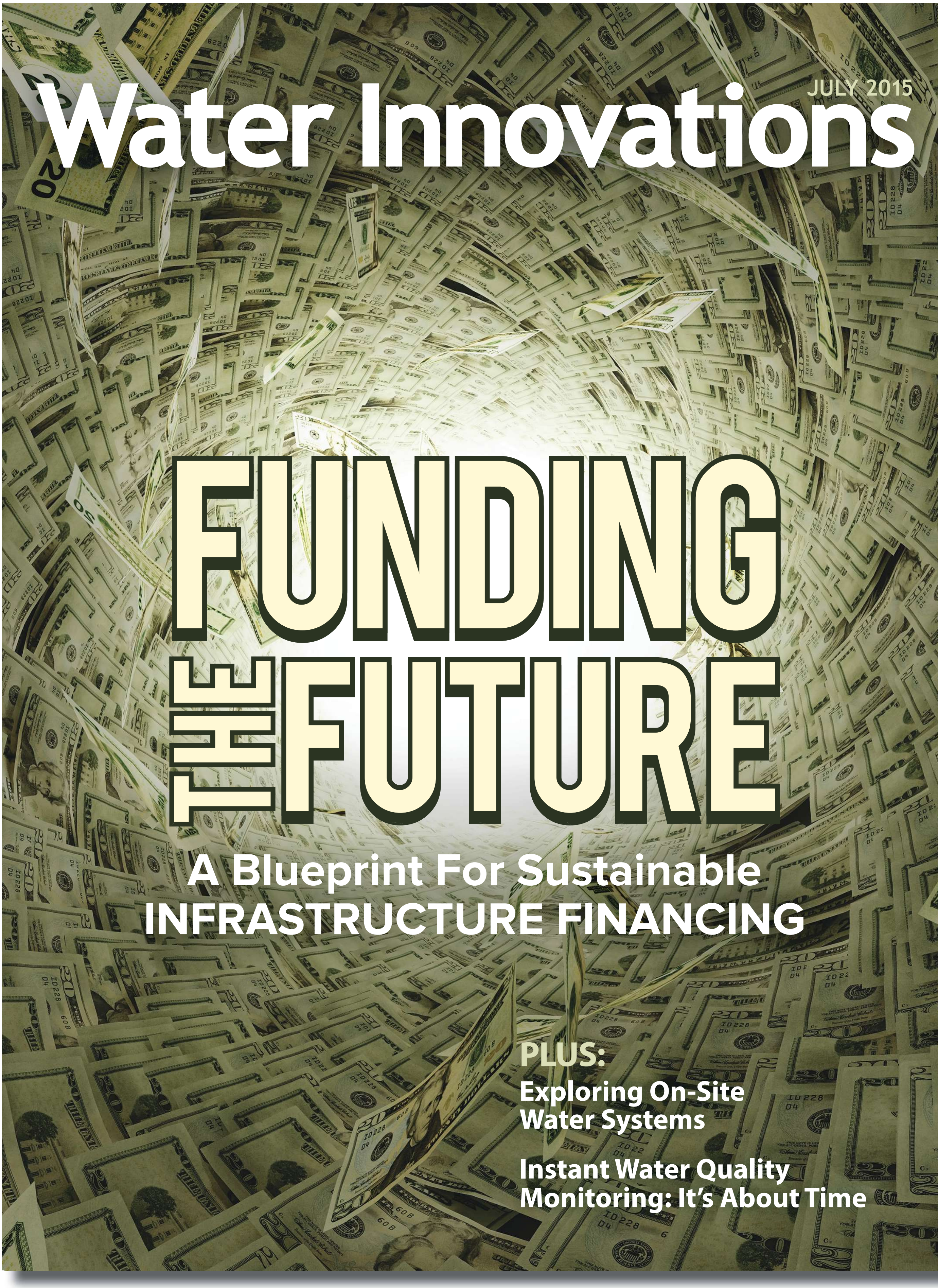

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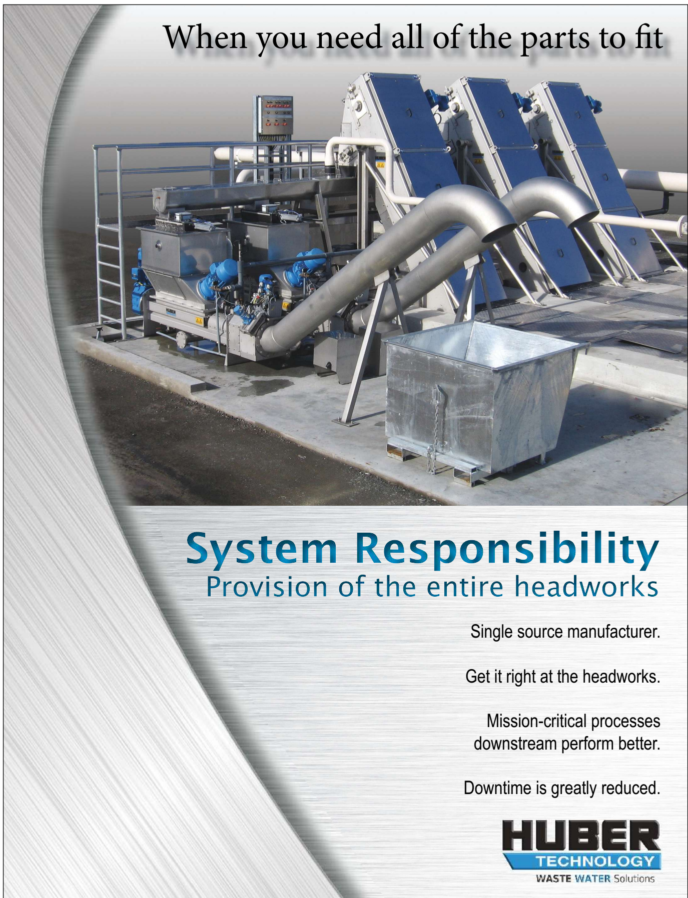


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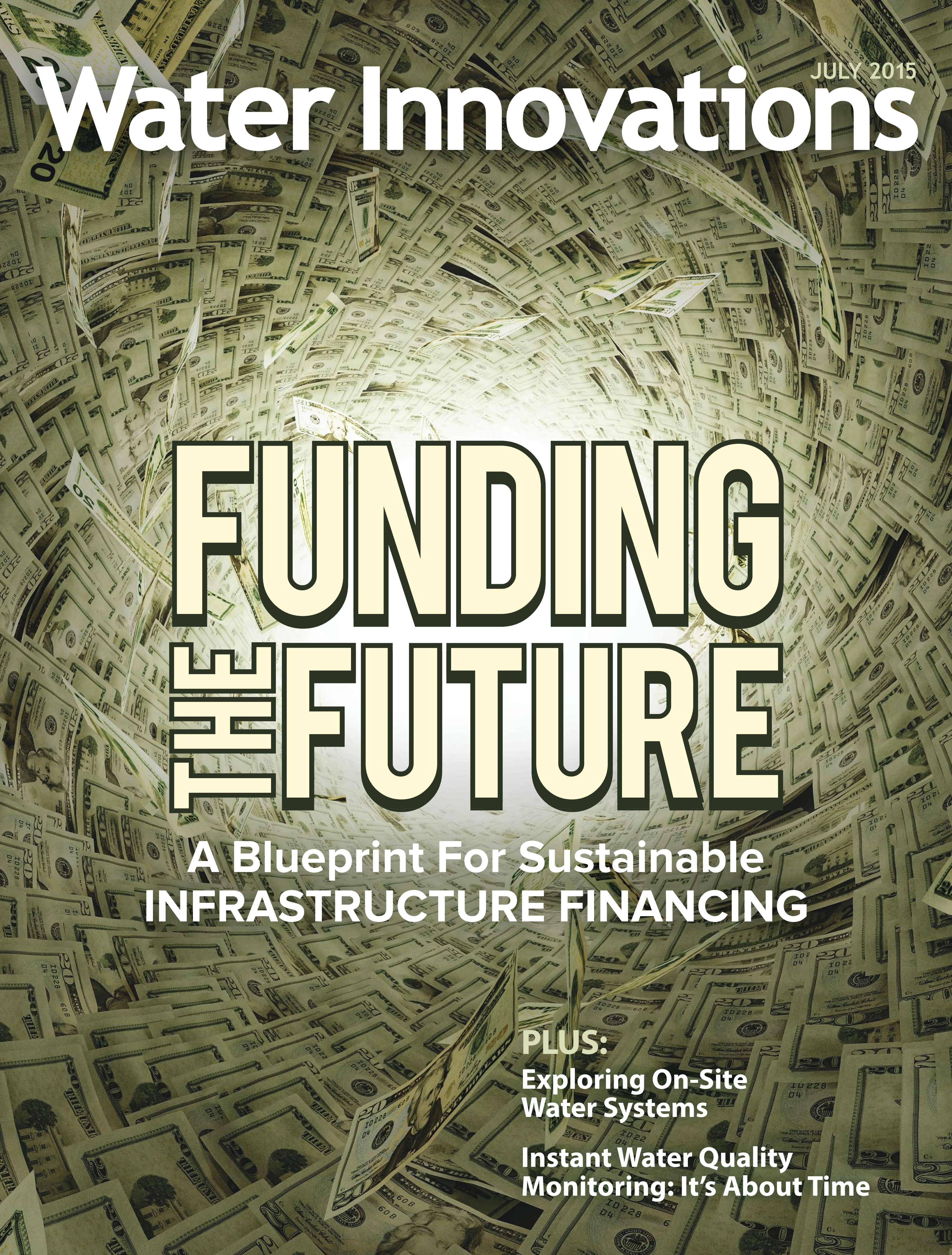

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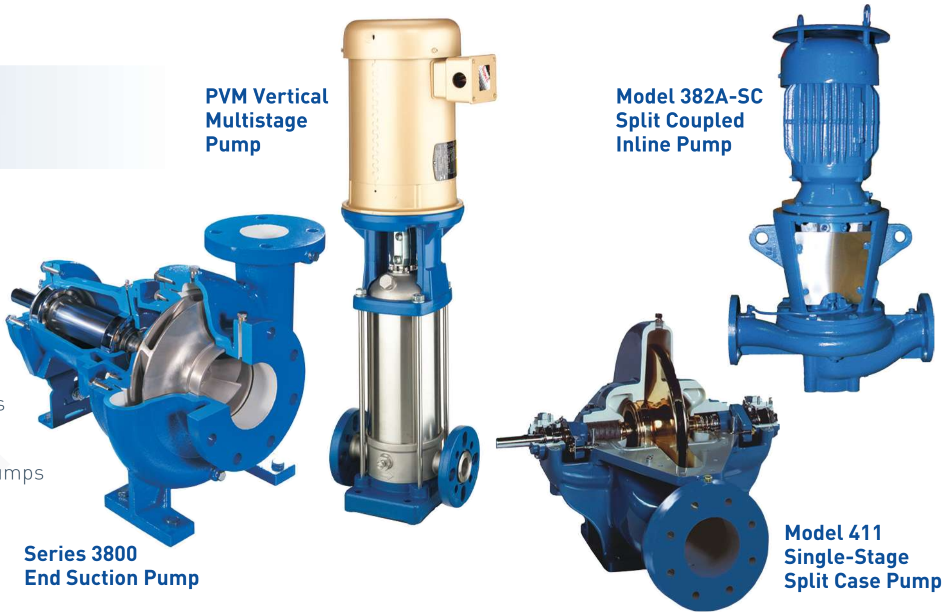

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3800	Up to 4,200	Up to 954	Up to 520	Up to 158	Up to 300	Up to 149
400	Up to 15,000	Up to 3,406	Up to 1,000	Up to 305	Up to 300	Up to 149
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EDITOR'S LETTER

By Kevin Westerling
Chief Editor, editor@wateronline.com

Instant Water Quality Monitoring: It's About Time

These are trying times in the water and wastewater industry, characterized by a general lack of resources — failing infrastructure, inadequate funding, and even a lack of water itself. But it's also an exciting time, with new technologies guiding the way to a brighter future.

Speaking Of Time …

Real-time contaminant detection has been called the "Holy Grail" for the water industry by Dr. Junhong Chen, a University of Wisconsin-Milwaukee (UWM) professor and leading researcher in the field of biosensors. Chen's vision is that of an "intelligent" water distribution system, where threats can be immediately identified and controlled. We're getting closer to that day, as three U.S. manufacturers are set to have handheld prototypes ready in 2016.

But what about real-time *wastewater* monitoring?

Due to harsher water and pollutants, real-time biosensors for wastewater were considered by Chen's team to be a trickier and farther-off proposition, but European researchers have recently defied this expectation and are putting the Holy Grail within everyone's grasp.

On-The-Spot Wastewater Monitoring

The European Commission (EC) reports that Professor Ahmed Al-Shamma at Liverpool John Moors University (LJMU) has developed a "multi-sensor fusion monitoring system" — custom electromagnetic wave sensors of different size and type, fused together into a novel prototype system. Borne out of LJMU's Water-Spotcheck project and funded by the EC's Marie Curie Actions fellowship program, the system potentially allows utilities to perform a la carte monitoring, customizing their sensor arrays to instantly detect specifically selected contaminants.

These claims were tested against actual wastewater flows during a pilot study at United Utilities in the U.K., where proof-of-concept was verified. According to the utility's technology development manager, Son Le, the multi-sensor system detected pollutants such as phosphates, nitrates, chlorides, pesticides, and bacteria with "consistency and high repeatability in real time without the need for biological and chemical laboratory testing" — i.e., without the need for a two-week wait.

That means instant control strategies, increased efficiency, and safer water.

Time To Innovate

Dr. Chen at UWM, Professor Al-Shamma at LJMU, and their respective teams are changing the future of water and wastewater treatment, but they are small parts of a larger story. Innovation is an absolute requirement to help overcome our monumental water challenges, but it doesn't happen without proper funding and support. In a perfect world, the public understands the true value of water, politicians and policy makers devote the necessary resources, and municipalities are emboldened to adopt innovative solutions — like real-time biosensors, or some of the technologies covered here in *Water Innovations*.

We'll get there someday, because we have no other choice. It's simply a matter of time.

Water Innovations

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Tomorrow's Sustainable City Starts With Sustainable Infrastructure Funding

Six critical lessons are shared from a leading study on best practices for infrastructure investment.

By Manju Chandrasekhar

To paraphrase the *2015 ARCADIS Sustainable Cities Index*, there is no perfect, sustainable, utopian city. But that may not be the point. For populations around the world, the main question is: How are we going to deal with the hand we've been dealt? How will we manage to achieve the triple bottom line of social, environmental, and economic viability? Where do we start?

Considering the critical role of water across that triple bottom line, upgrading water infrastructure should be job one; yet in most communities, it's not even close to the top priority. The reason? It's easy to think the issue is money. But it may be more accurate to say that the problem lies in how the general public thinks about how water infrastructure is funded — or financed. In many cases, the population assumes that capital for water infrastructure comes only from public funding, grants, or endowments. The trouble is public sources aren't keeping up with municipal water infrastructure needs. Communities where public funding falls short are facing some significant changes if they expect to enjoy a sustainable water supply.

Why? To start with, nationally the sheer enormity of the funding gap is so huge, it calls for new ideas. For several decades now, and through the economic downturn and its aftermath, communities across the U.S. held back on maintaining or upgrading water infrastructure, leaving the mountain of needed improvements even more difficult to climb. Estimates for the cost of repairing and updating U.S. drinking water infrastructure alone range from the U.S. EPA $500 billion projection by 2022, to the American Water Works Association's (AWWA) estimate that the cost will top $1 trillion in the next 25 years.

Sustainable Options Will Take Work

With the stakes so high, U.S. utilities have two avenues to pay for needed infrastructure: 1) convince the public to pay for the true value of water and 2) embrace private financing strategies.

On the one hand, water systems that depend on ratepayers and taxpayers for operating revenue haven't always elected to set rates in line with requirements to fund improvements. Those communities across the country now face a major hurdle: assessing what clean, safe, and efficient water supply and treatment are truly worth to the population, and demonstrating that value versus what ratepayers may be paying now. If funding is to come predominantly from public sources, planners will need to enhance users' perceptions of the value of their water treatment and supply. Changing public attitudes can take years, even under inspired leadership. As we all know, this exercise also can pit competing interests against each other, further complicating the effort.

On the other hand, planners are not always fishing where the money is. Our public regulatory and institutional frameworks are not sufficiently well-structured to tap alternate capital pools, i.e., private financing sources. The Water Infrastructure Finance and Innovation Act (WIFIA) primed the pump, infusing much-needed public funding to catalyze private investment, but with first-year spending capped at $40 million, it's clearly not the whole solution. The vision is that WIFIA credit assistance will generate $200 million in additional debt financing against private equity capital in the first year. Against a $500 billion need, it's easy to see that more resources outside of the public sector need to be brought in.

A Fresh Eye On Private Financing Best Practices

Despite being the beacon of free-market practices, in the eyes of private capital providers and project developers, the U.S. has unfortunately not been able to develop a successful and long-standing track record of using private investment or public-private partnerships (PPPs) to finance water infrastructure. But that doesn't mean the idea isn't viable. Several countries outside the U.S., such as Canada and the U.K., have structured some good private financing models for infrastructure, including water projects, and we can benefit from their experience.

A study of infrastructure investment worldwide — the *ARCADIS Global Infrastructure Investment Index* — points to several ideas that could be adapted for the U.S. Here are some important lessons gleaned from the report that should facilitate in attracting both private and public investment:

Start Well To End Well: There's no avoiding undertaking a thorough financial analysis to identify how to structure an offer — from using debt and traditional borrowing to equity investments by special-purpose vehicles combined with capital market instruments. As with any investment proposition, private investors are ultimately seeking stable, long-term, risk-adjusted returns in a business-friendly environment. But there are also risks that need to be addressed up front. To create opportunity for private funding, the right political, financial, and regulatory conditions also need to be present.

Connect Early On: Bringing all parties together to connect the built asset, the commercial issues, and the financial requirements up front should encompass the goal of achieving greater certainty of total life-cycle costs, both capital expenditures (CAPEX) and operating expenses (OPEX), across the investment program. For example, when the U.K.'s Thames Water Utilities Ltd. needed to achieve a step-change in delivery of its capital spending programs during a five-year regulatory period, the utility attracted and secured the best organizations and people in the industry ahead of the market and brought its input into the regulatory business plan submission early on.

Clarity Counts: Investors feel much more confident if the plan is clearly articulated, coupled with commitment to a defined program, timetable, and shortlists. The proposition should reduce uncertainty in every way possible, starting with a clear, accurate picture of the project's risks and opportunities.

Put Risk Where It Belongs: Investors also respond more positively if they see risk has been spread appropriately and they are not expected to bear the entire burden. Assigning risks to the appropriate parties shows not only good faith, but good management. For instance, use public funding to put a project on firm ground during initial development. Public funding might help pay for lining up all environmental clearances beforehand or for initial plans and permits. In the long run, this distributed approach helps create stronger relationships with investors.

Spread ROI Across Asset Life Cycle: More and more, owners consider the total life cycle of their assets to create a more sustainable approach to return on investment (ROI) over time. This helps make the case that responsibly investing more up front can provide better long-term value for the project.

Resilience Matters: After learning the importance of flood resilience the hard way, cities hit by Hurricanes Katrina, Sandy, and others made sure that rebuilding specs included designs that anticipate future storms and floods. For example, ARCADIS helped the Bay Park Sewage Treatment Plant in Nassau County, NY, secure $810 million in funding from FEMA and the State of New York for repair and improvement. As a result of these improvements, Nassau County will be able to pay for restoring the wastewater treatment facility damaged by Hurricane Sandy. But more importantly, since the county's new state-of-the-art flood mitigation is designed to a 500-year storm level, its improved storm-resiliency aspects can engender a perception with private investors that their investments will be comparatively safer than those in competing projects that are yet to achieve similar resiliency protection. If the facility needs any work in the future, investment in resiliency would help put the project to the top of investors' lists.

For many municipalities, bringing in private investment or creating public-private partnerships may be new, unknown territory. But look at it this way: Just as utilities are asking investors to see the promise of a project, public leaders need to have faith that the time invested in learning to tap new funding sources will pay off. Similarly, making the case to ratepayers and taxpayers isn't that different. As stakeholders, they need to be convinced that they are getting return on their investment. Putting together the pitch with investment in mind will go a long way to creating a more sustainable program for financing water infrastructure. ■

About The Author

Manju Chandrasekhar is a vice president at ARCADIS in New York, where his responsibilities include leading business development and client-relationship management activities of the firm's financial institution clients across the Americas. Manju leads ARCADIS' efforts to establish itself in an advisory capacity at the executive level, with a focus on financiers, developers, owners, and operators of infrastructure and real estate assets.

Using Empty-Bed Contact Time (EBCT) To Design Biological Odor Control Technologies

Odor control systems have come a long way, but certain hurdles remain. Improving EBCT design criteria will help engineers and utilities reach the finish line.

By Jim Joyce

There are many different treatment processes available to remove odor from foul air. Some processes force the air through a vessel containing a bed of activated carbon pellets where the odor compounds are adsorbed onto the carbon and clean air is released. Other processes force the air through a scrubber vessel, which acts like a "chemical shower" where the odor compounds in the air react with chemicals in the "shower" and are oxidized and removed before the clean air is released. Still other processes force air through biologically-active compost or a vessel containing plastic biological media where the odor compounds are captured and biologically oxidized for food, releasing clean air to the environment. These are only three common technologies for odor control, but virtually all other odor treatment processes also require a vessel containing a bed of media or a reaction chamber where the removal process takes place.

There are also design criteria used by engineers to design these different odor control processes. These criteria establish the minimum and maximum dimensions of the vessels, volumes of media, airflow rates, odor concentrations, and many other design conditions recommended by manufacturers or shown to be successful in past applications.

While each different technology has its own specific set of design requirements, there are common design criteria used by engineers to select and size odor control treatment processes. In most cases these criteria are founded upon scientific and engineering principles, historical performance, and years of routine testing that can be directly measured. Each major odor control technology has its own set of common design criteria, ranging from the oxidation-reduction potential of chemical scrubbers to the inlet humidity of activated carbon scrubbers. Engineers use these common design criteria to select, size, and design odor control treatment processes.

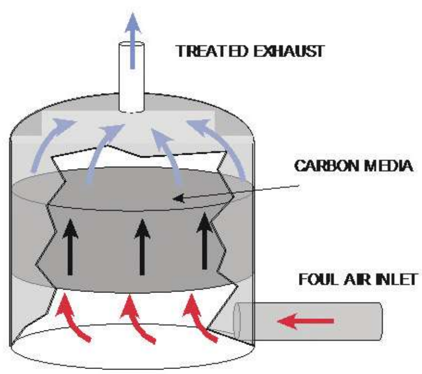
One of the most common design criteria is called "empty-bed contact time" or EBCT (also called "empty bed residence time" or EBRT). No single design criteria has been more used, and potentially misused, than EBCT. EBCT simply refers to the amount of time (usually in seconds) that air must spend in contact with the media or the contact chamber inside the process vessel. With no real basis in science or technology, this rule-of-thumb design criteria has persisted in odor control processes due to its simplicity. EBCT is calculated without regard for the volume of the physical media, hence the name "empty bed." The fact that the volume occupied by the media is not considered in the EBCT calculation makes EBCT a convenient but inaccurate design criteria. Different media with different densities and shapes will perform differently although the EBCT is identical. But how much inaccuracy is built into the EBCT varies by process.

Three different, common odor control technologies are evaluated for EBCT inaccuracy in the following discussion.

Activated Carbon Scrubbers

Figure 1 illustrates the basic components of an activated carbon odor control scrubber. The volume of carbon media which represents the "empty bed volume" is shown.

Figure 1:
Typical Activated Carbon Odor Control Vessel



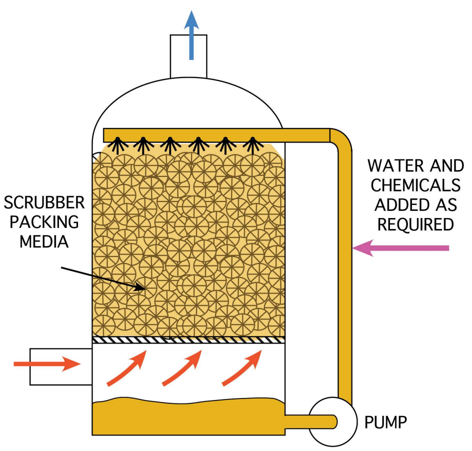
The required carbon media volume is determined based upon the balance of several factors including vessel diameter, carbon type, and empty bed air velocities. Media bed air velocities between 50 and 100 feet per minute (fpm) are recommended, with 60 fpm being used in most municipal odor control cases. Combined with the maximum recommended media depth of 3 feet (based upon head losses), this results in a 3-second EBCT for the media. Although EBCT is used by engineers as part of the design process, it is based on the results of common scientific principles plus standardized carbon testing using prescribed testing procedures (e.g., ASTM D-6646 in the case of activated carbon). ASTM stands for the American Society for Testing and Materials, which has published standard test procedures for most everything related to engineering, materials, and the environment. The testing is performed in strict accordance with approved written testing procedures. Since the EBCT design criteria for activated carbon odor control systems is based in large part on science and standardized testing, the inaccuracy impact is low.

Chemical Scrubbers

Figure 2 illustrates the basic components of a standard chemical-based odor control scrubber. The vessel commonly contains a plastic chemical-resistant packing, which provides a large surface area for the chemical-laden water pumped up through spray nozzles. The high surface area allows direct oxidation of odor compounds by the chemicals in the water. A small volume of the scrubbing liquid is allowed to drain out the oxidized byproducts. This volume of water is replaced by makeup water and fresh chemicals.

Chemical scrubbers are designed based upon the surface area of the plastic packing in the vessel, water and chemical concentrations and flowrates, and media contact time. The typical media EBCT for a chemical scrubber is between 2 to 4 seconds, with 3 seconds being common.

Figure 2:
Typical Chemical Scrubber Vessel And Media Configuration

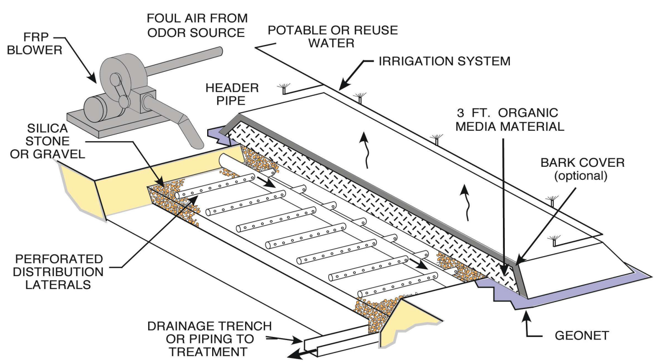


However, the EBCT for chemical scrubbers is heavily dependent upon the inlet odor concentration, the rate of chemical addition (chemical concentration), and the chemicals used. Higher inlet odor concentrations require higher chemical concentration, which is provided based upon chemical addition pumps controlled by sensors. Different chemicals also require different EBCT/chemical concentrations as the rate of oxidation of odor compounds is not uniform. Once again, EBCT is found to be a common design criteria but the reliance on EBCT is low, balanced by higher reliance on the inlet odor chemistry and the stoichiometry of the well-known chemical reactions taking place in the packing.

Biological Odor Control

Biological odor control processes are still considered a new entry into the odor control technology field, despite a 25-year history of excellent performance in the U.S. Biological odor control started with the development of "biofilters," which force odorous air through different types of organic and inorganic media designed to grow biological organisms. As the air is forced through the media, naturally present soil bacteria acclimate and grow on the media while consuming and removing the odor compounds before releasing clean air. Figure 3 is an illustration of a early in-bed, organic media biofilter.

Figure 3:
Common In-Ground, Organic Media Biofilter



These biofilters used compost, crushed wood products, large tree bark, and many different types of media, all with different shapes, sizes, tree types, and densities. While engineers learned how to control and operate these biofilters through trial and error, there was no standardized media testing. Many mistakes were made using media that were too fine, too coarse, too weak, too large, etc. The biofilters that worked well were scrutinized just as much as the biofilters that failed, but there was no concensus on the reasons to adopt any of them, so the only common criteria that was adopted by most designers was EBCT. Since EBCT for an in-ground biofilter is directly related to media depth and foul air flowrate, these criteria were, and still are, major design criteria.

The early biofilters that worked well had widely varying EBCT values. Evaluation of the EBCT data discovered that EBCTs below 60 seconds usually resulted in poor performance, while those above 60 seconds generally performed well. As a result, 60 seconds became the de facto EBCT for organic media biofilters. Further sampling and measurement of the exhaust from these biofilters revealed that approximately 20 seconds of

EBCT was required to remove H_2S (hydrogen sulfide), while the other 40 seconds were required to remove the volatile organic compounds (VOCs) in the inlet air. Even flawed, the EBCT of 60 seconds seemed to work.

However, it is easy to see that the different sizes of media (from fine compost to large sticks and branches) have vastly different surface areas, porosities, unit weights, and head losses. Over the ensuing years, engineers have been able to sample more and more inlet and outlet odor concentrations, drainage water constituents, and other operating parameters to assist with design criteria, but the lack of specific testing protocols (such as ASTM) places major design emphasis on the old EBCT criteria, which is used to this day. Although the EBCT design criteria is seriously flawed for organic media biofilters, it continues to be a point of contention in the design of these very effective and important odor control technologies.

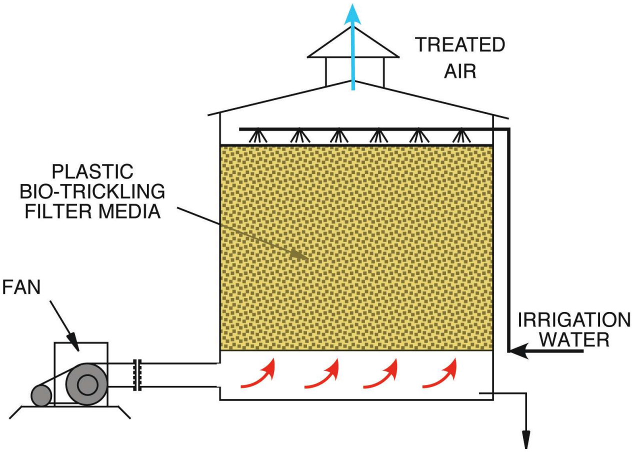
Some vendors of packaged biofilters advertised lower EBCTs for their products because they are "better" and deserve a lower EBCT design criteria. In fact, with no other standardized guidance criteria, a lower EBCT results in a smaller biofilter, which translates into lower cost. Some package system suppliers advertised extremely low EBCTs for their systems without any basis in fact that they would work at that rate, simply to be lower cost and win the job. It is often claimed in the literature that a certain packaged biofilter "only requires 20 seconds of EBCT to remove the odor" when, in reality, the fine print says "odor is H_2S," not VOCs. Of course, it is known that VOCs require twice the time to remove as H_2S, but the ploy works.

Biotrickling Filters

The same situation has happened with biotrickling filters. The basic process of a biotrickling filter is illustrated in Figure 4. Biotrickling filters (BTFs) are specialized biological odor scrubbers in that the biology is grown in special plastic media with very high surface areas, permeabilities, and odor removal rates. The odorous air is collected and forced through the specialized plastic media where certain species of biology grow to consume and remove the odor compounds. Irrigation water is sprayed on the top of the media and nutrients are added in some cases.

It is important to note that some researchers and manufacturers have invested heavily to test and progressively improve their biotrickling filter media to make it more effective and cost-efficient. This investment has allowed some structured biotrickling filter media providers to greatly outperform older-style media. Testing has shown that some new-generation biotrickling-filter-structured media have greatly surpassed the performance of earlier and more common media. Naturally, this investment is protected with patents and a certain amount of old-fashioned secrecy to prevent copying and ensure their market advantage.

Figure 4:
Common Components Of A
Biotrickling Filter Odor Control Process



While some manufacturers can claim total odor removal with much lower EBCTs (based upon higher-performing media), the engineering community is still skeptical of these claims in the absence of additional supporting design criteria.

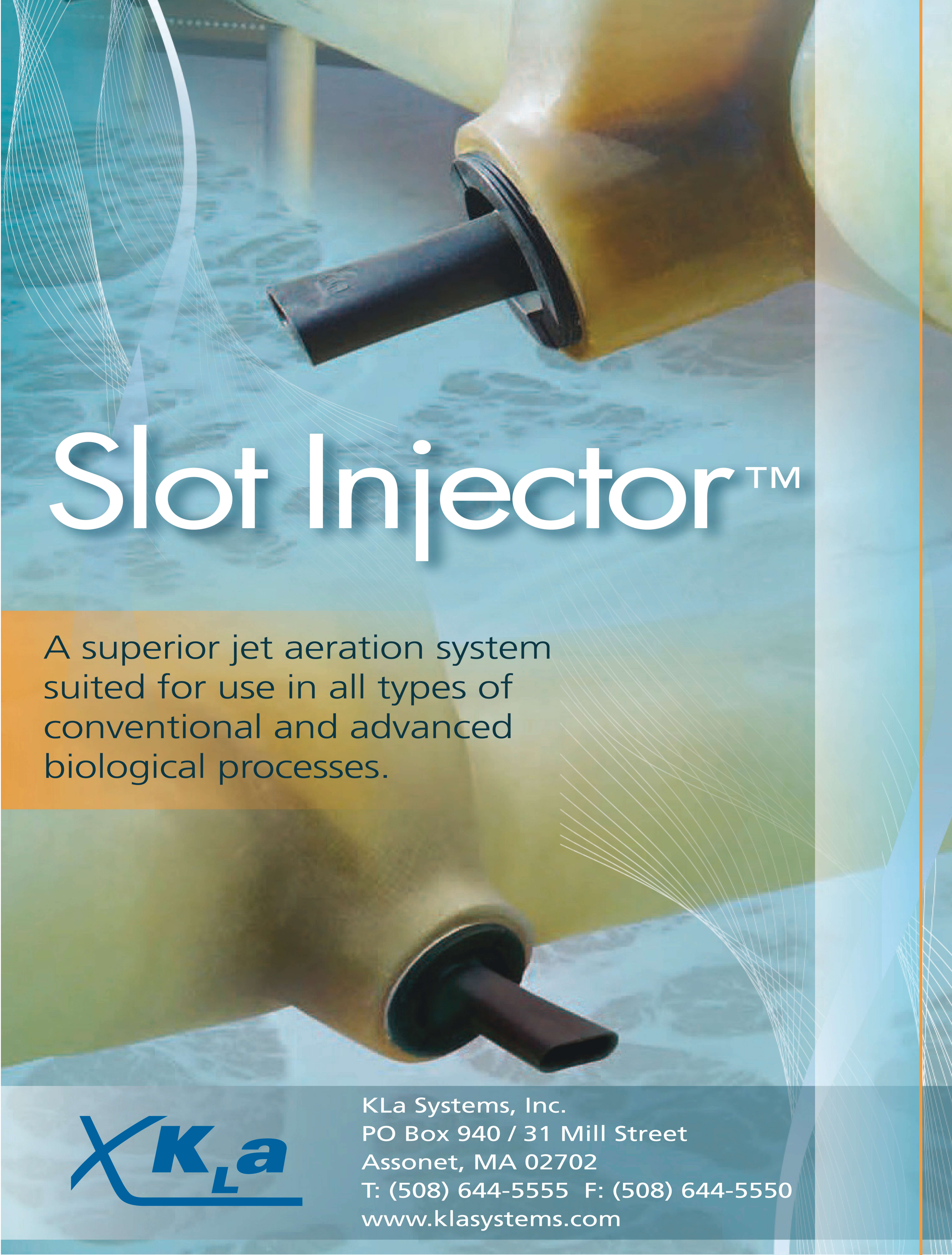
Summary

It is clear that biological odor control technologies are in need of additional standardized design. It is not that the sampling and testing methods necessary to calculate the specific odor elimination rate (or specific odor compound elimination rate) in grams/day/cubic foot of media are not available. Nor is it that we lack the knowledge of how to establish standardized testing for biotrickling filter media so that we can consistently provide high-quality odor controls. We simply lack the organization, the will, and the determination to prepare the standardized criteria and persuade ASTM to include these criteria as part of its program.

We stand on the brink of some breakthroughs in biological odor control processes, and we only have to reach out and grasp them. We must move biological odor control from "black box science" into the daylight of science. ■

About The Author

James Joyce, PE, has more than 36 years of experience in wastewater odor and corrosion control, and has written six manuals of practice and more than 50 peer-reviewed technical papers. Joyce has managed more than 500 odor and corrosion remediation projects worldwide and has conducted numerous technical workshops, seminars, and lectures. He holds bachelor's degrees in biology and civil engineering and a master's degree in environmental engineering from Virginia Tech.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The Case For Removing Disinfection From Wastewater Treatment

Membrane bioreactor (MBR) technology is proven to adequately remove microbial contaminants all on its own, eliminating the time, money, and focus spent on disinfection.

By Stephen Katz

A tremendous amount of pressure is put on municipalities to provide higher-quality effluent within increasingly constrained capital and operating budgets — they are required to do more with less. Wastewater treatment industry stakeholders should strive to understand and prove the capabilities of technology so as to enable the implementation of the required treatment levels within existing budgets. Membrane bioreactor (MBR) technology enables municipalities to effectively remove pathogens without the need — and cost — of an additional disinfection step.

Regulatory agencies provide guidance on safe limits of pathogens in water bodies actively used by the public for recreational purposes. In 2012 the U.S. EPA published recreational water quality criteria (RWQC) for protecting human health for primary contact recreational use, and in 2006 the European Union (EU) published the new *Bathing Water Directive*, which member states must follow to inform the public of bathing water quality. Since wastewater treatment plants discharge directly into surface waters and can be a source of these pathogens, microbial parameters are generally among their effluent water-quality standards. Historically, regulations have been based on total coliforms, fecal coliforms, or *Escherichia coli* (*E. coli*), but have more recently moved to favor *E. coli*, as it is the only member of the total coliform family exclusively found in the feces of humans or other warm-blooded animals and the best indicator of possible presence of intestinal-disease-causing bacteria, viruses, and protozoa. As further protection, facilities are typically mandated to include a disinfection step to the treatment flowsheet.

> MBR technology enables municipalities to **effectively remove pathogens** without the need – and cost – of an additional disinfection step.

MBR Efficacy

When considering municipal wastewater treatment by the conventional activated-sludge process (CAS) to achieve effluent quality requirements for microbial indicators, the addition of a disinfection step is required because the CAS process cannot reliably remove indicator bacteria to a low-enough level. In this treatment scheme, microbial removal is partially dependent on the settling of bacterial floc particles, a process which is subject to variability. MBR is considered the best available technology for achieving high-quality effluent, as it achieves secondary and tertiary wastewater treatment in one, compact step. When ultrafiltration membranes are incorporated into the MBR process, the dominant removal mechanism for coliforms is size exclusion. The coliforms may be directly excluded or may be indirectly blocked due to sorption to the activated sludge solids, which are themselves excluded. The presence of a dynamic filtration layer on the membrane surface can further enhance the size-exclusion capabilities of the membrane pores.

To help assess the long-term viability of MBR technology to effectively remove pathogens, GE conducted an extensive multiyear study where more than 2,000 samples were taken at 10 plants of various ages, hydraulic capacities, and geographic locations. Depending on the plant's effluent requirements, samples were tested for presence of total coliforms, fecal coliforms, and/or *E. coli* bacteria in the MBR permeate. The results of the sampling clearly showed that the effluent from the MBR systems without an additional disinfection step met pathogen-based surface water discharge standards for treatment plants and were below limits set for water bodies used for recreation. A summary of the results of this study are shown in Table 1 below.

Table 1:
Study Data Measuring Microbial Contaminants in MBR Permeate

	Total Samples Taken	Samples Less Than Detection Limit	Range of Plant Specific Geometric Means*	Geometric Mean of All Samples*	95th Percentile of All Samples *
E. Coli	772	80%	<1 to 1.4	1.1	3.4
Fecal Coliform	924	65%	<1 to 2.9	1.6	10
Total Coliform	346	52%	<1 to 10.9	2.6	34

* Units CFU/100mL

As the industry accepts the MBR process as a viable means of disinfection, it will be imperative to understand how plant operations will ensure that the MBR system is capable of meeting these microbial limitations. Studies have shown that in MBR operation, with a supported membrane, substantial membrane damage was required to cause a significant increase in contaminant levels. Minor breaches in membrane integrity had negligible impact because of contaminant sorption onto much larger floc in the activated sludge, which are largely rejected even by damaged membranes, and the impact of the dynamic filtration layer. Online membrane permeate turbidity monitoring — which allows for an online means of displaying solids concentrations in the effluent and ensuring membrane integrity — was sufficiently responsive to detect membrane damage that resulted in a significant increase in contaminant levels in the MBR permeate; a turbidity threshold of 0.2 NTU (nephelometric turbidity units) was appropriate for verification of contaminant removal below required limits. (For MBR applications, the measurement of online turbidity is considered the operational standard for monitoring performance of the system.) It is important to note that all of the current guidelines are based on absolute values in the effluent, and therefore the treatment efficacy needs to be independent of the influent concentration of the contaminants.

The Cost Of Disinfection

The addition of a post-membrane disinfection step — such as chlorination/dechlorination, UV treatment, or ozonation — to the MBR flowsheet comes with significant cost, from both a capital expenditure and operating standpoint. The total costs associated with the incorporation of a UV disinfection system into a treatment scheme are significantly more than just the

GE's LEAPmbr technology installed at the city of Hutchinson, MN

purchase costs of the equipment. It was estimated that the capital cost of including this equipment represents 3.3 percent of the overall capital cost of the project, and the operations and maintenance (O&M) cost represents 2.9 percent of the anticipated total O&M of the entire facility.

Regulatory Cooperation

Recent cases demonstrate that in certain jurisdictions regulators have granted municipalities the allowance to bypass disinfection due to the permeate quality achieved by the MBR systems. The following two cases provide examples of local regulatory bodies allowing municipalities to shut down their UV disinfection systems.

Hutchinson Wastewater Treatment Facility — City of Hutchinson, MN
In 2008, the City of Hutchinson Wastewater Treatment Facility completed a major expansion that included a GE LEAPmbr* filtration system running in parallel to the existing oxidation ditch activated sludge process. The MBR system added 1.27 MGD of capacity to the plant for a total treatment capacity of 3.67 MGD with the ability to treat a peak wet-weather flow of 9.62 MGD. The design included a UV disinfection facility for bacteria removal to reach the city's permit requirements for fecal coliforms of a monthly mean value of <200 MPN (most probable number) per 100 mL.

Soon after startup, testing was conducted to review the MBR system's ability to independently meet the discharge requirements without postdisinfection. During the testing, sampling was done as specified by the permit requirements from the MBR effluent and was tested for fecal coliform and *E. coli*. The results of the testing demonstrated that the amount of fecal coliform and *E. coli* in the MBR effluent was negligible for all tests.

Having validated the MBR's ability to meet the permit requirements without disinfection, the Minnesota Pollution Control Agency (MPCA) granted the city of Hutchinson permission to bypass the UV system. To date, the Hutchinson facility MBR system continues to produce water within the permit requirements without the additional treatment step. As a result, the city has saved several hundred thousand dollars by not having to purchase previously planned UV facilities, and has reduced operational, electrical, and maintenance costs.

Southwest Water Reclamation Facility – City of Henderson, NV
The Southwest Water Reclamation Facility (SWRF) in Henderson, NV, consists of a biological treatment system designed to include nutrient removal followed by a GE MBR system. The MBR effluent is directed to the UV facility, followed by postchlorination. The SWRF is designed to treat annual average daily flow of 8.0 MGD and peaking to an hourly flow rate of 13.6 MGD. The city's permitted requirements for bacteriological parameters, driven by the reclamation of the water, requires the effluent to meet <2.2 MPN of fecal coliforms per 100 mL as the mean of all samples taken in the month and a daily maximum of 23 MPN of fecal coliforms per 100 mL.

In 2012 and 2013, the municipality conducted a study to validate the treatment facility's ability to remove various virus and bacteria without the use of disinfection. During this time, samples of the MBR permeate were taken during various phases of operation (i.e., normal operation, high-flux operation, post-citric acid cleaning, and post-sodium hypochlorite cleaning). The samples were tested for total coliforms, fecal coliform, and *E. coli*, as well as for viruses. The study concluded that the MBR system was very effective at reducing virus and bacteria concentrations to very low levels and, in most cases, to non-detect levels without disinfection.

The city of Henderson was given permission by the Nevada Department of Environmental Protection to bypass the UV system. Postchlorination is still maintained to prevent bio-growth in the reclaimed water system. To date, the Henderson facility continues to bypass its UV system and the MBR system continues to produce water within the permit requirements. As a result, the city of Henderson is currently saving an estimated $93,000 a year in operational costs.

City of Hutchinson's final effluent after MBR treatment

As proven by the data and shown in the case studies above, MBR systems are capable of removing microbial contaminants and, therefore, do not need a disinfection step for discharge to surface waters. This presents a much needed opportunity for municipalities to save money. ■

*Trademark of General Electric Company; may be registered in one or more countries.

About The Author

Stephen Katz, PE, is a product manager for GE Water & Process Technologies with more than 10 years of experience in the water and wastewater treatment market. In his current role, he is focused on technical and commercial guidance for membrane bioreactor (MBR) technology, commercialization of new technologies for wastewater treatment, and strategic partnerships for the sale of GE's equipment portfolio. Katz graduated from McGill University in Montreal, Canada, with a bachelor's degree in chemical engineering.

Building Public Support For Efficiency-Oriented Water Rates

Utilities have the tools to explain why costs must rise while use goes down.

By Megan Chery

Water rates are on the rise as the water industry looks to fund unprecedented capital needs and cover increasing costs for everything from system maintenance to source water. Water rates increased by 23 percent from 2000 to 2010[1], and prices for water and sewer maintenance continue to rise at a rate much higher than the overall rate of inflation[2]. Simultaneously, utilities are moving towards efficiency-oriented rate structures that encourage consumers to use water wisely in an effort to meet growing demand with finite supplies. As a result, utility managers find themselves facing the unenviable communications challenge of having to ask customers to use less while paying more.

Water rates are typically subject to approval by at least one oversight body, such as a board of elected officials, who report to a diverse group of customers and stakeholders, requiring utilities to build external support for a rate change. Many utilities have struggled to effectively communicate the value — and cost — of a reliable supply of safe, affordable drinking water for today and for generations to come. With pipes buried underground and treatment plants far from view, water infrastructure and resource challenges have largely been "out of sight, out of mind" from the consumers' perspective. The result is a lack of awareness about the water service consumers have come to expect and the invaluable role of utilities. A 2011 survey from The Nature Conservancy revealed that 77 percent of respondents could not accurately identify the natural source of the water used in their homes[3].

The good news is that most utilities already have the tools to get their customers' attention, and new cost-free or low-cost resources can help managers succeed despite budget constraints and limited staff. With the right public engagement plan and by incorporating principles of good communications, utilities can smooth the way for rates that keep them fiscally healthy and ensure sustainable management of resources.

Engage The Public As Partners

The value of public participation in formulating policies has become increasingly important, and rate changes are no different. Involving customers and other stakeholders in the initial stages of rate revisions conveys the message that customer concerns will be taken seriously. A community that feels responsible for the stewardship of its water resources and has an opportunity to shape resource management is more likely to be receptive to and supportive of difficult decisions.

There are numerous models for initiating productive dialogue with the public around a rate change. Town meetings provide open, informal, and participatory venues for sharing information and expressing concerns. Advisory committees or task forces can provide a more structured format but may also require more effort on the utility's part to manage input and process recommendations. No matter the format, a successful public involvement process requires including diverse interests — especially those that may be averse to or significantly impacted by a rate change.

Utilities can also set themselves up for success by building dialogue with the public well before the need for a rate increase. Customer education should be a long-term effort and will result in greater public awareness over time. In 2013, the Albuquerque, NM Bernalillo County Water Utility Authority implemented Customer Conversations, an outreach program designed to generate public input regarding utility plans, policies, and programs[4]. Through interactive sessions regarding a variety of topics, they built a group of knowledgeable customers who, over time, became ambassadors for the water authority and set the stage to introduce needed rate adjustments to support revenue stability.

Tell The Utility's Story

Regardless of the model chosen, introducing a new rate structure to the public requires different preparation and a different approach than internal briefings. Utilities should be prepared to demonstrate how water use efficiency will benefit the community from social, environmental, and economic perspectives. An analysis of costs that can be avoided or deferred thanks to conservation can provide positive data points and messages for customers.

For example, Westminster, CO, determined that conservation programs implemented since 1980 had saved customers 91 percent in rates compared to what they would have been had new facilities been built to meet growing demand[5]. Compiling this data point helped communicate to customers that rates are rising whether they conserved or not, but conservation would help slow or reduce those increases.

Every utility's story will be different, but framing water use efficiency in terms of community well-being and providing backup data will help bring the point home. Managers should also be prepared for tough questions and be able to express complex topics in simple terms with the appropriate level of detail.

Plan Beyond Approvals

The approval of a rate structure change or rate increase is not the conclusion of the public engagement journey but rather the middle point. A well-organized implementation of a rate structure to the entire customer base is vital to the success of a rate structure in achieving its objectives. It is important to not overlook internal communications when preparing for a rate change. Customer service representatives and staff in the field are the utility's front line of interaction with customers, and they should be prepared to deliver the same messages as utility leadership.

When Cobb County Water System in metropolitan Atlanta implemented conservation rates that would result in a 300 percent increase in water bills for some large users, they engaged the entire organization and paid particular attention to customer service and field staff. They provided thorough training and developed resources such as FAQs and bill comparisons to help them respond to questions confidently, accurately, and consistently. They also instituted a customer response SWAT team consisting of two designated individuals who handled escalated inquiries[6].

Tailor And Focus The Message

In a world where consumers are bombarded with an endless stream of news and information from multiple devices, a relevant and focused message is the only kind that resonates.

Utility managers can break through by knowing their audiences and tailoring every message. Elected officials may be most concerned about the long-term impact to the financial and physical condition of the utility, compliance with regulations, immediate impact to the financial condition of the utility, and affordability when deciding whether to raise rates, according to a recent survey conducted by the Environmental Finance Center at University of North Carolina[7]. Business and community groups might care most about economic development. Utilities can prepare by providing clear information on individual bill impacts and how customers can reduce bills, or demonstrating how a rate increase, or lack thereof, will affect the utility's ability to deliver reliable water service.

It is also important to be transparent. Though the issue of rates may be complex, utilities can seek ways to offer clear explanations rather than assuming an issue is too complicated for the customer to grasp.

Create Or Curate High Quality Content

Every communications strategy should be supported by a content strategy, or the planning, creation, delivery, and management of the words, images, and multimedia used to deliver a message. A content strategy enables an organization to tell a consistent story across multiple channels, communicate what the organization stands for, and allow employees and partners to participate.

While not every utility has the resources to develop multimedia assets such as infographics or enlist a professional to develop the perfect sound bite, developing engaging content doesn't have to be cost-prohibitive. Fact sheets, FAQs, simple videos, or blog posts can help deliver the information customers need. Industry organizations are also pooling resources to create high-quality and adaptable content for utility use. The Alliance for Water Efficiency has produced consumer-friendly messages that can be adapted to support a rate restructuring, as well as a video that helps explain utility services and costs, available at www.FinancingSustainableWater.org.

Utilities can also be content curators. Collecting and sharing valuable content, while adding local flavor and insight, can help utilities become trusted, authoritative, and helpful in the eyes of customers. Organizations such as the U.S. EPA, the American Water Works Association (AWWA), and the Value of Water Coalition, the latter a new national effort to raise awareness of water issues, aggregate educational materials and videos to communicate the importance of water.

Think Outside The Bill

Finally, utilities should consider how they will get their message out. It is becoming harder to reach customers given the shift to electronic bills and auto-pay; utilities need to be present where customers are and deliver messages repeatedly. The majority of people need to hear a message three to five times before they absorb it[8].

Owned channels that the utility has control over, such as their website, email newsletters, and blogs can be the most cost-effective way to disseminate new content. Participating in social media communities such as Facebook and Twitter enables utilities to open up a two-way dialogue that is more authentic than traditional communications. D.C., for example, has recently used Twitter to humanize its three tunnel boring machines, named Lady Bird, Lucy, and Nannie. Each machine has a Twitter account to educate local residents about work to revamp the sewer system and converse in a friendly, humorous, and approachable way about neighborhood issues. The media can also be an asset and can help direct public opinion when utilities engage editorial boards and explain a rate change early in the process.


For utilities, communication pipelines build support for real pipelines.

Utilities cannot begin to tackle the challenges of the 21st century as silent providers of a misunderstood service. Fortunately, utilities also have access to 21st century tools to tell a compelling story and change customer perceptions. Even without a rate increase on the horizon, the time is now to begin developing a relationship with customers. It is only through greater awareness that customers will begin to understand that our water service is worth paying for and begin to trust their water providers to make the right decisions for their community. ■

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Tangential Flow Separation: A New Way To Treat Waste

Can "leaky hoses" really be considered an innovation? The answer is yes – when applied (ingeniously) for liquid/solids separation.

By J.H. Wakefield

Most water treatment professionals are familiar with the categorization of waste treatment processes into three general segments: 1.) sedimentation/settling of particulates in the waste stream and concomitant separation of these from the liquid phase of the waste stream as a first category; 2.) biological treatment technologies of one sort or another on the separated liquid phase as a second category; and 3.) tertiary treatment (usually chemical or physical in nature) to ensure removal of specific waste products that must be removed before any resulting effluent is discharged into the environment.

There are a plethora of different devices and processes that arise to address these various segments of the waste treatment process. In the following explanation, we shall examine a new technology that is applicable to both the initial segment (solid particulate removal) as well as to the final "polishing" process of the waste stream.

> The big **advantage** of this tangential flow separator technology is that it **lowers the cost** by controlling the cost of the polymers necessary and by allowing the use of zeolites (specifically, clinoptilolites) to both remove and bind a variety of offending ionic species.

Understanding Particulate Removal

Before we get started, it might be a good idea to review the basics of particulate removal in the entire wastewater treatment process. Particulates are assigned to categories depending on their physical state and sometimes even their chemical properties. The categories are: settleable solids, suspended solids, colloidal particulates ("solutions"), and soluble solids (i.e., solvated solids with the standard solvent being water, although other solvents are occasionally encountered).

Settleable solids depend on size and density as separation characteristics, but the process is also dependent upon temperature and particularly the velocity of the waste stream. Turbulence is also a variable, though it, too, is generally treated as a velocity-related parameter. Suspended solids are those of smaller size that do not readily settle out, so one normally utilizes coagulants/flocculants to effect the process. Coagulants develop a sticky, gummy mass that usually consists of a gel-like hydroxide (aluminum, iron, or even calcium) to entrap these smaller particulates as they become enmeshed in the formed matrix. A further step is completed as these trapped and bound particulates are sequestered in the matrix formed, and flocculants increase the extent of the matrix.

Colloidal particulates are those that are so small they do not spontaneously separate, and they carry an adsorbed electrostatic charge surrounding the particulate. This charged "coating" is referred to as the Stern Layer and has a thickness of a single hydrated ionic layer tightly attached by electrostatic forces to the colloidal particulate forming a first inner layer of charges. Because the colloidal particulate is electrically charged, it attracts ions and other colloidal particulates of the opposite sign. The particle and the attached ions of opposite sign form an electrostatic double layer. Additional ions of opposite sign to that of the colloidal particulates also accumulate next to the Stern Layer. These form a diffuse layer. These colloids are agglomerated by essentially tampering with these electrostatic charges in one way or another. Depending on the nature of a particular colloidal particulate, they may be "salted out," bridged by means of various polymers, removed by ion-exchange mechanisms, and/or flocculated by any and all of the above.

The last category of particulates to be removed is solvated particulates (usually molecular in nature, but not always) that are chemically treated — that is, reacted with some other functional group that results in their being bound or sequestered in the gel matrix. It is here that ion-exchange becomes a predominant "player."

Keep in mind that no matter what the nature of these individual particulates is, they are "converted" from being a

Forward progress: Tangential flow separators can be small and transportable, as shown, or scaled up for large flows.

member of the liquid phase to being a member of the solid phase. The final problem that arises is separating these two phases as efficiently and completely as possible.

New Separation Technology

It has come to my attention from several client companies that there is a new technology that works both in the initial and tertiary treatment of these waste streams. Several patents have been issued in this regard, and I have considered it best to address them as tangential flow separators. These devices are liquids/solids separators employing a unique principle, whereby “leaky” hoses utilize a laminar flow vector for the solid phase and a tangential flow vector for the liquid phase. The fluid path is contained within a tube (or hose, if you like), and the solid phase is forced down and out of the lumen of the tube. The liquid phase is collected by a mesh membrane of sorts and, for you chemical engineers out there, is related to a modified Frasch process minus the high pressures and temperatures. The solid phase continues down the tube where it is collected. The result is the removal of the solid phase from the liquid and the dewatering (or desolvating, depending on the solvent) of the solid phase.

As it results in removal of particulates and their concentration for disposal or other applications, these may be considered as primary treatment devices. If the waste stream has a specific character, such as a waste stream from a plating operation, these devices could be used as such.

But that’s not the whole story, nor the designed intent. Tangential flow separators have, in fact, been designed as tertiary treatment devices to address recalcitrant waste streams with difficult-to-remove regulated and/or dangerous components. This is the result of a “package” of coagulants/flocculents designed specifically to address these situations. A not uncommon method of addressing these problems involves the oxidation of offending ionic species (such as Cu++, Cd++, Pb++, and others), as well as sequestering those anions ($PO_4 \equiv$) that form insoluble precipitates and/or complex ions, and then utilizing the principle of ion-exchange to remove other offending anions (NO_3^-). This involves a clay (usually a montmorillonite), an inorganic coagulant (alum or ferric ion compound), and a specially formulated polymer (usually a cationic polymer) to complete the removal process.

The big advantage of this tangential flow separator technology is that it lowers the cost by controlling the cost of the polymers necessary (though not eliminating their usage) and by allowing the use of zeolites (specifically, clinoptilolites) to both remove and bind a variety of offending ionic species. Clinoptilolites are zeolites that function as scavengers for both anions and cations become highly charged and are readily removed as larger particulates from the liquid phase.

Considerations Regarding Flocculants

It is incumbent upon one wishing to separate solid and liquid phases to have them clearly delineated. The more completely they are delineated, the more effective the results.

To this end, different coagulants/flocculants are employed depending on the waste stream that is encountered. Included among these are natural flocculants such as the montmorillonite clays (Bentonite, for example), as well as various volcanic clays including the various forms of zeolites (clinoptilolite, for example). Either mixtures of these coagulants/flocculants are used, or possibly those with additions of processing chemicals including various inorganic salts and polymer ion-exchange moieties, in order to effect an acceptable separation for particular waste streams.

In any waste stream, there are both suspended and dissolved solids. The separation technology, whatever it is, is efficacious only insofar as it is capable of aggregating or precipitating these differing physical forms. So, both a physical and chemical reaction are usually necessary. Dissolved solids are precipitated, suspended solids are unsuspended, and both of these components are then collectively aggregated and removed via the tangential flow separation technology. How this separation occurs in any system is essential to understanding the functioning of the system and the rationale for its design.

How And Why It Works

Dissolved solids are the first to be considered. There are two ways to remove them: First, solubility may be altered by chemical means. To this end, the addition of various salts may affect their solubility and result in the formation of an insoluble precipitate. Secondly, these dissolved solids may be sequestered as solids in various complexes, which themselves are insoluble. By these means, virtually any dissolved solid can be removed. All one has to do is find an agent that will precipitate or sequester it. Bentonite is an economical and effective choice as a carrier, especially if it is treated to effect a particular separation.

The suspended solids are next on the agenda for particular waste streams. These are a bit more complex as they vary widely in chemical structure and even in the mechanism of their suspension. Some are suspended as a result of their size (either very large or very small). Those that are very large depend, for the most part, on the velocity of the waste stream and its temperature. Smaller ones usually depend on surface charge.

In removal, large ones are mostly an annoyance, but small ones can be a real problem, as surface phenomena are

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involved. The key to removing these particulates is to find what charge they carry, and, if possible, what engendered the charge. This is addressed by providing an opposite charge to aggregate the particulates (opposite charges attract). How this is accomplished may require a coagulant/flocculant that is itself oppositely charged. Most of the microparticulates carry a negative charge; therefore, coagulants/flocculants should usually have a positive surface charge. Many of the Bentonites do have a positive surface charge (remember they are ion-exchangers); if a more or differently charged surface is required, the addition of an aluminum salt can alter the structure of the Bentonite or can even be sequestered in other additions to the mixture, such as the various zeolites (which are also ion-exchangers [water softeners]). The bases resulting from aluminum and ferric/ferrous iron (aluminum and iron hydroxides) are commonly used as coagulants/ flocculants in water treatment and wastewater plants presently.

The tangential flow separator system is designed to add the necessary amount of coagulants/flocculants in order to aggregate the waste stream to an acceptable degree. This is affected by an air-driven mixer that injects the flocculant stream concurrently by mixing it into the waste stream. This mixer can be adapted to deliver any surface charge necessary to effect coagulation/ flocculation. Exactly how and at what step prior to filtration depends on the nature of the waste stream, as well as the physical parameters such as velocity, temperature, and particulate charge on the suspended particulates within the waste stream.

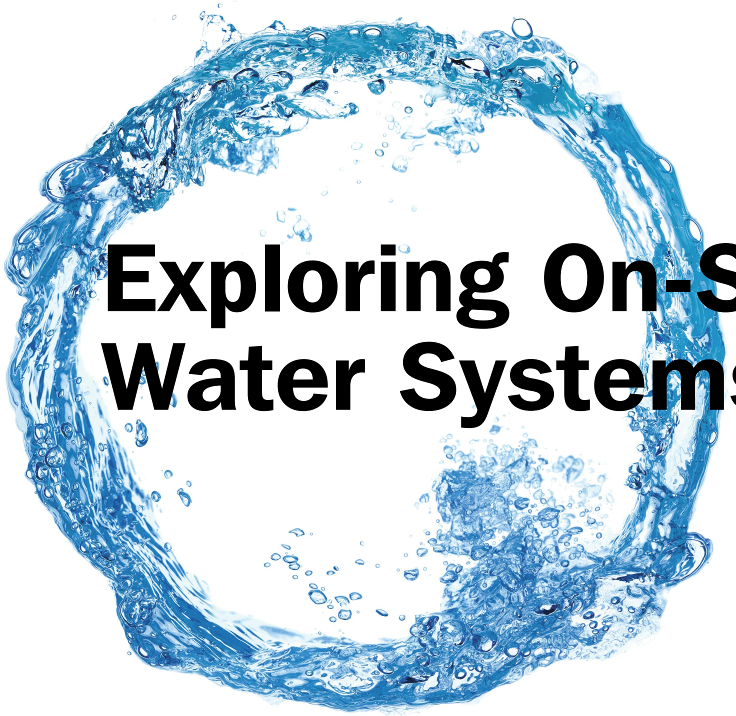
The tangential flow separator is then “charged” as the flocculant-treated waste stream enters the lumen of the separatory part. At this point, the solids are moved “down the line,” and the fluid fraction is separated and directed tangentially to the flow. This action results in a filtration situation in which the liquid fraction is flowing more or less perpendicular to the linearly directed flow of the solids as they proceed down the lumen. This results in the tangential flow separator acting as a “leaky pipe” for the fluid phase removal and as a solids concentrator for the solids moving down the separator’s lumen.

Advanced controls optimize the performance of the tangential flow separator’s physical processes.

Evidence regarding the separation efficacy resides in the before-and-after values of various impurities “of interest” in a particular waste stream that are determined from the seperated liquid phase. Of course, the solid phase likewise shows the efficacy of the process by the amount of fluid retained in the cake and by the amount of coagulant/flocculant comprising the solid phase of the treated solids emanating from the lumen. As flocculant inclusion into this cake is quite important from a regulatory viewpoint (yet limited as a processing aid), the amount present in the final cake determines the efficacy of the process as a whole. ■

About The Author

Dr. J.H. Wakefield is a consulting scientist/engineer with more than 30 years of experience in water/wastewater treatment. He holds advanced degrees in microbiology and physical/analytical chemistry and has been a practicing chemical and environmental engineer for many years.



Exploring On-Site Water Systems

Leading water organizations collaborate to produce a step-by-step guide for developing a local program to manage on-site water systems.

By Theresa Connor and Carita Parks

As strains on centralized water and wastewater facilities increase, many cities are looking for new ways to develop and manage local resources. One of those strategies is integrating smaller, distributed on-site water systems into broader centralized systems. The Water Environment Research Foundation (WERF), through its sustainable integrated water challenge, seeks to facilitate this kind of change by acting as a catalyst for a paradigm shift in water management for cities and towns toward sustainable systems that integrate wastewater, stormwater, drinking water, as well as other infrastructure (i.e., energy, transportation, parks, etc.). WERF and the Water Research Foundation (WRF) are working closely together on this significant research effort.

Today, buildings in New York, San Francisco, Santa Monica, Seattle, Tokyo, Sydney, and many other cities throughout the world are collecting and treating water on site to serve their own nonpotable needs in place of using potable water. WERF, WRF, and the San Francisco Public Utilities Commission recently released a joint project entitled *Blueprint for On-site Water Systems* to assist communities with developing a local program to manage and oversee on-site water systems that protect public health. Creating a local program to manage on-site water systems offers a proactive way to increase water resiliency and promote green building practices while protecting public health. The development of such a program should follow a sequence of steps that will inform critical decisions regarding the scope, structure, and implementation of the program.

On-site water systems promote water-resiliency by:

- Augmenting existing water supply portfolios by treating alternate water sources for beneficial use.
- Treating water only as needed for its end use application.
- Reducing potable water consumption for toilet flushing and irrigation.
- Minimizing stormwater flows to combined and separate sewer systems and/or storm drains.
- Increasing resiliency and adaptability of our water and wastewater infrastructure.

10 Steps For Developing A Local Program

1. *Convene a working group:* Establish a small working group to guide the development of the local program.
2. *Select the types of alternate water sources:* Narrow the specific types of alternate water sources covered in the program.
3. *Identify end uses:* Classify specific nonpotable end uses for your program.
4. *Establish water quality standards:* Establish water quality standards for each alternate water source and/or end use.
5. *Identify and supplement local building practices:* Integrate your program into local construction requirements and building permit processes.
6. *Establish monitoring and reporting requirements:* Establish water quality monitoring and reporting requirements for ongoing operations.
7. *Prepare an operating permit process:* Establish the permit process for initial and ongoing operations for on-site water systems.
8. *Implement guidelines and the program:* Publicize the program to provide clear direction for project sponsors and developers.
9. *Evaluate the program:* Promote best practices for on-site water systems.
10. *Grow the program:* Explore opportunities to expand and encourage on-site water systems.

Case Study: San Francisco's Nonpotable Water Program

The San Francisco Public Utilities Commission (SFPUC) provides retail drinking water and wastewater services to San Francisco, green hydroelectric and solar power to San Francisco's municipal departments, and wholesale water to

27 cities, water districts, and private utilities within three neighboring counties. In 2012, SFPUC spearheaded an effort to create a local program for regulating on-site water use called the Nonpotable Water Program.

The Nonpotable Water Program creates a streamlined process for commercial, multi-family, and mixed-use developments in San Francisco to collect, treat, and reuse water for toilet flushing, irrigation, and other nonpotable uses. The program allows the collection and treatment of alternate water sources to occur within one building or for multiple buildings to share treated alternate water sources for nonpotable uses. Established through an ordinance adopted by the San Francisco Board of Supervisors, this voluntary program encourages the use of water generated on site to expand water savings and further diversify SFPUC's water supply portfolio:

- **Rainwater** — precipitation collected from roofs or other manmade above-grade surfaces
- **Stormwater** — precipitation collected from at- or below-grade surfaces
- **Graywater** — wastewater from bathroom sinks, showers, and washing machines
- **Blackwater** — graywater and wastewater from kitchen sinks and toilets
- **Foundation drainage** — nuisance groundwater that floods basements
- **Other sources** as approved by the San Francisco Department of Public Health (SFDPH).

Developers and designers are responding to San Francisco's program by incorporating innovative on-site nonpotable water use systems into their projects — such as treating graywater for toilet flushing or using rainwater for spray irrigation. More than 20 new developments in San Francisco are proposing to collect, treat, and use a variety of alternate water sources for nonpotable applications.

For its momentum in San Francisco and worldwide and as a sustainable solution in the age of water scarcity, the *Blueprint for On-site Water Systems* is much more than the name suggests. It's a blueprint for the future. ■

About The Authors

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A Model For Private-Sector Stormwater Management And Water Stewardship

Toronto's Partners in Project Green promotes collaborative and innovative strategies for low-impact development (LID) stormwater management, focusing on the industrial and commercial sector.

By Alyssa Cerbu and Eric Meliton

As the urbanization of watersheds continues, the challenge of redevelopment and retrofitting to adjust for population growth and upgrading aging infrastructure persists. With many of these projects facing unique challenges that include high capital costs, disengaged municipal stakeholders, and a lack of awareness of key watershed management issues, the potential to implement a retrofit or redevelopment project becomes difficult. With the growing concerns about flood management, increased financial and operational risks, and the need to create resilience to adapt to the impacts of climate change, there is a movement towards sustainable watershed management among forward-thinking industrial and commercial end users.

In Ontario, Canada, the Toronto and Region Conservation Authority (TRCA) focuses on the implementation of integrated watershed management initiatives in the most heavily urbanized city-region in Canada, leveraging the need for adaptation and innovation as the core aspects of each project. TRCA has regulatory jurisdiction over nine watersheds and a portion of the Lake Ontario shoreline in Ontario. TRCA is one of the largest of the 36 conservation authorities in Ontario and among the most urbanized. By working directly with public, private, and nonprofit partners, TRCA delivers watershed management programs that contribute to the preservation of healthy rivers and shorelines, greenspace, and biodiversity and strengthen the notion of sustainable communities and businesses.

A joint collaboration between TRCA and the Greater Toronto Airports Authority (Toronto Pearson International Airport) in 2008 created the public-private partnership group called Partners in Project Green (PPG, www.partnersinprojectgreen.com). PPG pursues collaborative, sustainable initiatives with more than 600 private companies and public organizations and is supported with program and service funding received from regional municipal partners. The group's focus on sustainable business solutions through the power of industry collaboration has led to the development of a competitive, high-performance, and eco-friendly business climate surrounding the airport. This focus area is called the Pearson Eco-Business Zone, which encompasses 14,000 hectares (35,000 acres), 12,500 businesses, and 350,000 employees within its community.

The Water Stewardship Performance Committee (WSPC) of PPG has a mandate to:

- Develop and implement water-specific programs, events, and consortiums;
- Provide leadership through collective water stewardship projects and initiatives; and
- Set program targets and metrics and drive tangible results in water footprint reduction.

In 2014, the WSPC began projects focused on the implementing innovative low-impact development (LID) stormwater management technologies and practices collaboratively with companies belonging to the Pearson Eco-Business Zone. The projects were undertaken with end users in the industrial, commercial, and institutional (ICI) sector, while utilizing a network of service and technology vendors who offered exclusive pricing on products and services provided, thus enhancing the value to these retrofit water stewardship projects.

Governed by a committee of private sector and municipal representatives, the WSPC is responsible for helping to promote, construct, and demonstrate the success of lot-level LID stormwater management systems, including green roof, permeable pavement, and rainwater harvesting technologies. Their ultimate goal is the replication and proliferation of lot-level LID stormwater management projects across the Pearson Eco-Business Zone to reduce the burden on aging municipal stormwater infrastructure.

Sustained Enthusiasm And Leadership

Calstone Inc. (www.calstoneinc.com), a steel furniture manufacturer based in Toronto, has undertaken numerous sustainable initiatives in its 20 years of business, including promoting its remanufacturing program to recycle and reuse products returned by customers to achieve zero percent to landfill sites; utilizing 100 percent clean, green electricity from regionally sourced, low-impact wind and hydro facilities; and setting long-term goals to be 100 percent disconnected from the grid and serve as a model green manufacturer.

In 2014, Calstone approached Partners in Project Green for assistance with a proposed rainwater harvesting installation, which would mark its second on-site water stewardship initiative. Their first involved a 2,000-gallon stainless steel tank that captures water from one of the facility's six downspouts and uses it for cooling spot-welding equipment and flushing toilets. The second project would include disconnecting the remaining downspouts, while designing a way to utilize the rainwater for on-site irrigation, infiltrate the stormwater into the local Highland Creek watershed, and reduce the burden to the aged sewer infrastructure of Toronto.

The enthusiasm to pursue such a project is rare among small to medium enterprises in the ICI sector, which led to a full-scale

facilitation from the WSPC to work with an innovative visionary determined to implement an on-site water stewardship project.

With financial assistance, grants, and in-kind vendor contributions facilitated by the WSPC, the on-site rainwater harvesting and infiltration project reached a value of more than $100,000, whereas the original concept design proposed by Calstone Inc. was estimated at $5,000. These financial grants and incentives combined with the in-kind and discounted vendor contributions attributed to the reduction of potential capital costs associated with these types of projects, provide a collaborative model that can be replicated for other ICI sector participants seeking similar ways to improve overall sustainability.

Collaborative Endeavor

The final project completed by Calstone Inc. and the WSPC included the following:

- 42,000-square-foot rooftop retrofit
- Conversion of unusable land into an employee green space
- 8,400-square-foot infiltration and retention system (including two retention ponds, one infiltration pond, and one infiltration trench)
- Installation of a 9,300-liter (~2,450-gallon) rainwater harvesting tank to be used for on-site irrigation.

Calstone's on-site stormwater management system involves collecting rainwater from four of its six downspouts that were disconnected from the roof and feeding it to the municipal storm sewer. Once a storm event occurs, the water flows from the downspouts into the 9,300-liter rainwater harvesting tank or the infiltration trench. One of the tanks overflows into the three interconnected ponds, two of which provide temporary water retention and infiltration, while one is a permanent, striking water feature. These ponds are adjacent to a recycled materials walkway, which allows visitors and employees to walk alongside the new features and leads to the secondary infiltration trench at the back end of the building.

The official planting of drought-resistant native plants and shrubs was completed in spring 2015. Additionally, monitoring of the performance of these stormwater treatment and infiltration technologies will commence in 2015 and continue for two years. The findings gained from evaluating the effectiveness and cost viability of such systems can be used to encourage the installation of future ICI property retrofits elsewhere.

before

after

In total, it is estimated that the stormwater management system will be able to capture, infiltrate, and divert approximately 1.9 million liters (more than 500,000 gallons) of water annually. This will help restore a more natural water cycle to nearby Highland Creek. These stormwater best management practices also set Calstone Inc. apart from other medium-sized businesses in the area by providing an enhanced and distinguished green space for employees and showcasing dedication to exemplary water stewardship within their local watershed.

A Model For Sustainability And Corporate Water Stewardship

Calstone Inc.'s installation puts it ahead of the curve on addressing property-level LID solutions to stormwater management issues. Stormwater infrastructure in Toronto is aging and does not have the capacity to withstand the current population growth, increasing urbanization, and the threat of climate change, which is associated with occurrences of greater, more frequent storm events. This type of lot-level stormwater management demonstrates to the community at large a different and necessary approach to reducing the cost associated with retrofitting municipal infrastructure.

Additionally, at a property level, this type of infrastructure mitigates the risk of incurring property damage during large storm events, which Toronto has seen in the previous years (e.g., Insurance Bureau of Canada estimated the July 8, 2013 storm cost approximately $1 billion in damages) and is likely to occur more often in the future.

Calstone's project is a model for other ICI companies throughout North America and beyond to follow, as the collaborative project with PPG focused on the impact to the triple bottom line — social, environmental, and financial. Emphasis was placed on the social and environmental aspects of the project, with a financial impact experienced through incentives, in-kind vendor contributions, and a reduction in localized flood risk. When combined, these factors mitigate the overall risk of high capital expenditures expected for these types of projects, while addressing key issues associated with effective watershed management. By continuing to develop service and technology vendor networks willing to collaboratively pursue implementation projects with engaged government stakeholders, the notion of long-term replication of these types of projects may become a reality. ■

About The Authors

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