriers.

It is widely known that aluminum is very effective at stopping the permeation of VOCs. Scientists have developed a base layer comprised of aluminum film inserted between layers of flexible polyethylene with this in mind. The aluminum film results in a base layer component

continued overleaf...



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with 100 times greater chemical resistance against trichloroethylene (TCE) vapours, a VOC and chemical solvent commonly found on former industrial sites, compared to an HDPE-only base layer in the original composite system.

Moreover, this aluminum layer increases the vapour barrier's durability, which helps the vapour barrier system retain its structural integrity, both during and after its installation. Finally, there is no threat of oxidation or corrosion of the aluminum layer, as the other barrier components completely encapsulate it.

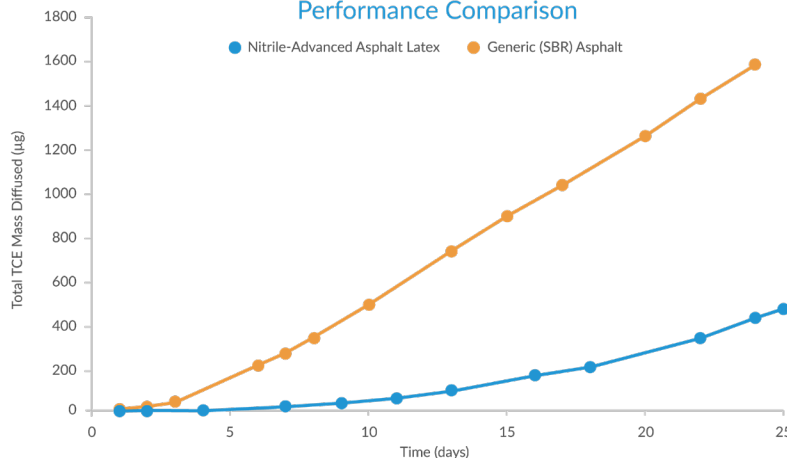
REGENESIS developed a new spray-applied barrier material, replacing the SBR-based latex waterproofing material with nitrile. Nitrile is a key component of chemically resistant PPE used in handling hazardous materials, including the blue disposable gloves that are ubiquitous in the medical industry.

Studies comparing the chemical resistance of the new nitrile-advanced asphalt barrier material to generic latex-asphalt barriers determined the nitrile-advanced asphalt latex material to be 10 times more resistant as a contaminant vapour barrier against TCE.

Besides improved chemical resistance, the use of nitrile in the spray-applied core provided an additional important benefit – the nitrile spray-applied core can be easily cleaned with detergent and water. Unlike the SBR spray-applied latex asphalt core used in the older vapour barrier systems, the equipment used for application does not require cleaning with petroleum hydrocarbon solvents such as diesel fuel. Subsequently, further potential negative effects to properties resulting from accidents or undisciplined cleaning practices are avoided.

This research and subsequent testing of the new contaminant vapour barrier materials has led to the first-ever suite of technologies created for the sole purpose of passively mitigating contaminant vapours. In tandem with the technological advances in the barrier components to improve chemical resistance, scientists also sought to further ensure the best possible installation practices for contaminant vapour barriers.

Nitrile-Advanced Asphalt Latex vs. Generic Asphalt Latex Performance Comparison



Chemical resistance performance comparison of nitrile-advanced asphalt latex v. generic asphalt latex.

IMPROVING CONSTRUCTABILITY AND INSTALLATION FOR CONTAMINANT VAPOUR BARRIERS

Speed to market is an often-used term in many industries, describing the urgency required to bring a new product or service to the market ahead of the competition. The construction industry, functioning as a servant to many other sectors, is inextricably linked to this concept. In brownfield redevelopment, the need for speed is exacerbated by historical contaminant issues. Addressing these can often delay a project, placing added pressure on both property developers and construction crews. A construction site that falls too far behind schedule can foster an environment leading to mistakes and shortcuts.

No matter how chemically resistant, a contaminant vapour barrier will fail if it is not properly installed. Recognizing the risk of non-performance due to improper installation, vapour barrier scientists developed the new vapour barrier technologies to be highly constructible. Furthermore, they created a training and certification program for their installation.

IMPROVING CONSTRUCTABILITY

Constructability is defined as the amount of time and labour required to complete a high-quality installation conforming to the manufacturer's specifications for contaminant vapour barriers. A vapour barrier that is highly constructible can be installed efficiently,

with a minimum amount of labour, and with little chance of sustaining damage during the installation.

Application efficiency, or speed of installation is improved markedly by incorporating spray-applied nitrile-advanced asphalt latex in these newest contaminant vapour barrier systems. Spray-application eliminates the need for taped or welded seams, reducing manual labour and decreasing installation times dramatically on larger projects. Compared to the older and more generic latex asphalt sprays, the nitrile-advanced core material cures more quickly, with the curing time differential more pronounced at lower temperatures.

Quality assurance and quality control (QA/QC) testing can also impact the time required to install a barrier properly. The most common QA/QC test for proper installation is a smoke test. In smoke testing, smoke is pumped underneath the vapour barrier while qualified testing personnel observe the barrier for weaknesses, which will typically appear at barrier seams, perimeter terminations and utility penetrations. Ensuring a proper seal efficiently around these potential weak points can also reduce the time for installation.

Durability is another component of constructability. Durability translates to the contaminant vapour barrier being able to withstand the physical stress of an active construction site. Barriers less than 30 millimetres thick may not endure construction activity; the

more modern barrier systems are substantially thicker. These newer systems also incorporate a geotextile layer to more easily transition from the ground to building surface and reduce the potential for punctures due to barrier contact with rough ground surfaces.

Additionally, the nitrile-advanced asphalt latex has improved tensile strength over the prior core materials used, improving these modern vapour barrier systems' overall durability.

IMPROVING VAPOUR BARRIER INSTALLATION

Over time, best practices have been developed into standard operating procedures to ensure that contaminant vapour barriers will function as intended over their service life. A vapour barrier installation best practice program involves properly training installers on the latest best practices for installation and validating a barrier's proper installation through QA/QC testing.

WHAT TO LOOK FOR IN A VAPOUR BARRIER SYSTEM

Proper training of experienced contaminant vapour barrier installers is equally as important to ensuring long-term performance as the vapour barrier materials themselves. To ensure training requirements are being met, the newest contaminant vapour barrier systems are installed by certified applicators, who are trained by the manufacturer.

QA/QC testing is the only means to document that a contaminant vapour barrier has been properly installed. A passed smoke test provides the project stakeholders with the assurance of its proper installation. Many see it as a necessary test that the vapour barrier must pass, especially considering the emphasis on speed to market within the construction environment. Other in-field QA/QC tests and vapour barrier inspection methods, such as thickness testing are frequently performed as well.

Building type can influence the vapour barrier type utilized (single layer vs. composite systems). These include foundation elements, such as grade beams, thickened slab areas, elevation changes and density of utility penetrations. Some vapour barrier designs are straightforward; others are more intricate and may require specific design expertise to ensure the right technology, or the right combination of technologies, is being employed.

In the field, issues often arise that require experienced handling by someone intimately familiar with the technologies, including their application, specific requirements or limitations, and the many different scenarios on a construction site. All of the latest vapour barrier technologies include technical support from the manufacturer, unequaled in the industry. ■

Hieu Nguyen is with Land Science, a division of REGENESIS. For more information, visit www.regenesis.com

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BELLEVILLE TESTS WASTEWATER ODOUR SUPPRESSANT

City water staff in Belleville, Ontario, have been testing a new odour-control product to break down and control sulfur compounds like hydrogen sulfide and mercaptans that can often fill the air surrounding the city's wastewater treatment plant (WWTP).

Staff invited the public to engage in a "sniff test" of a product called ProSweet at its St. Paul Street building, as the city considers entering into a \$60,000 pilot project to spruce up the neighbourhood's smell, or at least suppress it. Participants were asked to smell the waste material before and after adding the product.

"Everyone noticed a significant difference in the two samples and noted that the H₂S [hydrogen sulfide] scent was nearly undetectable," city staff stated on social media following the event. One city councillor at the event described the odour suppressant product as resembling the smell of hand soap.



Belleville councillor Chris Malette engages in a "sniff test" of ProSweet. City of Belleville.

In wastewater applications, a primary contributor to hydrogen sulfide is the biochemical reduction of inorganic sulfur compounds to sulfide by sulfate-reducing bacteria under anaerobic or low dissolved oxygen conditions.

Products such as ProSweet have become popular as more communities experience vocal contingents, particularly online, rallying against the sulfu-

rous odours at some treatment plants.

"Odour mitigation is one of the priority items to address at the Belleville Wastewater Treatment Plant and there is a specific project included as part of the Master Plan that will be implemented in the near term," city staff wrote in response to one of many community odour complaints filed in the fall of 2019.

In the Belleville Wet Weather Master Plan, various potential approaches were identified by city staff to address odour from the treatment plant, including improved housekeeping and operational adjustments; implementing an odour treatment system; creating odour modification or masking; and changing the treatment process technology.

Some WWTPs have utilized methods such as vanilla-scented misting machines.

"Public complaints about odour can negatively affect an industry's image in a community. Eliminating the odours eliminates complaints, which is an effective public relations policy with far-reaching benefits," states ProSweet's maker, SUEZ Water Technologies & Solutions, in a product statement.

The odour suppressant can either repair the microbial cell membrane to inhibit sulfate transport, or by inhibition of the metabolic pathway in the organism's use of sulfate as an oxygen acceptor. SUEZ also says that in previous applications of its technology, not only the public, but also wastewater treatment plant workers, have enjoyed the benefits of less sulfurous odours on the job.

The City of Belleville is serviced by a communal wastewater system that consists of approximately 200 km of gravity sewer, one major pressure sewer, three main larger capacity pumping stations, several smaller capacity sub-area pumping stations, and a single wastewater treatment plant. It provides secondary treatment and disinfection to wastewater, prior to the discharging of treated effluent to the Bay of Quinte. ■

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ALBERTA TOWN SECURES FUNDING FOR MAJOR STORMWATER PROJECT

The Alberta Town of Coaldale has received new funding towards the next stage of the Malloy Drain implementation project, aimed at combating overland flooding and stormwater capacity that has hurt the area over the last two decades.

As no natural drainage courses exist in the area, efforts have been made to include a combination of irrigation works, constructed drains, roadside ditches and storm ponds to collect and channel the rain and snowmelt runoff.

The three-phase project is the result of extensive study following major floods in 1995, 2002, 2005, 2010 and 2014. Local officials began in late 2015 on Phase 1 for the upgrade of 3,700 metres of drain, replacement of existing canal structures, and the upgrade of a highway crossing.

After flooding in 2002, elected officials and administrators from the Town, County and St. Mary River Irrigation District began discussions on the Malloy Basin drainage issues and MPE Engineering Ltd. was hired to undertake a stormwater study of the basin.

The latest round of funding is for the nearly \$3.1-million Phase 2B of the stormwater project, which consists of three components: repurposing the decommissioned Town of Coaldale water reservoirs for stormwater storage; building a natural fore-bay for stormwater collection; and installing a bioswale and pump to act as a natural filtration system to clean stormwater runoff as it moves into the new storage areas.

"This project is really quite amazing when you think about the scope



Phase 2A of the Malloy Drain implementation project in the Town of Coaldale, Alberta, cost \$5.4 million. Alberta Irrigation Districts Association

and complexity of dealing with this much water," said Cameron Mills, manager of economic development for the Town of Coaldale. "In Phase 2B alone we're talking about storage for 600,000 tonnes of water. This in and of itself is an impressive engineering feat." ■

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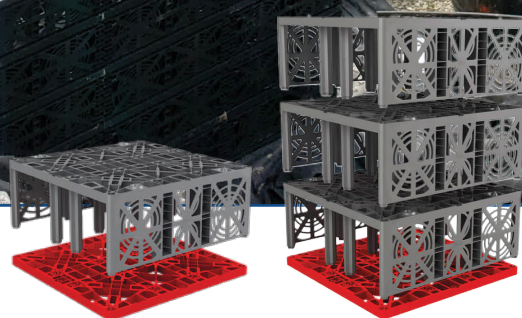


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APPLYING MULTI-CRITERIA DECISION MAKING IN WASTEWATER TREATMENT PROCESS SELECTION



By **Mohsen Barkh**

Engineers know how to design safe systems that will perform properly and achieve their design goals. However, implementing these systems in the real world requires more than a good design. Nowadays, choosing a water or wastewater treatment system is a multi-criteria selection process that involves more than a simple technical or financial evaluation.

Sustainability, expandability, adaptability with new and upcoming regulations, and social impacts of a treatment system are some examples of a long list of parameters that have to be considered and evaluated during the selection of a treatment process.

In the past, project managers and engineers used to apply traditional project evaluation methods such as net present value (NPV), internal rate of return (IRR) and benefit-cost ratio (B/C) calculations to make their final decision. However, it has become evident that

the traditional methods either do not apply to some water treatment projects (i.e., municipal projects) or else lead to unbalanced decisions made based on economic and financial analysis, while ignoring other important parameters.

In general, instead of optimizing results, the aim should be finding a consensus, agreement or compromise amongst all the intervening parties in a project selection. For this reason, researchers have tried to develop heuristic (empirical) methods where finding a compromising solution and not optimality was the goal. This satisfies stakeholders, the public and the environment, by not only choosing the best alternative but also generating a ranking of alternatives.

MULTI-CRITERIA DECISION MAKING

Multi-criteria decision making (MCDM) is a heuristic (empirical) method for selecting a solution that provides the best balance between different criteria and the stakeholders' needs. MCDM provides a ranking system for measuring the overall performance of the discussed solutions and shows the sensitivity of each method to the

changes in the selection criteria.

The first heuristic method for decision-making was developed in Europe in 1965 by Bernard Roy and baptized ELECTRE. It is the French acronym for "Elimination et Choix Traduisant la Réalité" or in English "Elimination and Choice Expressing Reality". After that, several methods such as; "Analytical Hierarchy Process" (AHP) (1980), "Multicriteria Optimization and Compromise Solution" (1980), "Technique for Order of Preference by Similarity to Ideal Solution" (TOPSIS) (1981) and "Preference Ranking Organization Method for Enrichment Evaluation" (PROMETHEE) method (1986) were developed to provide some in-depth and practical approaches to the multi-criteria decision-making process. (Munier, Hontoria and Jiménez-Sáez 2019)

There is a consensus amongst researchers that one method is not better than the other. Consequently, all of them are considered good and adequate for selection. Also, it is understood that there is not a universal method that can deal with any type and size of the problem.

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Dawson City Water Treatment Plant Project Captures Canadian Consulting Engineering's Award of Excellence

Located in historic Dawson City, Yukon, the community's new water treatment plant employs cartridge filtration technology, followed by ultraviolet and chlorine gas disinfection, and features solar photovoltaics and local biomass energy. The selection jury for this award-winning design was "impressed with the simple, yet efficient filtration solution developed by the project team using locally sourced material and trades".

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ing Services it was understood that the “Analytical Hierarchy Process” (AHP) introduced by Saaty in 1980, in conjunction with the Kano Model, could be a useful tool for evaluating water and wastewater treatment projects.

In the AHP method, criteria and their weights will be generated after discussing the importance of each element with the client and other stakeholders. In this method, the generated weights for criteria are used fundamentally to compute the weight of each alternative for the same criteria. To calculate the weight of each alternative, the “eigenvalue” method based on pairwise comparisons among criteria would be used according to the decision maker’s preferences. (Munier, Hontoria and Jiménez-Sáez 2019)

CRITERIA SELECTION

Although the main criteria are determined by the stakeholders and particularly based on the client’s preference, it doesn’t mean that all of them have sim-

ilar impacts on stakeholder satisfaction and they should be treated equally. Noriaki Kano developed a methodology known as the Kano model, to determine the impact of different criteria on customer satisfaction.

The Kano model classifies the important criteria into three distinct categories. Each category of criteria affects clients differently (Kurt Matzler 1998), (Chun-Chih Chen 2008).

1. The “must-have” or basic criteria. In this instance, clients become dissatisfied when the performance of any criterion is low, or the product attribute is absent. For example, if the treatment technology could not meet the treatment target or the flow rate is insufficient, the client becomes unhappy and dissatisfied. However, client satisfaction does not rise above neutral with a high-performance product criterion. Such criteria are shown in the decision making matrix as an essential (or must) category.

2. One-dimensional or performance

criteria. Here, customer satisfaction is a linear function of a specific parameter performance. High attribute performance leads to high customer satisfaction and vice versa. In water treatment projects, often the one-dimensional criteria are operating and capital (or rental in case of a temporary facility) costs which have an inverted relationship with client satisfaction.

3. Attractive or excitement criteria. In this situation, client satisfaction increases linearly with increasing attribute performance. There is not, however, a corresponding decrease in client satisfaction with a decrease in criterion performance. Examples of these criteria are productivity, modularity, operability and so on. These criteria are identified as criteria that do not belong to the other two categories.

DECISION-MAKING PROCESS

In the Kano model, the “weight” and “raw score” are two different sets of values
continued overleaf...

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that will be normalized in the decision making table between 0 and 10. As was discussed in the previous section, the “weight” of each criterion would be determined after consulting on the importance of the criterion with the client and other stakeholders. The low value of the parameter represents the decreased impact of the parameter on the client’s decision and visa versa. Therefore, the weight values in this method show the client’s preference and point of view for every criterion.

“Raw score” values, on the other hand, are provided by the experts from the water treatment team, based on their experiences and understanding of the criteria for the selected technology. Values in the “weighted score” columns are the product of the “weight” by “raw score” for each criterion. The “weighted score”, for the least important parameter, could be as low as zero (the parameter should not be considered at all) or as high as 100

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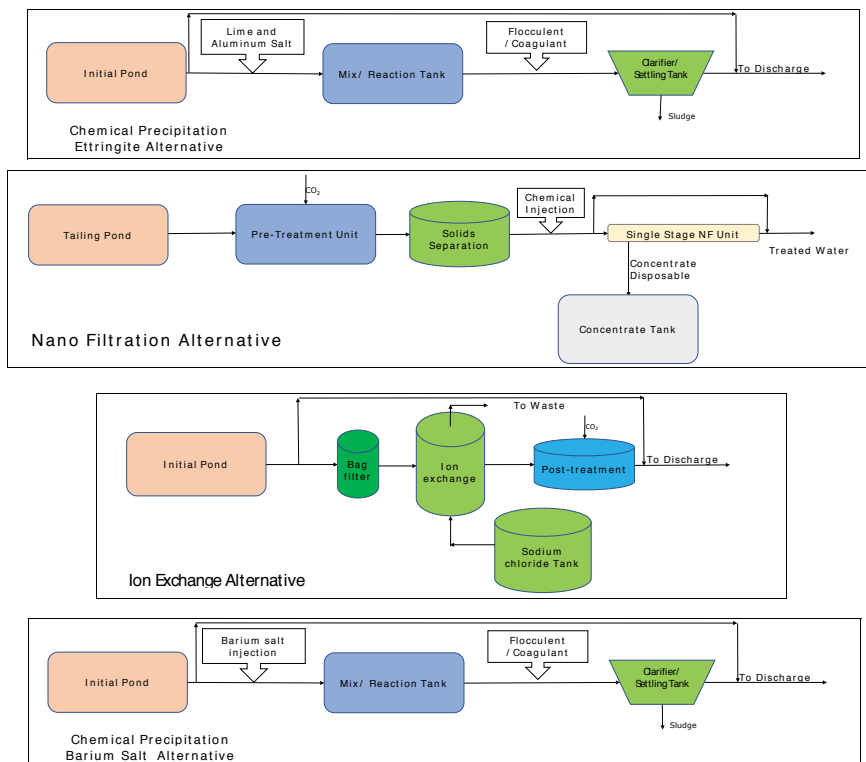


Figure 1: Block flow diagrams for treatment alternatives.



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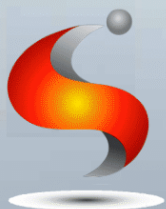
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Treatment Alternatives	Alt. 1-Prec.Ett.	Alt. 2-NF	Alt. 3-IX	Alt. 4-Prec.Ba
CAPEX				
Raw Score	9.9	7.3	8.4	9.9
OPEX (Estimated per Year)				
Raw Score	4.7	9.9	8.4	0.9

Table 1: Raw scores of capital and operating costs.

for the most important parameter.

Values in the total weighted score are the sum of the weighted score for each alternative. The treatment alternative with the highest total "weighted score" (rank) would be the most desirable alternative which could provide a solution with the highest balance between different criteria.

CASE STUDY: SULPHATE REMOVAL FROM A TAILINGS POND

The initial concentration of sulphate (1,779 mg/L) in the water of a tailings pond needed to be reduced to less than 1,000 mg/L before discharging to the environment. Sulphate could be removed using chemical precipitation (CP) by either barium salts (Geldenhuys 2003) or sodium aluminate in the ettringite process (Tolonen 2016), ion exchange (IX) technology and membrane technology (Lopez J. 2018). Therefore, it was decided

to investigate CP and IX processes by conducting laboratory-scale process development tests and membrane technology (in this case nanofiltration (NF)) by running a computer simulation.

Bench-scale tests showed that using 3.75 g of barium hydroxide per each litre of water could precipitate up to 97% of sulphate and reduce the sulphate concentration to less than 97 mg/L in 30 minutes. Also, the optimum dosage of sodium aluminate for the ettringite process was determined as 0.668 g per each litre of feed water to remove 98% of sulphate in 60 minutes.

The IX tests showed that a small volume (100 mL) of a proper ion exchange resin could treat at least 18 L of the feed water and produce treated water with less than 1,000 mg/L sulphate concentration. Computer simulation of the NF process presented that NF could pro-

duce treated water with a very low concentration of sulphate.

Since all of the selected technologies had high removal efficiencies, a bypass line for combining treated water with feed (untreated) water was considered to maximize the volume of dischargeable water with acceptable quality. The technical detail of process development tests and basic design was presented in the 2019 Perumin conference (Zeballos 2019).

Figure 1 shows block flow diagrams (BFD) that were depicted based on the conducted tests for two chemical precipitation processes, ion exchange and modelling for the NF membrane. The BFD and lab information about the reagent consumptions and operating conditions were used to estimate operating cost of each treatment alternative.

Equipment sizing was completed based on each alternative removal efficiency and the volume of feed stream which could be blended with treated water before discharge. The capital cost of each treatment alternative was estimated by using available quotations from different suppliers.

Operating and capital costs should have been reported in a suitable format

			Alt. 1-Ett.		Alt. 2-NF		Alt. 3-IX		Alt. 4-Prec.Ba	
			Prec. Ettringi		NF		IX		Prec. Ba	
"MUSTS" - Essential Criteria			Yes/No?		Yes/No?		Yes/No?		Yes/No?	
1	Technically Viable?		Yes		Yes		Yes		Yes	
2	Well Proven Technology?		Yes		Yes		Yes		Yes	
3	Safe?		Yes		Yes		Yes		Yes	
"WANTS" - Desirable Criteria		Weight	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
1	Complexity	5	9	45	5	25	8	40	9	45
2	Space Constrains	7	4	28	5	35	5	35	4	28
3	Reliability	6	5	30	5	30	5	30	5	30
4	Constructability	5	4	20	6	30	6	30	4	20
5	Operability	8	8	64	6	48	7	56	8	64
6	Maintainability	8	7	56	5	40	8	64	7	56
7	Modularity	6	3	18	7	42	6	36	3	18
8	Project Schedule	6	4	24	5	30	5	30	4	24
9	Solid Waste management	7	6	42	5	35	7	49	6	42
10	Waste Stream Management	7	3	21	9	63	9	63	5	35
11	Maturity of the Technology	10	6	60	5	50	6	60	7	70
12	Staff Safety measures	8	7	56	7	56	7	56	7	56
13	Skilled Operators	5	7	35	6	30	6	30	7	35
14	Electricity Requirement	7	7	49	5	35	8	56	7	49
15	Chemical Requirement	7	3	21	6	42	4	28	2	14
16	Lack of Logistic Risk	10	5	50	9	90	0.5	5	5	50
17	Capital Cost	10	9.9	99	7.3	73	8.4	84	9.9	99
18	Operating Cost	8	4.7	38	9.9	79.2	8.4	67.2	0.9	7
TOTAL WEIGHTED SCORE				756		833		819		742

Table 2. A decision making matrix, includes weight and score values for essential criteria and desirable criteria.

for the decision-making process. One of the best methods for reflecting the impact of the costs in the multi-criteria decision-making matrix was normalizing the values to a raw score between 0 and 10.

In this case, similar to the previous work (Mohsen Barkh 2018), the values were normalized between 0.9 and 9.9. Since the lower operating and capital costs were more favourable, 9.9 was allocated to the lowest cost, while the highest cost corresponded to 0.9 and the rest of the values distributed between those numbers proportionally. Table 1 shows the calculated raw scores for operating and capital costs of the different treatment alternatives.

CRITERIA SELECTION

The first step of the MCDM process was to contact the stakeholders to discuss the desirable criteria and their weight. The three basic criteria ("must-have" in the Kano model) were easily selected as "viable technology", "proven technology" and "safe technology". If the technologies were not safe or viable the stakeholders did not want to apply them. Also, the stakeholders were not interested in spending money on unproven technology and carrying additional financial risks.

Due to the social impact of the mine on neighbouring communities, there was a history of conflicts about the access road to the mine. For that reason, the stakeholders preferred to operate a treatment process with minimum dependency on the raw material and minimum risk of logistic issues. Therefore, the logistic risk was introduced to this case study, based on the client's request.

Operating and capital costs were identified as one-dimensional criteria with an inverse linear impact on stakeholders' satisfaction. An increase in either operating or capital costs would reduce stakeholders' satisfaction. For this reason, the highest raw score was allocated to the lowest cost and vice versa.

Results showed the most important "attractive or excitement" criterion for the stakeholders after the capital cost was the maturity of the treatment technology, followed by the maintainability, safety and operating cost. In this particular case, due to the availability of skilled workers

Continued on page 37



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THE PROJECT DELIVERY PROCESS HAS SUDDENLY BECOME MUCH MORE COMPLICATED



By **Rui De Carvalho**, R.J. Burnside & Associates Limited

It's a safe assumption that virtually everyone has been impacted to various degrees by the ongoing COVID-19 pandemic. In a word, it has been a game-changer. This unprecedented world event has forced all of us to quickly adapt in so many ways. The most significant is the requirement for physical separation and in the manner that we now must interact with others outside our immediate household.

When the mandate for lockdown was announced by the provincial government in Ontario in March, the consequences propagated throughout all aspects of our society and of course in the workplace. The designation of engineering services as an essential service effectively told us: our services are needed, you are engineers, so figure it out!

As was the case for most businesses that were to continue to deliver services, consulting engineers had to scramble to address issues, not only those relating to the sustainability of their business, but also on the long-established mechanics of delivering projects.

Project delivery, although not the formal definition, can perhaps be described as a complex series of interactions and activities involving a group of people that come together to accomplish an objective.

There are many players and aspects involved in these interactions. We do know, however, that the fundamental ingredient that makes this complex system work in an efficient manner is effective communication, not only among the internal and external members of the team, but also with the client and stakeholders. Unfortunately, a "human touch" is something that we engineers are often missing. I am referring to the need for effective human/social interaction that is always required and that engineers are characteristically poor at doing. In my opinion, this is already a challenge for most engineers at the best of times and, of course, greatly aggravated by the isolation and virtual communication.

For example, a project manager might coolly say: "Good morning Joe. How's that task coming along? Are you going to be finished on Friday as I had promised the client?" Whereas a more social approach would be to say: "Good morning Joe. How's it going? How was the weekend? How are you feeling these days trying to manage the kids and working from the kitchen table? Is there anything that we can do to help out with? So, do you think that we will still be able to meet that deadline of Friday? Sure hope that we can!"

The mandated lockdown came upon us without any time for

preparation, so this already complex process suddenly became that much more complicated.

Those of us that have worked internationally were quick to realize that those unique experiences provided us with a tremendous head start to the quick adjustment that was necessary in view of the unprecedented reality that was now upon us.

Those varied and unique experiences were obtained by working from distant hotel rooms, airport and hotel business centres, and often in very minimally equipped client and construction site offices. There were prolonged stays of weeks in locations where the Internet connection (when it worked) would be just a bit better than the old "dial-up". On project sites in sub-Saharan Africa, most of the project team was often completely remote and dispersed over several time zones.

There is actually a lot more space on that living room table that we rely on now, when compared to those distant project outposts, when one had to share the already small space on the same desk with another colleague.

Our international clients, funding entities, project executing agencies and other collaborators would also interact in the same manner. For many years, before the likes of WhatsApp came on the scene, email was the team's main collaborative platform, along with expensive long-distance telephone calls. Where the connection was somewhat more robust, there was Skype, perhaps with some choppy video.

The remote work conditions going forward here at the end of March were a whole lot better. We worked together and soon realized in those last days of March and into April, effective and efficient virtual collaboration on projects was definitely possible.

There were embarrassing lost connections during client meetings and we have also seen examples of the lighter moments when a member of the family suddenly appears in the background or perhaps the cat decides to walk across the keyboard. We adapted very quickly, and for the most part connectivity is now quite good, enabling modern day platforms such as Teams, Zoom and cloud storage to function well.

Unfortunately, the one weak component that has not kept up with all of this technology remains the human element that is in all of us. We are social beings, not particularly well adapted to working solo, day in and day out from the dining room table or even from the most well-equipped home office. Pixels on a Teams meeting can do the job for a time, but a collection of dots is definitely not a person! In time, we very much will need to return to some mix of both physical and virtual interaction.

Although the time and efficiency in adaptation varied for all of us, in part somewhat dependent on the degree of individual technical savviness, consulting engineers and our clients are

resourceful. For most, the ramp-up to the virtual collaborative platforms was relatively quick.

Nearly the entire year has gone by and we are now well into the so-called second wave of the pandemic. Consulting engineers, clients, agencies and other stakeholders continue for the most part to function well, working much differently than we were eight months ago. Projects continue to be delivered with success and we are getting better at this.

We have also discovered new efficiencies. The volumes of used printer paper in the recycle bins have decreased significantly for various reasons, and perhaps we have now discovered the real meaning of “print only when absolutely necessary”.

There is also an altered shift in the expectation and acceptance of the format of deliverables, from paper to the portable digital format. With the exception of those that continue to be involved in site works, most of us no longer spend hours on the road and in traffic to attend a one-hour meeting.

The schedule of the work day has now changed, because most of us are not spending hours each day trying to commute to the office. There may now be a fine layer of dust on many meeting room tables. Those of us working on international projects may need to be at our desks at 2:00 a.m. for a client presentation, or for a collaboration meeting on project details with our local partner.

But, we are also not having to endure a 14-hour plane ride and everything else that goes with such trips.

Given all of the new experiences of the past months that a global pandemic indirectly forces upon society, and the very significant shift in approach to the delivery of projects, the question becomes: how will the overall dynamic of project delivery fundamentally change post-pandemic?

Most of us are realizing that there are several aspects in our personal lives that may have altered indefinitely. It would also be very reasonable to conclude, therefore, that there will also be a significant and permanent shift in the overall paradigm of project delivery that will set the way forward.

Because we are human beings, my assumption is that most of us definitely look forward to resuming a good measure of in-person interaction. This includes having a coffee or a lunch, shaking a hand, looking at someone in the eye from a distance of less than two metres.

At the same time, I believe that for many, we may have seen the end of the five days each week in the leased office work space, the end of often inefficient numerous in-person meetings and the travel that may be necessary, and the end of producing volumes of project documents for physical distribution. Some of these may never have been taken out of the shipping box. Many aspects of project delivery have changed indefinitely.

There are other aspects that will also change the dynamics of our project teams and, for that matter, of our clients as well. There will be a significant increase in the mobility of professional staff, because the geography of where

one lives and works has become far less significant.

With all of this, one wonders if the fundamentals will remain. I believe that we will still need continued development of effective interpersonal skills, including our ability to better integrate the physical interaction with the virtual. This will continue to facilitate our ability to engage with others as we go forward from this unprecedented period. We must continually adapt to change and I am confident that we can do this. ■

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WHY KEEPING A NOTEBOOK CAN HELP YOUNG ENGINEERS BECOME RELIABLE AND PROMOTABLE



By **Pat Coleman**, PhD,
C.E.M., P.Eng., Stantec

We take notes to record and comprehend what is said or what we read. The last part, to comprehend, is essential. When we engage with others or read written material, we must think critically to dive below what was said to what was meant.

The first thing you need to do while listening is to take notes. They are not just a record, but also are a means not to have the same conversation twice, can be used to track the evolution of an idea or decision, free your mind to be articulate, build trust and maintain your focus.

Notes are the simple way to ensure everything is captured. Not just facts, but also the understanding. I learned in my career that an engineer who keeps good notes can be relied on and promoted. As such, I offer the following advice to young engineers.

Buy a notebook, put your name on it and carry it with you. Write down whatever you think is essential because you will forget. Put the date when you made the notes, where you are, and possibly who you are with. A note can be a diagram, a list of items, a calculation, or a mind map. If you have a business card or a slip of paper you do not want to lose, tape it into the notebook. When you have time, number the pages and create a table of contents. If you are given a task to do, note that with a mark in the contents table.

A notebook is not a diary or a day planner. A diary is to plan and then record how you use your time. A notebook is also not a scratch book. A "scratch" book may be an electronic or paper document where you record items you want to note in your daily summary. For example, "Told JB that we need to follow up with the client on the request for..." or "AG called, asked for a copy of our proposal for..."

LAPTOPS

Many educators discourage using laptops to take notes because a person can use a computer to record but not think. Many companies discourage laptops in meetings because they also distract, the screen creates a barrier, and people are tempted to multi-task. If you must bring a laptop, turn off all sounds and explain to your colleagues why you brought it. Tablets lying flat on the table so that others can see your screen are acceptable, provided you only use them for taking notes.

NOTE-TAKING

Note-taking can take many forms. The four most common are Cornell, Outline, Box/Bullet, and Mapping (e.g., mind mapping). You may switch forms depending on what you are reading or the meeting you are attending. The following advice on note-taking applies to all four methods:

- Do not write down every word. You are a participant, not a legal stenographer.
- Decide, while taking notes, what is important.
- Be an active listener, ask questions and then make notes.
- Use shorthand techniques (e.g., symbols, abbreviations).
- If you are inclined, use colours (e.g., different coloured pen or a highlighter).
- Review notes as soon as possible after you have taken them. Follow up if necessary.
- Be consistent.
- Spelling and grammar are not as necessary as clarity.
- Improve your handwriting (e.g., use a good pen, relax your grip, and practice).
- If you copy verbatim, make sure that is noted so that you can attribute the source and not be accused of plagiarism later.

If you are asked to take minutes, then you need to focus on recording decisions, assigned actions, and other important information. Your role as a scribe may limit how much you participate in the meeting.

CORNELL METHOD

Walter Pauk, an education professor at Cornell University, devised what is now called the Cornell Note-Taking System in the 1940s. The three critical elements of the system are observe, record and review.

I use the Cornell system, described below, during meetings, talking to someone in my office, watching a webinar, reading a paper, or attending a lecture:

- Before the event, split your page into three sections.
- During the meeting, make notes in the note-taking column on the right. You may add keywords or icons in the right hand "cue" column. If you are assigned an action, put it in the summary box at the bottom of the page.
- After the meeting, review the notes, add comments that clarify meanings, reveal relationships, establish continuity, and identify gaps in your understanding.
- Review both the cue and notes columns and write a short sentence in the bottom section capturing the main ideas that you need to remember going forward (e.g., "the review time for a report is now three rather than two weeks.").
- On the page following your notes, you may decide to write a summary with some reflections.
- Create action items. For example, you think you need to learn more about a topic discussed or ask a colleague about something they said in the meeting.
- Move your action items assigned to you and the ones you created to your to-do list (in your diary).

THE DAILY SUMMARY

The daily summary should conclude with an allocation of time to projects and tasks. Using your calendar, notebook, and scratch notebook, write a short summary of your day before leaving your desk. You can also use this time to gain perspective on the day and create the emotional space to engage with people after work. If you train your mind that you do not need to remember a concern once it is written

down, you can free up that part of yourself for something else. When you come to work the next day, you can open your book and start the day with a fresh perspective and a positive attitude.

Ignatius of Loyolla, an early 16th century Catholic saint, gave his followers good advice we can apply today. I will paraphrase. At the end of the day, before you leave your desk, open a new page in your notebook and do the following:

- Review and summarize your day. Allocate time to tasks or projects.
- List at least a few things you are grateful for (e.g., my boss thanked me for my contribution; I solved a problem for someone).
- List what you did well (e.g., I stayed focused all morning; I learned to use MS Teams with OneNote).
- List any concerns you have (e.g., I do not understand why the meeting we had did not go well, my chargeability is low).
- List what you think you will do differently tomorrow based on what you

learned today (e.g., I am going to set my phone alarm to do stretches every few hours at the desk, because my neck hurts at the end of the day; I will talk to my boss about how I can get more work.)

- If you need help, write down what you think you need and from whom.
- Set goals for the next day (e.g., I will finish my calculation on the pump sizing).

Now it is all written down, so forget about work and go live your life. You can pick it up tomorrow.

SUMMARY

The engineers I learned the most from kept notebooks, an inexpensive device that never ran out of power or struggled for an Internet connection.

Thomas Edison used over 2,500 notebooks. Darwin kept two journals, one where he recorded whatever supported his theory and the other one, whatever called his approach into question. They returned to their notes many times. They analyzed what they wrote, sifted through

what they learned, and then decided what they should do next. Engineers need to do the same. We need to page through our notes and ask ourselves:

- Is the information we received accurate and contains the necessary?
- Have we considered what is relevant?
- Do we understand complexities and interrelationships?
- Have we consulted widely and synthesized what we learned? Is what we decided defensible and grounded?

The last word I will give to Jack London: "Keep a notebook. Travel with it, eat with it, sleep with it. Slap into it every stray thought that flutters up into your brain. Cheap paper is less perishable than gray matter, and lead pencil markings endure longer than memory." ■

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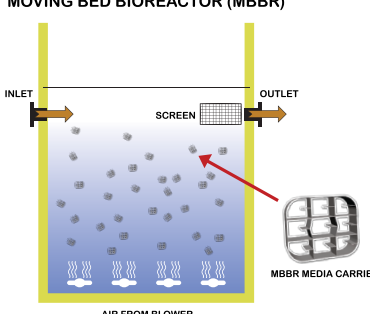
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CONSIDERING ALL THE IMPACTS OF THE PANDEMIC ON THE CONSULTING INDUSTRY AND CLIENT RELATIONS



Ken Campbell, P.Eng.,
ICD.D, R.V. Anderson
Associates Limited

When COVID-19 hit Canada in March of this year, many in the consulting engineering business had never heard of Zoom. Web-X meetings had to be set up by one of our administrative staff, and we watched teams play sports, rather than do our work on Teams. Working from home was something only a few of us did, and the daily commute was a normal part of life.

This has all changed. While some impacts of the pandemic have been negative, it is remarkable that some impacts on our business have been positive and hopefully will become permanent.

Since March, many consultant staff have been working from home. Most proposal and project meetings have been held virtually. Design and drafting work have continued. Construction site inspection and designer site visits have continued, but most construction progress meetings are held virtually. Clients have continued to release requests for proposal and awarded new assignments. Most consultants have been able to utilize new communication technologies to adapt and continue to deliver services, in many cases almost “seamlessly”.

POSITIVE IMPACTS

An informal poll of staff at R.V. Anderson Associates (RVA) showed there have been some positive impacts. There has been a savings in business travel time. One senior engineer says he is saving two hours a day on average, by not driving to client, construction and business development meetings. The saved time means he gets more done at work and has more time for himself and his family.

Others have said working at home has been great and saved them hours of commuting every day. That results in less

stress, reduced travel expenses and less negative impacts on the environment.

Virtual meetings can be more flexible as individuals with specific information or expertise can join the meeting for short periods as needed and computer screens can easily be shared. All participants can better access their own files and can quickly locate photos, drawings or other resources to share in the meeting. Participants can send emails or texts to non-participants to get quick answers to questions that arise during the meeting.

People are generally more available. It used to be that engineers were always out on the road, and it could be difficult to get a group of them corralled for a meeting. Now, meetings can often be organized within a day. Even when individuals are participating in a virtual meeting, they can usually respond about their availability for another meeting or call later in the day. Project roadblocks can be dealt with faster.

Interestingly, virtual meetings tend to start on time. There is less time waiting for stragglers to arrive. Participants aren't stuck in heavy traffic, or don't get “ambushed” by someone anxious to speak with them on their way to a meeting room.

In general, most staff are happy with some of the changes, and the consulting industry has been able to continue to deliver its work on time and realize some efficiencies through the move to remote work.

NEGATIVE IMPACTS

Unfortunately, there have also been some significant negative impacts caused by the shift in how consulting work is done.

For some, working from home can be a challenge. Staff with young families face a heavy burden of struggling to keep youngsters occupied, while trying to focus on challenging project issues. Some young parents miss their commute, where they had time to mentally “shift gears” from work challenges to home challenges. Some staff have lim-

ited home workspaces and much prefer their office workstation. Some staff don't get out of doors and struggle to get exercise or even a little fresh air.

Staff cut off from the office are also cut off from social connections. This is especially challenging for new staff. RVA has some new employees who have never met any of the people they work with, except through virtual meetings and calls. Getting to know the team and building positive collegial relationships is certainly a challenge for them.

Client relationships can suffer with the lack of in-person client meetings. Small talk, sharing coffee and muffins, having a working lunch, or just talking about items of personal interest is difficult at a virtual meeting. With less positive relationships, it can be harder to collaborate and more difficult to work through project challenges or conflicts. Lack of in-person construction meetings can have the same negative impact on relationships between consultant, owner and contractor staff.

Online meetings have other drawbacks. Sometimes, too many meetings are called. Sometimes, staff mute their microphones, do other work and don't pay attention. Sometimes, poor Internet connections can make meetings less successful. Sometimes, at large virtual meetings people are too shy to speak up. Meeting chairs need to be better organized and conduct their meetings in a more structured fashion in order to get full input from participants.

Online training is useful, but the loss of in-person professional development activities is a big negative impact. Technical seminars and conferences are key opportunities for staff to meet clients, learn about projects going on in their technical area, chat with suppliers and even compare notes with competitors.

These kinds of events help younger staff to recognize and get excited about their important role in society, contributing to safe roads, safe drinking water, a cleaner environment, healthy communi-

“When the pandemic starts to fade, consulting engineers, their clients, suppliers and contractors will have opportunities to make permanent improvements in staff working environments and development.

ties and a modern, efficient economy.

The most important aspect of professional development is on-the-job training. While virtual meetings and screen sharing help, there is nothing that beats two or three people sitting or standing around a table and grappling with a problem. In the virtual world, it's not easy to “walk down the hall” and ask for help. In a virtual world, you also can't overhear a conversation in the lunch room or hallway and offer ideas from your experience that could help solve a problem. So far, the virtual world simply doesn't replace a buzzing, energetic office environment.

RECOMMENDATIONS FOR THE FUTURE

We all hope that successful vaccines will be available soon and that the world can put COVID-19 behind it. When that happens, there are some important things we have learned, and some changes that should become permanent.

We have proven that working from home can be effective. We need to be open to allowing members of our workforce to continue with this arrangement. At the same time, we need to recognize that working in the office helps create a positive social environment, helps new staff get to know people and the organization, and is a better way for active on-the-job training and collaboration. We will need to find a new balance between these two options.

Clients and consultants need to use more virtual meetings than they used pre-pandemic. Routine meetings held virtually can be just as effective, save a lot of time and help the environment.

Proposal call meetings, routine project meetings, routine construction site meetings, and even some public consultation meetings where there are not significant public concerns are candidates for virtual treatment.

At the same time, all key meetings should be in person. These include project or construction start-up meetings where teams can get to know one another; key workshops where important decisions need to be reviewed and discussed; and meetings to discuss challenging issues or conduct negotiations.

We need to optimize the “culture” of virtual meetings. Meeting chairs need to be better organized and more directive. One of our project managers asks that people use the video feature for her meetings whenever possible. That way she can read faces, have better interactions and get to know people a little better. People on video are also less likely to be distracted by other tasks. We also need to get better at not talking over one another.

When the world returns to normal, all employers need to strongly support participation in seminars and conferences. We need these to keep building enthusiasm for our various technical areas and broadening our staff's knowledge.

In the future, we shouldn't need a pandemic to embrace technological advances. We need to continually be finding new ways to use technology to increase efficiency in all our operations - consultants, owners, suppliers and contractors.

The COVID-19 pandemic has been a tragedy for many in our world, but it has had both positive and negative impacts on the work of consulting engineers. When the pandemic starts to fade, consulting engineers, their clients, suppliers and contractors will have opportunities to make permanent improvements in staff working environments and development, as well as improvements to efficiency and our overall contributions to our economy and country. ■

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One of the more pressing concerns is that many of the challenges that exist for women only arrive after they've already landed a job. Monkey Business, Adobe Stock

OSPE WORKING TO WELCOME NEXT GENERATION OF WOMEN ENGINEERS WITH OPEN ARMS

By **David Nesseth**

An online signature counter is ticking away as engineers from across Ontario join the call to action for more inclusion and diversity in the male-dominated sector.

The new real-time ticker sits on the Engineering for Change website (www.engineeringforchange.ca), which lets virtual signees tweet out support under the hashtag #engineeringforchange. The site's owner, the Ontario Society of Professional Engineers (OSPE), hopes to gain 10,000 supporters who say their arms are open for the next generation of talented engineers, no matter who they may be.

Joining the cause is critical, OSPE leaders say, if the engineering community wants to end the journey down a path where just 32% of Canadian-trained women with engineering degrees actually put their talents to use.

"Women and other underrepresented groups are being held back from contributing to the vital work Ontarians need them to do," says current OSPE President and Chair, Réjeanne Aimey, who worked as a mechanical engineer in Ontario's automotive and nuclear industries.

DIVERSITY AWARD

While women's presence in fields such as business, law and medicine have nearly doubled over the last 30 years, engineering remains somewhat uncharted territory. OSPE believes that a key component of potentially altering this course could come through a plan based more in action than rhetoric.

One of the first tasks on the list will be to shed light on OSPE members who are already making real systemic change. These individuals will be featured under a Diversity and Inclusion Champion

Award in the years to come.

Following that, OPSE has its eyes on a summit with all Ontario engineering leaders to develop an industry-wide solution to barriers faced not only by women, but also the persistent gaps in data about the numbers of black, Indigenous, LGBTQ2+ persons, and persons with disabilities working in the sector.

Over the last five years, OPSE has often trained a spotlight on engineering's gender gap, formulating hard data like the fact that the number of women working in engineering over the last decade has increased by just 2% in Ontario.

It's a number OPSE leaders refer to as "dismal". Other findings have been stark and plentiful, but perhaps only add to what is an extraordinarily complex puzzle.

Nationally, 17.4% of newly licensed engineers were women in 2017, according to Professional Engineers Ontario. Of 14,905 engineering degrees awarded nationally in 2016, just over 19% were to women. This is despite the fact that women represent a strong majority of young university graduates in Canada, and that the number of female students applying for engineering programs in Ontario has tripled since 2005. But the more critical number of engineering license holders has barely moved.

FEMALE FACULTY MILESTONE

In science, technology, engineering and mathematics (STEM), the largest percentage of women typically pursue life sciences, while engineering often draws the fewest female candidates. Studies suggest that it could be anything from societal attitudes about what is considered appropriate for girls and women from a young age, to a culture within engineering where there is a distinct lack of visible role models. Female faculty in engineering programs can often be few and far between as well.

On that front, a marker of change did occur at Montreal's Concordia University just two years ago. For the first time in Canada, a faculty of engineering was named after a woman: The Gina Cody School of Engineering and Computer Science. Cody, who grew up in Iran, where women now make up more than half of the students in computer science

and engineering, donated \$15 million to the school.

"The goal is that in 10 to 15 years there will be so many examples like me that I am forgotten," said Cody, the first woman to graduate with a PhD in building engineering from Concordia. "I hope there will be so many women in science, engineering and technology that it's no longer an issue and that it becomes the norm," she added.

Support networks have been springing up all over the province. The Ontario Network of Women in Engineering (ONWiE) was formed in 2005 to support current female engineers and students alike. In 2019, the group hosted a two-day summit with Hamilton's McMaster University to help frame engineering in a more "female-friendly way", engaging more young women through a kind of rebranding of the sector.

"Engineering is about changing the world, and that's a message girls need to hear," stated a press release for the event. "Research has shown that female students are more attracted to careers that have a positive impact on society."

OSPE has also designed a successful pilot mentorship program that ran from 2015 to 2017. It resulted in the launch of 90 mentoring relationships, pairing participants from over 23 communities across Ontario. According to one protege, "after meeting with my mentor and taking her advice into consideration, I have overcome my fears and self-doubt issues. I have always used her advice when I run into conflicts. She inspired me to stand up for myself and be confident of the work that I produce." One of the highlights of the pilot program was the formation of an Ottawa Women in Engineering group.

OSPE's new plan supplements other ongoing plans in the industry such as the modest 30 by 30 goal set by Engineers Canada to increase the number of newly licensed female engineers to 30% by 2030.

ON-THE-JOB BARRIERS

One of the more pressing concerns is that many of the challenges that exist for women only arrive after they've already landed a job. A 2018 OSPE-partnered study entitled *Calling All STEM Employers* noted a range of issues, such as lacking a clear professional network; being in a work culture that may conflict with family responsibilities; or feeling generally undervalued by management. OSPE found that 45% of women in engineering reported feeling undervalued or disrespected in the workplace, compared to 20% of their male counterparts.

Other realities could prove discouraging to female applicants, too. According to OSPE, about one in three women currently in engineering get paid less than their male counterparts. The 2016 Canada Census revealed that salary differences were on average about \$10,000 per year less for women.

Unfortunately, OSPE's research also indicates that one in four women working in engineering have felt bullied or harassed at work.

Obstacles to increasing diversity in engineering are also continuing to become clearer through study. In 2018, there were five areas identified by the Ontario Fairness Commission related to bias in engineering's licensure process.

"This has gone on for too long, with little action by the lead-

ers of Ontario and Canada's engineering community," says OSPE CEO Sandro Perruzza. "This is a complex problem, with deep cultural and historical roots. We are calling on the best of Ontario's engineers to join us to break the cycles of prejudice and bias that we all know are there."

What do women need to succeed? The most common responses in studies over the last decade appear to recognize the need for more career development opportunities and a wider range of networking opportunities. Women have also been calling for more flexible hours and parental leave policies. Many women also reported seeing value in more diversity and sensitivity training for everyone in the sector, something that OSPE's new action plan intends to facilitate for any members of the engineering community who seek it.

"It's not an us-versus-them initiative. We are all in this together, and it will take all of the engineering community to make real change," observes Aimey. "I know all too well the unspoken professional culture that diverse underrepresented groups have to overcome just to be heard." ■

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Design with community in mind



WHAT IS ENVIRONMENTALLY CONSCIOUS BUILDING?

By **Thomas Bradley**

Over the course of the last 20 years or so, there have been several methods used to make construction greener and more sustainable. For example, the use of solar panels and the integration of eco-friendly, biodegradable materials into building design have been tried and tested.

Advances continue to happen as people look in closer detail at how buildings are created. Environmentally conscious building, also known as sustainable construction, is an innovative design idea that introduces more environmentally, socially and economically aware construction methods.

WHY DO CONSTRUCTION METHODS NEED TO IMPROVE?

As an industry, construction has a significant impact on the natural environment, economy, and society. As the industry grows, and materials become more limited and costly, traditional methods need to be adapted to keep them fit for purpose. Three critical areas of concern are energy, waste and CO₂ production.

According to NBS, which provides specification tools across multiple platforms, construction consumes almost 40% of total worldwide energy production, produces 30 – 40% of all solid wastes and between 35 – 40% of CO₂. By using environmentally conscious building methods such as solar technology, the industry can use new technologies and make the end-design and structure far more sustainable.

In the U.K. for example, the construction industry is using sustainable techniques to help meet their target of reducing CO₂ emissions by 50%, with 50% faster delivery and 33% lower costs from initial construction, all the way through the life span of an erected building.

TECHNIQUES THAT ARE ENVIRONMENTALLY FRIENDLY

One of the main design techniques



The ACROS Fukuoka building in Japan uses greenery on its slanted side to blend in with its environment. yiyama, AdobeStock

being adopted throughout the construction industry across the world is green building. Green roofs are often an aesthetic choice as well as a sustainable one, with the appearance of plants and flowers raising the building's appeal to investors, workers, residents and visitors.

A good example of green vegetation-based roofing is the ACROS Fukuoka Prefectural International Hall in Japan. Greenery is placed on the slanted side of the building to enhance its beauty. An additional benefit is the way in which the building blends with its environmental surroundings while still using as much of the site as possible – improving the building's long-term economic sustainability in the process.

Another environmentally friendly technique being explored involves building methods that enable skilled workers to create structures off-site and then transport them to the site location. Off-site construction typically takes less time, and less raw material may be needed to complete a project.

An example of this is England's Sun-

derland's Northern Spire Bridge, where the majority of the concrete deck components were precast off-site. The decision was a positive step-change to casting the concrete parts on-site, which can often result in noise and mess, whilst requiring more workers and creating more waste in terms of time and materials.

Researchers are also looking into how they can adapt current materials to make them more sustainable. Universities tend to carry out this research, with Cambridge's exploration of self-healing concrete a perfect example.

PROJECT LIFE CYCLE

When looking at how to develop and use environmentally conscious techniques, many aspects hinge on whether they will be successful throughout the building's life cycle. This includes planning, design and construction, through to building operation and maintenance, including refurbishment and even potential demolition.

Numerous factors can impact a building when looking at an asset's opera-



tional stage, and who will use it and how. For instance, building users produce moisture, therefore systems must be put into place to ensure efficient moisture removal.

The more organic material used in a building the more ventilation is needed, and this can lead to building financing issues. Therefore, a balance must be struck to ensure that guidelines are followed.

What happens after the building has served its purpose also needs to be considered. In the past, this stage of the life cycle has often been overlooked, creating unanticipated difficulties during demolition.

FUTURE OF ENVIRONMENTALLY CONSCIOUS BUILDING

As the consulting and construction sectors become more aware of the vital role they play in wider society, sustainable approaches to construction have become more frequently used. These include walls that self-regulate indoor temperatures and buildings made from living trees such as the Citicape House in London, which incorporates the largest living wall in Europe.

In the future, environmentally conscious methods such as the ones outlined, could lead to a new and better built environment. The possibilities are endless and could enhance construction efficiency as well as provide economic gains and improvements to physical health. ■

Thomas Bradley is with Mediaworks. For more information, visit: www.thenbs.ca

APPLYING MULTI-CRITERIA DECISION MAKING IN WASTEWATER TREATMENT PROCESS SELECTION

Continued from page 27

and the level of expertise at the mine site, the related “attractive or excitement” criteria such as “skilled operators”, “complexity” and “constructability” of the treatment process received the lowest weight.

The main advantage of the MCDM method is its flexibility in selecting the criteria for different sites and reflecting the stakeholders’ mindset on the decision-making process by allocating proper weight to each criterion. MCDM allows adding non-technical parameters such as sustainability, logistic, visual aesthetic and other criteria to the decision-making process.

DEVELOPING THE DECISION MAKING MATRIX

A decision making-matrix was developed to rank the technical nature of each reviewed treatment process based on the stakeholders’ priorities to facilitate the MCDM process. Technical experts generated a series of values between 0 and 10 as the raw score of the treatment process for the stakeholders’ selected criteria. Those values reflected the technical experts’ opinions about each treatment technology to the chosen criteria.

The weighted score of the treatment process for each criterion was calculated as the raw score of the criterion for the technology multiplied by the corresponding weight of the criterion determined by the stakeholders.

The weighted score value could be between zero (the parameter should not be considered at all) and 100 for the most important parameter. The small value of the weighted score represents the low impact of the criterion on the decision-making process.

“Total weighted score” row or sum of the weighted scores for each technology shows the overall rank of the technology in this selection process. The technology with the highest total weighted score

would be the most suitable treatment technology which not only could deliver the desirable outcome (in this case dischargeable water), but also could provide the best balance between technical issues and the stakeholders’ preferences.

In the case study, the nanofiltration process with a total weighted score of 833 was the most desirable choice based on selection criteria. Chemical precipitation using barium salts was the least favourable treatment technology. In this method, a sensitivity analysis could be conducted to identify the impact of individual criterion on the overall decision-making process.

CONCLUSION

A multi-criteria decision-making process is a heuristic method to select the solution which provides the best balance between different criteria (i.e., technical, social, environmental) and the stakeholders’ needs. The main goal of the MCDM method is to find a consensus, agreement or compromise amongst all the intervening parties throughout a project selection process. Therefore, instead of finding an optimal solution, the method generates a ranking of alternative solutions based on the financial, technical, social and environmental aspects of the solutions as well as any other important criteria for involved decision makers.

As was presented in the case study, the MCDM method is a flexible method that could be adapted for a simultaneous review of a wide range of criteria in each case. ■

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References available upon request.



Credit: visoot – Adobe Stock

ENVIRONMENTAL SECTOR JOBS TO SEE GROWTH IN SPITE OF PANDEMIC, REPORT SAYS

By **David Nesseth**

A recent environmental employment outlook report from ECO Canada forecasts moderate 8.1% growth from 2019 to 2029, representing more than 50,000 new jobs in spite of an economy hit hard by COVID-19.

According to the fall 2020 report *From Recession to Recovery: Environmental Jobs and Hiring Trends in the Decade Ahead*, environmental employment demand is projected to persevere over the next decade, while other markets may face longer recoveries ahead. But, how and when the environmental economy rebounds will depend largely on market forces, regulations, and decisions made by governments and employers, says Calgary-based ECO Canada.

“Given the drivers for environmental employment, they have not gone away because of the pandemic,” says Kevin Nilsen, president and CEO.

ECO Canada, short for “Environmental Careers Organization”, has prepared sector employment projections for nearly 30 years. This year was the first time that the workforce development organization has had to run a campaign on social media to actually find job seekers, despite the large number of companies hiring.

“It was really bizarre to me in this climate why we would have more employers looking for workers than job seekers looking for jobs,” says Nilsen, who expects that ECO Canada will have a new report in the coming months about the current supply of workers for the environmental sector.

Nilsen said at least two things could be happening. Workers with the necessary skills could be sitting back and waiting for the pandemic to end, or they could be incorrectly assuming that there couldn't possibly be jobs available in the current climate.

At present, ECO Canada estimates

that 620,100 Canadians are, in fact, working in the environmental sector. Half of these are considered part of the “core” environmental workforce, who require specialized environmental competencies, regardless of industry employer. That core environmental workforce is actually anticipated to grow at a slightly faster rate than the total environmental workforce, at 8.5% or 24,200 new jobs.

Together, expansion and replacement demands for environmental workers combine for nearly 233,500 net job openings by 2029. This adds up to nearly 38% of 2019 employment, says Nilsen.

The new report projects that the largest opportunity for environmental workers will come from the gradual retirement of an estimated 183,400 employees. Within the next decade, nearly 30% of the current environmental workforce will vacate their mostly mid- to senior-level roles, creating career progression opportunities for current and future workers, according to the report.

“As the economy rebounds from the pandemic, heightened government investment in these areas can lift the sector further and position Canada as a global leader,” the report states, adding that the government will need to keep environmental mandates and the workforce front of mind to meet labour needs.

In June, Natural Resources Canada announced \$15.8 million in funding for job and training initiatives for youth in STEM (science, technology, engineering, and mathematics), energy, clean technology, earth sciences, mining and forestry.

Over the last year, ECO Canada itself has facilitated nearly 3,000 jobs in the environmental sector and provided over \$23 million in wage funding to employers across all industries. As part of the Government of Canada's Youth Employment and Skills Strategy Program, a total of 2,218 student placements were completed between July 2019 and July 2020 for 549 employers across the country.

Recently, the organization received \$5.8 million in wage funding to facilitate 280 placements for post-secondary graduates in environmental jobs that require digital abilities, such as computer programming, digital marketing, software development, IT and data management.

“Educators and trainers are devising safe ways to deliver lab and field instruction to smaller groups or even remotely, while exploring applied learning modules to help transition from class to career.”

“Cleantech, in particular, is a promising sector that will benefit tremendously from the Digital Skills for Youth program,” Nilsen says, noting that it could grow from the current estimate of \$1.2 trillion to a projected \$2.5 trillion industry by 2022.

ECO Canada hopes that its new outlook report may help some workers and students identify where the greatest prospects are for green jobs related to their areas of interest and study, especially considering that many may have misconceptions about the number of job opportunities available.

The report is also designed to help educators and trainers fill gaps.

“Online instruction and learning have unexpectedly become a requirement and could become complementary to classroom instruction indefinitely,” the outlook report states. “Educators and trainers are devising safe ways to deliver lab and field instruction to smaller groups or even remotely, while exploring applied learning modules to help transition from class to career.”

In terms of sectors that may have been set back most by the pandemic and struggle to find new growth, the natural resources development sector stands out, says Nilsen. Prior to the pandemic, there may already have been evidence that a decline in oil and gas and mining was contributing to new growth and investment in the clean energy sector, he says.

“The beauty of cleantech and energy efficiency is that you bridge both the economic and environmental agendas. Companies are more willing to invest in something that will save them money here and now, and also give their organization a greener platform going forward,” says Nilsen, who adds that the green building sector in terms of retrofits has been particularly resilient.

For employers, ECO Canada says that they need to meet

the demand and prepare workers to step into more senior roles, which will account for over a third of core environmental net job openings. There is also an advantage to considering diverse candidates like women, youth, Indigenous and immigrant workers, many of whom often have high levels of skill and experience, the report states.

“There are two key things we need to be doing if we want to continue building and supporting Canada’s environmental workforce,” says Nilsen. “We need to upskill traditional workers and create a clear pathway for young people looking to work in the sector. For that, strong investment is needed and that’s why programs like those at ECO Canada are in place,” he added.

ECO Canada expects to see higher growth rates within sub-sectors such as energy efficiency, clean and alternative

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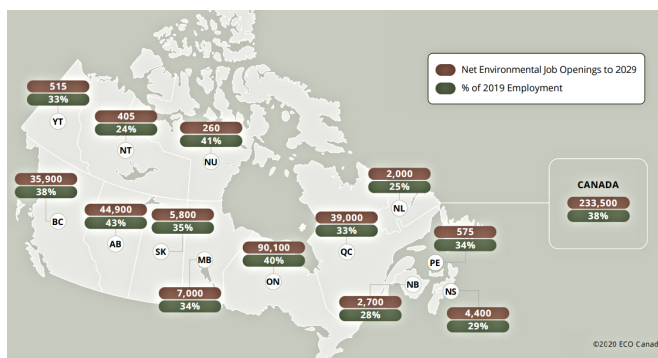
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Environmental net hiring requirements to 2029, by province and territory. Courtesy of ECO Canada



energy, cleantech, nature conservation, sustainable transportation, green building and construction, as well as water quality. Environmental jobs associated with policy and legislation, research and development, communications and public awareness, and sustainability are also expected to grow over the long term.

Environmental job opportunities will exist in every job family in Canada over the next decade. The outlook report notes that through job creation as well as high levels of retirement, nearly 70% of all openings (158,700 jobs) will be in roles related to management, natural and applied sciences, and business, finance and administration.

Engineering occupations, for instance, will account for over 23,400 net environmental job openings to 2029. Civil engineers, mechanical engineers and electrical and electronics engineers fill three of the 10 largest occupations with core environmental employment in 2019. The top three provinces offering engineering

opportunities for core workers from 2019 to 2029 are Ontario, Alberta and British Columbia.

"The pandemic and pre-existing factors have had permanent or long-lasting impacts on certain industries, regions and occupations," the report states. "With a national unemployment rate currently at 11%, some regions and industries measuring higher than others, displaced workers are a viable talent solution, and one that could also mitigate productivity risks, given their prior experience, applied knowledge and accumulated skill sets."

ENVIRONMENTAL JOBS ACROSS CANADA

The outlook report's data indicates that the majority of current environmental workers are in Ontario, Quebec, Alberta and British Columbia. Although less than 1% of the 2019 environmental workforce was in the territories, the region collectively has the highest EnviroShare at 6.4%. The 2019 EnviroShare is the pro-

portion of environmental workers compared to all workers at the occupational and regional level, and by applying these to forecasted employment data.

Ontario is expected to contribute nearly 40% of all net environmental job openings to 2029, equivalent to 90,100 jobs.

Quebec, the second largest provincial employer of environmental workers, is expected to see reduced employment growth during the forecast period (3%), compared to the higher growth rates observed leading up to 2019. In fact, nine in every 10 net job openings in the province will come from workforce retirement rather than job creation. Quebec will, however, focus its environmental commitment on sustainably managing its natural resources, relying on renewable energy, reducing the use of plastics, and repurposing recycled materials, among other priorities.

Alberta is expected to see the highest growth rate of environmental employment at almost 14%, resulting in 14,400 new jobs to 2029. Job growth will likely be driven by investment in cleantech, emissions reduction and renewable energy by businesses and individual consumers, and supported by retraining and upskilling the province's unemployed workers.

As well, many environmental consulting firms are based in the province. Factoring in replacement demand, the province will need to fill 44,900 net jobs over the next decade, or more than 43% of 2019 employment levels.

The Northwest Territories has the highest concentration of environmental workers at 7.2%. Yukon is a close second with 6.9%. Remediation of contaminated extraction sites is expected to provide significant environmental job opportunities over the next several decades. ■

David Neseth is a writer for ES&E Magazine, email: editor@esemag.com. For more information on ECO Canada, visit www.eco.ca

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THE IMPORTANT ROLE OF HIGH CAPACITY WATER FILTERS IN EDNA SAMPLING OF SURFACE WATER

By John H. McAdam

Surface water bodies are widely monitored, with the goal of understanding and cataloging the health of these ecosystems. A subset of documentable parameters relate to living organisms, the monitoring of which has been facilitated by the emerging field of eDNA. It has now evolved to the point where there are practical, if not complete, solutions to better understand the presence or absence of organisms in surface water ecosystems.

eDNA is an abbreviation for “environmental” and “Deoxyribonucleic Acid,” the building block of life on Earth. Living and deceased organisms (flora and fauna) shed DNA as a matter of course, and the essence of eDNA practice is to capture and analyze some of this DNA. This can lead to a better understanding of the organisms and the ecosystem from which the eDNA hails. This can be a very complicated matter given the staggering number of potential eDNA contributors, their relationship to and type of sampling point and the state of the eDNA recovered. Trying to sequence and identify every bit of eDNA captured for each sample is not practical and can be very time consuming and expensive.

Techniques have evolved to identify specific taxonomic groups versus individual species. This is a wider net and can be done quite quickly and relatively inexpensively. How eDNA is amplified and identified is ingenious and fascinating.

GOALS OF AN EDNA SAMPLING PROGRAM

A well-designed program is critical to the collection of relevant and useful data. The first decision is to establish the search target, which can be a specific species, or members of a taxonomic group (clade) which have evolved from the same ancestor and therefore possess significant DNA overlap. In the first instance, perhaps there is a specific inva-



eDNA sampling using a peristaltic pump and eDNA filter.

sive aquatic species of interest. Standard DNA or quantitative polymerase chain reaction (PCR) analysis can confirm its presence or absence so long as its DNA sequence is known.

The taxonomic group approach is more generic, but can answer the question about the presence of any member of a clade and can be followed up with more specificity, if needed. eDNA is particularly useful for fish, amphibian and mollusk detection and is more efficient than traditional means. The key to the taxonomic group approach lies in a system known as DNA metabarcoding and PCR.

The essence of metabarcoding is to identify a short sequence of diagnostic DNA (fragment) which contains enough variations to distinguish all of the species of the taxonomic group being investigated (the metabarcode), plus a little bit of the sequence at either end flank-

ing the diagnostic part. These flanks are referred to as conserved end members and must be common to all members of the taxonomic group of interest but to no other group.

Identifying this special section of DNA sounds like a daunting task except one can stand on the shoulders of the many researchers who have contributed to the three major global DNA databases and those who have published metabarcodes for many taxonomic groups. The three major DNA databases are the European Molecular Biology Laboratory, Genbank and the DNA Data Bank of Japan. With an appropriate metabarcode in hand, program planning can begin.

PROGRAM DESIGN CONSIDERATIONS

Many factors impact the design of the sampling program itself and so careful

continued overleaf...

thinking is required to determine what, where, when and how to sample. Factors to consider are the production, degradation, transport, diffusion rates, persistence and removal of eDNA from the type and size of water body to be sampled. Does one sample near shore or in the main current? At surface, below surface or at the bottom? Seasonality related to runoff and the productive cycle of the target species are also factors.

There is not a one-size-fits-all solution to program design. In fact, a pilot study may be required to establish a foundation for maximum biologic capture.

Chapter 12 of *“Environmental DNA for Biodiversity Research and Monitoring”* focuses on freshwater sampling, outlining useful information and some of the challenges. Referencing other studies, the authors note that whereas fish, amphibians and mollusks shed a lot of eDNA, arthropods and crayfish were more difficult to detect. They cite (Dejean et al., 2011) who determined that eDNA from bullfrog tadpoles in an aquarium and sturgeon in a pond lasts from a few days to a few weeks. A study on stream dwelling salamanders had difficulty detecting their presence as little as five metres downstream.

By contrast, another study (Civade et al., 2016) sampled for fish DNA downstream up to 6.9 km of the outlet of Lac Aiguebelette in France. This study concluded that the fish DNA travelled about 2 – 3 kilometres downstream.

The body of work related to eDNA studies is expanding rapidly but, as illustrated above, careful thought about each specific program is required in the design, collection and interpretation of sampling results.

HOW TO CAPTURE EDNA IN SURFACE WATER BODIES

Once the sampling site locations and protocols have been established, the next practical matter is sampling protocol. There is a compelling case to do filtration in the field as opposed to the logistical challenge of transporting samples to a laboratory setting.

Low-tech sample collection could simply consist of dipping a container into the target water and then gravity feeding the sample through a filter to capture eDNA. This can be slow and tedious.



VOC tubing inserted into an eDNA filter.



Caps to contain buffer in an eDNA filter.

Incorporating a pump into the process “automates” it somewhat and allows for the processing of larger volumes. Clearly, more eDNA is likely to be captured by processing larger quantities of water. Some protocols mandate a sample size of 70 litres or more.

Although filtration with 0.45-micron pore size is common, there is still work to be done with respect to optimum pore size as turbid water can plug a filter before the specified sample size is collected. In very turbid water, there may be a tendency to use filters with larger pore sizes to allow more throughput. But, unless there is some baseline comparative data with smaller pore sizes, results may be skewed.

A portable peristaltic pump can provide a lightweight and controllable sampling aid. Peristaltic tubing in the pump head is connected to another length of LDPE or HDPE tubing, which in turn has a filter installed at the sampling end. By connecting the filter at the intake end, the length of PE tubing and the peristaltic tubing itself do not contact the captured eDNA. This mitigates the need to change out the tubing for each sample. If this is not practical, then the filter can be

inserted between the peristaltic tubing and a disposable length of tubing which should be changed out after every sample location.

To aid in such sampling, Waterra provides a complete system that includes: a rugged 12V and battery operated, portable peristaltic pump; peristaltic and sample tubing; and various pore sizes of inline eDNA filters (300 or 600 cm² surface area) complete with buffer caps.

PROCESSING SAMPLES

Unless one is in a laboratory environment and the sample DNA is to be immediately extracted, it is important to stop degradation (primarily biological processes) of the sample. This can be achieved via three techniques: freezing, drying or buffering. Freezing is probably the least field practical. The drying approach uses silica gel, but drying a membrane in a sealed capsule is not easy and it might be difficult to retrieve the DNA from the dried membrane. Buffering can be field practical and there are several different buffer approaches. Room temperature buffer is advised. Alcohol-based buffers can be an issue if air transport is required to get the samples to the lab.

Using the buffer approach, the filter should be gravity drained after sampling. The filter should be held with the filter inlet up so that water drains down through the filter. This retains the eDNA in the filter.

Securely install a plug or cap (provided with Waterra eDNA filters) in this filter inlet end. Turn the filter over, fill the filter with buffer and securely install the second cap to trap the buffer in the filter. There are several commercially available buffers and some workers make up their own formulations.

ANALYZING SAMPLES: METABARCODING AND PCR

It is not the object of this article to present a treatise on DNA analytical techniques. But it is useful to have an understanding of a truly remarkable process called polymerase chain reaction (PCR) as it relates to metabarcoding. This is the domain of special purpose laboratories.

Structurally, the DNA molecule is a double helix which basically looks like a twisted ladder. The rungs of the lad-

der are comprised of bonded base pairs of adenine (A), cytosine (C), guanine (G) and thymine (T).

In detail, A only bonds with T and C only bonds with G so they form pairs and either end of any pair can bond to the side of the ladder. The ladder side rails have an asymmetrical repeating pattern of bonding sites referred to as 3' and 5'. Moving from 3' to 5', specifies a direction along the DNA molecule.

In a laboratory setting, a solution is made by combining the following:

- The field sample with eDNA;
- Primers (two types). These synthesized primers are exact matches for two of the flanks of the metabarcode fragment; one on each side of the ladder;
- The four base pairs – adenine (A), cytosine (C), guanine (G) and thymine (T), which are the building blocks for replication;
- A temperature resistant polymerase in a buffer. A common polymerase is Taq, which is extracted from the bacteria *Thermus aquaticus* that is found in the Yellowstone Hot Springs.

The PCR process is comprised of three temperature cycling steps that are repeated 20 to 30 times to amplify the amount of target DNA.

PCR amplification can have problems, including non-optimum selection of metabarcodes and flanking sections, poor quality of sample eDNA, imperfect primers, polymerase issues, non-optimum temperatures and so on. Laboratory consultation can help avoid or minimize some of these issues.

The role of eDNA filters to monitor and study aquatic environments is a growing and valuable tool. Processing large water volumes, especially in larger water bodies or in search of rare species, is helped by using filters with large surface areas which do not clog so quickly. Field equipment designed for eDNA field programs can make sample collection in the field more efficient. Data collected from such programs can be quite useful so long as careful planning and execution are carried out. ■

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The City's new primary water source will be the Rafferty Dam Reservoir. Madison Colbow/City of Estevan

SASKATCHEWAN CITY COMPLETES THIRD PHASE OF DRINKING WATER UPGRADE

Saskatchewan residents in the City of Estevan can expect “noticeably improved, less hard” drinking water, municipal officials explained, as they unveiled the third and final phase of the community’s drinking water system upgrade project.

As a result of the upgrades, the city of 14,000 that sits near the U.S.-Canada border will soon shift its primary water source from the Boundary Dam to the Rafferty Dam.

“This project has been several years in the making and we are happy to be able to announce that residents will have a cleaner water source with fewer trihalomethanes,” announced Estevan Mayor Roy Ludwig.

The first of three phases for the drinking water upgrades began in 2017, with the construction of two settling ponds to protect the Souris River by storing residuals generated by the water treatment plant. The ponds alternate collecting the residuals as part of the water treatment process.

Phases two and three of the drinking water upgrades were completed in tandem. These included construction of a 9.2 kilometre-long water pipeline that runs from

the original riverbed in the Rafferty Dam Reservoir to the Estevan Water Treatment Plant. The third and final phase of the project was the intake line from the dam and the construction of a pumphouse that will soon be commissioned. KGS Group was a primary consultant on the upgrades.

The City of Estevan Water Treatment Plant was established in the 1950s. Its average consumption of water is close to 5,000 cubic metres per day, with a peak daily use of 10,000 cubic metres.

Through the Provincial-Territorial Infrastructure Component – National and Regional Projects program, the governments of Canada and Saskatchewan are each contributing up to \$3.1 million toward the Estevan Water Treatment System Upgrades Project. The City of Estevan is responsible for any remaining costs of the project, which has a total eligible cost of \$9.4 million under the program.

Earlier, in 2004, several other upgrades were completed to improve the quality and the disinfection of the drinking water for the city. These included new filtration, chemical feed systems, and the addition of ultraviolet disinfection reactors. ■



This HRS digestate concentration system in Spain allows the farm-based plant to store its digestate until the most beneficial period for application to land as a biofertilizer.

EVALUATING THE BUSINESS CASE FOR USING WASTEWATER DIGESTATE

By **Matt Hale**

Digestate is the nutrient-rich organic liquid and solid residues left after anaerobic digestion. As such, it can be a valuable product, having multiple benefits when used as a soil additive or biofertilizer. However, due to economic or logistical issues, digestate is often only used as livestock bedding or biomass fuel. In the worst cases, it is seen as a waste product, which has to be dealt with.

Driven by the development of biomass fuels for electricity production at home and overseas, the economics of wood fibre for animal bedding have made sand and digestate more attractive options. If digestate is produced on-site, or nearby, it can be cheaper and easier to obtain than sand.

However, using digestate in this manner still requires some processing. This often involves composting, or drying in order to use fresh digestate, while the liquid fractions are applied to soils as fertilizer.

THE DISADVANTAGES OF DRYING DIGESTATE FOR BEDDING

While using digestate as livestock bedding is cheap and convenient in terms of nutrients, carbon footprint and energy use, it is far from an ideal solution. Depending on the feedstocks used, one tonne of digestate can contain: 2.5 to 25 kg of nitrogen; 0.4 to 10 kg of phosphorus; 1.5 to 11 kg of potassium; as well as sulfur, magnesium, and valuable trace elements such as zinc, copper and nickel.

Some of these nutrients will remain in the bedding after use (and indeed the livestock will add further nutrients), but many will be leached out and wasted. Drying digestate uses large amounts of fuel and drives off water, which could be added back to the feedstock at the start of the digestion process to improve mixing. There are better ways to remove water from the dry fraction of digestate, and also higher value uses for the digestate itself.

OTHER USES OF DIGESTATE

The main use of digestate around the world is as an organic biofertilizer in agriculture. Where biogas plants are producing large quantities, this makes sense, particularly if the liquid fraction can be distributed and applied around the farm using irrigation infrastructure. As fertilizer prices continue to rise, the "free" nutrition in digestate becomes increasingly attractive.

Applying digestate to land can improve soil health by increasing organic matter, reducing soil erosion and nutrient runoff, alleviating compaction, and reducing the need for chemical fertilizers and pesticides. Depending on the feedstocks used (such as energy crops, livestock manures and food or garden waste), and the crops to which the material is being applied, the feedstock or digestate will first need some form of treatment.

This is necessary to prevent the transmission of plant and animal disease organisms, or those which could harm human health (such as *E. coli*). There are different treatments available, but some form of pasteurization is the most commonly accepted and utilized technique.

Where digestate is being turned into other high value products, such as compost or soil improver for home gardens or commercial horticulture, then the need for such treatment is even more important. Scientists around the globe are also working on other uses for digestate, such as nutrient extraction, algae production, biopesticide production, or to create building materials.

HEAT EXCHANGERS IMPROVE PASTEURIZATION EFFICIENCY

HRS Heat Exchangers have developed two separate but complementary systems for the treatment of digestate. The HRS digestate pasteurization system (DPS) uses highly efficient heat exchangers, together with two or three holding tanks, depending on project size and digestate volume.

Using heat exchangers means that effective pasteurization of digestate to meet regulations, is possible by using surplus heat from elsewhere in the anaerobic digestion (AD) plant, rather than installing an additional heat source such as a biomass boiler.

A well-designed heat exchanger system can provide a continuous pasteurization process, which uses less energy than alternative systems. It can also allow additional thermal regeneration, or recovery, levels of up to 60%. This saved heat can then be used elsewhere, such as in an evaporation plant.

EVAPORATION RATHER THAN DRYING

The HRS digestate concentration system uses heat to separate water from digestate by concentrating it. This technique can reduce the overall quantity of digestate by as much as 80%, greatly lowering the transport costs associated with its removal. A typical 3.4 million BTU wastewater AD plant could produce 35 tonnes of liquid digestate every year, so the savings in storage and transport requirements are significant.

A well-designed concentration system will include measures to retain the valuable nutrients in the digestate, while the

evaporated water can be condensed and reused. For example, the captured water can be added back to the feedstock as it enters the digester, making the entire process almost self-sufficient in terms of water use and eliminating liquid discharges from the plant.

After concentration, the treated digestate dry solid content can be as much as 20% (often a four-fold improvement), making it much easier to transport and handle. Nutrient content is also increased.

EVALUATING THE BUSINESS CASE

As with any equipment, adding processes to an existing AD plant involves investment costs. However, it is vital to compare like with like and to compare the value of the investment, not only with alternative systems, but also with the costs of doing nothing. What is the overall energy cost over the life of the unit?

What are the downtime or efficiency penalties associated with batch-treatment processes? What effects does the

technique have on the composition of the digestate? How much will storage and handling cost over the life of the project?

There are many other issues to consider, but as these few examples indicate, the cheapest solution in terms of capital outlay may not be the cheapest over the life of an AD plant. This is particularly true if you have to invest in additional storage tanks or generate additional heat in order to service it. ■

Matt Hale is with HRS Heat Exchangers. Email: info@us.hrs-he.com, www.hrs-heatexchangers.com



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AIR INTAKE FILTER RECYCLES WASTE HEAT TO PREVENT WWTP EQUIPMENT FROM FREEZING

By **Rob Geyer**

Just as winter always arrives, intake filters for blowers and compressors always have the potential to freeze in cold, humid climates. In nearly all of Canada, filter freezing and early morning high differential pressure alarms can be a fact of life for plant operators.

Cold is not necessarily a problem for intake filters, and cold weather alone does not cause filter freezing. The cause of those early morning alarms is that the filter element is suddenly clogged with a high volume of particulate in the form of frozen water vapour. This combination of low temperature and atmospherically available water vapour, in the form of freezing steam, mist, falling snow or sleet, produces sudden high volumes of now solid particulate. When the filter “freezes,” it is not failing, but rather functioning, preventing unwanted particulate from entering an equipment inlet.

In addition to freezing vapour, falling snow or sleet, a third filter freezing condition is possible, even if the temperatures are above freezing. At 1°C or 2°C, for example, the very action of air rushing through a filter medium can create an evaporative cooling effect, resulting in frost build up on a filter element. In other words, the machine inlet creates its own frozen water vapour and ice. The higher the inlet air velocity, the more likely the problem becomes.

A wastewater treatment plant provides all the necessary ingredients for intake filter freezing. These include high volume inlet air requirements for aeration blowers and a continuous source of humidity, whether from the adjacent body of water (usually a river), or from the aeration basins themselves. These do not freeze, so create steam all winter.

As the mercury approaches and drops below freezing, condensate rising from the aeration basins crystallizes into ice. The blowers draw this ice into the filters, which increases restriction just the same as if the filter were drawing in dust.

Endustra Filter Manufacturers designed its Tri-Vent® intake filter with the series DK discharge-air knife, to recycle waste heat to discourage filter freezing.

According to Robert Geyer, company president, older filter designs were more prone to freezing. “We first encountered freezing issues with panel (rectangular) filters,” he says. The industry standard at one time was cellulose, or needle felt polyester filter elements, and filter face velocities were often 75 to 120 metres/minute. Initial restrictions on these traditional filter designs were in excess of 3" WG (747 Pa) or higher.

Increased velocities resulted in greater suction. When snow or ice was falling, the stronger suction would pull in the dense particulate, and when an evaporative cooling condition existed, frost would build up quickly. Amplifying the problem was the



The Tri-Vent® Series TM09 with freeze discouragement discharge-air knife was designed to use waste heat generated by air compression.

fact that the filters operated at higher restriction levels, making the systems more sensitive to the impact of sudden differential pressure spikes due to a cold snap or snowstorm. Finally, the cellulose media of the era absorbed moisture and the polyester entrained moisture, so the filters could literally freeze.

In the early 2000s, Endustra Tri-Vent intake filters addressed the deficiencies of legacy designs by operating at low initial restrictions and slower face velocities, often less than 1/2" WG (125 Pa) and 15 metres/minute. A further advantage of the improved design was proprietary hydrophobic filter media, which created an inherently freeze-resistant filter.

In one plant in Soldonta, Alaska, where average snowfalls exceed 80" and average high temperatures are below freezing

nearly half the year, “freeze resistant” is not enough. During a blower upgrade project, plant operators learned that Endustra offered a freeze discouragement system that did not require additional power and did not negatively impact blower performance. They decided to upgrade intake filters as part of their redesign, and they selected the Tri-Vent® Series DK in a top-outlet filter design.

The Series DK functions by taking advantage of the physics of air compression. Air compression by 5 KPa blowers commonly used in wastewater treatment plants typically increases air temperatures, between 20°C and 90°C. This temperature rise, in most applications, is a useless or often undesirable byproduct of air compression. In many situations, the heat must be removed from compressed air to make it usable for a process. When repurposed to discourage filter freezing, however, the hot discharge air effectively keeps blowers running in harsh weather conditions.

Two schools of thought govern discharge freeze discouragement: volume and pressure. The volume theory holds that 8 – 10% of the total volume of discharge air be redirected to mix with inlet air and bring that inlet air temperature above the freezing point. This method is expensive, not only because a higher volume blower costs more money, but also because the oversizing compromises the energy savings potential inherent in the turndown capacities of modern high-speed machines.

The pressure theory does not require a larger blower. Instead, this method of freeze discouragement works similarly to the way a car’s window defroster operates. Waste heat is routed from the blower discharge and conducted in directed jets of air, only when and where required, and the system operates quietly.

In the case of the Series DK, the total percentage of output air requirement is less than 1 – 2% of the total blower volume, and this volume is further reduced by automated controls which monitor environmental conditions and anticipate freezes, regardless of cause, proactively discouraging the natural consequences only when required, and only using as much discharge air as required.

“Air compression by the 5 KPa blowers commonly used in wastewater treatment plants typically increases air temperatures 20 – 90 degrees Celsius.

The operating logic is simple. When the permissible condition of ambient cold temperatures is registered (2°C or less depending on altitude), the controls monitor filter differential pressures. In a

properly configured Tri-Vent filter system, it takes a year or more for element differential pressure to increase 1500 – 2000 Pa above the starting point.

continued overleaf...

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With an average daily increase of less than 5 Pa, if during cold temperature the differential pressure spikes by more than 50 Pa in less than hour, the controls begin to modulate the discharge valve. The valve opens only as much as necessary, until differential pressures begin to decrease, and then gradually closes when differential pressures begin to approach those of the starting point.

So, not only does the discharge knife system use only 1 – 2% of the total blower output, discharge air is used only when necessary.

James Trissel, Soldonta Utility Department Manager, reported that freezing issues, which once happened “all the time” haven’t happened once since startup. Instead of early morning alarms, the filters “take care of themselves.”

The plant utilizes covered aeration basins, and the nearby river eventually freezes over. This means that for much of the winter, there is no rising steam to freeze. Continual regular snowfall, however, routinely caused filter problems

during the long, cold winters.

The DK system uses the same logic to prevent all freezing, but another attribute of the system is that discharge air warms the annular air knife in the filter inlet. As the tubular air knife heats, a portion of the radiant heat transfers from the warm metal to the cold inlet air, and any contact snow melts instantly. This radiant transfer is insufficient to melt all the incoming snow, but it will assist the de-frosting action of the air-knife jets.

Interestingly, the air knife does not need to melt or dissuade all the ice or snow on/in a filter. The discharge air only needs to melt a usable portion of the filter media until weather conditions improve. The filter medium does not absorb or entrain water, and the filter element itself doesn’t freeze. Therefore, once the snow stops falling and the air knife melts what remains, the filter element returns to normal operating conditions, and at this point the valve automatically closes. This intermittent control system keeps operation costs low and maximizes filter ele-

ment life in adverse climates.

The Series DK freeze discouragement system provides an economical solution to a persistent application challenge. It is available on all Tri-Vent filter arrangements, for connections as large as 48". A single control panel can operate up to six blowers with individual filters, or supply discharge air to one filter from multiple blowers in a common header configuration. ■

Rob Geyer is with Endustra Filter Manufacturers. Email: rob.geyer@endustra.com

SPONSORED PROFILE

Sentrimax – a Canadian business success story

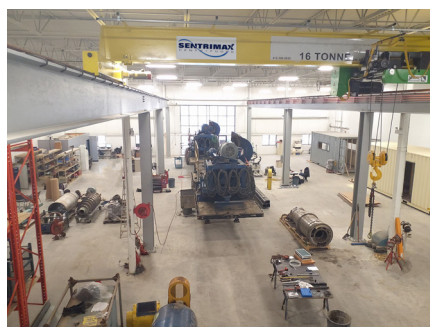
This past August, Sentrimax Centrifuges opened a facility in Kitchener, Ontario. The company was founded in 2002 by Max Musik and Tom Maxwell and began with the opening of its centrifuge repair facility in Edmonton.

Both men had been involved in the centrifuge industry, since the 1980s and with their combined knowledge and expertise, they were able to grow the company into a sustainable business.

In 2011, Sentrimax opened an office in Mansfield, Texas. Since then, this location has been very successful repairing and servicing centrifuges for the oil and gas industry.

Company president Tom Maxwell had a vision for expansion and he has backed it up by opening the facility in Kitchener to service the Ontario, Quebec, Maritimes, and the Northeastern U.S. markets.

Although Sentrimax has only recently opened its Kitchener branch,



Sentrimax Centrifuges' new Kitchener facility.

we have been working with municipal plants in Ontario since 2015.

The company is also in the middle of upgrading its facility in Edmonton. Major renovations and shop upgrades will help increase work with the municipal water/wastewater, and oil/gas sectors, as well as many other industries in Western Canada.

Sentrimax could have postponed

this expansion until the economy had improved, however, we felt it was the perfect time to expand. At a time when budgets are shrinking, we believe that we can save municipalities all over North America on repair, service, and replacement costs for their centrifuges.

As companies have had to downsize, lay off employees, or even close their doors this year, due to the COVID-19 pandemic, Sentrimax has bucked that trend. We are most proud of the fact that we have actually increased the number of employees at our Edmonton facility, including the hiring of two additional engineers. We have maintained staffing at our Mansfield facility as well.

We believe that the most important part of our company is our team of employees. They are “the centrifuge experts”. ●

For more information, visit www.sentrimax.com.

CHEMICAL FEED FLOWMETERS MUST BE EXTREMELY ACCURATE

By Amparo Burke

Water industry professionals require instruments that monitor flow rates extremely accurately. Blue-White's Sonic-Pro® MS-6 chemical feed flowmeter has measurable flowrates down to 10 millilitres per minute (one of the lowest flowrates available), and up to 10,000 millilitres per minute.

Its ultrasonic technology is an innovative addition to flowmeter offerings for the water and wastewater treatment industries. The flowmeter applies transit time ultrasonic technology to offer a broad flow range, and implementation of this technology provides an immediate solution to a problem the industry has struggled with for years.

Features of the MS-6 include a 4-20 mA output, frequency output, and high and low flow setpoints that can be utilized for no flow alarms. In addition, the flowmeter has numerous warning functions to alert of problems in the system, for instance air bubble or empty pipe situations.

No flow conditions can indicate there is a block in the chemical line or that the chemical tank is empty, and alarming to these no flow conditions is critical at plants. While chemical controllers can also provide this feedback, their reaction time is slower. This is because it takes time for the system to register a large drop in pH, and for the controller to signal an alarm. In contrast, the MS-6 communicates these problems instantaneously with the SCADA system. This capability helps ensure minimal downtime, as well as loss of production at the plant.

Accurately monitoring the amount of chemical being dosed into the system is crucial to ensuring effective water treatment. An over- or underdose of chemical can adversely affect treated water quality and can lead to wasted chemicals, which also has a financial impact.

With the high accuracy and functionality of the MS-6 flowmeter, plant operators and SCADA personnel are consistently provided feedback to optimize production.



Blue-White ProSeries MS-6 flowmeter.

With PVDF and PEEK wetted components, NSF 61 approval, and the necessary features to accurately monitor chemical dosing, the MS-6 is an excellent fit for drinking water applications. In addition, Blue-White manufactures a broad range of both diaphragm and peristaltic chemical dosing pumps perfect for precision pairing with the MS-6.

CASE STUDY

Heyward Incorporated, specializing in water and wastewater process equipment, has a branch in Charlotte, North Carolina which currently utilizes the MS-6 flowmeter. Heyward was using a gear flowmeter in a 20% cationic filter aid polymer neat feed application and experiencing gear flowmeter failure.

With the easy switch to the Sonic-Pro MS-6, there has been no flowmeter failure and the meter readings have consistently been accurate, based on draw downs. Blue-White believes all water treatment plants could benefit from the many innovative features and functions of the MS-6 flowmeter. ■

Amparo Burke is with Blue-White Industries. Email: sales@blue-white.com, or visit: www.blue-white.com



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THE INTERNET OF THINGS IS TRANSFORMING WASTEWATER COLLECTION SYSTEM MAINTENANCE

By Jay Boyd

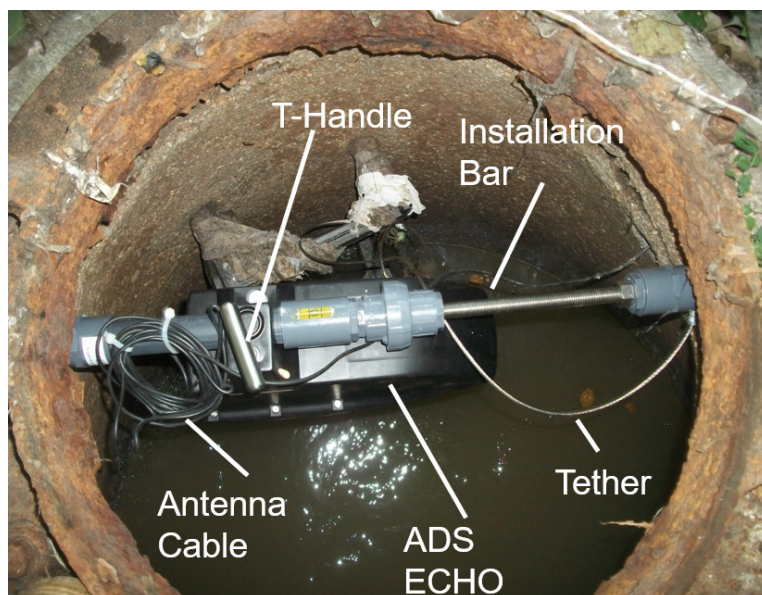
The capacity, management, operation and maintenance (CMOM) programs for collection systems have long established maintenance processes, including continuous, aggressive cleaning of the wastewater collection system.

Cleaning is considered preventative maintenance and is designed to keep sanitary sewers free of obstructions such as fats, oils and grease (FOG), roots, debris and sediment. All of these can reduce capacity and, worse, create blockages that cause sanitary sewer overflow (SSO)

It is quite common for utilities to have two concurrent approaches. The first is to clean the entire collection system on a regular cycle. Small collection systems may accomplish this annually, while large collection systems make take multiple years. The second element is to aggressively clean selected segments at high frequencies. Termed “high frequency segment cleaning” (HFSC), this approach is driven by a history of segments that have rapidly forming and/or excessive build up.

HFSC cleaning cycles can range from weekly to monthly to quarterly to semi-annually. Considered preventative maintenance, this aggressive approach is based on the historic build up behaviour of the segment where perhaps an overflow or series of overflows may have resulted. Cleaning is scheduled to “stay ahead” of that historic build up.

While the combination of system-wide and HFSC cleaning has demonstrated its effectiveness for reducing SSOs, it means ongoing costs. It is labour-intensive, requiring trained personnel to operate sophisticated equipment, such as combination trucks and specialized tools for the cleaning process. In addition, recurring costs, including insurance, equipment maintenance, consumables and more, form a significant portion of annual col-



Typical installation of a remote site sensor system.

lection system maintenance budgets.

While annual budget planning accounts for these expenses, pressures from aging collection system infrastructure tend to increase costs all the more. Revenue increases are often difficult to realize due to rate payer resistance. As a result, maintenance operations are often forced to do more with little or no increase in resources.

BELOW THE SURFACE

Conventional cleaning processes do not use continuous real-time feedback. Maintenance crews are directed to HFSC sites based on a rote, schedule-driven routine. This process assumes a build up is an ongoing occurrence and therefore cleaning is required.

Sometimes, utilities will test their scheduled cleaning frequency assumptions and may do a video inspection, which gives real-time information. Effectively, it takes a snapshot of the segment's condition and enables the decision to

clean, or not. While this approach is useful, additional personnel and equipment resources, e.g., CCTV, become impractical as an ongoing process.

In general, utilities must rely on historic information, not having access to real-time HFSC conditions. Veteran operators realize that there is a trade-off. They know that collection systems are dynamic. Build up may not occur with regularity, but instead in irregular patterns. Lacking ongoing knowledge of actual site conditions, scheduled cleaning can result in overcleaning.

Where utilities are short of staff, equipment and time, they must adjust their priorities such as scheduling, adding overtime, or delaying projects. These shifting priorities can contribute to organizational stress and increased expense.

The effects of overcleaning also create a progressive, unseen yet impactful effect on the collection system, with substantial financial implications. Cleaning with high pressure sprays can have a deleteri-

ous effect on pipes. Studies have shown that consistent and prolonged use of high-pressure sprays produces pipe wear, therefore shortening its lifespan.

In the case of high-risk pipes, already near the end of their useful life, high-pressure sprays may exacerbate this risk. The per kilometre capital cost for sewer pipe replacement is typically measured in millions of dollars. Thus, a reduction of asset life can have a severe impact on present and future capital budgets.

All in all, while aggressive high frequency cleaning has reduced the occurrence of SSOs, it has been achieved with reliance on scheduled overcleaning and the consequent impact on maintenance efficiency and asset wear.

UTILITIES IN NEED OF TRANSFORMATIVE CHANGE

One very large utility which maintains more than 4,828 km of pipe, was challenged with retirement and the corresponding loss of highly experienced staff. This was coupled with increased maintenance demands from their aging infrastructure.

Replacing experienced staff proved to be difficult with increased competition from other utilities, as well as private industry. To offset this, the utility hired less experienced personnel, which created increased training demands, and lowered on-time performance for meeting the cleaning schedule. This in turn lowered the ability to recognize developing collection system issues. These circumstances resulted in a reversal of a seven-year decline in SSOs per 161 km of pipe. Over the next two years, the SSO rate doubled.

Another smaller utility maintains some 240 km of sanitary sewer and an additional 80 km of stormwater pipes. They had 100 HFSC sites. This unusually large number consumed more than 80% of all maintenance time. Budget constraints left them unable to expand staff. Even a single staff member's absence could be disruptive to their cleaning schedule.

Another utility was challenged with the demands of their schedule alone. Here, 100% of maintenance staff time was spent on HFSC sites, which meant no system-wide cleaning maintenance

Studies have shown that consistent and prolonged use of high-pressure sprays produces pipe wear, therefore shortening its lifespan.

was being performed.

While these utilities' circumstances were different, there were commonalities:

- When crews arrived at an HFSC segment, they did not know actual segment conditions.
- The cleaning frequency for a given HFSC segment was predicated upon previous (historic) behaviours.
- Field observations regarding segment conditions subsequent to cleaning were largely subjective, unless video inspection followed; not possible in many cases.

IOT PROVIDES TRANSFORMATIVE RELIEF

To meet their challenges, these utilities sought out technology solutions, particularly with the Internet of things (IoT). Understanding that the core issue was that their maintenance staff was virtually blind to segment conditions, they saw the advantage of having remote site monitors utilizing inexpensive cellular communications and cloud-based software to provide ongoing real-time information. Moreover, they gained assurance that 24/7 on-site monitoring would also be a safeguard for preventing SSOs.

One supplier in particular offered software that had machine learning and the unique capability of identifying developing blockages predictively. It recognized distinct flow patterns and could distinguish a blockage from rain-induced level increases. This capability was accomplished through the software being "fed" more than a million days of human-reviewed and verified data.

The software made regular scans of all monitored sites and provided users with a dashboard summary prioritizing and grouping sites by high (red), medium (yellow) and no (green) urgency. Because the software was able to identify

early developing patterns, utilities had days, and up to weeks, of time to plan and respond accordingly.

Although somewhat rare, should a fast-developing blockage occur between the regular predictive scans, the monitor was designed with five level alarms to detect flow level changes. Low flows were indicative of a potential upstream blockage while high flows indicated a potential downstream blockage.

The IoT technology provided utilities with ongoing visibility of remote sites and a new understanding of site behaviour. Based on its capability, utilities hypothesized that if they used continuous IoT technology and cleaned only as those conditions indicated, they would have an opportunity to reduce overcleaning. This effectively right-sizes cleaning frequency, while concurrently lowering SSO threats.

STUDY SET-UP, APPROACH AND RESULTS

Two of the three utilities cited performed pilot studies, while the third fully implemented IoT technology. They all first identified and targeted segments with the highest cleaning frequencies. These could yield the fastest return in terms of cleaning reductions. Additionally, consideration was given to segments where a SSO would have high impact, i.e., a waterway, and to locations that were hard to access.

Once the monitoring systems were installed, operators were familiarized with the software, including appropriate alarm (level) settings and how to use the predictive software. Each utility determined their individual process for responding to the predictive blockage notifications, as well as responses to alarms should a fast-developing condition occur. In all

continued overleaf...



TABLE 1

CLEANING LOG	JUL-18	AUG-18	SEP-18	OCT-18	NOV-18	DEC-18	TOTAL
SITE	CLEAN	CLEAN	CLEAN	CLEAN	CLEAN	CLEAN	CLEAN
1	No	No	No	No	11/26/2018	No	1
2	No	No	No	No	11/26/2018	No	1
3	No	No	9/17/2018	No	11/26/2018	No	2
4	No	No	No	No	11/26/2018	No	1
5	No	No	9/11/2018	No	11/26/2018	No	2
6	No	No	No	No	11/26/2018	No	1
7	No	No	No	No	11/26/2018	No	1
8	No	No	No	No	11/26/2018	No	1
9	No	No	No	No	11/26/2018	No	1
10	No	No	No	No	11/26/2018	No	1
CLEANED-YES	0	0	2	0	10	0	12
CLEANED-NO	10	10	8	10	0	10	48

TABLE 2

Cost-Savings Analysis	Segments	Months	Cleaning Instances	Cost/Segment	Value
Schedule-Driven (Old Process)	10	6	60	\$ 400	\$ 24,000
Site Condition-Driven (New, Smart Process)	10	6	12	\$ 400	\$ 4,800
Reductions (Savings) - Total Ten Segments			48	\$ 400	\$ 19,200
Cost of Implementation* - Total Ten Segments					\$ 8,360
Net Productivity Savings - Ten Segments					\$ 10,840
Net Productivity Savings- per Segment					\$ 1,084
*Equipment, communications, software, installation, training, ongoing field services, warranty					

instances, the utility would clean based on segment conditions.

The duration of one study involving 10 pilot locations was six months. Each of these sites had been on monthly cleaning schedules. With their schedule-driven process they would have cleaned 60 times. Yet, during the six-month pilot and using the data-driven process, they cleaned only 12 times, for an 80% reduction. Of the 10 segment locations, two were cleaned twice, while the other eight were cleaned once. This frequency reduction indicated that the utility had been overcleaning all locations. (See Table 1.)

During the pilot, they also avoided a potential SSO at one site, receiving and responding to an alarm for a fast-forming blockage. The prevention of an SSO is an out-of-pocket savings, since an overflow carries with it a fine of undetermined value, depending on severity.

Through a thorough examination, the utility determined that the cost per segment cleaned was \$400. This accounted for factors such as amortized truck cost, insurance, maintenance, fuel, tools and consumables, and the cost of labour for

a two-person crew. Since they had eliminated cleaning 48 times at \$400 per segment, this was the equivalent of saving \$19,400. When utilities are being challenged by budget limitations and hiring is not possible, this solution can fill labour gaps. (See Table 2.)

In the second utility's four-month study, they realized an even more significant saving. It involved a mix of both weekly and monthly segments. Eight segments were being cleaned weekly and 12 were being cleaned monthly. With the schedule-driven cleaning process, weekly segments would have had 152 cleanings and the monthly segment 42 cleanings. Together the total would be 194.

Following the site-condition, data-driven process, a total of 185 cleaning instances were eliminated for a 95.4% reduction. Additionally, two developing SSOs were detected and prevented. The productivity cost of 185 reductions at \$400 per segment totaled \$74,000. They cleaned nine segments, reducing their cost to just \$3,600. This meant that maintenance resources were now available for other projects.

The third utility has fully implemented

IoT at more than 50 sites, distributed among monthly and some quarterly segments. The data shows they reduced cleaning by 87% at those segments. Moreover, their cost per segment cleaned is \$595, which is higher than the other two utilities. This reduction translated into a \$155,890 productivity cost saving.

DISCUSSION AND CONCLUSIONS

More than 20 years ago, it was considered best practice to plan and implement a rigorous and regular collection system cleaning program. Utilities developed schedules for cleaning their entire collection system, as well as targeting selected segments for high frequency cleaning. Consequently, SSO rates dropped.

Yet, utilities began to realize that they were "cleaning clean pipes". With the advent of the IoT technology, maintenance departments now have tools that can predictively assess remote conditions and provide indications when to clean. Moreover, SSO mitigation is elevated as monitored segments have continuous protection.

Yet, while there is a steady adoption rate, many utilities still lag and rely on the two-decade-old-plus method of scheduled cleaning. Why? One major obstacle to adoption is complacency. Often the response to robust data supporting an IoT optimized process is, "what I am doing today works. So, why change?"

In these circumstances, utilities would be better served to recognize that the old schedule-driven approach is not sustainable. Trends with retirement are affecting field staff experience levels and with that, efficiencies and effectiveness. As infrastructure ages, pressures on maintenance will continue to grow. Additionally, resistance to adoption often is rooted in the focus on the expense without deference to the return. However, if utilities take the holistic view of return-on-investment, they discover that the return is significant and fast, typically in less than a year.

In spite of these obstacles, IoT adoption continues, driven by proactive vision or necessity. ■

Jay Boyd is with ADS. For more information, email: elott@idexcorp.com. References available on request.

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UNIDIRECTIONAL DISTRIBUTION SYSTEM FLUSHING PROGRAM IMPROVES WHITE ROCK'S WATER QUALITY

By Saad Jasim

A unidirectional flushing program is an important component of any water utility's routine distribution system maintenance. It removes sediments, deposits and biofilm build up from the distribution system and improves water quality, triggering reductions in customer complaints. Incorporating unidirectional flushing (UDF) techniques allows utilities to improve the degree of watermain cleaning, reduce total water consumption per flush, and decrease the frequency needed.

Flushing of the distribution system is important to the maintenance and preservation or improvement of water quality and control of bacterial growth. Utilities could use a protocol to investigate problems, evaluate the objectives of flushing, define data collection requirements, plan and implement flushing programs, and refine or upgrade the existing program.

Since the City of White Rock, British Columbia, purchased the water department in October 2015, watermain flushing has been conducted regularly for a variety of reasons: corrosion control; sediment removal; taste and odour control; to maintain low turbidity; to maintain disinfectant residual; and to prevent the potential of bacterial growth.

It is a common practice to evaluate programs designed to improve water quality and reduce the impacts of certain parameters on the distribution system integrity. Analyses of flushing strategies should emphasize time series data for one location rather than comparing different areas at the same time.

WHY UNIDIRECTIONAL FLUSHING?

Flushing is one of the most powerful tools available to water utilities for addressing distribution system deficiencies and maintenance. UDF is designed to bring water through the system in a



Operators of the water department working on one section of the unidirectional flushing program. City of White Rock

controlled fashion at velocities sufficient to provide a scouring action within the distribution piping.

UDF is being utilized by a growing number of utilities as a cost-effective way of improving and preserving water quality in the distribution system. The level of effort associated with a flushing program depends on the significance of water quality deterioration attributable to the distribution system. Flushing programs can be implemented with few resources assigned to data collection. Nevertheless, continuing effort in data analysis is required if the program is to evolve into a useful and economical tool for water quality management.

To develop an effective program, and to be able to operate successfully based on the size of the distribution system, White Rock was divided into three areas.

Operation of the UDF program in the

City of White Rock's distribution system was implemented every year, from October to December, starting in 2016

The program was implemented twice in 2017 to achieve a higher improvement after noticing the results of 2016. After three years of conducting the UDF program, a significant improvement was noticed.

IMPACT OF THE NEW WATER TREATMENT PLANT

In March 2017, the announcement was made by the Government of Canada and the Government of British Columbia that the City of White Rock would receive a historic \$11.79 million in grant funding to construct a water treatment plant to remove arsenic and manganese.

The White Rock Water Treatment Plant (WTP) is designed to treat the city's existing groundwater supplies to

remove naturally occurring manganese and arsenic. This will ensure that an improved drinking water quality is supplied to residents which meets the guidelines and aesthetic objectives.

The water treatment plant process is multi-stage and includes the following key treatment components:

- Pre-oxidation with ozone for arsenic and manganese in the raw water supply.
- Addition of ferric chloride to remove phosphate and assist in reducing arsenic concentrations prior to the adsorption process with Bayoxide E33.
- Removal of manganese using GreensandPlus media filters.
- Adsorption of arsenic using Bayoxide E33 media filters.

The treatment objectives of the White Rock WTP are to deliver drinking water meeting the following operational targets:

- Mn < 0.02 mg/L
- As < 0.002 mg/L (95% of the time, 0.005 mg/L for 5% of operation)

Additionally, all other water quality

parameters shall meet the objectives of the Guidelines for Canadian Drinking Water Quality (GCDWQ).

The new White Rock WTP started operating at the end of March 2019. It has been delivering significantly improved water quality, with the manganese concentration brought to below detection limit. Supplied water to the distribution system prior to the plant operation contained an average of 120 – 150 µg/L of manganese.

Significant improvements were noticed during the operation of the UDF program in the city's distribution system. Data results clearly show the reduction in turbidity due to the removal of manganese deposits in the distribution system during the UDF program from 2016 to 2019. The cost of conducting the backwash is almost reduced by 50% due to the staff time involved and volume of backwash water used.

CONCLUSIONS

The UDF program improved the condition of the distribution system by removing sediment, biofilm and manganese deposited during decades of operation. This, in turn, reduces the potential impacts on water quality delivered to the public, and reduces the potential of having negative aesthetic impact on the water delivered.

In addition, this helps to reduce discharged water used in the UDF, and the volume of water withdrawn from the Sunnyside Aquifer. This is an important step in water conservation and management of water resources, and reduction of energy use, which is important in mitigating the impact of climate change. ■

Dr. Saad Jasim, P.Eng., is with Utilities Engineering and Municipal Operations at the City of White Rock. Email: sjasim@whiterockcity.ca



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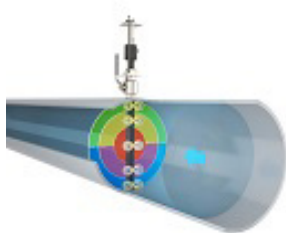
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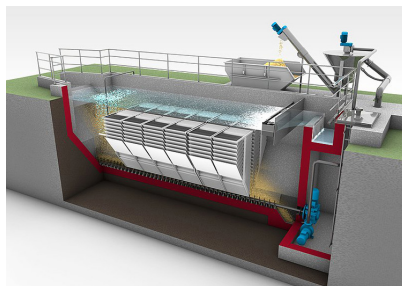
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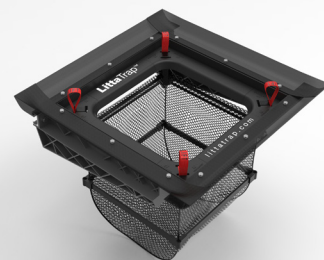
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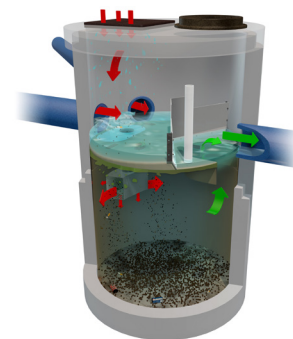
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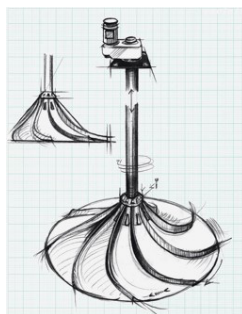
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HALTON REGION WINS AWWA DRINKING WATER QUALITY AWARD

A commitment to improvement at water purification plants in Burlington, Burloak and Oakville has led to Halton Region, Ontario, being selected as the first Canadian municipality to receive a First Year Directors' Award for Water Treatment from the U.S.-based Partnership for Safe Water program.

Presented by the American Water Works Association (AWWA), the international program is a collaboration of six drinking water organizations with a mission to improve water quality through the optimization of system operations.

Since Halton Region joined the program in 2016, its staff has learned processes and tools that optimized plant performance and drinking water. The partnership quickly put them on the road towards the 2020 award.

The region operates 12 water treatment facilities and delivers over 65 million cubic metres of drinking water daily to its some 580,000 residents. Its Burlington plant is the largest water treatment facility in Halton Region, with a rated capacity of 263 million litres per day.

"The Ontario Water Works Association commends the Region and its staff for their commitment to the Partnership, to its ongoing optimization efforts and to providing customers with the highest quality drinking water possible," said Michele Grenier, executive director of the Ontario Water Works Association, the Ontario section of the AWWA.

Halton Region was among seven U.S. states honoured with a First Year Directors' Award for Water Treatment in 2020. The states include: Colorado, Illinois, Indiana, North Carolina, Pennsylvania, Tennessee and Utah.

Currently, 250 water service providers and 400 treatment plants belong to the program. Partnership utilities receive recognition as they progress through the program's phases and reach optimization milestones, demonstrating their commitment to improving water quality and protecting public health.

B.C. DISTRICT SWITCHES OUT LAKE DRINKING WATER SOURCE OVER RISE IN ALGAL BLOOMS

Flooding and unusual weather patterns likely played a role in the unusually high amount of algae within Kalamalka Lake this year, states British Columbia's Regional District of North Okanagan (RDNO), which reported that it switched its drinking water source in October to protect customers with Greater Vernon Water.

The water utility sources approximately 45% of its water from Kalamalka Lake water and its Mission Hill Water Treatment Plant, and 55% from the Duteau Creek water source and its treatment plant.

"Customers on the Kalamalka Lake source may have noticed a difference in the taste and smell of the water," local officials stated in a public announcement. "Algae levels did not exceed a level that posed a health risk, but the RDNO switched water sources out of an abundance of caution," officials added.

RDNO told residents that boiling water is not an effective or recommended action when algae is present, but customers could choose to use in-house filtration systems, such as Brita filters, while the sources were being switched over.

Algae blooms in drinking water can cause gastroenteritis symptoms like vomiting, diarrhea, fever and headaches.

Greater Vernon Water supplies the City of Vernon and some areas of the District of Coldstream and Spallumcheen. It also includes the Outback and Delcliffe, which are two small systems that draw

water from Okanagan Lake.

Greater Vernon Water officials say that the algal blooms are part of the reason the utility is "actively seeking filtration" on the Kalamalka Lake source. Currently, different forms of filtration are being tested through its Mission Hill Water Treatment Plant Pilot Study, run by Sandwell Engineering Services and four manufacturers.

At the Duteau Creek Water Treatment Plant, water is first treated with a coagu-

lant and mixed to create a floc, according to city records. Clarification is achieved by dissolved air flotation. Chlorine is then added after treatment to ensure contact time for the removal of viruses, followed by UV disinfection. Mission Hill Water Treatment Plant uses a dual disinfection process of UV and chlorine.

The Mission Hill plant was commissioned on September 30, 2006, and partially funded through the B.C. community water improvement program. ■



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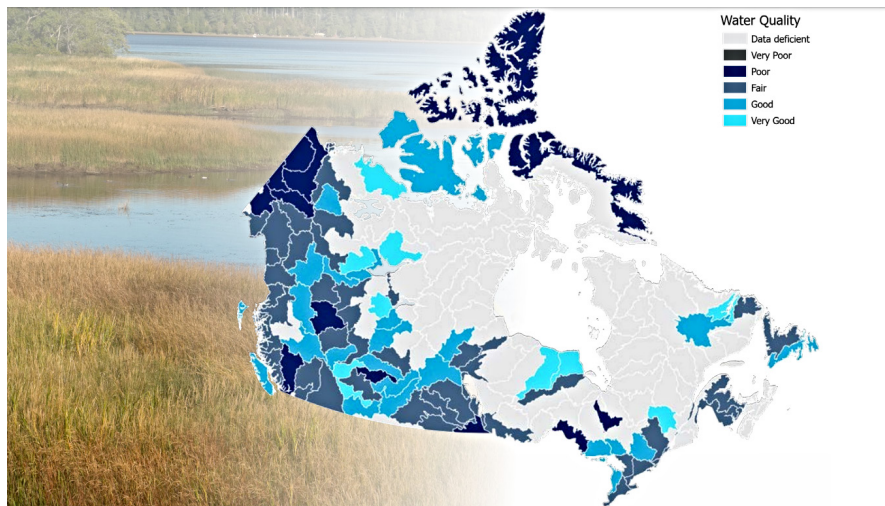
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Currently, different forms of filtration are being tested through Greater Vernon Water's Mission Hill Water Treatment Plant Pilot Study.

WWF REPORT WARNS OF DATA GAPS IN 60% OF CANADA'S SUB-WATERSHEDS



Water quality map of Canada. WWF Canada

A new report from World Wildlife Fund Canada warns that missing monitoring data from 100 of the country's 176 sub-watersheds may be obscuring threats. That missing data is putting freshwater health at risk, the report warns, as it means not knowing when and where to take action when it comes to understanding the most critical needs around health indicators. These include water quality, flow, fish and benthic invertebrates that live on the bottom of a water body as reliable gauges of water health.

"Despite the threats and wildlife declines, freshwater habitats are largely unprotected and understudied," the report states. It calls for growth in community-based water monitoring and is a follow-up to WWF's 2017 watershed assessment, when 110 sub-watersheds were found to be data deficient.

The Toronto-headquartered conservation organization says assessments should be carried out every three to five years to provide a holistic understanding of what is currently happening with freshwater ecosystems throughout Canada.

Environmental monitoring from Sequencing the Rivers for Environmental Monitoring and Assessment (STREAM), was critical to providing more data for the 2020 report. STREAM is a collaboration between WWF-Canada, Environment and Climate Change Canada, the University of Guelph and Living Lakes Canada.

The new report highlights issues with two sub-watersheds in particular due to a continuing inability to gain certain data points. These are the Northern Québec watershed and the Assiniboine-Red watershed throughout the prairies. The Northern Québec watershed remains data deficient with 10 of its 12 sub-watersheds not receiving a score.

"This is of concern since the area is home to some of the largest dams in the world and flows in those sub-watersheds have suffered impacts from man-made barriers," the report states.

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Additionally, the Assiniboine-Red watershed is now data deficient in all four of its sub-watersheds for the benthic invertebrate indicator.

"This area is dense in agricultural activity, which is a concern for benthic invertebrate communities due to pesticide runoff and erosion from overworked soil," the report states.

For sub-watersheds that scored poor or fair in the reports, the lower rankings were often associated with poor flow and water quality indicator performance.

The Upper St. Lawrence sub-watershed was previously data deficient, but is now considered in very poor health due to a very poor benthic invertebrate score.

Through this, certain species in a given area can help indicate if the water is healthy or not. Sixty-four per cent (107 of 167) of Canada's sub-watersheds are data deficient for this metric.

But, there were positive trends, too, since the 2017 assessment. For example, the Attawapiskat sub-watershed in northern Ontario was previously data deficient and now has an overall score of fair, partly driven by a fair water quality score.

The Upper St. Lawrence sub-watershed, previously data deficient, at least has more monitoring data available; however, it is now considered in very poor health due to a very poor benthic invertebrate score.

"With this report, we can make sure we're prioritizing restoration actions in regions that face the highest threats and continue protection of regions that are in good health, making sure we keep them that way into the future," said Megan Leslie, president and CEO of WWF Canada.

The report looks at the impact of man-made structures, such as dams, ongoing water extraction for agriculture, and resource development, on indicators like flow. Under the heading of hydrology, WWF gave 53% of sub-watersheds a score of poor or fair.

"The new data has revealed that river flow is a much bigger problem than we thought," the report states, noting that climate change may be playing a significant role, particularly in cases such as the Arctic Coast Islands.

In terms of water quality, 61% of sub-watersheds received a score of either

poor or fair.

Issues affecting water quality were often exceedances of aluminum, chloride, iron and phosphorus, as well as levels of dissolved oxygen below the concentration required for healthy aquatic life. High levels of phosphorus and low concentrations of dissolved oxygen are often associated with agriculture.

High chloride in urban areas is often a product of road salt application, the report noted.

In the more resource extraction focused areas of the Columbia or Battle River sub-watersheds, metals such as aluminum, cadmium, zinc, iron and mercury, along with nutrients, were the main parameter drivers.

Yukon and the Newfoundland and Labrador watersheds had benthic indicator scores go from poor, good or very good to data deficient in the reassessment, proving "how quickly data and assessments can become outdated and highlights the need for more strategic and consistent monitoring," the report states. ■



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Aerzen.....	17
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Barr Plastics	21
BDP Industries	2
Blue-White.....	7
Denso.....	9
Endustra Filter Manufacturers	45
ERIS – Environmental Risk Information Services.....	23
H2Flow.....	31
Halogen Valve	29
Harmsco Filtration Products	33
HRS Heat Exchangers Ltd.....	14
Huber Technology	19
Hydro International.....	13
Imbrium Systems	64
InfoSense.....	25
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RTS Companies	40
RV Anderson.....	24
Sentrimax.....	53
Service Filtration	24
SPD Sales.....	31, 39
Stantec.....	35
VEGA Instruments, Canada.....	11
Vissers Sales Corp.....	15
Water For People	49

WASTEWATER

UNIVERSITY OF GUELPH TO TRACK WASTEWATER FOR FOODBORNE ILLNESSES AND COVID-19

A new \$6.5-million outbreak detection project led by a University of Guelph food scientist aims to develop an approach to metagenomic detection of foodborne pathogens in raw sewage that could also apply to tracking COVID-19. Lawrence Goodridge will lead the three-year Stopping Enteric Illnesses Early project under Genome Canada through Ontario Genomics and track wastewater in Quebec City, Guelph and Winnipeg.

In combination with wastewater monitoring, project leaders will also monitor social media for keywords associated with enteric illness to detect possible outbreaks in specific geographical areas.

“Putting wastewater monitoring and social media analysis together could detect community outbreaks that might have otherwise gone undetected because the approach identifies infected people who aren’t yet showing symptoms or who do not show symptoms,” said Goodridge.

The project hopes to be a more proactive approach to the impediment that current surveillance methods rely on sick people to seek medical help when it comes to the identification of contaminated food.

It is estimated that only a small proportion of enteric and foodborne illnesses are actually reported to public health. Each year, some 4 million people

get sick from food borne pathogens with 14,150 people hospitalized, and even 323 deaths. The annual economic burden can reach \$4 billion, reports Genome Canada.

Enteric illnesses, which impact the intestines, can include illnesses such as botulism and salmonellosis.

**Social media
keywords associated
with enteric illness
will also be monitored
to detect possible
outbreaks in specific
geographical areas.**

The Stopping Enteric Illnesses Early project is one of 10 new genomics research projects across Canada to receive a total of \$16 million in federal support, through Genome Canada’s Genomic Applications Partnership Program.

A key advantage of this flexible ‘omics (biological sciences that ends with “-omics”) and social media surveillance approach is that it can be scaled for rapid detection of other pathogens.

Also, it will be immediately utilized to monitor levels of SARS-CoV-2 (the COVID-19 virus) in wastewater, as an early indicator of changing case numbers prior to clinical presentation,” states Genome Canada in its project description.

Goodridge’s project joins other Canadian efforts to monitor SARS-CoV-2 in wastewater, such as the Canadian Water Network’s Wastewater Coalition’s Inter-Laboratory Study.

It is in the first phase of a national pilot program to characterize the inter and intra laboratory variability associated with results from testing of SARS-CoV-2, using RT-qPCR after extraction from a common wastewater matrix. ■



Scientist Lawrence Goodridge will lead the three-year Stopping Enteric Illnesses Early project under Genome Canada through Ontario Genomics. University of Guelph.



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- Spiraflo & Spiravac peripheral feed clarifiers
- Closed loop reactor oxidation ditch systems
- Rotary brush aerators
- High efficiency single stage integrally geared blowers
- Direct drive turbo type blowers
- Aeration system controls & instrumentation
- Chain & flight clarifier systems & components (plastic, cast iron or stainless steel)
- Half bridge, centre feed, circular clarifiers
- Spiral blade clarifiers

TERTIARY TREATMENT

- AquaDisk® - cloth media tertiary filter
- AquaDiamond® tertiary cloth media for traveling bridge filters
- Filter Underdrain Systems

HIGH EFFICIENCY MIXING TECHNOLOGY

- High Performance Centrifugal Dispersing Impeller (HPCDI™) mixers

BULK MATERIAL HANDLING

- Shaftless & shafted screw conveyors
- Screw pumps (open & closed designs)
- Industrial grinders

ADVANCED LAGOON TREATMENT TECHNOLOGIES

- MARS™ Wastewater Lagoon Aeration
- NitrOx® Cold Weather Lagoon Ammonia Removal
- LRAS™ Advanced Lagoon Treatment
- PhosBox Lagoon Phosphorus Removals

TANK COVERS & DOMES

- Aluminum geodesic domes
- Flat aluminum and FRP tank covers
- Aluminum channel and launder covers
- Aluminum hatch covers

DISINFECTION

- UV disinfection systems
- Package & custom ozone systems

BIOSOLIDS PROCESSING/HANDLING

- Sludge storage bins & live bottom dischargers
- Rotary Drum Thickeners
- Gravity Belt Thickeners
- Belt filter presses & screw presses
- Centrifuges for thickening & dewatering

ODOUR CONTROL

- Biofilters
- Bioscrubbers
- Carbon adsorbers
- Chemical wet scrubbers
- Ionized air

FLOWMETERS

- Open channel flow metering (portable & permanent); wireless data transmission
- Non-contact radar & submerged sensor area velocity flow metering (portable & permanent); wireless data transmission
- Insertion mag flow meters with wireless data transmission
- Data loggers with wireless data transmission

INDUSTRIAL WASTEWATER TREATMENT

- PCI Series DAF with corrugated plates
- PWI Series DAF low profile, from 20-800 GPM
- Pipe flocculators
- Industrial wastewater treatment systems
- Coalescing oil/water separators
- Inclined plate clarifiers

PACKAGE TREATMENT PLANTS

- Package potable water treatment plants
- Package sanitary wastewater treatment plants
- Package industrial wastewater treatment plants
- Package industrial process water treatment plants

WATER TREATMENT

- Pressure filtration systems (removal of iron & manganese, arsenic, fluoride, radium, uranium)
- Filter Underdrain Systems

ADVANCED INDUSTRIAL STORMWATER TREATMENT SYSTEMS

- Removal of free oil, TSS, metals, nutrients, BOD/COD, bacteria, toxic organics, floatable trash

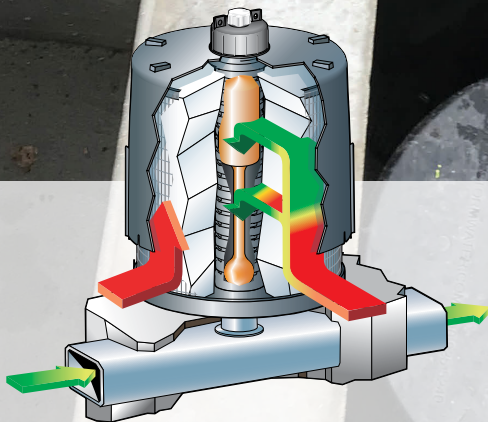


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