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VOLUME 31, NUMBER 7

JULY 2019

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FEATURES

ON THE COVER
Utilities are finding ways to make instant use of the massive amount of data available from throughout water systems as well as incorporating other sources. These real-time controls can improve efficiency and empower staff.

NEWS

NOTABLE

WATER ENVIRONMENT & TECHNOLOGY
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Volume 31, No. 7

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Water Environment Federation
The Water Environment Federation (WEF) is a not-for-profit technical and educational organization of 35,000 individual members and 75 affiliated Member Associations representing water quality professionals around the world. Since 1928, WEF and its members have protected public health and the environment.

WEF's Mission and Critical Objectives
Connect water professionals: WEF develops an engaged membership that is representative of the multiple practice areas of the water environment industry.

Enrich the expertise of water professionals: WEF provides a broad range of professional content and programming that is relevant and widely valued by the water sector worldwide.

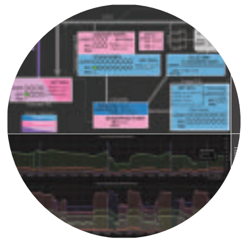
Increase the awareness of the impact and value of water: WEF generates an increased public awareness of the value of water leading to increased funding to protect water quality through appropriate levels of infrastructure, management approaches, and services.

Provide a platform for water sector innovation: WEF establishes the conditions that promote accelerated development and implementation of innovative technologies and approaches in the water sector.

Making Sense of the Data Deluge

The water sector is awash in data. It metaphorically flows into and out of our infrastructure like runoff during a heavy storm. The challenge we face now is controlling and processing all those numbers into relatable information that describes what's happening. This information can create the basis of insights into how to do things better. Some utilities and companies are demonstrating these gains now.

In Detroit, the Great Lakes Water Authority partnered with the University of Michigan to apply state-of-the-science technologies within a testbed of the Greater Detroit Regional Stormwater System. Together, they created a real-time control algorithm simulation study that demonstrates the potential to reduce combined sewer overflows. The work led to implementation of a decision-support dashboard to help operators maximize existing collection system and treatment capabilities. This better use of capacity could enable the authority to defer or avoid as much as $500 million in construction work. Read "Open-Storm Detroit Dynamics" on p. 28 for the full story.



p. 28

Similarly, "Digital Resource Recovery" on p. 50 describes five case studies that highlight applications of big data techniques. Big data can help transform after-the-fact analysis into live insight delivery and real-time advice generation. Tools like these can help leverage machine learning and artificial intelligence into improved performance, higher water quality, smarter preventive maintenance, and greater efficiency.

p. 50

— The editors

WATER ENVIRONMENT & TECHNOLOGY
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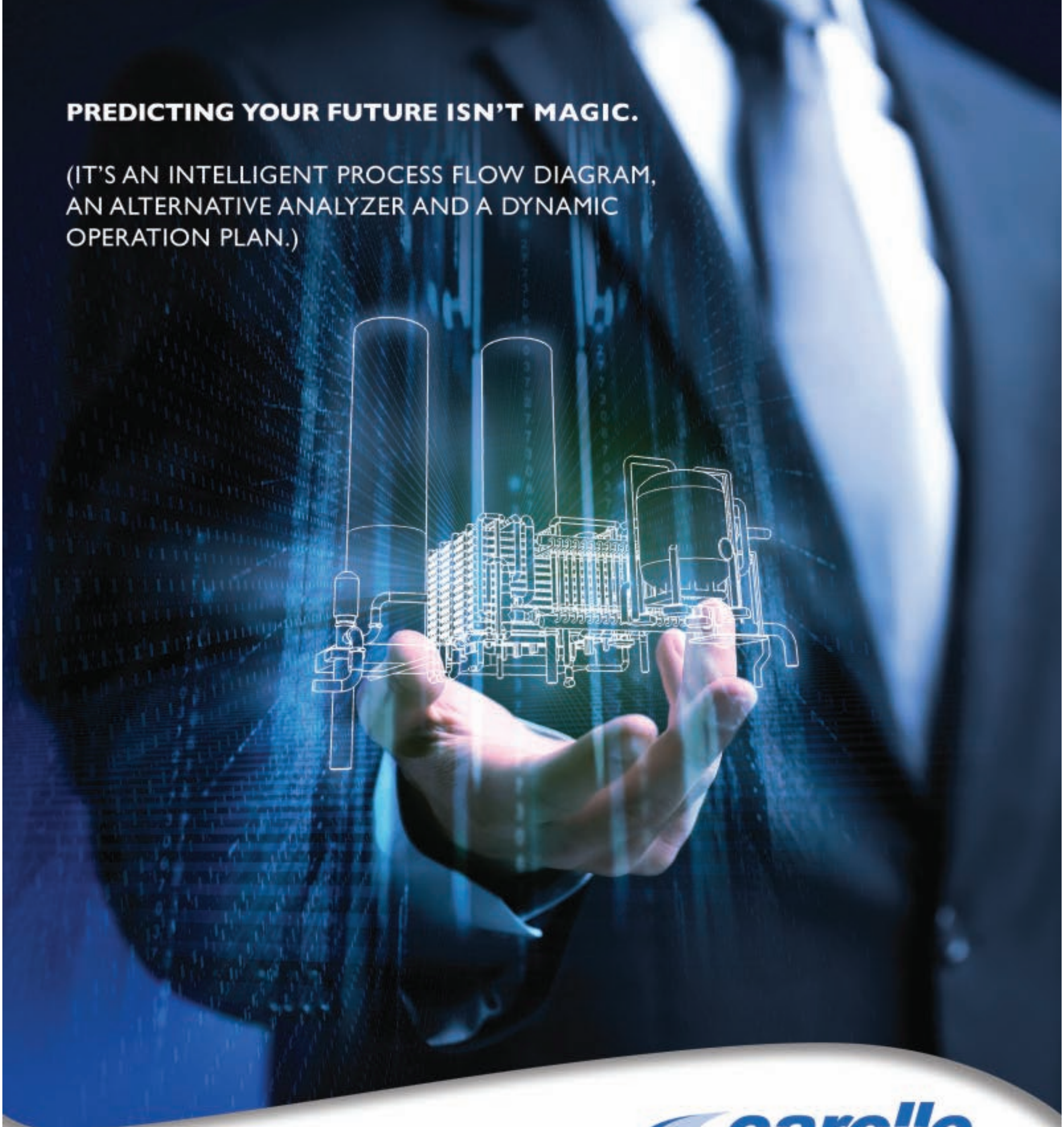
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Antibiotic Resistance Can Spread from WRRFs into the Environment

When humans consume antibiotics, trace amounts of those drugs end up in water resource recovery facilities (WRRFs). If those antibiotics encounter bacteria used during biological wastewater treatment, the bacteria gradually build up antibiotic resistance.

According to new research led by the University of Southern California (USC; Los Angeles), antibiotic resistance can pass from WRRF bacteria into the environment via effluent and biosolids application. Further, bacteria exposed to only small concentrations or just one type of antibiotic can develop resistances to a broad range of antibiotics.

That bacteria, once released into the environment, can pass its antibiotic resistance to future generations of bacteria, and in some cases even to others within the same generation, the researchers write in *Environmental Science & Technology*. If enough bacteria gain resistance, antibiotics eventually may no longer be able to treat infections and diseases.

The bacteria's ability to gain resistance to several antibiotics after exposure to just one type of antibiotic, as well as their ability to transmit resistance into the environment, could have something to do with plasmids, the researchers hypothesize. Plasmids — gene elements that are about 1,000 times smaller than most bacteria — can carry multiple resistance genes and are small enough to float through conventional WRRF filtration systems.

To arrive at their findings, the researchers fed a test-scale anaerobic membrane bioreactor with simulated influent containing various concentrations of the common antibiotics sulfamethoxazole, erythromycin, and ampicillin. The team now is working with such partners as the U.S. Department of Agriculture to examine how other waste streams — animal waste, for example — affect environmental antibiotic resistance, according to a USC press release.

WHO: University of Southern California (Los Angeles) and Rice University (Houston)

WHAT: Researchers find evidence that water resource recovery facilities (WRRFs) may be a significant portal for bacterial antibiotic resistance.

HIGHLIGHTS:

- Researchers simulate influent containing various amounts of three common antibiotics and feed it into an anaerobic membrane bioreactor.
- The team discovered antibiotic resistance genes in both effluent and biosolids produced by the bioreactor.
- Exposure to a single type of antibiotic can result in bacteria forming resistances to multiple drugs.
- Resistance may travel via plasmids, which are gene elements small enough to pass through conventional WRRF filtration systems.

RESEARCH: "Evaluating Antibiotic Resistance Gene Correlations with Antibiotic Exposure Conditions in Anaerobic Membrane Bioreactors," *Environmental Science & Technology,* Vol. 53, No. 7, http://bit.ly/2J1R7Ep.

According to new research led by the University of Southern California (Los Angeles), the antibiotic resistance developed by bacteria commonly used during wastewater treatment can spread into the environment via both effluent and biosolids. The bacteria also can develop resistances to multiple antibiotics after exposure to just one type of antibiotic. stevepb/Pixabay

Green Algae Successfully Remove Organic EDCs from Wastewater Effluent

Many plastics and pharmaceuticals contain endocrine-disrupting chemicals (EDCs), which can be harmful if consumed by wildlife and, in large enough concentrations, lead to fertility issues and increased cancer risks in humans. EDCs are often found in trace amounts in samples of treated wastewater, signaling that conventional treatment processes are unable to completely remove EDCs.

Researchers from the Desert Research Institute (DRI; Las Vegas) have reported success using a common form of freshwater green algae, *Nannochloris*, to remove trace EDCs from effluent.

The team grew algal cultures of *Nannochloris* in two types of treated wastewater effluent samples collected from the Clark County Water Reclamation District (Las Vegas) — one sample treated via ultrafiltration and the other via ozonation. Researchers measured changes in the concentration of seven common EDCs in the samples during 1 week.

In the ultrafiltration samples, the researchers discovered that the algae grew quickly and removed an average of 60% of the common EDCs, specifically 17β-estradiol, 17α-ethinylestradiol, and salicylic acid. However, the algae did not meaningfully reduce concentrations of the other four EDCs tested.

Similarly, in the ozonation samples, the algae grew slowly and did not noticeably diminish EDC concentrations.

Kumud Acharya, executive director of hydrologic sciences at DRI, remarked in an April 8 press release about the study that using algae to remove heavy metals and inorganic contaminants is a common practice in wastewater treatment. But, Acharya continued, using algae to remove organic pollutants is not as well-understood.

"Our research shows both some of the potential and also some of the limitations for using *Nannochloris* to remove EDCs from wastewater," Acharya said.

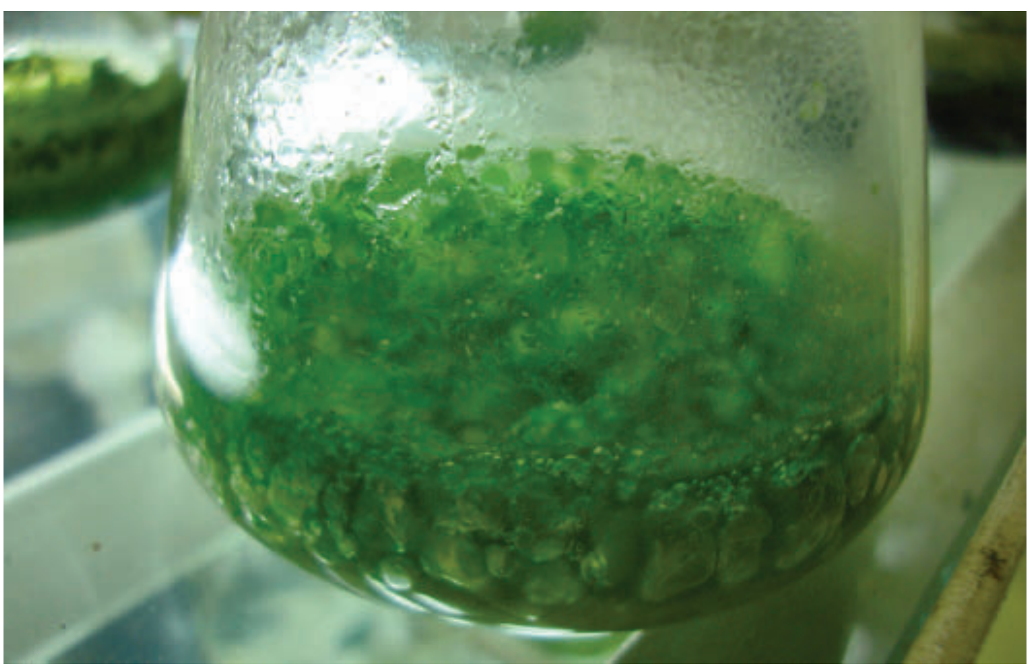
WHO: Desert Research Institute (Las Vegas)

WHAT: Method for removing trace amounts of endocrine-disrupting chemicals (EDCs) from wastewater effluent using freshwater green algae.

HIGHLIGHTS:

- Researchers grow algal cultures of *Nannochloris* in wastewater effluent samples containing trace amounts of common EDCs.
- Over 7 days, effluent treated via ultrafiltration spurs rapid algal growth while reducing three common EDCs by approximately 60%, but barely affecting the other four tested EDCs.
- Effluent treated via ozonation did not spur algal growth and led to no significant reduction in EDC contents.

RESEARCH: "Removal of seven endocrine disrupting chemicals (EDCs) from municipal wastewater effluents by a freshwater green alga," *Environmental Pollution*, Vol. 247, pp. 534-540, http://bit.ly/2GRMPMV.



New findings from the Desert Research Institute (Las Vegas) demonstrate the potential for *Nannochloris*, a common type of green algae, to remove endocrine-disrupting chemicals from treated wastewater.
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Coral Samples Reveal WRRF Contributions to Maui Nutrient Pollution

In coastal waters near Maui, Hawaii, nutrient pollution has caused a pattern of recurring algal blooms and widespread coral degradation. However, the main sources of the excessive nutrients have long remained unclear.

Thanks to a new analysis technique — similar to estimating a tree's age by counting the rings left behind on its stump — researchers have concluded that a biological nutrient removal process in place at a nearby water resource recovery facility (WRRF) contributes significantly to the pollution problem. The WRRF injects treated effluent into a local groundwater aquifer, which after many months, seeps into the coastal ecosystem via small, underwater vents.

To determine whether discharge from the vents influenced coral health, researchers drilled 50-mm (2-in.)-wide cores from live and dead coral specimens in three locations: two near the vents, and one about 150 m (492 ft) away. The researchers sliced the cores in half and used x-ray and computerized tomography imaging to reveal a series of stratified layers of coral, each containing different types and concentrations of nutrients.

During the WRRF's biological nutrient removal process, lighter isotopes of nitrogen are removed more easily than heavier isotopes. By analyzing the contents of each coral layer, the team found that concentrations of nitrogen-15 — a heavy isotope "known to be strongly indicative of denitrification and sewage effluent" — spiked dramatically in samples taken from near the vents beginning in 1995, the researchers write. The WRRF implemented its biological nutrient removal process the same year.

Nitrogen-15 contents in the coral near the vents continued to rise in the years since, in some cases reaching up to three times as much of the isotope as before 1995. Meanwhile, nitrogen-15 contents in coral samples collected away from the vents remained constant.

"There is no other process that would result in this signature, so it has to be from the sewage," said Adina Paytan, a research professor at University of California, Santa Cruz and co-author of the study, in a release. "Even though the treatment process removes some of the nitrogen, there is so much in the sewage that there is still a lot left, and when they inject it into the groundwater it ends up in coastal waters."

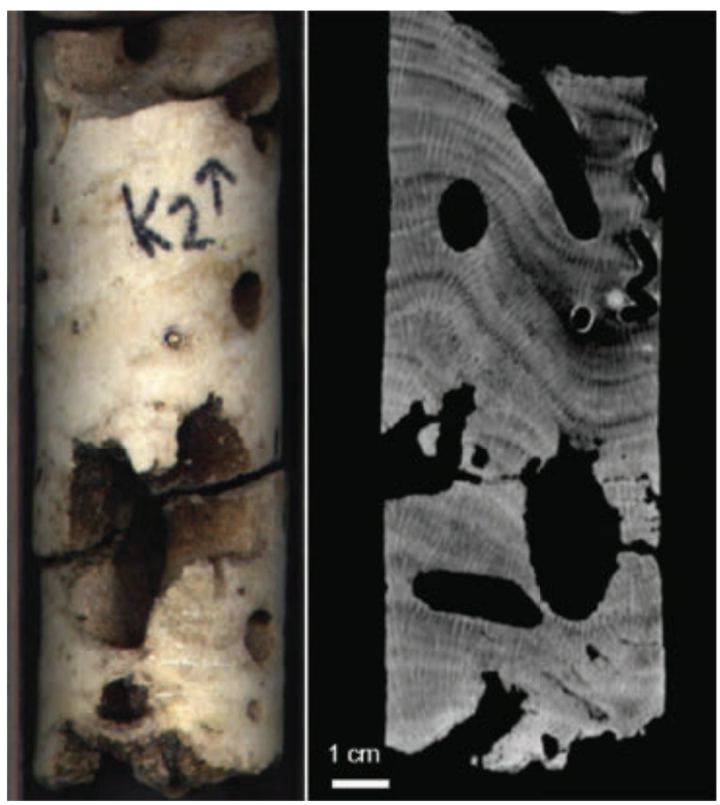
WHO: University of California, Santa Cruz and U.S. Geological Survey

WHAT: Researchers draw and analyze coral cores to reveal a chronology of nutrient conditions in coastal waters off Maui, Hawaii.

HIGHLIGHTS:

- Researchers gather coral cores both near and far from an underwater vent through which groundwater seeps.
- Using a new analytical method, researchers split the cores in half and use imaging technology to study each sample's historical nutrient contents.
- Analysis reveals a major increase in the amount of nitrogen-15, often an indicator of wastewater treatment activities, since 1995.
- Researchers conclude that the increase correlates with implementation of a biological nutrient removal process at a nearby water resource recovery facility.

RESEARCH: "Coral Skeleton $\delta^{15}N$ as a Tracer of Historic Nutrient Loading to a Coral Reef in Maui, Hawaii," *Scientific Reports*, Vol. 9, No. 5579, https://go.nature.com/2ZPybyy.



Off the coast of Maui, Hawaii, a groundwater aquifer that receives injections of treated wastewater from a nearby water resource recovery facility (WRRF) seeps slowly into the ocean via underwater vents. Near the vents, researchers discovered coral samples with high concentrations of nitrogen-15, an isotope closely associated with wastewater treatment. Nancy Prouty/U.S. Geological Survey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White House and Dems: Water Funding Needed

Other issues disrupt talks, neither party answers how to pay

By Amy Kathman

In a surprising move, President Donald Trump and congressional leaders met in April to discuss a possible $2 trillion infrastructure package that would address U.S. infrastructure needs. Trump, Speaker of the House Nancy Pelosi (D-Calif.), and House Minority Leader Chuck Schumer (D-N.Y.) agreed during the meeting that repairing crumbling U.S. infrastructure along with lowering drug prices and providing disaster relief are the few issues that both parties believe must be addressed in the 116th Congress.

After the bipartisan meeting held at the White House, all emerged agreeing to work toward the development of an infrastructure plan. Specific details were not determined or, at least, made public following the April meeting. These unresolved details include what forms of infrastructure will be included and how to cover the cost.

However, by mid-May, talks between Trump, Pelosi, Schumer, and other congressional leaders broke down due to unrelated issues, including whether or not to continue congressional investigations into the president. How or when meaningful bipartisan discussions on infrastructure will resume is not clear at press time — but what is clear is the critical need for an infrastructure package.

Needed Focus on Water

In previous statements, all parties had mentioned water infrastructure when calling for funding. When

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the Democratic lawmakers spoke after the meeting, they said Trump agreed that infrastructure investments should include roads, bridges, water systems, and more.

On Jan. 10, the Water Environment Federation (WEF; Alexandria, Va.) and 90 other organizations sent a letter to the U.S. Congress urging lawmakers to include water infrastructure as a major component of any infrastructure package during the 116th Congress. Specifically, the coalition of national, state, and regional organizations asked Congress to include funding and financing for drinking water, wastewater, water reuse, and stormwater infrastructure.

The letter included a reminder that water infrastructure is often co-located with such transportation infrastructure projects as roadways and bridges. When roadways are dug up or bridges are rebuilt, rehabilitating water lines at the same time avoids digging again later.

"An infrastructure package represents an excellent opportunity to provide necessary resources to meet long-term economic, public health, and environmental goals," the letter reads.

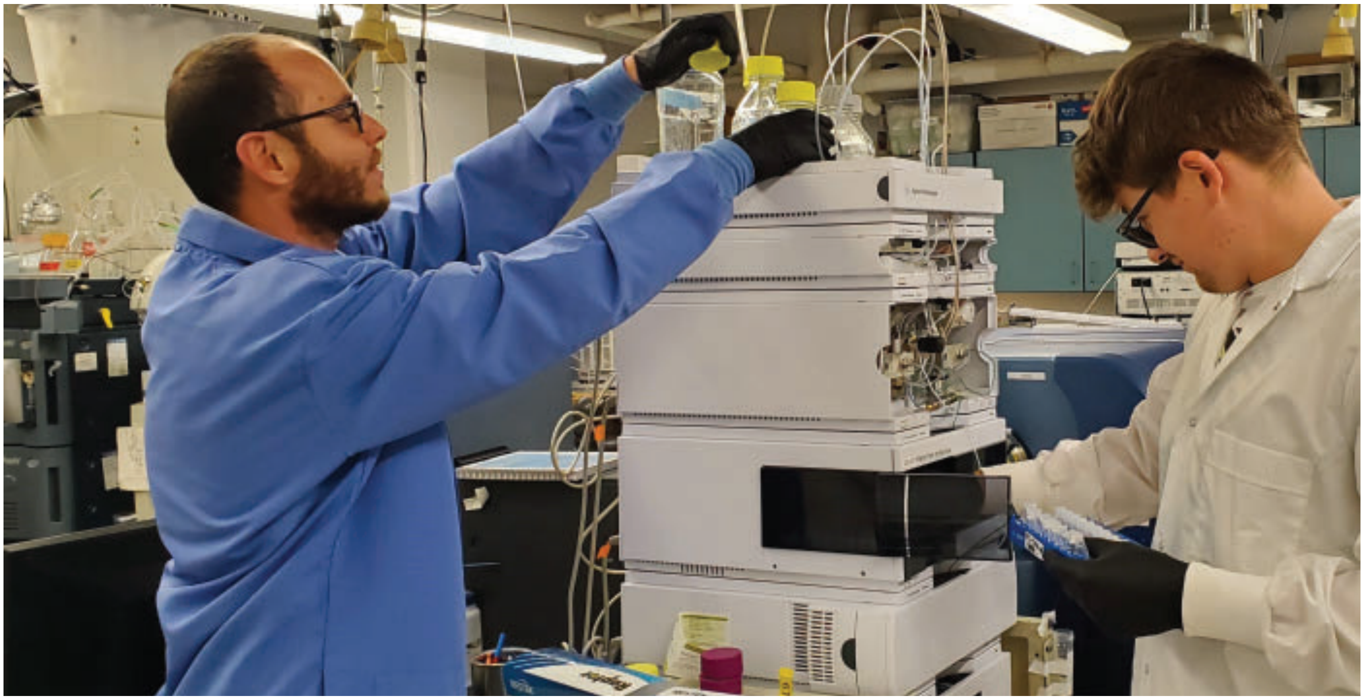
Investment in water infrastructure creates jobs and helps support the economy. "Every $1 invested in drinking water and wastewater infrastructure increases long-term gross domestic product by $6.35, creates 1.6 new jobs, and provides $23.00 in public health-related benefits," WEF and other organizations wrote in their Jan. 10 letter.

The U.S. Environmental Protection Agency estimates that U.S. water and wastewater infrastructure requires nearly $750 billion worth of investment during the next 20 years to maintain current levels of service. Independent estimates place this figure at more than $1 trillion. Aging infrastructure replacement needs account for much of the investment gap. While federal contributions to transportation infrastructure have stayed constant at approximately half of total capital spending, federal investment in water infrastructure has declined from 63% of total investment to 9% since 1977, according to the fact sheet, *The Economic Benefits of Investing in Water Infrastructure,* from the Value of Water Campaign.

Finding the Funding

Shortly after the president's April meeting with Pelosi and Schumer, many members of Congress questioned how the $2 trillion package would be paid for. Earlier that week, Schumer said a comprehensive infrastructure package could be funded by rolling back the 2017 tax cuts. In addition, Schumer could potentially attempt to tie the tax cut repeal to the passage of the first fuel tax increase since 1993 to help fund the package, according to an April 30 article in *Roll Call* online.

***Amy Kathman** is Government Affairs Manager at the Water Environment Federation. She can be reached at akathman@wef.org.*



Yaniv Olshansky, a postdoctoral research scientist at The University of Arizona (Tucson), and Anton Gomeniuc, a senior in chemical engineering, prepare water samples for the analysis of polyfluoroalkyl substances. The University of Arizona (Tucson)

Absorbing a Common Hazardous Material

Arizona team develops polymeric sorbents to remove PFAS from groundwater

By LaShell Stratton-Childers

Researchers at The University of Arizona (Tucson) are using a $1.2 million grant from the U.S. Department of Defense Strategic Environmental Research and Development Program to develop a new method for removing per- and polyfluoroalkyl substances (PFAS) contaminants from groundwater.

According to a press release from the university, PFAS has some of the most stringent concentration standards for water contaminants under U.S. Environmental Protection Agency regulations. The federal health advisory limit for the sum of both perfluorooctane sulfonate and perfluorooctanoic acid — two widely used types of PFAS — is 70 parts per trillion.

"One part per trillion is equal to one drop of water in the combined volume of 20 Olympic-size swimming pools," according to the release. PFAS is of such concern because it can cause cancer, low birth weights, and affect immune systems, according to the release.

But removing PFAS to the extremely low levels needed for safety can be challenging, particularly because PFAS is so pervasive.

"PFASs have been used for decades in many products such as nonstick cookware, waterproof clothing, carpets, fire-fighting foams or aqueous film-forming foams, and even food packaging," said the team's lead researcher Reyes Sierra, who is a chemical and environmental engineering professor at The University of Arizona.

"In some cases, they have contaminated our drinking water resources — groundwater and surface water. Sites in the vicinity of PFAS production facilities and firefighting training sites are particularly likely to be impacted by PFAS contamination."

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Better Sorbents

One of the most widely used methods to remove PFAS, and other contaminants, from groundwater is granular activated carbon (GAC) adsorption. According to the university news release, in GAC adsorption, "combusted organic materials similar to coal attract groundwater contaminants through sorption, a chemical process in which one substance, the contaminant — becomes attached to another — the sorbent."

Now the UA team has developed polymeric sorbents that they believe will be a better candidate than GAC.

"We tailored their chemical structure to enhance their affinity for PFAS compounds," Sierra said.

Sierra noted that GAC binds PFAS through hydrophobic interactions. "In contrast, the sorbents we are developing exploit multiple, complementary binding modes — for example, electrostatic and hydrophobic interactions — which we anticipate will make these materials more effective than activated carbon for the remediation of PFAS-contaminated water."

Sierra said that the team anticipates that the "sorbents we are developing could be applied to treat contaminated groundwater and that water pretreatment will not be required. Groundwater would be pumped and treated in an adsorber column containing the polymeric sorbent. It may also be feasible to inject the sorbent in the soil subsurface to prevent spread of the PFAS contamination."

Early Days

The team is in the initial phase of its research. Sierra said they started the project in August 2018.

"We anticipate that it will take 2 more years to complete the characterization and laboratory scale testing of the new sorbent materials," she said. "As part of the research, we will be testing actual PFAS-contaminated groundwater from two different military bases. We hope that our sorptive remediation approach will be technically and economically feasible, in which case, pilot testing would be the next logical step."

The team plans to use the $1.2 million grant to help provide information "on the sorptive performance of the different engineered sorbents and the impact of aqueous chemistry on the life-cycle of PFAS sorptive remediation," Sierra said.

The team also expects the grant will lead to an effective method for the remediation of PFAS-contaminated water and expand on the fundamental understanding of the mechanisms responsible for the adsorption of PFAS on engineered sorbents, she said.

"The project will support the involvement of several environmental engineering and environmental science students in a timely research topic," Sierra said. "These students will benefit from the training opportunities and mentorship afforded by the collaboration between the two departments — the Department of Chemical and Environmental Engineering and Department of Soil, Water, and Environmental Science — and the engineering company involved in this project."

LaShell Stratton-Childers is News Editor of Water Environment & Technology.

Colorado School of Mines Opens Hub for Groundbreaking Water Technologies

The newly opened Water-Energy Education, Science, and Technology (WE^{2}ST) Water Technology Hub, constructed in Denver by the Colorado School of Mines (CSM; Golden), features a retinue of state-of-the-art technology. Among its facilities are analytical and wet laboratories, fabrication equipment, and connections to the U.S. railway system, by which researchers can receive water samples from anywhere in the system. Colorado School of Mines

CSM celebrated WE^{2}ST's grand opening with a ceremony on April 2. CSM researchers will undertake their first project at the facility this year. The projects will focus on solar desalination in cooperation with the University of California Los Angeles. Colorado School of Mines

This spring, Colorado School of Mines (CSM; Golden) cut the ribbon on a new, 930-m^2 (10,000-ft^2) research center. The center is outfitted with facilities tailored to help researchers solve today's most pressing water quality and supply issues. Known as the Water-Energy Education, Science, and Technology (WE^{2}ST) Water Technology Hub, the center will enable more robust collaboration among academia, industry, and government, said WE^{2}ST Managing Director James Rosenblum, in a press release.

"To better partner with industry and municipalities and help them solve the real-world water treatment challenges they face, we needed more space than is typically available on a college campus," Rosenblum said. "We're excited to get to work at a much larger scale than ever before."

WE^{2}ST, located in Denver, occupies the space of a former industrial facility owned by NGL Energy Partners (Denver), who donated advanced equipment valued at approximately $800,000 to CSM. In addition to analytical and wet laboratories, amenities at the center also includes a fabrication facility and a research bay capable of holding up to 113,500 L (30,000 gal) of water. Railway connections to the hub also enable WE^{2}ST staff to import water samples from across the U.S.

A $1.5 million gift from the ZOMA Foundation (Denver) also will support programs at the facility as well as fund several graduate and undergraduate research fellowships.

Research at the center will kick off before the end of 2019 with a collaboration between CSM and the University of California Los Angeles focusing on solar desalination technology. The project is funded by a $700,000 grant from the U.S. Department of Energy. Other topics WE^{2}ST researchers plan to study include

- treating produced water from mining and industry operations;
- addressing emerging contaminants, such as poly- and perfluoroalkyl substances;
- remediating pharmaceuticals and personal care products from wastewater;
- managing saline and hypersaline waste streams; and
- exploring sustainable water reuse applications.

World Water Innovation Fund Spurs Global Collaboration on Water Research

Water utilities from Australia, Brazil, the U.K., and U.S. have agreed to pool resources and knowledge to drive innovation in the water sector as the effects of climate change and population growth take an increasing toll on global water resources. Results from the partnership, known as the World Water Innovation Fund, will be published online and shared freely with utilities around the world. Free-Photos/Pixabay

In a first-of-its-scope partnership, water utilities from four continents will work together to strengthen the resilience of global water supplies against climate change and population growth under the newly formed World Water Innovation Fund (WWIF).

Announced by Severn Trent Water (Coventry, England) CEO Liv Garfield at this year's Global Water Summit, WWIF members will pool funding and expertise to undertake large-scale trials of new technologies at their facilities, share conclusions, and avoid duplicating research efforts.

"By creating this fund, we've joined forces with like-minded companies from across the globe who recognize the challenges we face and who want to do things differently, to find new ways of working, and to leave a lasting water legacy for future generations," Garfield said at the summit, held April 8 to 10 in London.

By being the first utilities in the world to develop and deploy water treatment solutions funded by WWIF, the partnership is expected to directly benefit approximately 50 million customers, according to an April WWIF release. But because all research findings will be posted publicly online, utilities around the world will gain access to innovative techniques and technologies that they may not have the resources to develop independently.

According to the release, one effort the partnership will pursue involves coordinating leading researchers and manufacturers to standardize the use of robotics in the water sector by creating small devices that can actively seek out and repair leaks in collections systems. This advancement would save water while improving the safety of the wastewater workforce.

Founding WWIF members include

- Severn Trent Water;
- United Utilities (Warrington, England);
- Aegea Saneamento (São Paulo, Brazil);
- Los Angeles (Calif.) Department of Water and Power;
- DC Water (Washington, D.C.);
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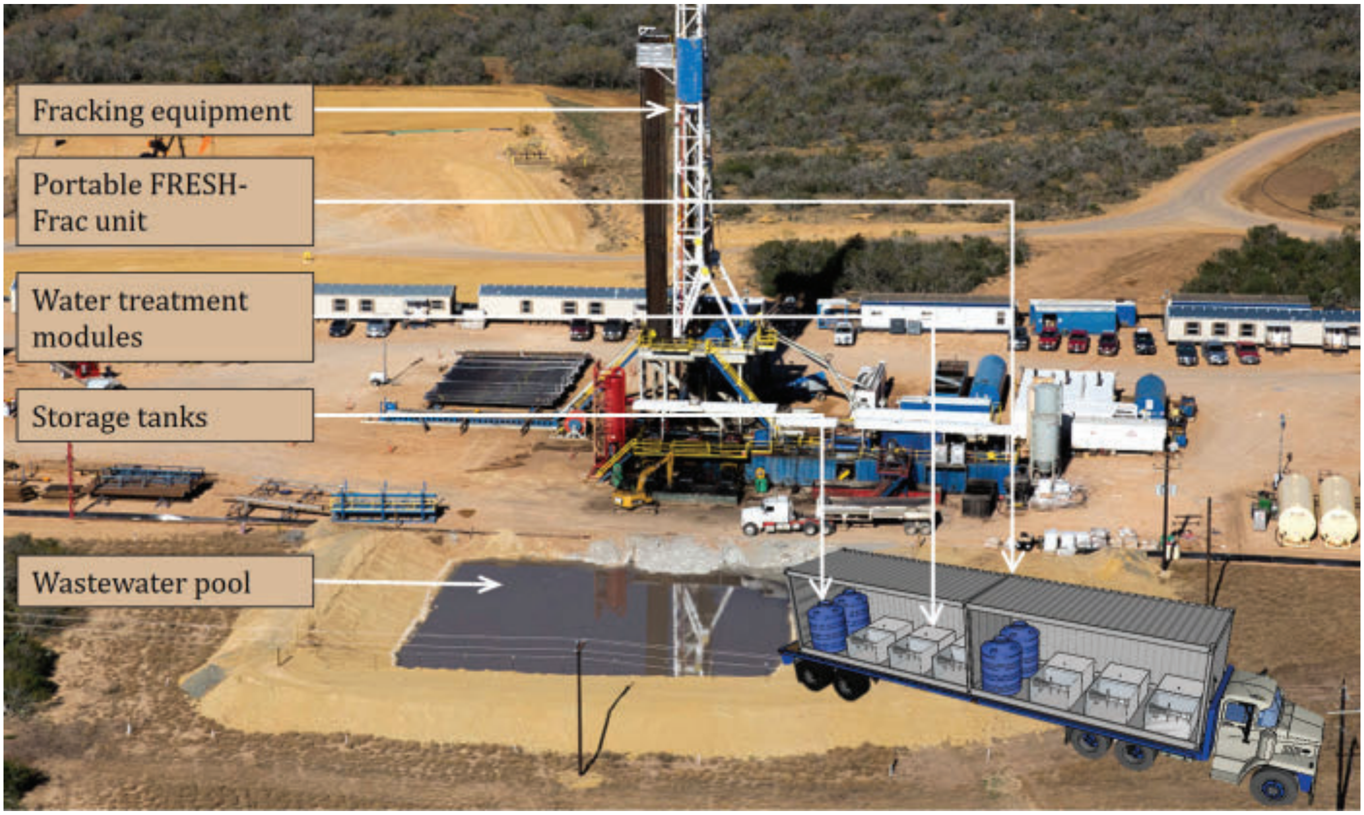
- South East Water (Victoria, Australia); and
- City West Water (Victoria, Australia).

Keep up to date with the latest WWIF efforts at www.waterinnovationfund.com or on Twitter at @WorldWaterFund.



A new treatment technology for fracking wastewater supported with a nearly $3 million grant from the U.S. Department of Energy promises to recover water fit for nonpotable reuse from pools of contaminated wastewater. Mobile, solar-powered, and low-cost, the technology uses a form of humidification–dehumidification desalinization to siphon grey water from wastewater. Oregon State University – Cascades

U.S. Department of Energy Funds Better Way To Treat Fracking Wastewater

The U.S. Department of Energy (DOE) has awarded $2.97 million to an interdisciplinary team of engineers aiming to address human and environmental health concerns associated with hydraulic fracturing.

Hydraulic fracturing, also known as fracking, is a common oil and gas extraction method that uses highly pressurized water to force open underground shale deposits, releasing resources trapped inside. While fracking typically yields more oil and gas than traditional drilling methods, it is water-intensive and can create large quantities of highly polluted wastewater. A 2016 study by the Yale University (New Haven, Conn.) School of Public Health identified at least 157 chemicals in fracking wastewater that are toxic to humans.

The team of engineers, led by Oregon State University – Cascades researcher Bahman Abbasi, will use DOE funding to develop a portable, scalable solution to recover water fit for nonpotable reuse from fracking wastewater, according to a March OSU release. Typically, oil and gas producers pump this wastewater back underground into injection wells, a practice scientists link to groundwater contamination and more frequent earthquakes.

"By extracting clean and reusable grey water from the contaminated water, we can reduce damaging public health and environmental impacts of reinjecting or storing untreated, contaminated water," Abbasi said.

The solution proposed by the team would humidify and dehumidify air as a means of separating and siphoning uncontaminated grey water from pools of fracking wastewater. The extracted water could then be reused for fracking or for agricultural and industrial applications. The treatment equipment would be solar-powered, able to fit inside a shipping container, and operate at a fraction of the cost of traditional treatment methods, according to the release.

Project partners include engineers from Michigan State University (East Lansing) and the University of Nevada, Reno. The team also includes partners from China, Germany, India, Iran, Nigeria, and Sudan.

Hydraulic fracturing, also known as fracking, is an extraction process that produces greater amounts of oil and natural gas but creates large volumes of wastewater often too contaminated for productive reuse. skeeze/Pixabay

Ohio Researchers Create Promising Plastic Packaging Substitute

In the food packaging industry, finding a biodegradable, eco-friendly alternative to plastic that is durable enough to withstand shipping, stocking, freezing, and microwaving has long eluded researchers. A new substance developed by Ohio State University (OSU; Columbus) researchers could represent a crucial breakthrough.

The researchers based their solution on poly(3-hydroxybutyrate-co-3-hydroxyvalerate), a biodegradable polymer referred to as PHBV. The polymer is created naturally by bacteria and commonly used in orthopedic devices and pharmaceuticals. Previous attempts to create a plastic packaging substitute from PHBV concluded that the material was too flimsy on its own to use viably. But by adding natural rubber to PHBV during the chemical bonding process, the material becomes about 75% tougher and 100% more flexible than the polymer by itself, according to an OSU release.

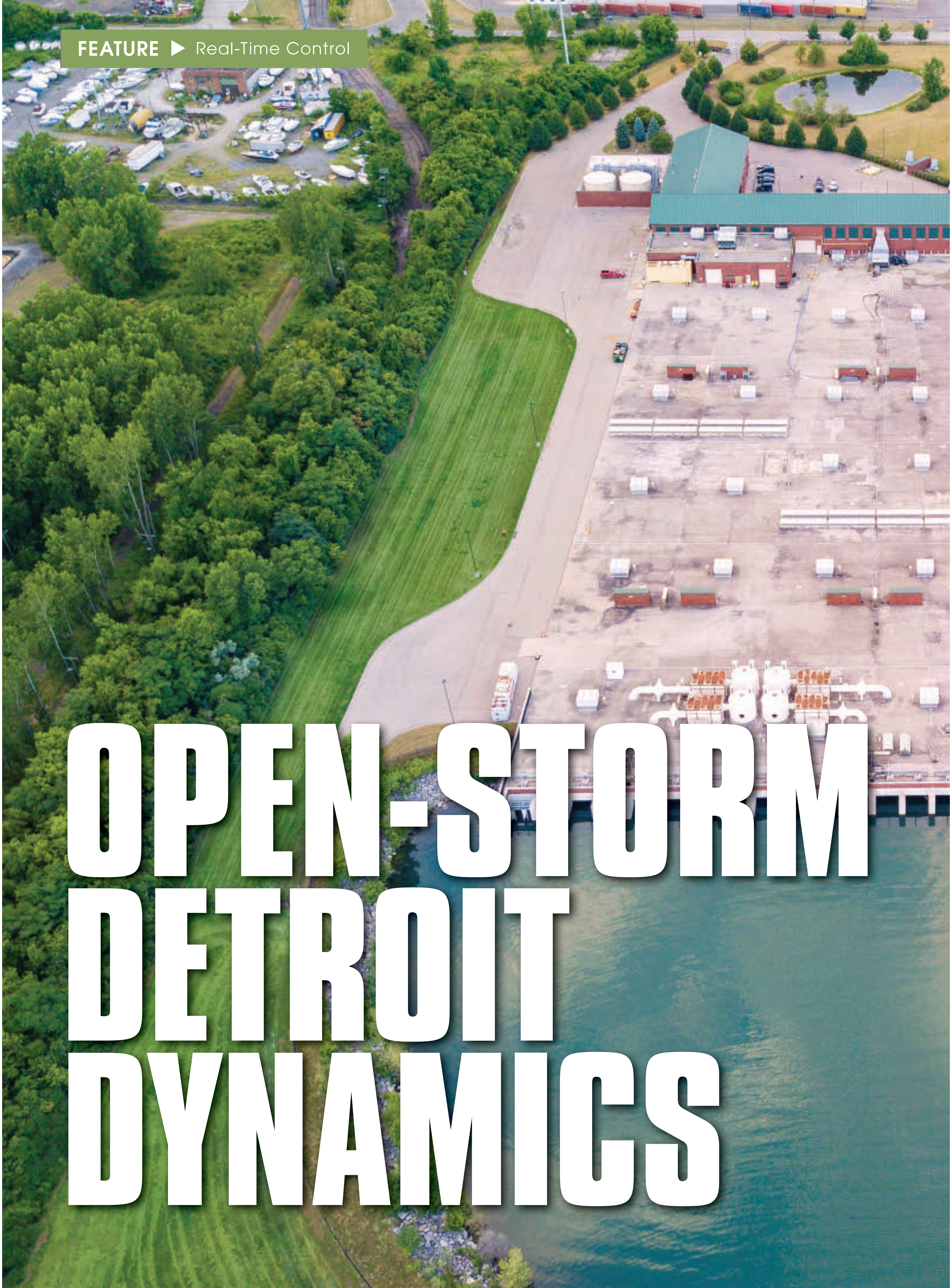
While adding rubber increases PHBV's toughness, it also reduces the material's strength by as much as 80%, explained study co-author Katrina Cornish, an OSU professor of horticulture and crop science. The difference means the polymer can withstand far less stress before losing its form.

"Imagine trying to pull a block of concrete apart with your hands. That's testing its strength. But karate chopping it with your hand or foot is testing its toughness — how easily it breaks," Cornish said. "You can never pull it apart, but if you're strong enough you can break it."

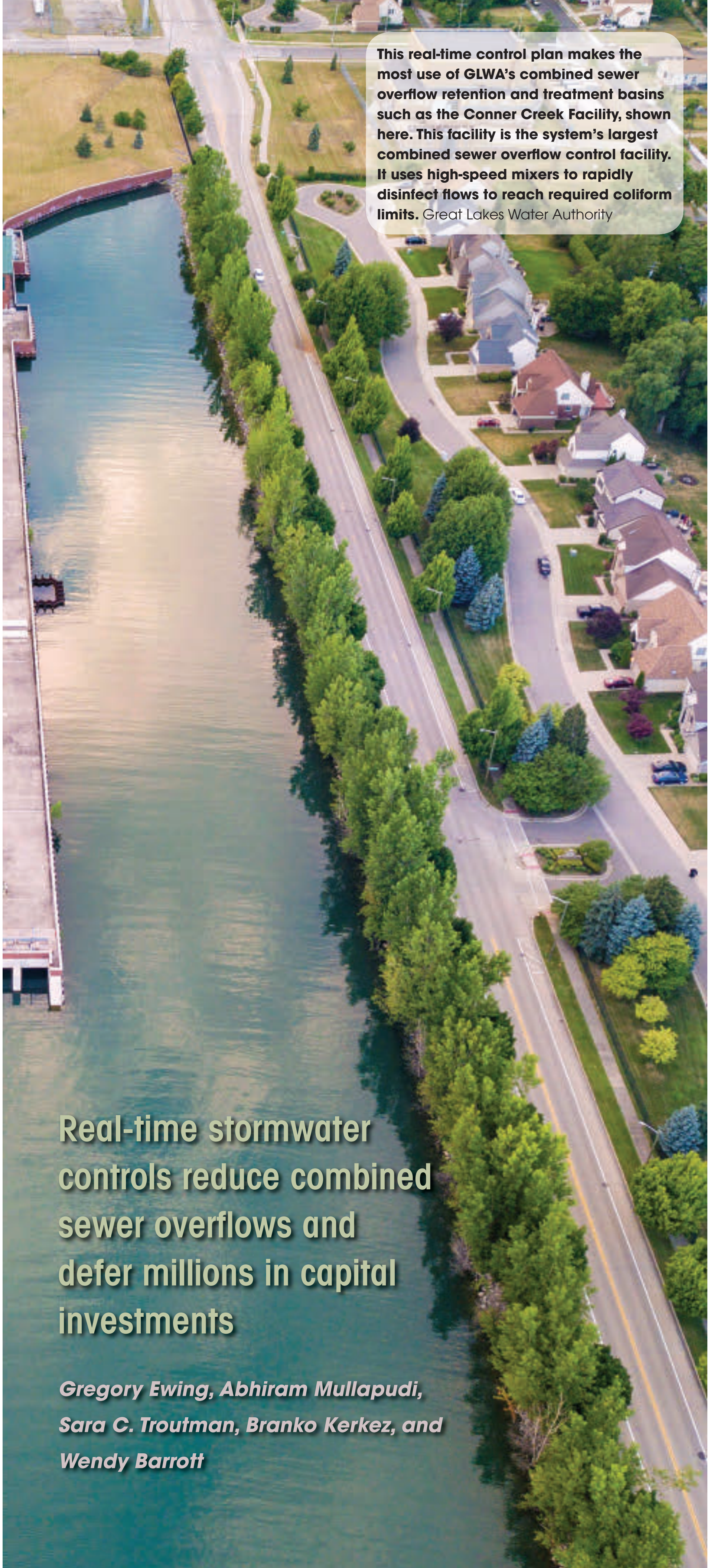
To create a PHBV-based material that is tough, strong, and flexible, the OSU team added two more ingredients during the bonding process: organic peroxide and trimethylolpropane triacrylate, which is a monomer commonly used to coat compact discs, hardwood floors, and other scratch-prone products.

The resulting polymer retained the toughness and flexibility of the PHBV and rubber mixture and led to reduced strength of of only about 30%, instead of 80%. The researchers are now exploring whether extra additives — such as tomato skins, eggshells, and even invasive waterway grasses routinely plucked by environmentalists — could increase the material's strength further, according to the OSU release.

Nonbiodegradable plastic in food packaging represents a major environmental concern, but previously developed biodegradable substitutes have not been durable enough for widespread use. Researchers from Ohio State University (OSU; Columbus) have developed a durable plastic substitute for food packaging using environmentally friendly materials. photosforyou/Pixabay



OPEN-STORM DETROIT DYNAMICS



This real-time control plan makes the most use of GLWA's combined sewer overflow retention and treatment basins such as the Conner Creek Facility, shown here. This facility is the system's largest combined sewer overflow control facility. It uses high-speed mixers to rapidly disinfect flows to reach required coliform limits. Great Lakes Water Authority

Real-time stormwater controls reduce combined sewer overflows and defer millions in capital investments

Gregory Ewing, Abhiram Mullapudi, Sara C. Troutman, Branko Kerkez, and Wendy Barrott

Real-time control of stormwater has the potential to improve system performance for a fraction of the cost of new construction. Through a utility–university partnership, the Great Lakes Water Authority (GLWA) and the University of Michigan are applying state-of-the-science technologies within a testbed of the Greater Detroit Regional Sewer System (GDRSS). Initial results from this effort are a real-time control algorithm simulation study that demonstrates the potential to reduce combined sewer overflows (CSOs) and a prototype implementation of a decision support dashboard powered by this real-time algorithm.

Motivated by the rise of autonomous technologies, such as self-driving cars, the goal of the project was to investigate the role of dynamic control on GLWA's collection system. Specifically, the team applied advanced data analytics to a wealth of existing sensor feeds to provide real-time recommendations for the operation of valves, pumps, and gates. The desired outcomes of dynamic, real-time control are to

- reduce combined sewer overflows;
- maximize current storage utilization by dynamically controlling pumps, valves, and gates; and
- equalize flows to GLWA's water resource recovery facility (WRRF).

The original design of the GDRSS was for CSO discharge. However, over time, customer and regulatory expectations of the system have changed such that today GLWA is in the process of updating its sewer system to significantly reduce untreated CSO discharges. GLWA estimates that construction of new CSO retention treatment basins (RTB) and green infrastructure to ensure that wet weather flows meet contemporary expectations may cost more than $1 billion.

However, a real-time control schema added onto stormwater operation presents a prudent opportunity to enhance the performance of existing assets, for an investment orders of magnitude less than new construction. As a guiding principle for this project, any solution would assist, not replace, the human operator in the management of the system by providing real-time decision support tools.

The Team

The Open-Storm Detroit Dynamics team is a utility–university partnership, bringing together the University of Michigan and

By maximizing in-line storage and equalizing flows, this control plan enables the GLWA Water Resource Recovery Facility to process more stormwater, which means better overall water quality in the area. Great Lakes Water Authority

GLWA. The team's goal is to enable GLWA's first generation of smart storm and sewer collection system control.

Combined, the team members offer years of experience in the operation and management of city-wide stormwater infrastructure and novel research in real-time control of intelligent water systems. The University of Michigan members of the team are part of the **Real-Time Water Systems Lab** in the department of Civil and Environmental Engineering, a research group internationally recognized in the area of smart water systems and, specifically, for the real-time control of stormwater systems.

Learn more about the Real-Time Water Systems Lab at tinyurl.com/bkerkez.

GLWA's System and Capabilities

The GLWA is a regional water and wastewater authority that services nearly 40% of the water customers in Michigan, including the City of Detroit and its surrounding suburbs — approximately 3.9 million customers. GLWA's combined sewer system experiences frequent CSOs to the Detroit and Rouge rivers. To combat these persistent untreated overflows, and with a National Pollutant Discharge Elimination System (NPDES) permit requirement to further reduce untreated CSO discharges, GLWA launched this real-time control project in late 2017 with the Real-Time Water Systems Lab. The project vision was to reduce untreated CSO discharges by first maximizing flows to the WRRF and then via treated outfalls.

Currently, GLWA has many of the components in their system necessary to realize dynamic control of their assets. GLWA leadership is committed to intelligent, data-driven solutions and supports infrastructure toward this end. GLWA, which has hundreds of sensors, operates a robust measurement and transmission infrastructure for flow, level, and precipitation measurements throughout the conveyance network. These field devices measure flow, level, rain, etc. every minute or even more frequently and report these data back through the GLWA supervisory control and data acquisition (SCADA) network. These raw data are available to operators in real-time via a web interface. Furthermore, GLWA currently operates its control structures (such as gates, pumps, and valves) remotely from a centralized system control center (SCC). Integrating the present capabilities, GLWA is well-positioned to incorporate dynamic control recommendations into their operations.

Turning Data into Information

A current trend in water and sewer systems is to increase instrumentation, providing unprecedented amounts of data on water levels, flows, and water quality throughout the system at any time. Yet, these raw *data* are not inherently *information* upon which someone can act. In fact, it is nearly impossible for any one person, or team, to analyze and interpret — in real time — the quantities of data that are generated in a system such as GLWA's. The GLWA SCADA systems consists of tens of thousands of points for all computer automated

equipment that are streaming in 24/7/365. These data are refined down to the most critical and shown on screens to provide operators an indicator of what is occurring in the system, allowing them to intervene or control the system as necessary. Given the number of points and complexity of the system, it can be easy to miss an opportunity to improve system performance, or perhaps, prevent flooding or a CSO discharge.

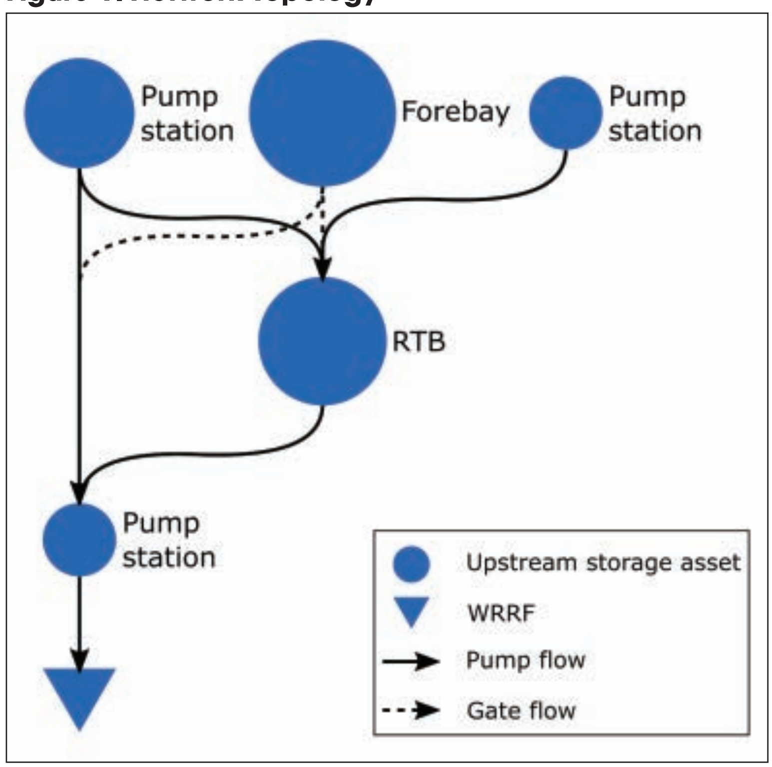
To leverage these data to their fullest potential, data analysis routines must be developed using local or cloud computing to aid operators in their decision-making. The strong data infrastructure and centralized control of assets present a great opportunity to improve GLWA system performance with the use of a decision support service layer.

The Plan

To test this idea, the team chose a subset of the larger system as a pilot. The pilot area was selected for the number and size of its controllable assets, including pump stations, inflatable bladder in-line storage dams, and 454 million L (120 million gal) of in-system storage. The in-system storage includes a 113 million L (30 million gal) retention treatment basin, and approximately 340 million L (90 million gal) of linear storage in the collection system. The operation of these assets plays an important role in both the flow to the WRRF and the quantity of CSO discharges the system may experience during a wet-weather event. Figure 1 (above) provides an idealized sketch of the major storage, control points, and their connections to each other.

With the pilot area chosen, the team then began developing control formulations based on historical precipitation events. Using these historical events as input to a stormwater model enabled the team to develop insights into the dynamics of the system and help inform how to

Figure 1. Network Topology



The size of the circles indicates the relative capacity among the upstream storage assets in the study area.

apply control algorithms on the controllable assets. Next, through an automated approach, the team systematically experimented in model space, with different parameterizations of control algorithms and tracked the theoretical outcomes. (The sidebar on p. 34 describes the algorithm.)

The best performing parameterization — that is, minimized CSO discharge while maximizing volumes to the WRRF and storage use — was then deployed on historical wet-weather events within the model environment to measure its efficacy. Finally, the team implemented this tuned algorithm in a decision support engine. The engine uses flow, level, and system state data (pump, gate, and valve status) from the GLWA network in real-time to provide control suggestions to the SCC operators through a web-based tool. Figure 2 (right) sketches out the basic elements of the plan to-date for this effort.

Implementation and Analysis

The team tested load-balancing control with an EPA SWMM input file representing a portion of the GLWA combined sewer collection system. Control actions are made during a simulation via **PySWMM, a Python language wrapper** for SWMM. Each controllable asset consists of an actuator — valve, gate, or pump — and an upstream storage element. These storage elements usually represent in-line structures or retention basins with significant storage volumes (millions of gallons). Downstream elements are conduits or storage basins that are at the confluence of upstream controllable flows. The results presented in the table on p. 33 were generated by applying the best performing parameterization across a variety of storm events, including the calibration storm event. Performance of the algorithm for each event was compared with a baseline value, calculated by running the simulation with an original version of the SWMM input file developed by GLWA and its consulting engineers. This model reflects current operating procedure and can be considered current "best practice" by GLWA.

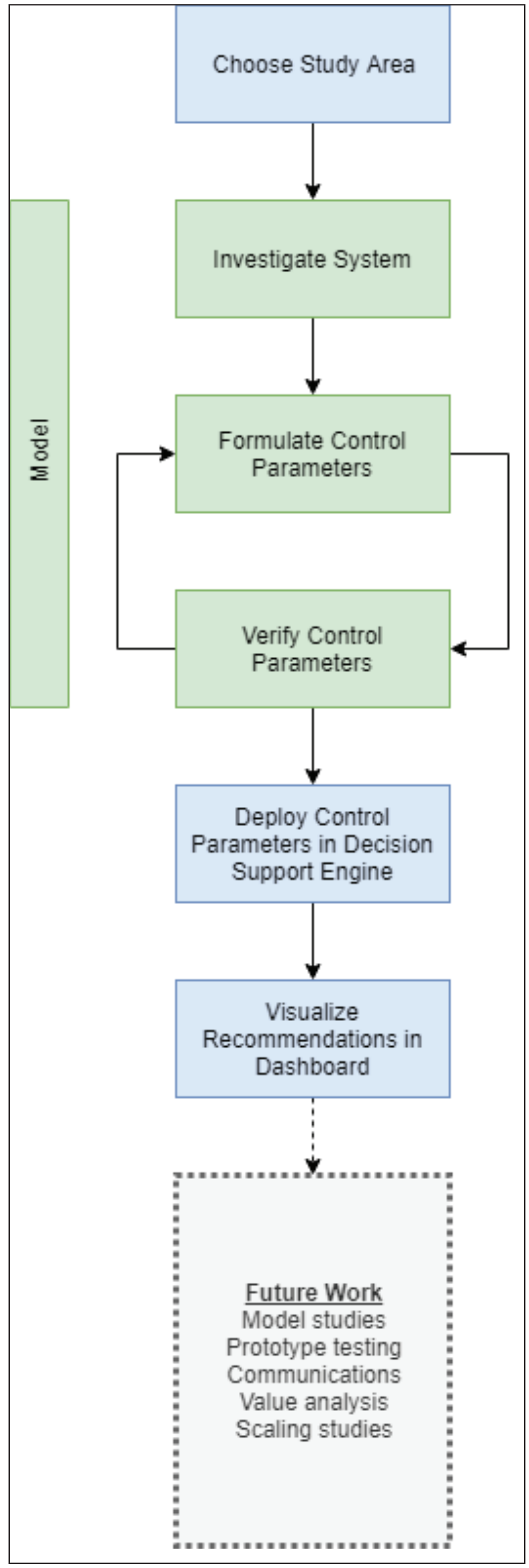
On the calibration storm event (16-hour duration, 1 in.) the team achieved a 77% reduction in CSOs using the load-balancing control algorithm. This parameterization was then used to make control decisions during simulation of four new storm events which, taken together, account for a range of event durations and depths.

For more information, see https://github.com/OpenWaterAnalytics/pyswmm)

Open-Storm Detroit Dynamics: Open to All

The freely available, open source technologies and algorithms used in the study were developed by the team with the support of the Great Lakes Protection Fund and the National Science Foundation's Smart and Connected Communities program: Open-Storm.org.

Figure 2. The Open-Storm Detroit Plan



Comparison of Outflow Volumes for Storm Events Using Current Operation Procedure (Baseline) Versus the Dynamic Control Algorithm

Event Date	Event Type	Event Duration	Precipitation Depth (in.)	Total CSO Volume (millions of gal)			
				Baseline	With Real-Time Control	Volume Reduction	Percent Reduction
4-May-17	Calibration	16	1.0	130	30	100	77%
11-May-18	Evaluation	96	2.8	1,666	1906	–240	–14%
2-Jun-18	Evaluation	1	0.7	47	46	1	2%
31-Jul-18	Evaluation	8	1.3	1,318	1274	44	3%
31-May-15	Evaluation	28	2.0	842	735	107	13%

Figure 3 (below) demonstrates the effect of the control approach on the inflow to the WRRF and the volume of CSOs during a storm event compared to the baseline scenario. During this event, there is a reduction in CSO volume of approximately 405 million L (107 million gal) — that's about 13% less volume compared to the baseline case for this storm event. Additionally, focusing on the inflow to the WRRF, the recession limb trails off more quickly and maintains a constant value of approximately 14,000 L/s (500 ft^3/s) at the end of the storm event, indicating that we can quickly stabilize to an inflow setpoint.

Similar positive results were observed for most other storm events using this parameterization of the algorithm. Note that the durations and precipitation depths for the evaluation events differ from the calibration event. Thus, the parameters identified during the single-event calibration are not likely to be optimal for the range of events evaluated. This suggests that further analysis is necessary to deliver event-dependent parameterizations that are known to perform well. Moreover, these results were achieved simply by using the storage capacity already present in the system, meaning no major capital investments from the utility would be required to have a significant effect on both CSO volume reduction and equalization of inflows to the WRRF.

Communication and Use

To communicate these recommendations, the team developed a decision support dashboard, shown in Figure 4 (p. 34). The design principle was to go beyond raw data to provide actionable information.

The dashboard will present to the operator the current state of the system as well as the recommended actions calculated by the control engine. For many of the control locations, this information is distilled into the number of pumps running or gates open in the system versus what the

Figure 3. Real-Time Control Versus Baseline

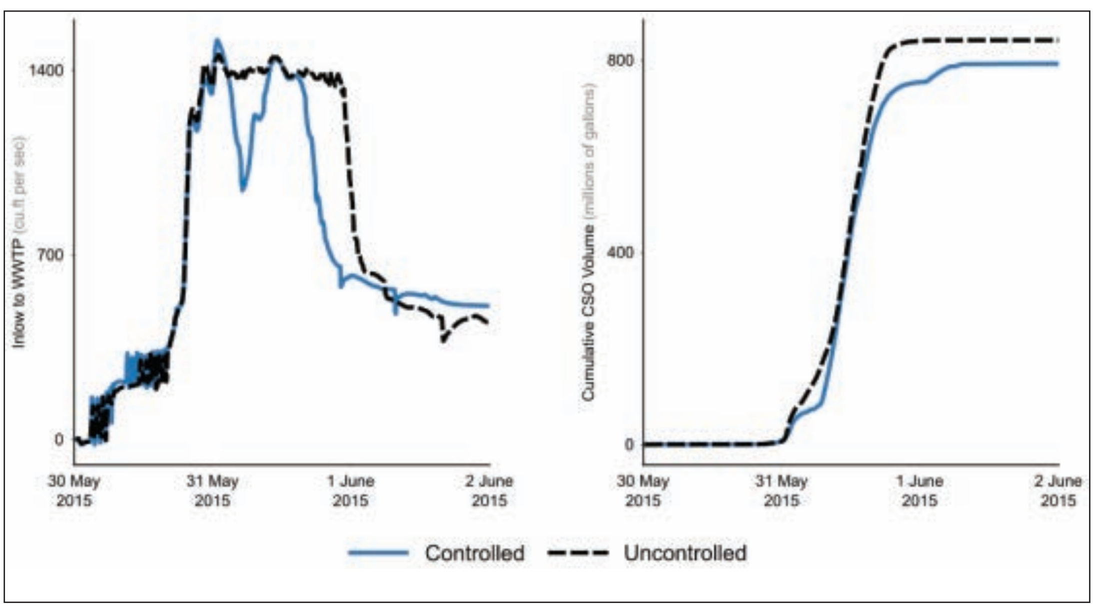
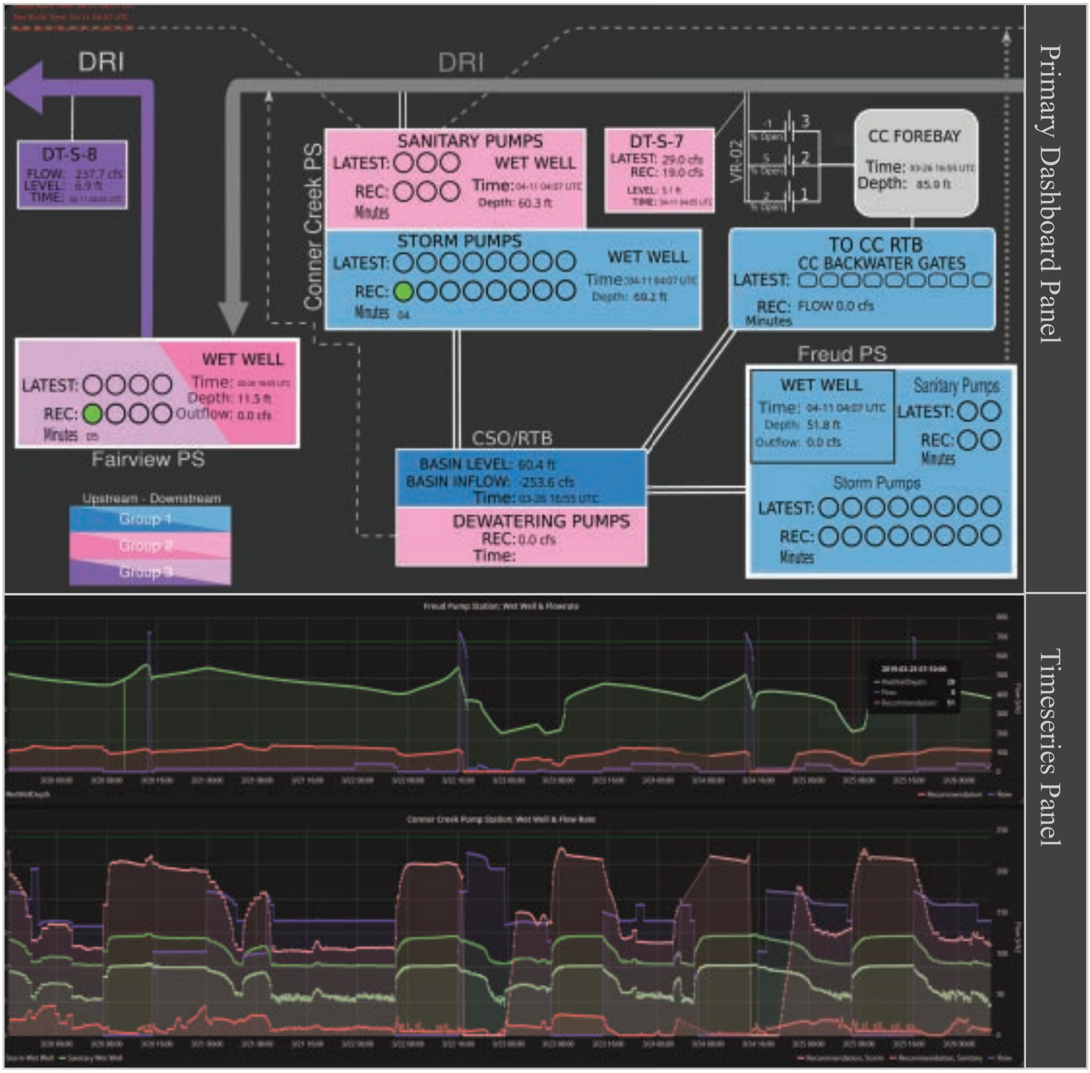


Figure 4. Real-Time Control System Dashboard



The Control Algorithm

This control algorithm is light-weight enough to be implemented in real-time, providing operators with recommendations of system-wide control actions during a storm event. In operation, the algorithm only uses the latest sensor readings from the system — not requiring a collection system model or extensive computational resources.

The control algorithm employed seeks to balance the capacity of any assets that can be controlled. Control decisions are made by allocating downstream volumetric capacity amongst the fullest upstream storage assets — such as pump stations, storage basins, and inflatable storage dams — respective to the average load across the system. The downstream point has an operator-defined setpoint to achieve; the downstream capacity is determined as the current volume above or below this setpoint.

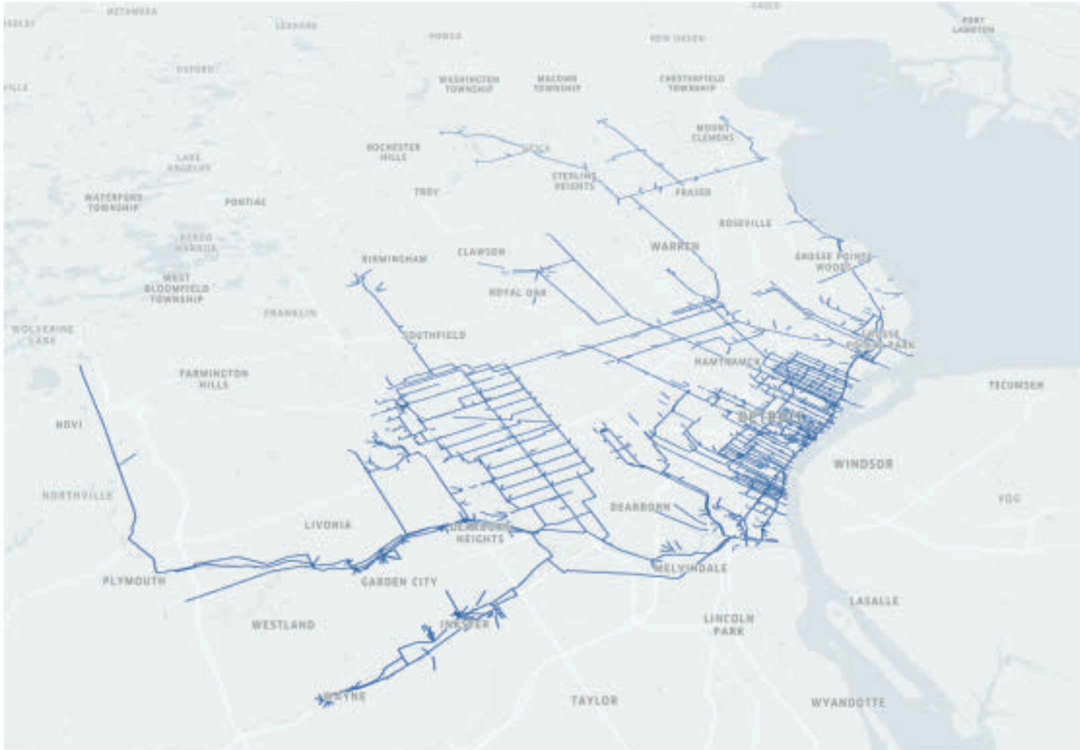
More information on load-balancing control can be found at tinyurl.com/OSDetroit.

control algorithm would recommend. Beneath the main panel are time series plots, showing system measurements and recommendations throughout time. This not only enables users to explore the dynamics of the system throughout events, but also displays the record of recommendations and how closely they were followed.

Future Work

This preliminary investigation suggests that application of real-time control and a decision support engine can play a role in GLWA's efforts to reduce untreated CSO discharges. The team has identified the following focus areas to improve the robustness of the application.

- Model studies: Investigate the behavior and performance of algorithm parameterizations using a large data set of precipitation events.
- Prototype testing: Use and monitor the decision support tool during wet weather events.
- Effective communication: Work with operators to improve recommendation communications



The team modeled a portion of the collection system as a pilot project. The area was selected for the number and size of its controllable assets, including pump stations, inflatable bladder in-line storage dams, and in-line storage capacity. Abhiram Mullapudi

within the dashboard.

- Value added: Analyze records of recommendations and operator actions to estimate the value add of the control recommendations.
- Translation: Establish methodologies and procedures required to move from prototype to operational use.

A Real-Time Solution

The takeaways from this research are as follows:

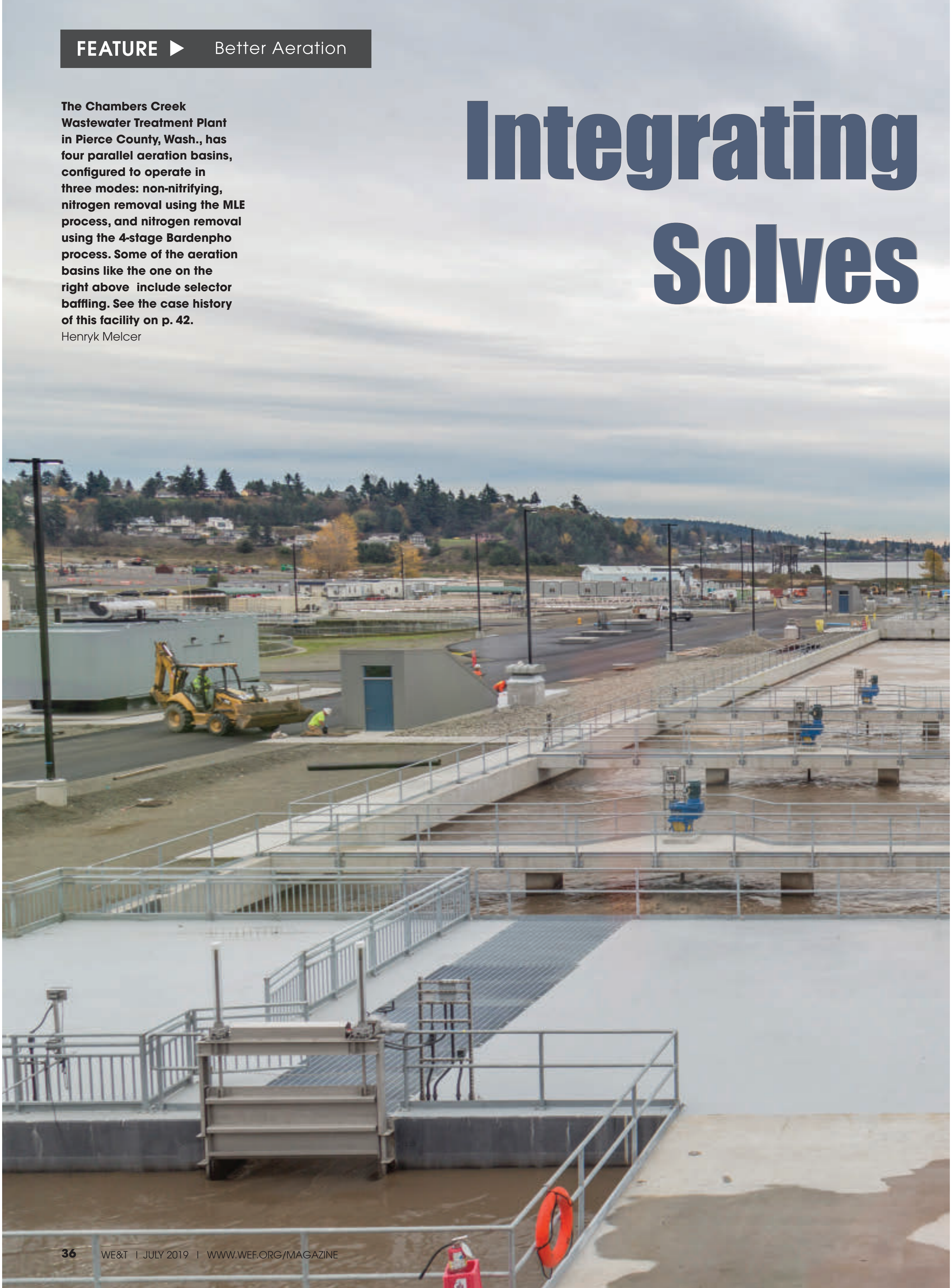
- With minimal capital investment, the team has been able to demonstrate, in computer simulations, a reduction in CSO volumes by increasing the utilization of sewer storage capacity informed by a load-balancing control algorithm.
- Increased utilization of as-built sewer storage capacity could help GLWA avoid significant capital investment to meet their performance objectives. Further studies are required to understand the value added within the testbed and across the whole system.
- The dashboard provides a one-stop visualization tool, displaying control recommendations in the context of the real-time state of the sewer network.

This project also won first place in the first-of-its-kind LIFT Intelligent Water Systems (IWS) Challenge at WEFTEC® 2018. This competition offered students, professionals, and technology experts the opportunity to combine their talents and innovation with tools and data to help utilities better understand the dynamics of complex systems for making better decisions and demonstrating the value of advanced sensing and/or data technology. Nineteen teams competed, but the 21 judges chose Open-Storm Detroit Dynamics as the winner of the $25,000 first prize.

__Gregory Ewing__ is a Ph.D. student at the University of Iowa (Iowa City, Iowa). __Abhiram Mullapudi__ and __Sara C. Troutman__ are Ph.D. candidates at the University of Michigan (Ann Arbor, Mich.). __Branko Kerkez__ is Associate Professor at the University of Michigan (Ann Arbor, Mich.). __Wendy Barrott,__ MSE, is Manager of Research & Innovation for the Great Lakes Water Authority, (Detroit). __Christopher Nastally,__ PE, is Manager of CSO Control Program for the Great Lakes Water Authority (Detroit).

GLWA project contributors include Biren Saparia, Mini Panicker, Anthony Troy, Jenny Casler, David McCord, Matt Starrman, Eric Griffin, Betty Thomas, Andrea Busch, Adrian Taylor, and Joe Burchi.

Integrating Solves



The Chambers Creek Wastewater Treatment Plant in Pierce County, Wash., has four parallel aeration basins, configured to operate in three modes: non-nitrifying, nitrogen removal using the MLE process, and nitrogen removal using the 4-stage Bardenpho process. Some of the aeration basins like the one on the right above include selector baffling. See the case history of this facility on p. 42.
Henryk Melcer

Aeration Control Underperformance

Problem aeration systems need a systematic approach to correct control and process shortcomings and to optimize performance and energy savings

Henryk Melcer, Tom Jenkins, David Redmon, Adam Klein, and Amanda Summers

Secondary aeration is the core of the treatment process in most municipal water resource recovery facilities (WRRFs). Operators have two objectives in optimizing performance: process and energy improvement. Automation is sought out to help achieve these goals.

Unfortunately, the promise of advanced process and control technology is not met in some facilities. Process and aeration systems fail to meet design objectives or projected energy consumption values. Operators struggle to maintain stable operation. These problems often are compounded by discrepancies between design and current loads. Internal side streams and industrial slug loads add to operational challenges. Ineffective control strategies can be the cause of process problems, excess energy consumption, and considerable operator aggravation in many facilities.

A procedure has been developed to determine and implement corrective measures for these problems. A combination of data collection, analysis, and control implementation has proven successful in providing stability and efficiency.

Process Fundamentals

To understand how this procedure can help first requires understanding the underlying interdependencies within a treatment system.

When problems arise in aeration basins (ABs), they dramatically affect process and energy improvement objectives. Settleability is related to AB environmental conditions and clarifier physical characteristics. Low dissolved oxygen (DO) concentrations stimulate filamentous growth and lead to poor settling. Oxygen transfer characteristics will dictate the level of DO that is achievable, particularly with fine pore aerators and high mixed liquor suspended solids concentrations. Excess oxygen results in wasted energy.

Increasing process complexity increases operating challenges. Discharge permits that require low concentrations of organics and nutrients create higher demands for operational consistency.

Automation strategies often fail to provide consistent control of process equipment. Advanced systems include analytical instruments developed specifically for wastewater treatment processes. Communications systems allow integrating process requirements, aeration control strategies, instrumentation, final control elements and controllers. Most-open-valve (MOV) and advanced DO control strategies are designed to minimize energy consumption. Ammonia-based aeration control produces low DO concentrations that stimulate simultaneous nitrification–denitrification.

Step 1 – Data Collection

The first step is collecting accurate process and energy performance data. This is the most critical step, because all subsequent activities rely on accurate data. It establishes the baseline data for defining the success of corrective measures and provides direction for these corrections.

Design documents are examined to determine the basis of design for loading, discharge expectations, and energy demands. It is tempting to take these values and go directly to the analysis step. However, experience has shown that actual process loads and performance can vary significantly from design expectations.

Given the dynamic and variable nature of municipal systems and the complex relationships among unit processes, it should not be surprising to find divergences.

Wastewater characterization data are examined, covering a time span sufficient to characterize the process and identify performance issues. Supervisory control and data acquisition (SCADA) trends and archived data can be correlated with laboratory data to clarify relationships and concurrent events. Actual DO concentrations, system air flows, blower power draw, and hydraulic loading are key factors. It is important to examine the available data for both the overall facility and for individual ABs.

Verification of actual equipment performance is critical. Blower flow, pressure, and power typically are tracked in SCADA and should be compared to original design expectations. This often highlights air flow or pressure excursions that indicate instability.

Field testing of diffused aeration performance can provide important insights to the process performance. The preferred method is *in situ* off-gas testing of each AB, using procedures defined in *Standard Guidelines for In-Process Oxygen Transfer Testing*, ASCE/EWRI Standard 18-18. This method can provide information on the spatial variation of the oxygen uptake rate (OUR), actual oxygen transfer rate (AOTR), field oxygen transfer efficiency (OTE_f), and alpha as a function of tank location. Alpha is the ratio of oxygen transfer in process water to oxygen transfer in clean water. These data, in combination with the desired DO profile, can be used to optimize the diffuser layout.

Off-gas testing can identify inadequately performing automation. Insufficient, excess, and erratic DO concentrations frequently occur when the aeration control system cannot match

Case History No. 1 – Bucklin Point Wastewater Treatment Plant in Rhode Island

Bucklin Point uses the Modified Ludzack-Ettinger (MLE) process for nitrification–denitrification. The facility is designed for an average daily flow of 174,000 m^3/d (46 mgd); actual dry weather flow was approximately 91,000 m^3/d (24 mgd) when Step 1 of the procedure was initiated. The facility's effluent permit required a monthly average of 8.5 mg/L total nitrogen. Three, geared, single-stage centrifugal blowers, 450 kW (600 hp) each, provide air for four plug-flow ABs with four diffuser grids per AB.

The initial control strategy was consistent with standard practice. Each grid included a control valve, air flow transmitter, and dissolved oxygen (DO) transmitter. PID logic was used to control DO, with the output of the DO loop providing the setpoint to a PID loop for grid air flow control. A programmable logic controller (PLC) employing PID logic was provided for each blower and a master panel PLC controlled all aeration basins and coordinated blowers using pressure control. MOV logic was based on adjusting the pressure setpoint. The PLCs were networked to each other and to the SCADA system.

On-site testing confirmed that blower performance met design requirements.

The Problem

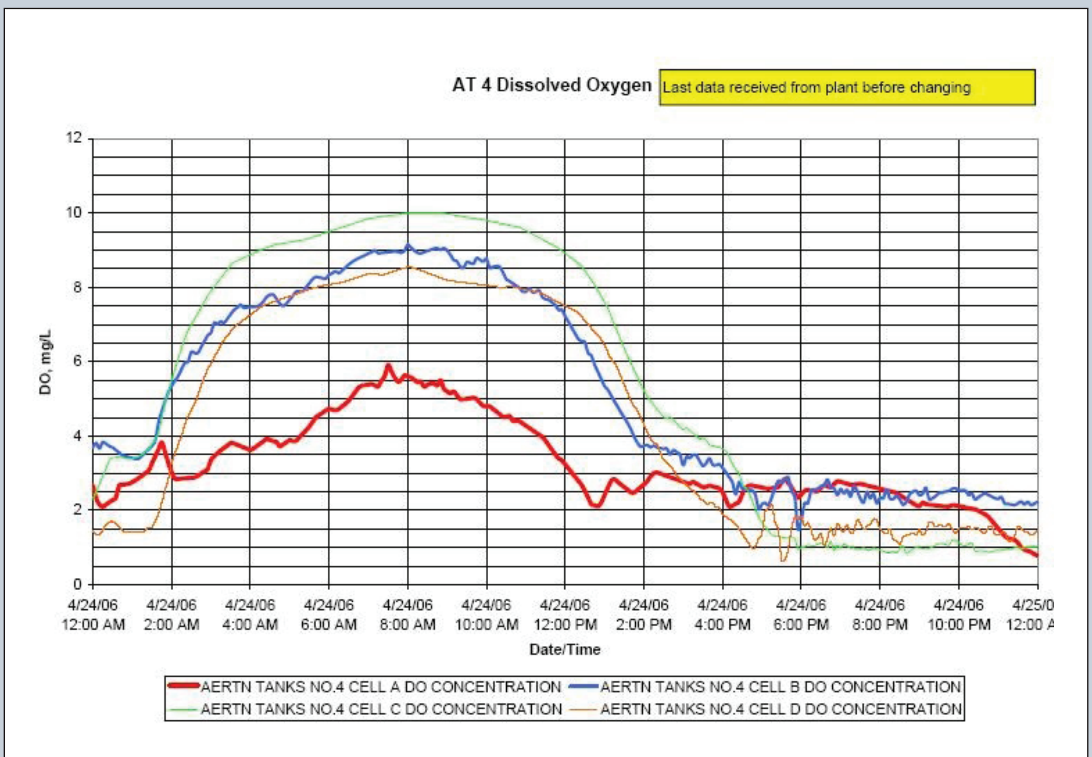
Following commissioning, the facility experienced aeration/blower control system problems. It was unable to adjust to changing process conditions and maintain proper DO concentration in the aeration basins, resulting in insufficient conversion of ammonia nitrogen to nitrate.

Denitrification was being inhibited by high DO in the internal mixed liquor recycle (IMLR) flow to anoxic zones. Energy consumption and costs exceeded expectations. A utility rebate was jeopardized because the pressure-based MOV logic was ineffective. Operations staff had to use manual operation to maintain process compliance.

Analysis determined that the blower operating range was capable of meeting process fluctuations, including turndown requirements.

continued on p. 40

Bucklin Point Dissolved Oxygen Performance Before Upgrade



The control hardware and instrumentation were properly sized and would be capable of providing the required control precision. It was determined that the control logic was the source of the problem.

The Fix

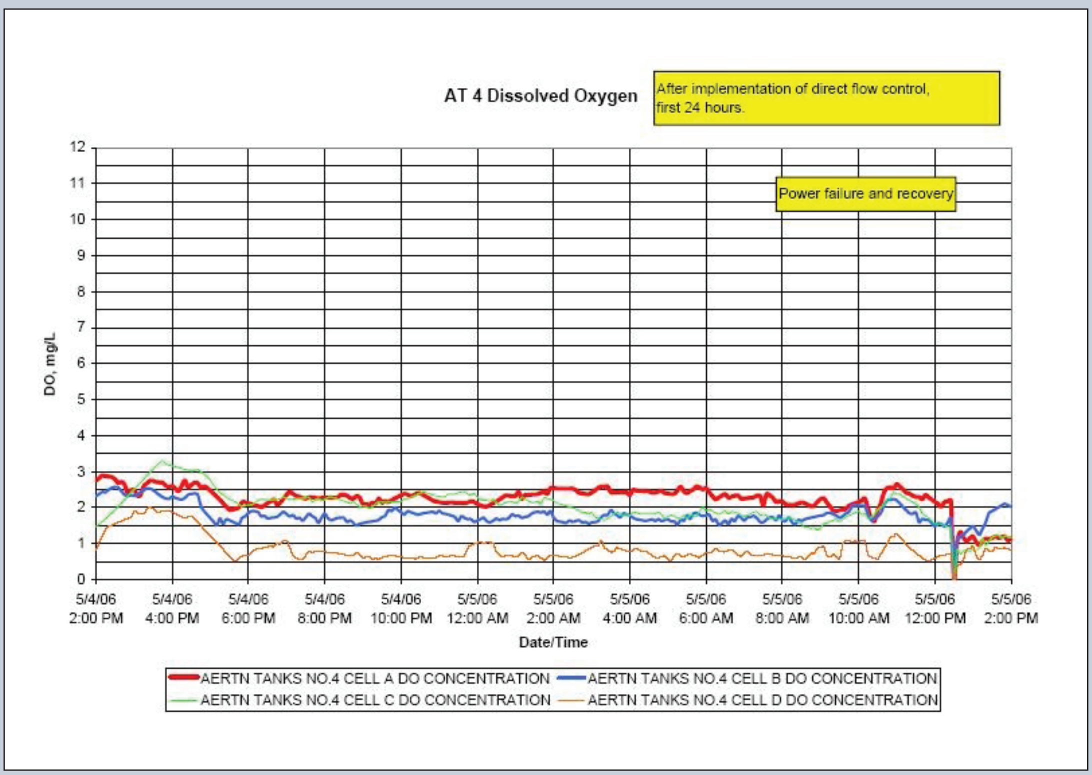
After assessing the system, several changes were made to the aeration control strategies. Floating control logic replaced PID for DO, zone air flow, and blower control. Pressure control was eliminated, and direct air flow control based on process air demand was implemented for the blowers. The MOV logic was modified to use zone air-flow demand and actual valve positions.

The results of the energy conservation measure (ECM) implementation were as follows.

- Aeration system energy consumption and costs dropped below original projections (and the utility rebate was secured).
- DO excursions declined to less than 0.50 mg/L from setpoint.
- The reductions in DO excursions reduced oxygen in the IMLR flow, which no longer inhibits denitrification.
- MOV logic is effective in minimizing blower discharge pressure (and associated energy consumption).
- Operator intervention with the aeration system (manual control) is no longer required to achieve discharge compliance.

Additional details provided by the authors on the Bucklin Point improvements may be found in the EPA publication *Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities*, EPA 832-R-10-005.

Bucklin Point Dissolved Oxygen Performance After Upgrade



process variations. Off-gas testing often reveals field instrumentation that is poorly or incorrectly calibrated.

Comparisons between measured and design performance data can highlight discrepancies between actual and anticipated performance. Solids retention time (SRT) changes OTE by affecting alpha. Differences between design and operating SRT levels also affect OUR. It is common in ABs with multiple aeration zones to find the diffuser distribution doesn't optimize AOTR or match process demand.

One of the most critical steps in the initial data gathering is operator interviews. This should include as many categories of staff as possible. In addition to process control and laboratory personnel, mechanics and electricians often provide insights to equipment concerns that affect process performance and energy use.

Step 2 – Analysis

The next step consists of using the collated data for analysis of equipment and process performance. This consists of a combination of conventional calculations and computer modeling.

Computer modeling software has evolved and has impressive capabilities. Modeling the existing system and loads can confirm that the waste is properly characterized by conformance with the performance data from Step 1.

Once the accuracy of the waste characterization and the equipment process configurations are confirmed, the effect of proposed changes can be analyzed. The model can be used to indicate if changes in the process configuration will be beneficial. The model also can be used to project the effect of future loading changes on performance and blower demand. It also can facilitate comparisons among existing flow and load distributions as well as under optimized conditions. Diurnal variations in flow and loading can be modeled and transient problems highlighted.

Conventional analysis can verify the adequacy of the existing blower system and controls. Modeling can identify the demands on the aeration blowers. The flexibility of the system in meeting low and high air demands can be confirmed. Existing manufacturer performance data can be used for the analysis, but care must be exercised to correct to expected variations in ambient and discharge conditions. Turndown limits often restrict performance, particularly in nutrient removal processes.

Investigating the adequacy of the existing aeration controls is a key component of this step. Responsiveness and stability are the primary concerns. Most facilities employ a traditional aeration control strategy, with independent DO and air flow control logic for each zone. Blower control logic is not directly linked to the aeration zone controls; the SCADA system or a master control panel (MCP) are used to indirectly coordinate the blowers and the aeration basins through pressure. In many systems, cost reduction efforts have eliminated the flow measurement, attempting to manipulate the control valves directly from DO error.

Proper sizing of control components is as important as right-sizing blowers. Oversized control valves make accuracy impossible to achieve.

Proper sizing of control components is as important as right-sizing blowers. Oversized control valves make accuracy impossible to achieve. Improperly ranged flow meters or poor piping conditions will produce results that are neither accurate nor repeatable.

Step 3 – Corrective Actions

The first two steps are directed toward enabling the third step: recommendations for corrective actions and their implementation. This step usually is conducted in stages, with the results of each change measured and verified as consistent with the projections. The stepwise implementation is dictated partially by technical considerations because it is prudent to confirm the analysis results were accurate.

Stepwise implementation also is influenced by economic considerations because municipal facilities usually are limited by budget constraints. The value of each change should be determined, based on initial cost, degree of process improvement, and reduction in energy cost. High-value items should be implemented first.

There are many options available for consideration in this stage. Some consist of

Case History No. 2 – Chambers Creek Wastewater Treatment Plant in Pierce County, Wash.

The Chambers Creek facility is an activated sludge facility designed for up to 170,000 m^3/d (45 mgd) maximum month flow. It has four parallel aeration basins (ABs), configured to operate in three modes: non-nitrifying, nitrogen removal using the Modified Ludzack-Ettinger process, and nitrogen removal using the 4-stage Bardenpho process.

Facility Concerns

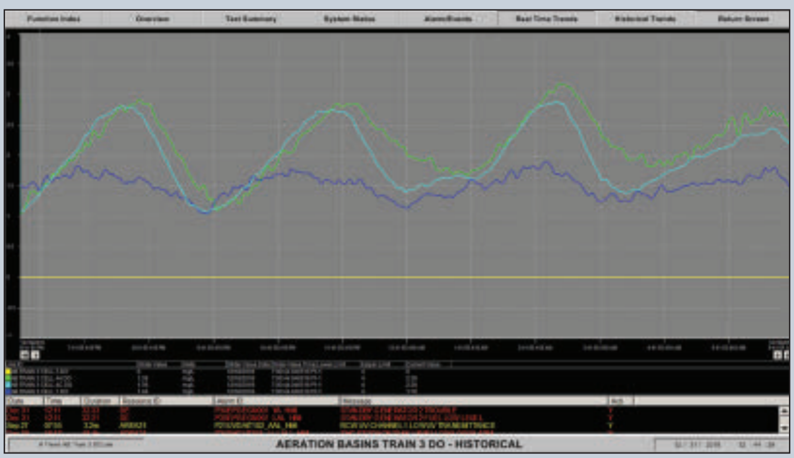
The staff reported that, of the four high-speed blowers available, two or three were operating most of the time and occasionally air flow limitations were experienced during weekends. Several potential process reasons were investigated, including changes in influent wastewater and side stream characteristics, SRT, air flow per diffuser, and dissolved oxygen (DO) control strategies.

No significant changes in influent and side stream characteristics were noted compared to the design assumptions. The facility had been operating in a non-nitrifying mode at a low SRT (2 to 3 days) since startup.

Facility staff had concerns over the stability of the DO control system. The DO concentration for all three aerated zones exhibited hunting, oscillating between target DO ± 1.5 mg/L as shown in the before portion of Figure 1 (below). Hunting is a cyclic disturbance of the controlled parameter with excursions above and below the acceptable operating range.

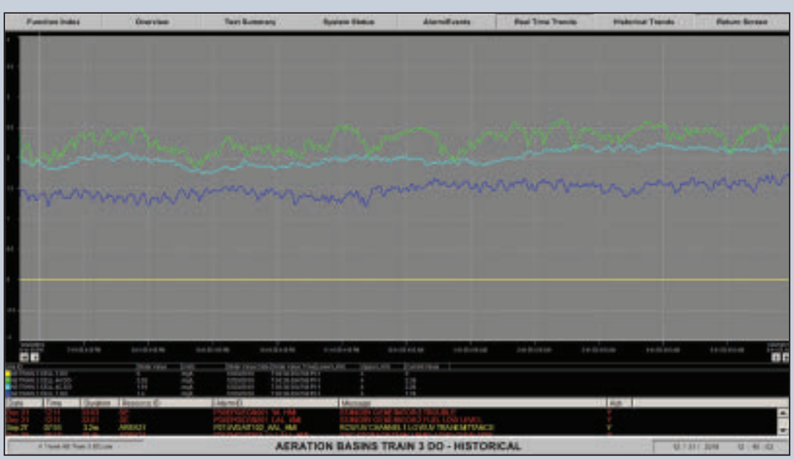
The aeration control system is divided into four air flow and DO control zones in each basin. Each zone is instrumented with air flow meters and motor operated valves, with DO probes in aerobic and swing zones. The system used PID loops for controlling DO concentration in each zone. The output of the DO control loop was used to directly manipulate the butterfly valves.

Figure 1. Effect of Control Strategy Change on Dissolved Oxygen



DO plots during 12 hours for aeration zones 4A (green), 4C (light blue) and 7 (dark blue) both before and after control strategy changes show the drastic difference in stability.

Before



After

The blower controls used PID logic to maintain discharge pressure. MOV logic manipulated the air pressure setpoint.

The PID control loops for blowers and DO could not be tuned to perform properly across the entire operating range, causing instability. Because of pressure limitations, it was not possible to run less than two blowers, regardless of process air demand; with two blowers at low demand conditions, there was excess power draw.

Alpha Measurement

Operation at low SRTs (~3 days) often is associated with low alpha values. Nitrification increases alpha as the organics that depress alpha are removed. An off-gas test was conducted at several locations within AB3 to measure alpha. The rate of off-gas evolution typically is measured for each off-gas collection hood sampling position employed and each test condition. AB 3 was in non-nitrifying mode.

The results indicated a low alpha value at the inlet to the first aeration zone. The first two hood locations produced alpha(F) values in the range of 0.22 to 0.26. All the following hood locations produced alpha(F) values in the range of 0.36 to 0.52 (day 1), 0.41 to 0.49 (day 2) and demonstrated the reduction in alpha at low SRT operation.

This effect was observed when the facility changed operation from non-nitrifying mode (3-day SRT) to nitrifying mode (15-day SRT) on April 1, 2019. The modeled air demand (calibrated to the values from the off-gas test) was compared to the measured air demand. Initially, there is good agreement between the two values but they begin to diverge as the SRT increases and nitrification begins at the mid-month period, eventually diverging to a difference of about 115 m^3/min (4,000 ft^3/min) by month end. (See Figure 2, below.) Indirectly, this showed that alpha had increased because the air demand was much lower than the model (with the lower alpha value) was forecasting.

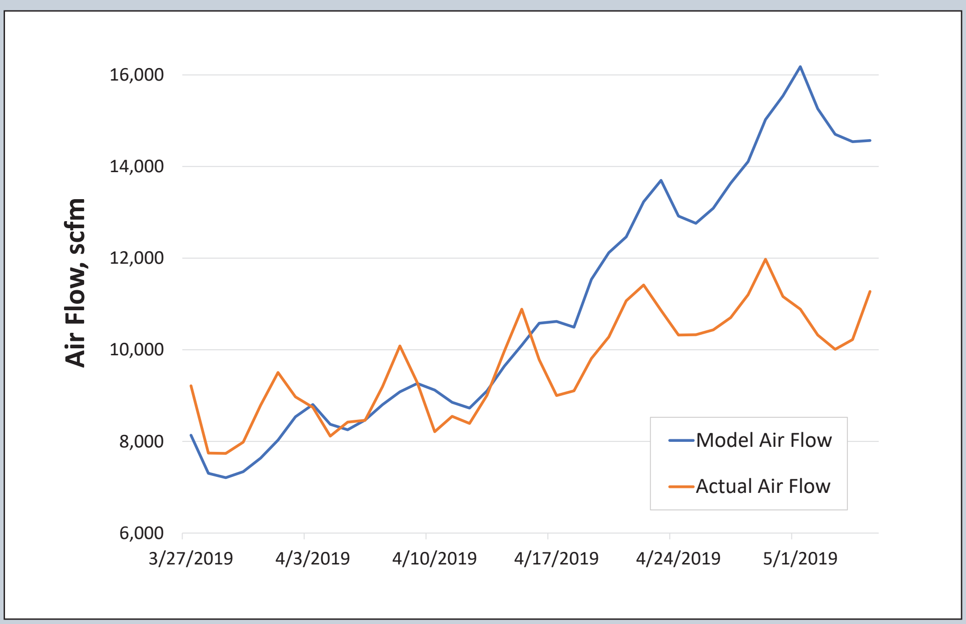
Off-gas data also indicated that the tapered diffuser spacing was nearly optimum.

DO Control Modifications

The aeration control strategy was revised, with floating control in place of the PID control loops. Direct airflow control replaced pressure control, with cascade loops of DO, air flow, and valve control. Advanced MOV logic was based on zone airflow and valve position.

The result was stable control of DO concentration (see the after portion of Figure 1) with DO oscillating between target DO ± 0.5 mg/L. Lower energy consumption resulted from minimizing blower discharge pressure and optimizing air flow rates. No modifications to the instrumentation hardware were required. Improvements were achieved by simply updating control strategies.

Figure 2. Modeled Versus Measured Airflow at Chambers Creek WWTP



Off-gas testing at the Chambers Creek Wastewater Treatment Plant measured alpha values. The results indicated a low alpha value at the inlet to the first aeration zone. See the case history of this facility on p. 42.
Henryk Melcer

operational changes that do not require capital investment.

- Taking underloaded aeration basins out of service may face operator resistance, but it can improve nutrient removal and typically will reduce energy use.
- Modifying internal recycle rates also can improve nutrient removal. The results of the modeling should be used to optimize SRT, return activated sludge (RAS) rate, and waste activated sludge (WAS) rate.

It is very common for failure of instrumentation and control systems and the resulting instability to cause or exacerbate process issues. This is true even if the systems use standard practices. Control strategy upgrades typically include replacing proportional-integral-derivative (PID) control with floating control and using cascade control: DO to air flow control to valve control in individual control zones.

Increasing the number of DO control zones often reduces energy demand and improves process control by tapering aeration level to match demand. Eliminating pressure control and, instead, pacing blower capacity directly from AB air demand improves both stability and energy efficiency. Implementing automatic blower starts and stops based on AB demand will have a similar effect.

Other changes require modifications to the process equipment. Capital expense is a concern for these changes, and some may require regulatory approval. Adding or modifying AB baffles can optimize nutrient removal and control filamentous organisms for improved clarifier performance. Installing classifying selectors also may help improve foam removal.

Blower systems often are candidates for modification. The emphasis often is placed on more efficient blowers, but adding or replacing blowers to achieve adequate turndown may be more effective. This enables meeting actual current and near-term loading demands in systems with excess capacity.

Optimizing biological nutrient removal to reduce chemical treatment is another upgrade with both process performance and operating cost benefits.

Providing control devices for individual diffusers grids or zones in each AB has multiple advantages. Tapering the aeration level as biological treatment progresses reduces energy. Zone control allows operators to reduce DO concentration in internal recycle streams. This in turn enhances nutrient removal.

The case histories on pp. 39 and 42 show the applicability and results of this process.

Trust the Procedure

When confronted with an underperforming WRRF, it is tempting to jump to conclusions. It is natural to consider the original design as definitive, particularly when it is based on standard practice. However, the procedure above will provide a higher level of confidence in the results — although it may be more time consuming.

It is important to avoid entering the procedure with preconceived notions. By establishing detailed process and energy baseline data the analysis will be more effective and the results more reliable. This, in turn, facilitates generating high value corrective measures.

The limitations of applying PID loops for controlling the nonlinear oxygen transfer process under constantly changing environments are not well understood. Using floating control is a more stable approach that does not require periodic re-tuning of PID control. Substituting direct airflow control for pressure control is underutilized and should be implemented more widely. Off-gas testing generates an understanding of process limitations in oxygen transfer and the inhibition of biological nutrient removal processes. It is important in formulating aeration control strategies and the selection of instrumentation.

The final objective is providing operators with reliable tools to help them consistently meet treatment objectives while minimizing operational costs.

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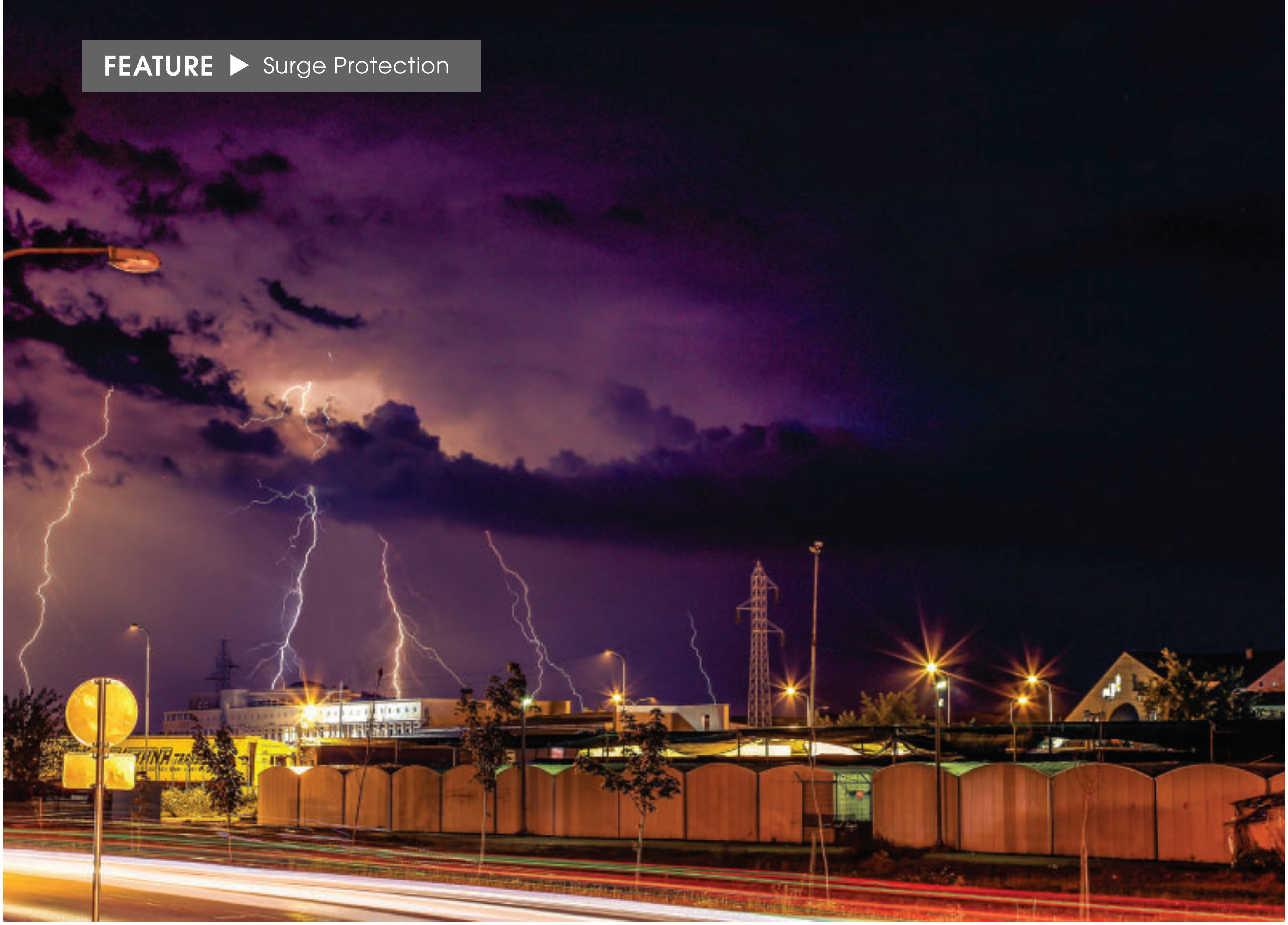
The authors wish to thank Allen Rogers, Principal at SKM Inc. (Bountiful, Utah), for his work on implementing the process described at the Chambers Creek Wastewater Treatment Plant.

Obsolescence of Pressure-Based Control

When automation was initially applied to aeration systems the prevailing technology was pneumatic control using three-mode control logic, called proportional, reset, and rate. This logic is now known as proportional-integral-derivative (PID). To keep adjustments in one aeration control zone from disrupting other zones and to force the blower output to track changes in zone demand, the blower air flow was controlled to maintain constant pressure. Today, however, programmable systems with communications capabilities and computer-based interfaces effectively have eliminated pneumatic controls, but the underlying control logic persists as standard practice for many designers. These systems are difficult to tune and are prone to instability. Maintaining constant pressure wastes energy, and MOV logic used to modulate pressure added complexity and further instability.

Newer designs are based on manipulating air flow at zones and blowers based on process demand, taking advantage of processor power and communications capabilities. More robust floating control algorithms are being used in lieu of traditional PID.



From the Sensor to the Controller

Reliable signal transmission in limited spaces

Ralf Hausmann, Dave Eifert, and Jack Coghlan

Water and wastewater treatment processes involve many electrical and data connections between the central control room, distributed areas throughout the facility, and across the distribution and collection systems. Hence, failsafe equipment operation becomes progressively more critical as system designs become more sophisticated.

System operators constantly are challenged to fit more and more equipment into smaller and smaller spaces as processes and facilities modernize. Moreover, the room available within control cabinets for surge protective devices (SPDs) shrinks with each new generation of processing machinery. Space-saving equipment designs calling for ever-narrower components have moved beyond just being a convenience to being mandated by equipment users. These new space management demands affect every process control equipment component, including SPDs. Modern SPDs that protect online measurement and control signaling circuits now must be packaged in smaller housings while maintaining the robust performance and reliability of their predecessors.

To meet these requirements, manufacturers have responded with modern SPDs that include models measuring just 3.5 mm (0.1 in.) wide. (See photo, p. 49.)

Market Megatrends

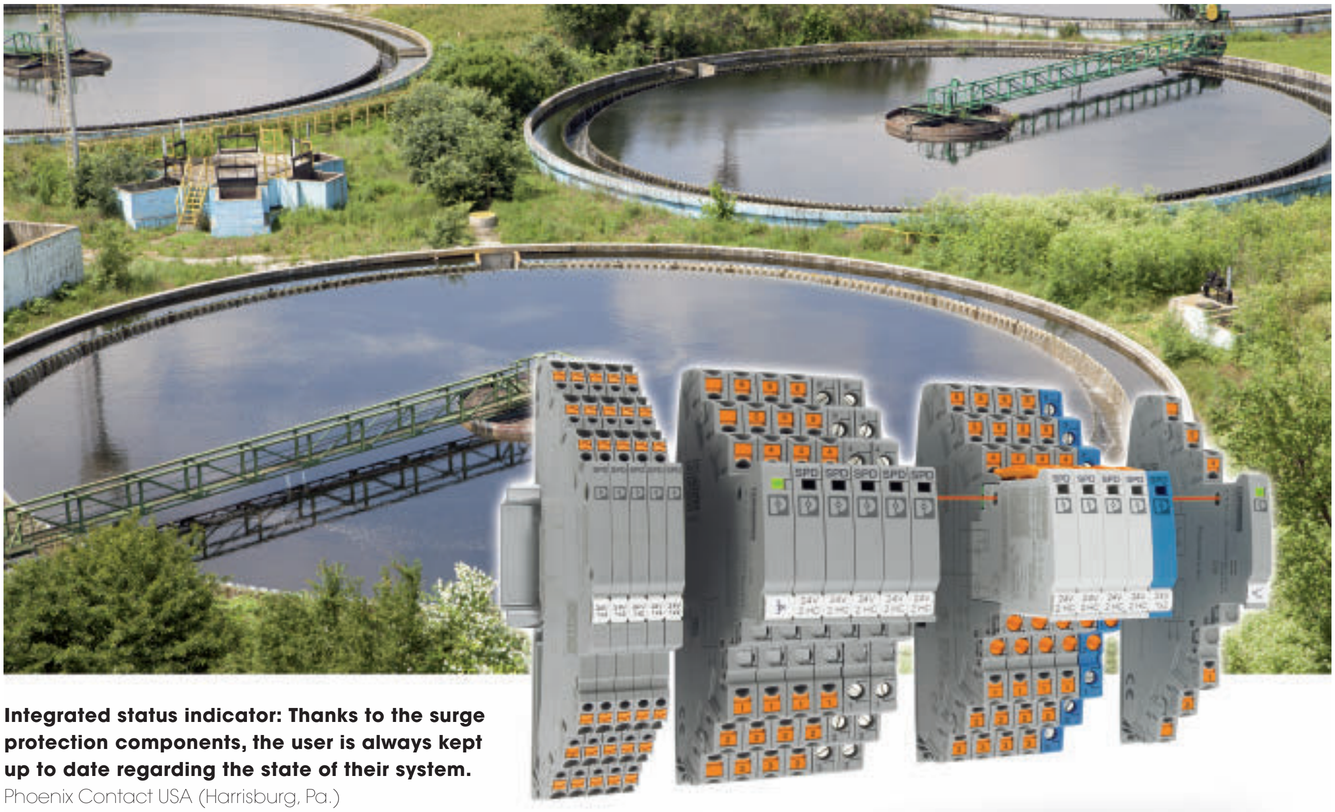
As veteran water sector workers retire, the workforce is shrinking. Equipment users increasingly are using automated data-gathering resources to ensure reliable system operations. It is now more important than ever to mitigate surge-related downtime caused by lightning and from the more common switching transients that are constantly generated within facilities. The drive toward implementing ever smaller and more compact components within the same amount of cabinet space applies especially to the water sector. SPDs protecting critical power and control circuits must now occupy as little space as possible within the control cabinet to optimize their installation and operational costs.

Protection in Limited Spaces

Data collection and distribution service functions often are centralized in the same location in modern water facilities. Contemporary system monitoring activities call for numerous input/output (I/O) channels to be housed within constricted areas, making physical space increasingly more valuable. Therefore, present-day SPDs need to provide the system's required levels of surge protection with physically smaller and more compact products. Because the width — how much horizontal space the unit occupies on the DIN rail — of the surge protector usually is the limiting dimensional factor in these applications, thinner surge protectors mean more space for other equipment.

These new SPDs are offered in models equipped with up to six terminal points to protect either two floating analog signal lines or two discrete signaling circuits that share a common reference potential. With their extremely narrow form factors, a group of these narrow suppressors can protect up to 572 signal lines while occupying just 1 m (3.3 ft) on the DIN rail. (See photo, p. 49.)

Integrated status indicator: Thanks to the surge protection components, the user is always kept up to date regarding the state of their system. Phoenix Contact USA (Harrisburg, Pa.)



Integrated status indicator: Thanks to the surge protection components, the user is always kept up to date regarding the state of their system.
Phoenix Contact USA (Harrisburg, Pa.)

Ease of Inspection

Lightning protection standards recommend regular visual inspections of SPDs for signs of wear and tear. While surge protectors featuring status indication can simplify the inspection process, it is preferred that they do not draw any ancillary power from the protected control circuits for that purpose.

These narrow SPDs not only meet that requirement, but also make it easy for the user to identify when an impaired SPD has been overly stressed by an overload event. The overload status information also can be remotely monitored by either interconnecting each suppressor's output contacts to a local programmable logic controller (PLC) or by integrating them into an auto-dialer or other notification system using optional interface modules. By doing so, equipment users can not only monitor SPD status in the control room, but they also can have an SMS text message sent to alert them that one or more surge protectors have been compromised.

Pluggable surge protection modules offer an additional advantage of quick and easy replacement, should the SPD ever be compromised by a catastrophic lightning strike or the effects of transient voltages.

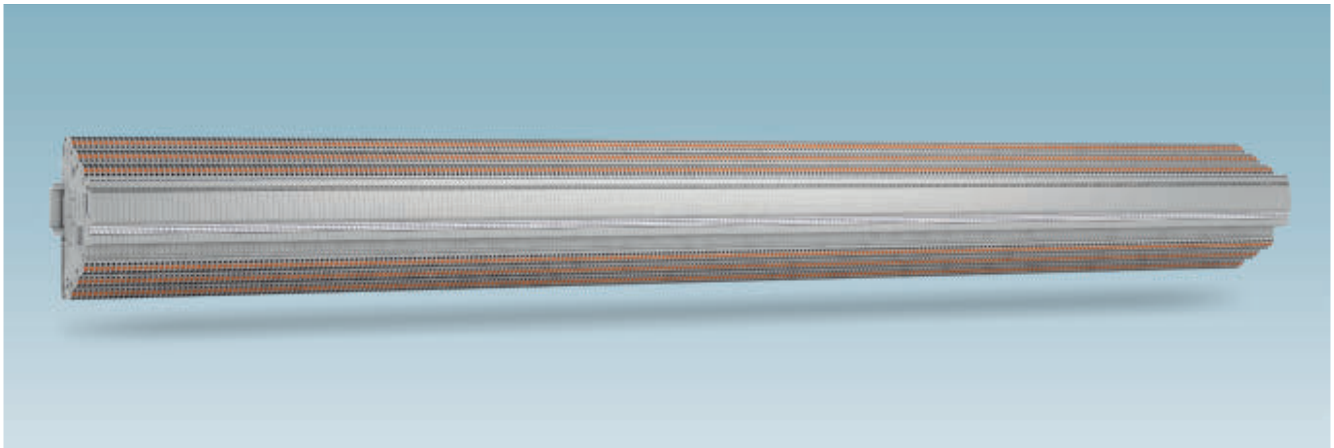
Permanent Installation with Push-in Technology

While SPDs with classic screw-connection terminals are readily available, SPDs featuring push-in connection terminals can streamline installation of large projects where numerous signal lines require protection. Because wiring conductors can be connected quickly with push-in technology and removed without any special tools, installing surge protectors with push-in connection terminals takes approximately half as much time as installing similar SPDs with screw-connection terminals.

Hazardous Operating Environments

Lightning and surge protection concepts especially are important for networking equipment operating in hazardous locations. Equipment users can reference the *IEC 62305 Lightning Protection Standard* as an inclusive handbook to help them assess their protection needs for equipment operating in potentially explosive environments.

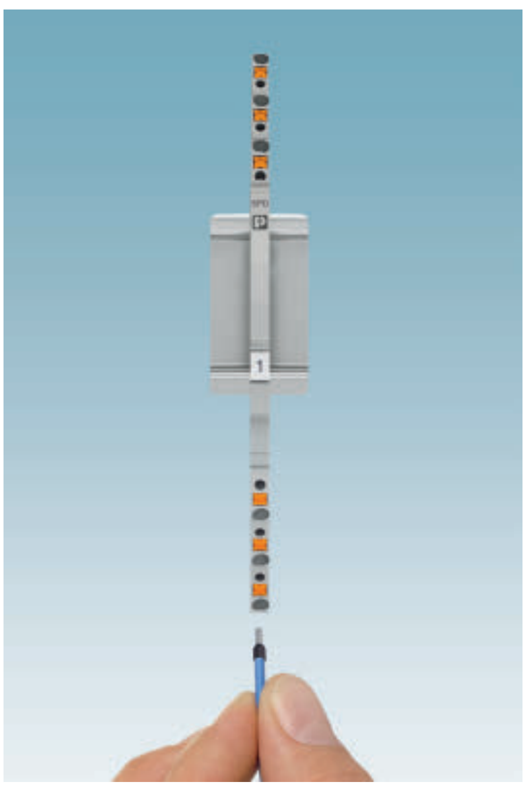
IEC 62305 is a four-part compendium that addresses protecting human beings, physical structures, and electrical equipment from lightning-related injury and damage. It is applicable for nearly all structures, including systems that operate in IEC 60079-10-1:2015 — defined explosive atmospheres. Likewise, it specifies the



The narrowest surge protection for control cabinets can protect up to 572 signals per meter. Phoenix Contact USA (Harrisburg, Pa.)

general construction and testing requirements for equipment and Ex-rated components that are intended to operate in volatile areas.

Intrinsically safe Ex-i protection advisories also advocate useful secondary protection considerations for equipment operating in explosive environments. Ex-i protection methods regulate component operating temperatures to safe levels and limit equipment voltage and current to levels insufficient to produce enough energy to ignite explosive gases, even if they simultaneously encounter two concurrent independent fault events. The necessity to protect equipment loads operating in these areas from surge activity is affirmed in IEC 60079, the pertinent standard regarding intrinsically safe circuit considerations.



Convenient connection: Thin conductors can be connected quickly with push-in technology and removed without any special tools.
Phoenix Contact USA (Harrisburg, Pa.)

Even short duration operational disruptions are unacceptable for critical systems that require high uptime and availability. These applications require robust SPDs that feature more stringent performance capabilities and that meet the added performance and safety requirements called for by intrinsically safe equipment applications.

Some narrow SPDs are designed to meet those enhanced Ex Zone 1 and Ex Zone 2 surge protection needs. Their Ex approvals are assigned according to the requirements defined by ATEX and IECEx. In North America, SPDs require UL Class I, Division 2 approval to operate in hazardous areas. SPDs that have the trifecta of hazardous location approvals (IECEx, ATEX, and UL Class I, Division 2) can be relied upon to protect equipment installed in water and wastewater treatment facilities anywhere in the world.

In water and wastewater facilities, surge voltages present an increased failure risk in large systems. These failures often have far-reaching consequences for people and the environment. A comprehensive and well-planned lightning and surge protection concept is therefore crucial. Using surge protection with remote status indication ensures quick detection in the control room. Use in explosion-protected areas is also trouble-free with the available approvals. Thanks to the comprehensive product range, there is a suitable solution for every application in water and wastewater technology.

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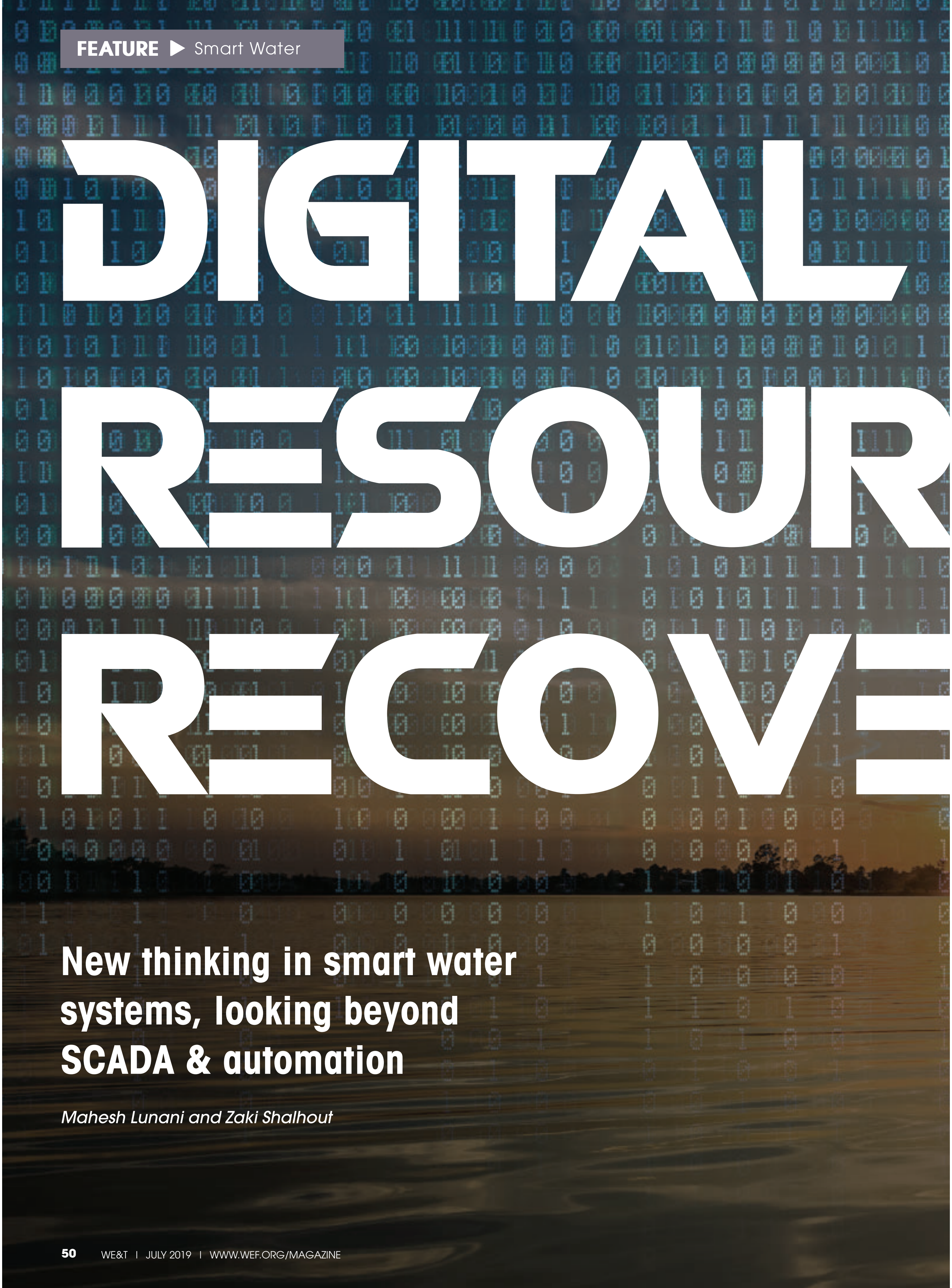


DIGITAL RESOUR RECOVE

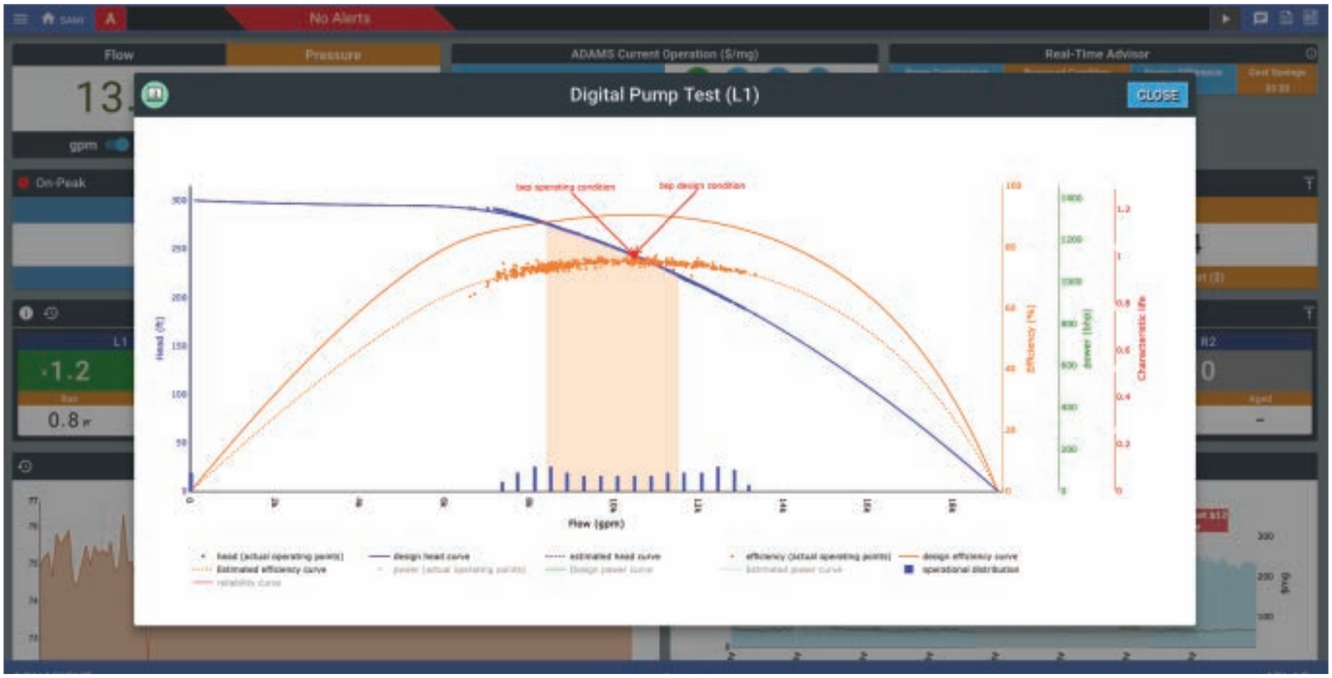
New thinking in smart water systems, looking beyond SCADA & automation

Mahesh Lunani and Zaki Shalhout

In the coming decade, the U.S. municipal water and wastewater sector is expected to spend between $15 and $20 billion on information technology and related hardware upgrades. Much of this money will be used to pay for new sensors, adding to the mountains of data (flows, pressures, levels, chemical concentrations, etc.) currently generated, stored, and secured by water utilities. Despite the high cost of current telemetry infrastructure management and the scale of planned upgrades, this fact remains true: Across the water sector, operational data is a largely untapped resource.

Compared to the private sector, public water utility adoption of so-called *big-data* technologies is in its infancy. Big data refers to the spectrum of modern technologies and techniques centered on the collection and analysis of high-volume data, with the ultimate goal of uncovering valuable insights. Big data has enabled private industry to streamline workflows, raise worker productivity, cut costs, and formulate improved plans based on accurate forecasts.

Figure 1. Pumping Dashboard Displaying Pump Curve



How Most Water Utilities Use Data

In the public water sector — with a few exceptions here and there — the picture is different. Real-time sensor data typically is directed into a supervisory control and data acquisition (SCADA) system and is used by operators and maintenance staff only for process monitoring purposes. In some cases, this data drives automated control systems. Laboratory sample data is logged manually in a laboratory information management system (LIMS) and accessed as needed for compliance reporting and occasional after-the-fact study. Field data is logged in spreadsheets or hand-written notebooks. In most cases, SCADA, LIMS, and field data are maintained separately; concurrent analysis requires a delicate juggling of query syntax, access permissions, and file formats. Management-level staff often is disconnected from live data, making decisions based on periodic (monthly, quarterly, etc.) reports summarizing key performance metrics.

Pulling even modest volumes of historical data is typically a time-consuming, labor-intensive process that requires hours of work to extract a few months of operational data. Due to the effort required, it has been common practice to relegate the analysis of historical operations and maintenance (O&M) data to one-off studies by external firms able to devote the resources required to manually collate and examine a utility's past data.

Leveraging Big Data

Big data technology is the key to streamlining and improving this process, transforming after-the-fact analysis into live insight delivery and real-time advice generation. It holds the potential to help leverage machine learning and artificial intelligence (AI) for improved performance, higher water quality, smarter preventive maintenance, and greater energy, material, and chemical efficiency in the water sector. Compared to the cost of new instrumentation, SCADA modifications, or large one-time studies, adoption of big data techniques can yield big benefits at small cost.

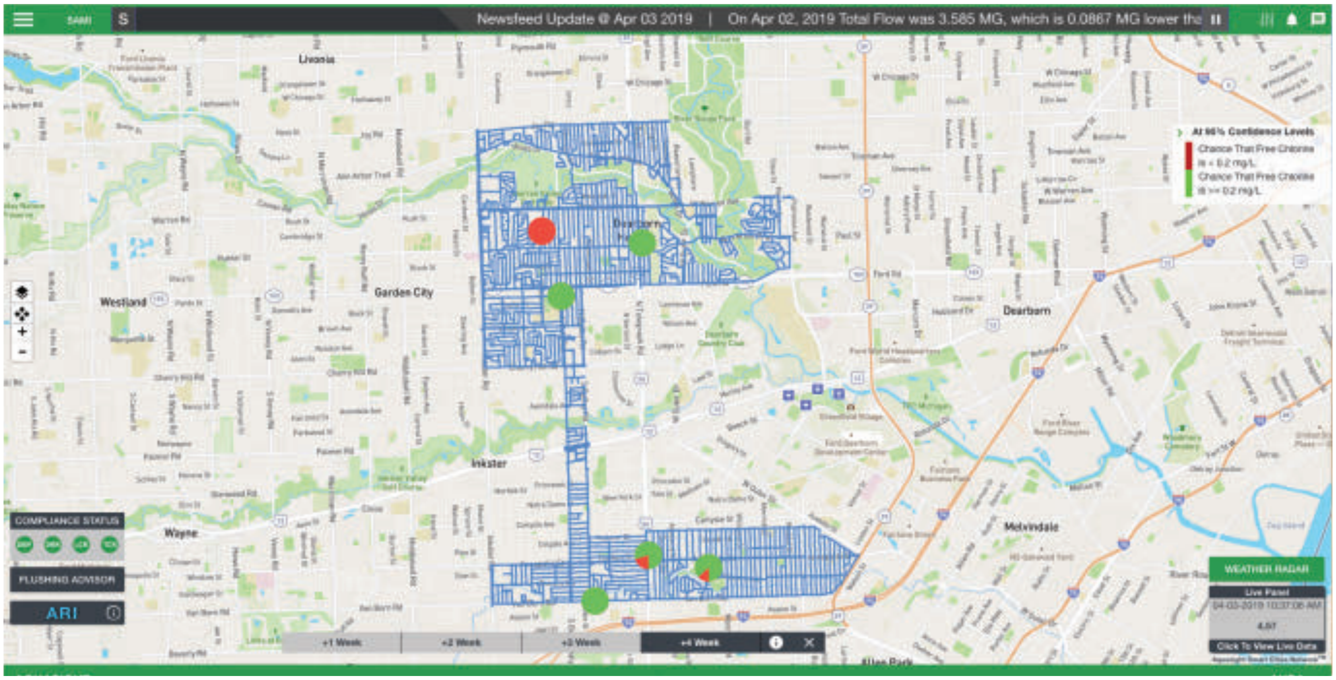
The following five case studies highlight several applications of big data techniques. These examples showcase some of the ways in which new technology is benefitting utilities and can serve as a starting guide to water sector leaders interested in adoption.

Case Study No. 1 – Energy and Reliability Optimized Pumping

While relatively new on the scene, adoption of these pumping-focused augmented intelligence solutions is already having an effect across the water sector. Success stories are not hard to find.

For example, in the Midwest, a 76-ML/d (20-mgd) water booster station with several pumps of varying age, condition, and instrumentation level, reduced its annual energy costs by more than 15% following the installation of a digital AI pumping platform. The platform connected to existing sensors and did not require installation of new hardware. The platform's digital advisor, in real time, issued operations advice on selecting the optimal pump combinations and run settings for the latest on-the-ground conditions. Figure 1 (above) shows what operators see on the interface.

Figure 2. Water Network Quality Platform Displaying 4 Week Projected Chlorine Level Risk



These choices seek to optimize for energy, pressure, and water quality. By merging operator expertise with AI, the system helped the station benefit from cutting-edge technology without posing unnecessary risk to their equipment or operations. Human operators retained ultimate control at all times. The combination of AI and human expertise resulted in a station that was operated more efficiently, under a control strategy that was more robust than either could achieve alone.

Case Study No. 2 – Water Quality Intelligence

Each year, approximately 27 million people in the U.S. receive drinking water from distribution networks that have been flagged for one or more violations of the Safe Drinking Water Act's health-based standards. Violations of this type occur when contaminants are present in concentrations that may be damaging to human health under long-term exposure.

Routinely collected data, both metered and sampled, holds the key to reducing the number of violations, many of which are related to high residence times and chlorine decay.

Water network data can be used to predict the odds of violation, thereby enabling proactive action to remedy emerging problems.

In one of the first applications of this practice, several communities in southeast Michigan have deployed a digital water network intelligence and water quality platform. In addition to network monitoring, warnings, and alerts, the platform addresses violations through a suite of quality risk assessments. For example, utilities are able to access forecasted quality levels up to a month in advance. This provides sufficient time to intervene before quality violations occur. Figure 2 (above) shows a chlorine level projection.

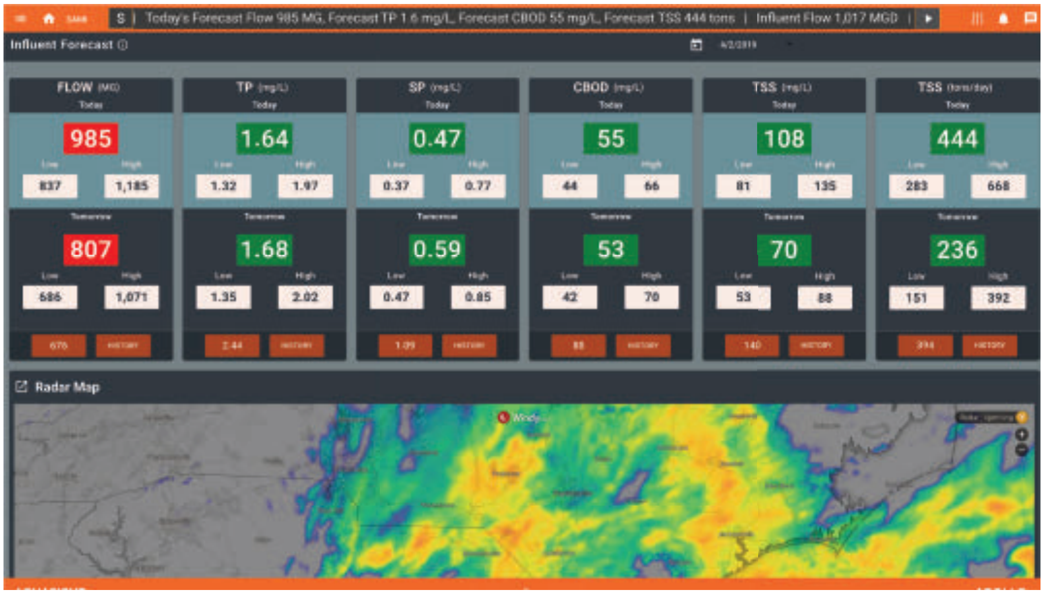
Case Study No. 3 – Optimal Polymer Dosing

In one wastewater treatment facility, management has adopted a digital platform that issues polymer dosage advice to operators. This facility adds polymer to biological sludge to help increase the effectiveness of mechanical dewatering.

Choosing an optimal polymer dose relies on a mixture of science and art. It requires an understanding of how best to adjust predetermined polymer dose rates based on visual cues coming from both observing the biological sludge and equipment. It is a process that is characterized by significant operator-to-operator variation and frequent overdosing.

By automatically capturing dosage patterns over time, a digital polymer dosage advisor has learned what dosage works best under different conditions. The digital advisor has helped facility operators effectively eliminate polymer overdosing. Through the platform, knowledge of veteran operators has been leveraged to instantly add years of experience to new operators. Elimination of polymer overdosing has reduced annual polymer costs by more than 20% without compromising the dewatering process.

Figure 3. Influent Flow and Chemical Load Forecast Dashboard



Case Study No. 4 – Influent Load Forecasting

One of the most significant challenges in managing water utility O&M is in correctly anticipating data-to-day process fluctuations. Chemical dosage, detention times, pump schedules, maintenance downtimes, and staff levels must be properly set to handle the day's conditions. Improper anticipation of the day's needs can lead to excess cost, long downtimes, and non-optimal resource allocation.

In the wastewater arena, influent flow and chemical load forecasting is particularly important as rain events can double or triple the amount of water a facility will need to treat. In addition, critical process choices depend on influent contaminant concentrations. These concentrations can take hours or days to measure in laboratory tests, reducing their usefulness in daily planning.

Typically, experience and intuition form the basis of next-day planning. Seeking to augment human forecasts with advanced algorithms, a water resource recovery facility (WRRF) recently has adopted a collection system forecasting platform. Figure 3 (above) shows an example. This platform helps predict facility influent days in advance. It combines several data sources to forecast influent flow and chemical loads. Operators are able to merge these forecasts with their own intuition and better set the day's treatment plan.

Case Study No. 5 – Smart Solids Planning

Due to the challenge posed by high day-to-day variability in incoming solids load, operators at a large municipal WRRF often were caught with solids inventory levels that were too high or too low at the end of the day. Off-target solids inventory meant that the operators would be playing a game of catch-up, trying to process yesterday's solids while dealing with new solids coming in today. Facility management sought out a pilot deployment of a digital solids advisor.

Combining data from multiple streams, the advisor automatically generates inventory targets and disposal quotas for the day. The advisor and the underlying algorithms deliver all implementation details required to carry out a plan while meeting all known process constraints. Adding additional process data and refining constraints based on operator experiences over time, the platform has become a valuable planning tool that has reduced the time necessary to formulate disposal plans. In addition, it is expected to stabilize the average performance, reducing the time spent at very high or low inventory.

Redefining the Use of Big Data

Today, new innovations in big data technology, such as the ones described above, are allowing water sector managers and operators to save money, streamline workflows, and increase performance. This is a different approach to operating water systems and it takes time and it takes strong conviction to embrace change.

In the wastewater sector, an emerging trend in recent years has been to refocus facilities from *wastewater treatment* to *water resource recovery*, as the latter better describes the mission of extracting nutrients and reusable water from waste streams. In a similar vein, a new commitment to think in terms of *digital resource recovery*, defined as a focus on extracting maximum benefit from existing data assets, can usher in an era of a better run, better managed, and better performing water sector.

***Mahesh Lunani** is Founder and CEO and **Zaki Shalhout** is product lead at Aquasight (Troy, Mich.).*

FRED HERVEY WATER RECLAMATION PLANT

Location: El Paso, Texas
Startup date: 1985
Service population: 130,000
Number of employees: 27
Design flow: 45,000 m^3/d (12 mgd)
Average daily flow: 24,800 m^3/d (7.5 mgd)

The Fred Hervey Water Reclamation Plant was one of the first facilities in the U.S. to treat reclaimed water to drinking water standards, improving its treatment processes during its 34 years of operation to meet changing regulatory standards along the way. Parkhill Smith & Cooper (Lubbock, Texas)

The Fred Hervey Water Reclamation Plant, which serves Northeast El Paso, Texas, was one of the first facilities in the U.S. to reclaim water to drinking water standards and use it for aquifer recharge. From 1985 to today, the facility has returned almost 114 million m^3 (30 billion gal) of water to its local aquifer through injection wells and infiltration basins. This effluent also irrigates a local park and a golf course and is used at nearby power facility. This reuse reduces the amount of water pumped from the Hueco Bolson aquifer or diverted from the Rio Grande.

To spread the word about its treatment efforts, the facility welcomes visitors year-round. Some of the most frequent visitors are from area schools and the El Paso Council of International Visitors.

For its stellar wastewater treatment efforts, the facility, in 1994, won second place in the No Discharge Category in the U.S. Environmental Protection Agency's Operations and Maintenance Excellence Awards. In 1998, it received the American Water Works Association (Denver) Conservation and Reuse Award. The facility also has received nine National Association of Clean Water Agencies (NACWA; Washington, D.C.) Gold Awards and two Platinum Awards for perfect program compliance under the expanded NACWA Peak Performance Award program since 2006.

The facility's flow equalization pond and storage system provides for short-term storage of above-average flows due to normal daily flow variations. This allows for a consistent influent flow. El Paso Water

The aeration basin tanks provide an environment where activated sludge organisms consume and remove suspended organic matter while added PAC adsorbs pollutants. El Paso Water

When influent first arrives at the Fred Hervey Water Reclamation Plant, it undergoes preliminary treatment with bar screens to remove trash. Meanwhile, any flow that exceeds average daily flow is diverted to flow equalization ponds for temporary storage.

After screening, sedimentation tanks help to remove sand and organic matter. Collected solids are stabilized in anaerobic digesters; this digestion creates biogas that, in turn, generates electricity.

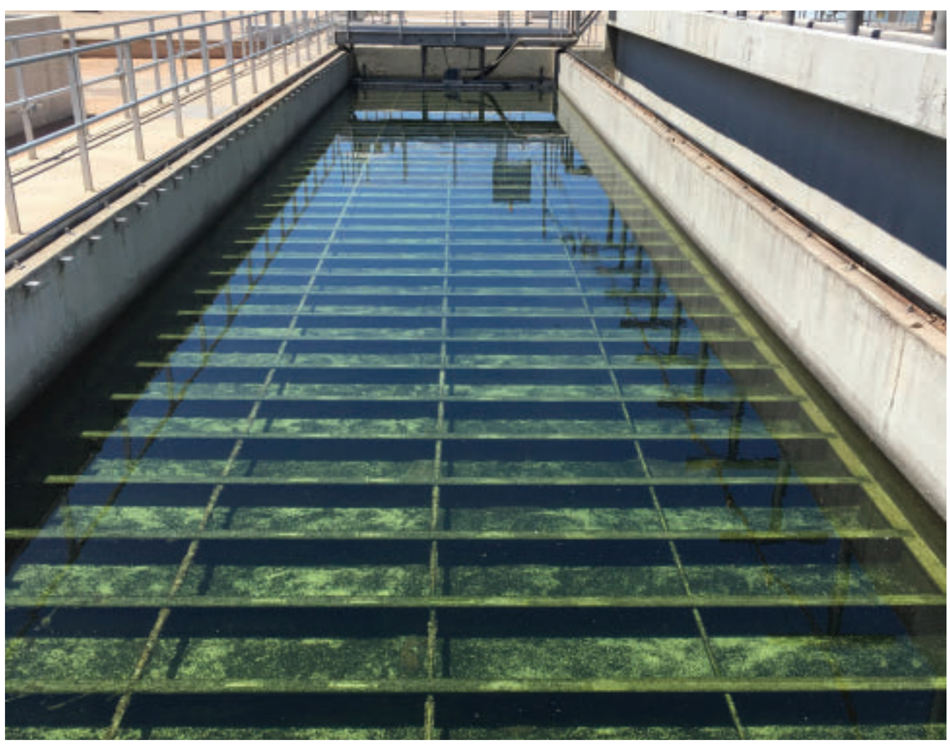
The wastewater, then passes into aeration basins where it is mixed with powdered activated carbon (PAC) for secondary treatment. Adding carbon to the biological treatment process helps to adsorb compounds that are not readily biodegradable. This reduces the chemical oxygen demand of the wastewater and removes toxins.

The secondary clarifier provides a calm, controlled flow zone where solids in the mixed liquor settle. The settled sludge, consisting of activated sludge and powdered activated carbon, is withdrawn from the tanks at a continuous, controlled rate by the return sludge pumps. Waste solids are dewatered with centrifuges and lime stabilized prior to landfill disposal. El Paso Water

As the first step in disinfection, the lime reactor mixes a high dose of lime to the treated water to raise the pH, kill viruses, and remove hardness, phosphorus, and heavy metals. Carbon dioxide is then added to lower the pH. El Paso Water

During the treatment, ozone is added to the treated water as the second step of the disinfection process for removal of viral and cyst organisms. The facility generates its ozone onsite. The action of ozone also breaks down organic material in the water improving the color, taste, and odor of the treated water. El Paso Water

The disinfection system is a two-chemical process using lime and ozone. First, clarified water receives a high lime dose to raise the pH, killing viruses and removing hardness, phosphorus, and heavy metals. Carbon dioxide is then added to lower the pH. Next, sand filters are used to reduce turbidity. Then, the filtered water is disinfected with ozone, which is generated onsite. As a final polishing step, the disinfected water is passed over activated carbon granules.



The sand filter removes light chemical flock from the effluent discharged from the second stage re-carbonation basins. This allows more effective contact of ozone with the pathogenic organisms and other oxidizable materials in the treated water. El Paso Water

Grit in the Pit

A North Carolina WRRF replaced traditional bar screens to improve employee safety and reduce maintenance time and costs

Problem: Forty-year-old bar screens were costly to maintain and operate and often created perilous situations for maintenance crews.

Solution: The utility installed a new bar screen system that requires less crew attention to operate properly and costs less to maintain.

The Water and Sewer Authority of Cabarrus County (Concord, N.C.) installed new stainless steel, link-driven mechanical bar screens. The four units are front-clean, front-return, mechanically cleaned screens. The new screens have eliminated the high maintenance costs required by the old screens and have eliminated the needed for many confined space entries. Duperon Corp. (Saginaw, Mich.)

In early 2016, the maintenance staff of the Water and Sewer Authority of Cabarrus County (Concord, N.C.) determined that four existing bar screens at the main pump station leading into the 100,300-m^3/d (26.5-mgd) Rocky River Regional Wastewater Treatment Plant needed to be replaced.

These bar screens had been installed in 1978 when the water resource recovery facility (WRRF) was built. Their replacement also provided a welcome opportunity to address serious operational challenges related to employee safety. The facility also saw this upgrade as a chance to reduce maintenance costs and times for the bar screens.

Process and Safety Risks

The bar screens at the main pump station remove debris from wastewater to protect the submersible influent pumps that convey the water to the headworks facility, which has climber fine screens and a grit removal system. While debris carryover often can be a challenge to bar screen operation, the Authority's challenge in screen operation was heavy grit build-up. Grit is not an unusual issue with aging wastewater infrastructure, but it can — and did — wreak havoc with the traditional bar screens that the Authority needed to replace at its pump station.

For example, when water flow increased during rain events, grit would inundate the old screens and jam the sprockets at the bottom of the system. To get the screen moving again, Christopher Carpenter, the Authority's maintenance manager, would send a maintenance crew of six or more to remove the clog.

These bar screens were deep — almost 12 m (40 ft) from the deck level to the bottom of the screen or about 16.8 m (55 ft) total — making them difficult to access at the bottom of a 1.2-m (4-ft) wide channel. To access them, maintenance crews had to enter a dark, 1.2- × 2.4-m (4- × 8-ft) pit to replace any broken components and shovel the grit out of the pit and into buckets that needed to be hauled back up to the deck. This would happen three to four times each month.

"The old screens constantly broke," Carpenter said. "Access was so hard, and it was a tremendous amount of staff time, and permits for confined space entry, sending six or more people to access the lower level, down a ladder into a dark pit to replace the chain and dig out the grit. The new screens would have to eliminate the need to send our employees down there."

No More Pit Work

The Authority hired Black & Veatch (Overland Park, Kan.) to work with its staff to select the best option to replace the problematic screening equipment. The new screens needed to be unfailingly reliable during wet weather events and the team was committed to finding a solution that would keep the maintenance crew out of the channel. While the team initially considered climber screens that were working well in other parts of the WRRF, this solution wasn't feasible. The space was just too tight at 6 degrees from vertical and the single carriage would have had insufficient cleaning

Prior to the installation of the new screens, maintenance crews had to enter a dark, 1.2- × 2.4-m (4- × 8-ft) pit to replace broken components on the old screens. The crews also had to haul buckets of grit up to the pump station deck. Now, pit work is no longer necessary; crews can access the screens at the new intermediate-level access door at the pump station. Duperon Corp. (Saginaw, Mich.)

cycle times for such a long unit.

The team agreed that the technology that would fully address their concerns was the FlexRake® FP-M 1-in. full-penetration coarse screens from Duperon Corp. (Saginaw, Mich.). The stainless steel, link-driven mechanical bar screens are front-clean, front-return, mechanically cleaned screens with no lower sprockets, bearings, or tracks that can jam below the deck. The FlexRake FP-M is ideal for vertical and near vertical applications, such as the one at Rocky River because the unique Flexor™ technology allows the screen to be vertical without adding submerged maintenance components into the channel.

"A lot of the previous issues were associated with the direction that the screen traveled," said Thomas Hahn, utility system engineer at the Authority. Hahn said the team wanted to minimize the need for maintenance to get to the bottom of the screen where grit would accumulate in the pit in the old rear-return style screening system.

"With the Duperon FlexRake screen, the pit was unnecessary and could be filled with concrete," Hahn said.

Also, with no replaceable or fixed parts below the deck and Jam Evasion™ technology that lifts or pivots around grit and debris, maintenance for the new screening system would no longer be an issue; the Authority could stop sending employees into the channel on a regular basis.

The new bar screens have no lower sprockets, bearings, or tracks that can jam below the deck and they are ideal for vertical applications, which works well at the pump station. Duperon Corp. (Saginaw, Mich.)

Withstanding Two Hurricanes

Soon after the new screens were installed, Hurricane Florence put it to the test in September 2018 followed by Hurricane Michael in October 2018. Although the authority is far enough inland that wind wasn't a concern for the screens, there was significant rainfall, especially during Hurricane Florence.

The flow through this pump station doubled to more than 190,000 m^3/d (50 mgd) during the hurricane. All four FlexRake screens ran during the event. Authority personnel had to replace a snap ring on one screen during the event, but they were able to return the screen to service with minimal downtime, and without having to access the bottom of the channel.

"All four screens at the Main Pump Station ran just fine," Carpenter said.

Because they performed so well, maintenance crews could focus on other things like grit inundating the headworks. "Although that had always been a problem, we had never really noticed because the crew always had to focus on keeping the bar screens running," Carpenter said.

Less Maintenance Time and Cost

Time and employee safety aren't the only benefits of the new equipment. The cost of maintaining the old equipment was significant, including $100,000 to rebuild each screen every 5 to 6 years. With all four of the old screens, the authority had planned to spend $800,000 per decade, plus the cost of confined space permitting, and the labor costs associated with sending staff to fix the screens three to four times per month.

Carpenter estimated that 10% of the authority's maintenance budget alone was spent on the bar screens prior to the new installation.

"All of this has been eliminated with the new Duperon equipment," Carpenter said. "We have had zero maintenance other than preventive greasing and inspecting. So far, we push a button, turn on the screens, and the system deals with the grit. We don't need to babysit it and there have been no problems at all. The Duperon screen basically walks itself over the grit so we've never had to send an employee down."

The **American Membrane Technology Association** (AMTA; Stuart, Fla.) announced that **Palm Beach County Utilities** (Boynton Beach, Fla.), **Brunswick County Utilities** (Bolivia, N.C.), and the **Procter and Gamble Co.** (Cincinnati) have become AMTA members. They join more than 60 membrane-using utility and end user members. AMTA is an advocate for the use of membrane technology in water treatment.

In recognition of his outstanding contribution for several projects including his technical expertise and professionalism, *Tom Ison*, electrical engineer at **Sulzer** (Winterthur, Switzerland), has been awarded the 2018 Electrical Apparatus Service Association (EASA) Karsten Moholt Exceptional Achievement Award. The annual award is made in memory of Karsten Moholt and Karsten Aleksander Moholt who are past president and regional director of EASA European World Chapter. It recognizes talented young engineers who have excelled in their role and made considerable contributions to their business.

Tom Ison (center)

Elena Smith, a chemical engineering student at the University of Wisconsin–Madison, received the 2018 WWEMA/W&WD Scholarship Award from the **Water and Wastewater Equipment Manufacturers Association** (WWEMA; Leesburg, Va.) and ***Water & Wastes Digest*** (*W&WD;* Arlington Heights, Ill.) at WWEMA's 110th Annual Meeting in Manalapan, West Palm Beach, Fla. Each year, *W&WD* collaborates with WWEMA to offer a $1,000 scholarship to a WWEMA-member employee or employee's child.

Elena Smith

Sauereisen Inc. (Pittsburgh) promoted *Michael J. Briglia* to associate materials scientist. Briglia will be responsible for new product development, contractor training, technical assistance, inspections on job sites throughout the U.S., and in-house quality control testing.

Michael J. Briglia

Freese and Nichols Inc. (Fort Worth, Texas) hired *Jimmy Gibson* to lead the firm's Environmental Practice. During his 27 years in the water sector, Gibson has led teams to solve complex problems for many environmental needs, including compliance, auditing, remediation, soil and groundwater assessments, decommissioning and demolition, and site cleanup. Gibson's role will include expanding the company's capabilities to provide full-service environmental consulting services to clients.


Jimmy Gibson

The company also hired *Karen G. Perez* to lead the firm's water, wastewater and stormwater expansion efforts in the El Paso, Texas, metropolitan area. Perez has built a strong reputation for her expertise in leading rural and municipal projects for water, wastewater, and stormwater systems; developing hydrologic and hydraulic models; and navigating federal and state government funding and regulatory agencies.

CHA Consulting Inc. (Albany, N.Y.) named *Tim George* water market leader and senior vice president. George will direct the firm's overall water-related planning, design, and project management activities, as well as its strategic and business development initiatives. He also will serve on the company's leadership team.


Tim George

Endress+Hauser Group (Reinach, Switzerland) made some changes on its executive board effective March 1, 2019.

Andreas Mayr was named chief operating officer responsible for sales, production, and support. Mayr also will serve as deputy CEO.

Peter Selders will become the new CEO of the group's center of competence for level and pressure measurement technology in Maulburg, Germany.

Jörg Stegert joined the group to oversee the entire personnel area as Chief Human Resources Officer.

Matthias Altendorf, who has led the family-owned company since 2014, will focus on aligning, growing, and strengthening the group, as well as further anchoring the corporate culture and values into the global network of companies.

The Lower South Platte Water Conservancy District (Sterling, Colo.) and other stakeholders selected Brown and Caldwell (Walnut Creek, Calif.) to lead the South Platte Regional Water Development Study. The study will advance the South Platte Regional Water Development Concept, an initiative that will bring municipal, environmental, and agricultural stakeholders together in new ways to manage and use the water supply more effectively. It is potentially a pivotal step toward achieving the goals of the South Platte Basin Implementation Plan and Colorado's Water Plan.

The analysis will focus on partner outreach and the identification of supply alternatives that consider timing, amount, and location of stakeholder water needs, possible organizational structures, water treatment strategies, and other drivers deemed critical to the potential success of the project. The final report will equip water providers with the information required to advance the concept in a collaborative and transparent way.


Brown and Caldwell

Initial concepts to be studied include multiple, operationally linked storage facilities capable of storing more than 185 million m^3 (150,000 ac-ft) of water and additional conveyance capacity strategically positioned throughout the basin. This infrastructure network will enable storage, reuse, and exchange of several water types, including unappropriated native flow, reusable supplies, and agricultural water derived from alternative transfer methods. Water will be delivered to meet diverse municipal, agricultural, environmental, and recreational needs.

Directing a multidisciplinary team, Brown and Caldwell will provide project oversight, coordinate a 60-strong stakeholder task force, evaluate agricultural requirements, and lead modeling.

The project commenced in March and a draft of the final study is scheduled for delivery within a year.

The City of St. Cloud, Minn., awarded Lystek International (Cambridge, Ontario, Canada) a contract to install its low-temperature thermal hydrolysis process as part of the city's Nutrient Recovery and Reuse Project at the NEW (Nutrient, Energy, and Water) Recovery Facility. The project was partially funded through a point source implementation grant made possible by the Minnesota Clean Water Legacy Act.

Lystek completed the installation of the system in January.

The new system is helping the city reduce biosolid volumes, which is solving pressing storage challenges while saving millions in infrastructure and operational costs. The solution also facilitates the recovery of valuable organic matter and nutrients from the city's wastewater biosolids to create a Class A quality biofertilizer product that is now available to the local, agricultural market.

St. Cloud's NEW Recovery Facility serves a population of more than 120,000 from the city and surrounding communities of St. Augusta, St. Joseph, Sartell, Sauk Rapids, and Waite Park. The facility has a design flow of 67,800 m^3/d (17.9 mgd) and features a biological nutrient removal system to help eliminate nutrient overloading into the local waterways.

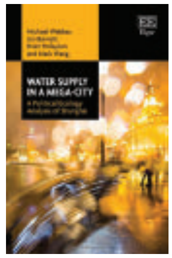
Water Supply in a Mega-City: A Political Ecology Analysis of Shanghai

Michael Webber, Jon Barnett, Brian Finlayson and Mark Wang, Elgar Publishing, ©2018 Michael Webber, Jon Barnett, Brian Finlayson and Mark Wang, *ISBN 978-1-78643-392-3 (cased), ISBN 978-1-78643-393-0 (ebook).*

This is a fascinating book. It tells the inspiring story of water supply and consumption in Shanghai from a nontechnical perspective. The book is an Australian project studying the interaction between different water actors: waterbodies, governments, infrastructure, and people. Shanghai is an interesting case because it enables the study of the dynamic interactions within the context of the enormous changes experienced this megacity in the last three decades.

The first observation of this book is that there is an enormous contradiction between what is perceived and what reality could be. The assumption for Shanghai is that water supply is not secure; water availability as well as water quality are assumed to be at risk. The authors demonstrate that this does not concur with the huge potential of the Chang Jiang River Basin, which has an annual discharge of about 70 times the total annual water use in Shanghai. In addition, Shanghai is a modern city with the necessary technological solutions for upgrading water quality.

To find the truth, the authors use hard facts and figures. Water availability in the Chang Jiang is described in detail, acknowledging that there are changes that threaten the water supply. The construction of dams — among them, the well-known Three Gorges Dam — is probably the most dramatic change that could lead to water stress. It is shocking to learn that five more reservoirs — each the size of the Three Gorges Dam — are planned on this stream. The role of building huge infrastructures, such as dams and reservoirs as well as the risk of salt intrusion are elaborated in separate chapters, worth reading as independent stories.



A second point of consideration is China's water management policy, specifically for Shanghai. This is a complex story with several challenges stemming from the dynamic factors related to population and water availability patterns. But, the authors note, groundwater consumption has decreased by a factor of 10 over the years. This is a result of the awareness of the risk of overextraction.

The last actor to be described in the book is the people or population, which is probably the most dynamic of all. The analysis presented in the book pays much attention to public perception of water quality, rather than to water quality directly, which is a different, nontechnical point of view that engineers often forget.

This book is a detailed case study and an important all-in-one analysis, but its relevance goes far beyond Shanghai. Chinese ways of water governance are increasingly exported to the rest of the world, notably to Africa and Latin America. This book gives us the framework to understand how other parts of the world are likely to develop. Better to be forewarned.

Bart Van der Bruggen *is a professor at the University of Leuven, Belgium, in the Department of Chemical Engineering.*

PRODUCTS

Detector

Markland Specialty Engineering Ltd. (Georgetown, Ontario, Canada)

▶ www.sludgecontrols.com

1 The Automatic Sludge Blanket Level Detector enables water and wastewater treatment facilities to measure, monitor, and control solid–liquid interface levels in clarifiers and sedimentation basins, including dissolved air flotation units; sequencing batch reactors; the constricted area of lamellas; and automate the removal of primary, secondary, and backwash silt/sludge. The detector enables users to program de-sludge pumps to operate only when necessary, reducing energy usage, wear-and-tear on pumps, and downtime for maintenance. In addition, it helps in preventing carryover and optimizing feed density for enhanced dewatering. The detector automatically adjusts the beam power intensity of the LED-phototransistor sensors in its vertical probe, enabling it to accommodate thick or thin biosolids concentrations, or light flocs, such as in the overlying cloud layer. No calibration required.

Telehandler

Bobcat (Seoul)

▶ www.bobcat.com

2 The Bobcat TL43.80HF is a compact telehandler with a width of 2.30 m and a length of less than 5 m from the rear to the fork face. It offers a range of 15 different rigid frame telehandler models, covering maximum lifting capacities between 2.6 and 4.3 ton, and maximum lifting heights from 6 m to 18 m. The system provides a new solution for heavy lift handling applications found in general industry, manufacturing, building materials, warehousing, quarrying, and mining. It also is ideal for heavy duty, high-productivity segment of the agricultural market, taking lift capacity, lifting height, and breakout force to unprecedented levels. It is available with a choice of three different AGRI packs for the farming market.

Water Meter

KROHNE Inc. (Beverly, Mass.)

▶ www.krohne.com

3 The WATERFLUX 3070 is the first all-in-one water meter with integrated pressure and temperature sensor. Simplified installation, integrated diagnostics, a long battery lifetime, remote communication options, and low overall maintenance make the meter ideal for installation in remote locations. The updated meter now offers a main power option with battery backup, and a Modbus RTU communication option for transmission of readings, meter status, and alarms. The polycarbonate converter housing with protection class IP68 rating is now standard for both compact and remote versions. The meter features IP68 waterproof plug and play connectors that don't require wiring onsite and a small installation footprint to fit into electrical cabinets.

Adsorbents

CycloPure (Encinitas, Calif.)

▶ www.cyclopure.com

4 The DEXSORB™ line of cyclodextrin-based adsorbents selectively target and remove hazardous micropollutants from drinking water. The substance's flexible formulations allow for its broad use in water treatment systems that serve communities, businesses, and households for applications that range from filtered water bottles to large municipal facilities. Derived from renewable corn-based cyclodextrin, the adsorbents represent a new class of water treatment adsorbents that safely eliminate such harmful chemicals as polyfluoroalkyl substances and perfluorooctane sulfonate, pesticides, and pharmaceutical compounds.

Adhesive

Master Bond (Hackensack, N.J.)
▶ www.masterbond.com

9 Master Bond has developed a formulation of opaque colored compounds, which represents a breakthrough in ultraviolet (UV)/visible light curing adhesive technology. These environmentally friendly products possess the capability of curing in a wide range of colors while offering the same combination of beneficial properties exhibited by transparent curing systems. They require no mixing, cure in seconds upon exposure to an appropriate commercial UV/visible light source, have excellent adhesive strength, thermal stability, chemical/moisture resistance, and electrical insulative properties. LED401 white is opaque white in color. It is a one-part system that cures fully upon exposure to a 405-nm wavelength light source.

LED Lighting

Larson Electronics LLC (Kemp, Texas)
▶ www.larsonelectronics.com

10 The EPL-LP-48-LED-SFC.LP is a Class I, Divisions 1 and 2, Class II Divisions 1 and 2 rated extra low-profile LED light fixture that provides 13,520 lumens of high-quality light drawing just 104W. This integrated linear LED uses special positioned boards within the fixture to provide wide area light without sacrificing quality or output. The LED produces a brilliant wide flood beam with 100-degree horizontal and 140-degree vertical spreads and has a standard 5000K color temperature to produce colors and details more accurately than traditional luminaries. The light operates on 100 to 277 V_{AC}, 50/60Hz current without any modifications and comes equipped with terminal strips for wiring.

Editor's note: *WE&T assumes no responsibility for claims made in product descriptions. Interested companies should send press releases and photos to prods@wef.org.*

MARKETPLACE

AD INDEX

Coming up in the August issue

Reuse in All Its Forms

The traditional image of reuse looks like a water-scarce area using reclaimed effluent to irrigate local animal feed crops or recreation areas. While valuable and useful, this image just scratches the surface of all the forms of reuse. The August issue will examine several different interpretations and applications.

For example, Nampa, Idaho, is using recycled water as a hidden economic development tool. As communities continually look for ways to attract new industries and retain existing ones, a recycled water program can be a unique differentiator. In Nampa's case, the economic development benefits paired with local control of the water resources have resulted in a plan to develop Idaho's largest recycled water program.

Reuse also can mean more than water. More and more utilities are interested in producing biosolids-based products for non-agricultural applications. Producing a quality product is the first step. However, equally important is understanding the many factors that affect marketability — price, customer service, and managing negative stigma. Ensuring the appropriate amount of sales and marketing activity is needed to safeguard a product's market share.

Also in this issue

- **Splash Shot.** Water everywhere — This spring, massive flooding affected several facilities throughout the Midwest.
- **Operator Essentials.** What every operator should know about reverse osmosis systems.
- **Problem Solvers.** Sunny Seabrook, Texas, finds the right gear for mixing.

WATER ENVIRONMENT & TECHNOLOGY
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