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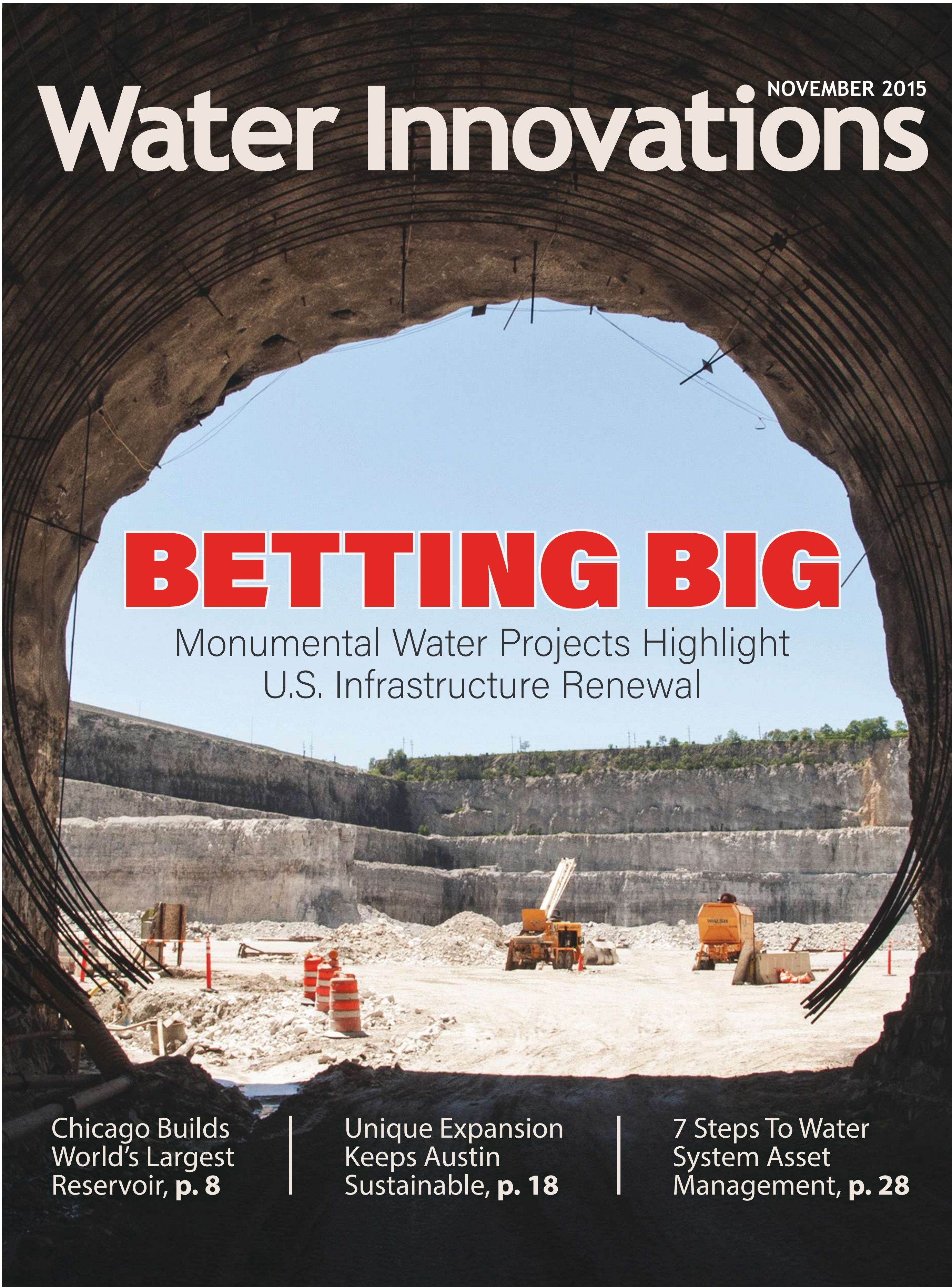

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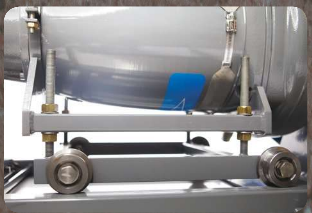

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EDITOR’S LETTER

By Kevin Westerling
Chief Editor, editor@wateronline.com

Guidance From Above:
Lessons In Water Technology Innovation

Ontario has become a world leader in water and wastewater technology development. Learn what policies and practices have facilitated success and which innovations are primed for impact.

While the U.S. has its share of water technology hubs — Cincinnati, Milwaukee, Pittsburgh, and Massachusetts spring to mind — Ontario, Canada, has generated more water-related patents over the past 30 years than any of its “water cluster” peers. The secret to the region’s success in developing potentially transformative water technologies is in the support provided from the Government of Ontario and from within the cluster itself.

The main vehicle for government support is the Water Technology Acceleration Project, or WaterTAP, which pulls together private, public, and academic resources to promote water quality and security — and Ontario business. Though WaterTAP was initially created for economic reasons, the effect of water technology innovation is universal. True breakthroughs pay dividends for us all.

I spoke to Peter Gallant, president and CEO of WaterTAP Ontario, to learn more about the commitment put into the program and the outcomes it has inspired. But first, some stats to appreciate the scope of Ontario’s water cluster:

- 300 early-stage innovation companies
- 900 established companies
- 100 water-related research institutes
- 8,200 annual post-secondary grads with water-related degrees
- 6,000 operators trained annually.

That’s the prologue. Now what does the future hold?

The Next Big Thing(s) In Water

According to Gallant, “The Industrial Internet of Things (IIOT), such as real-time sensors and the cloud, is changing the way the world manages water.”

As a testament to the type of collaboration fostered by water clusters, Gallant offered a real-world example of IIOT (and WaterTAP) at work: Ontario-based Echologics is partnering with AT&T and IBM to connect water pipes to the cloud using acoustic sensors, a wireless network, and software to help water managers make data-based decisions.

“Understanding the condition of your underground infrastructure is critical; you can’t afford the luxury of digging up the wrong section of pipeline,” Gallant noted. “Continuous monitoring technology allows utilities to be proactive.”

Contaminants are also being monitored in real time, thanks to technologies developed by WaterTAP companies including Real Tech and ManTech.

“This is a giant step forward for the industry,” explained Gallant. “Utilities can optimize the efficiency of chemical use, which can be one of the highest operating costs of treating water and wastewater. Timing can make a huge difference.”

In line with emerging industry trends and global needs, WaterTAP is also pouring resources into biogas energy generation, nutrient recovery from wastewater, and stormwater management and treatment.

The Role Of Government

In addition to merit-based funding programs for promising water technologies and the financing of state-of-the-art facilities to conduct municipal training and pilot testing, the Government of Ontario promotes water innovation by essentially mandating sustainability at utilities.

The Ontario Water Opportunities Act “enables the authority to require municipalities and other water service providers to prepare municipal water sustainability plans … [to] promote water efficiency as a cost-effective way to generate additional water and wastewater capacity,” the act states. Specifically, the mandate tasks utilities with “identifying innovative, cost-effective solutions for drinking water, sewage, and stormwater system challenges; optimizing systems and improving water conservation; [and] identifying opportunities to demonstrate and carry out new and emerging Ontario water technologies, services, and practices.”

To some ears, this “support” may sound overbearing, but it has certainly worked for Ontario — and there are lessons to be drawn, whether wholesale or piecemeal, from every exploration into water innovations.

Kevin Westerling

Water Innovations

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Greater Chicago: Historic Infrastructure Projects Enhance Windy City Water Quality

Chicago is giving its oldest wastewater treatment facility a disinfection facelift and using the world's largest reservoir to curb combined sewer overflows.

By Allison Fore

When the Metropolitan Water Reclamation District (MWRD) of Greater Chicago announced its latest initiative in wastewater treatment this summer, boaters, water skiers, and swimmers rejoiced.

This summer's achievements were an added layer in the grand process of water treatment for the billions of gallons of water that pass through MWRD facilities every year and a momentous occasion in the long-term quest to protect water along the Chicago Area Waterway System (CAWS), an attraction that is drawing unprecedented demand.

In July, the MWRD introduced disinfection via chlorination and dechlorination to its treatment process to reduce the amount of pathogenic bacteria in the water released from the Calumet Water Reclamation Plant (WRP) into the Calumet River system. The Calumet WRP serves more than one million people in a 300-square-mile area covering the south side of Chicago and surrounding south suburbs. In operation since 1922, the Calumet WRP is the oldest of the MWRD's seven plants. Calumet WRP treats an average 354 MGD and a maximum 480 MGD, enough to fill every floor of Chicago's Willis Tower. Using an existing chlorine contact chamber retrofitted for more efficient contact, the disinfection technologies neutralize or kill bacteria and other micro-organisms in treated water. The goal is to improve water quality and reduce health risks resulting from contact with the water.

MWRD was able to do what was needed for less than half the cost of the original estimate.

"I appreciate the ingenuity that went into this project from staff at the District and the investment made by our area leaders who made this possible," said U.S. Senator Dick Durbin. "Together, we have chosen to make our waterways a priority and take an important step in making our goal of a cleaner environment a reality."

The road to the Calumet WRP ribbon-cutting ceremony began in 2011, when MWRD officials instituted an internal blue ribbon task force to evaluate available disinfection technologies. The task force devoted eight months to research and testing to determine optimal solutions for disinfecting at the lowest cost. On March 1, 2012, the most cost-effective processes were determined to be chlorination/dechlorination for Calumet WRP and UV disinfection with low-pressure high-output lamps for O'Brien WRP in Skokie, IL.

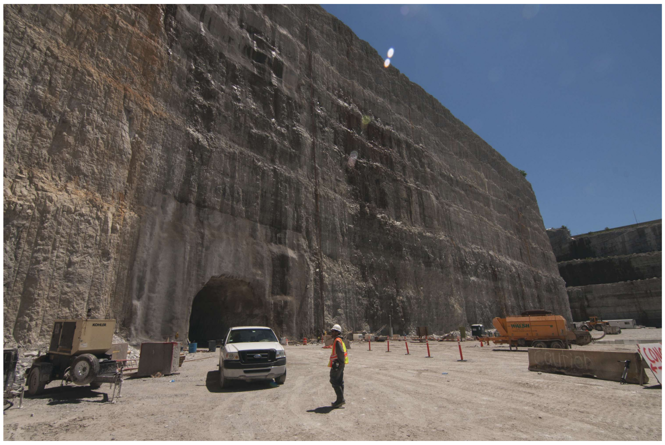
Adding The Final Chapter

Disinfection occurs after wastewater passes through a series of treatment processes. Primary treatment consists of removing any large material by physical means, including screening debris. Water then flows into chambers where heavy solids, such as sand and grit, sink to the bottom. The water then moves to settling tanks, and a significant portion of the organic solids settles to the bottom, while fats, oils, and grease (FOG) rise to the top. FOG is skimmed from the top, and the untreated solids are scraped from the bottom of the tank and treated further.

With the "settle-able solid" material removed, the flow proceeds to secondary treatment. During secondary treatment, a large population of micro-organisms consumes the remaining dissolved organic material. The water flows through a series of large rectangular aeration tanks that are seeded with bacteria and other microbes. Filtered air is pumped through the liquid to enable the microbes to breathe and grow. The microbes flourish and multiply, eating the remaining organic materials and nutrients in the constantly churning water. This mixture of microbes and water flows into a secondary settling tank. The microbes clump together and settle to the bottom of the tank where they become part of the organic residuals and are removed. Approximately 85 percent of these microbes are recycled to the start of the aeration tanks to continue the biological treatment process.

Lastly, the new disinfection process will work to destroy any remaining bacteria in the water. Engineers modified the existing chlorine contact basin by replacing all interior baffle walls and associated walkways; replacing weir gates, discharge gates, drain sluice gates, inlet sluice gates, and a bypass sluice gate; replacing liquid sodium hypochlorite diffuser piping; installing liquid sodium bisulfite diffuser piping; and installing sampling pumps. During this last stage of treatment, the water flows through a labyrinth of tunnel-like passages in the concrete contact basin, allowing time for the chlorine to kill off the harmful pathogens. The water is then dechlorinated and empties into the nearby Little Calumet River.

The reclaimed water has more than 99 percent of the impurities removed and is deposited into the Little Calumet River and



The above images show the massive scale of the Thornton Reservoir.

CAWS without any adverse environmental impact. The treated water is often cleaner than the water of the rivers and streams. The entire process from the time water reaches the treatment plant to the time it is cleaned and reclaimed takes less than 12 hours. In addition to directly benefiting the water environment, the disinfection project impacted the local economy by putting hundreds of tradespeople to work.

Disinfection also clears the way for direct reuse of the water by industry. MWRD has entered into an agreement with Illinois American Water, and together they are pursuing the local industrial use of this disinfected water. Other environmental benefits of reusing water include saving the energy used to treat the water and conserving Chicago's tap water, which is sourced from Lake Michigan.

"Disinfection marks another significant date in the history of the Metropolitan Water Reclamation District of Greater Chicago, dating back to 1889, when the District was first tasked with addressing the issue of contamination in Lake Michigan," said MWRD President Mariyana Spyropoulos. "Since then, we have constructed more than 60 miles of canals, reversed the flow of the Chicago River, and built seven water reclamation plants. Creating a disinfection facility at Calumet is another chapter in our history of water treatment and one more upgrade we have made to improve the region's water quality."

Two Forks Merge

Chlorination/dechlorination is not the only resource recovery initiative the MWRD is pursuing. The MWRD is also constructing a UV radiation system to disinfect water entering the CAWS at the O'Brien WRP. By using two distinct technologies, the MWRD will saturate the CAWS with disinfected water that enters the waterways from the south through Calumet WRP and the north at O'Brien WRP.

The UV disinfection system will become the largest wastewater UV installation in the world. O'Brien WRP, which treats 530 MGD, will have 1,152 TrojanUV Solo Lamps installed. The TrojanUVSigna system uses 1,000-watt low-pressure high-output (LPHO) Solo Lamps. The low-pressure lamp means that fewer lamps are needed to accomplish disinfection versus medium-pressure (MP) lamps. Fewer lamps require less tank volume, which translates into a lower capital cost than MP lamps. The low wattage of operation translates into longer lamp life and lower power consumption. The total power requirement for the traditional MP UV lamps to disinfect a 530 MGD effluent flow at the O'Brien WRP is 5,068 kW versus 1,191 kW for the Solo Lamps. The significant difference in power means a lower annual operating cost for the MWRD system.

The smaller number of lamps for the TrojanUVSigna system than the MP system also translates to reduced maintenance costs due to fewer lamps needing to be cleaned and replaced. The inclined configuration of the Signa system makes routine maintenance and lamp replacement quick and easy while the UV system is in operation.

In addition, the facility will feature roof-mounted water source heat pumps that provide heating and air conditioning in the UV disinfection building and neighboring switchgear building. The heat in the treated water will be recovered to heat and cool the building, another resource-recovery initiative at MWRD. This system consumes roughly 25 percent of the energy of traditional HVAC systems. An energy-recovery ventilator is also being installed in a sampling room, control room, and washroom, and a rain garden is being created between the two buildings.

Differences in existing infrastructure and hydraulics at the two plants required that a combination of methods be implemented. The task force also evaluated technologies that are best suited for both WRPs based on a triple-bottom-line approach that considered economic, environmental, and social criteria, while also providing quality customer service at the lowest cost. As a result, MWRD was able to do what was needed for less than half the cost of the original estimate. The MWRD restructured its capital improvement program (CIP) and adjusted operational efficiency goals to reserve $240 million in the budget for construction based on early estimates; however, the task force was able to hold the line on expenses so that the estimated costs for capital did not exceed $109 million. Ultimately, the MWRD has allocated resources to allow disinfection to occur without tax increases.

"The new Calumet disinfection facility will improve water quality for the growing number of people who kayak, water ski, and enjoy other recreational activities in the Chicago Area Waterway System," said U.S. EPA Region 5 Administrator Susan Hedman. "U.S. EPA is proud to have played a role in making this project happen — a project that created a lot of


The Calumet WRP disinfection facility's chlorine contact basin system, shown under construction and upon completion.

good jobs and will improve water quality for years to come."

Chicago's Grand Canyon

To maximize the water quality impact for the Calumet-Saganashkee (Cal-Sag) Channel, the MWRD ensured Calumet WRP disinfection came on-line in tandem with the Thornton Composite Reservoir; the 7.9 billion gallon reservoir is set to go online by late 2015, while disinfection will be in service for the 2016 recreational season.

The reservoir, tantamount to 12 football fields in size, is part of the MWRD's tunnel and reservoir plan (TARP), also known as the "Deep Tunnel." TARP consists of 109 miles of tunnels deep below the surface of the Chicago region and three reservoirs designed to capture and hold stormwater and sewage for treatment at water reclamation plants. Taken together, the tunnels (which hold 2.3 billion gallons), the Thornton Composite Reservoir in South Holland, IL, the Majewski Reservoir (which holds 350 million gallons) in the northwest suburbs, and the future McCook Reservoir (which will hold 10 billion gallons in the western suburbs), TARP will accommodate 20.55 billion gallons of water.

The ribbon-cutting ceremony at Calumet WRP drew major media attention, as well as U.S. Senator Dick Durbin (second from left).

At first glance, the reservoirs appear to be nothing more than gargantuan holding tanks for stormwater and a tool in the battle against flooding. Yet, the reservoirs serve a greater purpose for clean waterways by collecting combined sewer overflows (CSOs). These CSOs normally enter the CAWS after major rain events, but with the Thornton Composite Reservoir, CSOs have a holding place before the Calumet WRP can treat the water. This latest engineering marvel from the MWRD becomes the world's largest reservoir.

"It has drawn interest from across the world and, given the success of TARP, more cities are emulating our strategy," said Spyropoulos regarding the reservoirs. "We thank our predecessors with the MWRD Board of Commissioners who had the foresight in 1972 to adopt a plan that made flooding and water quality genuine issues to prioritize. In past years, that polluted, untreated water would enter our waterways — or worse, our basements. Because of TARP, combined sewer overflows have been drastically reduced, and the addition of Thornton will again lead to more water quality improvements upstream."

The Thornton Composite Reservoir will benefit 556,000 people in 14 communities throughout the south side of Chicago and south suburbs. It will protect 182,000 homes, businesses, and other facilities and improve water quality in the Calumet Rivers and Cal-Sag Channel by collecting CSOs before they enter waterways.

Between the advancements in disinfection and completion of the Thornton Composite Reservoir, the MWRD has made, in the words of Margaret Frisbie, executive director of Friends of the Chicago River, "the most significant water quality improvements in decades." ■

About The Author

Allison Fore has served as the Public and Intergovernmental Affairs Officer at the Metropolitan Water Reclamation District of Greater Chicago for four years. She has 20 years' experience in government communications, having also worked for the Illinois State Treasurer, Illinois General Assembly, and Indiana Department of Environmental Management. She received her bachelor of science degree from Indiana University and master of arts degree from the University of Chicago.

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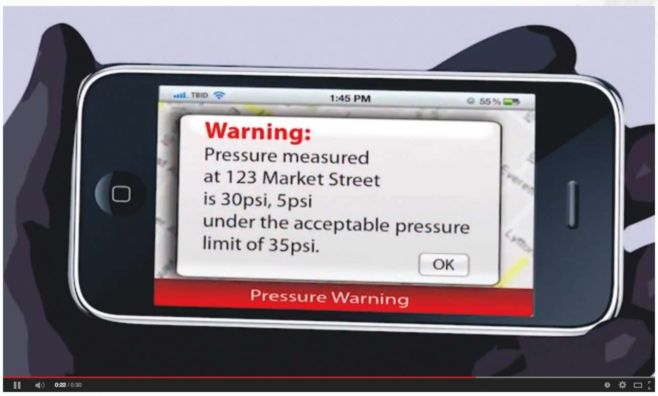

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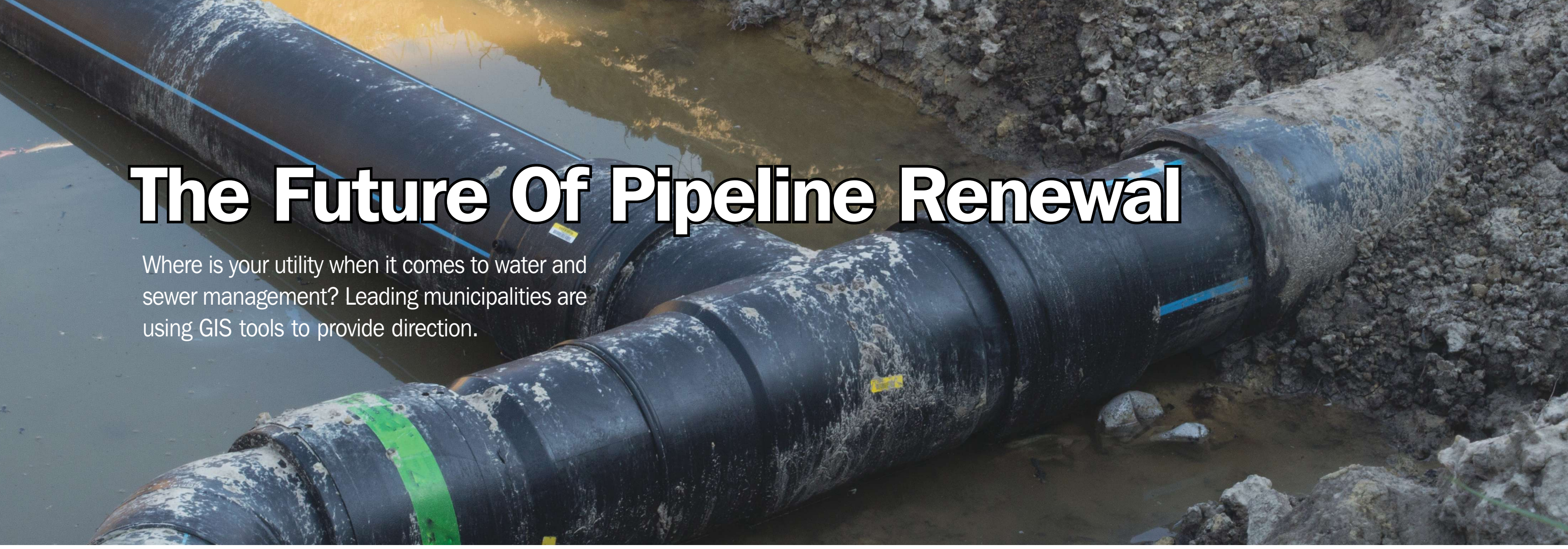


The Future Of Pipeline Renewal

Where is your utility when it comes to water and sewer management? Leading municipalities are using GIS tools to provide direction.

By Kipp Hanley

The Prince William County Service Authority's Enterprise Asset Management (EAM) Department is helping the utility further advance toward best-in-class status in the industry.

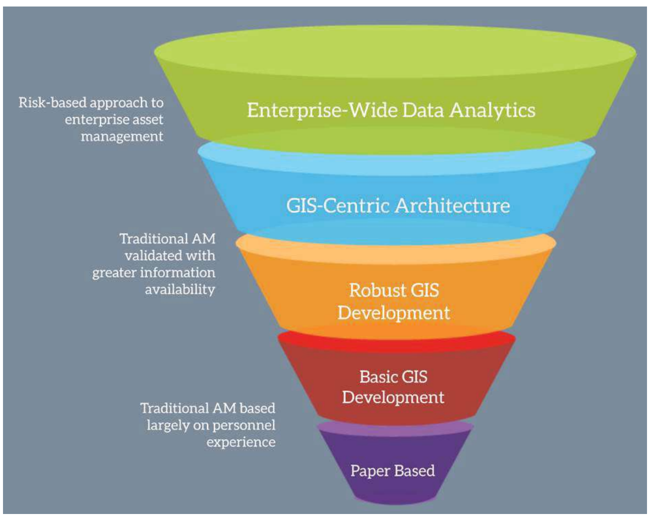
Formerly known as the Geographic Information Systems (GIS) Department, the EAM team is using an array of sophisticated tools and techniques to optimize the way the Service Authority manages its network of water and sewer assets. The EAM team's vision is to become a nationally recognized utility department for leading enterprise-wide asset management through information technology innovation and system integration, exceptional data quality, spatial data analytics, and integrated workflows. EAM programs are being increasingly developed in the top tier of high-performing utilities.

"Our primary responsibility is to align the Service Authority's vision and organizational strategies with a portfolio of enterprise asset management programs and projects. GIS is our most powerful tool in that effort," said EAM Department Manager Brandon Pfleckl. "Our greatest priority right now is creating ways we can quantitatively measure and analyze risk for each asset, then use that information to improve our ability to perform data-driven planning."

The tangible result of the EAM team's efforts is a suite of GIS applications that allow Service Authority personnel to spatially access and analyze information from a variety of IT systems via a single point, whether in the office or field — greatly enhancing the ability of personnel to make clear, justifiable decisions in an efficient manner.

The technology backbone includes a GIS-centric IT architecture where the GIS database acts as an information hub into which other systems can be integrated. The EAM team has integrated GIS with the Service Authority's computerized maintenance management system (CMMS), customer information system, and asset records databases. They are currently working to integrate with the systems control and data acquisition (SCADA), financial, and laboratory systems.

"When our folks are in the field, they will have a super-fast application that will be extremely reliable, giving them a tool to access a wide variety of information very quickly and analyze that information in a single context," said GIS Specialist Yeoanny Venetsanos.



The evolution of enterprise asset management

GIS Applications

In the last fiscal year, the EAM team has created applications for several Service Authority divisions, including O&M, Environmental Services & Water Reclamation, and Engineering & Planning. Each application is customized to the users' specific asset data viewing and analysis needs.

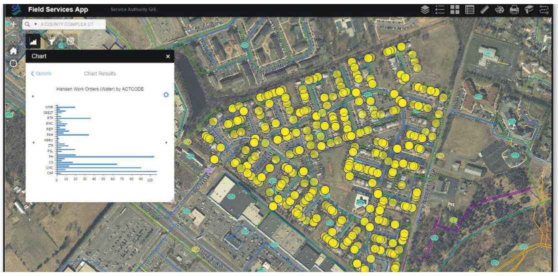
For O&M stakeholders, knowing the history of the work being done on those assets is a valuable tool, said O&M Division Director Don Pannell. For starters, customers' questions can be resolved quickly by using the GIS application. When a customer sees a blue water line mark on the street and a torn up sidewalk in front of their house, sometimes they assume it is the work of the Service Authority, said Pannell. By using the GIS-based Work Order History app, management can zero in on the neighborhood and immediately identify whether there has been any recent work done by the Service Authority in the area.

"If there is a mess in a ditch, we can look in our order history and say to the customer, 'Yes, there was a water main break last week,'" Pannell said. "It's a lot more satisfying to customers when we can tell them definitively what the issue is."

Using the GIS application to access work orders rather than the CMMS system can be beneficial in planning, said Pannell. As an example, a search on the CMMS can indicate how many breaks there are on a particular street and the block number. However, by zooming in on the exact location of where most of the breaks are happening through the work order history app, management can quickly understand where on the street a project may need to be done in the future.

Additionally, the GIS application can be used to locate assets with relatively high precision. For example, whether due to difficult terrain, snow cover, over-paving, or property changes, finding the precise locations of meters and other assets can be a difficult chore. By using the GIS applications and integrated GPS technology, users can see their position in the field relative to the buried utility assets underground. Users can simply walk toward the asset until their position is shown on top of the asset location, saving a great deal of time and effort.

A screenshot from Prince William County Service Authority's GIS-based Work Order History app



"Sometimes on the service orders, it may say some something like [the meter is] in the left rear or on the right side of a property, very general information about the location of the meter," said Mark Head, field services manager. "The GIS gives them a picture of where the meter should be located and the user's position relative to the asset location."

Field personnel can pull customer account details from the GIS app, saving additional time. Consumption history, customer contact information, meter type and installation history, service order history, and other account details can be gathered and studied in a few seconds in the field as compared to many minutes or hours previously.

Users can also analyze consumption trends for a customer (or an aggregate of the neighborhood) to see if there has been a spike in water usage, potentially indicating a leak at the residence. In the near future, users will be able to compare the customer consumption data with SCADA data to help identify localized water loss in the system.

Charting The Future

Building GIS applications that leverage data from several IT systems is just the beginning. At this point, the Service Authority has made tremendous strides to make existing workflows more efficient. The next challenge is finding ways to analyze the vast amounts of utility data in new ways to expand data-driven decision-making.

Quantitatively measuring asset risk at the individual asset level to improve risk-based planning and forecasting could provide a variety of benefits. Examples include CIP (capital improvement plan) repair-and-replace planning to determine what CIP plan will yield the lowest risk number at the least cost to ratepayers over time, greater precision with preventative maintenance planning to target high-risk assets first, and refined asset deterioration curves based on empirical data mapped in a GIS environment.

"By assigning a risk score to each asset, based on the consequence of failure of that asset and the likelihood that an asset will fail, the Service Authority will be in a much better position to precisely target CIP repair-and-replacement planning to maximize the positive impact of every dollar spent," stated Pfleckl.

The Service Authority is committed to operating as a best-in-class utility, and GIS technology is a centerpiece of that vision. As GIS data, workflows, and applications evolve, the EAM team will integrate additional systems and provide new ways of analyzing data. ■

About The Author

Kipp Hanley is a copywriter for the Prince William County Service Authority.

Zero Liquid Discharge Project Turns Treatment Byproduct Into Drinking Water

What's the most sustainable way of dealing with reverse osmosis and nanofiltration membrane concentrate, particularly in water-scarce Florida? Treat it and drink it.

By Phillip Locke, Fred Greiner, and Ryan Popko

Using unconventional sources often requires the implementation of new process applications to meet potable water treatment requirements and demands. Effectively treating waste streams can be an essential part of meeting alternative water supply goals. Although membrane treatments — specifically reverse osmosis (RO) and nanofiltration — feature significant benefits in treating water to a consistently high level, managing the treatment process byproduct, or concentrate, can be a challenge.

Meeting The Challenge

The City of Palm Coast, FL, had explored several methods to develop alternative water supplies, recover and reuse water, and reduce the utility's environmental impact. The city's consumptive use permit limited source water supplies, while regulatory constraints required an alternative means of concentrate disposal. Because of these constraints, the city elected to treat and recover its RO concentrate as an alternative water supply, using a unique zero liquid discharge (ZLD) process at the water treatment plant (WTP) No. 2 membrane softening facility.

The ZLD process is capable of treating 1.2 MGD of low-pressure RO concentrate using lime and soda ash softening, membrane filtration, and disinfection. It allows the city to treat and recover nearly 100 percent of the WTP-produced concentrate that was previously discharged to a surface water body. The process treats the concentrate stream to a level that complies with all primary and secondary drinking water standards when blended with the plant's finished water and increases the facility's capacity by 1.2 MGD without additional source water supplies.

An aerial view of WTP No. 2 shows many of the facilities built to treat and recover the plant's RO concentrate as an alternative water supply using the ZLD process, including (clockwise from top left) a sludge dewatering facility, a lime silo, a post-treatment and ultrafiltration building, and solids contact clarifiers.

Palm Coast's ZLD project evolved after the city's most recent National Pollutant Discharge Elimination System concentrate discharge permit renewal, as the U.S. EPA and Florida Department of Environmental Protection determined that the use of an extended mixing zone for water quality compliance was no longer feasible. The city evaluated 12 alternative disposal methods of concentrate based on treatability, feasibility, and economics. After bench-scale and pilot testing, the city selected ZLD for its WTP No. 2. The concentrate ZLD option provided concentrate recovery as an alternative water supply for potable use and for beneficial reuse of solids removed from the concentrate stream. The local water management district's push for the use of alternative water supplies was also a factor in ZLD selection.

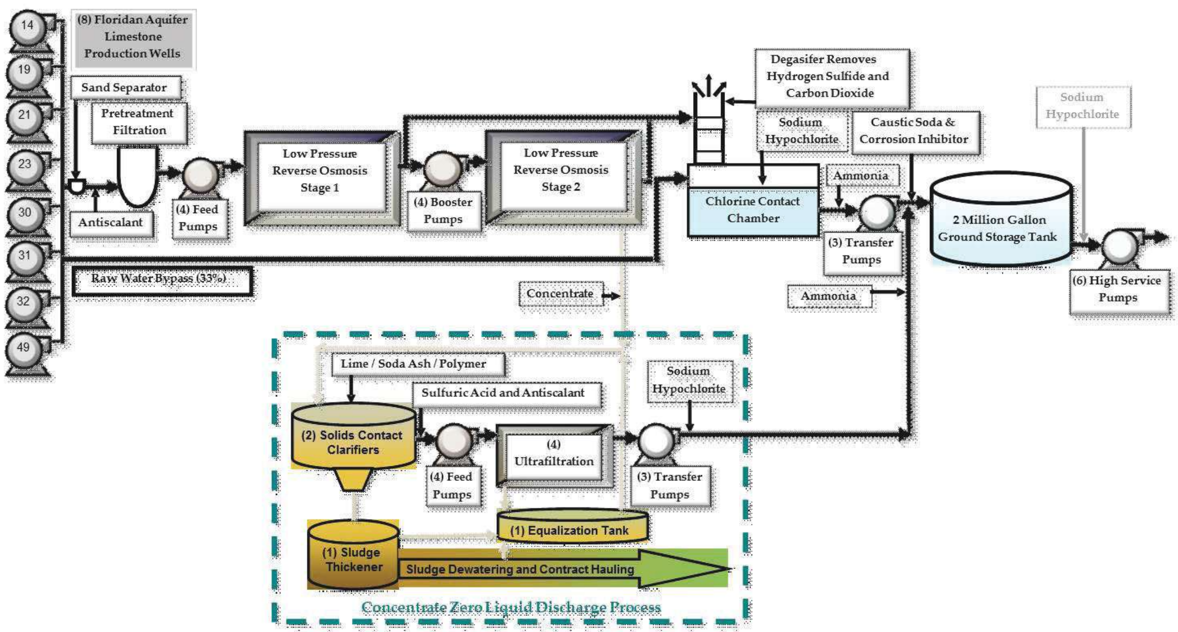
An aerial view of WTP No. 2 shows many of the facilities built to treat and recover the plant's RO concentrate as an alternative water supply using the ZLD process, including (clockwise from top left) a sludge dewatering facility, a lime silo, a post-treatment and ultrafiltration building, and solids contact clarifiers.

Process Design

The primary components of the ZLD process include lime and soda ash softening, clarification, ultrafiltration (UF) feed system, pressurized UF membrane system, UF backwash and cleaning system, disinfection system, process recycle and recovery system, solids handling system, sludge dewatering system, process and yard piping, electrical systems, and instrumentation and control systems. The table below presents the water quality parameters used to design the concentrate ZLD system.

Parameter	RO Permeate	RO Concentrate (ZLD Feedwater)	ZLD Water Goal[1]	Actual Water Quality[2]
Total Hardness (mg/L as $CaCo_3$)	4.1	1,650	<155	130
True Color (C.U.)	0	53	<65	41
Total Dissolved Solids (mg/L)	51	2,500	<2,320	966
Iron (mg/L)	.02	1.7	<.17	.01
Chloride (mg/L)	11.1	600	<1,368	320
Turbidity (NTU)	.10	8.8	<.41	.20

As detailed in the process flow diagram below, the concentrate ZLD process consists of softening by chemical precipitation followed by UF primarily to reduce carbonate and noncarbonate hardness, as well as some total organic carbon and color. Lime and soda ash are used to precipitate carbonate and noncarbonate hardness in two solids contact clarifiers, and a polymer is added to enhance settling. The pH of the softened water is adjusted and a scale inhibitor is added before water is transferred to the UF feed tank. The UF feed pumps transfer the softened water through automatic backwash strainers and a pressurized vertical UF system that removes the remaining suspended solids. The UF system was designed to provide 100 percent treatment capacity when one of the plant's four trains is offline for cleaning, maintenance, or repair. The UF elements are cleaned through permeate backwash, chemically enhanced backwash, and clean-in-place (CIP) operations.



The chemically enhanced backwash uses sulfuric acid, sodium hydroxide, or sodium hypochlorite. CIP operations use citric acid, sodium hydroxide, or sodium hypochlorite. The UF system is housed in a pre-engineered metal building designed to accommodate additional UF membranes and other components to allow for a future expansion of the ZLD process to 1.8 MGD. After the softened water is filtered by the UF membranes, the UF filtrate is conveyed to the UF filtrate and backwash tanks. The filtrate from the UF filtrate and backwash tanks is disinfected using free chlorine before blending with the combined permeate and raw water bypass water directly upstream of the existing ground storage tank and converting to chloramines for final disinfection.

In addition to the main ZLD process stream, two other process streams are associated with the concentrate ZLD process: a solids stream and a recycle stream. The system recovers over 99.3 percent of the concentrate. This occurs by collecting the five recycle/recovery streams and combining them in the equalization tank where they are recycled to the head of the ZLD process. The recycle streams include solids-laden softened water from the UF feed tank, UF pretreatment strainer backwash, UF-neutralized chemically enhanced backwash water, gravity sludge thickener supernatant, and belt filter press filtrate. The recovery and recirculation of the various streams within the concentrate ZLD process are imperative for successful implementation. The ZLD system was designed to produce lime sludge with approximately 50 percent dry solids.

Sludge removed from the solids contact clarifiers is transferred to a gravity sludge thickener. From there, solids removed from the gravity sludge thickener are pumped to the solids handling and dewatering system via rotary lobe pumps. Sludge is dewatered with two belt filter presses, which allows 100 percent redundancy. The dewatered solids are hauled from WTP No. 2 by the city's contract hauler, where they are mixed with recycled concrete for dust control and act as a binder in the production of a paver base.

Project Challenges

Recycle Streams. One of the project's biggest challenges was handling all the recycle streams needed to achieve 99.3 percent recovery. Because of each stream's varying volume, duration, and frequency, an equalization tank with a capacity of approximately 80,000 gallons was designed and sized to provide ample capacity for the flows. In addition to providing the requisite storage for the recycle flows, the equalization tank was also fitted with a mixing system that includes jet-type mixing eductors and a pumping system to keep solids suspended in the tank.

Three recycle pumps for the equalization tank transfer the various recycle flows back to the head of the ZLD process, directly upstream of the solids contact clarifiers, where the flows are mixed with the influent concentrate. Even with the equalization tank's fairly large capacity, flow control of the recycle stream is required to avoid surges and upsets to the ZLD treatment process. As a result of the recycle flows, the process units are designed to treat flows higher than the 1.2 MGD concentrate flow to accommodate the recycle streams. For 1.2 MGD concentrate, the treatment process is designed to handle an additional 0.65 MGD of recycle flow.

The equalization tank was installed below grade to allow for gravity flows to it, so self-priming (rather than submersible) pumps were selected, in large part because of the potentially corrosive equalization tank water. Submersible pumps would need to be constructed entirely of stainless steel to withstand the environment, which wasn't economically feasible. Flow control evaluations considered variable frequency drives (VFDs), motorized V-port discharge ball valves, and multiple pumps. VFDs were eliminated from consideration because of concerns about keeping the pumps primed at low motor speeds. Three pumps, along with a flow-controlled V-port ball valve on the common recycle line, were selected for the implementation.

Disinfection. Another significant challenge for the project was how to disinfect the ZLD-treated water without exceeding disinfection byproduct (DBP) limitations. The city was providing 4-log virus treatment in accordance with the Ground Water Rule through free chlorine addition to the blended permeate and raw water bypass in the clearwell prior to chloramination. The project's original concept was to combine the ZLD-treated water with the permeate and the raw water bypass streams in the clearwell, but higher TOC concentrations in the ZLD-treated water were a concern. Because the lime and soda ash softening combined with membrane filtration can provide 2-log virus inactivation, the ZLD-treated water was disinfected separately with free chlorine to provide the remaining 2-log virus treatment before chloramination.

Integrating With An Existing Facility

The concentrate ZLD process is complex and needed to be fully integrated with its respective components as well as the existing plant so the facility could operate as a single entity.

The instrumentation and SCADA system associated with the ZLD process was integrated into WTP No. 2's existing SCADA system.

This operational approach complies with the operating permit that was issued to incorporate the concentrate ZLD process and increase the plant's overall capacity.

Operational Considerations

Instrumentation And Electrical. The existing instrumentation and SCADA system at WTP No. 2 consisted of a centralized plant control system providing monitoring and operating capability from a centralized computer system. Plant operations were directly wired into the control room's programmable logic control cabinet, and the system was expanded to incorporate and completely integrate all the ZLD processes into the modified SCADA system. These changes allow operators to monitor and control all the plant's operations and processes from a single location.

Electrical And Standby Power. The electrical system for the existing facility was expanded and upgraded to accommodate the ZLD process. The existing emergency generator was rehabilitated and used for the concentrate ZLD process. A new emergency generator was installed to reinforce the plant's reliability. This approach was more cost-effective than replacing the existing emergency power system with a larger system to safeguard the expanded operations. The electrical system's design, including sequencing its two generators, minimized the need for plant shutdowns during construction.

Yard Piping And Underground Utilities. The existing raw water bypass piping was relocated to accommodate the new UF building. A significant amount of piping and other underground utilities exist onsite. As a result, new piping and other underground utilities placement was challenging, which is a common issue when improving an existing facility. The keys to success were identifying existing piping and utilities early in the project through the use of record drawings, subsurface utilities excavations, and staff's knowledge of previous plant improvements.

Current Status

Substantial completion of the concentrate ZLD project occurred on March 2, 2015. The team experienced a few challenges during startup, but these were overcome by close collaboration with the City of Palm Coast, the engineer of record (McKim & Creed, Inc.), the contractor (Wharton-Smith), and the original equipment manufacturer (Doosan Hydro Technology). Additionally, operational modifications are being tested and implemented to reduce DBP formation. In April, the team was awarded the David W. York Water Reuse Project of the Year award by the Florida Water Environment Association. ■

About The Authors

Phillip Locke, PE, is a senior project manager with McKim & Creed, Inc. and served as project manager and lead process engineer of Palm Coast's ZLD project. He has more than 20 years of experience, including serving as engineer of record for five advanced water treatment projects.

Fred Greiner is the chief operator of WTP No. 2 for the City of Palm Coast.

Ryan Popko, PE, served as project engineer on the ZLD project while with McKim & Creed. Currently, Ryan is a process engineer with JEA.

Keep Austin Sustainable: The Unique Case Of Water Treatment Plant No. 4

With people flocking to the trendy Texas metropolis, Austin needed a new treatment plant to sustain its growth – but a "sensitive" touch was required to complete the project while protecting the environment.

By Larry Laws, Katy Perrino, and Joseph Sesil

For years, Austin, TX, has ranked as one of the fastest-growing major cities nationwide. Between 2000 and 2010, the city's population grew by 20 percent, and today nearly 165 people move to Austin daily. Consequently, water demand will increase sharply for years to come. Growth projections predict that the population will increase by 500,000 people by 2040; this is on top of the more than 1.8 million current residents of the Austin metropolitan area.

Matched with increasing population, Austin's aging water infrastructure has magnified water challenges. The Green Treatment Plant was built in 1925 and decommissioned in 2008, leaving Austin with just two water treatment plants: the Davis Water Treatment Plant, built in 1954, and the Ullrich Water Treatment Plant, built in 1969. Both draw water from the same source, Lake Austin, and both are decades old, thereby increasing the risk of shutdown.

Planning And Execution At Austin's Water Treatment Plant No. 4

Austin's Water Treatment Plant No. 4 (WTP4) was completed, commissioned, and started up in November 2014. The plant, which is located on Lake Travis, is capable of treating 50 MGD with room to expand to 300 MGD. This investment adds reliability by giving utility customers an additional plant that draws from Lake Travis instead of Lake Austin, saves energy in serving Austin's north and northwest desired development zone, and provides continuous service during shutdowns and repairs of Austin Water's two other aging treatment plants and pump stations. WTP4 featured an unprecedented environmental commissioning process that worked to protect the environment at every step of construction and into the future.

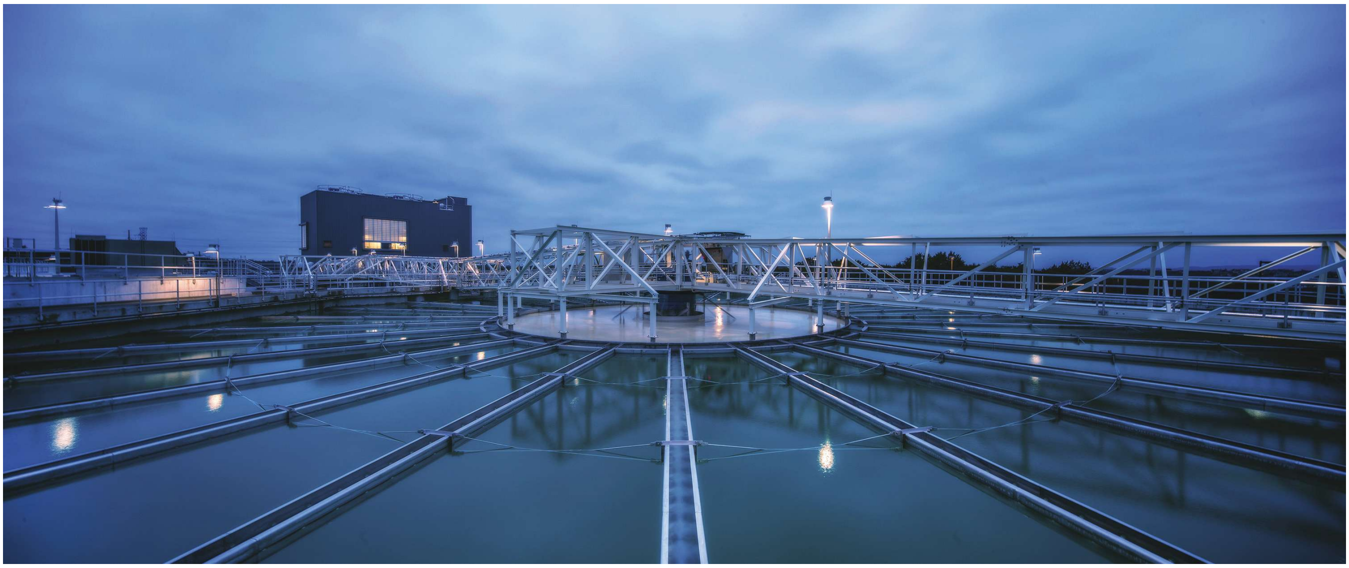
The facility includes an intake system in Lake Travis, a raw water tunnel and pump station, the treatment plant, and the Jollyville Transmission Main. The water's journey from lake to distribution starts at the raw water intake structure in Lake Travis. Fully submerged in the deepest part of the lake, the intake is a series of three stainless steel mesh filters and screens that remove large debris. Buoys mark the perimeter of the intake area to prevent boaters and swimmers from entering the area. Raw water travels from the intake system via a 9-foot tunnel to a raw water pump station, which moves water to the raw water transmission main, which then goes to the treatment plant.

Once the water reaches the treatment plant, it goes through an upflow clarifier water treatment process. The Jollyville Transmission Main (JTM) is a 6.5-mile, 84-inch-diameter tunnel that connects the water treatment plant to the Jollyville Reservoir. From this reservoir, the treated water enters the water distribution system. WTP4 replaced the capacity lost when the Green Water Treatment Plant was decommissioned in 2008. WTP4 buildings have achieved a silver rating through the Leadership in Energy and Environmental Design (LEED) national rating system. All facilities are designed to integrate into the surrounding landscape.

Design And Construction Of The Facility

Austin hired Carollo Engineers to design the plant and MWH Constructors to serve as the construction manager-at-risk (CMAR) on the plant, intake structure, and transmission mains. Time was added to the project schedule to incorporate value engineering changes developed by the team. The project was also extended to inspect and protect karst features that were encountered during excavation. The project team used Primavera scheduling tools to monitor and control the schedules of the more than 385 subcontracts. The team created an on-site "trailer village" where staff from public works, Austin Water Utility, MWH, subcontractors, consultants, subconsultants, and inspectors all worked together daily. Monthly executive team meetings were held at the plant site so project leaders could witness progress firsthand.

It was crucial that the project team collaborate on a daily basis. For instance, a significant construction challenge was creating the foundation to install the raw water intake tunnel. The foundation was built using a temporary trestle on top of the water on the edge of Lake Travis — one of the largest recreational lakes in Texas. The original concept called for a concrete gravity base that required extensive dredging. However, due to the limited amount of dredging allowed by the permit from the U.S.



Army Corps of Engineers and the water quality restrictions mandated by the Lower Colorado River Authority, the project explored an alternative method to the original design.

To find an economical and feasible alternative method, the CMAR and design team collaborated on constructability of the foundation during the design process. In addition, the CMAR used a unique approach to value engineering: asking contract bidders for additional value engineering ideas. Through this process, the project eliminated all dredging by employing a drilled or driven-pile foundation to support the intake in lieu of the original design. Another benefit of substituting prefabricated steel frames used by the driven-pile method for the original reinforced concrete frames to support the intake was that it cut by 90 percent the amount of time divers had to be in 150 feet of water in Lake Travis.

Addressing Environmental Concerns

The design and construction of WTP4, including its tunneling components, needed to address several environmental factors. In fact, the initial water treatment plant was set to break ground in 1984 until economic and environmental concerns delayed construction. Once the current site of WTP4 was deemed acceptable from economic and environmental standpoints, the city of Austin was able to move forward with its plans.

Completed filter building at WTP4

More than 12 potential sites were evaluated prior to finding this site as having the least negative effect on the environment. Criteria included the impact on migrating birds, karst invertebrates, and vegetation, as well as considerations for drainage, grading requirements, elevation and pumping requirements, and alignment of the tunnels built to distribute water from the site.

Before breaking ground on the project, Austin Water Utility and the city of Austin's Watershed Protection Department developed an environmental commissioning plan to guide the project in minimizing environmental impact and protecting the nearby environmental resources, sensitive species, and their habitat. The plan outlined a process that integrates environmental review and oversight of the project to meet the environmental goals beyond typical federal, state, and local regulatory requirements. The process specifically included an ongoing audit with recurring meetings, reviews, oversight, inspection, permitting, and other tasks.

The process required a collaboration with the city's project team, environmental commissioning team, and all contractors working closely together on design and construction methods. For the JTM tunnel, a key challenge was passing under the Balcones Canyonlands Preserve, a system of habitat preserves created to protect eight federally listed endangered species — six karst invertebrates and two bird species — and a threatened salamander known as the Jollyville Plateau salamander. The tunnel was to be built in the Glen Rose formation, which was made up of three limestone units — Edwards, Walnut, and Glen Rose.

The environmental commissioning plan and project team collaboration resulted in a balanced decision-making process for vetting the project design. Through this process, it was decided to shift the JTM tunnel's access shafts to the perimeter of the Balcones Canyonlands Preserve to avoid disturbing that critical habitat area. The project team conducted extensive groundwater assessments in the early stages of the preliminary design, proving that there are two distinct groundwater systems in the region. One system feeds the springs in the upper Edwards aquifer, and the team is tunneling through Glen Rose, which is the second system. There is very little interaction between the two, but in order to comply with demands from the environmental community for additional contingencies, the team lowered the entire tunnel a further 50 feet to guarantee that the project team would be in the lower aquifer at all times. Lowering the tunnel reduced potential environmental impact in the area's fragile karst geology.

Construction of the pump station building in Austin

In particular, karst voids within the Edwards formation provide a habitat for endangered cave-dwelling invertebrates, including six listed species of arachnids and insects. Strict controls on groundwater also exist in order to minimize any potential hydrological impacts to the karst system and the Balcones Canyonlands Preserve above, which has been set aside as a habitat for the Jollyville salamander and two species of protected rare birds.

The temporary support design for the shafts is based on groundwater modeling, which showed there are dolomite zones within the Edwards formation that contain most of the permeability. But there is very little vertical connection between these zones, so the project team wanted to keep water that was found at its same elevation. The shafts therefore have a sealed lining, consisting of grouted liner plates, throughout the Edwards and Walnut formations. When a permeable zone was hit, the project team would also over-excavate and add a gravel ring, essentially behind the grouted ring, so that the water could travel around the shaft and continue to feed the same karst structures that it was feeding before. Once below the transition to the Glen Rose aquifer, the temporary rock support becomes bolts and wire mesh.

There was intense coordination while the project team was sinking the shafts. The Environmental Commissioning Group was in the shaft 24 hours a day, and each time a void was found they were required to inspect it and ensure it was not a habitat for endangered species.

In addition to the JTM, the project included the 92-acre water treatment plant site. In an effort to involve the community prior to clearing the site, MWH Constructors teamed with the city and local environmental groups to host two on-site native plant relocation and rescue efforts. The events were well attended by the community. MWH provided safety vests and conducted a safety orientation for volunteers.

Upon completion of the WTP4 project, the administration building, located at the water treatment plant, earned a silver-level LEED certification. The project team worked closely on a daily basis with the city of Austin and its environmental team to enhance and sustain their environmental responsibilities.

Key Takeaways For Project Success

The project team's focus on safety resulted in an unprecedented safety record for a project of this size and complexity. The project exceeded 1 million man-hours without a lost-time accident. Almost 3 million man-hours were logged at five locations, including work at Lake Travis and tunneling more than 7.5 miles with many crews working around the clock. Safety was emphasized and recognized with celebrations to honor milestones reached. In addition to construction safety, the treatment plant uses a new process that creates nonhazardous chlorine molecules on-site from a simple, safe chemical reaction process. No chlorine or ammonia will arrive on tanker trucks.

The economic impact of this project is also a success. MWH hired 208 subcontractors and vendors and signed 385 subcontracts to work on the project. Eighty-eight percent of the vendors were local or regional. These contractors earned almost $285 million throughout the life of the project. WTP4 exceeded all the participation goals for minority and women-owned businesses; more than $63 million was earned by these businesses.

Public outreach was also a critical success factor for the project. Austin's citizenry is civic-minded and protective of environmental resources and quality of life. City staff, the consultant, and MWH Constructors worked together to keep the community informed with public meetings and newsletters. The project team also maintained a hotline that connected to a cellphone that was carried by a team member. This cellphone was answered 24 hours a day, seven days a week.

The project team worked together through many challenges, including a tight budget and an environmentally sensitive site, to produce a water infrastructure that will contribute to Austin's water security for decades to come. ■

Concrete roofing rebar being installed at the 10-million-gallon clearwell structure

About The Authors

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Nontraditional Nutrient Reduction Techniques

It always feels good to meet your goals – even better to exceed them. Learn how an upgrade to biological nutrient removal (BNR) resulted in enhanced nutrient removal (ENR) performance.

By Michele Braas

In recent years, many municipal wastewater treatment plants have needed to update processes and facilities to comply with more stringent environmental regulations related to cleaning up local bays and streams. For the Manheim Area Water & Sewer Authority (MAWSA), formerly known as Manheim Borough Authority, located in Lancaster County, PA, the operators took on the challenge of upgrading to BNR effluent levels. The organization reached Pennsylvania Department of Environmental Protection (PADEP) standards after installing a new facility and processes, and then went on to tweak processes through trial and error, achieving ENR with impressively low effluent levels.

The History

Nearly 10 years ago, the PADEP met with MAWSA and its wastewater engineer, RETTEW, to review the agency's strategy. The ultimate goal for the PADEP was to improve conditions in the Chesapeake Bay Watershed. The environmental agency set new total nitrogen and total phosphorus effluent limits for wastewater treatment plant (WWTP) discharges in Pennsylvania. MAWSA's WWTP would need to achieve an average of 6.0 mg/L total nitrogen and 0.8 mg/L total phosphorus discharge concentrations, based on the permitted flow for the facility. At that time, MAWSA operated a trickling filter plant, which could not meet the proposed nutrient limits without additional equipment and procedures.

After evaluating future needs, MAWSA and RETTEW analyzed alternatives such as sequencing batch reactors and fixed film filters. RETTEW recommended a phased oxidation ditch and integral anoxic tanks for MAWSA's BNR upgrade. The oxidation ditch is a continuous flow activated sludge system, with the main treatment processes isolated in separate oxidation ditches. The conditions of each ditch are altered between aerobic and anoxic conditions, thus achieving the desired treatment level. The recommendation also included an anaerobic selector for biological phosphorus removal. Other proposed upgrades included new return sludge and waste-activated sludge pumps, new variable-speed drives on influent pumps, two new final clarifiers, a supplemental carbon feed facility, a ferric chloride chemical feed system, and a biosolids storage facility. These changes would not only help MAWSA meet PADEP's goals but also prepare it to meet more rigorous discharge levels in the future if needed.

Traditionally, wastewater treatment facilities obtain ENR with the addition of filters or chemicals. At MAWSA, however, the facility's staff has been able to reach ENR-level discharges through optimizing its oxidation ditches.

The Upgrades

Released for construction bidding in mid-2009, the upgrades were slated for completion in 2011, meeting the PADEP's mandated timing of April 2012. The engineering design specified all upgrades to be installed on the same property as the existing facility, and treatment operations needed to remain continuous throughout the construction and installation. Undertaken by Wickersham Construction and Engineering, Inc. and Gettle, Inc., the contractors adhered to the schedule, allowing the new commissioning procedures to occur simultaneously with the decommissioning of the existing facilities.

Throughout the construction process, some unforeseen challenges surfaced. During excavation, the team discovered the underground presence of several unmarked and abandoned vaults and structures. These items were not shown on the as-built drawings. The contractor worked with RETTEW to modify the construction approach, completing the base for the oxidation ditch in three concrete foundation pours while the structures were simultaneously removed.

Because of the close proximity to a nearby creek, groundwater also became an issue during excavations and construction. The contractor brought in large pumps to dewater the excavations for the oxidation ditch and kept the project on schedule and within the original cost estimates.

The original estimate of construction costs for the work was $10.4 million. However, approximate total cost after bids were returned was $8.6 million. With the change orders and change in construction approach due to the unforeseen circumstances, the final costs were approximately $9.6 million.

Plant improvements included new pumps for return sludge and waste-activated sludge.

The Process

The newly installed BRN processes enabled the facility to meet PADEP nutrient discharge requirements. BNR typically refers to a system treating wastewater to an effluent level of total nitrogen 8 to 10 mg/L and total phosphorus 1 to 3 mg/L. In a BNR wastewater treatment facility, the microorganisms used to treat the wastewater are intentionally stressed, resulting in several nutrient-important results: the conversion of ammonia to nitrates and nitrites, the release of nitrogen gas, and the uptake of phosphorus. To ensure these biological conversions occur, the microorganisms' environment must be controlled, keeping the pH balance, alkalinity, carbon, and sludge age at correct levels. By controlling the microorganisms, their environment, and the phases of the installed oxidation ditches, MAWSA completes biological nitrogen removal through nitrification/denitrification, as well as some biological phosphorus removal.

The Next Step

ENR is a step further than BNR, resulting in effluent levels as low as total nitrogen of 3 mg/L and total phosphorus of 0.3 mg/L or less. Traditionally, wastewater treatment facilities obtain ENR with the addition of filters or chemicals. At MAWSA, however, the facility's staff has been able to reach ENR-level discharges through optimizing its oxidation ditches.

The authority's staff wanted to optimize the facility for its primary discharge requirements, so they tested and fine-tuned processes to reach lower effluent discharge levels. The goals were both to improve effluent discharge levels and find operating and cost efficiencies for the facility, something that was possible because of the facility's unusual quality influent.

MAWSA's facility does not feature typical quality influent. Rather, its influent has low biochemical oxygen demand (BOD) concentrations, featuring monthly averages of 160 mg/L, with lows as little as 50 mg/L. These concentrations result in a low food-to-microorganism ratio. After careful testing of the process, MAWSA determined that by operating at an older sludge age, it was able to compensate for the low food-to-microorganism ratio, as older microorganisms require less food than younger ones.

MAWSA now operates with a sludge age of 40 to 50 days, while a typical oxidation ditch will operate with a sludge age of 20 to 30 days. This environment, which supports an older sludge age, allows MAWSA to meet ENR conditions within its existing oxidation ditch process, during which nitrogen removal is obtained biologically. Phosphorus is also partially obtained biologically but also via chemical participation in the clarifiers.

The Pros And Cons

Operating the oxidation ditches at an old sludge age has several advantages. The older microorganisms require less dissolved oxygen than younger microorganisms. These conditions result

MAWSA's WWTP Effluent Quality Data

Month And Year	Average Monthly Total Nitrogen (mg/l)	Average Monthly Total Phosphorus (mg/l)
August 2014	2.12	0.11
September 2014	2.36	0.19
October 2014	1.99	0.16
November 2014	2.05	0.11
December 2014	1.70	0.10
January 2015	1.92	0.10
February 2015	2.13	0.10
March 2015	2.21	0.09
April 2015	2.17	1.38
May 2015	1.75	0.40
June 2015	2.41	0.20
July 2015	1.67	0.08
Average	2.04	0.25

A summary of MAWSA's treatment plant total nitrogen and total phosphorus concentrations from August 2014 through July 2015 (the most recent data available)

Wastewater enters oxidation ditches at MAWSA.

in an overall decrease in the need for aeration, which in turn equates to lower energy costs.

Also, as a result of the extended sludge age and hydraulic retention time, the microorganisms actually use their own protoplasm as food. They do this through a process known as endogenous respiration, when a living organism uses its own cellular mass instead of outside organic matter for energy. This results in less sludge per pound of carbonaceous oxidation. This brings down overall sludge production, resulting in reduced disposal, chemical, and electrical costs for biosolids.

Operating at higher sludge ages, however, is not without its disadvantages. The older microorganisms are less resilient than younger microorganisms. The system is therefore more prone to quantity and quality disturbances from changes in flow. In addition, older sludges are also more granular in shape, which increases the amount of time it takes to settle the sludge. The older sludges challenge the clarifier systems. To combat these issues, MAWSA adds ferric chloride to assist in settling in the clarifiers, which not only assists in settling the sludge but it also helps to remove phosphorus.

Like any wastewater treatment system and process, operating the oxidation ditches at an old sludge age has it disadvantages and advantages. MAWSA has determined that for its system, the advantages outweigh the disadvantages. The high sludge age ensures maximum usage of the new facilities, which in turn led to ENR-level nutrient removal results. The average monthly effluent concentrations from August 2014 through July 2015 were 2.04 mg/L for total nitrogen and 0.25 mg/L for total phosphorus (as seen in MAWSA's WWTP Effluent Quality Data table, on page 23).

By working together, the staff at MAWSA and the engineers at RETTEW have been able to blend the upgrades and process improvements to produce an excellent water quality effluent that exceeds the PADEP's limits and MAWSA's goals. This results in a positive outcome for the receiving stream in southeastern Pennsylvania, which is connected through a network of waterways to tributaries of the Chesapeake Bay. MAWSA's emphasis on operational quality is benefiting end users via reduced costs as well as the environment, by contributing to improvements to the Chesapeake Bay. ■

About The Author

Michele Braas, PE, specializes in wastewater system and drinking water distribution system design. She has coordinated design of wastewater treatment facilities, including BNR evaluations, sanitary sewer systems, and sewage pumping stations. Her experience also includes the writing of permit applications, grant applications, and contract documents, and the performance of construction administration.

New Tech Offers Low-Energy Oil And Gas Wastewater Management

By Dr. Zhiyong (Jason) Ren

Microbial capacitive deionization (MCD) shows promise as a sustainable, low-cost treatment solution for produced water.

Wastewater management during unconventional oil and gas exploration and production is one of the biggest challenges for the industry and society. Wastewater is the industry's largest byproduct, with the annual amount generated estimated at nearly 900 billion gallons (~21 billion barrels). Unlike municipal or other industrial wastewater, this wastewater (also called produced water) is highly variable in quality and quantity, and its physicochemical composition can be very complex. The water contains dissolved and suspended organics, total suspended solids (TSS), total dissolved solids (TDS), chemical additives, microbes, and naturally occurring radioactive materials. The water is considered hazardous waste and must be treated or disposed of safely. Currently about 90 percent of such water is disposed of through deep underground injection. However, this method leads to the loss of a precious water resource, and the safety and health concerns have been widely reported in recent years, such as frequent seismic activities around the injection area. The transportation of large volumes of water to injection wells and centralized treatment facilities has also generated problems in neighboring communities. Therefore, treatment and reuse of this water is an imminent need, especially in western states where drinking and irrigation water are lacking and water acquisition can be difficult.

Current water management costs already account for more than 10 percent of a well's operating expense, so it is difficult for the industry to implement even more expensive treatment technologies while maintaining profitability. In order to remove both organic contaminants and salts, traditionally multiple technologies are combined because biological treatment can be effective in organic degradation but is not suitable for salt removal; meanwhile, membrane-based desalination technologies are ineffective in organic removal and require extensive pretreatment to protect system components. Furthermore, both processes consume high energy for aeration and pumping, and previous studies showed 10 to 100 kWh of electricity is needed for the treatment of 1 m^3 of water.

A Simpler And Cheaper Solution

One approach to accomplishing sustainable produced water management is to develop technologies that remove both organic carbon and TDS without consuming external energy — or that potentially gain net energy. In this context, recently developed microbial capacitive deionization (MCD) may provide a market niche. MCD is based on the fundamental work derived from a platform called microbial electrochemical technology (MET). MCD employs microorganisms to break down organic or inorganic sources of electrons in the wastewater, and the electrons (i.e., current) flow through an external circuit to specially-designed membrane assemblies in the middle chamber and finally combine with protons in the cathode chamber to generate water. The current can be directly harvested as electricity or used for chemical production in

The main value proposition of MCD is that it offers a simpler solution for oil and gas water management because it can simultaneously remove hydrocarbons, salts, and metals in one reactor.

Electrical energy can be generated during ion discharge from the electrodes, similar to a rechargeable battery.

the cathode chamber, and the electrical potential generated between the anode and cathode drives the removal of salts, heavy metals, and charged organic matter for water purification and desalination. Electrical energy can be generated during ion discharge from the electrodes, similar to a rechargeable battery. The MCD process has been tested at lab- and pilot-scale, and a mobile trailer system with a capacity of 5 gallons per minute is being developed for field testing. Using actual produced water obtained from Denver-Julesburg Basin, which has chemical oxygen demand (COD) ranging from 1,100 to 2,600 mg/L and TDS ranging from 16,000 to 28,000 mg/L, the lab systems were able to remove 10,200 to 66,240 mg TDS/L/day and ~4,000 mg COD/L/day. In addition to water treatment, the system generates 89 to 131 W/m^3 of electricity, which is harvested and stored for powering online sensors.

The figure below shows the pilot system, developed by the University of Colorado at Boulder, which is stackable and can be mounted on a truck. The inset shows the water before and after treatment. Preliminary techno-economic analysis shows the MCD system is inexpensive to operate ($0.10 to 0.60/barrel depending on treatment need) and credited with low energy consumption; moreover, extra electricity and water are produced due to the use of sodium percarbonate as an electron acceptor.

Clear results: The MCD pilot shown with influent- effluent comparison.

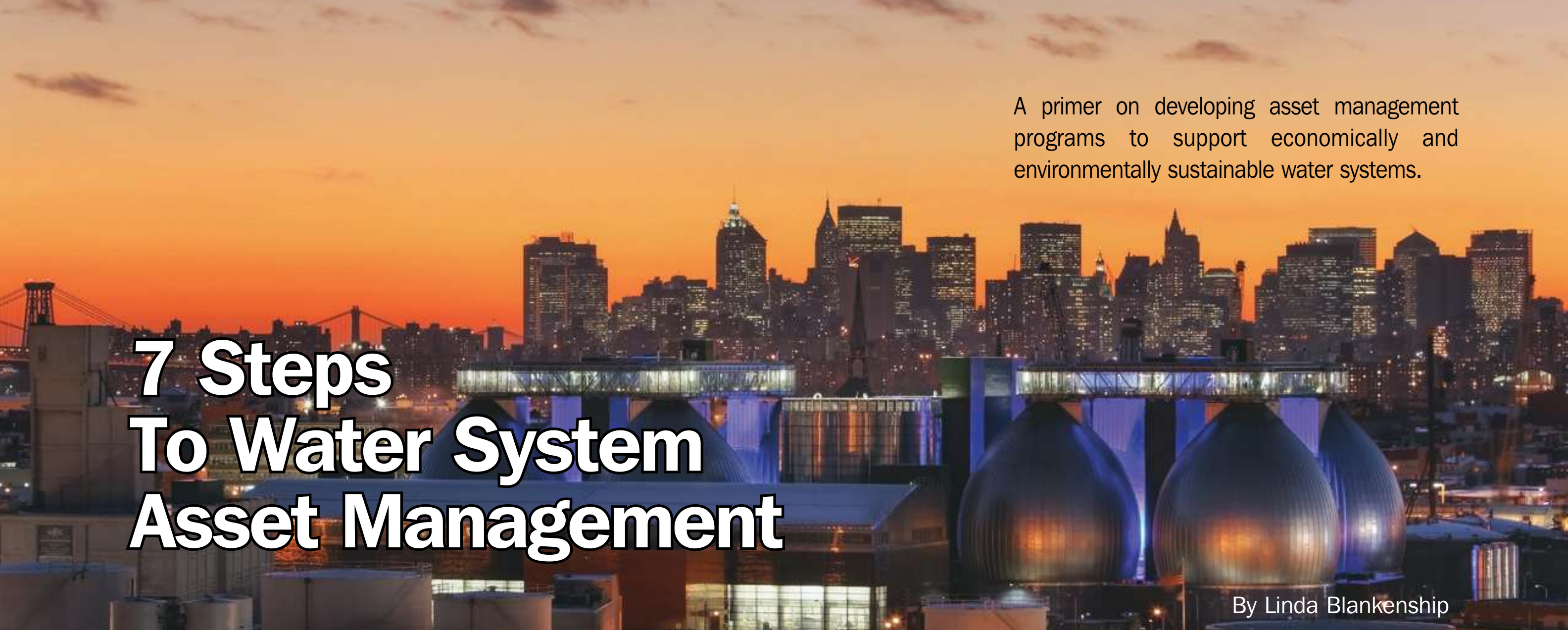
The main value proposition of MCD is that it offers a simpler solution for oil and gas water management because it can simultaneously remove hydrocarbons, salts, and metals in one reactor. This not only reduces system capital costs by eliminating multiple units, but it also reduces operational costs by reducing energy consumption and producing renewable energy and water. MCD can also be integrated with other treatment units with complementary functions, so overall efficiency can be improved. For example, MCD has been connected with electrocoagulation (EC), with EC removing TSS while MCD removes COD and TDS. In the meantime, MCD can provide the electricity needed by EC, making the system energy-neutral. If further treatment is needed for certain reuses, MCD can also be integrated with membrane technologies such as reverse osmosis or forward osmosis to provide high-quality effluent.

Challenges Ahead

While microbial electrochemical processes show good potential for oil and gas wastewater treatment and reuse, there are many challenges ahead. For extra-high-saline produced water like that generated at the Marcellus Shale in Pennsylvania or the Bakken formation in North Dakota, MCD may not be very efficient due to its limitation on adsorption capacity; rather, it may serve as a low-cost pretreatment for membrane distillation. Similar to the cost of other desalination technologies, the cost of TDS removal by MCD is still high for the industry compared with deep well injection, so further development and new incentives for external water reuse such as irrigation are needed for possible market adoption. There are several new articles covering the technology and market, and critical comments from experts can be found there: *Microbes Could Help Clean Up After Fracking* (CBS News) and *New Technology Could Make Treatment of Oil and Gas Wastewater Simpler, Cheaper* (University of Colorado Boulder). ■

About The Author

Dr. Zhiyong (Jason) Ren is an Associate Professor of Environmental Engineering at the University of Colorado at Boulder. He co-founded Bioelectric Inc., a cleantech startup focusing on innovative water and energy solutions. An expert in microbial and electrochemical processes for energy and environmental applications, Ren has been funded by NSF, DoD, EPA, and private sponsors to conduct water-energy R&D. He has published more than 100 journal and conference articles and has filed four patent disclosures. His research findings have been featured by NPR, ABC, and CBS. More info is available at http://spot.colorado.edu/~zhre0706/.



A primer on developing asset management programs to support economically and environmentally sustainable water systems.

7 Steps To Water System Asset Management

By Linda Blankenship

A city that struggles to supply water and treat wastewater is a city at risk. As critical resources to support a healthy population, water and wastewater underpin so many of the things that make a city sustainable, from agriculture and industry to energy and economic development. For this reason, cities that tackle water issues will find themselves at the top of the list of most sustainable, successful communities.

Priority Planning

On many levels, water system asset management is a cornerstone of sustainability and resiliency, supporting the insights, planning, and day-to-day discipline needed to optimize these both operationally and financially over the long-term. However, for water utilities seeking to manage sustainable systems, the challenges are all too familiar and usually start with budget struggles.

The tension between immediate needs and long-term imperatives can quickly derail asset management planning before it starts. Aging infrastructure competes with new construction for investment funds, making for some "apples and oranges" debates, like how to balance the need to renew old systems and also install new tunnels to manage combined sewer overflow (CSO). And what happens when the system becomes so patched and aged that you can no longer stay ahead of the failures? Reactive maintenance and repair is the most expensive and inefficient approach that a utility can undertake.

Funding is only one issue. The other is often information. It isn't really planning if you have no way to know what the effects of your actions will be. Information technology can provide some answers, but data sets may be incomplete or out of date. Leading approaches and practices of asset management can help bring the whole picture into focus, with benefits across operations, ultimately enhancing customer acceptance and stakeholder support.

In fact, at its fundamental core, asset management planning helps optimize the life-cycle cost of assets, while meeting levels of service that customers and other key stakeholders desire. But that doesn't make it any easier to get started. It can be as challenging to justify the cost in both time and funding to develop and implement an asset management plan as it is in any capital project.

Sometimes it's easier to get buy-in by demonstrating success on a small scale as a proof of concept. Fortunately, there are some ways to start small while also building the case for a comprehensive program.

Stepping Up (x7)

1. Produce quick and efficient focus with gap analysis. Every utility starts with some elements of an asset management program in place. Gap analysis, comparing current and leading best practices, helps define the best opportunities to improve levels of practice in select areas. It's about taking one step at a time and finding the most efficient path forward to improve. Almost any gap analysis will define "quick wins" (programs that can be accomplished within a year with resources generally available). Quick wins help to achieve a feeling of accomplishment and momentum toward the next and perhaps more challenging phases of the project.

2. Creatively use existing asset and performance data. Existing data within a utility is often underutilized. But this data will be gold when it comes time to gain public, governmental, and financial support. Tools available today can quickly and easily pinpoint the availability and completeness of basic asset attribute data. Even if key data is missing, it's still possible to creatively gather, supplement, and leverage existing data for planning. For example, analyzing pump flow and related SCADA (supervisory control and data acquisition) data can help identify inefficiencies and opportunities for energy savings, which in turn can translate into funding for other program initiatives. Water main break data is commonly available and can be used to predict future performance and reduce the risk of critical failures.

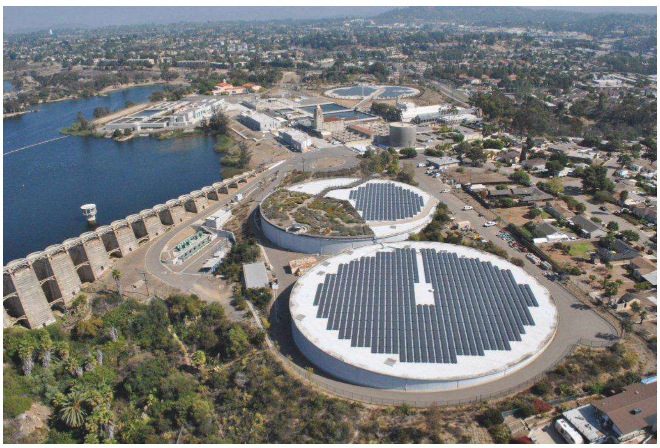
3. Review and set levels of service with future improvements in mind. Setting levels of service can make a big impact in operational demands. A maximum two-hour outage can have you scrambling, whereas a four-hour outage may be acceptable. Seemingly modest adjustments in these water and sewer service goals can greatly affect resources as well as operations and capital investment strategies. Alternatively, the long-range plan may start with manageable goals but with milestones in place to step up to more ambitious levels of service.

4. Analyze and plan to manage the risks. Risk is fundamentally about the consequence and likelihood of failure, typically calculated using a point scale. Consequence of failure is often based on triple-bottom-line principles for economic, social, and environmental impacts. Examples include direct cost to repair, proximity to sensitive receiving waters, critical customer outages, road closures, and similar considerations that can usually be readily mapped.

Likelihood of failure should be based on consideration of the four possible failure modes: mortality, efficiency, level of service, and capacity. For example, a mortality failure is one in which the asset is physically incapable of performing its function, such as a sewer main collapse. The consequences of this might produce multiple impacts, depending on the situation. If raw sewage reaches a waterway or a nearby waterbody, it could impact public health. If it runs under a street, the failure could cause traffic delays. Economic consequences could follow seepage into water or buildings.

An efficiency failure results when there are more cost-effective and feasible alternatives, such as opting for inefficient equipment motors with high energy costs. In this case, the consequence is generally economic. Level-of-service issues related to an asset failure, as compared to an enterprise-wide level of service, could include a pump that cannot achieve the required wastewater flow during peak demand times. The consequence of failure could be sewer overflows that result in fines and negative environmental impacts. Capacity failure could include a pump that cannot provide adequate water supply during peak periods, resulting in reduced revenue.

5. Develop a prioritized plan. Fundamentally, asset management is about change management. Change management takes time. Therefore, it makes sense to develop a prioritized plan so that staff has the opportunity to do their "day job" and still participate meaningfully in the development of the asset management program. It's important to adapt practices to fit within one's own utility — again, that takes time. Most utilities take between three to five years to make significant progress with the development of their asset management program. Whether you use the U.S. EPA 10-step process or the newly adopted ISO 55000 standard, the core concepts of managed risk, planned service levels, and life-cycle cost are still important components.



Like many top municipalities, the City of San Diego, CA, which operates the Alvarado Water Treatment Plant (pictured), relies on asset management to inform decision-making.

6. Create a holistic, connected picture of operations and capital needs. One of the more significant insights that asset management creates is the need to manage the life-cycle cost of assets — from planning, design, and construction through the often long operational cycle. A capital investment today can be a decision that a utility lives with for a long time. So practices that connect the two, even if they reside in separate budgets, will yield benefits down the road. Simply put, a cheap capital investment today can be a high operating expense through a lot of tomorrows.

7. Implement the plan and measure results. As the old saying goes, "You can't manage what you don't measure." Some key performance indicators really help gauge progress or make visible how changes are driving performance improvements. For instance, the percentage of planned maintenance work orders completed compared with the ones scheduled for critical valves and pumps can be a leading indicator of whether there might be issues with achieving a level of service of 100 percent of customers with no water outages of greater than two hours. It's important to track progress and trends to know what areas need to be improved and which ones can wait.

Managed Risk And The Reward

At its core, asset management can be seen as a matter of managed risk, no matter what the asset is. Utility managers who do the hard work of advancing the level of practice of asset management will ultimately leave their utility more sustainable for the future.

For example, in a project managed by the Water Environment Research Foundation[1], the authors found that best practice utilities routinely (at least annually) sought to identify the "big picture" risks to the operations. They developed a risk register and discussed these risks with their elected and appointed officials, then senior leadership developed plans to manage these risks. The risks that they considered were broad, from natural disaster risks, such as flooding and earthquakes, to man-made risks, such as labor issues, healthcare costs, or the impact of a disgruntled employee who wants to sabotage control systems.

In the end, once started, asset management quickly brings benefits that become essential. It improves financial performance, efficiency, and effectiveness; manages risk; informs asset investment decisions; and improves reputation, compliance, and sustainability. ■

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About The Author

Linda Blankenship is Associate Vice President with ARCADIS US, Inc. She was the principal investigator and program manager for the WERF research challenge "Strategic Asset Management Implementation and Communication," developing leading practices, tools, and guidance. Linda has more than 25 years of experience working on a wide variety of drinking water, wastewater, groundwater, and stormwater issues, holding senior positions while managing major infrastructure planning in local government as well as managing regulatory affairs, technical programs, and research support in major water industry associations.

Assessing PPCPs: How To Handle The Micropollutants That Pose A Major Threat

By Melanie Redding and Brandi Lubliner

A study conducted by the state of Washington's Department of Ecology and the EPA assessed the efficacy of PPCP treatment removal rates of various wastewater treatment processes.

Pharmaceuticals and personal care products (PPCPs) are widely present in the environment. PPCPs are anthropogenic contaminants; their presence in the environment results from the universal, frequent, and cumulative usage by multitudes of individuals. Large quantities of pharmaceuticals are used to treat and cure diseases and other medical conditions. PPCPs enter the environment primarily as they pass through the body or are improperly disposed of in toilets, sinks, and the trash.

PPCPs include drugs made for humans and animals — prescription and over-the-counter drugs. This definition includes drugs used for human, veterinary, livestock, and aquaculture. It includes diagnostic agents, nutraceuticals, and excipients.

Personal care products are items that individuals use every day to take care of themselves. They include a wide variety of products — shampoo, deodorant, toothpaste, lotions, makeup, after-shave lotions, hair dyes, anti-dandruff shampoos, teeth whiteners, sunless tanning products, colognes, and fragrances. There are more than 10,500 chemicals used in personal care products. Only 11 percent of these chemicals have been tested for safety in the U.S.

Low concentrations of PPCPs have been detected in surface water, groundwater, marine waters, soils, sediments, and drinking water. Conventional wastewater treatment plants were not designed to treat for PPCPs, and it is widely believed that the PPCP compounds migrate into groundwater and surface waters from treated and untreated wastewaters. There is concern about the effects on wildlife and human health from these chemicals at low concentrations in the environment. It is unclear how the unintended exposure to low concentrations of multiple chemicals may affect an organism or an individual.

Conventional wastewater treatment plants were not designed to treat for PPCPs, and it is widely believed that the PPCP compounds migrate into groundwater and surface waters from treated and untreated wastewaters.

Tracking The Problem

PPCPs enter the environment from several different sources. Human sources are the predominant ones, releasing PPCPs after they have been used, either as they are washed off the body or excreted. Additionally, PPCPs are often disposed down the drain or in the trash, and these enter the environment either through wastewater treatment systems or landfills. Other sources include livestock, agriculture, pets, and aquaculture.

Humans typically excrete 50 to 90 percent of the active ingredients in ingested drugs, either as unmetabolized pharmaceuticals or as metabolites. When these excreted chemicals leave the body, they typically enter a municipal wastewater treatment facility, an on-site sewage system, or a reclaimed water treatment facility. Treatment processes vary in their treatment efficiency for PPCPs. Typically, wastewater from the treatment system is discharged into the environment.

Consumers dispose of an estimated 25 to 33 percent of

Washington Department of Ecology's Brandi Lubliner collects a sample at a wastewater treatment plant.

The results of this study indicate that PPCPs are routinely found in municipal wastewater, PPCP removal varies between wastewater treatment processes and specific chemicals, and advanced nutrient reduction and tertiary filtration may provide additional PPCP removal.

pharmaceuticals sold, either to a landfill or wastewater treatment plant. Ultimately, these disposed PPCPs enter a municipal wastewater treatment facility, an on-site sewage system, or a reclaimed water treatment facility. Unused or expired PPCPs thrown away in the trashcan and disposed in a landfill can be mobilized in the environment via landfill leachate.

The fate of PPCPs in the environment is complex for a number of reasons. First, there are thousands of chemicals used in the manufacture of a wide variety of PPCPs. Not all PPCPs are similar chemically, and the different types of chemicals react differently to different treatment processes. The individual chemical structure dictates whether PPCPs will biodegrade, volatilize, degrade into metabolites, or concentrate and persist in the environment.

Treating The Problem

The treatability of PPCPs depends upon the physicochemical properties of each compound of interest and the specific set of treatment processes. Some treatment processes efficiently remove some chemicals but are ineffective at treating others. Some treatment processes merely remove the chemical from one media and transfer it to another media without destroying it. For example, nonylphenol is removed from water through settling, but in the process it is partitioned into the sludge. Once land-applied, it remains in the environment, available for transport to groundwater or surface waters. Typical treatment processes include adsorption, filtration, volatilization, photodegradation, biodegradation, chemical alteration, and plant or animal utilization.

In summary, no single treatment process effectively removes 100 percent of PPCPs. Some treatment processes reduce some pharmaceuticals to very low levels, while other pharmaceuticals remain resilient.

In 2008, the Washington Department of Ecology and the U.S. EPA conducted a study to characterize PPCPs at five municipal wastewater treatment plants in the Pacific Northwest. The goal was to characterize wastewater treatment removal efficiencies for these compounds by monitoring a range of treatment processes and their effect on PPCP removal. This study compared untreated wastewater (influent), treated wastewater from secondary treatment, advanced tertiary treatment for nitrogen and phosphorus (nutrient) removal, tertiary treated reclaimed water, and biosolids.

Target analytes included 172 organic compounds, PPCPs, hormones, steroids, and semi-volatile organics. Removal efficiencies were evaluated for each analyte at the five wastewater treatment plants.

The study found PPCPs in all samples, and their concentrations were comparable to those reported in the literature from other studies. Overall, conventional secondary treatment reduced 21 percent of the 172 organic compounds to below detection levels and achieved high removals for hormones and steroids. Advanced nutrient removal and filtration technologies reduced the number of compounds detected by 53 percent. A total of 20 percent of the 172 compounds were found only in the biosolids, suggesting that some PPCPs can concentrate in solids.

None of the wastewater treatment technologies was able to remove all of the compounds. These resilient compounds include carbamazepine, fluoxetine, and thiabendazole. These three PPCPs may serve well as human-influence tracer compounds in the environment.

The results of this study indicate that PPCPs are routinely found in municipal wastewater, PPCP removal varies between wastewater treatment processes and specific chemicals, and advanced nutrient reduction and tertiary filtration may provide additional PPCP removal.

Based on these findings, researchers recommend that consumers do not flush leftover, unwanted, or expired drugs. Instead, they should be taken to a pharmacy which has a take-back program. It's best to contact the local health department, law enforcement office, or pharmacy for information on local medicine take-back programs and initiatives to support pharmaceutical stewardship in a given area. If a take-back program is not available, medicines should be taken out of their original containers, mixed with an undesirable substance (such as kitty litter or coffee grounds) and placed in an impermeable container, then put in the trash. ■

Go to https://fortress.wa.gov/ecy/publications/documents/1003004.pdf to read the full study conducted by the state of Washington's Department of Ecology.

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About The Authors

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Source Water Protection: There's An App For That

In Oregon, a mobile toolkit helps promote healthy ecosystems and protect community drinking water.

By Danielle Dumont

To continue supplying high-quality drinking water to ratepayers, many municipal utilities are looking outside the box. Miles beyond the walls of their drinking water facilities, they are focusing on protecting the water supply at its source and discovering that new technology can play an increasingly important role in restoring the forests and streams within their service areas.

For example, the Eugene Water & Electric Board (EWEB) in Eugene, OR has spent the last four years working with a number of partners and landowners on a program to protect healthy riparian — or streamside — forests around its sole source of drinking water for more than 200,000 residents. EWEB's Voluntary Incentives Program (VIP) focuses on protecting approximately 9,500 acres of riparian forestlands along the McKenzie River and its tributaries.

Under the VIP, landowners with property in the area that meets specific standards for ecologically-functional riparian areas can qualify to receive annual payments and other incentives in return for long-term protection agreements. Landowners who do not meet these standards for compensation can still enter the VIP to restore degraded riparian areas and may be eligible for protection incentives once standards are met.

Into The Woods

Healthy riparian forests, consisting of a mix of rushes, grasses, shrubs, and trees, provide a suite of benefits for downstream water users. These benefits include flood mitigation, erosion control, pollutant filtration, and water-cooling shade, in addition to providing habitat for salmon and other regulated species in western states.

In 2014, EWEB and its partners began a pilot project to test the VIP concept with 15 landowners. The results of the pilot are informing the feasibility of a full program implementation in 2016. Part of the pilot includes the development of riparian vegetation survey protocols and standards, as well as testing The Freshwater Trust's StreamBank® Monitoring app, a digital data collection tool for surveys. The Freshwater Trust is a nonprofit organization that protects and restores freshwater ecosystems using science, technology, and incentive-based solutions.

"StreamBank Monitoring is being used to assess and quantify the level of function in riparian forests affecting EWEB's source water," said Olivia Duren, riparian analyst for The Freshwater Trust. "With the data from StreamBank, EWEB can make recommendations to landowners for protecting high-quality woodlands and floodplains or restoring degraded areas."

StreamBank Monitoring is part of the larger StreamBank patented toolkit of web-based and mobile applications for watershed restoration planning, monitoring, and tracking. StreamBank allows municipalities, utilities, and conservation partners engaged in source water protection to better understand the economic and environmental returns of restoration projects.

"StreamBank has evolved since 2007, when we first developed a version of it to help streamline grant funding and permitting for watershed restoration projects," said Alan Horton, managing director of The Freshwater Trust. "Since then, we've continued to expand and adapt the platform to meet the needs of various projects and partners, including time-saving tools for characterizing streamside vegetation function for source water protection programs."

StreamBank Monitoring is a popular tool in the StreamBank toolkit. It is a tablet-optimized app for collecting project data in the field and compiling that data for analysis and reporting. There are nine features in the app, including vegetation monitoring, riparian function assessments, shade measurements, photo point monitoring, redds surveys, and substrate monitoring.

"The StreamBank Monitoring app is built on a monitoring protocol that is flexible enough to be used for various projects but also specific enough to be especially useful for vegetation monitoring," said Sharon Gordon, ecosystem services analyst for The Freshwater Trust. "This places the app squarely in between simple, out-of-the-box monitoring apps and custom-made apps that aren't easily transferrable to other types of data collection."

A Look In The Toolbox

The StreamBank Monitoring app is geared toward riparian vegetation actions. It features a user interface designed to mimic workflow in the field and provide a visual record of tasks completed to help organize efforts on-site and avoid data collection omissions.

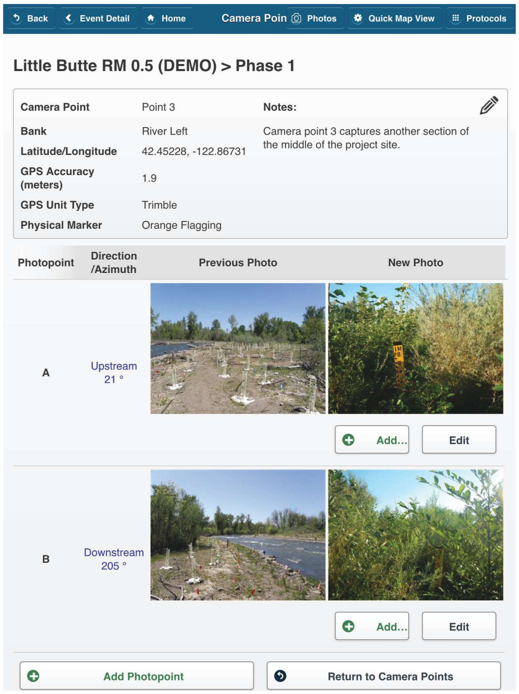
The built-in validation rules help ensure that data collection is complete and that values are within an expected range. It's possible to carry forward relevant data from previous sampling events (e.g., location latitude and longitude) to maximize efficiency. The menu selections significantly speed up data collection versus written notes, which also improves data quality by helping ensure that all users are documenting site conditions in the same way and directing attention to all major factors, such as browsing by wildlife, that could damage plantings. A quantitative vegetation monitoring feature is compatible with a wide variety of protocols and common metrics; for example, the app is flexible enough to allow the user to measure the amount of woody understory cover in terms of stem density, cover, or both. On-board tablet functions, such as a camera, are integrated into the app as a time-saving measure to avoid carrying separate pieces of equipment into the field.

Rachel Werling, an Oregon State University extension instructor, has tested the StreamBank Monitoring app with high school students as part of the Student Watershed Assessment Team (SWAT) program, which trains students to collect quality scientific data for natural resource management efforts in Jackson County, OR.

"Compared to traditional data entry methods with pen and paper, the StreamBank app halved the time we spent collecting field data," said Werling. "For example, it was quick and easy to snap photo points to visually capture changes at a site using the camera on the tablet. The app then recorded GPS location, site name, and other data along with the photo. Without the app, the students spent a lot more time transferring and processing data when we returned from the field."

Werling's time-saving experience with StreamBank Monitoring matches other users' experiences. Duren noted that StreamBank Monitoring usage by The Freshwater Trust's field staff has saved, on average, three and a half hours per acre in vegetation monitoring data entry, management, and analysis. Most sites are at least two acres, so this saves almost a full eight-hour staff day per site.

"StreamBank Monitoring bypasses the process of entering data by hand from paper datasheets, thus saving time, and also prevents decisions from being made based on poor quality data, because errors can be recognized quickly and fixed more readily on site," said Duren.



With photo point monitoring, users can capture photos at the same location over a period of time, providing a visual record of project site conditions.

Putting Data To Work

Back in the McKenzie River area, EWEB has successfully used the StreamBank tool to help define and visualize healthy riparian systems.

"With StreamBank, the metrics collected at reference sites are then compared with landowner [assessed] conditions, allowing landowners to see what constitutes a healthy riparian area and what actions they can take to increase the health of these critical areas," said Karl Morgenstern, environmental management supervisor of EWEB.

EWEB has established a boundary identifying riparian forests and floodplains that are eligible to enroll in the VIP. Participation is open to private landowners, local governments, and non-profit organizations that own land within the designated boundary.

"The VIP is built on the concept of creating and sustaining protection and restoration activities at a meaningful scale and connecting upstream landowners with downstream water users," said Morgenstern. "To that end, an integrated approach to managing our shared water resource is important."

Additionally, the Metropolitan Wastewater Management Commission (MWMC) in Springfield, OR is beginning to use the data collected by EWEB and its partners for a complementary program in the same service area. Integration of these two water programs is increasing efficiency, because data does not have to be recollected by MWMC staff. It is also minimizing program costs, because site identification and prioritization have already been completed for the subbasin, and interested landowners have already been identified.

While EWEB is focusing on preserving healthy riparian areas, MWMC will focus on restoring the areas that lack healthy streamside vegetation. These combined efforts will allow maximized conservation and restoration outcomes for both source water protection and wastewater compliance.

The StreamBank toolkit can also be applied to other types of watershed restoration and protection programs. It can conduct GIS mapping of potential riparian restoration sites, prioritized according to ecological and economic criteria, for water quality trading programs geared toward temperature compliance for wastewater facilities.

It can model a "water budget" for the sustainable allocation of surface water and groundwater resources for uses, such as irrigation and municipal drinking water, using water-quantity and water-usage data. Finally, multi-stakeholder, cooperative source water protection program planning can be done based on conservation priorities as well as pollutant reductions.

Werling sees the big picture when it comes to all the field data generated by restoration actions. "Monitoring the success of restoration projects, sometimes more than 20 years for large trees, is a big deal," she said. "It's exciting for professionals and citizen scientists to use digital tools such as StreamBank to collect reliable data." ■

About The Author

Danielle Dumont is the Marketing Manager for The Freshwater Trust in Portland, OR. She brings nearly two decades of experience in corporate and marketing communications to The Freshwater Trust's environmental consulting and watershed analysis services.

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