MARCH 2024

Water Innovations

ON ALERT!

FLOODS, SCARCITY, and CONTAMINATION:

Water Risks (And Solutions) Abound

TABLE OF CONTENTS

MARCH 2024

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Editor's Insight

Articles

Advertiser Index

FROM THE EDITOR

By Kevin Westerling
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Testing The (Storm)Waters

Heavy rains in California prove the worthiness of the "sponge city" concept.

Water scarcity and flood management are two of the biggest issues facing industry professionals across the U.S. and around the world, but quite often we think of those challenges as regional and separate — the arid West vs. the water-logged Northeast, for example. But in California, they must deal with both extremes, thanks to long stretches of drought interrupted by periods of intense rainfall that can be too much to handle, especially in urban areas — a cruel irony of sorts. ("How about some rain and not *all* the rain?")

From crisis comes opportunity, however, and California is adapting to the seemingly new normal by capturing the deluge and saving it for a non-rainy day. In doing so, they provide proof of concept for other cities that, with climate change effects ongoing, will need to adapt similarly. The concept is that of a sponge city — one that favors permeable and green surfaces over impermeable and gray — to solve two problems at once. Such an approach wasn't always necessary for cities that were built on old desert ground, but that was before the term "atmospheric river" came into common parlance.

Cry Me A River

Atmospheric rivers are bands of moisture, typically long and narrow, that vary in strength and size but have the capacity to hold — and release — tremendous amounts of rainwater. According to the U.S. National Oceanic and Atmospheric Association (NOAA):

"[T]he average atmospheric river carries an amount of water vapor roughly equivalent to the average flow of water at the mouth of the Mississippi River. Exceptionally strong atmospheric rivers can transport up to 15 times that amount."

The reason we are becoming more familiar with the term is because the phenomenon itself is happening more frequently because of climate change. According to *Wired*,[1] "for every 1 degree Celsius of warming, the atmosphere can hold 6 to 7 percent more water, meaning there's often more moisture available for a storm to dump as rain."

So, yes, they will only become more potent as temperatures rise.

Soaking It In

As an example of current conditions, *Wired* noted that early February's atmospheric river in Los Angeles "dumped 9 inches of rain on the city over three days — over half of what the city typically gets in a year."

But, because of the city's ability to capture much of it, perhaps we can lose the pejorative and say that it *supplied* 9 inches of rain over that time. Per the article, "between February 4 and 7, the metropolis captured 8.6 billion gallons of stormwater, enough to provide water to 106,000 households for a year."

Traditional dams and catchments also played their parts, to be sure, but Los Angeles was not and could not be in the position to manage — and leverage for future use — huge, atmospheric-river levels of rainfall prior to the incorporation of both green spaces (gardens, swales, etc.) and brown spaces — constructed "spreading grounds" to which stormwater can be diverted to form dirt basins, eventually percolating down to the aquifer.

In addition to saving water and averting floods, spongier cities also ease the burden on treatment plants that don't have the capacity to take on ever-escalating volumes of stormwater, thereby averting pollution events.

The takeaway is that the times, and the weather, are changing. In times past, it may have been true that only areas with frequent rain were candidates for these measures. Now, as proven in Los Angeles, it seems that nearly every city is, as Elaine Benes would say, sponge-worthy. ■

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Reducing **Flood Risk** In A Highly Urbanized Area

How the city of Aurora, CO, via the Fitzsimmons-Peoria Stormwater Outfall Project, modernized outdated infrastructure in response to current needs and future threats.

By Caroline Burger, Jim Kriss, and Swirvine Nyirenda

Most urban areas in the U.S. were built before stormwater managers truly understood the extent of the impact of converting pervious areas into impervious areas or just how much the population would grow — both in number and geographic area. As a result, a significant portion of stormwater infrastructure, particularly in the older portions of our cities and towns, are well undersized for the intended levels of service.

Reducing Flooding Risk In An Older Portion Of The City Of Aurora

A highly congested and rapidly developing area of the city was subject to chronic flooding due to undersized stormwater infrastructure constructed in the 1970s. As a result, the city prioritized the implementation of the Fitzsimmons-Peoria Stormwater Outfall Project to comply with current stormwater standards. The project was a large-scale effort that replaced approximately 15,000 feet of aging 24- to 96-inch storm drain pipes through a highly urbanized area that is undergoing rapid redevelopment. The improvements will provide improved flood protection for approximately 230 residences and 40 businesses.

To improve success in meeting these goals, Carollo assisted the city with engaging a construction manager at risk (CMAR) contractor, BT Construction. The final design efforts were completed as a collaborative team consisting of the city, the CMAR contractor, and Carollo. Together, the team evaluated alternatives to mitigate these constraints throughout the project while minimizing public disruption and project cost.

Sewer Modeling And Enhanced Construction Techniques

Computer Modeling Efforts

Carollo conducted a complex computer modeling effort using InfoWorks ICM in both 1-dimensional (1-D) and 2-D components. These models were constructed to confirm that the new stormwater pipeline and connections were sized to adequately convey predicted stormwater flows, reducing the risk of flooding. The 1-D components evaluated underground infrastructure; the 2-D components evaluated how much stormwater would remain on the ground surface.

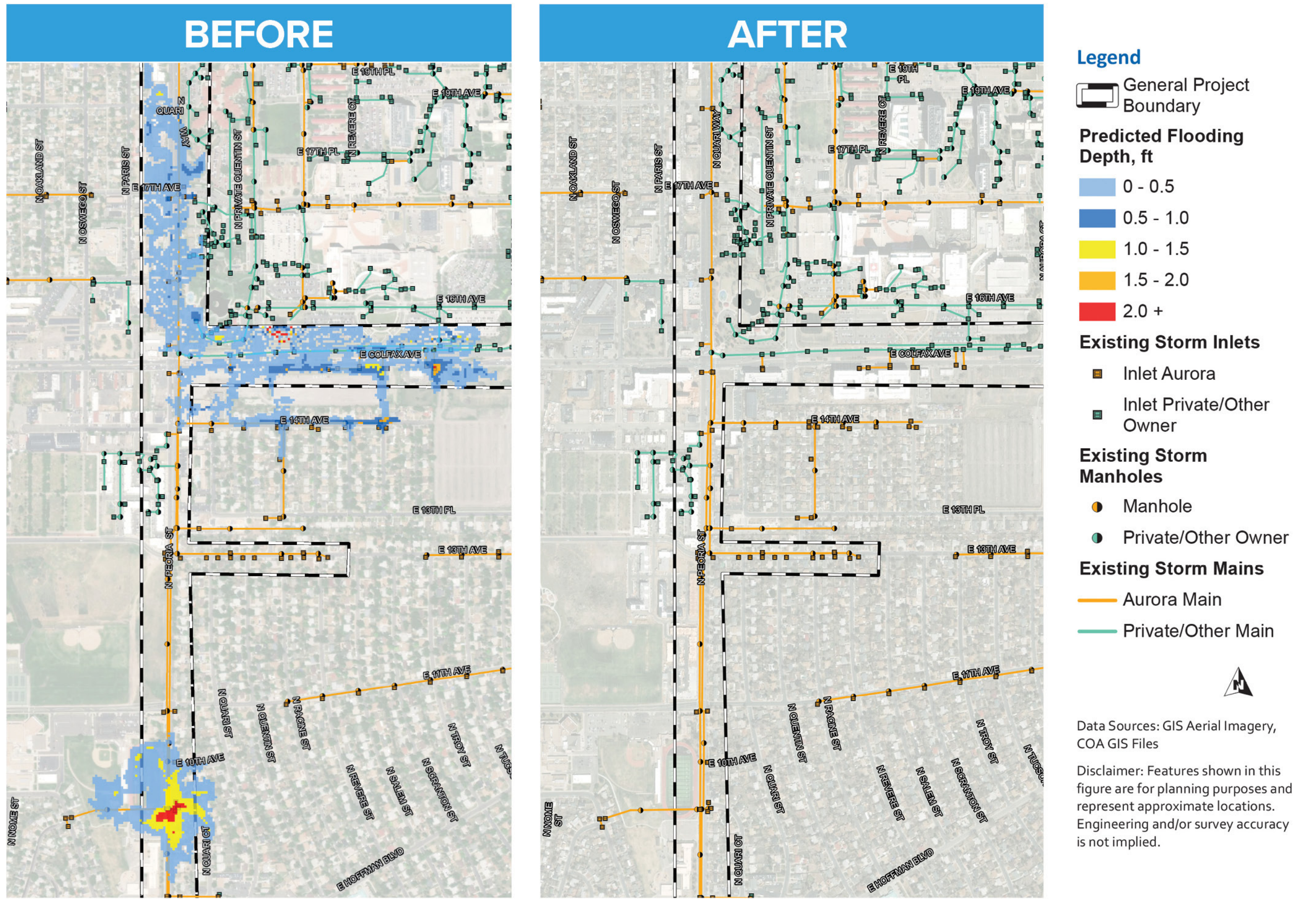
Pipeline Design and Construction

Pipeline routing was established to protect existing utilities and infrastructure while minimizing disruptions to traffic. Pipeline alignments were selected with consideration of construction sequencing, required traffic control devices and diversions, cost, and construction duration. The project also required numerous large manholes and junction structures. These structures were designed as a combination of both cast-in-place and pre-cast structures, with a preference for pre-cast to minimize construction duration where feasible.

Most of the pipeline was constructed using open trench construction with passive shoring (trench boxes) and some limited active shoring (slide rail with minimal dewatering needed using sump pumps). Four major arterials required large diameter trenchless crossings. The variability of ground conditions required a combination of open face tunnel boring machine (TBM) for two of the tunnels and closed face microtunnel boring machine (MTBM) for the other two crossings. The city, CMAR contractor, and Carollo evaluated each construction technique and approach with consideration of cost, feasibility, safety, and minimizing public impact.

Successful Project Outcome And Delivery

The new storm drain system has the capacity to collect and convey a larger flow rate to the discharge at Sand Creek. Carollo performed Hydrologic Engineering Center's River Analysis System (HEC-



The flooding predictions for an Aurora neighborhood were modeled using InfoWorks ICM software. The results of the model for the 100-year design storm event are depicted in the above graphics and highlight the reduction in flooding predictions once the proposed changes are completed.

RAS) modeling of Sand Creek utilizing the existing published Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) maps and base flood elevations with new flow rate inputs for the project basin. While the discharge flow rate increased significantly, the discharge time was well ahead of the peak attenuation of base flood elevations at our discharge location. Therefore, we were able to prove a no-rise condition and avoided the need to submit a Letter of Map Revision (LOMR).

Using the CMAR delivery method, the city was able to develop alternatives during the design phase that improved basin stormwater management, mitigated risk, minimized public impacts, and totaled an overall cost within the contractor's $31M guaranteed maximum price.

Notable Project Design Elements

- *Minimizing construction impact.* Measures were taken to minimize disruptions to the community, as portions of the existing infrastructure flow through highly developed areas.
- *Trenchless crossings of major roadways.* These were needed to minimize traffic disruptions. Variability in ground conditions required different trenchless technologies to ensure successful installations.
- *Discharges not affecting the regulated Sand Creek floodplain.* Our team proved that the increased flows would result in a no-rise condition of the floodplain to avoid a LOMR. ■

About The Authors

Caroline Burger, PE, has 22 years of experience working with public and private clients. Her expertise includes urban hydrologic, hydraulic- and nonpoint-source pollution modeling and design, stormwater utility development, and program management. She has developed numerous municipal stormwater management plans for municipalities across the country. Caroline is a previous Engineering Division employee for the city of Madison, WI, where she led the city's Watershed Study Program. Caroline is also a partner in PV & Associates and helps to develop the urban water quality model WinSLAMM.

Jim Kriss, PE, was the project manager for the Fitzsimmons-Peoria Stormwater Outfall. He has 32 years of design and construction experience, incorporating both traditional and alternative project delivery methods. His expertise includes mechanical pumping and piping systems, pipelines, sanitary and storm sewer pipelines, sanitary force mains, hydraulic design and modeling, and more.

Swirvine Nyirenda, PE, CFM, is project delivery services manager in the Planning & Engineering Division of Aurora Water, whose project delivery services team executes a capital improvement program of approximately $150 million per year. He has an MS degree in environmental engineering from Tulane University.

MIXING ZONES:

Balancing Compliance, Environmental Protection, And Cost Efficiency

Wastewater dischargers can be both environmentally and fiscally responsible by mastering the mix of objectives.

By Karoline Qasem

Imagine pouring a tablespoon of chocolate syrup into a tablespoon of milk. The taste is overwhelmingly chocolatey. In a glass of milk, that tablespoon of chocolate syrup makes the drink near perfect. But what happens when you pour that same tablespoon of chocolate syrup into a gallon of milk? You might not even notice it.

That analogy gives insight into the concept behind environmental mixing zones when it comes to waste entering public waters. While the concentration at the discharge point may be too high for a tiny stream, that same amount is diluted and safer in the mighty Mississippi River.

For wastewater facilities nationwide, understanding the dilution process at the point of discharge is key to securing flexibility in environmental permit compliance.

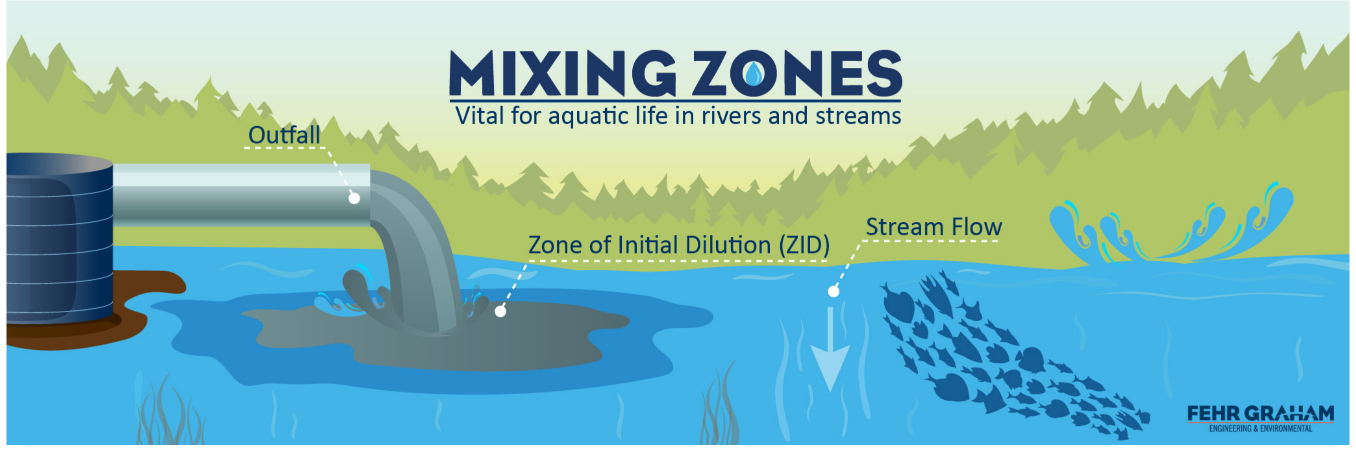
Using Mixing Zones

From an environmental standpoint, a mixing zone refers to an area in a river or lake where wastewater is discharged. As the pollutants move away from the discharge location, they mix with fresh water and become diluted — ideally, this dilution reduces pollutant concentrations to levels that adhere to safety standards, protecting fish, plants, and humans who use the water for recreation.

The idea behind a mixing zone is to offer flexibility to wastewater treatment facilities as they try to meet U.S. EPA guidelines. Wastewater treatment facilities are designed to clean up wastewater before releasing it — in some cases, for longer periods depending on the complexity of the treatment. The goal of the mixing zone is to provide a balance between economic feasibility and environmental protection by the time wastewater reaches the main waterway. Mixing zones allow wastewater facilities to study their impacts on local waterways and determine how much their water needs to be cleaned before it's safe to discharge. Perhaps it isn't at a safe level the moment it reaches the river, but if it doesn't overwhelm the water, it gets to a safe water quality standard as it reaches a permissible distance.

> For wastewater facilities nationwide, understanding the dilution process at the point of discharge is key to securing flexibility in environmental permit compliance.

Consider the chocolate milk analogy. That tablespoon of chocolate is concentrated when mixed with the tablespoon of milk, but considerably less intense when mixed with a gallon. If the level of pollutants isn't too dense for fish to pass through safely, treatment facilities can avoid excess cleaning processes — and higher costs — by proving that discharged pollutants reach an environmentally safe level at a certain distance.



Obtaining Flexibility With Mixing Zones

When a facility applies for a National Pollutant Discharge Elimination System (NPDES) permit, it needs to prove it can meet the stated limit of pollutants discharged into the local body of water. But what the permit writer might not tell you is that, with proper testing and planning, a facility can be approved for a higher pollutant level if it can prove that these pollutants will dilute to safe levels within the confines mixing zone.

How large is that zone? It depends on several factors, including the nature of the water body, effluent water characteristics, pollutant properties, the design of the discharge port, etc. It might take a long time for pollutants to dilute in a small stream, while that would happen almost immediately in a large lake.

Any time a mixing zone is an option, it creates the possibility for a community to have substantial savings on unnecessary water cleaning.

Regulatory compliance for mixing zones is complex, focusing not only on cost-effectiveness but also on stringent environmental protection standards. In some cases, having a proper mixing zone might not be enough. In sensitive ecological areas, a facility may be required to conduct a mussel survey to determine if mussels are present beneath the discharge area. This requirement is to assess the impact on these sensitive species, reflecting the larger ecological considerations of these zones. If that's the case, there is no flexibility with mixing zones, and the permit may not be granted. Fehr Graham's certified diver conducts mussel surveys, which is a requirement in these situations.

It's also important to note that not all waterways in all locations qualify for mixing zone options. Regulations differ and are specific to location. Consider a wastewater site slightly upstream from a common swimming nook. A mixing zone likely won't be an option in that scenario.

Permit renewal requirements also vary. In Illinois, for example, permit holders were asked recently to re-evaluate their mixing zone years to ensure the plan put in place still works. A drought or an influx of pollutants could change the safety levels for a facility.

Calling On Mixing Zone Experts

The complexity of these guidelines, combined with understanding the minimum data requirements for mixing zone studies, suggest that technical professionals should be engaged.

Experts use sophisticated near-field models such as the Cornell Mixing Zone Expert System to determine the dilution levels in the water as it travels downstream. That helps identify the best way to meet water quality standards, either through implementing best practices or installing diffusers at the outfall point where wastewater enters the river.

> Any time a mixing zone is an option, it creates the possibility for a community to have substantial savings on unnecessary water cleaning.

Experts can also help write a mixing zone plan for the state environmental regulatory agencies that details not only the data needs but also outline proposed methodologies, data collection strategies, and modeling approach.

The first step in using the flexibility that mixing zones offer is one that many facilities miss — realizing that these options exist. Now that you have moved beyond that barrier, you're free to bring in experts who can walk you through the steps of testing and planning that will help you obtain an NPDES permit.

The end result? A stable ecosystem and substantial cost savings. And that's a win-win. ■

About The Author

Karoline Qasem, PhD, PE, is a powerhouse in water resources engineering. At Fehr Graham, she specializes in watershed, water quality, hydrodynamic modeling, regulatory permits, nutrient criteria development, watershed planning, stormwater management, and more. Her groundbreaking research, particularly at the interface of environmental engineering and ecology, has revolutionized our understanding of urban streams. Reach her at kqasem@fehrgraham.com.

AOPs And Industry: Guidelines For Effective Contaminant Removal

Using ozone and UV advanced oxidation processes (AOPs) can help industrial facilities achieve compliance, but what's the right process for your application?

By Steve Martin

Industrial wastewater is heavily regulated in the U.S. to prevent contaminants and toxins from entering sources of drinking water, which then must be treated by municipal water treatment plants. Advanced oxidation processes (AOPs) offer exceptional benefits in achieving EPA compliance and preventing contaminants from leaching into groundwater and surface water.

How Ozone AOP Works

Ozone is an appealing option for wastewater treatment. It is generated onsite and eliminates a wide variety of inorganic, organic, and microbiological problems.

When a high-voltage alternating current is applied across a dielectric discharge gap that contains an oxygen-bearing feed gas, oxygen molecules are separated into oxygen atoms (O), which react with other oxygen molecules (O_2) to form ozone (O_3).

Ozone is dissolved in water, forming free radicals that have excellent oxidizing capacity on pollutants and molecules. This process is preferred over UV AOP when the water has low UV transmittance and/or high total organic carbon (TOC), when peroxide quenching is a concern, or if a plant requires the application of ozone for additional reasons.

How UV AOP Works

Ultraviolet (UV) light alters the DNA of harmful organisms without the use of chemicals, rendering pathogens unable to reproduce and cause harm. UV AOP is proven effective at inactivating 1,4-dioxane as well as other harmful contaminants often in wastewater, such as NDMA. There are essentially two kinds of UV AOP: UV plus hydrogen peroxide and UV plus chlorine.

With UV/peroxide, hydroxyl radicals are generated by photolysis of hydrogen peroxide, which splits the hydrogen peroxide into two hydroxyl radicals that react within microseconds with contaminants in the water. The hydrogen peroxide is dosed and mixed in before the UV reactor.

With UV/chlorine, the chlorine dissolves in water to form hypochlorous acid (HOCl), which dissociates to form OCl- at high pH. (The higher the pH, the more OCl-.) Both absorb UV and form hydroxyl radicals, but OCl- is a significant hydroxyl scavenger, so even in small amounts it can render this process less efficient than using UV/peroxide. For this reason, UV/chlorine is used more often when the pH is lower, such as in potable reuse AOP where the pH of reverse osmosis (RO) permeate is normally less than six.

Other Factors To Consider:

- Energy use and costs
- Available footprint (UV systems require less space)
- Availability of oxygen (ozone is more cost effective if oxygen is available onsite)
- Current technologies in use
- The cost of peroxide and residual peroxide destruction

AOP And 1,4-Dioxane

AOP is the most technically and economically feasible solution for treatment because 1,4-dioxane is highly soluble in water and therefore not effectively treated with granular activated carbon (GAC) or air stripping. 1,4-dioxane will even pass through RO membranes, so AOP represents the most suitable treatment solution.

The Whole Effluent Toxicity Test

Any industrial facility that discharges water directly into "waters of the United States" is subject to oversight of the National Pollutant Discharge Elimination System (NPDES) according to the Clean Water Act. This oversight requires that facilities perform whole effluent toxicity (WET) tests, which measure the effects of facility wastewater on test organisms — specifically, their ability to survive, grow, and reproduce. The effect of a facility's wastewater on aquatic life can suggest what the larger impact on an ecosystem and the safety of its water would be. WET tests are either acute or chronic.

Acute tests measure the immediate impact (like mortality) of effluent on life forms representative of a general aquatic setting, and the test duration is usually 24, 48, or 96 hours.

Chronic tests measure the longer-term impact of effluent, such as growth, mobility, and reproduction. For chronic tests in freshwater settings, test duration is between four and eight days. For testing on marine/estuarine organisms, test duration is between 1 hour and nine days.

Case Study

A West Virginia manufacturing facility needed to reduce effluent toxicity by 50% and cut sludge disposal costs.

GAC was rejected due to high operating cost. UV was eliminated due to low UV transmittance and high organics content. The facility ultimately chose ozone AOP treatment for its ability to oxidize the molecules causing toxicity, including surfactants, phenols, hydrocarbons, cyanide, pharmaceutical micropollutants, and 1,4-dioxane. The system reduced effluent toxicity to as low as 0, and the plant will save up to $150,000 annually in sludge disposal costs.

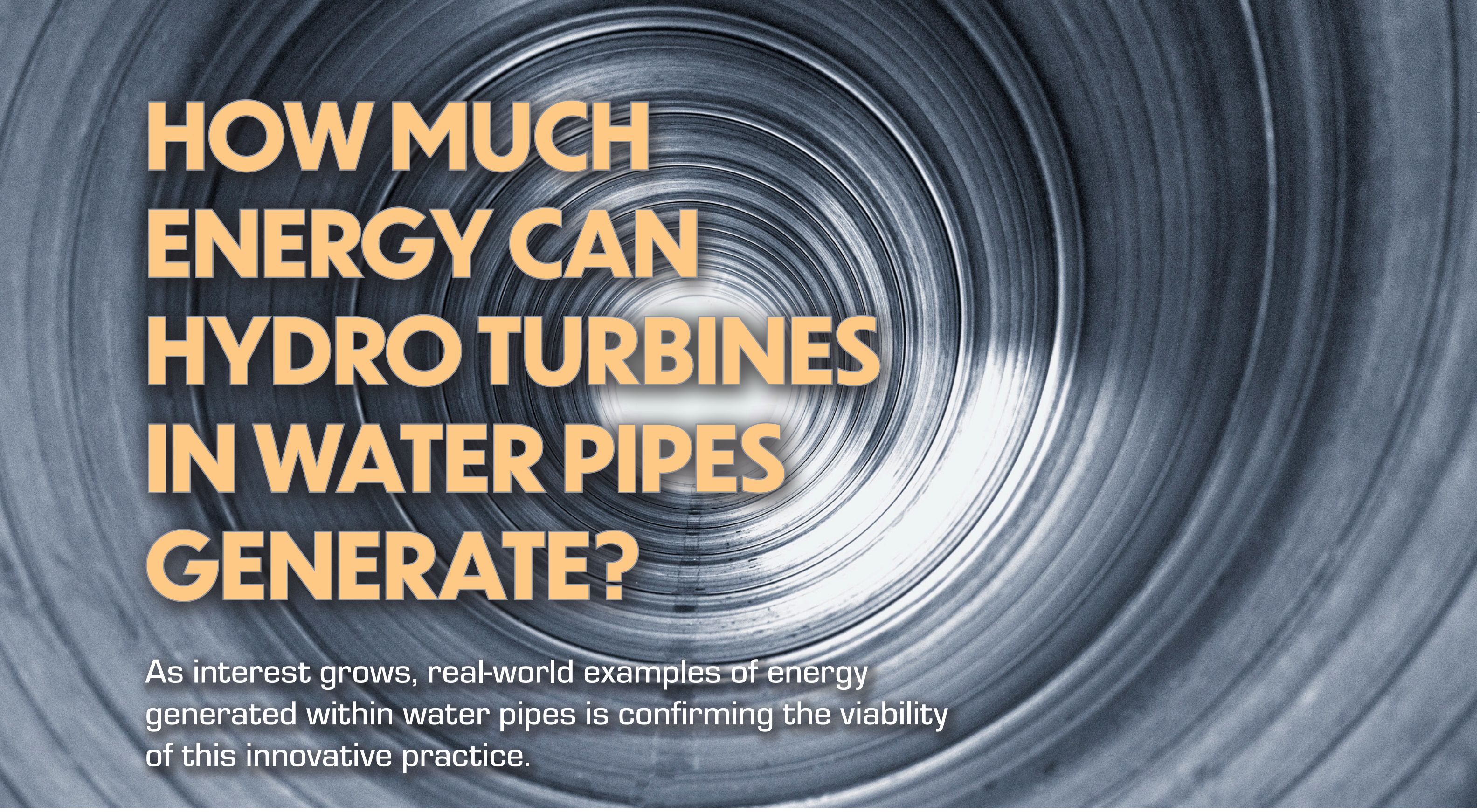
Should A Customer Consider Piloting Or Testing?

Piloting and testing are often mandatory. AOP systems require significant investment and the complex differentiation and high variability among water quality necessitates pilot or laboratory testing.

After identifying the best method, laboratory or field piloting enables proper sizing of the system. Piloting can overcome the challenges of variability presented by seasonality, weather, and many other factors that affect water quality over time and provide the opportunity to adjust design parameters that will deliver the right treatment for the application. ■

About The Author

Steve Martin is the global product manager – UV for De Nora Water Technologies. With 20 years' experience in UV disinfection for both municipal wastewater and drinking water, Steve has demonstrated expertise in developing innovative solutions, ensuring the safety and quality of municipal water supplies.



HOW MUCH ENERGY CAN HYDRO TURBINES IN WATER PIPES GENERATE?

As interest grows, real-world examples of energy generated within water pipes is confirming the viability of this innovative practice.

By Emily Newton

Hydro turbines are critical infrastructure components, creating energy from moving water. As people continue exploring feasible ways to reduce fossil fuel dependency, some wonder if they could make hydropower from drinking water. Combining an in-pipe hydro generator with existing water networks could become an energy-generation option.

How realistic is it for mini hydro turbines to become energy generators? Although this usage of water pipes is not widespread, more decision-makers are open to the idea, and some are testing it to learn more about the potential benefits and challenges.

Mini Hydro Turbines Succeed In Washington

Mount Vernon, Washington's Skagit Public Utility District has used an in-pipe hydro generator since 2020, allowing the organization to offset its pumping station costs. That decision has resulted in measurable payoffs. The system runs for about 20 hours daily, generating about 16-18 kilowatts of electricity.[1]

General Manager George Sidhu said this approach offsets about $1,000 in monthly utility costs, and the technology will pay for itself in about eight years. Plans are also underway to use hydropower from drinking water to support other energy needs in the surrounding area, including at a high school.

The Skagit Public Utility District uses a commercial solution from InPipe Energy, one of the main companies offering products in this space. Its product bypasses or replaces the pressure relief valves in all gravity-based and pressurized water systems. Those valves ensure the water from pumping stations or reservoirs is at the correct pressure for customers in homes and businesses to use it.

InPipe Energy's products use friction as a pressure regulator, along with a microturbine and in-pipe hydro generator. The turbine spins as water flows, powering a generator that creates electricity. These key components are also inside a box, making the installation process easier and quicker.

InPipe Energy's representatives can also take potential clients through a seven-step process of identifying their current infrastructure's suitability for the technology and assessing how much energy they should expect to generate after installing it. Those details can help people make well-informed decisions and aid them in applying for grants.

Researchers Explore Getting Hydropower From Drinking Water

Some people have also examined how mini hydro turbines fit into net-zero energy strategies. Since the late 20th century, tidal power has emerged as an alternative energy source, deployed in countries including Scotland and Canada.[2] It's no surprise people have looked at other types of water-associated energy and tried to tap into them. After all, many innovations come from individuals willing to push the boundaries of what others thought possible.

In one case, researchers looked at how mini hydro turbines could become part of a university building's net-zero energy in Pakistan.[3] It was a 4,800-square-foot, three-story structure where most energy usage stemmed from passive heating and cooling solutions.

The researchers proposed an in-pipe hydro generator based on a rooftop water tank supplying the entire university. This setup would have vertical pipelines running from the rooftop to the ground, with turbines installed 1 foot apart within that infrastructure.

The team planned to have 23 turbines per pipe, each with an effective head of 1 foot. They also incorporated noise dampeners around each pipe to compensate for the sounds generated as the system operated. Moreover, an energy management system supported the system's cost-effective operations.

Calculations about the water reservoir's height and the pipes' diameters suggested the system would reach a maximum water discharge velocity of 10.45 meters per second and a flow rate of 230.9 liters per second. Experiments showed the system generated 168 watts of mechanical power when moving at 250 rotations per minute.

While exploring the methods of getting hydropower from drinking water, the researchers combined their in-pipe turbines with a solar power system. They found the two components collectively gave the best energy-generation results.

Many people don't consider hydropower a renewable energy source, even outside Pakistan. For example, it accounts for approximately 7% of the power generated in the U.S., although there's more work to do in adopting it.[4] However, experiments like this one show the potential of integrating it into existing buildings, supporting other energy-saving initiatives. Such results could encourage people to be more open-minded about the possibilities.

California Municipality Chooses In-Pipe Hydro Generator

In California, representatives from the East Bay Municipal Utility District (EBMUD) became interested in whether mini hydro turbines could replace an existing water pressure regulator while simultaneously generating electricity for the area.

Estimates suggested using it could generate approximately 130,000 kilowatt-hours of electricity per year.[5] Additionally, the system should offset almost 6 metric tons of carbon dioxide emissions, helping EBMUD achieve its aspirations of becoming carbon neutral by 2030.

Since 2000, EBMUD has gradually cut its carbon emissions through various efforts. Those include hydropower reliance, plus biogas, solar energy, and efficiency upgrades through improved or replaced equipment. However, EBMUD's board members liked how this in-pipe hydro generator would support the municipality's dual mission of cutting emissions while providing clean water for its 1.4 million customers.

This case study proves people can pursue multiple aims using mini hydro turbines. That reality could make decision-makers more open to these options, showing they're worth the money and effort to install. When interested parties can show data suggesting the technology will meet several goals, it should be easier for them to acquire funding and approval to move forward.

Similarly, once other leaders see good results from parties pioneering the use of in-pipe hydro generator solutions, they'll become more motivated to explore those options, too. Once that happens, there will be a collective push toward viewing hydropower as a viable energy source. Plus, putting the turbines inside existing pipes is a space-saving possibility that should keep costs down.

Irish Startup Examines the Potential of Mini Hydro Turbines

Sometimes, efforts to get hydropower from drinking water occur after those involved have been on significant, relevant journeys that helped them reach that point. Such was the case with Easy Hydro, an Irish startup launched by Dr. Daniele Novara.[6] Following his university education in energy management, business, and energy engineering, Dr. Novara was selected along with six others to participate in a European Commission-hosted hydropower workshop.

That event helped Dr. Novara learn about recent innovations, ultimately informing his decision to create the startup. Easy Hydro's solutions stand out because they're off-the-shelf products that do not require a water reservoir to work.

Novara pointed out that getting hydropower from drinking water is an excellent energy recovery method because excess pressure generally dissipates as heat and noise. Capturing it for energy generation is a practical, eco-friendly possibility. The ideal customers for Easy Hydro's technology are water-intensive sectors, such as food processing, irrigation, and mining. All those already have extensive pipe networks well-suited for adding miniature turbines.

The Easy Hydro system generates up to 600 kilowatts of energy, or enough to cover the needs of 300 households. When exploring the potential for getting hydropower from drinking water within the European Union alone, Novara said his company's solution could create 2 gigawatts of energy if installed within all pipes. That's the equivalent of a large nuclear power station.

The company's solution relies on standard water pipes operating in reverse mode. Novara said his turbines are less expensive and easier to maintain than standard ones. Plus, the system is easy to scale, opening possibilities for installing several throughout a chosen area.

Treating Water Pipes As Energy Generators

These real-world examples show plenty of potential for installing mini turbines inside existing water pipes. Such evidence will be critical in raising people's confidence in this newer technology, showing how such investments can pay off and become part of renewable energy and emissions-reduction plans. ■

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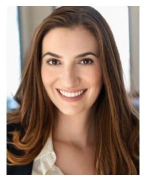

Emily Newton is an industrial journalist. She regularly covers stories for the utilities and energy sectors. Emily is also editor in chief of Revolutionized (revolutionized.com).

THE VITAL ROLE OF MEASUREMENT IN EFFECTIVE WASTEWATER RECOVERY

How digitalization technologies, including data analytics and asset management, can offer smart, sustainable solutions to our planet's wastewater treatment challenges — and help combat the challenges of global water scarcity.

By Amina Hamidi

Our growing thirst for water — for drinking, sanitation, agriculture, and industry — seems unquenchable. Global water demand is expected to increase by 20%–30% by 2050. But with the UN predicting a global water deficit of 40% by 2030, society is facing a catastrophic and possibly unprecedented water crisis as demand substantially outstrips the Earth's available freshwater supplies.

The situation is already dire for a quarter of our planet's 8 billion population. The UN states that around a quarter (2.2 billion people) lack access to safely managed drinking water. Meanwhile, some 4.4 billion people live in areas where sanitation is poor or non-existent. With global population projected to increase by a further 2 billion by 2050, it's clear we need new ways to improve the way that water is managed, from production of potable water through to the discharge and reusability of wastewater.

At the 30th anniversary of World Water Day in March last year, the UN launched its new Water Action Agenda, with the warning that governments must work four times faster to meet the UN's sixth Sustainable Development Goal (SDG) by 2030. In particular, UN SDG 6.3 calls for an improvement in water quality by halving the proportion of untreated wastewater globally, increasing recycling, and minimizing the release of hazardous materials.

With 48% of global wastewater left uncollected or untreated, achieving SDG 6.3 requires that this figure must be halved to just under 24%. Put another way, reaching the UN's target means that the total amount of uncollected and/or untreated wastewater that's currently lost in the wider environment (171.3 billion m^3/yr, or ~45 trillion gals/yr) needs to be reduced by 85.6 billion m^3/yr (~22.6 trillion gals/yr).

Treated wastewater that's returned to the water cycle can be reused for irrigation and a wide range of industrial uses, and even for drinking if it's been suitably processed. At ABB, we've been working with researcher Development Economics to explore how wastewater treatment can play a part in alleviating global water scarcity. Based on an analysis of the same data used by the UN, our own investigations confirm an urgent need to accelerate the treatment of wastewater for reuse and reentry into the water cycle. Our research shows that global wastewater treatment capacity needs to increase annually by 8.56 billion m3, or approximately 2.26 trillion gallons, to meet UN goals. Using a 50-million-liter daily (13.2 MGD) capacity wastewater treatment plant as a benchmark, this means that investment in an additional 469 treatment facilities per year is required, equivalent to 3.4 million Olympic swimming pools each year. And here lies the problem: Currently, some 80% of the world's wastewater flows straight back into the water cycle without being treated for its safe reuse.

A seemingly innocuous error in readings from a sensor or the unnoticed failure of a control valve can have severe consequences for the quality or safety of water being produced.

A vital resource is literally going down the drain.

Aside from its close relationship with water scarcity, the management of wastewater also plays a huge role in the issue of water pollution. Nearly half of all the wastewater coming out of households — from toilets, sinks, drains, and gutters — currently flows back into nature without harmful substances removed. Reducing the volume of untreated wastewater will similarly reduce the amount of untreated sewage that's currently being pumped into rivers and oceans with hugely negative effects on public health, fisheries, animals, and marine biodiversity.

The effective management and treatment of wastewater thus has a dual role to play, both in the battle against global water scarcity and helping to manage the impact of untreated sewage on our fragile ecosystem.

Today, there are various wastewater treatment technologies available, including biological treatment, chemical treatment, and membrane filtration. These can be combined in efficient treatment systems capable of producing high-quality treated wastewater. What's more, advances in technology, including artificial intelligence (AI), machine learning, and cloud and edge computing, can support the optimization of wastewater treatment systems, helping to monitor the quality of wastewater in real time and adjust the treatment process accordingly.

Wastewater treatment is a complex challenge, with the quality and reliability of the output depending on the orchestration of many often-interrelated processes. Water might superficially appear to be a relatively "clean" product compared with heavy industries such as mining, oil refining, and chemical production; however, it's a little-known fact that water treatment consumes as much as 3% of the world's total energy output, while contributing to over 1.5% of global greenhouse gas emissions. Meeting the wastewater treatment targets our report has identified must be achieved in the most energy- and resource-efficient way possible. And that's where the use of technology to support efficient operations and drive better-informed decision-making is key.

Published in 2022, ABB's Energy Transition Report has explored how greater integration of automation, digital, and electrical technologies can make wastewater plant operations more efficient and sustainable. The report's findings suggest that the effective application of automation and digital solutions can help wastewater sites reduce their own carbon emissions by up to 2,000 tons per annum. In the context of around 50,000 treatment sites worldwide, that adds up to potential CO_2 savings of 100 million tons annually. What's more, there's the very welcome additional dividend of forecasted annual operational savings of up to $1.2 million per plant, or a potential $60 billion OPEX savings globally each year.

There's clearly a lot to play for. So how can digitalization and automation solutions help wastewater operators realize these savings in practice — and contribute to alleviating global water scarcity plus a reduction in water pollution and improved sustainability?

Toward Digital Water

In a modern wastewater treatment facility, automation focuses on the use of digital systems to monitor and control plant operations in real time. By automating routine tasks and processes, operators can reduce the risk of errors while improving overall efficiency and reliability.

In a typical plant, there are hundreds or thousands of measuring points where sensors monitor a large number of parameters and detect changes in the environment. These range from measurements of pH, dissolved oxygen, presence of other chemicals, and the composition of biogas released during treatment to physical characteristics such as temperature, pressure, level, and flow rates.

As well as measuring the quality of the water being treated, this instrumentation also plays a critical role in helping operators track other crucial performance indicators, including efficiency, energy consumption, and whether equipment is likely to fail or require maintenance. A seemingly innocuous error in readings from a sensor or the unnoticed failure of a control valve can have severe consequences for the quality or safety of water being produced.

As with all process automation challenges, key to optimizing the efficiency and reliability of wastewater treatment is the interpretation and use of accurate data gathered at every stage of a complex journey.

By combining real-time sensor data with AI and ML, operators can spot changes in device behavior, identify potential issues, and even predict when equipment is likely to fail.

Managing the potentially enormous number of measurement devices in a typical wastewater treatment plant is a major challenge for operators, especially at large sites. With many plants having an operating lifespan of around 40 to 50 years, it's likely that the installed base of sensors, analyzers, and instrumentation systems represents hardware with a mix of ages and communication standards. Many of these devices will have a wealth of data associated with them. And it's this data that provides the key to optimizing plant performance, efficiency, and safety while reducing operational costs.

A prerequisite for realizing the full value of this data is that it should be readily shareable. This can be a particular challenge for water operators dealing with a multiplicity of systems and communication protocols, and even more so when their operations may be scattered across multiple remote or inaccessible locations.

Helping operators make sense of this data deluge are asset management systems — such as ABB's Ability SmartMaster platform — that link operational and engineering data with information management. This creates an environment where data can be collected and shared easily with other users who need access to it, either onsite or organization-wide. In this context, cloud and edge computing play a crucial role in storing, processing, and making available large amounts of data collected from IoT sensors and other systems. By accessing this data from anywhere, plant owners can make faster, better-informed decisions that help secure better outcomes. ML and AI also have a critical role to play in modern asset management solutions, helping identify deep patterns and trends in large volumes of data collected from IoT sensors and other plant operations. This analysis yields insights that can be harnessed to optimize the efficiency of day-to-day plant operations.

An effective asset management solution pays immediate dividends in terms of enabling predictive maintenance and helping

operators to collect and analyze data from vast numbers of devices of different types, makes, and ages. As well as helping gauge when an intervention is necessary, this allows plant operators to build a clear picture of how the performance of a particular device measures up against other similar devices in the fleet. This can be particularly useful where a device — such as a temperature or pressure sensor — is exhibiting anomalous behavior that's not consistent with other devices in similar or identical applications.

Combining operational technology (OT) and information technology (IT) via a unified asset management platform also gives engineers easy access to critical data via phones and tablets. As well as providing valuable guidance for maintenance and enabling smarter deployment of engineering resources, this simplified access to data also helps to address the growing issue of global skills shortages as experienced specialist engineers retire and are replaced with more generalist team members who may lack the same in-depth knowledge.

The progressive digitalization of sensing and measurement technologies — coupled with the deep analysis of data using AI/ML, cloud, and edge computing — also unlocks possibilities for water companies to enhance the efficiency, reliability, and cost-effectiveness of their wastewater treatment operations. Traditionally, plant maintenance has followed a fixed schedule where devices and systems are serviced at specified intervals whether they require maintenance or not. This can impact operators in terms of unnecessary downtime while potentially unneeded maintenance takes place, as well as the cost of needlessly replacing devices that are still functioning adequately.

By combining real-time sensor data with AI and ML, operators can spot changes in device behavior, identify potential issues, and even predict when equipment is likely to fail. By scheduling maintenance activities in advance, operators can dramatically reduce the occurrence of actual failures and minimize plant downtime.

Meeting The Challenges Of Water Scarcity

As with any industrial process, identifying opportunities to optimize wastewater treatment processes starts with accurate measurement. The latest advances in smart measurement, asset management, data analytics, and predictive maintenance allow plant operators to make their own contribution to meeting the UN's sustainable development goals by ensuring that wastewater is treated to the highest quality before being returned to the environment.

While technology can play a significant role in optimizing wastewater treatment, it's not the only factor. Proper management practices — including source control, wastewater reduction, and effective treatment and disposal — are also critical in ensuring the overall success of treatment as a solution to alleviate water scarcity and reduce water pollution. ■

About The Author

Amina Hamidi is the business line manager of ABB's Instrumentation business within Measurement & Analytics, overseeing smart instrumentation products, solutions, and services. She joined ABB in 1998 as a R&D engineer, became chief technology officer of ABB's electrification business in 2017, and joined the Measurement & Analytics leadership team in 2022. A French citizen, Amina holds a PhD in electrical engineering from INPL (Institut National Polytechnique de Lorraine, Nancy, France).

Quick Solutions To PFAS In Drinking Water, Especially For Smaller Systems

With funds falling short of costs for pending PFAS rules compliance, utilities require an economical treatment solution.

By Neal Megonnell

As the drinking water industry awaits news from the U.S. EPA about final maximum contaminant levels (MCLs) for six common PFAS compounds, utilities across the country fall on a broad spectrum between proactively mitigating PFAS contamination in their drinking water to having no idea where to begin.

MCL finalization is imminent, and utilities are expected to have three years to achieve compliance. The EPA estimates about 66,000 systems will need to test for PFAS and between 3,400 and 6,300 public drinking water systems will require mitigation. When considering the funding needs, the subsequent mitigation systems upgrades, and the inevitable strain on the supply chain, three years is an aggressive timeline.

A Large Problem For Small Systems

The funding alone is a high hurdle. The American Water Works Association (AWWA) estimates annual costs for capital, operating, and maintenance expenses of $3.8 billion — more if PFAS waste must be handled as hazardous. Even with unprecedented water infrastructure funding through the Bipartisan Infrastructure Law, the cost will far exceed the funding. The expense will adversely impact utilities of all sizes, particularly smaller systems that lack resources to afford large capital expenditure and the administrative staff to manage the paperwork required to procure government funding.

> PFAS removal technologies are expensive regardless of size and resources, but small systems will be particularly challenged by the new regulations.

Fortunately for small systems, the industry has solutions that allow utilities to quickly start treating drinking water for PFAS without a massive capital outlay. One such solution is a water treatment media exchange system such as EZPro, the latest offering from AqueoUS Vets (AV). This plug-and-play system can accommodate utilities of all sizes but is especially well-suited for smaller, low-flow systems.

It is worth noting that small systems serving less than 10,000 people make up 93%[1] of all water systems and represent about 52 million people. Most of these systems have three employees or fewer and can only allot roughly 7% or less of total expenditure to CAPEX. PFAS removal technologies are expensive regardless of size and resources, but small systems will be particularly challenged by the new regulations.

An Easy Fix?

EZPro eliminates the need for outside design, installation, or service, giving utilities independence and freedom from third-party media service providers. It requires no sewer or electrical hookup, so the treatment system can be completely assembled and ready to connect to a water supply in less than one day. As a modular product line, it offers the flexibility of increasing flows or treating multiple contaminants by selecting the specific filter to meet treatment goals. The system can be sized to treat 5 to 100 gallons per minute, and exchanging the media is comparable to changing a refrigerator filter.

While larger systems require an outside technician to repeatedly come to the site to change out media, with this modular product line, the utility can easily, safely, and quickly replace the media itsself. The filter media can achieve PFAS levels of below 4 ppt — which aligns with the EPA's predicted MCLs — helping utilities achieve compliance quickly and economically.

A small footprint and fast installation make the exchange systems a good fit for rural or small water utilities, planned urban developments, RV parks, hotels and resorts, and small industrial operations. Some suppliers, including AV, offer leasing options on this technology, eliminating the need for a big capital expenditure and making the technology even more accessible.

While the nationwide effort to mitigate PFAS in drinking water is daunting, the professionals committed to securing a safe and healthy water supply are already delivering solutions. For small water systems that struggle with budget constraints and small staffs, a water treatment exchange system with easy media replacement is an appealing, cost-effective option to help them get started straight away on getting PFAS out of their water. ■

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1. https://www.epa.gov/sites/default/files/2015-12/documents/epa816r10022.pdf
2. https://www.epa.gov/system/files/documents/2023-03/How%20do%20I%20calculate%20the%20Hazard%20Index_3.14.23.pdf

REGULATORY BACKGROUND ON MCLs FOR PFAS

A historic regulation, this rule marks the first time the EPA has established national drinking water regulation for PFAS, regulating PFOA and PFOS as individual contaminants and four other PFAS — PFNA, PFHxS, PFBS, and GenX chemicals — as a mixture. The proposed MCLs for PFOA and PFOS are 4 ppt each, much lower than anticipated. An additional “hazard index”[2] applies to a combination of the other four compounds and cannot exceed a value of 1.0 for the combined group of PFNA, PFHxS, PFBS, and GenX chemicals.

At the state level, state-promulgated standards and regulations vary widely, with about half of U.S. states having no standards or regulations and the other half with standards or regulations ranging from 2 to 100 ppt for PFOA and/or PFOS (and still other standards for other types of PFAS). Many more are in the process of establishing their own MCLs for PFAS. Utilities in states that have not passed a regulation for PFAS in drinking water, and in those with limits above the levels ultimately announced by the EPA, will soon be subject to the EPA's MCLs.

About The Author

Neal Megonnell, vice president of media applications for AqueoUS Vets, has over 33 years of experience in the activated carbon industry. He is a member of AWWA's Activated Carbon Committee, a voting member of the ASTM D28 Activated Carbon Committee, and several other industry-related groups and committees. Neal spent many years of his career in R&D, has published multiple papers, and holds two patents related to activated carbon. He earned a BS in chemistry from the University of Pittsburgh, and MS degrees in colloids, polymers, and surfaces as well as chemical engineering from Carnegie Mellon University.