JANUARY 2022

Water Innovations

TOP 10 TRENDS FOR 2022

EXPERT INSIGHTS INTO TODAY'S
CRITICAL WATER & WASTEWATER ISSUES

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EDITOR'S LETTER

By Kevin Westerling
Chief Editor, editor@wateronline.com

In 2022, Water Quality Gets The Attention It's Due

With the funding brought forth by the bipartisan infrastructure bill passed late last year, as well as aggressive policies and regulation to rid water supplies of per- and polyfluoroalkyl substances (PFAS) and lead, 2022 shapes up as the year we finally address our industry's most troubling and challenging contamination issues in a meaningful way, with the help of innovative companies such as Sanexen (and others featured throughout these pages).

Sanexen's ALTRA Proven Water Solutions address the aforementioned contaminants, among others, and their technology has been awarded the 2021 Clean50 Top Projects Award, the 2020 Water's Next Award in the Projects and Technology: Drinking Water category, and the coveted "Efficient Solution" label by Solar Impulse. This was under the guidance of Martin Bureau, the company's vice president, innovation, who below addresses a range of questions posed about PFAS, lead, funding for treatment and infrastructure renewal, and more.

Bureau began his career in engineering in 1992 with a bachelor of engineering in metallurgy, followed by a master's degree in physical metallurgy and a doctorate in materials science. He worked in applied research at the National Research Council of Canada (NRC) and has authored more than 200 scientific journal articles and international conference reviews, in addition to coauthoring more than 30 patents.

Prior to his current role, Bureau led the research and development/engineering team, during which time Sanexen was awarded grants totaling $3.1M — from Sustainable Development Technologies Canada (SDTC), Transition Énergétique Québec (TEC), Recyc-Québec, and Québec's Ministry of Economy and Innovation — for the technological demonstration of their technologies.

Though based in Québec, Canada, his company serves all of North America, and Bureau is well-versed in U.S. water issues, as evidenced in the following exchange.

How will the focus on PFAS, and new state and federal maximum contaminant limits, affect operations for water utilities?

The new focus of the EPA, whether it's at the state or the federal level, is now putting tremendous pressure on water utilities for their wastewater and potable water treatment plant and, in turn, they are channeling that pressure to the sources of PFAS upstream in their networks. Industrial plants that release PFAS in their wastewater stream as well as landfill sites and other sources of underground water contamination from PFAS, such as legacy sites (firefighting training areas, orphan/abandoned industrial sites), are expecting to have their state EPA (or the like) on their back for, at this point, reporting on the level of contamination that they release to the wastewater streams or underground water, and eventually putting in place treatments for addressing these contaminants. Potable water treatment plants will have to install water treatment systems to address PFAS. Depending on their size, the water utilities will have millions to tens of millions of dollars in CAPEX to invest in those new treatment systems. Wastewater treatment plants may be able to just transfer the responsibility of treating PFAS to the upstream sources if they are identified by the surveys of the EPA.

What factors will determine how the utility proceeds with treatment?

The factors that will determine whether they need to invest now are the enforceable criteria to meet depending on the case, whether it's geography or type of water. If the source of contamination upstream is identified, the utility may be able to avoid or postpone the investments by putting pressure to invest in a treatment at the identified source.

Is the funding issue settled with the infrastructure package that was passed? What financial hurdles still need to be cleared?

The Infrastructure Investment and Jobs Act contains a total of $5 billion for five years for drinking water and wastewater systems to address emerging contaminants like PFAS, $1 billion targeted to wastewater utilities to mitigate PFAS in wastewater discharges, and $4 billion to help drinking water utilities remove PFAS from drinking water supplies or connect well owners to local water systems. The federal funding begins in fiscal year 2022 (October 1, 2021). The $4 billion going to drinking water utilities will be disbursed through the Drinking Water State Revolving Fund (DWSRF, $800 million each FY 2022-26) as grants that would be available to water systems of all sizes. (See chart.)

Year	Clean Water Emerging Contaminants	Drinking Water Emerging Contaminants	Total	Match
2022	100,000,000	800,000,000	900,000,000	0%
2023	225,000,000	800,000,000	1,025,000,000	0%
2024	225,000,000	800,000,000	1,025,000,000	0%
2025	225,000,000	800,000,000	1,025,000,000	0%
2026	225,000,000	800,000,000	1,025,000,000	0%
Total	$1,000,000,000	$4,000,000,000	$5,000,000,000	

Lead is the other predominant drinking water threat, also addressed in the funding package with earmarked dollars. What are the next steps on the path to 'lead-free'?

The Infrastructure Investment & Jobs Act has a total of $15 billion, $3 billion per year, directed to lead service lines.

Congress also included a total of $11.7 billion for the Drinking Water State Revolving Fund (SRF) and Clean Water State Revolving Fund. These are loan funds and require some matching dollars from the municipality/water utility. The Drinking Water State Revolving Fund has provided loan funds that directly support lead pipe replacement projects.

This is the largest investment in clean water and drinking water infrastructure in history. The next steps are for states to apply for funding to the EPA, which will transfer the money for FY 2022 as soon as possible. Once the states receive the money, they will begin bidding projects.

What other treatment needs and trends do you see on the horizon?

1,4-dioxane has attracted attention recently, and we see growing concerns for other types of contaminants related to industrial chemicals like flame retardants based on brominated organic compounds used for textiles, for example; chlorinated solvents still massively employed everywhere; pesticides (e.g., organophosphates); phthalates and other plasticizers for plastic-based products; and, of course, microplastics, which we find as microparticles in every aquatic living organism. Finally, a massive need right now for treatment is to address PFAS content in biosolids and sludges that are sprayed into agricultural fields for fertilization purposes. We have seen recently commercially available composts made from those biosolids with very concerning concentrations of PFAS (100 ppb).

Where do you see innovation fitting in? Are utilities, engineers, and industry embracing new technologies at a suitable rate to surmount current and future challenges?

The processes to get rid of these contaminants are known. As innovators, our challenge is to adapt them in such a way that they can fit into existing water treatment infrastructures. Water utilities struggle to find budgets just to maintain their water systems. Investing massively to address new contamination that was not even suspected a few years ago is simply not thinkable. The recent infrastructure bill will help water utilities cope with some of the challenges, but not all. Far from it.

And what challenges do you think are the most difficult to solve? What will keep water managers up at night in 2022 and beyond?

Meeting the parts-per-trillion criteria for PFAS put in place in some states for water sources that currently have hundreds of parts per trillion, if not more, within the timeframe proposed.

What do you hope to see in terms of industry action toward ensuring water security and sustainable operations for the long term?

Instead of trying to address PFAS concentration at the publicly owned water treatment system, where PFAS levels are low since they are highly diluted, with sometimes millions of gallons per day of water flow rates, I hope that we're going to see responsible industries making the right decision to address their PFAS emissions right at the source, which would be, collectively, outstandingly cheaper. ■

Water Innovations

101 Gibraltar Road, Suite 100
Horsham, PA 19044
PH: (215) 675-1800
FX: (814) 899-5587
Email: info@wateronline.com
Website: www.wateronline.com

CHIEF EDITOR
Kevin Westerling
(215) 675-1800 ext. 120
kwesterling@vertmarkets.com

PUBLISHER
Travis Kennedy
(215) 675-1800 ext. 122
tkennedy@vertmarkets.com

PRODUCT MANAGER
Bill King
(215) 675-1800 ext. 100
bking@vertmarkets.com

MANAGING EDITOR
Karen White
(814) 897-9000 ext. 316
kwhite@vertmarkets.com

PRODUCTION DIRECTOR
Lynn Netkowicz
(814) 897-9000 ext. 205
lnetkowicz@vertmarkets.com

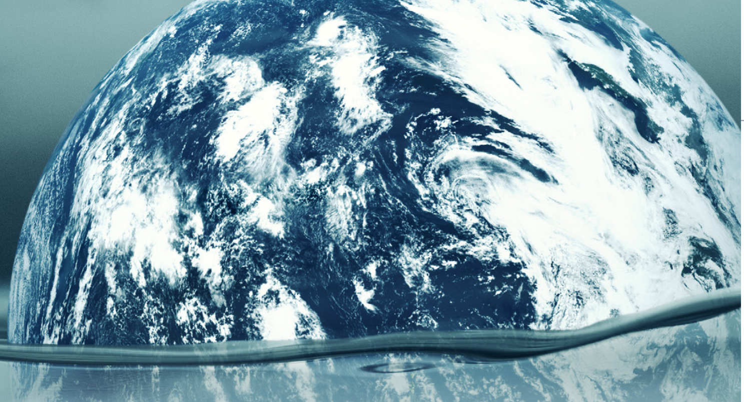
CREATIVE DIRECTOR
William Pompilii
(215) 675-1800 ext. 145
bpompilii@vertmarkets.com

PRODUCTION MANAGER
Susan Day
(215) 675-1800 ext. 101
sday@vertmarkets.com

DIRECTOR OF AUDIENCE DEVELOPMENT
Martin Zapolski
(814) 897-9000 ext. 337
mzapolski@vertmarkets.com

DIRECTOR OF ONLINE DEVELOPMENT
Art Glenn
aglenn@vertmarkets.com

Eprints and NXTprints
The YGS Group (800) 290-5460
VertMarketsReprints@theYGSgroup.com
www.theYGSgroup.com



As Climate Change Worries Deepen, Water Utilities Must Address Vulnerabilities, Raise Resilience

The existential and operational threats posed by climate change are clear and imminent, if not present, but how ready — and how concerned — are water and wastewater utilities?

By Ed Rectenwald, Jim Schlaman, and Andrew Smith

From chronic headaches about aging infrastructure to cyber threats and shifting regulations, water utilities have no shortage of complexities that keep operators up at night. Rising worries about climate change and its effects on the resilience of water systems increasingly are complicating matters, with a devastating Texas winter storm serving as the latest alarm in an industry that long has given the topic a relatively cold shoulder.

In February 2021, the powerful wintery blitz that blanketed much of the Lone Star State with snow, ice, and record low temperatures knocked out power and heat to millions of homes and businesses for days, disrupting crucial water service in the process. Many pointed to climate change as the likely culprit.

Dramatically, the Texas freeze underscored the often overlooked yet glaring interrelationship of energy, electricity, water, transportation, and communications infrastructure systems. When one fails, catastrophes can cascade.

That reality begs two questions as climate change — the force behind evidence of more severe and frequent storms — drives difficult decisions. Are utilities and communities doing enough to "harden" their water, wastewater, and stormwater infrastructures and assets against climate change, the phenomena manifesting itself elsewhere in seemingly more common droughts, flooding, hurricanes, and wildfires? Or are they at the very least starting to plan for such upgrades — and creatively sorting out how to pay for them — in the interest of dependable water security and supply? And in the scheme of things, how much hardening is enough?

The short answer: Water utilities could or should do more, as a survey of more than 200 U.S. water industry stakeholders for Black & Veatch's recently released *2021 Strategic Directions: Water Report* makes vividly clear.

Even as water utilities serve as the glue that helps bind communities, climate change impacts ranked fifth among respondents' most significant perceived resilience concerns, handily outdistanced by the top and perhaps predictable choice of two-thirds of the survey takers — potential catastrophic infrastructure failure in a sector that's grappled for decades with aging infrastructure. Natural or human-made disasters — some associated with climate change — ranked second, cited by nearly six in 10 respondents (57 percent) — down dramatically from 84 percent in 2020. Extended drought and water supply restrictions followed at 44 percent, with climate change impacts finally coming in at 29 percent, relatively unchanged from the previous year.

What are your most significant resiliency concerns?
(Select up to three concerns)

Source: Black & Veatch

	2020	2021
Infrastructure catastrophic failure	**55.7%**	**67.4%**
Natural or man-made disaster	83.5%	57.3%
Cyberattack	34.0%	56.2%
Extended drought/supply restrictions	38.1%	43.8%
Impacts from climate change	30.9%	29.2%
Terrorist attack	12.4%	5.6%

While climate change and the challenging reality that it's a moving target appears to get short shrift in decisions involving resiliency, increasingly extreme weather events still should compel water utilities — many underfunded and starved for capital — to proactively plan ways to harden their assets as a backstop against natural or manmade disasters. In 2020 alone, a historically busy Atlantic hurricane season produced 30 named storms, including a half dozen major hurricanes. Severe wildfires scorched millions of California, Colorado, and Oregon acres — and large swaths elsewhere around the globe — while flooding inundated portions of several states. This year, drought and wildfires continued to grip much of the western U.S.

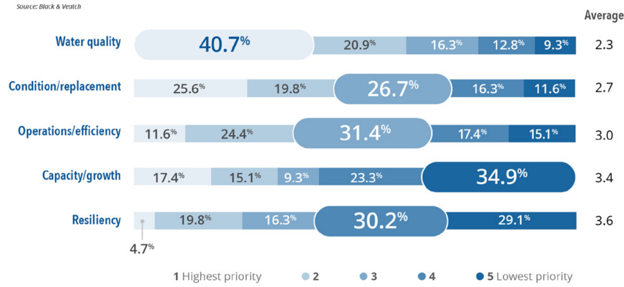
Against that worrisome backdrop, federal help is on its way to hasten greater climate resiliency. Signed into law by President Biden in November, the $1.2-trillion Infrastructure Investment and Jobs Act includes $550 billion in new spending, including billions to modernize U.S. water, wastewater, and stormwater systems. Classified by the White House as "the largest investment in the resilience of physical and natural systems in American history," the measure allocates nearly $51 billion to drinking water, wastewater, and stormwater infrastructure, along the way investing in water recycling for western U.S. states.

"Investing in infrastructure — specifically water — has vast support from the overwhelming majority of Americans. Water is too essential to wait," Mami Hara, CEO of the US Water Alliance trade group, said after final congressional approval of the infrastructure bill, sending that 2,702-page measure to Biden for his ultimate signature.

"With enactment of the bipartisan infrastructure investment package, Congress and the (Biden) administration recognize the essential role water recycling is playing in helping communities confront the impacts of climate change and build more resilient and sustainable water resources for their communities," added Patricia Sinicropi, the WateReuse Association's executive director. "This is an important day for water in the U.S."

How are the following types of projects being prioritized by your organization?
Rank the following from 1 (highest priority) to 5 (lowest priority).

Source: Black & Veatch



Which of the following elements are included in your water supply plan?
(Select all that apply)

Source: Black & Veatch

By Population Served	Less than 500,000	500,000 or more
Water conservation and/or drought management	**62.9%**	**75.0%**
Scenario planning	57.1%	60.7%
New reservoir storage	37.1%	32.1%
Climate change/variability	17.1%	50.0%
New surface water supplies	14.3%	32.1%
We do not have a water supply plan	14.3%	3.6%

Resiliency Still A Lesser Priority

Perhaps of little surprise, many system managers remain acutely focused on meeting state and federal water quality standards and simply keeping the system running. Addressing anything beyond the job's operational mandates often tends to be deferred as "tomorrow's crisis" — something to tackle only after today's crises are dispatched.

The Black & Veatch survey amplifies that. Projects that ensure or enhance water quality — the chief mandate of water providers — held the most sway among respondents, with roughly four in 10 casting that as their highest priority. Bolstering the conditions of assets or replacing them altogether was the chief priority of one-quarter of respondents, followed by addressing capacity and growth (17 percent) and operations and efficiency (12 percent). Projects intended to improve resiliency drew just 5 percent, with nearly three in 10 labeling resilience as their lowest priority.

Larger water utilities — those serving at least 500,000 people — listed resiliency as their third-highest priority, behind water quality and matters involving asset condition or replacement. For utilities with fewer than 500,000 customers, resilience languished at the bottom of five priority choices, reflecting that resilience planning is a luxury for those smaller water systems.

A similar split between larger and smaller water utilities surfaced when respondents were asked about elements of their water plan. Three-quarters of larger systems surveyed said water conservation and/or drought management was part of their blueprint, compared to 63 percent of smaller systems. Officials at systems of various sizes had roughly the same responses about scenario planning and new reservoir storage.

But a large gap emerged when it came to climate change or variability, with half the respondents at larger utilities saying such factors were part of their water roadmap — compared to 17 percent of smaller water systems.

Water's Value And The Climate Threat

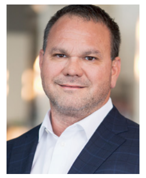
The U.S. built a lot of water and wastewater infrastructure more than a century ago, but capital spending has dropped off sharply. Until systems break, water and wastewater functions remain an "out of sight, out of mind" proposition. But breakdowns are happening more frequently, given the prevalence of aging infrastructure stressed by population growth and migration.

As climate change worries escalate — and citizens, regulators, and other stakeholders demand greater resiliency in such critical infrastructure — utilities large and small would be well-served to strategize thoughtfully now about upgrades, knowing that such projects are years in the making.

Water and wastewater utilities should begin by having earnest conversations with their boards, critical stakeholders, and customers about water's value, pressing the salient point that the environment isn't static.

Key to it all is understanding that it's not about the infrastructure's performance over past decades but what challenges the assets will have to handle sooner or later. And the fact that it's far cheaper to repair or replace assets now before systems weaken and fail than playing catch-up — and pointing fingers — when trouble strikes. ■

About The Authors



Ed Rectenwald is a hydrogeology national practice lead for Black & Veatch's water business.

Jim Schlaman is the director of planning and water resources for Black & Veatch's water business and serves on the One Water Council for the US Water Alliance.

Andrew Smith is the national watershed, stormwater, and flood management practice lead for Black & Veatch's water business in the Americas.

Digital Protection:

Lessons From 2021 For A More Secure 2022 *(And Beyond)*

While the water industry continues to embrace the benefits of automation and digitalization, it is equally important to be cognizant and resistant to the inherent risks.

By Rick Andrew

2021 was a growing year for most of us as we adapted and remained flexible through the ever-changing pandemic. As a global community, we have taken the obstacles from the past couple of years and have used them as learning tools to move forward with awareness and courage.

This past year has been no different for the water industry; it has provided learning opportunities for us to develop new solutions to manage water remotely as we continue to work in virtual environments. With the opportunity and convenience of working remotely, we rely heavily on this new digital environment we have created. Our new digital dependence opens us up to new challenges and potential threats for cybersecurity attacks.

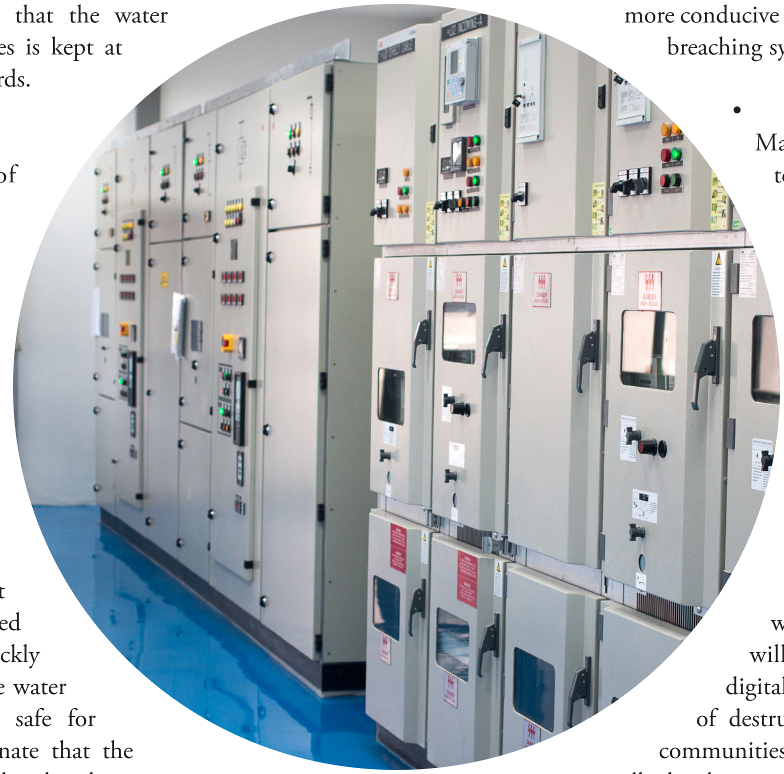
Moving Forward

As we embrace the new virtual normal in our professional and personal lives, we have become vulnerable to different cybersecurity threats. Sophisticated online hackers make a living off companies and individuals entering personal and confidential information online and in various software programs. Some may wonder what this has to do with the water business. Our industry is no exception and faces an increased chance of cybersecurity threats and attacks on our water and wastewater systems.

Over the years, one of the standard digital tools used by the water industry has been supervisory control and data acquisition (SCADA) technology. Most large drinking water utilities automate essential water treatment functions and physical processes with this system. Additionally, many smaller utilities with less financial resources to invest in cybersecurity have also started adopting SCADA over the years. This makes them particularly vulnerable to a cybersecurity attack. Many utilities using digital systems such as SCADA are not digitally secure, regardless of size.

It's safe to say that our top priority in the water industry is to provide clean and consumable water to our communities. We know that a slight adjustment to chemical levels during the water and wastewater treatment process can result in severe illness and even death to those who consume it. Because of this, it is crucial for water and wastewater utilities to implement systems that will block any hackers working to contaminate the water supply. An easy first step is education. Take time to learn the best online security system for your company that will add a layer of digital protection. In addition, it is important to be prepared with standard operating procedures to quickly and efficiently act in the case of a security breach to mitigate any potential impacts to the company, employees, and customers. We can use these two effective steps to protect our digital water treatment processes and help ensure that the water released to our communities is kept at proper consumption standards.

It is essential to be aware of the different risk drivers for a destructive cybersecurity attack on water and wastewater utility treatment plants to know where to start protecting your plant.



Risk Drivers

The importance of cybersecurity protection for our industry was made apparent last year when one of Florida's water treatment plants was compromised. The cyberattack could have caused extreme harm to the city's population of 15,000 people when the hacker raised sodium hydroxide levels in the water. Luckily, the plant worker who initially identified the critical issue moved quickly and efficiently to ensure the water delivered to the city was safe for consumption. It was fortunate that the Florida plant worker caught the dangerous issue right away, but we must remain vigilant and make sure our water utilities have strong cybersecurity capabilities to stop the potential threat of hackers.

It is essential to be aware of the different risk drivers for a destructive cybersecurity attack on water and wastewater utility treatment plants to know where to start protecting your plant. This includes ransomware attacks, phishing attacks, data leakage, hacking, and insider threats. Additionally, the following factors increase a water utility's risk of being hacked and threatening the water supply:

- *Legacy/Outdated Infrastructure* – 60 percent of breaches are successful due to an unpatched system with a patch available for the fix. Ensuring an organization's infrastructure is up to date is an essential step in ramping up digital security.
- *Lack of Password Controls* – Many companies use only single-use passwords and do not utilize multifactor authentication, making it easier for hackers to get into the company's systems. Along with this, allowing simple passwords for logins creates a digital environment more conducive for hackers to be successful in breaching systems.
- *No Security Checks* – Many companies rely on technical security tools but have neglected to create any assessment against a security baseline. Ensuring everyone in the company complies with a bare-minimum set of security measures can help bolster water utilities' digital security.

Stepping Into The Future

As time moves forward, water and wastewater utilities will have to increase their digital protection and awareness of destructive attackers to keep our communities safe. As an industry, we will also have to increase our knowledge of cybersecurity attacks and create plans for countering attacks if the digital protection is breached. Our digital world is continuing to grow, and being able to quickly adapt is going to be crucial when dealing with commodities as precious as our drinking water. ■

About The Author

Rick Andrew is NSF's director of global business development, water systems. Previously, he served as general manager of NSF's Drinking Water Treatment Units (POU/POE), ERS (Protocols), and Biosafety Cabinetry Programs. Andrew has a bachelor's degree in chemistry and an MBA from the University of Michigan. He can be reached at 1-800-NSF-MARK or by email at Andrew@nsf.org.

Private Investment Trends In Water And Wastewater Utilities

Initial advice for utilities considering privatization, public-private partnerships, and consolidation

By Christopher Mackin

As the population increases and more people live in water-scarce regions, more demands are placed on already stressed water resources and systems. In the U.S., many systems struggle with aging infrastructure and increasingly extreme weather events including droughts, floods, and freezes.

The water sector, municipal officials, and local governments face many barriers to properly addressing these issues — from fragmentation within the industry to increasingly stringent standards and regulations, as well as limited funding. Moving from publicly operated water services to privatization and/or consolidation may be an attractive option for communities that want to improve their water systems. Receiving investments from private equity partners and/or combining resources with nearby utilities offers municipal water systems the potential to improve their efficiency, sustainability, and fiscal stability. This consequently offers value to communities if it streamlines processes and reduces their costs.

There is significant demand for new water supplies, novel wastewater treatment, and potable and non-potable water reuse, but local decision makers should understand all of the variables to ensure their communities are protected. This article explores many facets of privatization, including:

- What's driving the current demand for improved water systems in the U.S.?
- Why are investors interested in water and wastewater utilities?
- What utilities should understand when considering privatization, public-private partnerships (P3s), or consolidation.
- How to plan a successful merger or acquisition.

What's Driving Demand In The U.S.?

Demand for private acquisition of water systems in the U.S. has been increasing for a while. Between growing communities in water-scarce regions, aging infrastructure, and years of underinvestment, plus financial stresses exacerbated by the pandemic, the private sector is positioned to help — especially when considering historically low interest rates and increased support from governments around the world to transform outdated systems.

Growing Population

Most of the growth within the water and wastewater treatment market is driven by rapidly growing population and urbanization. New residents can strain current systems as they move to areas with limited water supplies, and research has projected that many regions of the U.S. experiencing population growth — including parts of the Great Plains, the Southwest, central Rocky Mountain states, California, the South, and the Midwest — could see their fresh water supply decrease by as much as one-third[1] within the next 50 years.

Aging Infrastructure

Increased demand for new water resources also spotlights issues related to aging infrastructure and years of underinvestment. Exacerbated by years of underinvestment and new challenges from climate change, many systems need investments to make them more sustainable both short- and long-term. Aging water infrastructure also loses water at an alarming rate, and it's estimated that drinking water systems in the U.S. currently lose at least 2.1 trillion gallons of treated water per year[2] (approximately $7.6 billion) to water main breaks and leaky pipes.

Financial Impacts Of COVID-19 On The Water Sector

Water and wastewater systems experienced financial shocks during the pandemic, and the cost of COVID-19 on water and wastewater utilities combined is predicted to exceed $27 billion[3] due to utilities eliminating shutoffs for non-payment, anticipated increased delinquencies, and reductions in non-residential water demands. Taking all of this together with increasingly stringent standards, industry stakeholders may consider privatization or consolidation to help their communities better deliver on their promise of safe water and a clean environment.

Financial Support

In the U.S., President Biden proposed a comprehensive approach to improving infrastructure through his American Jobs Plan. While the plan was still up for debate at the time this was written, details included $111 billion in clean water and drinking water investments. The plan proposed prioritizing federal spending on several aspects of water quality proposing, including:

- $56 billion toward upgrading and modernizing America's wastewater, stormwater, and drinking water systems through grants and low-cost loans
- $45 billion toward removing all of the lead service lines across the country
- $10 billion toward monitoring and remediating PFAS in drinking water

The current administration also supports the Bipartisan Infrastructure Framework, a $1.2 trillion transformational investment in clean water infrastructure, clean power infrastructure, remediation of legacy pollution, climate change resiliency, and more. This plan is the largest investment in clean drinking water and wastewater infrastructure in American history. The framework calls for:

- The elimination of all lead pipes and service lines in the country's drinking water systems
- $55 billion toward building out and repairing water infrastructure
- $5 billion toward the Western water shortage

Outside of federal support, private markets are also well-positioned to provide much-needed capital along with innovative approaches that can help struggling communities. Interest rates have recently been at historic lows, and in March of 2020, the Federal Reserve slashed interest rates to 0 percent to shield the economy from negative consequences of the coronavirus. In turn, private equity firms have been able to leverage debt with lower interest rates to acquire and improve assets like water systems.

Investor Interests

Financial markets around the globe periodically experience volatility, as shown by the 2008 economic recession and recently with the COVID-19 pandemic. Now, investors are looking for financially stable, "recession-proof" businesses to act as a hedge against macroeconomic downturns.

"Water utilities have always been a safe harbor for capital during choppy times in the equity markets. Investors trade off beta or volatility for more predictable yet modest returns," says Jud Hill, cofounder and managing partner at Ecological Service Partners, an investment fund dedicated to environmental services and water assets. "In fact, water utility equities have often been referred to as 'widow and orphan stocks' because of their low risk profile."

To Hill's point, investors have historically purchased water and power utilities as long-term holdings for their dividend income and stability. While this still holds true, the trend toward clean energy along with friendly legislation and heightened investments in renewable energy resources has some analysts predicting strong growth for the utilities industry over the next decade.

Water, wastewater, and reuse system assets that can boost a fund's environmental, social, and governance (ESG) ratings are proving attractive. The S&P Global Market Intelligence report[4] released in April of 2021 revealed that ESG funds outperformed the S&P 500 between March 2020 and March 2021. In 2020, flows into sustainable investment funds in the U.S. achieved a nearly tenfold increase from 2018, surpassing $51 billion.

Investors are interested in publicly traded water utilities because they have more potential to expand customer count than other utilities while producing steady returns.

"When looking at the whole picture, it is not surprising that many water utilities actually jumped 10 to 15 percentage points in value during the first quarter of 2020, coinciding with the onset of the pandemic. This was a classic 'flight to quality' or safety, as water has always had reasonably stable demand," added Hill. "Now, water utilities are trading at their pre-pandemic values and have seen little volatility over the last 18 months."

As described in the following sections, utility privatization, P3s, and consolidation offer water and wastewater systems different benefits, but there are key differences between these strategies that stakeholders should understand before moving forward.

Privatization

Privatization is when a government-owned property or business becomes privately owned. The current low interest rate environment will likely encourage increased privatization of assets as investors acquire them at low cost. When a public utility considers changing to become privately owned and managed, there are three key groups that will have to be convinced in order to ensure a deal goes through: policymakers, community members, and the press. These groups have the power to make or break a deal, so it's critical to address their questions and concerns.

Utilities, their investors, and their partners should arrange public meetings with community members, prepare clear messaging about their proposal, and be prepared to make necessary changes. Most importantly, they need to listen to the customers. If utility customers are saying they value public utilities and have no desire for privatization, that carries a lot of weight. Elected officials will want to keep their constituents happy.

Public-Private Partnerships

Governments can also work in tandem with the private sector via P3s for potential cost savings. P3s involve cooperation between the public and private sectors in one or more areas of the design, development, construction, operation, ownership, or financing of infrastructure assets, or in the provision of services.

According to a report from the Reason Foundation[5], the City of Tampa was able to save $85 million on a 15-year water public-private partnership, and also saved 50 percent on a 30-year deal for its desalination plant by tapping the private sector instead of using in-house service. The report also cites Seattle as another example of privatization cost reductions, where the city was able to save a combined $120 million on separate projects by not using in-house services.

Consolidation

Consolidation of utilities involves combining assets, liabilities, and other financial items of two or more entities into one. The different types of consolidation include:

- *Direct Acquisition:* Higher-capacity utility acquires the assets, operations, and customers of another system and absorbs them into its existing governance, operational, and financial frameworks.
- *Joint Merger:* Two or more relatively equal partners both adjust governance, operations, and financial frameworks to create a new entity that is owned and controlled by the previously separate parties.
- *Balanced Merger:* Two or more entities consolidate with the goal of establishing a governance structure that provides a basis for at least some direct participation by the pre-existing utility in future decision-making.
- *Regional Agreements:* Do not combine legal entities, but rather, pool utility resources, buying power, and technical expertise to do more across a wider area than a single utility could do alone.

As an example, the City of Raleigh merged seven local utilities[6] into a full-service regional water and wastewater provider, serving 570,000 people over a 299-square mile service area. The consolidation resulted in the creation of lower regional uniform rates, reduced operational and maintenance costs, and improved efficiencies in water and wastewater asset investment as well as access to lower cost capital. Overall, the consolidation of these systems is estimated to have saved the region an aggregate of approximately $350 million.

Successful Mergers And Acquisitions

If a water or wastewater system undergoes a merger or is purchased, there are certain things they should know to ensure they receive the best deal while protecting customers.

Build a strong team.

Going through an M&A process alone is not advisable. At minimum, utilities should have a business attorney, a Certified Public Accountant (CPA), a Certified Financial Planner™ (CFP®), and an industry consultant to protect their interests during the transaction.

Clearly define goals.

With their team of advisors, utilities should determine what they want to achieve with private equity partners or consolidation. Whether the current owner/operator is moving on completely or merging with nearby facilities, the level of involvement post-transaction will help determine the right private equity firm and avoid regrets down the line.

Know what the utility is *actually* worth.

Understanding a utility's true value helps in framing negotiations and setting realistic expectations; a reputable advisor should be present to help with this process.

Understand earnouts.

Buyers will sometimes offer the seller an "earnout," or contingent payments, which is money set aside until certain performance targets are achieved by the seller. Careful consideration should be given to earnouts because some contingencies can quickly turn into golden handcuffs.

Between the nation's growing population and rapid urbanization, the need to identify and create new water sources continues to grow. This will continue to drive the private sector's interest in the water and wastewater treatment market, particularly because water utilities are viewed as low-risk investments with consistent demand. Ultimately, privatization and consolidation of water assets can offer communities and investors improved efficiency, financial stability, and greater sustainability. ■

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About The Author

Christopher J. Mackin, CFP, is a partner at Bleakley Financial Group, where he and his sister, Michelle, are teamed up to provide wealth management strategies to owners of environmentally conscious businesses. Christopher is a Registered Investment Advisor and holds a certificate in Retirement Planning from The Wharton School and a BA in economics from Rutgers University.

How To Truly Eradicate PFAS From Our Drinking Water

As so-called "forever chemicals" get more attention from regulators and the public at large, the pressure is on to eliminate these pervasive contaminants — forever.

By Amy Dindal

America's problem with perfluoroalkyl and polyfluoroalkyl substances, or PFAS, is deep and multifaceted, and there is an urgent need for innovative solutions to PFAS in our society, even as the country waits for the U.S. EPA to determine a regulatory framework. Battelle researchers and scientists have been studying PFAS for years and we continue to invest millions of dollars into progressing the technical assessment, degradation, and destruction of these persistent substances.

Since they were first introduced in the 1940s, the unique physical and chemical properties of these chemicals have made them ubiquitous, as they are especially useful for making consumer products that resist heat, oil, stains, grease, and water. PFAS molecules are made up of a chain of carbon and fluorine atoms linked together — one of the strongest bonds that can be made in organic chemistry — and because of their enduring nature and widespread use, PFAS have accumulated everywhere. They are in soil, surface water, the atmosphere, the ocean, food, humans, and much more, which is why they've earned the nickname "forever chemicals."

More research is needed to fully understand the health impacts of PFAS exposure but according to the EPA,[1] studies show that exposure to PFAS at certain levels can lead to infertility risks, thyroid disease, certain types of cancers, and developmental problems in adolescents. This has led to growing concerns about the amount of PFAS currently in our drinking water. In a 2016 study,[2] Harvard University researchers found that drinking water supplies serving more than 6 million Americans contain unsafe levels of PFAS, and in 2019, the nonprofit organization Environmental Working Group (EWG) published research[3] that indicates PFAS are likely detectable in all of the nation's major water supplies.

To take action toward reducing PFAS in our water supply, the EPA announced in October that it will set federal drinking water standards in the next two years for two of the most widely studied PFAS chemicals — PFOA and PFOS — and it will require chemical manufacturers to test and publicly report the amount of PFAS contained in the products they make. The EPA also intends to implement measures to prevent the release of PFAS into the environment and expedite the cleanup and disposal of the chemicals at military and industrial sites. The bipartisan infrastructure package, passed in November, includes roughly $10 billion in funding to address PFAS contamination.

Meanwhile, individual states are beginning to move forward with their own PFAS oversight and regulations. Michigan Gov. Gretchen Whitmer recently announced plans to substantially limit the state's purchase of products made with toxic PFAS chemicals, and environmental groups in Wisconsin are lobbying for interim tests and regulations while the EPA determines the new federal rules. New Jersey has been at the forefront of state regulation — in 2018, it became the first state to establish a drinking water standard for a PFAS chemical when it set a maximum contaminant level for PFNA at 13 parts per trillion (ppt). The state also currently enforces limits of 14 ppt for PFOA.

Getting PFAS Out Of Our Water

There are currently several ways to remove PFAS from drinking water, including treatment with activated carbon, ion exchange resins, or high-pressure membranes. Filtering water through tanks containing granular activated carbon (GAC) is the most common practice. As the water passes through the tanks, PFAS stick to the tiny pieces of GAC, which are an effective adsorbent because they are a highly porous material that provides a large surface area. The filtered water is dispensed at the outlet of the GAC tanks, along with the spent GAC that must be removed. There are GAC systems at water treatment facilities across the U.S., but one of the challenges of this approach is that the spent GAC[4] must be heated to 1,300°F in an oxygen-free environment to be reactivated.

When PFAS needs to be removed quickly, water can be treated with powder activated carbon (PAC), which is added directly into rapid mix tanks. The PFAS adhere to the powdered carbon as the water passes through; however, just like GAC, the remaining sludge that contains adsorbed PFAS must be properly disposed.

Single-use treatment with positively charged anion exchange resins (AER) is also effective for removing negatively charged contaminants such as PFAS. Small beads made of hydrocarbons work like tiny powerful magnets, attracting and holding PFAS to them to filter the water being treated. The remaining resin is then incinerated rather than regenerated, which means there is no contaminant waste stream to handle, treat, or dispose. The downside is that AER treatment can be quite costly.

GAC and single-use ion exchange treatment technologies effectively extract PFAS from drinking water, but only achieve temporary decontamination and generate problematic secondary waste composed of the adsorption material and concentrated PFAS. This waste must be hauled away to be incinerated or disposed of in a hazardous waste landfill. In addition, these types of removal methods simply transfer PFAS from one media to another, so they're ultimately just recirculating PFAS in the environment.

Another option for treating water is to filter it through high-pressure membranes, such as nanofiltration or reverse osmosis, which are both extremely effective at removing PFAS. Approximately 80 percent of the water coming into either a nanofiltration or reverse osmosis membrane passes through it, leaving around 20 percent as a high-strength concentrated waste. But because the remaining waste can be difficult to treat or dispose, the EPA believes this approach makes the most sense as point-of-use technology for a homeowner, as the volume of water being treated would be much smaller and the high-strength concentrated waste stream would be much more manageable.

Going Beyond Removal To Total Destruction

Given the persistent properties and potential health risks of PFAS, there is a critical need for innovative technologies that can destroy these substances in contaminated media without transferring them elsewhere or creating harmful byproducts. Battelle has been conducting comprehensive PFAS research for many years and has pioneered numerous assessment and mitigation solutions, including a new, onsite PFAS destruction technology that will permanently close the loop on PFAS decontamination.

This groundbreaking innovation is powered by supercritical water oxidation (SCWO), which breaks the strong carbon-fluorine bonds within PFAS molecules and decomposes the material into a non-toxic waste stream. Water above a temperature of 705°F and pressure of 221.1 bar is considered "supercritical," a special state that accelerates certain chemical oxidation processes. For example, organic compounds are usually insoluble in liquid water but become highly soluble in supercritical water. And when an oxidizing agent is present, supercritical water dissolves and oxidizes various hazardous organic pollutants.

Battelle's PFAS Annihilator[5] system is housed in mobile units that can be deployed to address onsite destruction needs. The technology obliterates PFAS in contaminated water to undetectable levels in seconds, leaving only inert salts and PFAS-free water behind. Once the treated water has been tested to confirm that the PFAS have been eradicated, it can be safely discharged back into the environment. In addition to reducing liability, destroying PFAS to the lowest levels of detection also eliminates the possibility of non-compliance with any future federal regulatory limits.

Regardless of what federal regulations and policies are in the pipeline, development of effective, economically viable destruction technologies is the only way to truly extinguish the threats PFAS potentially pose to human health, and Battelle and others are working to bring these permanent solutions to life. In December 2020, the EPA issued interim guidance[6] on suggested technologies for PFAS management, and mechanochemical degradation,[7] supercritical water oxidation,[8] electrochemical oxidation,[9] and pyrolysis and gasification[10] were called out as promising destruction solutions that merit further research and analysis.

Wiping out these resilient and pervasive substances won't be easy, but with the help of science, it can and will be done. ■

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About The Author

Amy Dindal is the PFAS Program Manager for Battelle.

PRESSURE TRANSIENTS AND WATER CONSERVATION IN A TIME OF DROUGHT

BY JAMES DUNNING

With water supply at a premium and pipelines deteriorating, drinking water utilities must do all they can to preserve their existing assets.

"The clouds appeared and went away, and in a while they did not try anymore."

-John Steinbeck, The Grapes of Wrath

Steinbeck may have been writing of the miseries of the Depression-era Oklahoma Dust Bowl, but the challenges of drought are anything but historical for many. With areas of the western U.S. registering "D4 – Exceptional Drought",[1] pending federally mandated allocations from Lake Mead are potentially but one example of a new reality for a region so heavily dependent upon agriculture and water availability.

For the water utility, of course, the challenges of continuing drought are myriad, including negative impacts on quality, increased demand, and, ultimately, loss of supply. Add to that the aging and consequently decaying state of water supply pipeline infrastructure and the challenges are truly multidimensional.

Now, none of those challenges are news to anyone in the sector. Indeed, books could and have been written on the causes, impacts, and multiplicity of responses to them. What is new, however, is the critical role that pressure transient identification and mitigation can now play. Within an expanding portfolio of solutions, data-led insights and proactive management are increasingly the equal partners of reaction-oriented event management. And within that, pressure transient management has a key role to play to extend pipeline lifetimes and reduce leakage and burst rates to preserve water.

Pressure Transients

Pressure transient events are variations in pressures caused by fast changes in flow. On a calm supply network, flow variations are typically small, resulting in small pressure transient events. However, not all networks are calm and large flow changes, both positive and negative, can lead to both vacuums (column separation), risking foul water ingress, and over-pressure events[2] accelerating pipeline failures. In the more extreme scenarios, pipe breaks or collapse can occur, costing the water utility hundreds of thousands of dollars in repairs.[3,4]

Typical causes of large and fast flow changes, and hence large transient events, found on water networks include aggressive pump starts and stops (see Figure 1).

Other causes include fast valve opening and closing operations, unstable pressure-reducing valves (PRVs), non-return valves slamming shut, pipeline bursts, water theft, and poorly controlled use by large industrial customers.

Non-return valves are a good example to examine in a little more detail as their sudden closure (when not operating correctly) can result in very large positive pressure events. A non-return valve is a type of valve which allows flow in only one direction and prevents flow in the opposite direction, also known as backflow. In normal conditions, the non-return valves remain open in the intended direction of the flow and then closes as soon as reverse flow starts. In these conditions, backflow does not gain momentum and there is no water hammer event. In contrast, however, a faulty non-return valve with worn hinges or debris inside can be slow to close, allowing the reverse flow to be generated. That backflow then catches the non-return valve, slamming it shut to create a significant water hammer, which can either cause both reduction in asset life (pipeline fatigue) or even immediate failure.

As water hammers could unintentionally appear in a supply network, designs typically allow for a small excess in pressure, but they are not designed to withstand a constant fatigue overload. Add to that aging pipeline material and corrosion, and the ability of those pipelines to withstand transients diminishes further.

The challenge previously, of course, has been to be able to monitor at a sufficiently high resolution — first to confirm that transients are occurring, and then to trace their origin. Fortunately, with advancements in both sensor and battery technologies, such monitoring is possible and cost effective, and not just on a limited survey basis but across utilities. Furthermore, the more monitoring that has been undertaken, the more it has become apparent that network operations, including transients, are themselves a significant cause of leaks and bursts.

So what to do to reduce those transients and, in turn, reduce leaks and bursts? That is where "network calming" comes in.

Network Calming

Network calming is a technique applied by water utility companies to reduce fatigue in pressurized network pipes by mitigating the number and/or magnitude of transient events in their pipeline system. The results are asset lifetime extension, financial savings, and water loss reduction.

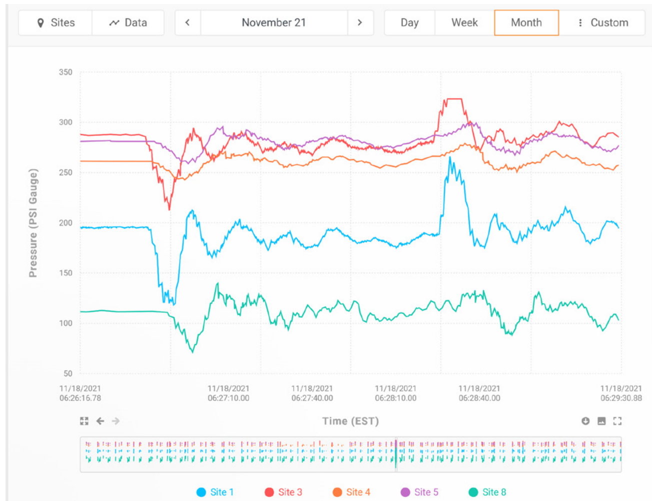

Figure 1: Transient event due to pump stops

As water hammers could unintentionally appear in a supply network, designs typically allow for a small excess in pressure, but they are not designed to withstand a constant fatigue overload.

To perform network calming, it is necessary to monitor with devices able to detect pressure transients in the network. Traditional pressure loggers only sample at a low rate, typically one sample per 15 minutes, and as a result completely miss transient events, which can travel along a pipe at 1,000 yards per second and faster. To capture pressure transient events, a more advanced pressure monitor is needed to continuously monitor pressure at a high sample rate. Such devices are typically sold as pressure transient monitors.

Network calming can be divided in three steps: deployment, source identification, and mitigation.

The first step in the application of network calming is to correctly identify the area or areas of interest to deploy the transient loggers or units, also known as deployment planning. To optimize deployment planning, and so maximize the likelihood of finding transients in an area, two things should be considered: a high break density area and possible sources of transients. To determine high break areas, a historic analysis of breaks in the area can be run. Usually, breaks' locations are logged into a GIS software and a heatmap is created. Those areas with the highest break concentrations will light up in a darker color. After identifying the area, it is also important to verify whether there are transient sources nearby. Some examples of transient sources are pump or booster stations, unstable PRVs or regulator stations, large customers drawing significant quantities of water (usually found in industrial states), or even water theft. An example of a deployment can be seen in Figure 2.

Once high-risk areas are identified and units are deployed, the next step is to determine the source of significant transients detected by the units. It is possible to detect the source of a transient event by using the time at which a transient was detected by two or more devices (see Figure 3) and the distance between the units (following the pipeline). This process is called triangulation. If the source of a transient event is coming from a station with several assets such as several pairs of pumps, overlaying the transient arrival time with SCADA activity would help the user to identify the specific asset causing the surge more easily.

The final step in network calming is to mitigate the transient. Once the source of a transient is identified, several methods can be applied to guarantee the mitigation of the surge, depending on what is causing it. As one of the most common sources of transients is valve operation, it is important to have slow valve closure protocols in place, either manual or mechanical. Another source is pump activity, which can be calmed by installing variable speed drives (VFDs), which allows pumps to start and stop more gradually, reducing the rate of change of flow and minimizing the transient. When slower operations are still not enough due to the way the network operates, additional assets such as surge tanks can be installed outside a pump station after the check valves. These serve as a "cushion" by absorbing excessive pressures generated by pump activity. Some other alternatives are air valves, pressure relief valves, or bypass pipes.[5]

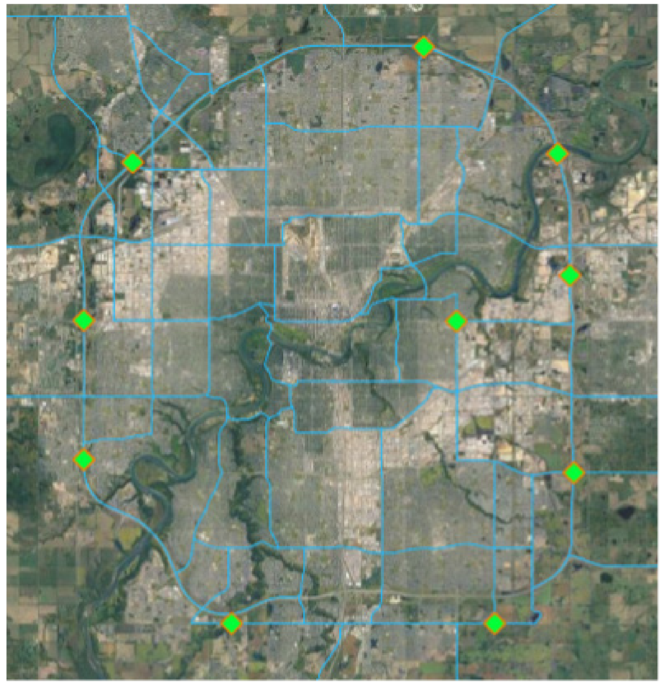

Figure 2: Example of deployment of transient loggers on a city network. The pipe network is in blue.

Figure 3: Example of triangulation. The red flag indicates source of the event.

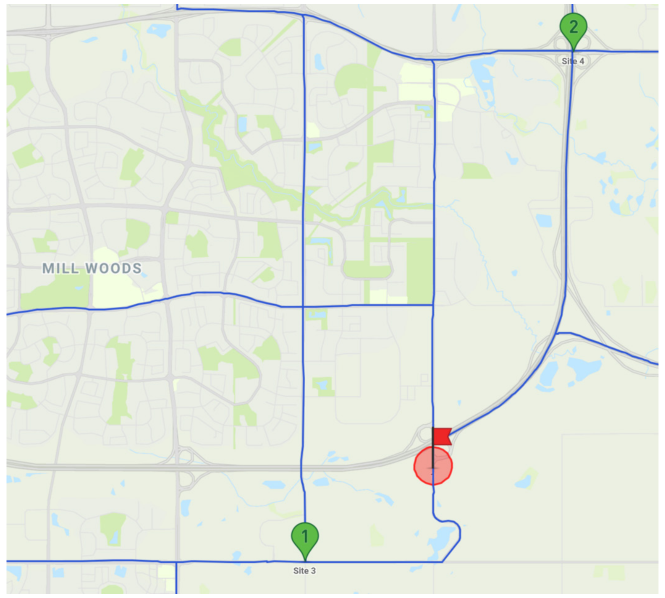

Figure 4: Break event triangulation (NB fictional location)

Network calming can be done on a short-term or long-term basis, depending on the goal of a project. Short-term network calming focuses on moving a batch of transient loggers from one area of interest into another in a short period of time. This technique specializes in looking for specific transient events that the user believes are occurring, or understanding what events are currently happening in the network. As an example, if a high break density area is detected near a pump station, it is possible that the station might be contributing to the breaks, producing a significant number of transients of considerable magnitude. To confirm this, transient loggers may be deployed and triangulations carried out should any transients be detected to confirm their source. Similarly, if high water demand is detected by one or more flow meters in the network near an industrial state, transient loggers may be used to triangulate the feed of a specific client in that industrial state.

Long-term network calming, on the other hand, focuses on leaving loggers in a location for a long time to understand seasonal changes or to permanently monitor a vulnerable asset and detect break events as soon as they happen. An example of long-term monitoring is the detection of transient activity coming from a pump or booster that operates only during a set time of the year to support the network, or how assets nearby respond to its operation.

Another long-term monitoring technique is the permanent monitoring for breaks (bursts). Break events are sudden major fractures in the pipe walls that lead to its partial or total division. Break events generate large and fast transient events, which can be detected by units and their sources identified using the triangulation technique mentioned previously. Detecting an alert about breaks reduces the response time of water utilities, saving money and water.

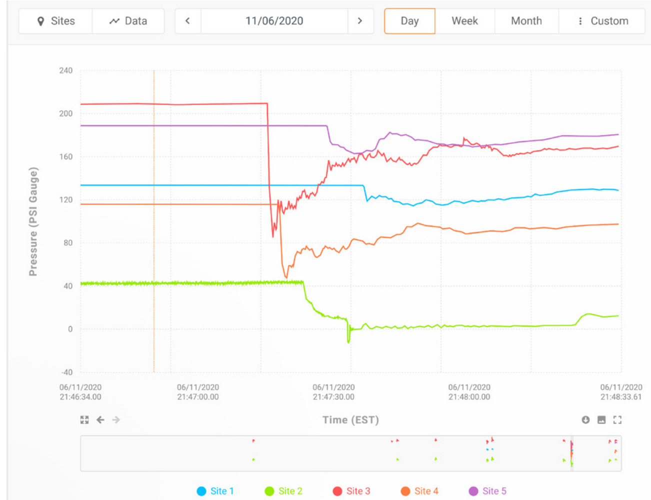

Figure 5: Transient generated as a result of the break event

Lake Mead and Lake Powell in the U.S. are currently at 39 percent capacity with a 66 percent chance Lake Mead will fall to the point where California will be required to impose even more extreme water conservation measures. As of November 2021, meanwhile, there had been 48,725 wildfires across the U.S., burning 6.5 million acres. The pressures on utilities to maintain standards of quality and supply are not going to reduce, regardless of the factors weighing down upon them. This article is, of course, also only focusing on one element of the strategies that can be deployed in addressing those challenges. With high-resolution data now increasingly available for monitoring water supply pipelines, however, utilities now have the opportunity to understand and address those challenges actively rather than reactively. With that, they have the opportunity to make new inroads into reducing leaks and bursts on their networks and extend the life of their already aging networks. ■

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About The Author

With more than 25 years of experience in the utility sector, James Dunning joined Syrinix as CEO in 2010, leading its growth as an award-winning global market leader in providing high-resolution, data-led insights for water utility networks. Prior to Syrinix, James served as a City lawyer and graduate of the London Business School, as well as holding senior positions within the corporate utility sphere and as a successful entrepreneur in the renewable sector.

State-Of-The-Art Wastewater Analysis Systems Will Be Key To Guarding Public Health In The Future

Wastewater is suddenly an important source for data and insight for solving problems beyond the scope of traditional water management.

By Ari Goldfarb

COVID-19 unleashed the worst public health crisis of our lifetimes, but it also revealed some of our strongest heroes and assets.

Much-deserved praise has gone to healthcare workers, vaccine scientists, and the supply chain employees who helped the world operate through the coronavirus lockdown.

But one powerful aid has attracted far less attention. It is the key piece of infrastructure that has helped to detect, track down, and prepare for the next outbreak of the deadly virus. What's more, it could play a vital role in preventing such a crisis from happening again.

Sewers: Our Secret Weapon

Though wastewater infrastructure has traditionally been invisible — we usually don't think about it because it just works — utilities have turned it into a key tool to combat the pandemic. New technologies have allowed utility workers and scientists to map and predict the spread of COVID-19 across more than 50 countries, 200 universities, and 1,000 locations, all through advanced wastewater analytics.

Engineers and public health scientists have concluded advanced wastewater technology can help protect us from the next contagion as well as keep track of other serious public health concerns. The technology already is being used to track down and stop industrial polluters, drug traffickers, and environmental disasters in rivers and oceans.

It all points to the urgent need to upgrade wastewater testing and analysis systems with state-of-the-art technology. This upgrade needs to be a top priority for policymakers to make spending decisions as part of the $1.2 trillion infrastructure legislation recently signed into law by President Biden.

Tech achievements with wastewater during the coronavirus pandemic have been remarkable.

One automated wastewater testing system found nearly 85 percent of all COVID cases on a San Diego college campus. The technology was powerful enough to detect a single infected, asymptomatic person in a dorm — up to three days before individual testing could yield clear results.

An airline used wastewater testing to find COVID in passengers on international flights arriving in Dubai. Early-warning systems via wastewater also helped detect numerous asymptomatic cases in Hong Kong. In Florida, health researchers say wastewater monitoring has revealed COVID surges in prisons and nursing homes four to six days before any uptick in case reports or hospitalizations.

There's a good argument that the use of wastewater-based epidemiology, or WBE, provides the most accurate picture of a community's COVID status.

About 30 percent of all people with COVID are asymptomatic and typically not tested. They can spread the sickness without knowing it.

Though many people don't get tested, they all go to the bathroom. In wastewater, engineers can track COVID from both symptomatic and asymptomatic people.

As an early warning tool, wastewater-based epidemiology has helped public health officials isolate the infected and prepare hospitals for surges of sick hospital patients by stocking up on medicines and ventilators.

Wastewater Surveillance Beyond COVID

In Israel, health officials found and contained an outbreak of polio in 2013-2014 via wastewater monitoring. By investigating the molecular composition of the virus found in local sewage, scientists concluded that the virus came from Pakistan, then spread into Israel, Egypt, and Syria.

Years before coronavirus, scientists learned from wastewater in the Middle East a crucial public health lesson: even the most heavily protected political borders are open to the spread of disease.

Law enforcement has also taken notice of the revealing details in wastewater. Scientists in the U.S., Belgium, Germany, the Netherlands, and Spain have monitored sewage to track the use of illegal drugs, including opioids, cocaine, and methamphetamines. In China, officials used wastewater analysis to track down and arrest drug manufacturers.

By monitoring drug levels in wastewater, Chinese officials concluded that methamphetamine use dropped by 42 percent and ketamine use decreased by 67 percent after major law enforcement crackdowns.

Adding smart technologies to wastewater treatment generally adds 2 to 5 percent to the overall price of infrastructure, but those investments more than pay for themselves through improved public health.

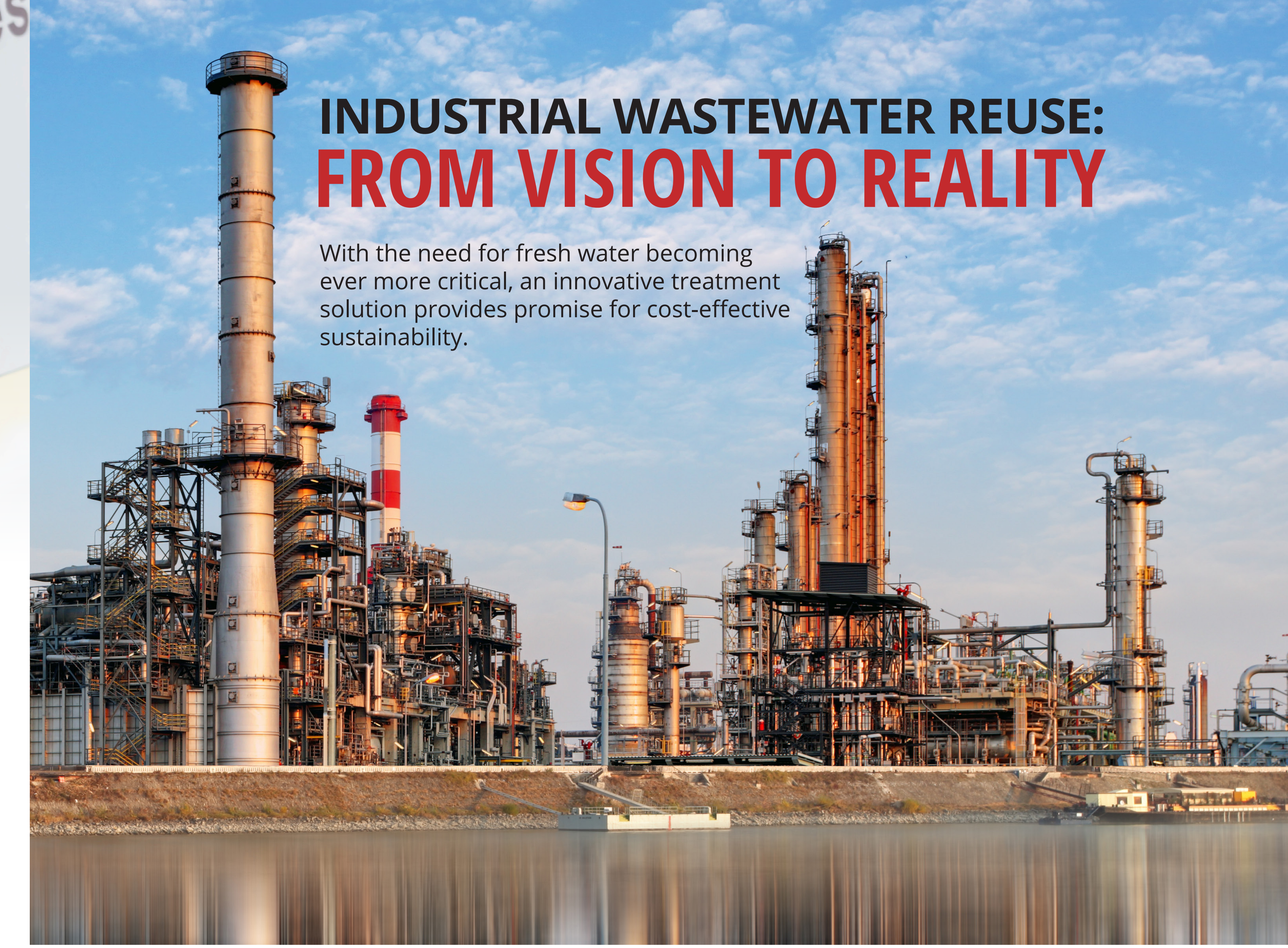
COVID wasn't the first pandemic, and it won't be the last. One lesson we should learn from this lockdown is that wastewater monitoring can help prevent and mitigate the next public health crisis. ■

About The Author

Ari Goldfarb is CEO of Kando, an Israel-based company providing data-driven wastewater management solutions to help cities worldwide keep rivers and oceans cleaner while stimulating the reuse of water.

INDUSTRIAL WASTEWATER REUSE: FROM VISION TO REALITY

With the need for fresh water becoming ever more critical, an innovative treatment solution provides promise for cost-effective sustainability.



By Matan Alper

Water is a precious commodity that was once available almost free of cost. Unfortunately, this is no longer the case and water for industrial use has become costly and scarce.

Water is used for multiple purposes in all industries, and the vast amount of it ends up as industrial wastewater. There are several options for effluent disposal, some of which are direct surface discharge, evaporation ponds, deep well injections, discharge to a local wastewater treatment plant, and so on. However, all these solutions are costly and do not add any value to the plant's operation.

Three main forces drive industries to search for new water treatment approaches and technologies — the cost and availability of fresh water to be used in the industry, the cost of effluent disposal, and the need to comply with stricter environmental regulations governing the discharge of industrial effluents.

These factors have made it critical for industries to look for and implement technologies to reduce the amount of fresh water withdrawn from natural sources by increasing wastewater reclaim, reducing effluent discharged to the environment, and cutting the operational costs associated with water treatment, while complying with regulations. As a result, there is a growing need for cost-effective solutions that maximize effluent treatment recovery and reuse of water in industrial facilities, while minimizing disposal costs.

Existing conventional water treatment solutions struggle to provide a satisfactory answer to these water challenges. One of the industry's most significant barriers in addressing the growing water challenges is that the industrial effluents are typically characterized by very challenging water chemistries. This complex chemistry limits the ability to reach high recovery and maximized reuse due to the risk of scaling, fouling, and biofouling. Therefore, new technological approaches and out-of-the-box thinking are required to develop new, cost-effective solutions that can push industrial water reuse to its limit, thus solving many of the industry's water challenges.

Pulse Flow RO vs. Traditional Reverse Osmosis (RO)

The key to reaching high water recovery and reuse of water is implementing cutting-edge treatment technologies that can handle challenging water chemistries. Conventional industrial water treatment solutions can be OPEX-intensive and often fail to minimize the amount of effluent for disposal. In addition, the conventional water treatment solution, and more so the RO part of it, hasn't changed much over the previous few decades. This typically includes two to four stages of RO, operating at continuous and fixed hydraulic conditions, and is accompanied by frequent clean-in-place (CIP) and maintenance work, which is OPEX-intensive.

Pulse flow reverse osmosis (PFRO) technology is a new, innovative method for operating reverse osmosis water reuse systems that enable high recovery, high flux, and low OPEX. It works by constantly changing the osmotic and hydraulic conditions so that biofouling and scaling are greatly diminished.

Contrary to the standard multistage RO process, PFRO discharges the brine flow periodically, in a pulse flow process with short production cycles. At the end of each cycle the brine is discharged at high velocity for a short time. This enables the system to operate with very high recovery and reduced scaling potential by taking advantage of the ability to operate in short production cycles. The production cycle is shorter than the induction time of the sparingly soluble salts existing in the brine stream, therefore there is no risk for scale formation. In other words, a shorter production cycle facilitates higher recovery.

The Pulse Flow RO Method

PFRO operates in two steps: production and flushing.

During production, the brine valve closes and stops brine from being discharged. This results in 100 percent of the feed flow passing to the permeate side, or in other words, dead-end filtration.

During flushing, the brine valve is opened for a short period of time, enabling brine to discharge at a high velocity. This creates a high shear force of short and rapid pulses.

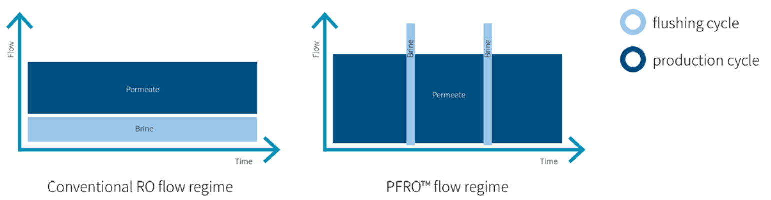


Figure 1. Conventional RO flow regime vs. pulse flow RO flow regime

PFRO does not deviate from standard membrane operating processes and is fully covered by membrane manufacturers' warranties.

In a commercial-size RO train, production and flushing cycles are distributed among the pressure vessels in such a way that, in total, the feed, permeate, and brine flows are almost constant over time. The pressure vessels (PVs) are divided into groups. Each group has a single brine valve that periodically opens and closes. This way, only a small fraction of the PVs is in a flushing mode at any given time, enabling the high-pressure pump to operate in a stable working manner.

All vessels — both in production mode and in flushing mode — continuously produce permeate, and all pressure vessels receive feed flow from the high-pressure pump, in parallel. The total dissolved solids (TDS) levels of the feed streams do not change inside the first membrane of the pressure vessel, and variations increase at its end.

Unlike the conventional multistage RO train approach, the pulse flow RO is a single-stage RO train designed for any recovery (see Figure 2).

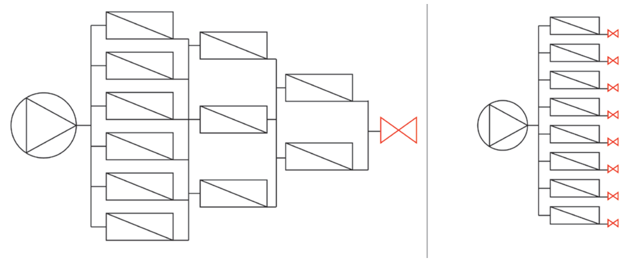


Figure 2. RO train structure — traditional (left), PRFO (right)

Conventional RO design includes multiple stages to maintain the required minimal brine flow in the last membrane of the pressure vessel. This multistage design includes some drawbacks compared to the PFRO configuration:

- Pressure drop (PD) during each stage is usually 1 to 1.5 bars (15 to 23 psi), resulting in a total PD of about 3 to 4.5 bars (44 to 66 psi) — causing increased power consumption.
- Flux decreases during the second and third stages, requiring additional pressure vessels and membranes or installation of booster pumps — causing increased CAPEX.
- Complicated interstage piping — causing increased CAPEX.

Case Study: BWRO Concentrate Minimization (Abilene, TX)

The Abilene Hargesheimer Water Treatment Plant receives water from a lake and desalinates via a three-stage brackish water RO (BWRO) process with a recovery rate of 80 percent. The brine flows into evaporation ponds. Due to the limited size of the existing brine ponds, the RO brine amount is reduced by an enhanced evaporation system involving sprayed water (turbo misters). This creates an environmental nuisance to the nearby residents due to convection of salt droplets by the wind.

Further desalination to reach higher recovery using conventional RO is not possible, due to the high calcium sulfate, calcium carbonate, and barium sulfate supersaturation. The goal set in the case study demo was to use PFRO technology to achieve an additional 80 percent recovery over the rejected brine from the conventional RO, to reach an overall recovery of 96 percent.

Overview Of The Demonstration System

The PFRO demonstration plant in Abilene, TX, was composed of two 8" pressure vessels in series, each with 4 x Dow FILMTEC™

Abilene Hargesheimer Water Treatment Plant

SW30-XLE-400 membrane elements in a single-stage operation. Feed water quality is shown in Table 1.

The unit operated with an average flux of 8.8 gfd (15 LMH) and with an 80 percent recovery in a single RO stage. The specific flux was ~0.040 gfd/psi.

The rejected brine from the existing RO includes calcium sulfate and calcium carbonate in supersaturation concentrations, such that it could not be further used by a standard RO process since the water is "out of range" for the software of the antiscalant manufacturers.

Results And Discussion

The demo unit at the BWRO desalination facility at Abilene was in operation from March to June 2021. The PFRO system managed to achieve an additional 80 percent recovery on top of the existing 80 percent of the BWRO system, reaching a total recovery of 96 percent. In practice, this means that the brine for disposal was reduced by 80 percent and additional fresh water was produced for reuse. All the operating parameters (specific flux, head loss, and permeate conductivity) showed very stable performance. This indicates that there was no accumulation of scaling or fouling. The system operated as part of the 2,000 hours acceptance test.

Conclusion

The pressure is on to relieve the strain on natural resources, reduce operational costs in the industry, and minimize effluent disposal. As water for industrial applications becomes less readily accessible, the industry must look for ways to recycle and reuse treated water.

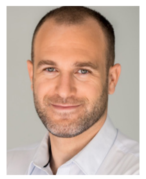
Reverse osmosis membranes are subject to scaling, fouling, and biofouling by dissolved and suspended substances that are present in industrial effluents. However, standard RO systems do not maximize recovery due to those challenges of complex industrial water chemistry. Innovative industrial water treatment technologies make it economically feasible to convert different types of industrial wastewater back into usable water for processes, making this treated water an asset again, rather than a potential financial and environmental liability.

Analyte	Units	Contract
Barium	ppm	0.84
Boron	ppm	0.3
Calcium	ppm	569
Magnesium	ppm	327
Potassium	ppm	52.2
Sodium	ppm	477
Chloride	ppm	972
Fluoride	ppm	1.7
Nitrogen, Nitrate (As N)	ppm	0.6
Sulfate	ppm	1790
Total Dissolved Solids (Residue, Filterable)	ppm	5000
Alkalinity, Bicarbonate (As CaCO3)	ppm	756

Table 1. Analysis of feed water into pulse flow RO

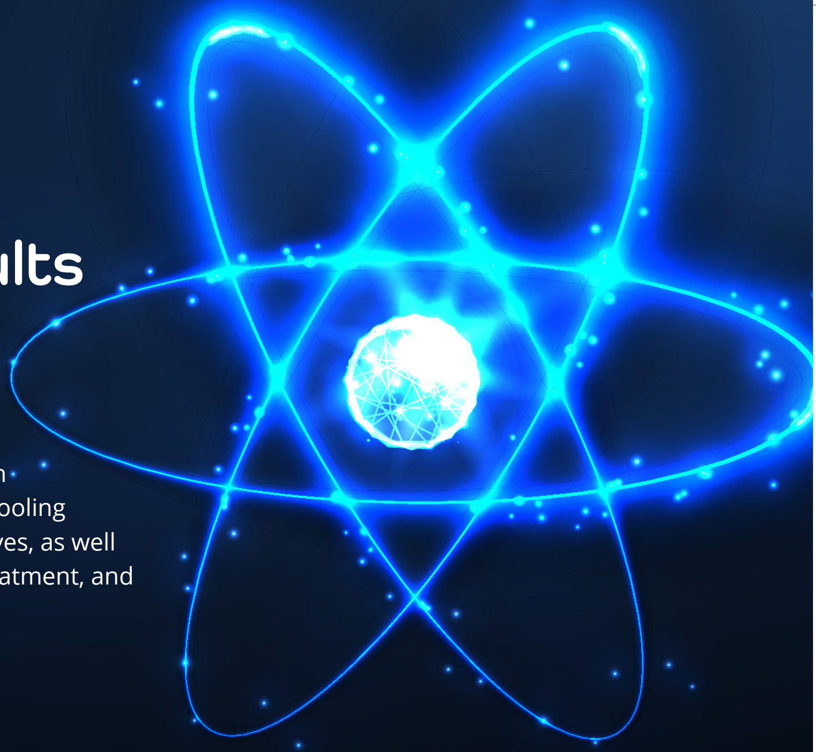
The PFRO solution for industrial wastewater treatment overcomes the challenging limits mentioned above, thus providing added value in the form of substantially lower disposal costs, recovery of additional clean water for reuse, and, if needed, a smaller downstream thermal zero liquid discharge (ZLD) system, resulting in lower CAPEX and OPEX. ■

About The Author



Matan Alper holds a B.Sc. in chemical engineering (summa cum laude) from the Technion – Israel Institute of Technology and an MBA from Tel Aviv University, where he specialized in strategy and entrepreneurship. Matan started at IDE Technologies in 2019 as a business development and product manager, and today, Matan is heading the industrial water business unit of the company.

A New Spin On An Old Technology Yields Surprising Results



A new advanced oxidation process has been born from a quest to find a more sustainable disinfection option for high water consumption applications, revolutionizing cooling water treatment and other operations with similar objectives, as well as entirely different fields like aquaculture, wastewater treatment, and animal drinking water applications.

By Daniel E. Gruenberg and Emma Flanagan

Oxygen is one of the most abundant elements found in nature, and living organisms need it as they oxidize nutrients to obtain energy for growth. Normal atmospheric oxygen, which makes up 21 percent of the air we breathe (O_2), is known as the ground state as it's the lowest energy level of the oxygen molecule. This atmospheric oxygen is also named by its electron configuration called triplet oxygen (see Figure 1). The O_2 molecule is unique in that it has two unpaired electrons found in separate orbitals, but each with the same spin, making oxygen one of the few magnetic gases. The Pauli exclusion principle requires that no two electrons occupying the same orbit can have the same quantum state, so each electron in the same orbital must have the opposite spin.

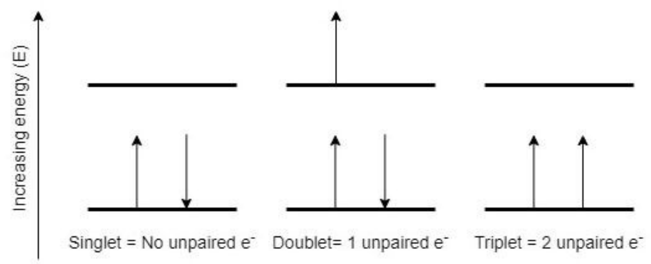


Figure 1. The three energy levels of oxygen

A flip of an electron spin in the outermost layer of the molecule will result in an excited singlet state oxygen ($^1O_2$), a potent oxidant very efficient in the inactivation of pathogens and the degradation of organic contaminants. In order for ground state triplet oxygen to become singlet oxygen, two things have to occur. Firstly, one of the 2p electrons must flip spin state, and secondly, it has to move from the Pz orbital to the Px orbital. These actions are typically induced by a photosensitizer molecule reacting with ground state oxygen ($^3O_2$). In Figure 2, ground-state oxygen is shown with orbitals Px on the left side and Pz on the right, with the same spin on the outermost level. The singlet oxygen is represented after the electron on the ground state's right-side orbital (Pz) had changed spin direction and paired with the electron on the left side orbital (Px).

An illustration depicting the orientation of the orbitals in geometrical molecular space is shown in Figure 3. Each orbital occupies two mirror lobe shapes. Px orbital is oriented along the x-axis, Py orbital is oriented along the y-axis, whereas Pz orbital is oriented along the z-axis.

The triplet and singlet oxygen spin layout is shown in Figures 4 and 5. The images show triplet and singlet states oxygen electrons in their 2px and 2pz, outermost orbitals.

Singlet oxygen is a powerful oxidizing agent, and it is very reactive and unstable. The half-life is less than 0.04 microseconds,

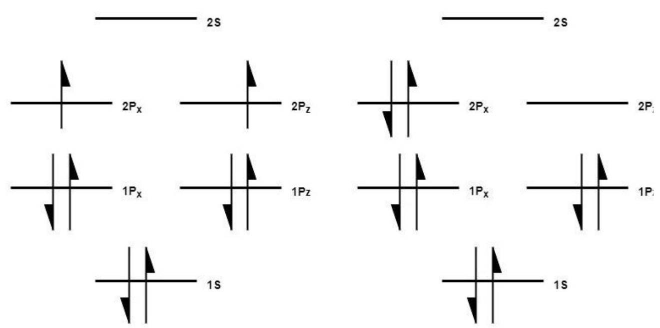


Figure 2. Orbital spins of triplet and singlet oxygen

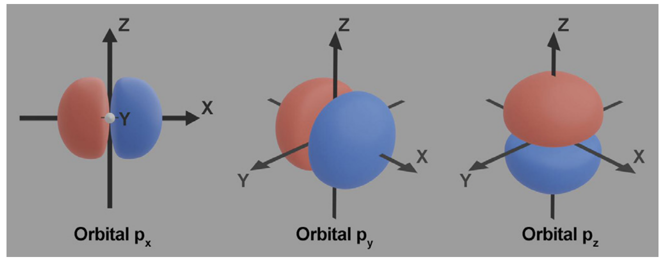
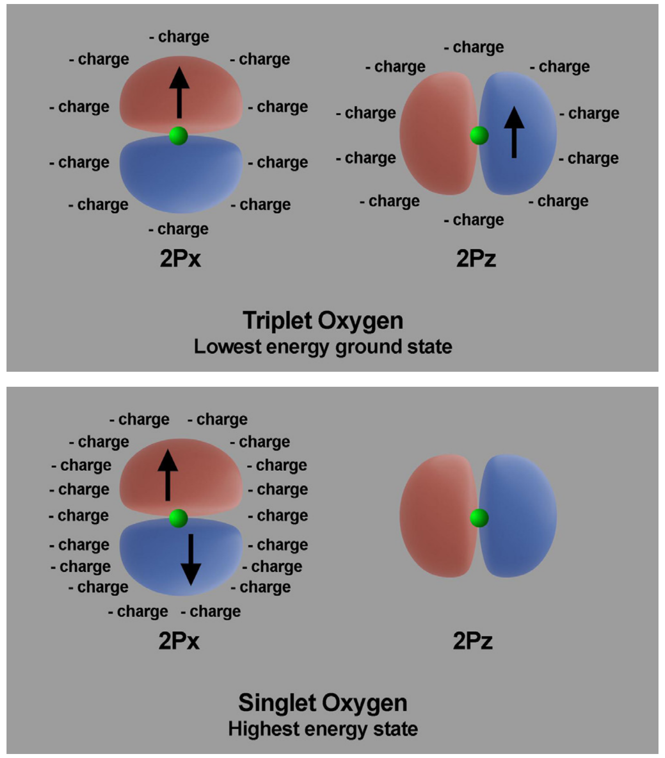


Figure 3. Orientation of the orbitals in molecular space



Figures 4 and 5. Arrangement of electric charges in ambient oxygen and in excited oxygen

but before it reverts to its triplet state, it produces other reactive molecules when it contacts water. The primary reactant is hydroxy radicals, but a complex slew of other reactive molecules is formed in water which, in turn, produce further oxidation reactions in aqueous solutions.

Singlet Oxygen Is Extremely Useful

Singlet oxygen is an historically interesting molecule. It was first identified in the 1930s, although many aspects of its chemistry have emanated from the work of Christopher S. Foote, an American chemist, who conducted experiments in the 1960s where evidence was obtained supporting $^1O_2$ generation via two independent routes, a photochemical reaction (dye-sensitized photooxidation), and a chemical reaction (NaOCl with H_2O_2). The biological importance of the singlet form as a reactive oxygen species (ROS) has only been discovered since the 1980s, and it plays diverse roles in photosynthesis, cytotoxicity, and oxidation of various biochemicals.

When oxygen-based oxidation is investigated, the mainstay ROS has been ozone, O_3. Ozone is not as reactive as singlet oxygen and it has low solubility in water, reducing to impractical levels above 40°C. Ozone is relatively easy to manufacture in small quantities, but the feasibility of commercial production comes with drawbacks when requiring large industrial amounts. Ozone can only achieve advanced oxidation with the addition of catalysts, UV, or less effectively with the assistance of pH adjustment. While some chemists have postulated about singlet oxygen's possible appeal, it has not yet been made commercially available. Its attractiveness stems from its reaction with water being an electrochemical reaction, so gas dissolution, which is difficult, and even impossible at higher temperatures with ozone, shifts the advantage in favor of singlet oxygen.

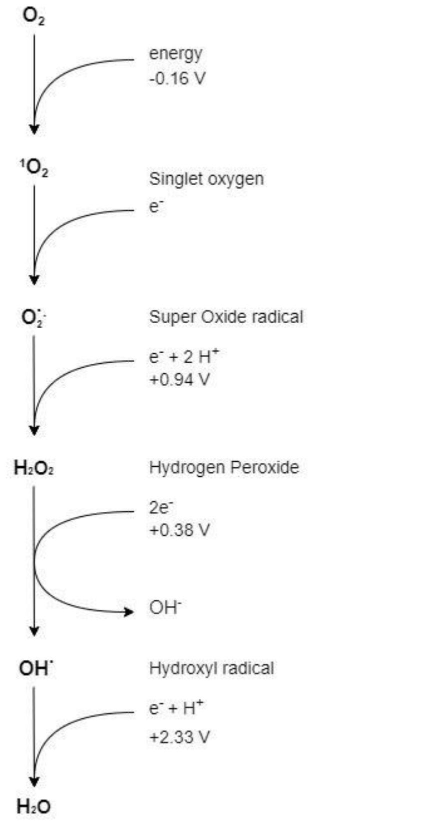


Figure 6. Reactive oxygen species derived from ambient oxygen

Let's examine the singlet oxygen molecule and then discuss the implications of the difference between ozone and singlet oxygen as an ROS in industrial applications.

Three main techniques have been used to produce the singlet state of oxygen:

- excitation in the singlet state through ultraviolet irradiation in the presence of photosensitizers
- chelation with transition metals
- specific chemical reactions that result, under controlled conditions, in the emission of singlet oxygen

Singlet oxygen is short-lived in water as it interacts with other molecules by combining with them and transferring its excitation energy. The oxygen then returns to the triplet state, whereas the molecule that the oxygen has interacted with becomes excited. It has an oxidation potential of 2.42 mV, and together with hydroxyl radical •OH, at an oxidation potential of 2.8 mV, is one of the two most oxidative reactive oxygen species. The hydroxyl radical, the telltale sign of an advanced oxidation process (AOP), is the most powerful but shortest-lived ROS in water treatment, and it helps break down most chemical contaminants because it is a very non-selective oxidizer. Singlet oxygen reacts quickly with water to form hydroxy radicals, peroxide, and other ROS. In gas form, singlet oxygen is less aggressive toward sensitive metals, polymers, and elastomers, so, for example, while Teflon tubing is required for ozone, polyurethane is sufficient for singlet oxygen.

We understand that three different mechanisms activate oxygen:

Absorbing energy: When the oxygen molecule absorbs enough energy and the spin is reversed, this change stimulates the oxygen to react with organic molecules in a way it could not before.
Gaining an additional electron: Oxygen can gain an extra electron (i.e., it is reduced) to form superoxide, which in turn produces hydrogen peroxide.
Gaining an oxygen atom: Oxygen can gain an extra oxygen atom to form ozone (O_3).

A New Force

Although various types of energy can be used to produce singlet oxygen and it has been more than 90 years since its discovery, efficient production in large quantities has not been made available in the industry. We report the first known large-scale production of singlet oxygen from the air as a practical solution in water treatment applications. Aquavative Technologies, Co., Ltd., a startup company based in Thailand, has innovated a hybrid photo/magneto-catalyst method to generate singlet oxygen from ambient air. Several pilot operations are underway, with a full range of applications requiring an effective AOP in the pipeline.

This new AOP is known as the Aquatron® process. It utilizes a proprietary hybrid magnetic/photonic nano-catalyst to affect the oxygen molecules in the incoming air and decrease the amount of photochemical energy necessary to convert it to singlet oxygen. While previous technologies have produced singlet oxygen in milligram (mg) quantities in the lab, now for the first time, large gram (g) or kilogram (Kg) quantities are available for industrial applications.

Singlet oxygen has several properties that make it interesting to apply in a broad range of applications. In cooling towers, hydroxyl radicals and singlet oxygen provide biocidal activity, biofilm removal, anti-scaling, and scale removal, as well as anti-corrosive properties. These applications include all areas that previously required the use of four or five different hazardous chemicals. When this new nano-catalytic process is coupled with a novel low-power electronic scale removal process, blowdown is no longer necessary. This saves water, and chiller efficiency is increased. Commercial applications for cooling towers have incorporated world-class Internet of Things (IoT)-based chiller efficiency and cooling tower (CT) efficiency monitoring, which is managed via Oracle's advanced cloud-based management system, Oracle Cloud Infrastructure (OCI). Monitoring with thermal probes has an accuracy of less than 0.01°C uncertainty, which is about 10x the accuracy of most industrial thermal probes. When coupled with flow and kW measurements, chiller efficiency and load (kW/Ton +/- 5 percent) can be recorded to the cloud in real time. This integrated system of data from the different devices and the applied analytics optimized management represents the first time the industry was able to get this kind of chiller load and efficiency monitoring that is low cost enough to use in almost any size system.

How Does This Innovation Compare To Other Technologies For ROS Generation?

Advanced oxidation processes have received close attention for the treatment of recalcitrant molecules that cannot be removed by traditional biological wastewater treatment processes. Legacy AOPs include techniques such as O_3/UV, H_2O_2/UV, Fenton (Fe^{+3}/H_2O_2), etc. The O_3/UV process requires extensive processing equipment to produce clean, dry, concentrated oxygen for supply to the ozone generator, which is notoriously picky and pesky to maintain. All the other AOPs require transport and the use of chemical inputs. Contrarily, hybrid magnetic/photonic devices produce industrial quantities of singlet oxygen from ambient air, and no chemical inputs are needed.

Advanced oxidation processes have received close attention for the treatment of recalcitrant molecules that cannot be removed by traditional biological wastewater treatment processes.

Large-scale industrial ozone generators require very clean, dry air (<-55°C dewpoint typically), which has the nitrogen removed in molecular sieves to obtain a very dry gas with about 90 to 95 percent oxygen, which feeds through a high voltage potential. Any moisture or other contaminants will result in sparks that destroy the generator's dielectric coating. Any engineer who has maintained ozone generators in industrial settings is well aware of the difficulties in managing ozone generators. The equipment to prepare the air for ozone production can cost as much as or more than the ozone generator itself.

Relative to the mineral oxychloride solution AOP reagent (MOCl), both AOPs have a very high yield of hydroxyl radicals. In contrast, MOCl employs chelation with transition minerals as the source of energy and can prolong and support the regeneration of (ROS) long after the point of activation without requiring external power at any point in the process. This self-catalytic continuation of AOP manifests a background chlorinated compound that accredits free chlorine residual as a viable method of monitoring mineral oxychloride implementations. When ambient air is catalyzed with magnetic/photonic energies, it produces singlet oxygen in the gas phase; however, with complete solubility in water, it will immediately convert to hydroxyl radicals. The mineral oxychloride AOP is implemented in the liquid phase from beginning to end. Both technologies support efficient monitoring with oxidation-reduction potential (ORP).

In addition to the obvious differences between magnetic forces and radiation requiring external energy source, and MOCl being a ready-to-use liquid chemical, we can say in simpler terms that both have comparable performances near the point of injection, while the mineral oxychloride treatment is at the same time more enduring, derived from a radical chain reaction that supports continuing regeneration of singlet oxygen and hydroxyl radicals. The continuing productivity of oxygen-based oxidants in water treated with MOCl is induced by the expendable oxidation energy from the mineral catalysts. This vibrational energy is readily available in solution, and when chlorine ions are present, they will form bonds with accessible dissolved oxygen and generate HOCl and OCl.

In drinking water, singlet oxygen allows for easy and effective removal of chemicals like endocrine-disrupting and pharmaceutical-active compounds, brominated hydrocarbons, and traces of personal care products, which can be very difficult to break down.

When considering which technology of generating singlet oxygen will be best suited for a particular application, one must examine the pros and cons of having prolonged oxidative reactivity supporting extended residual protection, along with the presence of chlorinated molecules supporting the option of free chlorine residual as monitoring control. Also important is evaluating whether a chemical OPEX is preferable, or if a larger CAPEX with lower running costs would be a better fit for your project.

Today, ozone is the most popular form of reactive oxygen sold worldwide, but singlet oxygen has many inherent advantages to ozone. Ozone's difficulties in producing large quantities, requiring complex equipment and its lack of solubility, which further drops at higher temperatures, is a major issue. High-concentration ozone (5 to 20 percent) is required for most processes to reach high ORPs, but these high-concentration generators are costly to purchase and operate and require expensive peripheral equipment. In contrast, singlet oxygen's reaction with water is an electrochemical process not affected by gas solubility. For these reasons, many customers are looking at new applications of this ROS, where ozone isn't currently competitive. Finally, the reactions of hydroxyl radicals are more efficient for many organic molecules relative to ozone-based oxidation.

What Else We Are Seeing

In shrimp hatcheries, an experiment was run on two influent water reservoirs, comparing traditional chlorination/thiosulphate deactivation with singlet oxygen treatment. Both reservoir sites showed complete eradication of thiosulfate-citrate-bile salts-sucrose (TCBS) strain-based vibrio counts. However, a significant difference was found in the TCBS counts of water samples from the larval rearing tanks downstream. In the post-chlorination downstream tanks, TCBS counts were 2-3 x 104 CFU/ml, whereas larval rearing tanks using water from singlet oxygen treated reservoirs showed only 1-2 x 103 CFU/ml, and about 20x fewer vibrio bacteria caused higher shrimp survival rates and minimal deformities compared to traditional chlorination.

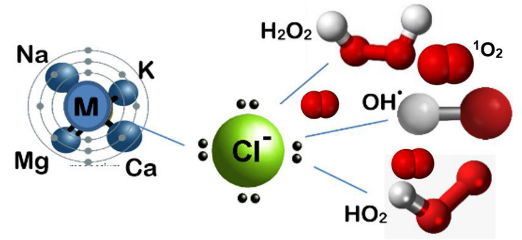


Figure 7. Proposed structures for mineral oxychloride advanced oxidation reagent, $M_xO_yCl_z$

Power plants have shown significant reduction of fuel consumption as well as reduction of chemicals and water consumption after the new proprietary hybrid nano-catalyst equipment has been installed to treat their cooling water.

In drinking water, singlet oxygen allows for easy and effective removal of chemicals like endocrine-disrupting and pharmaceutical-active compounds, brominated hydrocarbons, and traces of personal care products, which can be very difficult to break down. It has been successfully implemented in an innovative bottled drinking water with reduced cluster size and the clients love that their water tastes very good and feels more refreshing. The singlet oxygen treatment allows for cost-effective removal of trace contaminants and optimization of the quality of the water.

In animal drinking water systems, singlet oxygen's ability to not only disinfect with hydroxyl radicals, but its ability to attack biofilms in the water-distribution system make it an attractive option for broilers, layers, swine, and dairy operations. ■

About The Authors

Daniel E. Gruenberg, is the Chairman & CTO of Aquavative Technologies, Co., Ltd., a Thailand-based startup with focus on designing, installing, and monitoring of innovative water treatment solutions with goals of saving water, reducing chemical use, and producing "negawatts" by promoting efficiency through continuous monitoring of systems and heat exchange processes. Email: daniel@aquavative.com

Emma Flanagan is the CEO/CTO of Envirocleen, LLC, an Illinois water treatment chemical consulting company, manufacturer, and distributor of mineral oxychloride advanced oxidation reagent and quantum disinfection technologies. Email: emma@envirocleen.com

Industrial Automation Will Create A Future-Proof Industry

The arrow is pointing up for the water and wastewater industry, thanks to funding and technology advances, but certain work remains to ensure the promise is fulfilled.

By Louis Arone

The past year and a half have tested the patience of all industries, particularly the water and wastewater sectors. The recent bipartisan U.S. infrastructure bill took nearly three months after it passed the Senate to be approved by the House. And although the Infrastructure and Jobs Act was officially signed into law late last year, the industry is still anxiously waiting for further negotiations around the allotment of those and additional funds.

However, progress has been made, and many industry leaders remain hopeful for 2022 — with funding of $55 billion for the water infrastructure and $8 billion for the western United States' infrastructure specifically.[1] So exactly how will the bill's implementation support the industry this year and for years to come, as climate change and aging infrastructure continue to impact our existing systems?

The answer is creating sustainable and resilient infrastructures through industrial automation. Through funding and investment of software-driven digital transformation, we can make the promise of the infrastructure bill a reality for the water industry.

The Three-Step Journey For A Greener Future

There is a simple path to sustainability for the water and wastewater industry. Starting with industrial automation, the infrastructure bill can help municipalities take three critical steps to transform their sustainability goals into tangible results for a greener future.

To achieve a net-zero operations industry,[2] organizations must:

- Reduce energy across operations using data. A wealth of data makes the invisible visible and can be analyzed and translated into actionable intelligence for energy and operational efficiencies.

- Substitute existing energy sources for cleaner alternatives. With electricity being the most efficient form of energy, it can serve as the best vector of decarbonization.

- Engage the supply chain as part of wider decarbonization efforts. According to a 2020 CDP study,[3] supply chain emissions are more than 11 times higher, on average, than operational emissions. The water industry is an integral one, as one of the few resources that is needed for virtually all transformation processes that have production activities. And because the supply chain is often the largest part of an organization's carbon footprint, the water industry must take a strategic approach here to help reduce organizations' overall emissions.

Funding The Right Investments To Make The Industry Future-Proof

The funding included in the infrastructure bill is a necessary opportunity to upgrade our water and wastewater infrastructure and facilities. In the $55 billion water infrastructure investment, the funding includes $15 billion for lead pipe replacement, $10 billion for chemical cleanup, and money to provide clean drinking water in tribal communities.

When investing the actual dollars, our highest priority should not only be focused on communities that are the most at risk but also concentrating our efforts on how we can accelerate water reuse, water loss, and energy-efficiency projects — something the bill is aiming to address specifically in the funding for western water infrastructure. At least $8 billion will be put into addressing water treatment, storage, and reuse facilities that have been devastated by ongoing drought conditions in the western half of the country.

To successfully invest these dollars, it means we must take advantage of new technologies. We do not, and should not, build plants like we did 20 to 30 years ago. Moving forward, our systems need to be sustainable and smart. To ensure resilient systems, this means building future-proof plants and networks, taking advantage of the digital transformation and the tools that exist today.

The year 2022 will be an exciting year for the water and wastewater industry because now we have access to technology that we never had in the past with a drastically smaller cost, thanks to the cloud. All the cloud-based predictive analytics are allowing the industry to move from reactive to proactive. Based on operational efficiency, these tools can help operate water facilities and municipalities more efficiently.

Cybersecurity Concerns On The Rise

If we invest our money and energy in industrial automation, we anticipate cybersecurity concerns to take center stage with all the tools being managed in the cloud.

Up until this point, we've been accustomed to a privatized world of industrial automation. When you think of our own private lives, half of us live in an Apple universe and the other half in an Android one, with Amazon (Alexa) acting as an occasional third player in home automation. These devices don't always play well together, so many naturally stay with one vendor.

Customers tend to choose one programmable logic controller (PLC) vendor and end up stuck with software and hardware provided by that single seller. Known as "vendor lock-in," this stifles innovation and limits the customer to only the options that vendor provides. For example, a PLC is configured at the factory using software provided by the manufacturer of the PLC. As the customer, they have no choice but to use their software and their hardware because the two are tightly intertwined. And, unlike end users who can control what goes in their plants, municipalities don't have the luxury of choosing their sole vendor.

This is where industrial automation comes in — specifically universal automation, which allows facilities to use software on any hardware compatible with it. Software such as EcoStruxure Automation Expert, an asset-centric automation system designed to manage the complete automation lifecycle for next-generation industries, is an example of a technology that municipalities can integrate to adapt to the software-driven digital transformation. The software addresses customers' needs for flexibility, interoperability, and efficiency from industrial operations standards.

Plants must modernize every 20 years or so. Through universal

A mock-up of a universally automated wastewater facility.

automation, costs associated with modernizing are lower and downtime with facility updates are largely eliminated, as it bypasses vendor lock-ins by allowing the use of another seller's technology or product. The promise is that all vendors will create smart products (hardware and software) that adhere to the IEC61499[4] and universal automation standards. This will create an environment where the customer can choose best-in-class products from any manufacturer now and into the future.

Looking Toward The Future

Our water industry is facing unprecedented challenges. With an aging infrastructure that is battling unparalleled environmental changes associated with climate change, it is critical that leaders focus their investments to create resiliency of our water and wastewater facilities.

Universal automation is the latest big step forward in automation technology and coincides with the three-step path to transform the water and wastewater industry's sustainability goals into tangible results for a sustainable, net-zero future. ■

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About The Author

Louis Arone is a manager of the System & Architectures Team, Industrial Automation Business, at Schneider Electric U.S. Arone is skilled in process automation, control systems design, motor control, VFDs, PLCs, HMIs, and SCADA systems.

A NEW PERSPECTIVE ON FUNDING NONPOINT SOURCE POLLUTION SOLUTIONS

While municipal wastewater treatment facilities fight hard to keep waterways clean, other ("nonpoint") sources contribute greatly to environmental pollution. But there is funding, and now guidance, available to help solve the problem.

By Pete Antoniewicz

For more than three decades, Clean Water State Revolving Funds (CWSRF) have been helping states, municipalities, and environmental groups reduce pollution pressures on the nation's waterways. But people might be shocked to learn how disproportional funding has been for addressing point source pollution vs. nonpoint source (NPS) pollution.

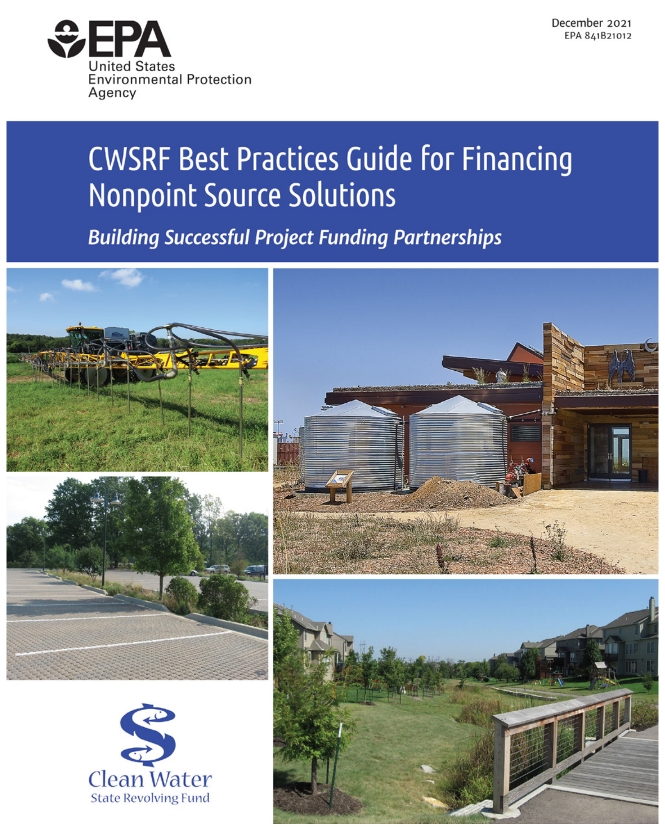
The recently released U.S. Environmental Protection Agency (EPA) document, *CWSRF Best Practices Guide for Financing Nonpoint Source Solutions* (EPA 84121012), is designed to improve that imbalance (Figure 1). It offers a broad perspective on putting CWSRF funds to use properly, creative ideas for navigating the technical constraints of such funding programs, and real-world experience from states that have successfully tackled a variety of NPS challenges.

Time For A Change

Pollution in any form or from any source is a threat to clean water goals. Some forms might be more acute or immediately destructive than others, but all have the potential to compromise quality-of-life issues for humans and wildlife alike. Despite the overall successes of the CWSRF program, its expenditures have been primarily focused on point-source pollution problems. Consider these statistics outlined in the new best practices document:

- More than 90 percent of the $145 billion spent to date under CWSRF financing has been focused on point source pollution management efforts.
- Approximately three-quarters of instances classified under the EPA's Total Maximum Daily Load (TMDL) program are attributed primarily to NPS, yet less than 4 percent of CWSRF funding has been devoted specifically to addressing NPS needs.

In an attempt to balance that focus, the new EPA document explores eligibility requirements, best practices related to leveraging CWSRF funding for NPS projects, ways to bolster CWSRF funding with other funding sources, and various mechanisms to


EPA
United States Environmental Protection Agency

December 2021
EPA 841B21012

CWSRF Best Practices Guide for Financing Nonpoint Source Solutions

Building Successful Project Funding Partnerships

Clean Water
State Revolving Fund

Figure 1. This 60-page document outlines the importance of Clean Water Act programs focused on nonpoint sources (NPS), best practices for successfully funding such programs, and examples of successful NPS-related projects — ranging from urban and agricultural runoff to stream and wetland restoration to septic system upgrades and more. (Source: U.S. EPA)

make funding more accessible to partners in NPS pollution control and remediation efforts (Figure 2).

NPS Strategies At Work: Encouraging More Of A Good Thing

The guide offers some thought-provoking suggestions that water-

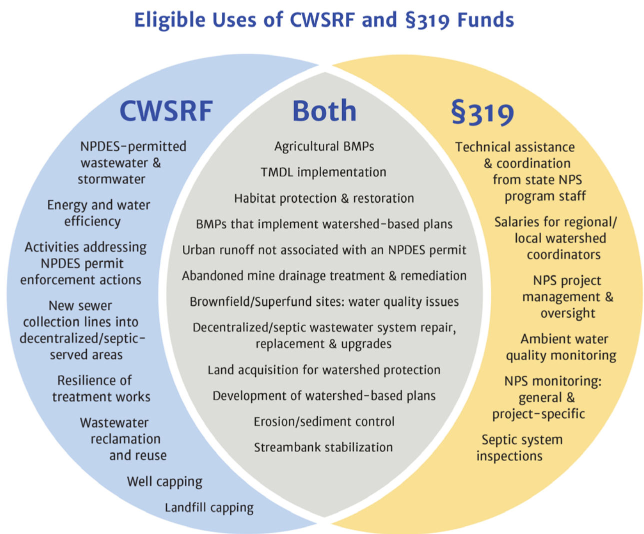


Figure 2. The new EPA guide is a combination of educational and action-oriented resources, ranging from eligibility requirements to financing opportunities (shown above) to customized strategies for NPS programs. It also provides readers with scores of URL links to more detailed national program resources and informational websites, state-specific programs, and footnoted resources used to develop the guide. Source: CWSRF Best Practices Guide, Figure 1-2)

use leaders can use to improve the brainstorming, selection, and implementation of new NPS pollution reduction solutions. Here is a cross-section of those possibilities:

- *Aligning Water Quality Goals/Priorities* – Recommendations include assessing targeted issues to address, looking for changes state CWSRF programs can make to facilitate financing, and creating opportunities for innovation and collaboration. That includes building on the work of others to customize specific strategies to suit the challenges at hand.
- *Identifying Barriers* – Addressing historic barriers in the administration, funding, and loan repayment of NPS projects is an important step toward increasing the opportunities for attacking NPS challenges. By outlining new strategies and past examples of how to navigate those barriers, this document can help state administrators revisit their ongoing challenges with a new eye toward making the system work for them.
- *Alternate Funding And Repayment Resources* – These include options for NPS project cofunding, alternate financing mechanisms, and creative avenues for loan repayment — such as targeted fees, taxes, carbon credits, sales/rentals, etc. — as well as informing stakeholders about financial incentives.
- *Encouraging Partnerships* – Municipal and nonprofit organizations wanting to improve upon current NPS pollution problems can benefit from working with allies, especially those who have experience with related efforts. Collaborative efforts among stakeholders from watershed groups, private homeowners, energy utilities, and other governmental organizations can pay off in making it more practical to achieve new CWSRF environmental improvement goals.

The Proof Is In The Performance

Finally, to encourage realistic new actions to bolster NPS clean-up efforts, the guide outlines a series of case study projects tailored to state-specific CWSRF regulations and creative funding options. These projects are currently paying dividends in clean water applications from coast to coast.

- *Making CWSRF Funding Work for NPS Efforts* – Learn how Ohio, Iowa, and Minnesota leverage between approximately $300 million and $500 million each in CWSRF financing through private borrower funding and pass-through loans for improving or replacing septic systems, restoring stream banks and habitats, controlling erosion, and helping to fund agricultural best practices.
- *Wastewater Upgrades* – In the state of Washington, collaboration among the state's Department of Ecology, Department of Health, county or local health departments, and community development financial institutions is providing access to financing for repair and replacement of failing septic systems.
- *Agricultural Nutrient Management* – The Agricultural Water Quality Loan Program in Arkansas improves water quality by funding a variety of eligible practices ranging from riparian buffers to animal waste management/storage to drainage system outlets to livestock watering facilities, and more.
- *Natural Restoration* – Projects sponsored by traditional utilities in Iowa are being used for activities such as streambank stabilization, native vegetation restoration, and capturing stormwater via rain gardens and permeable paving. NPS projects coupled with a more traditional publicly owned water utility project in the same watershed earn a reduced interest rate.
- *Forest Thinning And Wildfire Restoration* – Read how the state of Arizona worked to reduce the threat and impact of wildfires that generate NPS pollution.

Learn More

Government and nongovernment organizations interested in generating more funding opportunities to protect their local waterways and environment from NPS pollution can download the guide from the EPA website. ■

About The Author

Pete Antoniewicz is an industrial content writer at *Water Online*, where he draws on his journalism degree and experience writing for a variety of industrial and high-tech companies. He can be reached at pantoniewicz@wateronline.com.

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