Blue Planet?
Reuse, Desal, and the Future of Water
The recent implementation of Ocean Outfall legislation in Florida has created a groundswell of reuse master planning and process investigation in the southeastern portion of the state, as municipalities must prepare to shut down their ocean outfalls and reuse 60 percent of the outfalls’ baseline flow for a beneficial purpose by 2025.

In response to this impending deadline, the City of Hollywood turned to Hazen and Sawyer to investigate options for reuse required under the new law. Three options were initially identified – expanding the public irrigation system, recharging the Biscayne aquifer, and recharging the Floridan aquifer. Serving coastal cities with a high groundwater table, the City’s Southern Regional Wastewater Treatment Plant (SRWWTP) has a salty effluent, rendering it unsuitable for irrigation reuse without reverse osmosis (RO) treatment, and the required piping network would need to be extended well beyond city limits, escalating the cost of implementing the mandated reuse to $1 billion. Effluent going into the Biscayne aquifer, the predominant source of drinking water for all of southeast Florida, would require costly microfiltration (MF)/RO/ultraviolet advanced oxidation process (UVAOP) treatment before injection into the high-quality aquifer. After a review of the legislation, discussions with regulatory agencies, and exploration of available options, Floridan aquifer recharge was identified as potentially more cost-effective and environmentally-friendly direction for the City.

When faced with an imposed reuse mandate, the City of Hollywood (FL) turned to Hazen and Sawyer to develop a treatment approach that demonstrates emerging contaminant oxidation without reverse osmosis, which has the potential to greatly reduce costs and carbon emissions.

**Innovations in Indirect Potable Reuse**

Hazen and Sawyer recently completed a custom pilot study to develop an innovative reuse treatment option and help Hollywood (FL) cost-effectively comply with the Ocean Outfall legislation.

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Due to the brackish quality of the Floridan aquifer (TDS > 500 mg/L), alternative treatment processes using ultrafiltration, ion exchange, ozone and ultraviolet light (UV) based AOPs, as well as biofiltration, were examined as an alternative to the full advanced treatment (FAT) approach of RO and UV AOP that is currently the standard treatment in potable reuse applications. Prior to use as drinking water, raw water from the Floridan aquifer requires nanofiltration (NF) or RO membrane treatment to achieve potable quality, allowing the City to consider less-expensive recharge process schemes without redundant RO or NF membrane treatment. If successfully permitted, this reuse project utilizing Floridan aquifer recharge could potentially save the City about $100 million dollars in capital costs over Biscayne aquifer recharge and about $800 million in capital costs over irrigation-level treatment and expansion of the public access irrigation system.

Pilot Study Program Objectives and Guidelines

Based on the specific characteristics of the SRWWTP effluent and the aquifer water quality, Hazen and Sawyer developed a customized plan of study to achieve acceptable emerging contaminant oxidation using treatment technologies that are more cost-effective and have a smaller carbon footprint than traditional MF/RO/UV-AOP treatment. The goal of the pilot project was to demonstrate the ability to reliably produce water that satisfied primary and secondary drinking water standards (with the exception of certain constituents naturally present in the Floridan Aquifer, such as sodium and chloride) and removed emerging contaminants.

If successful, it would likely define future aquifer recharge standards for Broward County.

After considering the impacts associated with Broward County Code compliance, the project team approached the County with the treatment concept.
Pilot Schemes

1 – UV/AOP
This process scheme included secondary treated effluent from the SRWWTP followed by deep bed filters (DBF), ion exchange (IX) for TOC removal, IX for ammonia removal, ultraviolet advanced oxidation process (UV-AOP) and biological activated carbon filters (BAC).

2 – Ozone
This process scheme includes secondary treated effluent from the SRWWTP followed by deep bed filters (DBF), ion exchange (IX) for TOC removal, IX for ammonia removal, ozone, biological activated carbon filters (BAC), and UV.

The Broward County Environmental Protection and Growth Management Division (BCEPGMD) suggested that certain water quality requirements for aquifer recharge may be waived based on demonstration of reasonable emerging contaminant oxidation. As a result, the pilot study was designed to meet this goal using alternative treatment technologies that are fully protective of the environment, have reduced carbon emissions, and are more cost-effective, while being predicated on regulatory waivers for COD, TDS, chloride, sodium, and phosphates.

The pilot test was conducted for approximately 10 months (i.e., actual operation of the pilot equipment, not including start-up). Throughout the study period, the pilot plant operated 24 hours/day, 7 days/week, with the exception of scheduled monthly equipment cleanings. The pilot used portable treatment system containers on site at the SRWWTP, treating secondary effluent from the facility. From the outside, these pilot systems looked like standard shipping containers. Inside, they offered advanced treatment systems that used ozone, ultraviolet light, and hydrogen peroxide to create an AOP, which enabled the project team to evaluate and optimize different methods for treatment with a few clicks of a button.

Results
Pilot-scale testing of these novel approaches demonstrated that an effluent quality that complies with state regulations and removes emerging contaminants can be achieved while offering additional benefits to the public and the environment by way of substantially reduced costs and carbon emissions.

As summarized in the table on the following page, both piloted treatment technologies successfully oxidized emerging contaminants well below the targeted limits.

The pilot test found that both Process Scheme 1 and 2 are viable options for recharge in Broward County to satisfy the new state reuse requirement. The present value of the treatment necessary for full compliance with state recharge regulations is estimated to be $190 million, while full treatment compliance with Broward County regulations have an estimated present value of $590 million. However, this pilot testing achieved an effluent quality that complies with state regulations and removes yet-to-be-regulated emerging contaminants at a present value in the range of $290-330 million, which is half the cost of traditional treatment methods. The annual O&M costs of the piloted treatment schemes ($6.8-8 million
annually) would also be half of that of traditional treatment methods ($16.2 million annually). This approach offers additional benefits to the public and the environment by way of substantially reduced carbon emissions. Meeting Broward County standards through traditional treatment would release an estimated 26,000 tonnes of annual carbon emissions, while the piloted treatment schemes would release less than half as much (12-14,000 tonnes).

### Future Applications

As growing demand strains existing drinking water supplies and increasingly stringent wastewater effluent standards lead to more advanced wastewater treatment, indirect potable reuse is becoming a feasible scenario for more utilities. A majority of potable reuse schemes in operation or being planned in the U.S. make use of AOPs and RO to ensure maximum contaminant removal. This pilot developed two potable reuse schemes where RO or NF membranes are not incorporated at the reuse facility, potentially reducing carbon emissions and saving municipalities significant capital and O&M costs.

The City of Hollywood is currently debating the public policy implications of various treatment options and their impacts with the appropriate regulatory agencies. Utilization of a tailored approach to reuse promises a solution that is the most protective of public health and the environment.

### Parameter Current Limit (mg/L) Pilot Effluent Averages (mg/L)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Limit (mg/L)</th>
<th>Pilot Effluent Averages (mg/L)</th>
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<tr>
<td>BOD₅</td>
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<td>TSS</td>
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<tr>
<td>Sodium</td>
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<td>776</td>
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<tr>
<td>TDS</td>
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<tr>
<td>Phosphates</td>
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<td>1.2</td>
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<tr>
<td>COD</td>
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### Red Background: Based on demonstrated emerging contaminant removal, waivers will be sought from the Broward County Environmental Protection and Growth Management Division (BCEPGMD)

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<td>14</td>
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</tbody>
</table>

Hazen and Sawyer staff constructed and operated the pilot plant, collecting data for ten months.

### Hazen and Sawyer Pilot Technique

**Slashes Costs...**

*Complies with state regulations and removes yet-to-be-regulated emerging contaminants

**...and Carbon Emissions**

Carbon dioxide emission (in tonnes) would be cut to approximately half
The Nassau County Department of Public Works owns and operates the 70-mgd Bay Park Wastewater Treatment Plant (BPWWTP), which was heavily damaged during Hurricane Sandy. When faced with rebuilding the facility, the County decided to capitalize on the opportunity and proactively prepare the plant for anticipated future nitrogen removal requirements. As part of the recovery and rebuild efforts, the County turned to Hazen and Sawyer to assist with evaluating and demonstrating innovative solutions.

Hazen and Sawyer developed an innovative nitrogen removal process for Nassau County that meets stringent regulations and is estimated to save up to approximately $1 million/year in chemical costs.
technologies that would enable the facility to achieve nitrogen removal in the most efficient way possible. While conventional methods were considered, a comprehensive process evaluation identified sidestream treatment as a promising alternative.

In this approach, a novel biological process called deammonification would be utilized to biologically remove approximately 10% of the total nitrogen at the BPWWTP. Deammonification is an emerging process that can reduce the cost of wastewater treatment for many facilities, enabling an approximately 63% reduction of theoretical O2 requirements, an approximately 100% reduction of supplemental carbon requirements, and a significant reduction in biomass handling requirements when compared to removal through a mainstream activated sludge process.

A cost evaluation conducted as part of our research indicated that the BPWWTP would observe potential savings of approximately $1 million per year using deammonification by avoiding supplemental carbon and aeration costs.

**Technology Alternatives and Selection**

Presently, there are three main technology options for equipment related to performing sidestream deammonification, as seen in the table below.

After a careful consideration of the available technologies, the DEMON™ process was selected for piloting at the BPWWTP. The DEMON™ process employs a sequencing batch reactor configuration, coupled with a hydrocyclone, for the selective wasting of nitrite oxidizing bacteria and the retention of anaerobic oxidizing bacteria (Anammox). The Anammox bacteria are the main biological catalysts behind the deammonification process.

The reactors are filled from a filtrate/centrate equalization tank and operated in batch mode. Aeration is followed by mixing and then sedimentation. The effluent is then decanted from the sequential batch reactor. Each cycle (fill, reaction, settle, withdraw) is repeated approximately three times per day.

**DEMON Pilot Testing and Results**

Hazen and Sawyer, in collaboration with World Water Works and Nassau County, piloted the DEMON™ process at the BPWWTP from August to November 2013.

<table>
<thead>
<tr>
<th>Reactor configuration</th>
<th>DEMON™</th>
<th>ANITA Mox™</th>
<th>Cleargreen™</th>
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<tr>
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<td>MBBR or IFAS</td>
<td>SBR</td>
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<tr>
<td><strong>Control parameters</strong></td>
<td>floc</td>
<td>pH, NH4 loading</td>
<td>pH, NH4 loading</td>
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<tr>
<td><strong>Design Loading (kg N/m3-day)</strong></td>
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<td>1.2 to 2.0</td>
<td>0.7</td>
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<tr>
<td><strong>Technology Provider</strong></td>
<td>World Water Works</td>
<td>Veolia/Kruger</td>
<td>Degremont</td>
</tr>
</tbody>
</table>

The DEMON process pilot, which achieved and maintained high levels of nitrogen removal throughout testing, can enable utilities to save over $1 million a year in chemical costs.

The DEMON™ process pilot, which achieved and maintained high levels of nitrogen removal throughout testing, can enable utilities to save over $1 million a year in chemical costs.
Start-up of the system was accomplished within 20 days to meet 80% removal of influent ammonia, and this high level of performance was maintained for the duration of the pilot. Additionally, no supplemental alkalinity or carbon was required, demonstrating that the sidestream deammonification process is a viable, cost-effective strategy for nitrogen reduction at the BPWWTP.

As a result of the success of this piloting effort, we are currently working on a full-scale design of a sidestream deammonification system for BPWWTP using the DEMON technology.

Future Applications

Even though the deammonification process is an emerging technology, opportunities for process optimization are already being explored. As part of the Bay Park project, Hazen and Sawyer, in collaboration with Manhattan College researchers, developed and utilized an Anammox-specific activity assay. This assay, which tracks anammox activity during periods of both high and low activity and can be applied to other deammonification systems to compare results, represents a simple and effective strategy that can be used to directly monitor the health of the Anammox bacteria in the deammonification process. It also provides the industry with a first step toward diagnosing and solving process instabilities that can arise from dynamic full-scale operation of deammonification systems.
Like many coastal utilities in water strained areas, West Basin is studying the incorporation of desalinated water into its potable supply. Hazen and Sawyer recently studied how it can avoid problems in its distribution system.

Increasing populations and strained water supplies are creating significant drinking water challenges for communities worldwide. More and more, providers are having to expand their portfolio of sources to bridge the gap between supply and demand. While water reuse is a viable tool for any utility, coastal communities have the opportunity to turn an abundant natural resource – the ocean – into a viable potable supply.

As the cost of importing water continues to rise, desalinated ocean water has become a cost-effective supplementary water supply for a growing number of utilities on the west coast of the United States. One utility pioneering the incorporation of “desal” (desalinated water) into a drinking water system is the West Basin Municipal Water District (West Basin), provider of wholesale water service to 17 cities and approximately one million people in southwest Los Angeles County. West Basin is an industry leader in water recycling and conservation and established a goal of serving 10 percent of the local water supply with desalinated ocean water by the year 2020.

Water Quality Integration Study

West Basin’s recent Water Quality Integration Study evaluated the impacts of introducing desalinated water into the existing potable water distribution system. Hazen and Sawyer conducted a four-month pipe loop study with assistance from Separation Processes, Inc. (SPI) and various technical advisors. The study evaluated corrosion-related impacts of stabilized desalinated water and blends with other local sources on different pipe and household plumbing materials in pilot-scale pipe loops. Two additional aspects of the testing - disinfectant residual...
stability and disinfection by-product formation - were investigated both at pilot-scale and through more in-depth testing in the laboratory by the Metropolitan Water District of Southern California (MWD).

Prior to introduction into a drinking water distribution system, desalinated water requires post-treatment. This treatment involves the addition of some minerals back into the water to provide a water quality that is non-corrosive toward distribution system materials. In particular, desalinated water requires the addition of alkalinity (buffer capacity), calcium, and pH adjustment. Without post-treatment, the water can extract metals or cement from pipes, which can result in regulatory level exceedances, aesthetic concerns, and infrastructure issues. With proper stabilization, desalinated water can be integrated into a distribution system without incident. For this study, ocean desalinated water generated at West Basin’s Ocean Water Desalination Demonstration Facility (OWDDF) was stabilized using calcite contactors prior to testing the water in the pipe loop and bench-scale studies.

**Technical Approach**

An initial aspect of this study was the identification of treatment targets for key water quality constituents. A literature search and utility survey were conducted to review the current knowledge and experience on desalinated water stabilization in terms of water quality targets for corrosion control. The pipe loop study was conducted with new cement mortar-lined steel pipes (CML loops), used unlined cast iron pipes harvested from the local distribution system (UCI loops), and new copper pipes with lead solder and harvested brass meters (CU loops). These pipes and materials represent the different types of potential materials in the distribution systems that are susceptible to corrosion if the desalinated water

**New Global Desal Capacity since 1980**

![Graph showing new global desal capacity since 1980.](image)
has corrosive tendencies. The pipe loops were tested with stabilized desalinated water, MWD water, a blend of desalinated water and MWD water (50:50), a blend of MWD water and groundwater (25:75), and a blend of desalinated water and groundwater (25:75).

Pipe loops were operated on a weekly basis, with fresh water filled in pipe loop tanks on Day One and recirculated water discharged on Day Seven. UCI and CML pipe loops continuously recirculated water for six days, then the water was replaced on the seventh day. Copper pipe was operated in a flow-through manner with 0.5 hours of flow, 11.5 hours of stagnation, 0.5 hours of flow and so on for the seven-day period. First flush samples were collected after approximately eight hours of stagnation from the brass meters and, separately, from the copper pipes.

Water in the pipe loop tanks was sampled three times a week: when the tanks were freshly filled (Day One), in the middle of the week (Day Five) and at the end of the week (Day Seven). The freshly filled water served as a baseline for the weekly testing and also ensured proper blending was achieved in the pipe loop tanks that required blended water. Samples from the middle of week were monitored to characterize chloramine degradation. Samples from the end of week were monitored for corrosion products.

The pipe loop study continued for four months to allow evaluation of differences in corrosion observed for the water sources and blends.

Bench-scale testing was conducted by MWD using Unlined Cast Iron

Cement Mortar-Lined Steel

Copper with Lead Solder and Brass Meter
simulated distribution system (SDS) methods to evaluate chlorine stability and DBP formation. In short, the bench-scale study evaluated stabilized desalinated water, various blends of desal with MWD water and/or groundwater, and MWD water (i.e., the same blends as pilot tested). The desal water and MWD water were chloraminated, while the groundwater was tested with either chloramines using natural ammonia or chloramines after breakpoint chlorination to first remove natural ammonia.

Results and Findings

For highly tuberculated unlined cast iron pipe loops, release of iron and manganese from deposits was similar for all blends tested. Iron and manganese concentrations dropped below the secondary MCLs during the testing (<0.3 mg/L total iron, < 50 μg/L manganese). Results showed that 100% desal water or blends of desal with groundwater or MWD water did not cause higher total iron release compared with 100% MWD water.

For CML pipe loops, aluminum and pH were monitored as primary indicators of cement mortar dissolution. Throughout the testing, the recirculated waters were below the aluminum secondary MCL of 200 μg/L; pH increases were observed for all loops, especially during the first two months since the pipe surfaces were unsealed. After this period, pH stabilized around 8.5 -8.6, slightly above pH levels in fresh waters. Overall, stabilized desal and desal blends were not more aggressive toward cement mortar-lined pipes than other blends tested.

For CU pipe loops, the desalinated water alone or in blends did not show an increased tendency to leach lead from lead solder or brass meters. Copper and zinc concentrations in the stagnant waters were well below the action level of 1,300 μg/L for copper and secondary MCL of 5,000 μg/L for zinc for both copper pipe segments and the brass meters.

Pilot testing showed that disinfection by products were very low in 100% desal – both fresh and recirculated waters. No increase in DBPs was observed for blends compared to the proportion of the original water quality contributions.

The bench-scale testing conducted by MWD evaluated chloramine stability at two pH levels, temperatures, and bromide concentrations. Results showed that chloramines can be stabilized with a chloramine contact time of approximately four hours, with reboosting at that point before water enters the distribution system. Overall, replacement of MWD water with desal in a distribution system is expected to decrease TTHM, HAA5, or iodinated DBP concentrations in the distribution system.

The results of the pilot and bench tests indicate that the introduction of desalinated ocean water (with appropriate calcium, alkalinity, and pH levels, and stabilized chloramine residual) into a range of typical and representative distribution system and household materials is not expected to cause negative impacts on water quality, corrosion, or disinfection. These pipe loop studies provided proof that municipalities can safely utilize desalinated water or blends to supplement their water supply without sacrificing water quality or damaging their distribution system.
In May 2002, the Towns of Apex, Cary, and Morrisville (NC) formally agreed to jointly commission the Western Wake Regional Wastewater Management Facilities (WWRWMF) Study to evaluate options for providing long-term wastewater management services for western Wake County. As a result of the evaluation, those local governments elected to proceed with plans for the construction of regional wastewater management facilities to serve the needs of western Wake County to the year 2030. The Town of Cary was designated as the lead agency for the project partners.

Hazen and Sawyer was selected to perform program and construction management services for the eight major construction packages that comprise the Western Wake Regional Wastewater Management Facilities project. The project includes three pump stations, one water reclamation facility (WRF), and all the pipes that connect them. The West Cary and Beaver Creek pump stations move raw wastewater from the Towns to the new WRF for treatment. The third pump station, at the WRF site, and a force main take the treated effluent from the Western Wake WRF to a discharge point. The discharge of the treatment facility will also satisfy the terms of an interbasin transfer (IBT) certificate that requires effluent to be discharged to the Cape Fear River basin, the source of drinking water for the Project Partners.

Hazen and Sawyer recently completed construction and program management services on a major wastewater project in a growing county in North Carolina, ensuring sufficient treatment levels for decades to come.

Work at the 18mgd treatment plant included construction of liquid treatment and solids handling facilities, administrative buildings, and an effluent pump station.

Regional Wastewater Management Facilities project. The project includes three pump stations, one water reclamation facility (WRF), and all the pipes that connect them. The West Cary and Beaver Creek pump stations move raw wastewater from the Towns to the new WRF for treatment. The third pump station, at the WRF site, and a force main take the treated effluent from the Western Wake WRF to a discharge point. The discharge of the treatment facility will also satisfy the terms of an interbasin transfer (IBT) certificate that requires effluent to be discharged to the Cape Fear River basin, the source of drinking water for the Project Partners.

Four of the eight construction contracts were based on the same site: the treatment plant. Daily coordination was needed to ensure the projects were constructed in the proper order and without interfering with other aspects of the program.
Construction Coordination

The eight construction contracts had to be completed at the same time, and since every facet of the project was dependent on the others, scheduling management was of the utmost importance. Seven different contractors were selected for the eight contracts, providing additional challenges. Hazen and Sawyer held weekly meetings with these contractors to facilitate coordination among these contractors and devise a full construction schedule that accounted for all of the moving parts. We also developed a scheduling and electronic document management control system that seamlessly integrated all WWRWMF contracts.

Four of the concurrent contracts were based on the same site: the treatment plant. Daily coordination of the various contractors was required to ensure work got done in the proper order and without adversely impacting other components of the project. Our staff also managed coordination between the various points of overlap among these four contracts, including shared access roads, interface points between contracts, traffic control, and equipment deliveries.

Design and Constructability Reviews

The eight different components of the project were designed by five different design engineers. Since all of the projects were intended to operate in concert and consistency between designs was paramount, Hazen and Sawyer utilized an intensive multidiscipline approach at the outset of the project to ensure consistency between plans and specs, coordination between contractors and projects, and optimal plant performance when completed.

Due to our longstanding relationship with Western Wake Partners and our facility design expertise, we continued to improve the third-party design as construction proceeded. These improvements will result in improved process flexibility and more cost-effective plant operation upon completion. We also managed and reviewed all shop drawings, RFIs, RFPs, change orders, and other submittals to ensure that no proposed changes would adversely affect plant operations or another component of the program.

We continued to improve the third-party design as construction proceeded, resulting in improved process flexibility and more cost-effective plant operation.
Significant Community Outreach

The residential location of the project site required additional attention to noise mitigation, traffic management, and environmental compliance. Hazen and Sawyer worked with stakeholders to provide comprehensive community outreach, regular status/progress reporting, and regulatory monitoring to minimize any adverse effects on quality of life surrounding residents. Local residents were given advance notification of all construction activities that could potentially impact them.

Meetings with community leaders and one-on-one meetings with residents most affected by construction were held on a regular basis to ensure open communication and foster public acceptance. A program website was developed to provide residents and other constituents with regular updates, construction photos, and resources. Additionally, our staff worked directly with the Western Wake Partners to provide additional related benefits to the community that included sewer service. As a result of these efforts, minimal community-related issues arose during construction.

“Hazen & Sawyer’s services providing construction management have been extremely valuable, particularly with regard to managing the numerous, concurrent critical schedule milestones on this important project…”

Program Outcomes

“Hazen & Sawyer’s services providing construction management have been extremely valuable, particularly with regard to managing the numerous, concurrent critical schedule milestones on this important project for the Western Wake Partners,” said E. Alexandra Jones, engineer with the Town of Cary.

Construction of the facilities began in September 2011, and the facilities are now complete and in final check-out and start-up activities ahead of schedule and within the original project budget. We provided extensive training to the facility operators, including conducting 15 training sessions on site. In addition, we are preparing electronic O&M manuals to help ensure optimal operations long after we have left the site. As the final component of the project, we are providing complete start-up, testing, and commissioning services for the entire system and post start-up process and energy optimization to ensure these facilities meet the needs of the Partners going forward.

Hazen and Sawyer assisted the Western Wake Partners’ extensive community outreach effort that included regular meetings with the community, the development of a website about project progress, and informational materials such as this fact sheet.
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AWARD WINNING work

Abstracts
from ACE, WEFTEC and other conferences from around the globe