JANUARY 2017

Water Innovations

TOP 10 TRENDS OF 2017

EXPERT INSIGHTS INTO TODAY'S CRITICAL WATER & WASTEWATER ISSUES

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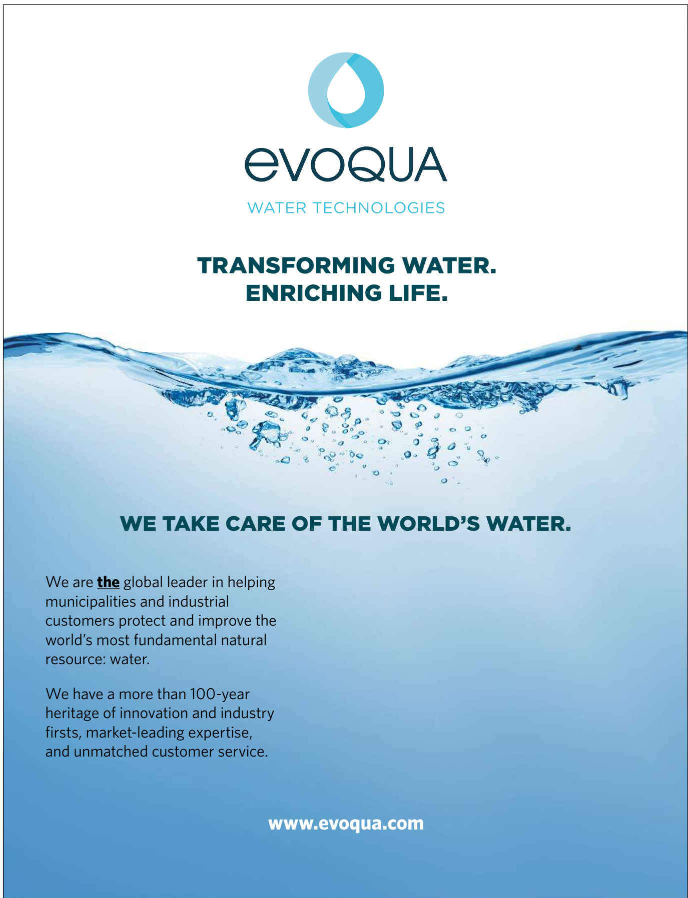

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EDITOR'S LETTER

By Kevin Westerling
Chief Editor, editor@wateronline.com

7 Keys To 'One Water'

It's a buzzword for the industry, but what does it really entail?

To illuminate and promote the idea of One Water, the US Water Alliance recently outlined seven characteristics common to the approach, defined as "managing all water in an integrated, inclusive, and sustainable manner to secure a bright, prosperous future for our children, our communities, and our country."

Water Innovations supports the concept as well. For each of the seven "hallmarks of One Water" from the *One Water Roadmap* report (US Water Alliance, December 2016), there is a corresponding solution to be found in the "Top 10 Trends Of 2017" — an indicator that the One Water philosophy and water industry innovation go hand-in-hand.

A mindset that all water has value. "All water can and must be managed carefully to maximize its benefit."
The volume of water lost in the distribution system has become a focal point for municipalities in recent years, brought to the fore because of scarcity, economics, and continuously deteriorating pipes. But another reason for the attention is the newfound ability to detect leaks through technological advances. Among the most impressive techniques is a noninvasive, satellite-based system that saves labor hours while also saving valuable water (see "'Far Out' Technology Simplifies Pipeline Leak Detection").

A focus on achieving multiple benefits. "Design and implement programs with a focus on achieving multiple benefits — economic, environmental, and social."
You may already be familiar with the "triple bottom line" approach to sustainable development, a framework that considers the three Ps — profit, people, and planet — and is very compatible with One Water. Environmental impact bonds, described in "Financing Infrastructure Through Environmental Impact," have the triple bottom line baked into the investment, with financial risk that is shared and therefore minimized.

A systems approach. "Tackle problems based on the complete lifecycle of water and larger infrastructure systems — rather than limiting ourselves to one piece of the equation."
Water reuse can happen at various stages of the water cycle and can be executed by various players (industrial, municipal, on-site). Shortening the typical route from wastewater to useful water expands supply and preserves infrastructure, bringing immediate value to practitioners and long-term benefits to the industry at large (see "Stepping Up Water Reuse — From Irrigation To Direct-Potable").

Watershed-scale thinking and action. "Communities must reconcile their water demands with the imperative to sustain the resource for future generations."
Watersheds are shared, and thus it is a shared responsibility to keep them clean. For wastewater treatment plants (WWTP), it's imperative that they stay ahead of potential threats. Understanding risk can help prevent pollution events, mitigate those that occur, and justify infrastructure investment. To help, "A Comprehensive Software Tool For Assessing Risk At Wastewater Treatment Plants" has been introduced.

Right-sized solutions. "Focus on the appropriate scale of intervention to achieve the desired outcome."
WWTPs serving large cities with ample budgets can afford big, expensive improvements, but sometimes smaller-scale solutions are more sensible and cost-effective. There are also times when a small utility with limited resources needs a big fix. While the One Water philosophy can be applied at any scale, the utility and the public are best served when solutions are "right-sized" to efficiently meet the objective. "A Small Utility's Path To Climate Change Readiness" is a case in point.

Partnerships for progress. "Recognize that all sectors are part of the solution to a water-secure future."
Protecting our water supply is a group effort — it takes many hands to achieve it, or just a few to spoil it. Water stakeholders across the board can align capabilities for mutual benefit while also serving the One Water initiative. For example, the Water Research Foundation co-funded a project with Halifax Water in Nova Scotia that makes water treatment more sustainable, with excellent prospects for wide-scale implementation (see "In-Line Turbines Harness Energy For Water Utilities").

Inclusion and engagement of all. "Leverage investments in water systems and water resources to build stronger communities, a clean environment, and thriving local economies for all."
Water connects us all, and water and wastewater utilities, as caretakers of this precious resource, are inextricably bound to the community at large. Sadly, this bond often goes unacknowledged beyond the surface-level relationship of service provider-to-customer, amounting to missed opportunity. Not so in Chicago, where the wastewater utility turned a one-time nuisance ("sludge") into a literal growth opportunity, detailed in "Evolving From Controlled Biosolids Distribution To Revenue-Generating Compost".

There is much more to the One Water story, of course. It is a cyclical, never-ending journey, like that of water itself. The One Water goal, as with *Water Innovations*, is to help guide your way.

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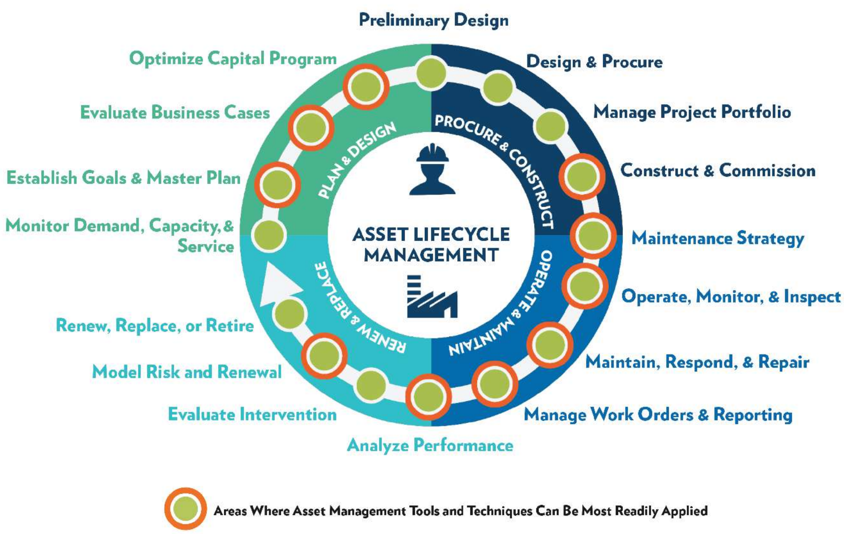
Defining Your Asset Management Pathway

How to create or enhance a utility asset management program using four simple tactics.

By David Sklar

When water and wastewater utilities start to think about asset management, oftentimes the initial discussion centers around activities such as assessment, compliance, and reporting. The first words people hear are typically things like "lifecycle costing," "asset hierarchies," and "business risk exposure." With all of the lexicon around asset management programs, it's sometimes easy to lose sight of the fact that the real value is in the outcomes the program can deliver in terms of improved system reliability, quicker crew response, and a sharpened focus on renewal needs.

When thinking about asset management, it is important to remember that the data, systems, and analytics aren't ends in themselves but must be integrated with more fundamental improvements to business processes. These must be embraced not just by asset management staff but by the entire organization. If an asset management program is to be truly transformative, it must go beyond analytics and deliver fundamental benefits that resonate with frontline employees involved in water and wastewater operations, maintenance, and customer service — the staff who deal most directly with the infrastructure and customers.



I often hear from utilities that have struggled with their implementation efforts: What can we do differently to start on a pathway that results in less theoretical and more actionable outcomes? Whether starting a new program or enhancing an existing one, establish a strong foundation and a practical approach. Although the U.S. municipal water sector is well past the "awareness" stage of asset management, the diverse drivers and lack of a specifically mandated framework means that utilities have a lot of flexibility in deciding how they want to approach and implement their programs. While common wisdom would still suggest drawing upon accepted industry standards such as ISO 55000 and the IIMM (International Infrastructure Management Manual), it is not necessary to check all the boxes to be successful. It's important to remember that at its core asset management is still an approach and philosophy and offers a lot of flexibility to tailor a specific program to meet your needs.

To ensure short-term implementation successes, think of tactical outcomes: Can it make work easier and more efficient for field staff? Can it provide more accurate information to speed decision making? Can it help improve customer service and system reliability?

Staying true to some common principles, each utility is free to determine its own appropriate pathway by focusing on initiatives that are aligned with the organization's overall strategic goals, achievable, and most likely to be impactful in the short term. There are four simple tactics that can help any water, wastewater, or stormwater utility enhance an existing program or start from a strong foundation.

Formalize The Team And Define Outcomes

Start by getting an energized team and ensuring they have ample time to dive in and get involved, are driven by a clear charter and mandate, and have active executive-level support. If needed, provide background training and education and promote collaboration and breaking down of silos — don't just focus on planning and analysis but ensure equal roles for O&M, finance, and information technology. Set clear team expectations including milestones and target outcomes to track progress. While it's important to have a strong leader(s), the asset manager also needs to stay grounded and realize that the

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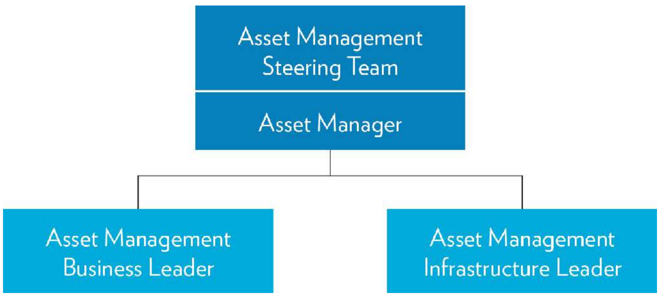
www.duperon.com | 800.383.8479 | dcsales@duperon.com asset lifecycle requires equal collaboration with O&M, which is responsible for most of the hands-on work throughout the life of the asset. In many cases, successful asset management programs appoint "asset owners" from O&M who work collaboratively with asset management team members to develop plans and make investment decisions. Avoid the "ivory tower" mentality and look to create an asset management structure that embraces the entire organization. For one city in the Southeast U.S., the asset management structure included an infrastructure leader residing in the O&M organization responsible for executing asset class strategies and appointing formal work planners and schedulers. The planner positions are experienced staff with CMMS "power user" expertise who also understand the details and realities of field work.



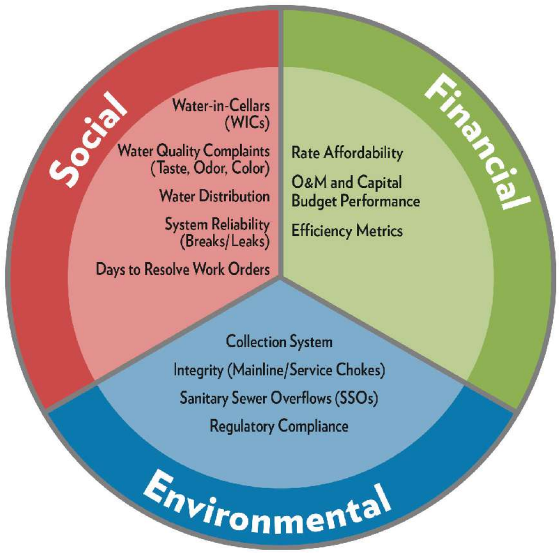
Define Priority Initiatives

Take an objective approach to defining priority initiatives and look past the typical asset management condition assessment and asset management plan development tasks. Don't just focus on writing reports and manuals. Ask fundamental questions such as: Is this going to have a significant positive impact on our organization? Will customers benefit? Can we readily communicate the benefits to stakeholders and public officials? Be sure to pick both short-term and long-term activities and don't focus only on maintenance, as asset management initiatives can span the entire lifecycle including planning, design, and construction. When establishing your priorities, quantify current cost and performance and develop specific metrics and milestones that are likely to demonstrate benefit within 12 months. This will help garner early support and pave the way for longer-term improvements. For one city in the Northeast, the asset management program was first implemented for linear infrastructure (sewers and water mains) in order to tackle critical issues with sewer overflows, basement backups, water main breaks, and water quality complaints. Once these service-level issues have been addressed and stabilized, the program will be rolled out across other asset classes over time.

Measure, Manage, And Communicate

Pick the right metrics and clearly understand how they will be used to communicate benefits and outcomes. Improving performance data, accuracy, and transparency are key tenets of asset management. While system-wide improvements can take years to manifest themselves, look for ways to demonstrate early positive trends using rolling averages as well as measuring localized and neighborhood improvements that demonstrate an approach focused on "service equity." Most importantly, use metrics actively, openly, and transparently — if goals aren't being achieved, be adaptable and change tactics as needed. Stay grounded with real and meaningful measures — think of areas that are visible to both staff and customers including water quality, system reliability, and response and restoration times for emergency events. For internal staff, consider metrics like work order backlog, preventive maintenance compliance, and asset failure rates.

Early on in the process, active communication is key. Use newsletters, posters, and brochures to inform staff and promote awareness. Creating simple, targeted, annual asset management updates can help ensure the support of customers, stakeholders, and elected officials. Many utilities across the U.S. are now publishing annual asset management reports with detailed metrics across social, financial, and environmental domains.



Understand Your Roadmap

Always consider the asset management program an evolving journey. Industry practice and technologies related to maintenance management systems, mobile technology, and condition assessment techniques continue to advance, and programs need to maintain step as well. Keep the program fresh with quarterly formal reviews and open discussions, involve new individuals, and don't be afraid to change direction. Identify and incorporate new initiatives as the need arises, adapt to changing strategic plan priorities, and reprioritize as needed to keep a focus on delivering benefits. Focus your efforts by starting with smaller pilots and gain internal support for a more comprehensive rollout based on strong business cases and benefit justification. Create your own customized "living" road map that evolves and serves as your pathway to success. ■

About The Author

David Sklar is a principal consultant with WSP | Parsons Brinckerhoff, a global engineering and professional services organization. Based in Washington, D.C., David leads the firm's asset management and business strategy offerings within the water and utility sectors. He is a recognized industry leader with over 20 years of experience across energy, water, and public works. His key areas of expertise include asset management, environmental sustainability, capital planning, process improvement, and performance management. David holds a B.A. in economics from Boston University and an MBA in sustainability from the University of Colorado at Denver. www.wsp-pb.com/USA

What Is A 'Safe' Amount Of PFOA?

Polyfluoroalkyl and perfluoroalkyl substances like PFOA and PFOS have emerged as the contaminants of greatest concern for many consumers. While the U.S. EPA has issued a health advisory with limits on the chemicals, some affected communities wonder if their restrictions go far enough. So, what is an acceptable amount of PFOA in your drinking water?

By Peter Chawaga

Perfluorooctanoic acid and perfluorooctanesulfonic acid (PFOA and PFOS) have become the most feared and discussed drinking water contaminants among consumers.

Contamination can be traced back to manufacturers of numerous consumer products, including Teflon™, though many companies agreed to phase out their production of PFOA and PFOS by 2006. The substances were also found to have entered water sources via firefighting foam from military operations, though these too have pledged to put an end to use of the chemicals.

Despite the recent vows to change, communities across the country have found the substances in their water, indicating years of undisclosed consumption. Polyfluoroalkyl and perfluoroalkyl substances (PFASs), a family to which PFOA and PFOS belong, have been known to cause cancer, development effects to fetuses, liver effects, immune effects, thyroid effects, and other complications, according to the U.S. EPA. Town hall meetings have been organized and regulators have been grilled over health concerns.

> **The EPA has established a lifetime health advisory level of 70 parts per trillion (ppt), claiming this would offer a margin of protection for all Americans.**

Where Things Stand

The EPA has not established a national primary drinking water regulation for PFOA and PFOS, though water systems are required to monitor them under the third Unregulated Contaminant Monitoring Rule (UCMR 3) established in 2012, which could be a path to regulation.

"In accordance with the Safe Drinking Water Act (SDWA), EPA will consider the occurrence data from UCMR 3, along with the peer-reviewed health effects assessments supporting the PFOA and PFOS health advisories, to make a regulatory determination on whether to initiate the process to develop a national primary drinking water regulation," the agency said.

For the EPA to regulate PFOA and PFOS, they must be found to have adverse health effects and occur frequently at levels of public health concern, and there must be a meaningful opportunity for health risk reduction by public water systems, per the SDWA. The agency said that it will continue to evaluate scientific evidence on the need for stricter PFOA and PFOS regulation.

In the meantime, the EPA has established a lifetime health advisory level of 70 parts per trillion (ppt), claiming this would offer a margin of protection for all Americans throughout their life from adverse health effects resulting from exposure to PFOA and PFOS in drinking water.

"EPA has established health advisories for PFOA and PFOS based on the agency's assessment of the latest peer-reviewed science to provide drinking water system operators and state, tribal, and local officials who have the primary responsibility for overseeing these systems, with information on the health risks of these chemicals," the agency said. "To provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water, EPA has established the health advisory levels of 70 parts per trillion."

The agency reached its advisory levels by examining the effects observed in available animal studies.

"EPA modeled data from multiple studies of various duration which observed adverse health effects including development, body and kidney weight, liver, and immune endpoints," the EPA said. "For both PFOA and PFOS, the reference doses (RfDs) based on multiple adverse effects resulting from short-term and longer-term exposures, fall within a narrow dose range… EPA selected the RfDs for PFOA and PFOS based on the most sensitive effects so that they are protective for the general population and sensitive life stages."

However, this advisory is strictly voluntary and water utilities have no obligation to meet it. Furthermore, questions have been raised over the effectiveness of its 70 ppt limit.

A Different Take

The New Jersey Department of Environmental Protection's Drinking Water Quality Institute (NJDWQI) serves a state with a greater frequency of PFASs in its drinking water than any other besides California, according to a Harvard University analysis. It is responsible for determining maximum contaminant level (MCL) standards for hazardous pollutants in drinking water and, in that capacity, its commissioner asked it to examine PFAS compounds.

"Each compound is examined independently for its health effects, treatability, and detection methods," said Dr. Keith Cooper, academic governor for NJDWQI and professor of toxicology at Rutgers University. "NJDWQI potential health-based MCL were based on sensitive and well-established animal toxicology endpoints that are considered relevant to humans based on mode of action data."

NJDWQI shared its findings from that analysis in a September presentation. In regards to the EPA's 70 ppt advisory for PFOA, the publicly available PowerPoint from that presentation reads, "It cannot be concluded that exposure to these drinking water concentrations is protective of the most sensitive populations with a margin of exposure."

Among the conclusions shared in NJDWQI's public report on PFOA were that continued exposure to even relatively low levels of PFOA in drinking water is known to cause substantial increases in PFOA in blood serum and that the considerable evidence for increased risk of health effects from low-level PFOA exposure suggests a need for caution. Ultimately, the NJDWQI concluded that a 14 ppt MCL would be more appropriate.

Cooper did not want to speculate as to how the EPA should determine its health advisories. He did, however, laud the NJDWQI's approach to determining its own MCL.

"In many instances, it is not the approach as much as it is the specific studies and endpoints used and the risk assumptions applied that you have differences between groups," he said. "The NJDWQI gains its strength by having a diverse group of experts working on a single compound. The evaluation is based on the science and does not become influenced by the policy issues."

How To Respond

When asked how it responds to those calling for stricter limits on PFOA and PFOS, the EPA reiterated its criteria for regulating contaminants under the SDWA — its potential for adverse health effects, frequency at levels of public health concern, and whether or not there is a meaningful opportunity for health risk reduction at public water systems — and indicating its evaluation of the chemicals is ongoing.

For those concerned about their exposure to PFASs in drinking water, it may not be wise to wait for federal regulations to tighten. For the time being, individual water systems and institutes like the NJDWQI stand the best chance of protecting consumers from undue exposure. Local options include closing contaminated wells and changing blending rates or treatment with activated carbon or high-pressure membrane systems.

In any case, it is worth finding out for yourself. ■

About The Author

Peter Chawaga is the associate editor for Water Online. He creates and manages engaging and relevant content on a variety of water and wastewater industry topics. Chawaga has worked as a reporter and editor in newsrooms throughout the country and holds a bachelor's degree in English and a minor in Journalism. He can be reached at pchawaga@wateronline.com.

A Small Utility's Path To Climate Change Readiness

From the lessons of Superstorm Sandy, a road map to resiliency for small, at-risk utilities emerges.

By Rina N. Dalal

How does a small coastal utility deal with recurrent service outages and the expense of repeatedly rehabilitating storm-damaged infrastructure? The South Monmouth Regional Sewerage Authority (SMRSA) has developed a program that serves as a model for other utilities seeking to reduce the impacts of climate challenges.

SMRSA serves 60,000 people across eight coastal New Jersey communities including Belmar, Brielle, Lake Como, Manasquan, Spring Lake, Spring Lake Heights, Sea Girt, and a portion of Wall Township. Founded in 1970, SMRSA's sewerage collection and conveyance system consists of a 9.1 MGD wastewater treatment plant, 11 pumping stations, and 11.8 miles (18.9 km) of force main. Treated wastewater effluent is conveyed to the Atlantic Ocean.

> **The goal of the program is to incorporate greater resiliency into the authority's infrastructure so that it is prepared for the impacts of a rising sea level, storm surges, and frequent and intense rain events.**

The extreme wet weather events that plague the region bring flooding and storm surges to SMRSA's sewer service area. Superstorm Sandy, which was one of the worst storms to impact the area, rendered 10 out of 11 pump stations inoperable and cost the authority $10.5 million in damages. Two shoreline pump stations received severe structural damage when a 13-foot storm surge brought 7 feet of saltwater and several tons of sand onto the pump station sites. The authority found itself in a cyclical pattern of destruction followed by rehabilitation of its critical infrastructure in the aftermath of severe storms. In some cases, the authority would spend hundreds of thousands of dollars to replace an asset after a storm, only to have it destroyed shortly thereafter. SMRSA recognized that it was necessary to include climate challenges in long-term planning goals.

To meet these objectives, SMRSA has begun to execute a Climate Change Readiness Program for its sewer service area. The goal of the program is to incorporate greater resiliency into the authority's infrastructure so that it is prepared for the impacts of a rising sea level, storm surges, and frequent and intense rain events. In addition, the authority seeks to reduce greenhouse gas emissions from its facilities and achieve independence from utility power so that they may provide uninterrupted service during a power outage.

First Mitigate

The U.S. EPA defines climate change mitigation as "human intervention to reduce the human impact of the climate system." Mitigation strategies include reducing greenhouse gas sources and emissions, which contribute to climate change. To mitigate effectively and meet its greenhouse gas reduction goals, SMRSA identified energy conservation and renewable energy generation opportunities within its facilities. A utility-wide energy audit was conducted to determine the authority's energy usage. The audit revealed that in addition to some low-hanging fruit options for energy conservation within the treatment plant, the implementation of a cogeneration system would yield the most energy conservation and greenhouse gas emission reduction benefits.

In 2010, the authority constructed a combined heat and power (CHP) cogeneration facility. The cogeneration system is a renewable energy generation system where greenhouse gas emission reduction is achieved. Methane gas produced by the anaerobic digestion of the plant's residual sludge is utilized to fuel two on-site internal combustion engines that generate approximately 50 percent of the wastewater treatment plant's

SMRSA cogeneration system

electrical energy and nearly 100 percent of the thermal energy required to operate the facility.

Utilizing this energy reduces the use of utility power and has displaced the emission of approximately 1,035 metric tons of CO_2 during 2015. This is the environmental equivalent of 150 houses off the electrical grid. The cogeneration system not only allowed SMRSA to reduce dependency on grid-based power, but it significantly curbed methane gas release into the atmosphere. On average, SMRSA is currently utilizing 99 percent of the digester gas produced by the treatment plant to fuel two on-site internal combustion engines. Approximately 1 percent is lost to the atmosphere through its flare as methane, as opposed to 70 percent prior to the installation of the cogeneration system. The implementation of the CHP program has had a five-year payback on its initial investment. "The resultant savings that are realized every year thereafter are being utilized as a revenue stream to fund additional climate change related incentives," says Michael Ruppel, executive director of SMRSA.

During Superstorm Sandy, the treatment facility lost power supply for 14 consecutive days. During a power outage, SMSRA's cogeneration system must be shut down for the safety of the utility personnel repairing other portions of the power grid. Therefore, the authority was forced to rely on its diesel-fired standby auxiliary power systems to run the plant. While this allowed for reliable service from the treatment plant, access to diesel fuel was limited as other utilities in the region faced similar challenges. The lesson learned from the Sandy experience was that if the authority could increase the electrical and thermal energy production of the existing cogeneration system, it could provide continuous treatment capability during similar storms without relying on grid-based power or diesel fuel systems.

To meet the full electrical demand of the treatment plant, the authority plans to install a third engine to expand the existing cogeneration system. A new dual-fuel 315 kW internal combustion engine and generator, operating on both natural gas and methane gas, will be installed. The two existing 140 kW internal combustion natural gas engines will be upgraded to 160 kW duel fuel engines (natural gas and biogas) and be operational only when there is a power outage or during periods when the 315 kW internal combustion engine is offline for maintenance or repair. During a power outage, the 160 kW internal combustion engines will be operated on natural gas only. The available methane gas that is generated by the treatment plant will fuel the 315 kW internal combustion engine. When methane gas is no longer generated by the treatment plant, natural gas will be used to fuel this engine. The combined operation of the three engines will supply enough power to operate the treatment plant, thus allowing the CHP system to operate in "island" mode, with zero reliance on a grid-based power system. Construction of the cogeneration system is anticipated to be completed in 2018.

Adapting To Climate Change

While mitigation strategies address one of the underlying causes of climate change, adaptation plans seek to prepare for and adjust to climate change challenges.

While mitigation strategies address one of the underlying causes of climate change, adaptation plans seek to prepare for and adjust to climate change challenges.

SMRSA's pump stations are particularly vulnerable to the impacts of sea level rise and storm surge during wet weather events because of their low-lying and, in some cases, shoreline locations. To address this vulnerability, SMRSA has implemented the unique concept of a mobile enclosure that houses critical electrical equipment and can be removed from the pump station to a safe inland location in the event of a storm-related emergency. The mobile enclosure closely resembles a mobile home trailer and can be mobilized within an hour's notice.

Diesel-powered portable pumps and/or a sacrificial generator render the pump station fully operational during a storm. Once the storm subsides, the enclosure can be moved back to the station and all electrical equipment is put back online. Electrical and control connections between the enclosure and the pump station and its equipment are made with cables and plugs that are opened to allow removal of the enclosure. An expendable portable generator and transfer switch will be transported to the site to operate the station if utility power is lost. Ryan Krause, authority engineer, noted, "This capability

Belmar pump station mobile enclosure

will minimize any damage to the station's electrical equipment and significantly reduce downtime of the station." The station is capable of returning to normal operation within hours after a storm, whereas with a conventional station, if the electrical and control equipment were to be damaged, the station could be out of service for weeks until the equipment is replaced, causing significant environmental damage.

The first mobile enclosure was constructed at a pump station in Sea Girt, N.J. in 2011. When Superstorm Sandy swept through the region, this pump station was the only one that was operational within SMRSA's system. SMRSA sought the same level of protection at its other pump stations but understood that resiliency could not be a one-size-fits-all approach. Ruppel stated "We recognized that without an understanding of the scale, location, and timing of the climate change challenges that could occur, we were at a loss when adopting effective resilience strategies for the pump station." Prior experience told them that each station was uniquely impacted by weather events.

As a result, SMRSA partnered with the EPA to undertake a pilot study of EPA's Climate Resilience Evaluation and Awareness Tool Version 2.0 (CREAT 2.0). By providing historical and projected climate data, this computer software tool assisted SMRSA in understanding potential climate change-related risk to the pump station infrastructure. Due to the fact that the tool provides data from multiple climate scenarios, SMRSA can understand their risk across multiple possible future climate conditions: "hot and dry" or "warm and wet." The tool also enabled SMRSA to understand how the implementation of resiliency measures, such as the mobile enclosure, may reduce the risk to those threats. SMRSA has undertaken an ongoing effort to utilize CREAT to select the most resilient and cost-effective adaptation measures for the 11 pumping stations. This allows the user to navigate their way through the uncertainty surrounding climate change and plan for the best- and worst-case scenarios.

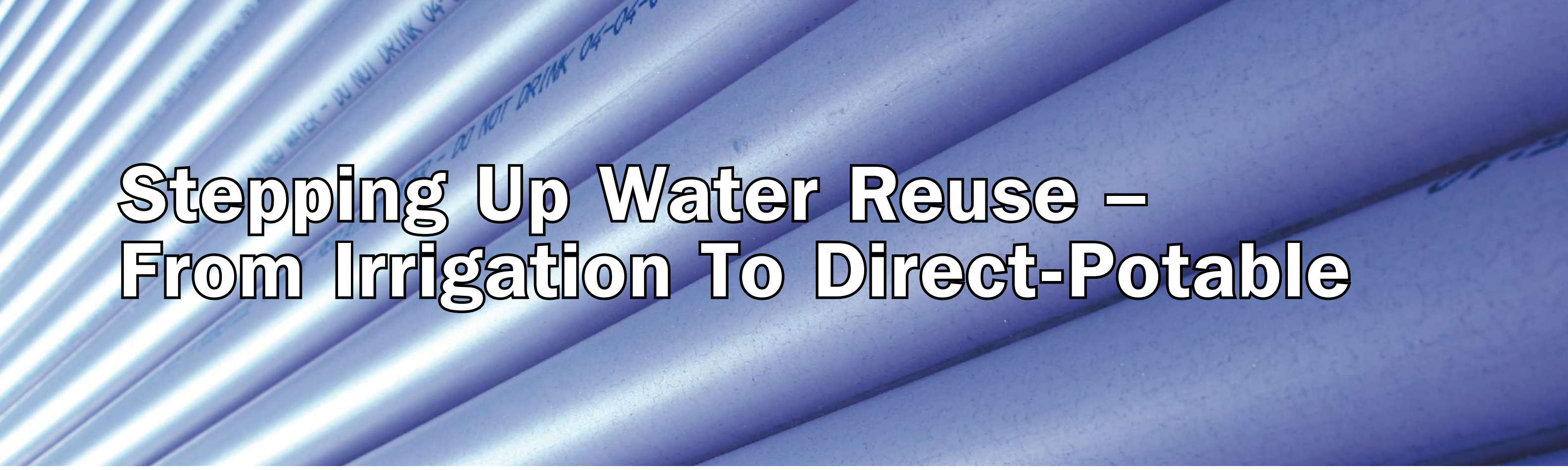
The mobile enclosure design has been replicated twice within SMRSA's service area in the town of Lake Como and the Borough of Belmar. Due to its renowned success, the project has been heralded by the Federal Emergency Management Agency (FEMA) and the EPA as a Best Management Practice for mitigation of damages related to extreme wet weather events. The scalability of the design concept gives it the potential to be implemented by other critical utility service providers that face similar challenges.

Due to its renowned success, the project has been heralded by the Federal Emergency Management Agency (FEMA) and the EPA as a Best Management Practice for mitigation of damages related to extreme wet weather events.

Planning for climate change challenges brings complex issues for water and wastewater utilities which must balance reliability, cost constraints, and the uncertainty of what future climate challenges may bring. By embracing cutting-edge solutions and proactive planning strategies, South Monmouth Regional Sewerage Authority stands at the forefront of the industry as being one of the first climate-ready utilities. ■

About The Author

Rina N. Dalal is a senior staff designer at T&M Associates headquartered in Middletown, NJ, a full-service environmental engineering consulting firm. She works in the Water Resources Practice where she contributes to climate change resiliency and water and wastewater infrastructure improvement projects. She holds a bachelor's degree in Environmental Engineering and a master's degree in Sustainable Design.



Stepping Up Water Reuse – From Irrigation To Direct-Potable

Water reuse is trending up. Here are nine developments to watch in 2017.

By Christopher P. Hill

Water scarcity, both long-term and short-term, is already affecting large parts of the world. Persistent drought and the need for better stormwater management are expected to intensify with climate change and urbanization. Fortunately, with scarcity comes a silver lining: more and better water reuse strategies are taking hold, generating more efficient uses of the water we have.

With the relentless pressure to balance demands for, and supplies of, water for drinking, agriculture, industry, energy, and recreation, water authorities continue to turn to stormwater, graywater, and wastewater reuse to meet the needs of their customers.

While the industry looks globally for answers, utilities can't ignore local needs and conditions. Thanks to their collective contributions and local adaptations, water reuse continually reinvents itself. Watch these trends for 2017.

1. **Reuse is on the rise, especially in California and Florida.** In fact, according to a new study forecasting water reuse in the U.S. (http://www.wwdmag.com/water-recycling-reuse/california-surpass-florida-largest-market-water-reuse), while Florida may have the most installed capacity, California has enough projects in its pipeline to surpass Florida's numbers. The study projects that overall, municipal reuse in the U.S. will increase 58 percent by 2026.

   The supporting infrastructure for water reuse, from purple pipes to advanced treatment for direct potable systems, will ultimately boost water sustainability for many years. For example, the Arcadis Sustainable Cities Water Index report notes that while no U.S. cities make the top 10 in the water sustainability ranking of 50 cities worldwide, both Los Angeles and San Francisco rank higher than other U.S. and European cities in water reuse. This existing base puts these California cities in a better place to achieve sustainability goals into the future.
2. **Potable reuse sets the pace.** The big interest now and into the future will be for potable reuse. We've figured out how to use water for irrigation. Recycling water for drinking holds even more promise for water-starved communities.
3. **Up next: Direct potable reuse.** The industry's goal — making direct potable reuse (DPR) feasible, reliable, safe, and accepted — is a work in progress, but one that makes headway every day. According to the California Direct Potable Reuse Initiative's "Reporting on significant progress," the studies sponsored by WateReuse and WateReuse California, creating the foundation for economic considerations, treatment regulations, safety standards, and operational protocols will better enable DPR to be employed in California.
4. **Proven in El Paso.** To address peak summer needs, the El Paso Water Utility (EPWU) tested the feasibility of direct potable reuse, and is now on track to bring a full-scale system online. Arcadis conducted a pilot test to establish treatment criteria, and identified the treatment protocols that would meet or exceed all standards and regulations.

Pilot testing for EPWU's planned Advanced Water Purification Facility

   Now the utility is developing a DPR system to recycle 10 MGD of treated secondary clarifier wastewater effluent to supplement the city's current drinking water supplies. The full-scale system will provide ongoing data that can optimize DPR design elsewhere.
5. **Reuse of stormwater and graywater continues to expand and adapt.** Not to be ignored, the popularity of graywater and stormwater reuse will fuel projects on multiple levels, often solving multiple problems at once.

Research will help answer questions like how to reduce viral pathogens and develop guidelines for treatment to prove feasibility of potable reuse as a regular practice.

Thinking has shifted from "Can we do this?" to "Here's how we'll do this." For example:

- **Florida A-FIRST project — Runoff for irrigation,** Altamonte Springs, FL

Located near Orlando, FL, Altamonte Springs took a holistic approach to both stormwater management and water supply for irrigation. To increase supply, relieve use of its aquifer, and manage runoff from highway I-4, the city developed the first stormwater capture from highway I-4 to be used for irrigation. The new Altamonte Springs-FDOT Integrated Reuse and Stormwater Treatment (A-FIRST) redirects up to 6 MGD of captured stormwater for irrigation — 1.5 MGD to the city and another 4.5 MGD to the neighboring city of Apopka — to reduce pumping from the aquifer and eliminate up to 3 MGD of peak flow to the Little Wekiva River. In addition, the project eliminates the need for more stormwater retention ponds, which in the past could allow pollutants to seep into groundwater.

- **Los Angeles Urban Stormwater – River as green infrastructure,** City of Los Angeles, CA

In a win-win for the city, the Los Angeles Stormwater program combines flood control and pollution reduction to monitor and reduce pollutants in stormwater runoff. The Los Angeles River Revitalization Master Plan looks forward to the day when, rather than channeling stormwater to the ocean from its many iconic viaducts, the LA River will start to return to a natural environment, supporting recreation and water quality as well as stormwater control.

Recycled water flow via purple pipes at the treatment plant

This effort builds on others aiming to rebalance the proportion of LA water that comes from imported supply, and to recycle larger volumes of water for local and regional use.

6. **Planners are re-thinking irrigation as a reuse application.** Even as reuse for irrigation continues to expand, the rise of potable reuse technology raises an important question: After all that cost and treatment, is irrigation the best application for recycled water? The thinking is that water is too precious and should be used for a higher purpose — drinking water.
7. **Costs are making the purple pipes less practical.** While the concept of reusing graywater remains very popular, the cost of implementation remains a barrier. The main trouble is that cities were not designed with purple pipes, or those marked for recycled water, and the retrofit can be cost-prohibitive.
8. **Ongoing research and discovery: Understanding health and environmental impacts.** Research will help answer questions like how to reduce viral pathogens and develop guidelines for treatment to prove feasibility of potable reuse as a regular practice.

   For example, between now and 2018, the Water Research Foundation (WRF) is conducting a new study to provide guidelines and requirements for water reuse to protect public health: "Conventional Drinking Water Treatment of Alternative Water Sources: Source Water Requirements." This research will develop quality parameters, objectives, and treatment protocols for the design, operations, and monitoring of incorporating alternative sources into drinking water supplies.
9. **Regulations remain regional.** Policies and regulations for reuse will continue to address local needs. On one hand, Arizona prohibits direct potable reuse by law. On the other, Florida is changing its law for recycled water to make it more viable. Local conditions reign. We may never see federal standards or regulations since these would have to address a national need and more universal conditions. ■

About The Author

Christopher Hill, PE, BCEE, ENV SP, is a vice president of Arcadis, the Water Supply & Treatment Lead for North America, and a board member of the Water Environment & Reuse Foundation. He has 24 years of experience as a drinking water expert, applying innovative vision and proven technical expertise to more than 100 projects for cities and communities around the world. Chris has a keen understanding of the water cycle, which includes wastewater treatment and resource recovery, and is recognized as a thought leader in alternative water supply solutions such as reuse and desalination.

Selecting A Flow Measurement Technology

What's the right flow measurement method for your operation? A leading independent lab breaks down the options and considerations.

By Philip S. Stacy

What is your flow rate? Seems like a simple question; however, the answer may be quite complex. A lot of variables contribute to whether or not measuring flow is easy or nearly impossible. Variables consist of, but are not limited to, flow conveyance material and size, fluid type, fluid "cleanliness," acceptable level of uncertainty, and expected range of flow rates and velocities.

Assessing these variables is critical before selecting and installing a measurement technology. To assist with initial selection and evaluation, the following information provides the reader with an overall list, and preliminary evaluation, of flow measurement technologies.

Flow Measurement Technologies

The following is a comprehensive list of available technologies that can be used to monitor flows, regardless of system operation or components, along with brief descriptions of each technology group. This list provides the basis of a technology evaluation, with technologies organized into five different groups by their modes of operation: velocity meters, differential pressure technologies, other closed-conduit devices, open-channel control structures, and generated system curves.

- Velocity meters
  - Turbine meters
  - Propeller meters
  - Vortex meters
  - Magnetic flow meters
  - Ultrasonic flow meters
  - Calorimetric meters
- Differential pressure technologies
  - Elbow meters
  - Orifice plates
  - Flow nozzles
  - Venturi meters
  - Flow tubes
  - Target meters
  - Pitot Tubes
- Other closed-conduit flow meters
  - Mass flow meters
  - Positive displacement meters
- Open-channel control structures
  - Weirs
  - Control flumes
- Generated system curves
  - Dye dilution
  - Current meter flow measurement

Velocity meters are flow meters that measure the velocity of a flow which, when multiplied by a known flow area and velocity profile, can be correlated to a volumetric flow rate. For these meters to provide accurate results, they must be placed in locations with uniform flow. Velocity meters can be intrusive or nonintrusive. Intrusive meters may increase the pressure loss in a pipe and are also prone to fouling as they are located within the flow. Nonintrusive velocity meters are typically mounted to the outside of a pipe, but in some cases they may require the installation of sensors and conduits along the pipe walls within the pipe.

Differential pressure flow meters are the most common devices for flow measurement used today. They operate on the basic principle that an increase in the velocity of flow is accompanied by a decrease in the pressure of the fluid under consideration. The pressure drop across the meter is proportional to the square of the flow rate. The flow rate across these meters is obtained by measuring the pressure differential, extracting the square root, and multiplying this by an area and a meter coefficient. The simplest form of a differential pressure-type meter consists of a pressure-detecting element located in the flow path, operating in conjunction with a measuring unit.

Other closed-conduit flow measuring devices include mass flow meters and positive displacement (PD) meters. Mass flow meters, also known as inertial flow or coriolis flow meters, are devices that measure flow as a mass per unit time, unlike other flow meters that measure volume per unit time. To determine the volumetric flow rate, the mass flow rate is divided by the fluid density. If the density of the fluid changes over time or if there are entrained air bubbles, converting the mass flow rate to a volumetric flow rate may not provide accurate results.

Installed magnetic flow meter

PDs operate by isolating and counting known volumes of a fluid while feeding it through the meter. By counting the number of volumes that pass through the meter, a flow measurement can be obtained. There are many different PD designs, each using a different means of isolating and counting these volumes. These meters are highly accurate on the order of 0.5 percent over a 10:1 range of flow and do not require straight runs of pipe like other flow meters. As these meters collect the flow medium and move it, they are only used for small-diameter pipes, (e.g., 12 inches or less). PD devices have tight tolerances, which can lead to fouling if used in flows that contain suspended particles (100 microns or fewer). These particles can also lead to erosion of the finely machined parts, impacting accuracy. These meters can be constructed out of many materials including plastics and metals.

Open-channel control structures can be used to determine flow rates by measuring the area of the flow stream and the head of fluid producing the flow. Weirs provide a simple means of measuring flow in open channels. A weir consists of a vertical plate or other obstruction placed across the open channel with a level or specially shaped opening or notch. This obstruction increases the water level behind the weir. When a fluid flows over the weir, its flow rate is a function of the water depth above the weir crest. Common weir constructions are the rectangular, v-notch, and broad-crested.

Flume control structures are shaped, open-channel flow sections that force flow to accelerate. This acceleration is produced by reducing the cross-section of the flume. As the flow accelerates, it passes through the critical depth, which results in a unique water surface profile for a given discharge. This allows the use of a head versus discharge relationship for flow measurement. Flumes range in size from small (1 inch wide) to large structures (over 50 feet wide) and can accommodate a wide discharge range (50:1). The accuracy of control flumes is similar to that of weirs. The head loss in a flume control section is about one-fourth of that needed for a sharp-crested weir. In some long-throated flumes, the difference in head loss may be as low as one-tenth of what would be expected with a sharp-crested weir. However, control flumes are generally more expensive than weirs.

Generated system curves can be created by correlating pump speed (if applicable) and system pressure to a known flow rate. The successful use of system curves relies upon obtaining enough pump speed and pressure versus flow data points and verifying the data points over time. This technique would only require the permanent installation of pressure taps and would only impact operations during the flow measurement and verification periods. By accurately measuring the flow, it is possible to determine flow rates under a wide range of flows and/or pump speeds. At locations with varying water levels (i.e., tidal water sources), measurements will need to be taken over a range of water heights to account for changes to the intake and discharge heads. To create a secondary check of pump speed versus flow, pressure differential monitoring devices in the system should be recorded during testing to determine pump speed and flow versus head differential. Generated system curves can be created using any of the flow metering methods detailed above; however, there are two commonly used methods that do not require permanent installation of equipment. The two most common methods for measuring water flow in the field are the dye dilution technique and the area-velocity method using current meters. Providing details of these field techniques would require the writing of an additional article and are not detailed herein.

See the following table for information on applicable pipe sizes for each technology and typical vendor-listed accuracies.

Selected Applicable Technologies	Pipe Size (inches)	Typical Vendor Listed Accuracy
Ultrasonic Flow Meters (transit time)	>0.5	±0.2% to ±5%
Ultrasonic Flow Meters (Doppler)	>0.5	±1% to ±10%
Turbine Meters	0.25 to 24	±1% to ±5%
Propeller Meters	2 to 72	±2% to ±5%
Vortex Meters	1.5 to 16	±0.75% to ±1.5%
Magnetic Flow Meters	>0.1	±0.25% to ±1%
Calorimetric Meters	>0.5	±1%
Venturi Meters	>2	±0.7% to ±1.5%
Elbow Meters	>2	±5% to ±10%
Orifice Plates	>0.5	±2% to ±5%
Flow Nozzles	>2	±0.75% to ±1.5%
Flow Tubes	>3	±0.7% to ±1.5%
Target Meters	<2	±1% to ±5%
Pitot Tubes	>3	±3% to ±5%
Mass Flow Meters	0.25 - 6	±0.15% to ±10%
Positive Displacement Meters	<12	±0.5%
Weirs	N/A	±2% to ±5%
Control Flumes	N/A	±2% to ±5%
		Precision Uncertainty
Dye Dilution	N/A	±1% to ±2%
Current Meters	N/A	±1% to 2%

Evaluation Criteria

The criteria listed below should be used to evaluate the relative advantages and disadvantages of each flow monitoring alternative and to select and develop those options that are feasible for implementation. The criteria represent key aspects to any ultimately successful flow monitoring program and do not appear in order of priority.

- Options should be designed to operate over the expected range of flow rates.
- Options should provide an acceptable level of accuracy.
- Options should function under expected debris conditions.
- If applicable, options should allow continuous flow monitoring.
- If applicable, options should not impact the operation of the condenser cooling system.
- Options should have minimal impact, to the extent possible, on the existing civil/structural features.
- Options must be commercially proven at power-generating facilities.
- If applicable, options must meet all safety requirements.
- If applicable, options must minimize hindrance to facility operations during the installation of the metering devices.
- The technology is available and does not require further engineering development.

Notes:

1. When assessing proven industry options at facilities with dissimilar physical, hydraulic, and environmental conditions than the site under consideration, best professional judgment must be used to determine applicability.
2. Available technologies are defined as alternatives that provide data in sufficient detail to develop a conceptual design and/or technologies that have been constructed at other similar facilities.
3. Each technology must be qualitatively assessed to identify whether it has engineering advantages over the other technologies. For example, one technology would have an advantage over another if it requires fewer civil/structural modifications for its installation or if it is similar to another option but more accurate.

Summary

Selecting a flow meter system for industrial applications can be challenging given the myriad choices available. This is compounded when the user understands the many significant application variables that influence the choice. This may explain why, historically, industries have struggled to quantify fluid flows, especially large conduit and large flows. Where facilities rely on accurate flow measurement, an operational understanding of the principles behind each flow metering technology is crucial. ■

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About The Author

Philip S. Stacy, director of calibration services at Alden Research Laboratory, is responsible for all flow meter testing performed at Alden's flow measurement facilities, providing technical and administrative supervision of its Flow Measurement Department to ensure the highest standard for calibrating fluid meters to an accredited certified uncertainty of 0.1 percent in accordance with ISO/IEC 17025:2005.


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‘Far Out’ Technology Simplifies Pipeline Leak Detection

Satellites provide the latest, perhaps most efficient, method for spotting underground leaks, ushering in a new era of non-revenue water management.

By Lauren Guy

Currently, two main methods are used to manage non-revenue water around the world: smart water management systems and acoustic leak detection.

Most water managers use these methods because they are the best solutions available — tried-and-tested, results-driven technologies. However, these approaches to monitoring non-revenue water are also notoriously time-consuming and expensive, as they require prohibitively high investments in infrastructure and equipment relative to the number of leaks that are identified.

A quick assessment of non-revenue water management in a majority of cities around the world indicates that most simply react to anomalies in their water management systems, such as measuring drops in pressure within a district metered area (DMA), analyzing a smart water management system, or responding to a distressed call from a citizen reporting that a burst pipe has turned into a fountain of water on the street. Vast quantities of non-revenue water are wasted each year; this has prompted some technology providers to suggest that water leakage in urban environments is now akin to an epidemic.

Answers From Above

Now, a new tool for detecting non-revenue water leaks is available — a solution that utilizes spectral images from satellites, adapted from techniques used to search for water on other planets. Developed by Utilis, a water management company based in Israel, this noninvasive technique can identify more water leaks in the same amount of time as current non-revenue water solutions available to water managers.

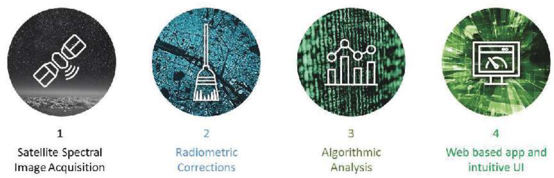
Remote sensors collect data by detecting the energy that is reflected from Earth. Remote sensors can be either passive or active. Passive sensors respond to external stimuli. They record natural energy that is reflected or emitted from the Earth’s surface. The most common source of radiation detected by passive sensors is reflected sunlight. In contrast, active sensors, which are the primary devices used by Utilis, are also known as radars. These devices use internal stimuli to collect data about the Earth. For example, a laser-beam remote sensing system projects a laser onto the surface of Earth and measures the time that it takes for the laser to reflect to its sensor.

Over the course of several years, numerous tests were conducted to identify the unique signature that treated water reflects to the radar. Using a unique wavelength in the radar spectrum, it was discovered that treated water reflected differently than other sources of water, such as sewage, rain, or drainage. The base assumption is that if treated water is present underground, it can only be coming from a nearby pipe.

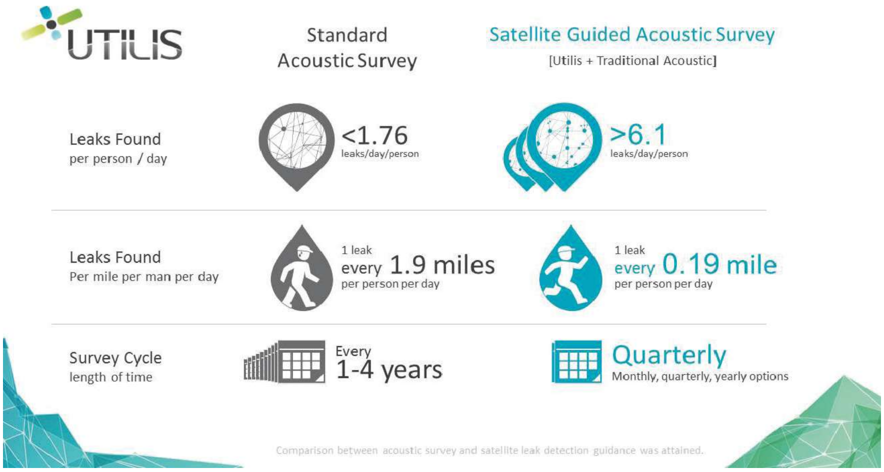
Of course, when dealing with data acquired from 400 miles above Earth, there is potential for problems to arise. Radar is susceptible to noises caused by vegetation, high buildings, metal objects, and the atmosphere. Those issues need to be tackled by a team of signal processing experts before the best possible results may be produced.

The process itself is quite intuitive:

1. A radar sensor acquires images.
2. An algorithm is used to prepare raw data for analysis; this process includes the removal of noises caused by different objects as previously described.
3. A sieve with the known spectral signature of treated water is used to extrapolate only the treated water leaks.
4. Normalized data is presented graphically with findings displayed on a GIS web-based application. Field teams on the ground receive “leak sheets” generated by the system to confirm and repair the leaks.



Using these methods, it’s possible to scan an entire system every few weeks in a matter of seconds, rather than going to the same location every few years with the conventional solutions. This is the true power of remote sensing.



O&M Implications

The ability to scan an entire system every few weeks makes it possible to suddenly observe the micro-evolution of a leak. Subsequently, the organization can make more informed decisions about what leaks or areas to prioritize and even check to ensure that a fix was made to a satisfactory level.

The technology makes no alterations to the day-to-day operations of the municipality or the utility — the on-field crew will still use the same equipment for validation processes. However, instead of walking miles per day blindly hoping to find something, the crew gains the ability to narrow down the cumulative distance to just a few hundred feet overall per day, with a pool of five to 15 leaks to show for a day's work. Thus, the organization can better utilize its personnel and become more cost-effective without any additional investment.

According to Utilis, a regular field crew of four people working with a standard acoustic process will uncover 1.76 leaks per day, on average. By comparison, satellite-based technology allows one person to find 6.1 leaks per day, and the same location will be surveyed again in a matter of weeks.

In contrast to usual acoustic technologies (hydrophones, loggers, correlators, high-sensitivity devices) that look for signs of water (mostly by sound), remote sensing enables utilities to look — for the first time — for the water itself. ■

About The Author

Lauren Guy, co-founder of Utilis, has eight years of experience in scientific R&D, including microwave-sensing studies of other planets (predominantly Venus and Mars). He holds a B.S. in Geomorphology & Remote Sensing and an M.S. in Geophysics, and currently serves as the CTO and head of R&D at Utilis.

A Comprehensive Software Tool For Assessing Risk At Wastewater Treatment Plants

Understanding risk is the first step to combating system failure and protecting the public and the environment from unsafe water.

By Lingfeng Wang

With climate change and increasing occurrences of extreme weather, water resources are becoming critically important to support human lives and societal development. Water recycling and reclamation is an essential way to sustain our water resources. Wastewater treatment plants (WWTPs) are among the most critical infrastructures that play a key role in reclaiming water resources. Thus, the reliable operation of WWTPs is of critical importance. It is a pressing task to assess the reliability of WWTPs in an objective manner for making judicious decisions in budget allocation, maintenance planning, and staff projections. For this purpose, a probabilistic reliability evaluation software tool is developed to comprehensively quantify the reliability of WWTPs. By hedging against uncertainties, the tool is designed to enable informed decision making in asset management for massive WWTPs with aging facilities and limited budgets. The major novelties of this software tool are twofold: (1) the holistic modeling of WWTP reliability and resiliency considering a variety of random uncertainties; and (2) the quantitative analysis of the effluent water quality risk. Specifically, the reliability and resiliency evaluation method considers the long-term WWTP influent profile, the mechanical failures of the WWTP components, and the influence of the electric power supply. Sequential Monte Carlo simulation and fault tree analysis are applied to sample the long-term system states and calculate the available wastewater treatment capacity related to the sampled system states. Additionally, the effluent quality risk in the WWTP is quantified by considering various kinds of factors, such as mechanical failures and test sensor failures related to effluent quality.

Probabilistic Reliability/Resiliency Evaluation Of WWTPs

The reliability of a WWTP indicates its capability to perform wastewater treatment of the required amount and quality. Reliability analysis of a WWTP is beneficial to objectively quantifying the WWTP's capacity to treat wastewater and providing valuable information about the adequacy of wastewater treatment facilities. The reliability of WWTPs is influenced by various factors, including the time-varying influent to WWTP, random failures of mechanical components, availability of its electricity supply system, and human errors. Considering the aging wastewater reclamation facilities in the U.S., it is highly necessary to develop a comprehensive method to quantitatively assess the reliability of WWTPs by accounting for all these variables and uncertainties, but performing an objective reliability evaluation for such complex systems is quite a challenging task. Conventionally, deterministic reliability criteria were used to indicate the overall system reliability of critical infrastructures. However, the reliability characteristics of system components, such as the widely used availability parameters, mean time to failure (MTTF) and mean time to repair (MTTR) are, in fact, stochastic in nature. Deterministic criteria fail to account for these stochastic characteristics, and therefore probabilistic reliability evaluation methodologies are preferred in order to more comprehensively evaluate the reliability performance of critical systems or infrastructures with uncertainties. In light of these considerations, this decision tool deploys a probabilistic methodology to perform reliability evaluation for WWTPs. A diverse set of probabilistic reliability indices is defined and calculated to quantify the WWTP reliability from different perspectives, including the Expected Wastewater Treatment Capacity, Percentage of Untreated Wastewater, Failure Probability of Wastewater Treatment, Expected Wastewater Not Treated, Probability of Insufficient Capacity Margin, Loss of Load Frequency, Loss of Load Duration, and Probability of Insufficient Capacity Margin.

Additionally, quantifying the ability of the WWTP to recover from the failure state to the normal state is also much needed for WWTP designers and operators. In this project, the WWTP's capability of transitioning from the failure state to the normal state is quantified in the resiliency analysis. The term of resiliency measures how quickly the WWTP could bounce back to the normal state after a major failure occurs. There are various definitions of resiliency in different contexts, as it is an evolving concept. In this software tool, the resiliency of a WWTP is characterized by the average recovery rate (ARR), which is the probability that the WWTP being in a failure state recovers to a success state within a specified time period.

Effluent Quality Risk Analysis

The development of modern industry, expansion of populations, and the increasing coverage of the domestic water supply have resulted in a substantial increase in wastewater production. In some countries, the WWTP effluent is the water source for the drinking water system and sometimes is directly used for agriculture. There is an increasing need for good quality water; therefore, the wastewater should be adequately treated and the effluent quality must comply with the discharge standard. Insufficiently treated wastewater may lead to environmental and public health issues.

The main purpose of this function of the software tool is to perform an effluent quality risk assessment considering the reliability of WWTPs. Based on the main fault tree built for effluent quality risk assessment, the probability that a WWTP may have a water quality problem can be calculated. The emphasis in wastewater treatment is placed on guaranteeing that the possible pollutants that could be contained in the wastewater are removed or inactivated to a safe level. The overall removal or inactivation efficiency of the biological hazards is determined based on the fault tree model built for the WWTP. The fault tree analysis (FTA) considers possible causes of the effluent quality problem, including mechanical failures, electrical failures, and other possible causes (e.g., human errors, insufficient contact time, etc.).

Based on the treatment plant procedure, the removal or inactivation efficiency of the biological hazards during each process in the WWTP can be studied. Typical pollutants are defined for treated discharge quality assessment, including biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrogen, phosphorus, oil and grease, suspended solids, and coliform bacteria. The overall treatment procedure of a WWTP is divided into three different types: physical treatment (primary treatment), biological treatment (secondary treatment), and chemical treatment (tertiary treatment or disinfection). Based on the function of each treatment process, the pollutants are linked to one or several treatment processes for removal or inactivation. In the fault tree analysis, the quality risk assessment of each pollutant is analyzed separately, and the overall quality risk assessment of the WWTP is determined based on the results of each part.

For the quality risk assessment of each pollutant, three main conditions are considered: the treatment process failure, the facility monitoring system failure, and the effluent quality test sensor failure. The treatment process failure mainly considers the mechanical failure of the treatment equipment and other causes (e.g., insufficient or excessive chlorine, insufficient contact time). The monitoring system failure indicates the failure of the monitoring equipment that is used for fault detection and diagnosis in each treatment process (e.g., the supervisory control and data acquisition [SCADA] system). Effluent quality test sensor failure means the failure of sensors that are used for effluent water quality tests.

A set of effluent water quality risk metrics can be defined and calculated by the software tool, including the Probability of Excessive Suspended Solids; Probability of Excessive Oil and Grease; Probability of Excessive BOD, Nitrogen, Phosphorus; Probability of Excessive COD and Coliform Bacteria; Failure Probability of WWTP Effluent Quality Test Sensor; and Probability of Unsatisfied Effluent Quality.

More planners and regulators rely on risk-based decision making. This unique, versatile software tool is believed to be a useful addition to the existing asset management tools in the current market for facilitating informed decisions on risk reduction in the evolving wastewater sector. ■

Acknowledgment
This project was supported by National Science Foundation Industry/University Cooperative Research Center on Water Equipment & Policy located at University of Wisconsin-Milwaukee and Marquette University.

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Evolving From Controlled Biosolids Distribution To Revenue-Generating Compost

Chicago continues its long tradition of innovative biosolids management by introducing a new model for sustainability and community service.

By Allison Fore

Since the Metropolitan Water Reclamation District of Greater Chicago (MWRD) was created in 1889, it has worked to clean and protect the local waterways by treating wastewater and managing stormwater. Much can change in 127 years, and the evolution of the MWRD's work with solids generated by the wastewater treatment process offers a prime example of that change. The MWRD serves an equivalent population of 10.35 million people in an 883-square-mile area, covering nearly all of Cook County, IL, which includes Chicago and 128 suburban communities. To meet the demands of the vast amount of waste generated by the region, the MWRD owns and operates seven water reclamation plants and 22 pumping stations. The MWRD treats an average of 1.4 billion gallons of wastewater each day, with the capacity to treat over two billion gallons per day.

At a time when there is growing scrutiny over fertilizers and pesticides, we are supporting a natural trend that is both resourceful to our environment and also our taxpayers.

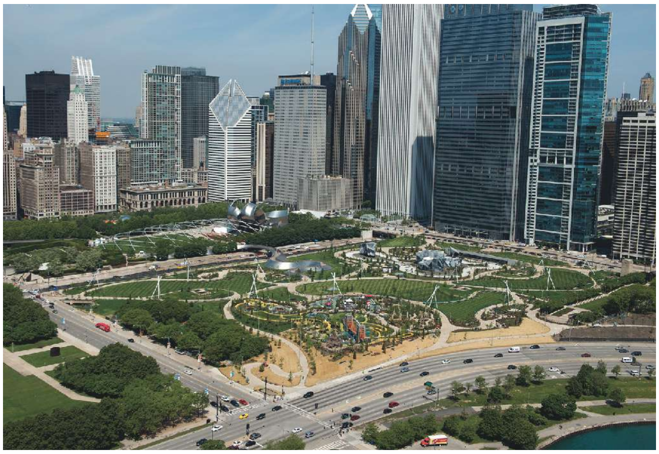
40 Years Of Successful Biosolids Use

For the past four decades, the MWRD has successfully used biosolids to reclaim land, support agriculture, enhance recreational areas, restore and replenish the tree canopy, partner with community gardens, create green landscapes, and use for educational purposes. There are more than 100 users fertilizing golf courses and athletic fields at public parks and school grounds with biosolids. A safe, nutrient-rich, organic product resulting from the wastewater treatment process, the use of biosolids leads to cost reductions, improved soil quality, and increased water retention.

Beginning in the 1940s, the early days of wastewater treatment, the solids generated were sent to landfills. However, in step with the environmental movement of the 1970s that saw the birth of the U.S. EPA and the Clean Water Act, the MWRD purchased 14,000 acres of strip-mined land in downstate Fulton County, IL, and set about restoring the severely degraded land back to usable real estate using MWRD biosolids. Known as "The Prairie Plan," MWRD biosolids were barged 200 miles south along the Illinois River and were distributed over the property as a way to recycle urban wastes safely into the natural environment. The Prairie Plan transformed thousands of acres of strip-mined soil into productive agricultural land where corn, soybeans, wheat, and hay have flourished for decades. The project also produced some of the best outdoor recreational property in the state; the property is now home to abundant wildlife, including a healthy deer herd, wild turkey, quail, and waterfowl. The Prairie Plan received the American Society of Civil Engineers' Outstanding Civil Engineering Achievement Award for 1974.

A Temporary Setback

At the same time the MWRD was developing and implementing the Prairie Plan, it had also developed a sewage sludge product called NuEarth, which was air-dried Imhoff sludge, and given away for horticultural uses. Between the 1970s and 1990s, however, scientists raised concerns about the levels of heavy metals that were found in biosolids throughout the U.S., so distribution came to a halt. In 1986, the MWRD implemented pretreatment and industrial waste programs that led to drastic reductions in the concentration of metals in biosolids. The trace metals found in most biosolids produced today far exceed federal Exceptional Quality standards. Trace metals such as copper, molybdenum, nickel,



Biosolids compost was used to develop the grounds of the new Maggie Daley Park in Chicago.

selenium, and zinc are essential plant nutrients that can be found in MWRD biosolids but at a fraction of the maximum allowable levels. MWRD biosolids provide soils with major nutrients such as nitrogen, phosphorus, and potassium, minor nutrients such as calcium, magnesium and sulfur, and with metals such as iron and manganese that serve as micronutrients and stimulate healthy soil.

Biosolids Program Receives State of Illinois Validation

While the MWRD has been building its biosolids program for decades, the growth of the program was limited as the state of Illinois did not recognize all federal biosolids regulatory standards. That changed on July 20, 2015, when Illinois Gov. Bruce Rauner signed legislation amending the Illinois Environmental Protection Act adopting the USEPA Part 503 EQ biosolids standard to recognize EQ biosolids as a resource and not a sludge or a waste. EQ biosolids, according to federal and state regulatory standards, are a superior alternative to chemical fertilizers for turf grass in landscaping, parks, and athletic fields, as well as for agriculture. The legislation recognizes EQ biosolids as a safe, beneficial, and renewable resource that should be used locally and made available to the public. The new law is in line with federal standards, which provide that the EQ biosolids are "a resource to be recovered" that "can be used on land as a beneficial recyclable material that improves soil tilth, fertility, and stability." This high-quality product will no longer be subject to more stringent regulation as a sludge or other waste and instead will be allowed for nearly unrestricted distribution.

"At a time when there is growing scrutiny over fertilizers and pesticides, we are supporting a natural trend that is both resourceful to our environment and also our taxpayers," said MWRD President Mariyana Spyropoulos. "Recognition of Exceptional Quality biosolids in the state of Illinois is consistent with federal rules and is an important step towards achieving a resource recovery model. Changing the law made good environmental sense and good economic sense."

The composting program has sparked an entirely new enterprise from which to grow and expand, generate revenue, and ultimately protect the environment.

Resource Recovery Ordinance Opens Doors To Composting

The MWRD's Board of Commissioners, a nine-member elected body that creates policy for the 2,000-person government agency, implemented a Resource Recovery Ordinance in October 2016. This ordinance allows the MWRD to accept vegetative materials, such as yard waste and other organic materials, for beneficial reuse. MWRD staff developed a program in which wood chips and yard waste such as leaves, branches, and twigs are composted with biosolids to produce a composted biosolids product. Through this composting program, biosolids will be used locally instead of being hauled to distant farmlands, thereby reducing the agency's carbon footprint and providing the opportunity to distribute a product that is more economically and environmentally beneficial. The composting program has sparked an entirely new enterprise from which to grow and expand, generate revenue, and ultimately protect the environment.

In addition to being used for healthy lawns and landscaping purposes, the compost is safe for use in growing food crops. In 2016, the MWRD partnered with ChicaGRO Intergenerational Growing Project to help convert more than 70 vacant Chicago neighborhood lots into backyard community gardens that use the compost in planting beds and growing vegetables. Brownfields that have languished for years are also finding new life through MWRD composted biosolids; the 87-acre Lake Calumet Cluster Site, home to five former U.S. steel plants along Lake Michigan on the Southeast Side of Chicago, is being restored from rocky terrain to a green space that will one day be a stop for migratory birds. At the MWRD's Hanover Park Water Reclamation Plant, workers are developing a tree nursery that will flourish with the use of the composted biosolids. In addition, the MWRD has distributed more than 25,000 oak tree saplings as part of a new initiative called Restore the Canopy, Plant a Tree. The program, implemented in April 2016, educates the region about the importance of the tree population that has been decimated in recent years, as well as the lasting benefits that trees provide in managing stormwater. Each tree sapling is distributed in the compost blend.

Goals For Biosolids Composting Program

In 2016, the first year of the composting program, the MWRD met an internal goal of producing 10,000 tons of composted biosolids. In 2017, the goal is to produce and sell 50,000 tons, and

The MWRD partnered with ChicaGRO Intergenerational Growing Project to help convert more than 70 vacant Chicago neighborhood lots into back-yard community gardens that use MWRD's new compost in planting beds and growing vegetables.

MWRD biosolids were used to fertilize and green Chicago's Ping Tom Memorial Park.

in 2018, the goal is to sell 100,000 tons. At this time, the plan is to charge $30 per cubic yard, and recipients must complete a short application.

Partnership With The City of Chicago

In 2013, before implementation of the Resource Recovery Ordinance, the MWRD partnered with the City of Chicago to share tens of thousands of cubic yards of wood chips as a bulking agent for composting MWRD biosolids; the wood chips derive from 13 million ash trees lost in the city due to the emerald ash borer devastation. Because the mixing ratio is 3:1 wood chips to biosolids, the compost blend requires a steady flow of wood chips, yard waste, and other feedstock. The compost has a greater range of uses than either resource alone and helps reduce the city's landscaping costs.

Biosolids Composting Operations Process

The biosolids composting operations are located at the MWRD's Harlem Avenue Solids Management Area (HASMA) in Lyons, IL, and Calumet Solids Management Area (CALSMA) on Chicago's south side. The composting process raises the temperature of the biosolids and wood chip mixture, killing off pathogens and meeting the USEPA Part 503 regulations for Class A biosolids pathogen reduction. The windrows are turned five times over 23 days, and the temperature is maintained at 55 degrees Celsius. Following the composting process, the product is left in open windrows for curing to complete the stabilization process. The final product is screened to remove large pieces of wood chips before distribution.

Yard Waste Collection Efforts

Finding feedstock to create the compost has become a priority for the MWRD. There is not an endless supply of wood chips or trees so the new Resource Recovery Ordinance helps bridge that gap. The ordinance allows the MWRD to develop a program to collect wood chips and yard waste to blend in the compost process. To recover costs, the MWRD will charge a tipping fee of $20 per cubic ton to receive feedstock and create a new revenue stream through the sale of composted biosolids.

Serving a large area means there is a wide base from which to search for this feedstock. The MWRD is reaching out to area landscaping contractors and tree-trimming companies, waste haulers, utility companies that trim trees, area paper mills, municipalities, and park districts. The MWRD is also installing a composting facility, which requires less energy than heat drying, at CALSMA. The composting facility will be a covered positive aeration system and will have the capacity to process 25,000 dry tons of biosolids per year. The process will require a 1:3 biosolids to feedstock mix ratio by volume and one temperature probe per pile, and necessary equipment includes mixers, loaders, and screeners.

Additional market analysis will be performed to determine demand and potential revenue from the sale of the finished product, which is proving to meet the MWRD's strategic goals in producing a Class A material, reducing and eliminating odors during solids management procedures, reducing transportation, creating readily available end-use products independent of weather variation, reducing operational land requirement and carbon footprints, increasing solids distribution within Cook County, and ensuring financial and environmental sustainability with a potential revenue stream. The goal is to achieve 70 percent local utilization by 2017 and 100 percent by 2018.

The future for generating income for the taxpayers of Cook County through biosolids composting is bright. More information about MWRD biosolids and composted biosolids is available by calling (708) 588-4201. ■

About The Author

Allison Hirsch Fore has served as the public & intergovernmental affairs officer at the MWRD for five years. She has more than 20 years' experience in government communications, having also worked for the Illinois State Treasurer, Illinois General Assembly, Indiana Secretary of State, and Indiana Department of Environmental Management. She received her Bachelor of Science degree from Indiana University's School of Public and Environmental Affairs and Master of Arts degree from the University of Chicago's School of Social Service Administration.

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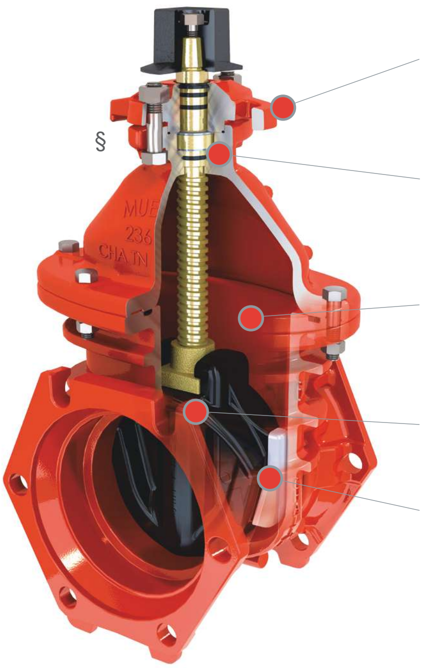

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In-Line Turbines Harness Energy For Water Utilities

Halifax Water and the Water Research Foundation's study finds that turbine generators can do more than just replace the work of pressure-reducing valves (PRVs).

By Jeff Knapp and Linda Reekie

Water systems have an untapped potential to recover energy using in-line hydroelectric generation and to reduce net energy consumption, greenhouse gas emissions, and operating costs. The Water Research Foundation (WRF) co-funded a project with Halifax Water, Nova Scotia, Canada to investigate the installation of a hydrokinetic in-line energy recovery turbine generator within its water system to determine the system's benefits and operational characteristics.

The journey began in earnest in 2010, when Halifax Water began investigating the feasibility of energy recovery instead of traditional pressure reduction using pressure-reducing valves (PRVs) in its water distribution system. A driver was the launch of the new provincial renewable energy initiative called the community feed-in tariff (COMFIT) program, which offered preferential energy rates to renewable energy generation projects that led to the reduction of greenhouse gas emissions in Nova Scotia. The approved COMFIT rate of $0.14/kWh for run-of-river hydro allowed the Halifax Water project to proceed based on sound financial and performance estimates and a reasonable return on investment (ROI). Without this preferential energy rate, the project's rate of ROI would not have been as attractive and may have prevented the project from moving forward.

Halifax Water retained a consultant to conduct a preliminary study of the potential for energy recovery using an in-line turbine (ILT) from Halifax Water's control chambers that used PRVs or flow control valves (FCVs) for downstream pressure and flow control. Several potentially viable sites were identified. The selected site, the Orchard Control Chamber, was thought to be the best initial site for research and development of a prototype system because of its relatively stable but significant diurnal flows and level of pressure reduction. Furthermore, the Orchard Control Chamber supplies water to two large reservoirs that provide significant hydraulic cushion for pressure transients that could result from the operation of the ILT, thus presenting a low risk because the potential failure of any prototype turbine generators would have a minimal impact. The Orchard Control Chamber was also in close proximity to an easily accessible point of interconnection with the electrical grid.

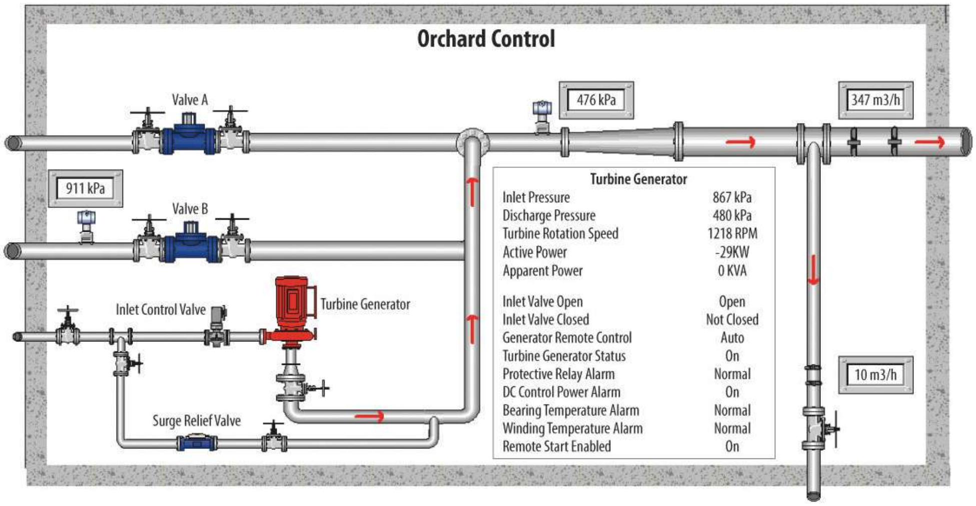
Two types of turbines were considered to recover energy from the differential pressure and flow inside of the pressure-controlled water supply system: a Francis turbine and a reverse-acting pump, or pump-as-turbine (PAT). A fixed-geometry PAT was selected as the preferred technology given the relatively stable diurnal flows expected through the Orchard Chamber. The flow characteristics of this type of turbine were determined to be ideally suited to the application, with runaway flows and heads being limited by the internal resistance of the fixed impeller and volute geometry of the turbine, and its ability to control flow to the turbine through the inlet control valve. The PAT had a number of other advantages over other types of hydro turbines, including:

- Simple design and ease of application
- Similar operational and maintenance considerations to regular pumps
- Availability for a large range of heads and flows
- Availability in a large number of standard sizes
- Lower cost
- Availability of spare parts
- Ease of installation
- Ease of integration within an existing system
- Direct coupling of turbine/generator resulting in lower friction loss, longer bearing life, and less maintenance

The turbine and generator were selected with a turbine size based on the average diurnal flows of 3.9 cubic feet per second and a head of 130 feet.

From the project outset, the objective was to develop, install, and commission a small in-line recovery system that could be used in place of, or operated in parallel to, an existing PRV system, and operate effectively and within a pressure-controlled municipal water distribution system. A critical factor was the ability of any in-line energy recovery system to control upstream and downstream pressure transients in the water distribution system because of the lack of tolerance of some of the older sections of Halifax Water's distribution system for significant pressure or flow transients. A portion of the Orchard research project was also to investigate how pressure transients could be controlled and/or eliminated. Data was collected to allow Halifax Water to identify both normal and upset operating conditions created by both the water supply system and the operation of the ILT and bypass PRV system. The data was collected to allow Halifax Water to correlate downstream effects (pressure/flow transients) with the operation of the ILT and the bypass PRV system and identify detrimental conditions.

The project involved the development, design, installation, and commissioning of the Orchard Control Chamber ILT for energy recovery. It also looked at the operational characteristics and effects



Energy recovery from PRV chambers

on water quality and the overall water distribution system.

From the design and development perspective it was important to:

- Verify existing site flows and pressure dynamics
- Verify electrical system integration requirements
- Implement functional requirements for supervisory control and data acquisition (SCADA) monitoring and control
- Complete the civil, mechanical, electrical, instrumentation, and control system designs, process and control narratives, and risk mitigation strategies
- Procure, install, interconnect, test, and commission the ILT

From the research perspective, it was important to:

- Collect data and analyze turbine and distribution system operating characteristics
- Investigate operational effects on the distribution system, such as pressure and flow characteristics and water quality impacts
- Identify pressure and flow transients and develop control and risk mitigation strategies to protect water quality and mitigate other negative impacts

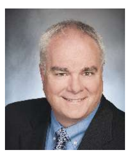
The Orchard site was estimated to have a power capacity of 33.4 kW, a system availability of about 80 percent, and an annual energy output of 225,000 kWh/year, with an estimated annual revenue of $31,500 from the sale of electricity to the local electric utility, Nova Scotia Power. A simple payback of 9.1 years was calculated without accounting for WRF funding and other outside funding sources and 15.4 years had the outside sources not been available and the project funded solely by Halifax Water. The project has been operational since October 2014. In 2015, the turbine produced a total of 228,500 kWh of renewable electricity, the equivalent of the energy use of approximately 25 Nova Scotian households, and an annual revenue of $31,900. The system is currently on track to exceed these results in 2016, due primarily to operational optimization efforts.

Some important recommendations and lessons learned during this project included:

- Every successful project requires an internal project champion or project manager who is committed to seeing the project through to successful completion. This includes keeping finances in check, keeping the project on track, and helping with system integration when the project becomes operational.
- Each site must be carefully evaluated for its energy recovery potential, taking into consideration the diurnal flows, pressure reduction, and long-term utilization of the site. The sites with the highest flows, pressure differentials, and longest operating hours are usually those to consider for technical and economic details.
- Any project must meet provincial, state, or federal regulations established for the design and operation of water treatment and distribution systems. For instance, for this project "NSF/ANSI 61 — Drinking Water System Components — Health Effects" certification was required for the PAT.
- An accurate financial model must be developed, depicting realistic capital costs for the project, including accurate energy generation estimates.
- Utility staff that will be responsible for the ongoing maintenance and operation of the turbine generator should be consulted early in the process.
- Consider hiring a reputable contractor who can provide both mechanical and electrical installation services and has completed similar scale renewable energy projects in the past.
- Conduct post-installation testing and condition monitoring to understand how the energy recovery system operates and affects the water distribution system and to maintain acceptable levels of water quality and service.
- Monitor the turbine generator performance in terms of forecast versus actual energy revenues, operating costs, ROI, and payback to help evaluate the success of the project.

Implementing an ILT energy recovery project can be achieved by water utilities if they undertake the careful front-end planning and evaluation, thorough system testing, and ongoing system monitoring and control. If implemented and operated correctly, ILTs can provide long-term clean energy recovery and energy revenues. ■

About The Authors



Jeffrey Knapp, FEC, P.Eng., CEM, is manager of energy efficiency at the Halifax Regional Water Commission, Nova Scotia's largest water, wastewater, and stormwater utility. Halifax Water provides water, wastewater, and stormwater services to over 80,000 customers in the Halifax Regional Municipality.

Linda Reekie, WRF research manager, joined the Foundation staff in 1997. Prior to the Foundation, Linda worked at a county health department in Colorado for 10 years, coordinating the water quality program for five years. She also has five years of experience as an environmental planner for a county planning agency in Pennsylvania. She graduated from Pennsylvania State University with a B.S. in environmental resource management.

Financing Infrastructure Through Environmental Impact

With Environmental Impact Bonds, everyone can win. Shared risk means there are no big losers even if the project falls short.

By Julie King

Environmental finance was in the spotlight recently with two fixed income products. In September, DC Water and Sewer Authority (DC Water) issued the first Environmental Impact Bond (EIB) as part of its $2.6 billion program, DC Clean Rivers Project. The EIB will provide up-front capital for the construction of green infrastructure for the Rock Creek sewer shed with the aim of reducing the approximately 2 billion gallons of combined sewer overflows (CSO) that pollute local watersheds and tributaries each year when stormwater runoff exceeds the drainage capacity of the sewage system. The five-year, $25 million EIB was sold by private placement to two investors, Goldman Sachs Urban Investment Group and the nonprofit investment fund, Calvert Foundation.

In October, the City of Gothenburg, Sweden received the 2016 UNFCCC Momentum for Change Lighthouse Award as the first city in the world to issue a green bond. Proceeds from the green bonds are being used, within the city's stringent environmental framework, to fund climate change and environmental sustainability projects that aggressively promote its objectives of transitioning to a low-carbon economy and climate-resilient growth.

These two investment instruments represent a growing trend — and opportunity — for infrastructure finance, particularly for water infrastructure. UN Water has concluded that "...water is the primary medium through which climate change impacts the earth's ecosystem and people ... [and] adaptation to climate change is mainly about better water management."[i] By combining the EIB's mandate of investing-for-impact with increasing demand from investors for Environmental-Social-Governance (ESG) investments, it is no longer contradictory to talk about building infrastructure and protecting the environment.

By combining the EIB's mandate of investing-for-impact with increasing demand from investors for Environmental-Social-Governance (ESG) investments, it is no longer contradictory to talk about building infrastructure and protecting the environment.

Impact Bonds: Innovation In Financial Structure

The EIB issued by DC Water is a financing mechanism designed to share risks and align incentives between investors and the municipality. DC Water uses the EIB proceeds to pay for the costs of installing green infrastructure. Using a tiered payment approach to share performance risk, the amount of the return then paid to investors is tied directly to the degree of success or failure of the green infrastructure in achieving its impact objective: managing stormwater runoff.

It will be considered successful if it falls within the conditions of Tier 2 of the payment structure (see Table 1). If the green infrastructure exceeds expectations, DC Water will make an Outcome Payment to investors for sharing the performance risk; if it falls short, investors will make a Risk Share Payment to DC Water. If the green infrastructure is successful in controlling stormwater runoff and managing the problem of CSOs, it will be validated as an effective climate adaptation tool, which is also a goal of the EIB.

"The Impact, from an investor perspective, is about improvement to the water system," explains Derek Strocher, CFO of Calvert Foundation. "The return mechanism ... is tied to the outcome results. If the project outperforms, then investors receive an additional payment. If the project underperforms, then investors pay back a risk sharing amount."

Strocher continues. "What we, as an investor, are doing is encouraging service providers like DC Water to take a chance on an impactful project like green infrastructure by offering to soften the blow if doesn't work out .... Impact bonds can encourage all sorts of companies to take chances with their businesses to improve the environment ... or any other social issue they are qualified and

Performance Tier	Outcome Ranges	Contingent Payment
1	Runoff Reduction > 41.3%	DC Water will make an Outcome Payment to Investors of $3.3M.
2	18.6% <= Runoff Reduction <= 41.3%	No contingent payment due.
3	Runoff Reduction < 18.6%	Investors will make Risk Share Payment to DC Water of $3.3M.

Table 1: Tiered Payment Structure (Source: DC Water EIB Fact Sheet).

confident to tackle by knowing that if they don't get the (full) results they hoped for, there's someone there to share some of the pain. If it does work out, then everybody wins, including/especially them by growing their business."

Impact Investing Sector

Impact Bonds are one of the innovative financing mechanisms within the impact-investing sector.[ii] The term "impact investing" was first coined at a convening of investors and philanthropists organized by the Rockefeller Foundation in 2007 to brainstorm how to entice private capital to fund programs and projects for the public good. Impact investing quickly evolved into a nascent global industry,[iii] and by 2010, it was officially recognized as a separate asset class by JP Morgan, Goldman Sachs, and other global financial institutions.[iv]

The objective of impact investing is simple: "unlock significant sums of private investment capital to complement public resources and philanthropy in addressing pressing global challenges."[v] While sums are still small in comparison to total investments, in the 2016 Annual Impact Investors Survey from the Global Impact Investing Network (GIIN), a reported $15.2 billion in impact investments was made in 2015, with respondents expecting to increase investments in 2016 by 16 percent, to $17.7 billion.[vi]

Impact Bonds were an impact-investing tool that gathered momentum initially in the U.K., ultimately resulting in the Social Impact Bond (SIB) to reduce recidivism at HMP Peterborough in 2010. Since then, more than 60 impact bonds have been launched worldwide, with the DC Water EIB being the latest example of innovation as the first-ever "2.0" version of an impact bond.

Impact Bonds 2.0

Based on the collective experience of impact bond veterans Goldman Sachs and Calvert Foundation, the DC Water EIB was designed as a model that other municipalities and companies can use to attract traditional fixed income investors, not only to fund reduction of CSOs but to encourage the use of impact bonds and to scale the use of proven environmental solutions to infrastructure needs.

Before coming to Calvert Foundation, Strocher was a member of the Working Group for Development Impact Bonds[vii] during his tenure at the World Bank. He is especially well positioned to contrast the EIB with early constructions of impact bonds.

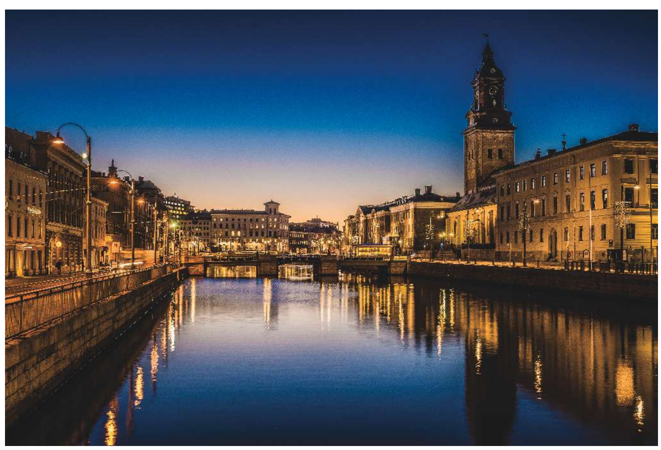
"IBs 1.0 were investments in projects," Strocher comments. "If the project failed for any reason (e.g., the service provider turned out to be inadequate, the potential results were overestimated, etc.), then the investor likely lost their money .... Investors in IBs 2.0 are fixed income investors that largely aren't seeking significant risks (e.g., new intervention approaches, sovereign risk, risk of inexperienced service providers, etc.) in a project structure, all for a modest return.[viii] The 2.0 model offers those investors the support of a company's underlying business, on top of which they share (to varying degrees by structure) the outcome risk. That risk profile can reach typical fixed income investors."

Strocher explains the attraction of impact bond investments for a mission-oriented investment firm, such as Calvert Foundation and for fixed income and impact investors generally.

"We analyzed [DC Water] (for credit risk) and the outcome return as a separate risk analysis to determine whether the financial return potential [as risked] combined with the Impact potential would meet our Impact investing hurdles. The first risk analysis is very common for a fixed income investor, and returns are commensurate. The second risk analysis, which layers on a second level of return/or repayment, is where the innovation lives. The risk we are sharing is about the success or failure of green infrastructure to deliver its intended results. We can do that by funding the project through a company and not having to put our principal at the same risk as project financing. We still accept DC Water's credit risk ... (or) other service providers in other deals. So, while this deal carries little principal risk for investors (and hence returns are commensurate), it carries substantial total return risk based on the success of the green infrastructure. In 1.0 models, there was a need for an intermediary to "manage" the performance of the service providers, but in a 2.0 model, the incentives are aligned much better because the service provider is highly motivated to manage performance because their company is underpinning the project and will benefit by producing successful outcomes, even though that means paying a higher (success) return on the IBs. This is the big difference between 1.0 and 2.0: the service provider (the one creating the Impact) has full skin in the game."

Green Bonds: The City of Gothenburg, Sweden

In 1987, Gothenburg's Board implemented a comprehensive environmental strategy to remediate the consequences of the city's history of heavy industry and move toward a sustainable urban environment. As one of Sweden's largest enterprises, the city



Gothenburg, Sweden

established the environmental framework as the starting point and overarching standard for all its subsidiaries and projects.

Magnus Borelius is Head of Treasury at the City of Gothenburg and is responsible for the green bond (GB) program. Enjoying a triple-A municipal rating, the city has issued four green bonds since 2013 for a total of 4.36 billion Swedish Kronor (approximately $488.2 million), which represents 10 percent of the city's outstanding debt. A new issue is planned for 2017. He explains their GB strategy.

"As part of Gothenburg's framework of meeting climate change and sustainable environmental objectives, we established categories, such as waste management, sustainable transportation, water management, etc. Some of these are smaller projects. But there are larger projects, as well ... We have not defined what is 'green' or 'not green.' Instead, we established these categories, and investors in the green bonds know their money will be going to projects that fall within one or more of these categories."

Borelius continues. "When we started, we didn't know if this would succeed or if there would be demand from investors. We were surprised by the huge interest from investors. All of our green bonds have been oversubscribed ... [and] we have investors calling for private placement of the future green bonds we issue. They are mostly institutional investors — bank treasuries, asset managers, pension funds, insurance companies ... [that] are Swedish, Scandinavian, and from Europe, especially Norway, Germany, [and] Switzerland."

Shared Features

Common to both bonds is achieving an environmental impact and doing so through rigorous vetting processes. Gothenburg started by having the GB investment structure validated by an independent evaluator.[ix] Thereafter, all investment targets were jointly vetted and selected by the City Office, made up of the departments of Urban Development and Treasury. The Environmental Administration scrutinizes their selection, with final approval for funding verified by the City Executive Board.

Similarly, the EIB was designed with outside counsel and independent advisors. The parameters in the tiered performance structure were established by DC Water from existing runoff measurements and verified by outside engineers, with final approval by the investors.

The approach to measuring results varies between the two bonds. Where Gothenburg has no formal evaluation standard, the EIB ties returns to verified results. But both structures require monitoring and reporting on compliance with the environmental objectives. For the GB, each subsidiary reports regularly on project status and Treasury monitors every project's economic development, including environmental indicators. In turn, this information is included in annual reports to investors.[x]

Distinct Differences

Gothenburg purposely chose not to issue "impact bonds" because of how "impact" might suggest a political agenda. Instead, issuing "green" bonds aligned with a more traditional financing structure and a universally held standard in Sweden of benefitting the environment. This crossed party lines and was a common denominator for small and large companies in the city's portfolio. This is a clear distinction from impact bonds, which seek to integrate innovation into the entire process of problem solving — from establishing collaborations to designing risk-sharing financial arrangements.

One of the most obvious differences between the two bonds is the "demonstration" aspect of this first EIB. Its purpose is to prove green infrastructure for water management and the impact bond as a model for financing impactful solutions. On the other hand, green bonds have become much more common, with almost $75 billion issued in 2016, up from $42.2 billion in 2015.[xi] Gothenburg's green bonds are tested and funding multiple projects.

The End Game

These bonds represent two alternatives to mobilizing private investment to achieve environmental and social objectives. As the Rockefeller Foundation stresses, this effort is "critical, because philanthropy and government only have billions to spend, while private markets hold an estimated $210 trillion."[xii] This is not an insignificant point for nature either. It is dependent on all parties delivering sustainable results. ■

[i] UN Water, Fact Sheet on Climate Change

[ii] Impact investments are investments made into companies, organizations, and funds with the intention to generate social and environmental impact alongside a financial return. See also: The Core Characteristics of Impact Investing, the Global Impact Investing Network (GIIN).

[iii] Establishment of the Social Impact Investment Taskforce, headed by Sir Ronald Cohen by the UK during the 2013 G8 Social Impact Investment Forum. Concentrated efforts by the Taskforce served as a significant catalyst in rapidly mainstreaming the concept of 'impact investment' and the development and maturing of innovation in a wide variety of investment models along what was called the "Impact Investing Spectrum" — from corporate investment in social and environmental initiatives and enterprises to optimising the areas for application of more traditional models of philanthropy.

[iv] Impact Investing Emerges as a Distinct Asset Class. See also JP Morgan Report: Impact Investing: An Emerging Asset Class.

[v] GIIN.

[vi] Respondents are comprised of fund managers (60%), foundations (13%), banks (6%), development financial institutions, family offices and pension funds/insurance companies (2-3% each) – p. XI

[vii] Development Impact Bonds are a type of impact bond aimed specifically at funding international development investments in emerging and frontier markets. Other organizations involved in the Group included the Rockefeller Foundation, the Bill and Melinda Gates Foundation, Citigroup, USAID, OPIC, Omidyar Network and government agencies such as the Swedish and UK International Development Agencies.

[viii] *"...hence the need for guarantees, early repayment triggers, etc. in many of those early 1.0 models, or indeed the need to find "particular" investors..."*

[ix] Cicero: the Norwegian Center for Interdisciplinary Climate Change Research.

[x] Investor reporting, City of Gothenburg (English).

[xi] ClimateBonds.net

[xii] Innovations in Finance for Social Impact, Judith Rodin, President, The Rockefeller Foundation.

About The Author

Julie King is managing director of Galileo Agency, a boutique agency working with companies and civil society organizations in impact areas — such as water, renewable energy, and the environment — to commercialize products, initiatives, and impact strategies.