Water Innovations
JANUARY 2023

TOP 10 TRENDS FOR 2023

Expert Insights Into Today's Critical Water & Wastewater Issues

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FROM THE EDITOR

By Kevin Westerling
Chief Editor, editor@wateronline.com

Water Innovations: Positive Energy For 2023

The past few years have been especially difficult for everyone, water and wastewater professionals included, with no shortage of turmoil and obstacles. There is some momentum for positive change, however, with innovative solutions at the heart of recovery, advancement, and ultimate prosperity.

Every new year is a time of optimism, promising that next year will be better than the last. And while 2022 improved upon its predecessor — we did seem to turn the corner on COVID — another widespread and pervasive problem emerged. It was The Year of Inflation, which is not as existentially threatening as COVID but perhaps equally pernicious, affecting nearly all aspects of life and causing hardship for individuals, families, communities, and nations, as well as many businesses (while others managed to benefit) and, yes, water and wastewater utilities.

Inflation is notoriously difficult to tame, and far from the only challenge that utilities will continue to face throughout 2023, but optimism still reigns supreme around this time. "This will be our year" is the common refrain. And why not? Every challenge offers opportunity — to innovate, to be more efficient, to rise above and become better for it.

This "Top 10 Trends for 2023" edition of *Water Innovations* invites you to seize the opportunity, offering ideas and solutions for surviving this moment and thriving well into the future.

Several topics covered have been trending for some time, but they are no less significant as we turn the page to a new year. In fact, when it comes to replacing lead service lines, addressed with "A 2023 Road Map To Replacing The Nation's Toxic Lead Pipes," we are at the apex of concern. As author Maureen Cunningham of the Environmental Policy Innovation Center notes, we must "match the pace of lead pipe replacement with the urgency of the problem."

PFAS — the catch-all term for per- and polyfluoroalkyl substances — has been the other contaminant to dominate water headlines in recent times, prompting many states and the federal government to fast-track action plans. But whereas the news in previous years initially focused on its discovery, prevalence, and potential impact, and then on rule making, we have now uncovered enough solutions to fight back and make "forever chemical" a misnomer (see: "Leachate — A Key To Unlocking The Chain Of Recirculating PFAS Forever?").

Unfortunately, trends often correlate with threats, due to the nature of water stewardship — the top priorities of which are to ensure safe and available water. Therefore, we must also pay heed to cybersecurity ("Additional Technology To Help Thwart Cyberattacks"), source water contamination ("Regulating Farm Pollution To Reduce Harmful Algal Blooms"), climate change impacts ("Benchmarking As A Tool To Optimize Operations And Lower GHG Emissions"), and sustainability ("Adopting A 'One Water' Approach In Florida Through Integrated Master Planning").

But it's not all doom and gloom. As previously stated, the new year is a time for optimism, and we're proud to cover advancements driven by innovation ("Water Systems Get Smart With Digitalization" and "Doing More With Less: Densified Activated Sludge Systems For Water Resource Recovery Facilities") as well as service to the community and environment ("Customer Engagement And Water Infrastructure Projects: How To Achieve Success" and "Industry 5.0: What It Means For Industry And Water Management").

It doesn't hurt that many of these solutions will also help to curtail the effects of inflation by bringing more efficient processes to bear — because, while inflation was 2022's big issue, we fool ourselves to be taken in by unbridled optimism and the notion of a clean slate for the new year. In 2023, we will continue to battle many of the same challenges with which we have become achingly familiar, and perhaps some new, unexpected ones as well. The larger challenge for the industry is to combat them with care, courage, and commitment to the cause — safeguarding the world's most important resource. ■

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A 2023 Road Map To Replacing The Nation's Toxic Lead Pipes

One of the great water-management and societal challenges of our time is to get the lead out of our nation's drinking water — a daunting but achievable task, if approached correctly.

By Maureen Cunningham

In recent months, there have been national headlines on the devastating effect the COVID-19 pandemic has had on children's math and reading scores across the country, leading to a swift call to action by educators, parents, and politicians to rectify this.[1] What has not garnered as much attention, but has had similar educational effects for children — as well as detrimental health impacts — is lead poisoning, which affects the ability of children to learn, pay attention, and succeed academically.[2] Exposure to lead also results in societal impacts that cost billions of dollars, if not more,[3] with an immeasurable cost to our quality of life. There are 86,000 or more lead exposures among children each year, which is far too many.[4] Though lead pipes are only one source of lead poisoning, the solution is relatively straightforward: Replace the lead service lines (LSLs) carrying our drinking water.

In 2022, Newark, NJ, became one of only about a dozen cities across the country — and the largest of them — to replace all of its 23,000 lead pipes, though smaller cities, including Framingham, MA; Spokane, WA; Stoughton, WI; Lansing, MI, and others have also replaced theirs.

In 2023, the question is: How do we position more communities across the country to replace their lead pipes?

EPIC's top 10 list of recommendations empowers utilities, communities, and policymakers with tangible steps forward and provides a road map to ensure that lead becomes a thing of the past — not over our lifetimes, but over the next decade.[5]

1. Elevate and support lead-free water champions.

Local and community leaders can — and should — play a key role in helping their communities advance lead service line replacements (LSLR). Often, the communities that are moving forward in this have the support of their local officials, backed by strong utility leaders. From passing resolutions and ordinances to removing administrative barriers and raising funds, local government leaders can dictate the speeds and scales of their programs. Mayor Lombardi of North Providence, RI, was so moved by the lead crisis in Flint, MI, that he subsequently found funding to replace lead pipes for many of his town's low-income residents. Edgerton, WI, passed a municipal resolution in 2022, setting a five-year timeline to replace its lead pipes.[6] Replacing an estimated 10 million lead pipes in 11,000 communities will take a groundswell of leaders and champions over the next decade.

In 2023, the question is: How do we position more communities across the country to replace their lead pipes?

2. Locate and map lead service lines quickly — and replace as you go

Finding and mapping lead service lines through inventories is one of the first steps in developing a successful LSLR, and it includes good record-keeping[7] and data-management practices.[8] The U.S. EPA August 2022 Guidance for Developing and Maintaining a Service Line Inventory recommends that water systems complete inventories at the same time as replacement efforts and "as soon as possible," and provides an inventory template.[9] States like Illinois, Michigan, and New Jersey have set more aggressive inventory deadlines, earlier than the federal government's October 2024 deadline — and other states could follow suit.

Inventories are essential in enabling a community to understand the extent and location of the problem and to be able put together plans for financing, prioritizing equity, and replacing pipes. Municipalities that finalize inventories not only have a better idea of costs, but they will also be in a better position to access funding while it's available. The Infrastructure Investment and Jobs Act (IIJA), for example, with its $15 billion for LSLR, has a five-year distribution window.

3. Embrace new and emerging technologies to replace lead service lines.

Better technologies and innovations are emerging every day and pushing the needle on how fast municipalities can not only replace lead pipes, but also help digitize paper records, locate LSLs, and create visual tools. The EPA Guidance references the use of predictive modeling, ground-penetrating radar, web maps, field applications, and closed-circuit television inspections in LSLR programs. Machine learning can be used to predict where LSLs are likely to exist based on information about the properties, historical data, work done in the vicinity, and the evidence from inspections or replacements.[10] Companies highlighted in EPIC's Menu of Options[11] and in the 2021 Water Data Prize[12] offer expertise in these and other technological solutions that can save utilities time and money — both critical aspects of getting the lead out faster and more efficiently.[13]

4. Make information accessible to the public — before there's a crisis.

As municipalities with water crises have realized, having the trust of the public is critical; but once lost, it's harder to regain. Utilities need to communicate earlier, better, and at every milestone that occurs in their program — and be in sync with their elected officials. Utilities need to take the extra step to conduct better outreach to communities, bringing the information to where residents are, across various social media platforms and venues, and in the format and language they need.[14] Using lead dashboards, as Benton Harbor, MI,[15] and Platteville, WI,[16] both have done, will help keep important LSLR milestones and progress in the public eye.

5. Engage and make joint decisions with community partners.

Faith-based groups, homeowner associations, community-based organizations, and other local stakeholders can all be partners with utilities in replacing lead pipes. These stakeholders can help engage with residents, urging them to test their water and check the composition of their service lines, giving them information about the community's LSLR program, identifying neighborhoods most at risk, and educating on lead risks. Community partners can also work in tandem with the utility in reaching otherwise hard-to-reach residents in different venues, formats, and languages, including going door-to-door. The group called Benton Harbor Team Solutions, for example, hosts a radio show to inform residents on lead-related progress.[17]

6. Focus on equity and prioritizing at-risk populations in replacement efforts.

Utilities can ensure an equitable distribution of funds at the local level by prioritizing at-risk, low-income, and socially vulnerable populations, neighborhoods, and communities in replacement efforts and by covering homeowners' costs. Identifying demographic information, environmental risks, and social vulnerability indexes alongside inventories and mapping can help prioritize those most at risk. An example is the New Jersey Water Risk and Equity Map, which enables users to visualize where LSLs are located, alongside other risks and income levels.[18]

7. Develop a multi-year financing plan, taking advantage of multiple funding sources.

Costs to replace lead pipes vary greatly, and cost savings need to be explored. LSLR for one pipe, before inflation, was as low as $1,200 in some parts of the Midwest, and up to $27,000 in Chicago.

While IIJA has a portion of the total funding needed to replace every LSL in the country through the Drinking Water State Revolving Funds (DWSRFs), there are other federal sources, that can be combined: Water Infrastructure Improvements for the Nation (WIIN) for small, underserved, and disadvantaged

Finding and mapping lead service lines through inventories is one of the first steps in developing a successful LSLR, and includes good record-keeping and data-management practices.

communities, accessed by Trenton, NJ; the Water Infrastructure Finance and Innovation Act (WIFIA), which provides long-term, low-cost supplemental loans, accessed by Englewood, CO, and Chicago, IL; the American Rescue Plan Act (ARPA) State and Local Fiscal Recovery Fund (SLFRF), accessed by Newburgh, NY, and Pittsburgh, PA; the USDA Rural Development Program, which provides low-interest, fixed-rate loans to smaller communities, accessed by Bloomer, WI; and HUD's Community Development Block Grant (CDBG), targeting low- and moderate-income residents, accessed by North Providence, RI, and Toledo, OH.

States also have funding programs for LSLR, such as the Massachusetts Water Resources Authority (MWRA), the Michigan Clean Water Plan, and the New York Water Infrastructure Improvement Act (WIIA), in addition to new, voter-approved bond act funds, H2Ohio and the Pennsylvania Infrastructure Investment Authority (PENNVEST).

In addition to public funds, financing through municipal bonds (even for private-side replacements) is possible[19] for those with the capacity to take on debt as well as impact bonds used in Newark, NJ.[20] There is also a bigger role for banks to play in LSLR, as evidenced by the Federal Reserve Bank of Chicago.[21]

8. Advance equity, innovation, and efficiencies through contracting and better procurement.

The contracting and procurement phase of LSLR is an opportunity for policy change and improvements. A focus on cost-saving measures, aggressive timelines, prevailing wages, local workforce training, and prioritizing local-, women-, and minority-owned labor and businesses can all be set in the bid contracts that municipalities use to procure the necessary workforce, ensuring alignment with state procurement laws.

The sheer number of communities with LSLs may require more innovation in contracting and procurement. Public-private partnerships (P3s), community-based partnerships (CBPs), and pay-for-success contracting can be used to create efficiencies of scale and faster LSLR,[22] especially if bureaucratic hurdles are removed and multisystem applications are made possible and more accessible to utilities.

9. Advance policy changes to ensure a more equitable distribution of funds.

While funding is often pointed to as the main solution, key policy changes at the local, state, and federal levels can make a difference. Municipalities can pass ordinances to mandate full service-line replacement, grant the right of entry to a property even if the owner does not, ensure LSLR at the time of a real estate or tenant transfer, and reimburse homeowner costs. Cities like Benton Harbor, MI; Malden, MA; and Green Bay, Madison, and Milwaukee, WI, have all passed local laws and ordinances.

States, too, have roles to play in prioritizing equity, ensuring proactive notification requirements, standardizing and centralizing inventory data (and making it publicly accessible), setting faster timelines, and removing other bureaucratic hurdles. Illinois, Michigan, and New Jersey have all accomplished this in varying degrees through legislation.

At the federal level, needed policy changes include more definitive language on the use of all public funds for private-side LSLR, expanded definitions of LSLs, and more equitable distribution of IIJA funds to lead-burdened states. And particular to IIJA funds through DWSRFs, several policy reforms are needed, such as offering 0% interest loans for all LSLR projects, changing how disadvantaged communities are defined and principal forgiveness loans are distributed to ensure equity, enabling census blocks rather than water system boundaries to determine disadvantaged eligibility, and maximizing the use of set-aside funds for LSLR pre-construction tasks. The federal government can also play a role in ensuring that state Intended Use Plan (IUP) processes and reporting requirements are standardized; encouraging inventories to be standardized, centralized, and publicly available; and tracking LSLR funding and replacement rates across the country.

10. Match the pace of lead pipe replacement with the urgency of the problem.

Let's face it: Replacing 100% of the 10 million pipes scattered throughout the country is no easy feat — and doing it faster will be even more difficult.

Though slow is the easiest path forward, we cannot afford to see our children and our society dealing with the far-reaching and generational effects of lead poisoning when the solutions are at hand. This is truly an "all hands on deck" moment, requiring all levels of government, nonprofits, community groups, and the private sector. Today, there is a momentum to get the lead out created by the Biden-Harris administration not seen before in our lifetimes. We need to seize this momentum and ensure that the pace of our efforts matches the true urgency of this solvable problem. ■

LEADSERVICELINES

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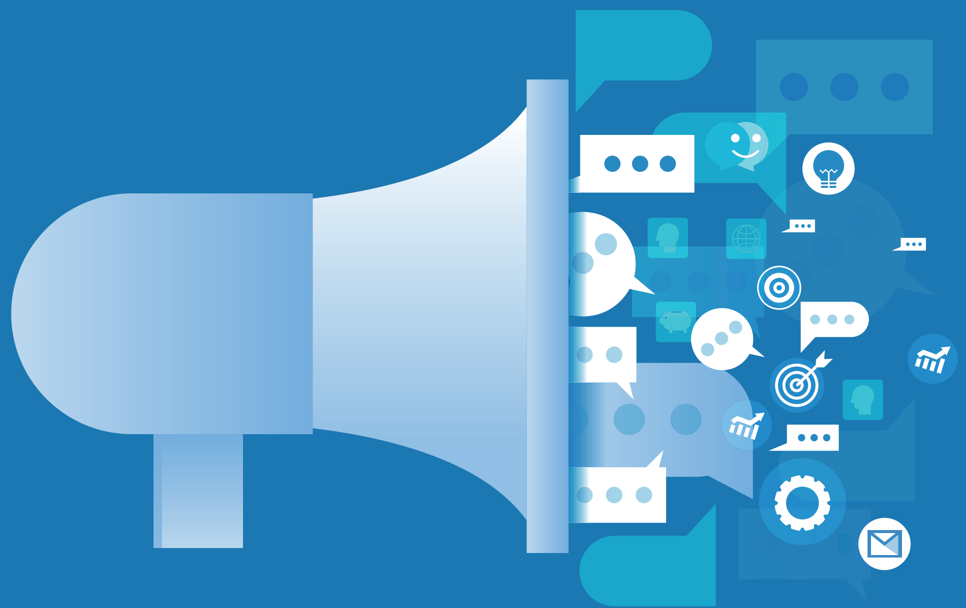
Maureen is the chief strategy officer & director of water strategy of EPIC. Prior to joining EPIC in 2020, Maureen was senior director for Clean Water at Environmental Advocates NY, where she championed statewide legislation and policies, and executive director of the Hudson River Watershed Alliance, where she helped dozens of community groups protect their water resources. Maureen holds a master's degree from the Yale School of the Environment and a bachelor's degree from the American University. Maureen also serves as a town ouncilmember outside of Albany, NY.



Customer Engagement And Water Infrastructure Projects: **How To Achieve Success**

Communication between a utility and its customers has historically been sparse and negative — complaints on one side, bills and notices on the other — but healthy communication is now encouraged as a key aspect of successful infrastructure development.

By Rebecca Zito

Utility and energy providers have learned that both public and stakeholder engagement play major roles in the long-term success of water infrastructure projects. Investing in the right technology, tools, and services to communicate information can help your water utility secure public support and reduce (or eliminate) community resistance in the long run.

Ongoing customer engagement during infrastructure projects requires a multifaceted and well-executed approach. It's imperative to remain transparent, prioritize continuous communication, and meet customers where they are.

Here's how water utility providers can use customer engagement when carrying out infrastructure initiatives:

1. Involve the Community

The Pittsburgh Water and Sewer Authority, which serves a population of 465,000 residents and businesses in Pittsburgh and surrounding communities, is currently investing in a massive water, sewage, and stormwater infrastructure update that's part of a $1.4 billion improvement program. We plan to reinvest, rebuild, and modernize many of our large-scale pumping and water distribution pieces into 2026.

> "Every community is different. That's why it's important to have a well-defined process when targeting specific individuals, households, and communities."

As part of this yearslong undertaking, we're using different techniques to include customers in the discussion and keep them informed, from social media posts to community meetings. At in-person meetings, we ask for input from the community during different design stages. We also keep customers informed about the current project status and relevant information that could impact their lives.

During these meetings, we direct customers to the Pittsburgh Water and Sewer Authority website, which lists all of our construction projects. We've also developed project brochures and mailed them to residents within the project area. Door hangers can also be used. Again, it's all about keeping residents informed and meeting them where they are.

2. Prioritize Geo-Targeting

Every community is different. That's why it's important to have a well-defined process when targeting specific individuals, households, and communities. This can include the following steps:

1. Utilize a geographic information system (GIS) to define the project area.
2. Identify the residents and businesses located in the defined geographic region.
3. Hold a community meeting, letting residents know what's happening and encouraging them to ask questions.
4. Reach out to community ambassadors who are familiar with these neighborhoods and communities. Encouraging people who live in these areas to talk to their neighbors adds a more personal dimension to the conversation, benefiting both the utility and the residents.
5. Notify residents and businesses via emails, automated phone calls, or letters as you enter various stages of the water infrastructure project.
6. Set up a project page on your website and update it with in-depth information on current project statuses, such as the construction impact and estimated length of time.
7. Use social media to expand project awareness during the early stages. Update and post regularly.
8. Continue the conversation on social media and during in-person meetings.

3. Encourage Continuous Communication

No one likes ongoing construction in their neighborhood — it can be noisy and disruptive. However, this can initiate a two-way conversation between communities and water utilities.

Establishing a point of contact during the initial stages can help. A communications project manager can facilitate calls and complaints from residents, answering questions and offering as much information as possible. How long will the project last? What are the long-term benefits of the project? Highlighting the many ways a water infrastructure upgrade will benefit the community can offset the annoyance of short-term inconveniences.

As the Pittsburgh Water and Sewer Authority continues its infrastructure and stormwater update, we've found many opportunities for community engagement when incorporating green infrastructure.

Stormwater projects tend to be more visible to communities because they often occur on the surface. We're putting rain gardens, vegetation, and permeable pavers into a public space. These are things people can see. Once you start executing a project like that, it creates an opportunity for a conversation about anything else the neighborhood needs. This helps the utility participate in productive discussions, establishing a positive dialogue that builds trust.

4. Engage and Involve Community Partners

Outside of construction and infrastructure projects, forming advisory groups with community stakeholders and partners is an effective model when implementing programs that are new to the utility, or will directly affect a large number of customers.

Bringing together a diverse group of engaged community representatives will help you talk through potential challenges and shape a program before its launch. Some advisory groups will only meet for a short period, whereas others have an ongoing relationship to continually review and adapt a program as needs or expectations change.

The two-way dialogue created with advisory groups builds awareness and understanding of the challenges that both the utility and customers may face. These are opportunities for heart-to-heart conversations with those who are directly impacted by an expanded service or new program. Working with an engaged group of stakeholders builds trust and establishes informed advocates for the utility.

The Pittsburgh Water and Sewer Authority has formed advisory groups to establish the foundation for a new stormwater fee, advance customer assistance programs, and the ongoing implementation of our Community Lead Response.

The Importance Of Customer Engagement

The silent utility provider has become a thing of the past. Transparency, frequent communication, and awareness have become critical factors in the success of infrastructure projects. Not only does customer engagement help water utility providers avoid unwanted backlash and resistance, but it also helps them better serve customers. ■

About The Author

Rebecca Zito is the senior manager of public affairs for the Pittsburgh Water and Sewer Authority. She is an accomplished communications professional with nine years of experience developing communication programs for local government and publicly owned and managed water utilities. She is a skilled community engagement architect, writer, collaborator, and content strategist. Rebecca is passionate about the art of storytelling to build awareness about the initiatives that shape a community.

Water Systems Get **Smart** With Digitalization

By Dominique Verhulst

Utilities can more confidently commit to digital transformation once the benefits, as well as the elements critical to its success, are understood.

A digital transformation can help utilities to innovate and adapt, as well as dramatically change their relationships with their customers.

Three days. That's the amount of time, on average, that a human can live without water. There's no doubt that the supply dynamics behind how we get our water are complex. Still, it should be cause for alarm that, by 2030, global demand for water is projected to outstrip supply by 40%, according to the World Economic Forum.[1]

Water utilities need a flexible and dynamic solution to the longstanding challenges that many face. Digitalizing operations with Industry 4.0 and Industrial Internet of Things (IIoT) technologies can provide that way forward.

But realizing this digital future won't be easy. Digital solutions require careful architecting to avoid adding more complexity. However, making the move to digitalization can be transformational. Let's take a look at how.

What's Stopping Change?

There are three reasons why water utilities are struggling today, and they are significant.

Unpredictability. The availability of raw water from sources such as rainfall, wells, rivers, and lakes is constantly changing. At the same time, customer demand and service requirements fluctuate. And there is increasing social pressure around sustainability and conservation. Utilities must embrace these variables, which isn't always easy.

Cost efficiency. For decades, utilities have been forced to "sweat their assets" — essentially, make their past investments in infrastructure last as long as possible. Chronic underinvestment poses a real threat to water quality and availability. Many are also facing significant water loss and associated wasted energy required for its production and distribution.

Visibility and control of utility assets. For some time, utilities have built solutions specifically to address individual use cases. The result is a patchwork of fragmented and often proprietary operational systems, a diversity of end devices, and immense system complexity.

It's tough to introduce a successful end-to-end solution at scale when faced with customized communication protocols and approaches to device discovery, communications, security, management, diagnostics, analytics, and enterprise integration. Even utilities that want to be innovative are stifled. There seems to be no obvious way to embrace new technologies and meet evolving business requirements.

What Can Digitalization Offer?

The answer lies in giving staff and customers easy access to a simpler, faster, and more flexible way forward.

Imagine employees empowered by key data — the kind of data that can predict issues, automate operations, and optimize systems. This enhanced situational awareness is foundational for more informed decision-making, streamlined processes, improved network operations, and accelerated response times.

Picture an environment where more open, flexible systems are deployed to deliver efficient, standards-based visibility and control, automating water management with the help of virtual information and contextual overlays. And smart water applications are deployed across the operations lifecycle — for leakage control, pressure management, water efficiency, reuse (greywater, rainwater, and effluent), water conservation, and demand management.

Data extended to customers works in a similar manner. Now, customers have timely access to consumption data that can help identify water leaks, appliance inefficiencies, and opportunities for conservation.

A digital transformation can help utilities to innovate and adapt, as well as dramatically change their relationships with their customers.

But these advances can also bring serious headaches. A utility may end up with added complexity if it does not have the right architecture to support it — an architecture that is backed by artificial intelligence (AI) and machine learning to drive virtual asset operations with automated self-calibration, operation, and sensor-to-sensor communication.

Why An Open IIoT Architecture?

With the proper architecture, the result is total operational transformation. Optimize the whole lifecycle of water by connecting water resource management, operations, and citizens with supply, distribution, wastewater, and irrigation systems.

This creates more intelligent assets and provides a more holistic management approach that delivers new operational efficiencies and improved water quality, alongside a more environmentally sustainable system.

As such, utilities should look for these four specific features in their digital transformation approach to have confidence that it will work:

1. *A standards-based, low-power wide-area (LPWA) wireless communications network.* This standardizes connectivity between devices and networks and creates a flexible, cost-efficient, and sustainable system.
2. *Common, open datasets to enable holistic analysis across different devices and systems.* This enables an end-to-end view of operations.
3. *Flexible, open, standards-based digital platforms that automate*

What an open IIoT architecture gets right is the end of proprietary systems and data silos that are holding utilities back from meaningful change.

and optimize operations. This enables the rapid development and deployment of new services, applications, and business models.

4. *Vendor-agnostic device management.* This lets utilities freely use any device, seamlessly integrated into a common data management and analytics system for unified operations and optimal efficiency.

These are critical elements in driving intelligent digitalization and interconnection of all systems and hardware. This is possible through advances in the Internet of Things (IoT), which is now industrialized (IIoT) for larger-scale networks and applications in mission-critical environments.

Now a utility's physical and digital realms can be synchronized, resulting in two transformational benefits. First is pervasive digital automation, which supports sensing and control with real-time communication and analysis. Second is augmented IIoT solutions, which enable contextual analytics, device security verification, and data privacy, as well as automated device management and control to simplify how devices are deployed and managed.

Lifecycle Water Management Is Inevitable

What an open IIoT architecture gets right is the end of proprietary systems and data silos that are holding utilities back from meaningful change.

More open, flexible digital systems deliver efficient, standards-based visibility and control, meaning that a utility can automate water management by augmenting data with virtual information and contextual overlays. Utilities will see productivity increase. They can quickly adopt new technologies to stay relevant and create more flexible, collaborative, and adaptive business processes.

Rapidly evolving technologies around sensors, communications, water efficiency, information management, analytics, automation, recycling, and wastewater management can improve the utilization and viability of water networks.

Additionally, utilities can see, understand, control, and automate operations better with AI and machine learning. These two technologies drive virtual asset operations that self-calibrate, operate, and communicate with other sensors.

With global water demand projected to increase 20% to 30% per year by 2050, according to the United Nations,[2] what utility doesn't want to transform to this new digital reality?

The Technology Behind Smart Water Networks

With the introduction of IIoT solutions, utilities can approach water management in a more holistic manner and accelerate their transitions from conventional operational approaches to smarter, more adaptive networks.

New open, standards-based LPWA communications and flexible open digital platforms are enabling low-cost, ubiquitous access to low-power IIoT sensors and data. This is enabling a new era of innovation within the water industry and driving significant change, letting operators automate and optimize operations, providing new services, and supporting new applications and business models.

Cellular network narrowband (NB) IoT is maturing, and now delivers the benefits of cost efficiency and enhanced battery life.

The 3GPP standards-based NB-IoT service offers the required coverage, scale, and extremely low power draw. This delivers economies of scale that enable improved and cost-effective IIoT capabilities. Consequently, it's being used with many meters and sensors. With solutions based on a licensed spectrum, it has low interference, quality of service (QoS), and security, while providing standards-based connectivity. This, in turn, creates more flexible, cost-efficient, and sustainable operations.

Forward-Thinking Connected Digital Water Strategy

Transitioning to an open IIoT operations architecture is the best way forward for utilities to accelerate their sustainable efforts, as well as adapt to the shifting availability of raw water and fluctuating customer demand.

Industry 4.0 and IIoT technologies facilitate a data-driven approach that can empower water utilities to enhance business operations via automated and optimized systems, while cost-effectively adding value to customers.

In this digital future, more open and flexible digital systems paired with cellular, standards-based, low-power, wide-area communications will deliver greater visibility and control, allowing utilities to automate more water management. ■

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About The Author

Dominique Verhulst currently heads up the Global Energy Practice at Nokia. Leveraging Nokia's full portfolio of fixed, mobile, IP & optical, applications & analytics, and professional services products, Dominique and his team provide complete end-to-end solutions for the utility, oil & gas, and mining industries. He is the author of the "Teleprotection over Packet Networks" e-book and co-author of several publications from the University of Strathclyde. He has over 30 years of experience in the telecommunications networking industry, holding senior sales and marketing positions at Nokia, Alcatel-Lucent, Newbridge Networks, Ungermann-Bass, and Motorola.

LEACHATE – A Key To Unlocking The Chain Of Recirculating PFAS Forever?

PFAS contamination is ubiquitous in the water cycle, but landfill wastewater leachate poses an opportunity to treat concentrated streams and break up the continuous movement through the water cycle.

By Fabrizio Sabba, Christian Kassar, Patrick McNamara, and Gary Hunter

Per- and polyfluoroalkyl substances, better known by their acronym — PFAS — and often called "forever chemicals," have been gaining increased attention over their presence in the water cycle. Indeed, PFAS are found in all parts of the water cycle, including wastewater, groundwater, surface water, and drinking water. They are ubiquitous because of their widespread use in consumer products such as food packaging, electronics, carpets, shampoo bottles, non-stick pans, and a plethora of other items. Moreover, these PFAS were designed to fight fires and coat our pans while cooking — it should be no surprise that they do not readily biodegrade in the environment. Since a wide variety of everyday products contain PFAS, landfills, and therefore leachate, are a hotspot for PFAS. If PFAS can be treated at landfills prior to leaching into surrounding waterways, the movement of PFAS through the urban water cycle could be limited. So, while leachates are undoubtedly a high, concentrated stream of PFAS, they are also an opportunity for treatment.

Landfill Leachate And PFAS Issues

Leachate is the product of precipitation infiltrating through the solid waste and potentially resulting in a rather complex mixture of dangerous contaminants for human and ecosystem health. Municipal landfill leachate is a source of PFAS contamination due to the extensive discharge of PFAS-rich consumer products. PFAS could take several different routes towards environmental contamination after placed in landfill facilities.

In the U.S., publicly owned treatment works (POTW) are usually responsible for the treatment of this waste leachate, which is commonly co-treated with domestic sewage. While the volume of leachate varies, it can be as much as 1% of the total influent volume at a POTW. The concentrations of PFAS can reach high concentrations in the order of ppm (or mg/L). PFAS treatment can be a challenging problem given the physical and chemical composition of landfill leachate that includes high levels of total organic carbon (TOC), total dissolved solids (TDS), and total suspended solids (TSS), and, in some cases, heavy metals, which may also be at ppm levels. These variables can all impact the downstream technology and the resulting removal and destruction efficiency. Different technologies have been implemented to reduce the discharge of PFAS into the environment.

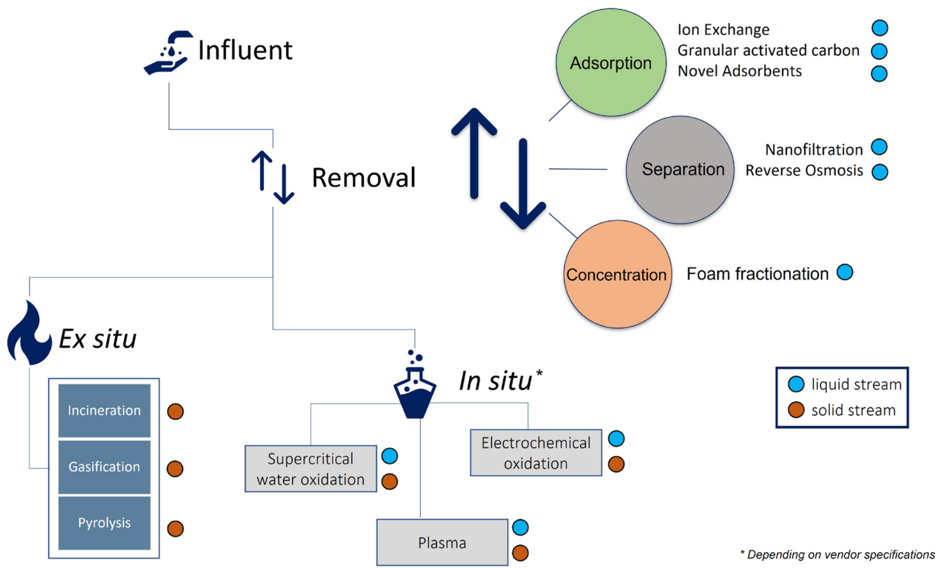
Technologies To Treat PFAS In Leachate

It is important to state upfront that there are no technologies to

date that are able to provide complete PFAS removal in the presence of disrupting species, such as high TOC and TDS, which might cause scaling, fouling, competition, or reduction in treatment efficiency. Conventional biological processes are proven ineffective for PFAS treatment due to their recalcitrance nature. Overall, treatment technologies remove PFAS via either separation/concentration or chemical transformation/destruction.

PFAS can be separated and concentrated into different media based on the technology used. For example, membrane separation processes (e.g., reverse osmosis) accumulate PFAS into a concentrated reject stream; liquid-liquid separation processes (e.g., foam fractionation) coalesce PFAS into a sludge-like foamy waste, and adsorption technologies (e.g., activated carbon and resins) precipitate PFAS onto porous materials or recover PFAS in the spent ion-exchange regeneration solution. Chemical transformation/destruction processes are comprised of redox-based and heat-based technologies. Redox-based technologies include supercritical water oxidation, electrochemical oxidation, and plasma. These processes are highly effective at meeting treatment requirements, while at the same time also offering a modular and *in situ* alternative. Heat-based destruction technologies are characterized by the presence of heating units and can occur in the presence (e.g., incineration and gasification) or absence (e.g., pyrolysis) of oxygen. These processes can volatilize PFAS and contribute to the formation of new, and sometimes unknown, PFAS gaseous byproducts.

As a guiding principle, minimizing the volumes and increasing the PFAS loading rate by concentrating the influent increases the effectiveness of destruction technologies and reduces operational costs. However, these technologies are far from being perfect and have some limitations, as discussed in the next section.



Available technologies to concentrate, separate, remove, and destroy PFAS from waste streams (Credit: Black & Veatch)

Shortcomings Of Current Technologies

Separation/concentration technologies provide cost-effective means for PFAS removal. Among these technologies, foam fractionation shows to be the most promising for landfill leachate applications, since it leverages the common foaming issues of leachate and the surfactant properties of PFAS while minimizing biological waste production due to low pretreatment requirements (for example, TOC removal can be avoided). Given that PFAS remains harmful after shifting to another media (e.g., foam), a destruction step is still necessary. The current common *ex situ* approaches of dealing with PFAS-laden waste can have sustainability challenges. For instance, incineration would generate high carbon dioxide (CO_2) emissions and harmful halogenated species as products of incomplete combustion, while disposal of PFAS waste would only re-contaminate landfills.

Treating and managing PFAS-laden waste has been comprehensively evaluated through life-cycle assessments (LCAs), which showed that combustion technologies, especially incineration, were the greatest contributors to adverse environmental impacts linked to high energy demands and fossil fuel depletion. The leading impact categories pertained to human toxicity cancer, water eutrophication, and ecotoxicity, whereby communities with lower levels of income, education, and infrastructure development were the most impacted. Moreover, a well-trained staff should operate the incinerators and thermal reactors to provide the right temperatures (i.e., >1,000°C), residence times, oxygen supply, and proper maintenance. Failure to secure at least one of the latter conditions would result in the formation of PFAS intermediates due to partial mineralization. A middle-ground solution is needed to address equity and social justice issues associated with exposure to PFAS from untreated waste (i.e., disposal) or harmful emissions (e.g., incineration).

Emerging destruction technologies have proven to be viable *in situ* alternatives with >99% treatment effectiveness, high modularity, and short reaction times, but have also presented several limitations given the minimal number of scale-up studies, which reflects the low level of readiness for full-scale deployment. Most novel processes require high energy inputs to degrade PFAS — whether by increasing the temperature and pressure of the receiving waters and/or producing radical species. Additionally, the complexity of leachate presumes continuous fouling and replacement of expensive equipment due to salt deposition, electrode passivation, or system degradation from extreme operating conditions (e.g., high temperatures, pressures, hardness, TDS). Other challenges include the formation of toxic byproducts such as trihalomethanes (THMs), haloacetic acids (HAAs), chlorate,

If PFAS can be treated at landfills prior to leaching into surrounding waterways, the movement of PFAS through the urban water cycle could be limited.

and perchlorate through the degradation of untargeted species (e.g., TOC, natural organic matter). Finally, destruction processes have only been proven effective for long-chain PFAS (e.g., perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) while shorter-chain counterparts (e.g., perfluorobutane sulfonate (PFBS), PFBA) are understudied. The latter compounds are less surface active and more soluble in water, therefore requiring the addition of chemicals such as coagulants, metal catalysts, polymers, and surfactants to promote degradation.

Ongoing And Evolving Regulatory Changes To PFAS Levels

On October 18, 2021, the U.S. EPA laid out a strategic approach to address PFAS and set a roadmap with specific timelines to deliver advanced policies and take action to protect human health and the environment, and hold polluters accountable for PFAS contamination. Particularly, this comprehensive approach is a commitment to action for the years 2021-2024. The roadmap is based on three goals: research, restrict, and remediate:

- *Research* represents an important aspect of tackling the "novel and unknown" topic of PFAS as we increase the understanding of the environmental impacts and the adverse health effects associated with long-term exposure to PFAS.
- *Restrict* becomes a cost-effective key action to minimizing human exposure and ecotoxicity by reducing industrial discharges of PFAS-containing products in the environment. Since PFAS partition between several phases other than water, such as soil and air, tackling PFAS at its source would mitigate its ubiquity.
- *Remediate* is to clean up what is already out there in the environment. This is a critical step that calls for urgency to minimize ecotoxicity and human health concerns.

As research on this topic advances, the EPA is issuing lower drinking water health advisory limits for legacy PFAS (e.g., PFOA, and PFOS) while concurrently finalizing new advisory limits for other PFAS (e.g., hexafluoropropylene oxide dimer acid, GenX, and PFBS). While waiting for federal guidance, some states have moved forward with PFAS control measures for biosolids as well. More than 30 states have already started taking state-level approaches to control and mitigate PFAS, whether as part of a monitoring strategy or a source reduction plan.

The regulatory pillar to resolving the issue associated with PFAS contamination is crucial but promising. This becomes even more promising on a federal level with the EPA's most recent and exhaustive PFAS Strategic Roadmap, which will provide a stricter course of action and an alleviated PFAS environment in the coming years.

What Will Research Focus On In The Future?

In recent years, the removal and destruction of PFAS has become an active topic of research with substantial progress. However, research is still heavily needed on this matter, and the following points require particular attention:

1. **The quest for scale-up studies**
   Despite the effectiveness of innovative PFAS-specific technologies, most studies are still at laboratory-scale level and pertain to specific operating conditions, thus limiting their commercial applicability. There is a need for conducting scale-up studies that compare multiple technologies under uniform conditions to provide a standardized treatment approach for PFAS applications.

2. **The need for better detection**
   As of June 2022, the EPA has issued new health advisory limits in drinking water several orders of magnitude lower than the existing detection limits. Given that the federal PFAS exposure regulations are expected to be promulgated soon, an enhancement of PFAS detection methods should be highly pursued to provide cheaper and more accurate detection measures. Noteworthy, Method 1633 is anticipated to be approved soon, and it tests for 40 PFAS in a variety of environments, including wastewater, biosolids, soil, and landfill leachate. Validation and subsequent approval of this method will allow research, monitoring, and potentially even regulations to move forward.

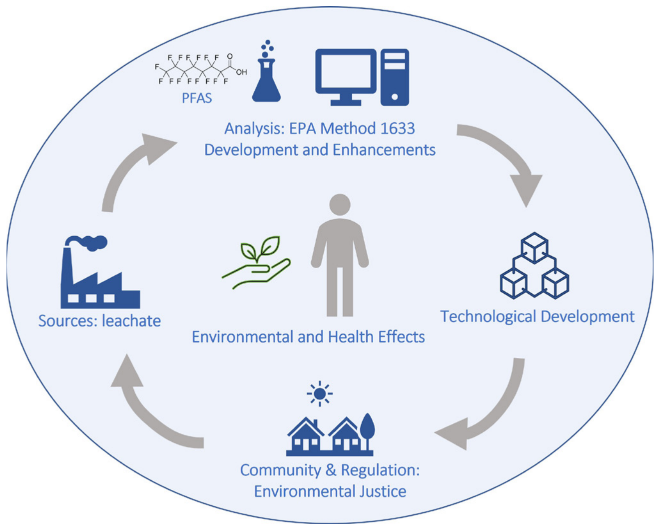
3. **Highly wanted economical solutions**
   PFAS are highly resistant to degradation, ubiquitous in the environment, and harmful to humans. Emerging destruction technologies are propitious in terms of treatment efficiency but are not ready for implementation due to lack of scale-up studies and associated capital and operating costs. To better serve deprived communities that do not have the prestige of acquiring high-end technologies, the federal government should continue promoting research investments in municipal facilities to pursue economically viable solutions for managing PFAS in treatment plants.

4. **Environmental justice concerns over incineration**
   Incineration, due to its unknown production of PFAS gaseous byproducts, has been the focus of attention for many studies of environmental justice. Particularly, a connection between the location of these incinerators and the characteristics of the communities indicates that individuals with lower incomes and lack of education are at higher risk of exposure, denote a case of environmental justice and health equity. Further research is needed on incineration to advance the knowledge about its safety and to establish exposure prevention practices to ameliorate individual and community protection along with health equity.

Given that the federal PFAS exposure regulations are expected to be promulgated soon, an enhancement of PFAS detection methods should be highly pursued to provide cheaper and more accurate detection measures.

The Bottom Line

Several emerging treatment arrangements have been used to address PFAS contamination in landfill leachate using bench-scale tests and showed promising candidacy to substitute conventional processes. Nonetheless, the applicability of emerging technologies is still constrained by the limited availability of bench- and pilot-testing results. More research development is needed using the multi-technology validation approach (i.e., side-by-side testing under uniform conditions) before deployment at full-scale and under more challenging conditions. The additional data will help identify the most cost-effective tandem treatment trains, reduce the formation of toxic intermediates, and refine the operating costs by improving the hydraulic capacity and energy requirements. While these emerging technologies may not be ready for use on a practical scale, their prospects and development show rapid progression as new water regulations increase their pressure.



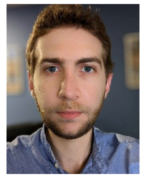
Summary of future key issues related with PFAS in leachate (Credit: Black & Veatch)

In the meantime, as emerging technologies strengthen, a particular and comprehensive strategy is required to reduce the use of PFAS chemical at the source. There will be more pressure as state regulatory agencies ban the use of PFAS in industrial and commercial applications. For example, Michigan and New York are banning PFAS in firefighting foams and Washington State passed bills eliminating PFAS in food packaging, all of which is encouraging other state regulatory agencies such as Rhode Island and New Jersey to consider similar measures.

The adverse health impacts associated with chronic exposure to PFAS are inevitable in deprived communities due to exponential bioaccumulation in environmental matrices. This calls for urgent and immediate measures. Will the regulatory and technological developments transpire in time? Or will the rapid spread of these harmful chemicals be too large to be contained? Whatever the future holds for regulatory environments, as long as PFAS are in consumers' products, then PFAS will be in leachate. Therefore, leachate will serve as an opportunity to break the chain of PFAS going from consumer products and into the ever-cycling urban water cycle. ■

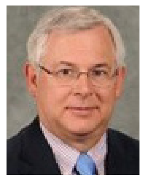
About The Authors

Fabrizio Sabba, PhD, is a Process Engineering Associate with Black & Veatch. His interests include biological processes for nutrients removal and resource recovery during water and wastewater treatment, with a focus on process modeling, biofilm modeling, and biofilm treatment technologies. Currently, he is tackling PFAS removal and destruction via evaluation of different technologies at bench-scale and full-scale.



Christian Kassar is currently working in the Process and Design Water Engineering industry at Black & Veatch. Christian's work interests include surface and subsurface water treatment processes for target chemical contaminants, with a narrower emphasis on emerging substances such as PFAS.

Patrick McNamara, PhD, PE, is a wastewater process engineer with Black and Veatch and an associate professor with Marquette University. He researched the impacts of PFAS on anaerobic digestion for his PhD, and has been leading research on pyrolysis of biosolids for the last 10 years. He was recently awarded a Water Research Foundation project with his Black & Veatch team to study the impacts of thermal treatments on the fate of PFAS in solid, liquid, and gas streams.

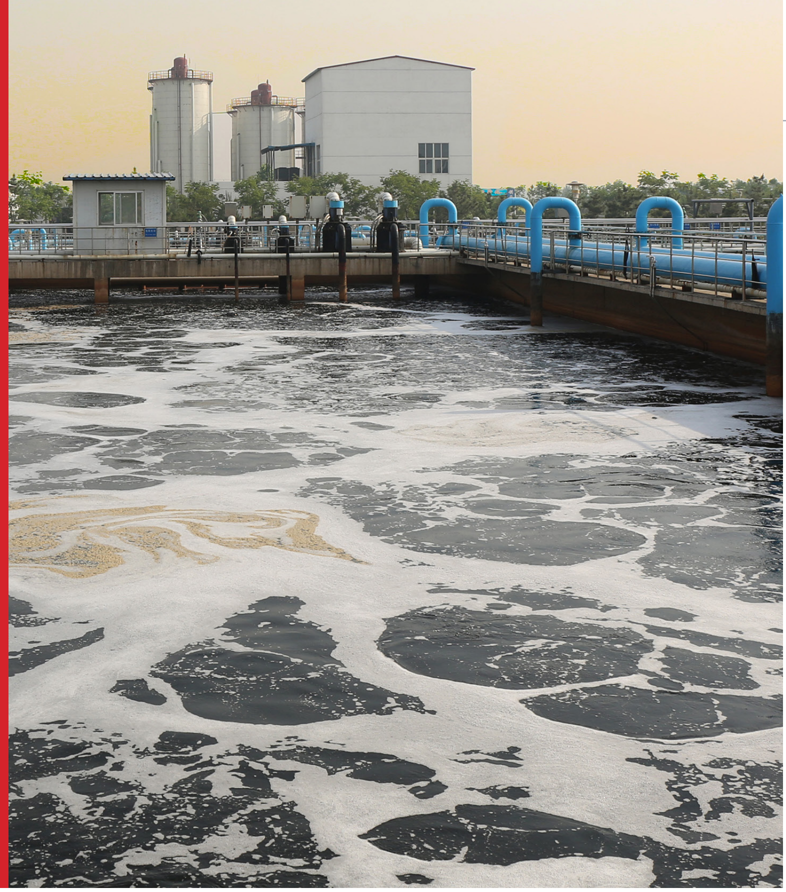


Gary Hunter is a Wastewater Treatment Technology Practice Lead at Black & Veatch. He is responsible for process evaluation for both domestic and industrial wastewater treatment facilities. In this role, he is responsible for industrial pretreatment programs, screening, grit, filtration, and disinfection process trains of the treatment plant. In this work, he has gained expertise in the design, operation, and troubleshooting of wastewater treatment processes. He serves as a UV process consultant to EPRI, conducting studies and training for water and wastewater facilities across the U.S.

DOING MORE WITH LESS:

Densified Activated Sludge (DAS) Systems For Water Resource Recovery Facilities

As wastewater treatment plants — or water resource recovery facilities (WRRFs), more preferably termed — continue to strive for efficiency, DAS has emerged as a space-saving intensification solution.



Jointly authored by members of Hazen and Sawyer (Gaya Ram Mohan, Wendell Khunjar, Ron Latimer, Yewei Sun, Alonso Griborio, Alyssa Mayer, Will Martin, Ben Levin, Joe Rohrbacher), Portland Water District (Scott Firmin), Gwinnett County Department of Water Resources (David Jones), and Metro Water Recovery (Rudy Maltos, Blair Wisdom, Dan Freedman, Liam Cavanaugh)

There are approximately 14,000 WRRFs in the U.S., 5,000 of which possess permits that include some form of nutrient limit on their discharge (EPA, 2012). Recognizing that WRRFs account for 10% to 15% of the overall nutrient load to surface waterways in the U.S., utilities are increasingly challenged with meeting new or lower nutrient effluent limits. A key challenge and opportunity for a growing number of utilities is to find financially responsible and effective nutrient treatment.

Biological treatment via activated sludge has been a backbone of WRRFs, exploiting the selection of various functional groups of bacteria that have the ability to remove contaminants like organic carbon, nutrients (nitrogen and phosphorus), and pathogens. A core principle behind the success of activated sludge is effective solids/water separation to retain the microorganisms and produce an effluent free of soluble and particulate contaminants. Solids/water separation has historically been achieved by gravity via clarifiers/settlers and filters with more recent use of membrane separation.

For activated sludge systems that rely on gravimetric separation of solids and water, the rate at which sludge settles and compresses is a critical factor that influences how WRRF infrastructure is sized and operated. Densification of activated sludge has emerged as a strategy for WRRFs seeking to improve the rate-limiting step of gravimetric settling to unlock treatment capacity and achieve process intensification. Densification is the process of growing and retaining particles with improved settling characteristics. Densification improves sludge-settling characteristics over conventional activated sludge by allowing operation at high mixed liquor suspended solids (MLSS) concentrations (e.g., 4,000 to 8,000 mg/L) while still employing gravimetric settling (e.g., secondary clarifiers or sequential batch reactors). Process intensification via densification allows utilities to optimize the use of existing facilities and reduce the need for additional infrastructure (e.g., tanks, equipment) while also potentially reducing energy and chemical consumption.

For these reasons, densified activated sludge (DAS) systems have received widespread interest within the water sector. For example, the aerobic granular sludge (AGS) process that was developed via a public/private partnership in the Netherlands and branded as Nereda and AquaNereda has become widely applied across the globe, with over 90 full-scale plants as of 2022 (Pronk et al., 2015). The current AGS technology utilizes sequencing batch reactors (SBRs), where plug-flow feeding and washout of slow-settling particles (i.e., tall reactors with short settling time) are applied to produce exopolymeric substances (EPS).

DAS can also be achieved in non-SBR configurations. Recent work has shown successful densification at lab-, pilot-, and full-scale in a variety of shallow, completely mixed, continuous-flow bioreactors and clarifier configurations (Avila et al., 2021; Daigger et al., 2018; Sturm, 2020; Wei et al., 2021b); (Li et al., 2015; Sun et al., 2019; Xu et al., 2020; Zou et al., 2018) (Avila et al., 2021).

What Is Densified Activated Sludge?

Activated sludge systems can experience a wide range of settling

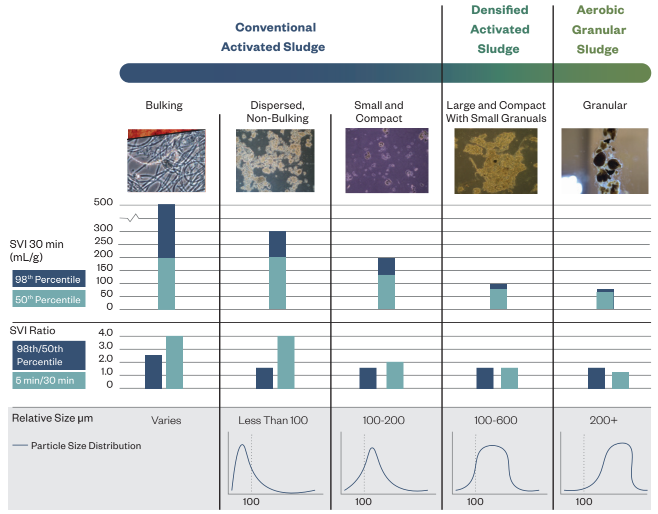


Figure 1. Continuum of activated sludge-settling characteristics

conditions, ranging from filamentous bulking to flocculant to partially densified to fully granular. DAS terminology represents a continuum of settling conditions that generally are characterized as having rapid settling velocities and low variability in long-term settling properties and whose composition comprises a combination of flocs and granules (Figure 1). AGS systems like Nereda/AquaNereda represent a highly intensified version of DAS whereby granules (particles > 212 µm) comprise greater than 70% of the sludge matrix.

What Factors Contribute To Full-Scale Densification?

Researchers in the 1970s and 1980s noted the benefits that metabolic and kinetic selectors can provide regarding settleability (Chudoba et al., 1974; Chudoba et al., 1973). While these researchers were focused on achieving flocculant activated sludge, they set the groundwork for DAS.

Several factors have been identified as being critical to achieve densification:

Control of selector zone food to microorganism (F/M) ratio and feast to famine regimes: Biological selection forms the basis behind DAS. Providing appropriate-sized zones (kinetic selection) allows selection for organisms that rapidly uptake readily biodegradable substrate under anaerobic, anoxic, or aerobic conditions (metabolic selection) to produce alginate like extracellular polysaccharides (EPS) (Lin et al., 2010) and internal carbon storage products. Famine conditions are then required to allow organisms to consume stored products, which facilitates structured growth into dense particles.

Control of shear conditions in properly loaded systems: Shear forces have also been shown to influence the production of EPS in biological systems as well as the abrasion rate of particles. The combination of biological and shear force selective pressures can therefore yield compact and dense particles that increase rate of settling in activated sludge.

DAS systems have been documented ever since activated sludge systems have been in operation. Many operators can attest to having long, documented periods where sludge settling has improved significantly; however, effluent suspended solids remain high (Jenkins et al., 2003).

Selective wasting of biomass to retain dense particles: Physical selection acts to preferentially retain fast-settling particles while wasting the slow-settling fraction and surface-froth-type organisms. This approach can result in the decoupling of solids retention times between the flocculant and granular phases. Several strategies have been employed in practice to achieve selective wasting, namely surface-wasting, hydrocyclones, lamella plates, upflow settlers, and mechanical sieves.

Laying the Ingredients for Densification at the East End Wastewater Treatment Facility

Portland Water District's (PWD) East End Wastewater Treatment Facility (20.8 MGD rated capacity), located in the Presumpscot watershed of Casco Bay, previously experienced sludge settleability issues caused by inadequate dissolved oxygen levels and excessive filamentous growth in the biological treatment process. PWD conducted a study to determine upgrades to improve sludge settleability and process reliability as related to nitrification.

PWD installed fine-bubble diffusers to improve air delivery to the biological treatment process and added kinetic and metabolic selector zones to reduce sludge bulking. Since completion of the aeration upgrade, average sludge value index (SVI) values reduced from 250 mL/g to around 120 mL/g.[1] Ammonia levels of less than 1 mg/L have been consistently observed since the improvement in settleability have allowed PWD to more reliably maintain solids inventory necessary to achieve nitrification. This project demonstrates the value of utilizing biological selection as a means for facilitating the early stages of densification — i.e., the development of small and compact flocs.

Leveraging Densification for Treatment Capacity at the Crooked Creek Water Reclamation Facility

Crooked Creek Water Reclamation Facility (CCWRF), owned and operated by Gwinnett County Department of Water Resources, is designed to treat 16 MGD using an anaerobic-anoxic-aerobic (A2O) configuration. The facility does not practice anaerobic digestion and has consistently achieved measurements of effluent ammonia (NH3-N) and total phosphorus (TP) less than 1 mg/L and 0.3 mg/L, respectively.

The older oxidation-ditch-type plant was upgraded in 2021 to an A2O process with a design emphasis on promoting DAS; and since start-up of the new bioreactors, the SVI at the 50th and 95th percentiles have remained low at 62 and 78 mL/g, respectively.[2] Through the use of DAS, it is anticipated that the CCWRF can be re-rated from 16 to 25 MGD without the need for new bioreactor basins. Results from this plant indicate that it is possible to achieve stable densification in continuous flow applications using kinetic and metabolic selection only.

Positioning for the Future at the Robert W. Hite Treatment Facility

Metro Water Recovery's (Metro) Robert W. Hite Treatment Facility (RWHTF) is a 220 MGD facility that currently achieves effluent total inorganic nitrogen (TIN) < 10 mg/L and total phosphorus (TP) < 1 mg/L. Metro commissioned a full-scale, continuous-flow DAS demonstration train to understand the role that DAS can play in addressing anticipated reduction in effluent nutrient limits over the next 20 years.

Results have confirmed that DAS improved settling characteristics and would allow Metro to load clarifiers at surface overflow rates (SORs) > 700 gallons per day per square foot (gpd/sf) and solids loading rates (SLRs) > 60 pounds per day per square foot (ppd/sf), nearly twice current loading limits.[3] This could allow Metro to defer construction of new aeration tanks and clarifiers, treating the wastewater to a higher quality and within the existing footprint. Results from Metro demonstrate that DAS can best be achieved using a combination of metabolic, kinetic, and physical selection.

Densify To Intensify

As utilities consider the future of treatment at WRRFs, DAS implementation should be considered to:

- Improve settleability with a view to increasing capacity of existing infrastructure, while also improving nutrient removal capabilities.
- Reduce sizing of new WRRFs, given the smaller, more efficient nature of biological nutrient removal (BNR), secondary clarifier equipment, and facilities.
- Position utilities to synchronize nitrification/densification/phosphorus uptake processes, which will reduce energy costs, carbon outputs, and greenhouse gas (GHG) emissions. ■

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ADDITIONAL TECHNOLOGY TO HELP THWART CYBERATTACKS

The future is connected, but it must also be secure — especially when it comes to public water.

By Cody P. Bann

Water infrastructure is critical to national security, economic stability, and public health and safety. While necessary for operations, the increasing automation of the water sector has opened it up to malicious cyber activity that could disrupt or manipulate services. In 2009, President Obama declared cybersecurity threats to be among "the most serious economic and national security challenges we face as a nation."[1] In January 2012, the U.S. Director of National Intelligence also noted that cyber threats pose a critical national and economic security concern in testimony given before the U.S. House of Representatives.[2]

Over the past two decades, federal investment in water systems has equaled only 4% of the amount that state and local governments invested, and most of the federal funding was in the form of low-interest loans, not grants. Fortunately, the White House has earmarked $2 billion from the bipartisan infrastructure bill that was signed into law last year to go toward strengthening U.S. infrastructure against cyberattacks. This couldn't come at a more critical time, as cities such as Los Angeles, San Francisco, Portland, OR, and Oldsmar, FL have experienced hacks and the ongoing threats that the volatile geopolitical climate poses.

Water And Wastewater Infrastructure Security

After the September 11 attacks in 2001, George W. Bush's administration directed efforts to secure critical infrastructure through programs such as the National Strategy to Secure Cyberspace, which addresses the vulnerabilities of supervisory control and data acquisition (SCADA) and industrial control systems (ICSs) — essential to effective water utility operations — and called on the private sector to work with the government to provide trusted control systems. The Presidential Policy Directive of 2013, under President Obama, echoed President Bush's Homeland Security Presidential Directive in affirming that water was among the 16 critical U.S. infrastructure sectors that must be protected.[3]

There are close to 200,000 drinking water systems in the U.S. that provide tap water to nearly 300 million people. This critical infrastructure spans tens of thousands of miles, involves many remote sites, and requires multiple networks with complex software and hardware needs. The sheer size and scope of these systems offer hackers many exploitable entry points. As utilities transition to the cloud, remote access, smart devices, and the Internet of Things, IT and OT are no longer separate. Over the past decade, the technology behind water infrastructures and utilities has become more interconnected with OT and IoT devices. The various connected devices such as controllers, sensors, and smart meters are being used by water utilities to remotely monitor and manage processes. In a recent West Monroe survey, 67% of utility leaders cited cybersecurity as their top concern of the converged IT and OT network.

A cyberattack causing an interruption to drinking water and wastewater services could erode public confidence, or worse, produce significant public health and economic consequences.

"The diverse nature of the water and wastewater sector, with organizations of varying size and ownership, the sector's splintered regulatory regime, and a lack of cybersecurity governance protocols, presents significant cybersecurity challenges, states a report by the American Water and Works Association (AWWA), *Cybersecurity Risk & Responsibility in the Water Sector*. "Moreover, entities within the sector often face insufficient financial, human, and technological resources. Many organizations have limited budgets, aging computer systems, and personnel who may lack the knowledge and experience for building robust cybersecurity defenses and responding effectively to cyberattacks."[4]

Remote Alarm Notification Software Offers Additional Security

The AWWA further warns: "Failing to address cybersecurity risk in a proactive way can have devastating results. Failing to take reasonable measures and employ best practices to prevent, detect, and swiftly respond to cyberattacks means that organizations and the people who run them will face greater damage — including technical, operational, financial, and reputational harm — when the cyberattacks do occur."

Utilities face myriad challenges to managing cyber risk due to varying water and wastewater infrastructure and entities of vastly different sizes, capabilities, resources, and types of ownership. However, turning to additional technology is one answer.

AWWA acknowledges — and many utilities have become aware — that replacing legacy systems and networks can be extremely costly. However, it is nonetheless essential to work with cybersecurity experts and solutions providers to update, if sufficient, or overhaul outdated systems. Experts can help to prioritize risk with a cybersecurity plan that, at minimum, complies with basic standards to restrict physical and technical access via firewalls, logging, and encryption, etc.[5]

Additionally, many SCADA systems are simply overexposed to the internet by remote desktop applications (e.g., Remote Desktop Protocol [RDP] and TeamViewer). In an attempt to provide process and asset information to operators, organizations have provided much more, ignoring the principle of least privilege and opening their entire control systems and their hosts to remote desktop access by hostile parties. Such broad remote access techniques present an increased security risk for organizations, a risk that Oldsmar experienced firsthand last year when an improperly secured TeamViewer application allowed an unauthorized party to increase the amount of sodium hydroxide being added to its water treatment process.

Advanced remote alarm notification software allows remote operators access to only the information they need from SCADA, but not access to the SCADA itself or its operating system's host. Such notification software is compatible with more secure, layered networks in which a series of firewalls provides added protection from attacks. This is done by deploying notification solutions alongside the SCADA system at the network's control level and using notification modalities that are not internet-facing or distributing internet-facing notification processes to higher levels. For example, internal email servers, SMS modems, and voice via Private Branch Exchange (PBX) devices allow communication with the outside world without internet exposure. Likewise, separating the processes that interface with SCADA from those that interface with external email servers, Voice over Internet Protocol (VoIP) solutions, and cloud apps allows internet-based notifications without compromising security.

Of course, there are valid use cases for desktop sharing software that do not violate Principle of Least Privilege (PoLP) and go well beyond operator access to process information. For such systems, it's critical that the remote desktop solutions be implemented with sound security.

There are several steps that utilities should take to improve their cybersecurity:

- Updating to the latest versions of software;
- Employing multifactor authentication;
- Using strong passwords to protect RDP credentials; and
- Ensuring that anti-virus systems, spam filters, and firewalls are secure, properly configured, and up to date.[6]

Utilities should also take steps to secure any remote access software. They should not use unattended access features, and IT leaders should configure the software such that the application and associated background services are stopped when not in use.[7] Integrating the remote alarm notification software through the SCADA system is critical to further reducing cyberattacks.

The New Normal

According to McKinsey & Company's report, *Critical resilience: Adapting infrastructure to repel cyber threats*, cyberattacks should be thought of as a certainty akin to the forces of nature. The report's authors advise: "Just as engineers must consider the heaviest rains that a dam may need to contain in the next century … those digitizing infrastructure must plan for the worst in considering how an attacker might abuse or exploit systems that enable infrastructure monitoring and control."[8]

It's a sobering, but essential, recommendation, for as important as connected infrastructure will be for the future of utility management, the safety of our water systems remains paramount. ■

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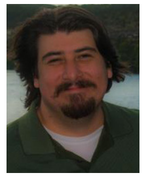

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Regulating Farm Pollution To Reduce Harmful Algal Blooms

As nutrient pollution increases the incidence and severity of harmful algal blooms, it is obvious and important to point mitigation practices toward a prime culprit — the agriculture industry.

By Emily Newton

Algae collectively comprise the water-dwelling organisms that give essential nutrients and oxygen to the surrounding aquatic environments through photosynthesis. However, harmful algal blooms (HABs) occur when algae growth becomes uncontrollable, threatening life above and below the water's surface.

These blooms look different depending on whether they happen in freshwater or saltwater. Those in freshwater generally appear as a green, scum-like coating on the surface. However, ocean blooms are orange, brown, or pink colored, leading to their often-used "red tide" nickname.

HABs can occur naturally. For example, the aging of bodies of water causes the weakening of hydrologic flows and the buildup of sediment, both of which cause favorable conditions for the uncontrolled growth of algae. However, humans contribute to harmful algae blooms, too.

Agricultural runoff is one of the main causes, happening when phosphorus and nitrogen make their way into bodies of water from nearby farms. Both phosphorus and nitrogen can cause nutrient pollution that accelerates algal bloom growth.

Such nutrient pollution can also create so-called dead zones, where the water has little to no oxygen. The U.S. has more than 160 dead zones, including in the Gulf of Mexico, which is the largest.[1] Nutrient pollution from the Mississippi River Basin causes that dead zone every summer.

Such consequences have led concerned people to assert that it's time to take action against harmful algal blooms. It's ongoing in the form of research, regulation, tracking, and reduction. Here's a closer look at what's happening.

Tracking Harmful Algal Blooms To Promote Knowledge

Scientists know that harmful algal blooms are more widespread than they once were. However, the first known instances of these events happened earlier than people realize.

A timeline from the U.S. National Office for Harmful Algal Blooms shows the earliest events of red tide occurring in Florida in 1844.[2] However, a 1799 event, also listed on the timeline, concerned members of a Southeastern Alaska hunting party becoming ill after eating mussels.

Nearly 100 of the hunters died, and researchers believe the affected people ate mussels affected by paralytic shellfish poisoning. Some species of microscopic algae produce the associated toxin.

The U.S. Centers for Disease Control and Prevention lists six illnesses caused by algae-related poisons.[3] People can get sick from eating contaminated seafood but also by swimming in water affected by algal blooms or breathing in the air surrounding them. A person's symptoms depend on the length and type of exposure and how it occurred.

Since HABs threaten both human and environmental health, people need to stay abreast of how they occur and to what extent. That happens through various means.

Using Satellites To Watch For Algal Blooms

NASA has deployed several Earth-observing satellites to check bodies of water for possible algal blooms. People use the associated data to create chlorophyll maps. They show green areas on bodies of water that suggest the likely presence of current or impending excessive algae growth.

A 2017 case of using this monitoring method reportedly saved $370,000 for officials by allowing them to warn members of the affected community sooner than they otherwise could.[4] They tested the water and then posted warnings for humans and their pets to stay away from the area in question.

Creating Forecasts To Monitor Trends

Forecasting is a critical part of planning in many industries. Coca-Cola uses it to determine the right times to deliver 500 million beverages to vending machines.[5] Hospitals depend on it to ensure that facilities have the right resources to deal with flu outbreaks and other situations that typically cause strain. Forecasting also supports algal bloom management.

The National Centers for Coastal Ocean Science (NCCOS) creates short and long-term forecasts of HABs by region.[6] The short-term ones happen once or twice a week, showing things such as the size of a bloom and its likely movement. Then, long-term forecasts aid officials in knowing the probable severity of a bloom season in a particular region. Algal blooms typically flourish in the summer when the water is warm.

However, scientists say other climate change-related effects could make them more severe.[7] That reality could make forecasting even more important in the coming years, especially if climate change makes harmful algal blooms begin to show unexpected characteristics.

Implementing Regulations While Furthering Education

Most U.S. states have laws restricting the overall use and application of fertilizers.[8] Those are a good start. However, it's less common for states to also offer certifications and educational programs for people who use fertilizer, especially those doing so at the industrial level.

The people who plan and run such programs must put themselves in the positions of agricultural professionals and focus on the things that are most likely to get them to act. One angle to take is discussing the potential money saved by curbing the overuse of fertilizers.

Giving Farmers Practical Tips To Manage Agricultural Pollution

It's also crucial to give farmers the knowledge and understanding needed to make positive changes to their practices. Some good starting points are to teach and encourage farmers to apply fertilizer with better accuracy. That means using it at the correct times and in the proper places, while distributing the correct amounts.

Agricultural professionals must take care to protect their assets from the elements. That often means ensuring structures such as barns have the appropriate waterproofing. Factors such as drainage systems, hydrostatic pressure, and buoyancy uplift are a few of the many things to consider when waterproofing a building.[9]

Setting aside time for building repairs or upgrades can also make farmers aware of damaged or missing fencing. Such infrastructure problems can contribute to harmful algal blooms by allowing livestock to access nearby natural water sources. When animals drink from them, they can introduce agricultural contaminants that eventually contribute to algal bloom activity.

A relatively new option is to create conservation buffers by planting trees, grasses, and shrubs along the edges of fields. This builds a barrier against agricultural runoff by absorbing nutrients or having a filtering effect before they reach the water. A 12-year study from The Nature Conservancy of such constructed wetlands showed they bring significant benefits. The research indicated that applying this technique to just 6% of the agricultural land could cause a 50% reduction in nitrogen.[10]

Another option is to make it easier for farmers to purchase equipment that reduces agricultural runoff. Nathan Nelson, a professor of soil fertility and nutrient management at Kansas State University, said equipment that injects phosphorus underground minimizes runoff. However, it's usually expensive to buy and operate.[11] If farmers could take advantage of rebate programs or similar incentives, they may find such investments more appealing and manageable.

Looking Toward The Future

Minimizing harmful algal blooms won't be easy, but progress is more likely to happen with collective efforts. In one case, the Ohio Lake Erie Commission mentioned curbing nutrient pollution as its top priority in restoring and protecting Lake Erie.[11] Some of the plans in the statewide effort include planting cover crops and building new wetlands.

However, other options exist, too. Researchers from the University of California-Davis explored how to use less fertilizer to grow rice in one recent example. They believe modifying the crops to produce a chemical that induces soil bacterial nitrogen fixation would enable reduced fertilizer dependence.[12] Such efforts may not come into the mainstream for a while. Still, they highlight some of the fascinating possibilities.

It's Time To Take Preventive Measures Against Harmful Algal Blooms

As this overview shows, individual farmers can take some thoughtful and practical steps to minimize the agricultural runoff that contributes to HABs. However, the most prolonged changes will likely come from policy makers who can use their power and influence to lay the groundwork for progress.

Now is an excellent time for legislators and others to prioritize HAB mitigation. Relatedly, concerned professionals and everyday citizens can pressure those parties through petitions and other types of collective action.

People familiar with the matter can recognize the ill effects caused by harmful algae blooms. Now, they must act to spur improvements in agriculture and other sectors. ■

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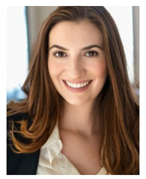

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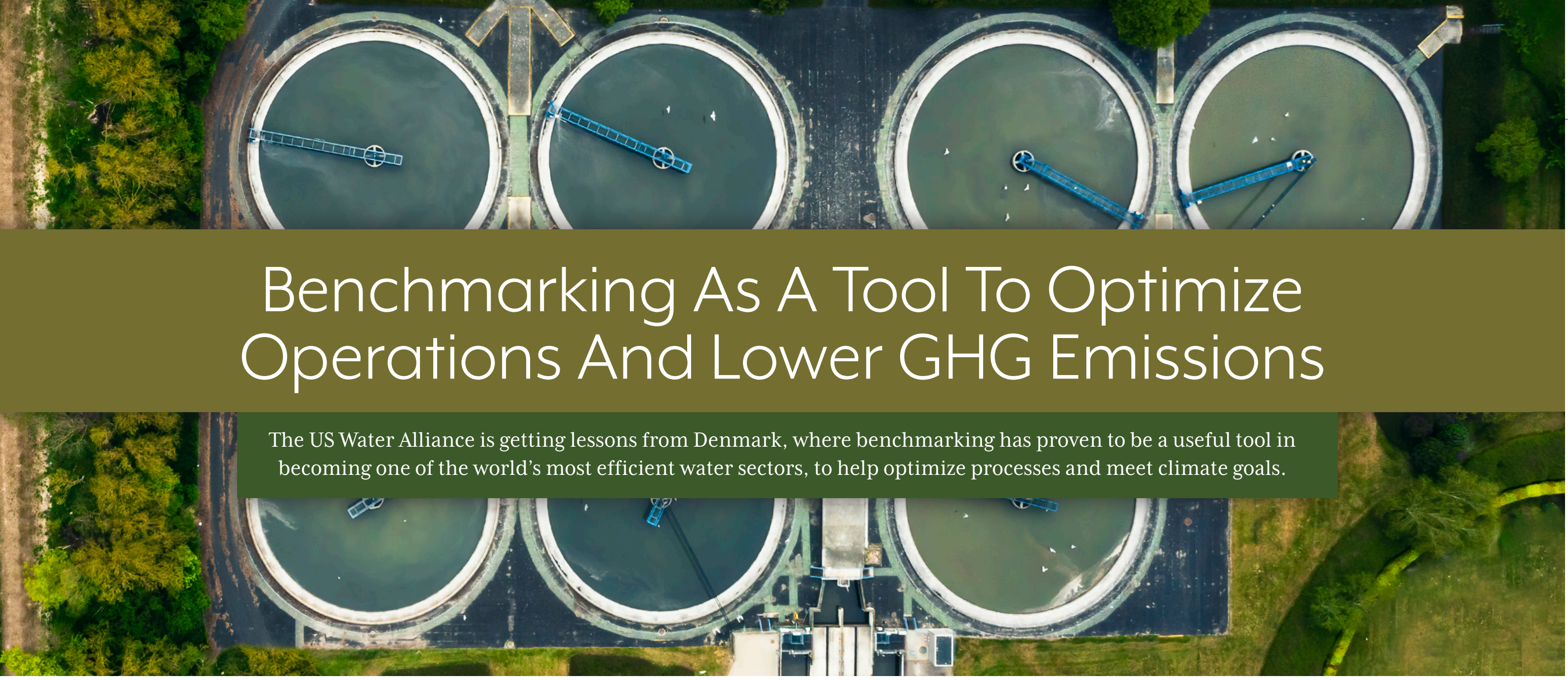


Benchmarking As A Tool To Optimize Operations And Lower GHG Emissions

The US Water Alliance is getting lessons from Denmark, where benchmarking has proven to be a useful tool in becoming one of the world's most efficient water sectors, to help optimize processes and meet climate goals.

By Mette Madsen

The race to net zero is a global challenge in the water sector. Technology and digitalization are important tools to reduce energy use and water loss, but collecting data is also an important part of implementing high technology solutions to further digitalization and prioritize efforts and investments.

Benchmarking is a tool that can uncover the potential for optimization for the utilities and enable data-driven decision-making by collecting a wide range of data from water utilities' operations, analyzing them, and publishing a report where the utilities are benchmarked across various economic and performance data points such as water loss, energy use, and investments.

"From decades of using benchmarking in the Danish water sector, we have learned that water utilities can use the data to exchange experiences with competitive partners and to make smart decisions regarding everything from contracts to investments. Knowledge sharing is essential, both locally and globally. We are experiencing great interest in Danish experiences and solutions in the U.S., which we are facilitating through our Water Technology Alliance and our partnership with the US Water Alliance and the [Danish] Water and Wastewater Association," said Consul General of Denmark in Chicago and head of water, Jesper Køks Andersen.

Benchmarking Is An Integrated Part Of Optimizing The Danish Water Sector

The Danish water sector has utilized benchmarking for decades. It began with voluntary benchmarking initiated in 1999 by eight water utilities who wanted to compare themselves to each other, and in 2003 the first IT platform was launched to report data for benchmarking. In 2010, a water sector act was adopted in Denmark to ensure that water utilities have high environmental quality, that they consider nature and security of supply, and are run in an efficient and transparent way.

With that, economic benchmarking was introduced, and in 2011 it was implemented, to imitate market competition in the monopoly that naturally exists in the water sector. Through economic incentives such as revenue caps, the purpose of economic benchmarking is for all utilities to become as economically efficient as the most efficient utilities in the sector, and in that way protect consumers from high prices.

The law covers all municipally owned water and wastewater utility companies, as well as private-public water utility plants, that sell more than 53 million gallons yearly flow. Revenue caps are yearly efficiency requirements on total revenue, both operational and capital, of 2% maximum. Companies that sell over 211 million gallons are subject to individual efficiency requirements that are based on efficiency potential.

When economic benchmarking was first established, focus was on reducing the operational budget. However, in 2016 the act was updated to encompass both operational and capital expenses to ensure that the utilities make efficient and long-term investments, for example in technology and infrastructure. Another form of benchmarking conducted by the Danish Environmental Protection Agency (EPA) was also incorporated, performance benchmarking, which involves non-economic parameters such as health, environment, and energy.

The three types of benchmarking — voluntary, performance, and economic — are all utilized in the Danish water sector today and conducted by three different entities. The Danish Water and Wastewater Association (DANVA), a national nonprofit industry and stakeholder organization for Denmark's drinking water and wastewater utilities, handles the voluntary benchmarking, the Danish Competition and Consumer Authority is responsible for the economic benchmarking, and the Danish EPA conducts performance benchmarking. The data for benchmarking are reported once a year by the utilities into one system, from which the relevant data are shared with the organizations responsible for the respective benchmarking.

"The benchmarking report submission is highly based on mutual trust. The economic benchmarking has requirements for documentation, and DANVA and the Danish EPA trust that the utilities' data reports are factual. It is the same numbers that they use for their annual business reports that they present to their boards," said Thomas Sørensen, manager of data application at DANVA.

Sharing Knowledge Is Imperative

Every year, DANVA presents an overview of benchmarking through their publication *Water In Figures*, which presents the numbers, takeaways, and developments in the Danish water sector's operations to foster knowledge-sharing and learning for the best.

"The voluntary benchmarking provides deeper insights into what separates the utilities from one another. From our report for sludge handling, utilities can see if their colleagues have found a smart solution they can learn from, such as the ideal length of contracts, prices for sludge disposal, or the benefits of having an internal sludge storage," said Thomas Sørensen, Manager of Data Application at DANVA.

Aarhus Vand is a Danish water company that utilizes benchmarking to optimize their operations and ensure long-term planning and financing. In the first years of collecting data, it was a considerable task for the company. However, with time the process has become highly automated and easy to complete.

"We have an interest in knowing these numbers. Benchmarking can provide us with targets to pursue. There is consensus in the Danish water sector that we want to be measured and perform and improve on central aspects, such as water loss and energy use. We cannot optimize based solely on the figures; discussing the findings with other companies is imperative. It is the community in the Danish water sector taking part in benchmarking and setting common goals that drives the sector," said Søren Larsen, subject manager of asset management in Aarhus Vand.

Claus Homann, chief operations officer and chief of strategic development in Aarhus Vand, added:

"We have a cooperation of like-minded companies, where we look at the benchmarking report together to discuss if there are areas where we can become smarter and better. That shows some of the great strength in the Danish water sector: openness and cooperation."

Three Types Of Benchmarking In The Danish Water Sector

- Economic benchmarking is mandatory by law and involves the overall economy. It is conducted by the Danish Competition and Consumer Authority, which is an independent public authority. It involves economic incentives, such as revenue caps, to make utilities run as efficiently as possible.
- Performance benchmarking is also mandatory and conducted by the Danish Environmental Protection Agency. It measures non-economic parameters within health, the environment, and climate.
- Voluntary benchmarking also looks at the economy, but in more detailed subcategories covering the entire cycle from utility to consumer and nature, including employee sick leave, water loss, bursts on distributions pipes, energy, planned and budgetary investments, groundwater protection, and discharge from wastewater treatment plants to the aquatic environment. It is conducted by the Danish Water and Wastewater Association.

Benchmarking In The U.S. Water Sector

Benchmarking also exists in the U.S., through, for example, the American Water Works Association's Utility Benchmarking Program. However, there is no current national blueprint or regulatory drivers for benchmarking. In 2022, the US Water Alliance launched a cohort of 10 utilities from across the U.S. with the goal of accelerating equitable climate mitigation strategies and meeting greenhouse gas (GHG) reduction goals at water and wastewater utilities. The cohort is establishing a collaborative approach, sharing knowledge between the utilities for them to find solutions to reduce energy use and water loss, among other things.

"Participants in the cohort are eager to share and learn from one another about their approaches, and we are working closely with Brown and Caldwell to develop a maturity model that will enable utilities to self-assess their GHG reductions efforts and voluntarily benchmark with one another. We plan to build off this as interest grows and deepen our climate mitigation work in 2023," said Renée Willette, vice president of programs and strategy at the US Water Alliance.

Through a partnership between the US Water Alliance, DANVA, and the Embassy of Denmark in Washington, D.C., the partners share experiences, solutions, and innovations to reach net zero in the water sector — a benefit both for the utilities in terms of reducing operational and capital expenses and the planet in terms of reducing GHG emissions.

In November, the US Water Alliance and their cohort traveled to Denmark for an inspirational tour of the Danish water sector, where they also had the possibility to exchange knowledge on benchmarking.

"At the national scale, the Danish water-sector-wide goal for net zero and Denmark's national benchmarking system is an inspiration for many of us here in the United States. One of the greatest lessons we can learn from the Danish water sector is that, when done collaboratively, benchmarking can provide both mutual support and friendly competition that helps individual utilities and the entire sector succeed together," said Willette. ■

About The Author

Mette Madsen is the marketing and communications advisor for the Trade Council of Denmark in North America — Energy and Environment. The Trade Council helps small and large enterprises to foster innovation, start exporting, and expand their activities to new markets. Mette earned a Master of Arts in communication studies and global studies from Roskilde University in Denmark and currently resides in Chicago, IL.

Adopting A 'One Water' Approach In Florida Through Integrated Master Planning

A One Water master plan under development for the city of Winter Haven, Florida, serves as an example to other communities looking at the future through a One Water lens.

By Mike Britt, Jon Dinges, and Jo Ann Jackson

Aptly nicknamed "Chain of Lakes City," Winter Haven is nestled east of Tampa in the middle of the Florida peninsula and is home to 50 lakes within or adjacent to its borders. In addition, Winter Haven is at the headwaters of the Peace River — its watershed a primary contributor to the Charlotte Harbor Estuary, the second-largest on Florida's coastline. Winter Haven's primary source of water, the Floridan aquifer system, is naturally replenished in the area through rainfall. This network of water resources is the inspiration for what is called the Sapphire Necklace, a natural solution and a vital component of what now has become Winter Haven's One Water strategy.

Rapid Growth And Its Environmental Impact

Located in the second-fastest-growing region in the U.S., Winter Haven faced tension between growth and economic development and preserving and restoring natural systems. Rapid population growth and urbanization have resulted in even more stress on an already limited natural water supply, which had been severely impacted through ditching and draining over the past century.

Water scarcity issues in Winter Haven date back decades. The city is in the Southern Water Use Caution Area designated by the Southwest Florida Water Management District. As such, the city must comply with requirements over use of water. In addition, the location of the city brings its own set of challenges. Sitting at the highest elevation of the watershed means that the only water entering the city is through rainfall. With all these challenges, current estimates indicated that Winter Haven could exceed its consumptive use permit before 2035.

Spearheaded by the US Water Alliance, the One Water concept seeks to shift water resource management away from traditional linear (e.g., use and disposal) and segmented (e.g., drinking water, wastewater, and stormwater) thinking. Instead, it approaches water as a singular and recyclable resource where every drop in the use cycle has value.

Winter Haven's One Water approach is supporting a resilient and sustainable water supply through restoration of the area's lakes and wetlands to provide natural storage; reclamation and reuse of water resources using the latest technologies; and replenishment of area aquifers using nature-based solutions.

Despite these challenges, Winter Haven wanted to tell a different story. With a rapidly growing population coupled with limited water supply and historic loss of water resources, it was clear Winter Haven needed to make major, future-looking changes to restore, enhance, and protect its water ecosystem.

Looking At The Future Through A One Water Lens

Guided by Black & Veatch, a leading global provider of critical human infrastructure solutions, in 2019, Winter Haven initiated a regionally minded master plan based on the concept of One Water.

Spearheaded by the US Water Alliance, the One Water concept seeks to shift water resource management away from traditional linear (e.g., use and disposal) and segmented (e.g., drinking water, wastewater, and stormwater) thinking. Instead, it approaches water as a singular and recyclable resource where every drop in the use cycle has value. The concept of One Water was the city's answer to all of its water challenges.

Winter Haven operates a water supply treatment and distribution system, a wastewater and reclaimed water system, and a stormwater system. The One Water master plan provides a roadmap for reducing stormwater runoff and wastewater discharge, recycling as much water as possible through infiltration and reuse. The focus is on integrating Winter Haven's built and natural water systems.

Winter Haven's One Water approach is supporting a resilient and sustainable water supply through restoration of the area's lakes and wetlands to provide natural storage; reclamation and reuse of water resources using the latest technologies; and replenishment of area aquifers using nature-based solutions.

As a result of the plan, Winter Haven expects to see 5,000 acres of restored wetland nature parks, improved flood control and water quality, approximately 70 billion gallons of new water storage, high-quality waterfront development, and the ability to better balance the water budget.

A Small City With Big Ideas

Water, economic success of a community, and health of the environment are all interconnected — making Winter Haven's One Water approach universally instructive. This small town of about 50,000 residents leveraged the same elements and frameworks that are being used in Los Angeles, which has a population of nearly 4 million. Not only does this illustrate forward-looking planning as the city continues to grow, but the city's implementation of a One Water plan paves the way for smaller, growing towns to leverage water planning of larger cities, helping to mitigate the risks that come with a quickly growing population and the stress it puts on water resources.

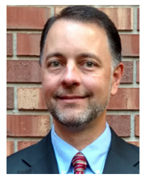
In addition to its innovative, large-scale approach to implementing a One Water plan, Winter Haven used the nature-based solutions at its fingertips: its Sapphire Necklace. A centerpiece of the One Water plan, this network of natural lakes, restored wetlands, and floodplains provides an array of services, including storage, filtration, recharge, and flood protection. The network of nature presents opportunity to reinforce community character, provide nature-based community amenities, and capitalize on new development. With an emphasis on water-balance potential and future land use, the Sapphire Necklace is a key piece to Winter Haven's One Water puzzle.

Growing In Concert With Nature

Winter Haven's One Water plan illustrates how a small town can utilize the same water planning as used for larger urban areas — planning for a future of rapid growth and development while preserving its natural resources. Further, Winter Haven serves as a model for other towns seeking to implement a One Water plan on a larger scale. ■

About The Authors

Mike Britt, One Water Project Manager, City of Winter Haven, is a professional engineer and water resource planner with 35 years of experience managing water in Central Florida. He has an undergraduate degree in civil engineering from Georgia Southern University and a master's degree in urban and regional planning from Florida State University. Mike was the city of Winter Haven's natural resources director for 25 years and assistant utilities director for seven years before taking his current position as the One Water project manager. Mike's career focus has been the establishment of sustainable water management practices that consider the full value and benefit that water provides.



Jon Dinges, Regional Water Resources Lead, Black & Veatch, has more than 27 years of experience in water resources engineering. He has managed a diverse array of programs and projects including storm water, floodplain management, water supply assessment and planning, water quality improvement, hydrologic restoration, minimum flows and levels, reclaimed water, natural systems restoration, and integrated water resource management planning.

Jo Ann Jackson, One Water Practice Leader, Black & Veatch, has a strong background in water supply and water reuse planning, spanning her 35-year career. Her experience includes nearly every type of water reuse from traditional urban irrigation programs to environmental enhancement/wetland treatment systems to potable reuse. For six years, she worked directly for city government, overseeing the city of Altamonte Spring's water, wastewater, and reuse systems, which has given her a utility perspective to complement her consulting background. She formerly served as a director of the Florida Water Environment Association Utility Council and was selected to serve as a utility appointee to the Florida Potable Reuse Commission, charged with developing a regulatory framework for potable reuse in Florida.

INDUSTRY 5.0: What It Means For Industry And Water Management

While Industry 4.0 is still very relevant for digital transformation, Industry 5.0 has loftier ambitions — to transform the whole of business and society, sustainably.

By Bernie Anger

The next phase of industrial revolution — Industry 5.0 — is quickly emerging. It evolved from Industry 4.0, which, among other advances, brought together leaps in industrial automation with cloud-type technologies and data analytics to drive productivity.

But unlike Industry 4.0 and the three industrial revolutions that preceded it, Industry 5.0 is not driven by the creation of new innovations to revolutionize manufacturing or transform production methods. Instead, it advocates for a monumental shift in priorities — placing societal value and long-term sustainability alongside or ahead of profits.

> **At its core, Industry 5.0 can be viewed as a call to action and striving for a greater purpose.**

According to the European Commission, Industry 5.0 provides a vision of industry that aims beyond growth and productivity as the sole goals and reinforces the role and contribution of industry to society and the planet. As a result, industries can play a leading part in addressing our most pressing challenges.

Industry 4.0 profoundly changed manufacturing with the advent of cloud-connected automation. It showed us the power of data, reflected in better process visibility, advances in predictive analytics, and even scenario planning. New concepts such as AI, machine learning, edge computing, the Internet of Things (IoT), and digital twins became part of the industrial vocabulary and tool kit, and when applied to production assets and processes, resulted in operation efficiencies and the ability to gain insights to inform future decision-making.

Industry 5.0 complements this whole paradigm and proposes using those same investments — the same technology and connected ecosystems — to develop solutions to global issues such as climate change and water stress. At its core, Industry 5.0 can be viewed as a call to action and striving for a greater purpose.

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Industry 5.0 As A Journey

Industry 5.0 should be viewed as a journey. And different companies are at various stages along this journey. Some have a head start based on greater awareness about the growing importance of environmental stewardship and adopting environmental, social, and governance (ESG) reporting metrics. Many of these organizations have long-standing corporate social responsibility (CSR) programs, which can include measures to conserve water or commitments to using renewable energy. For them, Industry 5.0 provides a catalyst and a framework to accelerate their sustainability performance.

For companies just starting, Industry 5.0 is a building block for developing sustainability-focused initiatives or resource-efficient strategies. One of the first steps they can take is to understand their use of natural resources or their environmental stress points. Carbon footprint is an often-used metric. Companies can also set out to measure the amount of greenhouse gas (GHG) emissions they release or the volume of waste they produce. Determining a water balance and the true cost of water is another. Systematizing these metrics can provide a baseline for setting sustainability performance goals that can be both measured and improved with support from the Industry 4.0 technology tool kit.

Embracing An Industry 5.0 Approach With Water

Whether driven by a CSR commitment or a local water conservation mandate, the demand for efficient water use has never been greater. Moreover, the close link between industrial water usage and energy consumption — and the influence of associated rising costs and carbon footprint — further accentuates the value of implementing Industry 5.0 solutions for water.

One of the ways to get started is through a digitally enabled water balance. Using this approach, a company could evaluate water use across its total footprint and look at every water-related flow — every input and output — at each of its plants. Applying Industry 4.0 technologies in the methodology, such as connected sensors and instruments, digital dashboards, digital twin models, and predictive analytics, will dramatically enhance the accuracy and usability of the calculations.

With a healthy online water balance, plant operators can locate the best opportunities to intervene in the plant to use water more efficiently or develop circular and closed-loop solutions that recycle and reuse process water. Real progress can be made when a plant begins collecting data automatically and combines the data with algorithms to optimize each process, including how each asset operates in terms of saving water. The overall approach starts at a macro level with the water balance and becomes increasingly focused with the help of digital technologies.

The benefit of digital tools is that they generate key insights to make the right set of decisions. And further, they help automate aspects of the work — freeing operators to tackle the next layer of problems. Beginning an Industry 5.0 journey does not always mean that a company will have to invest significant capital in new digital capabilities. In fact, many may already have some of the data and the automation infrastructure for moving ahead. Whether new technologies are required, realizing an ROI is best determined by each company and its situation based on context. But at a minimum, companies are encouraged to embrace a holistic approach when calculating their actual cost of water.

Organizations can maximize their Industry 5.0 implementations by partnering with solutions providers that offer domain expertise and leadership in applying digital technologies. By connecting the different data sources that already exist and complementing them with Industry 4.0 instruments and analytics, companies can identify the best path forward and transform their data into actionable intelligence — enabling them to reach their sustainability goals faster. ■

About The Author

As chief digital officer for Veolia Water Technologies & Solutions, Bernie Anger leads the business's overall digital strategy. His global Digital Enablement team combines an industry-leading portfolio of hardware and cloud-based IOT solutions with domain expertise to deliver powerful customer outcomes through data. Prior to joining Veolia in 2021, Bernie spent his career in corporate environments ranging from entrepreneurial startups to Fortune 50 companies, including GE and its spin-off Abaco Systems, Inc., where he served as CEO.