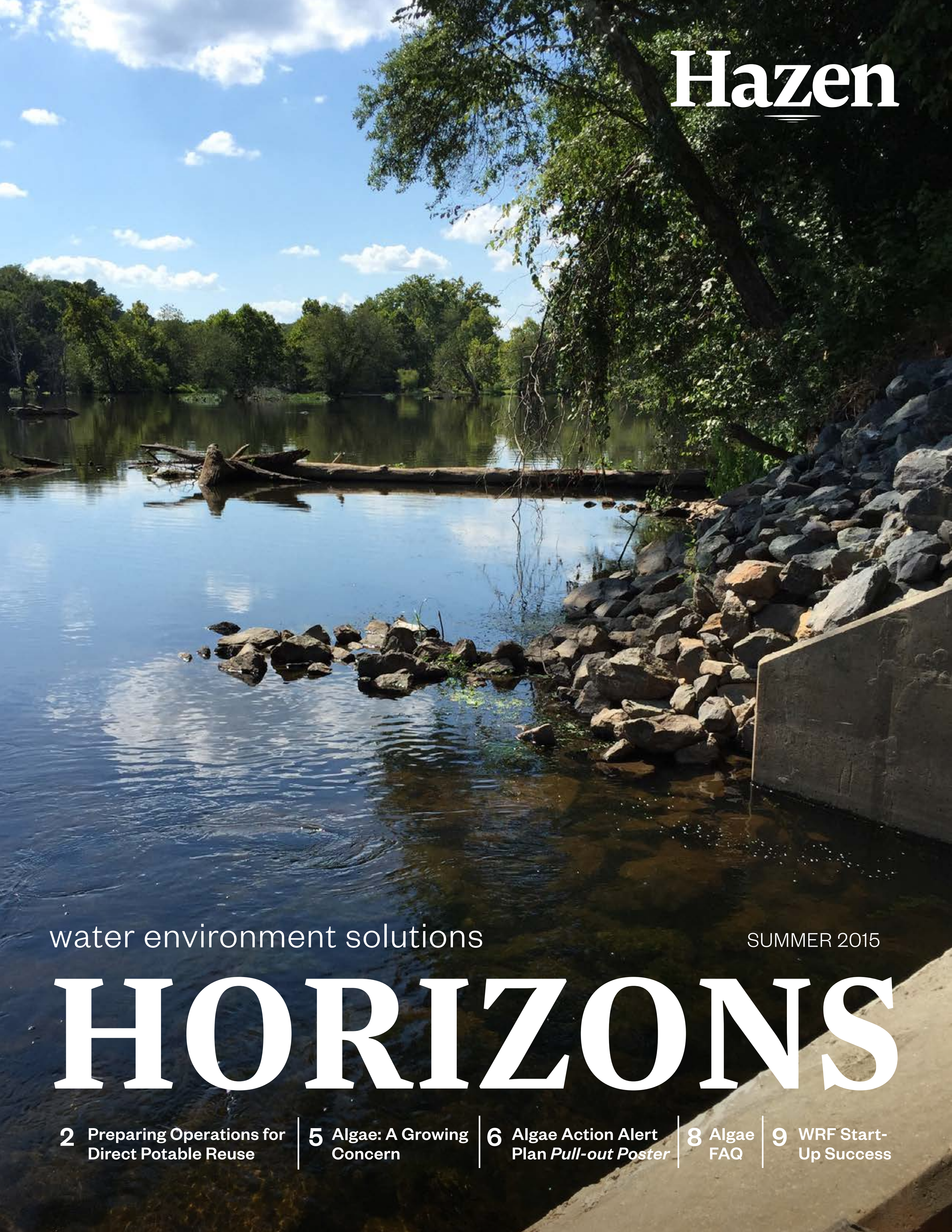


Hazen

water environment solutions

SUMMER 2015

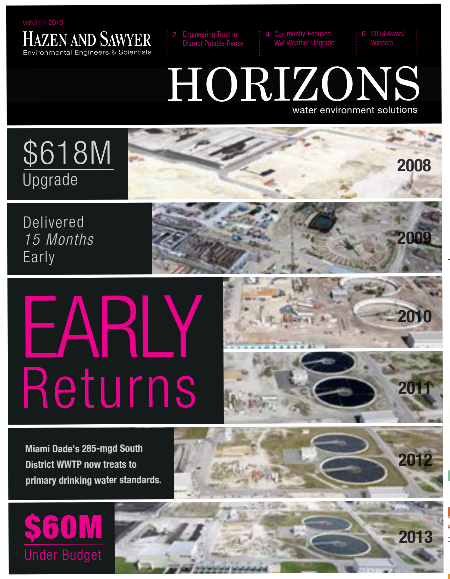
HORIZONS

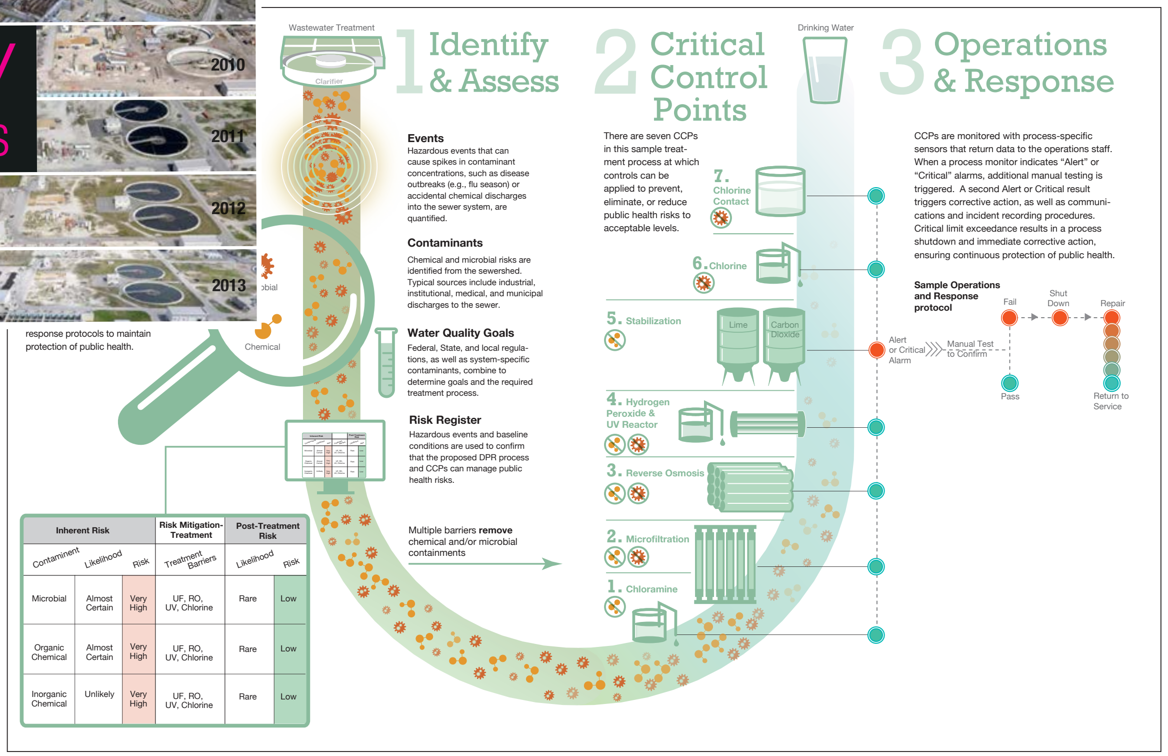
Preparing Operations for Direct Potable Reuse

Direct potable reuse (DPR) represents significant innovation in the field of public health. While the technology upon which it relies has been proven for many years, the barrier to more widespread adoption has been a reluctance, real and perceived, among customers to consume drinking water produced from wastewater that did not travel through “nature” between uses. Consumer education and widening gaps between supply and demand have helped overcome this reluctance, yielding a recent boom of DPR development.

This recent development reveals another “human” barrier to widespread adoption of DPR. DPR facilities are typically highly automated and include several advanced technologies, many of which are not currently well-covered in existing training and certification programs. DPR operators will in most cases be drawn from the existing pool of drinking water and wastewater operators. These operators have a valuable knowledge base, but they will need to be supported with additional technical training and operational management plans and procedures as they undertake their new roles.

For more information on critical control points (CCPs), visit hazenandsawyer.com and check out the Winter 2015 Horizons.



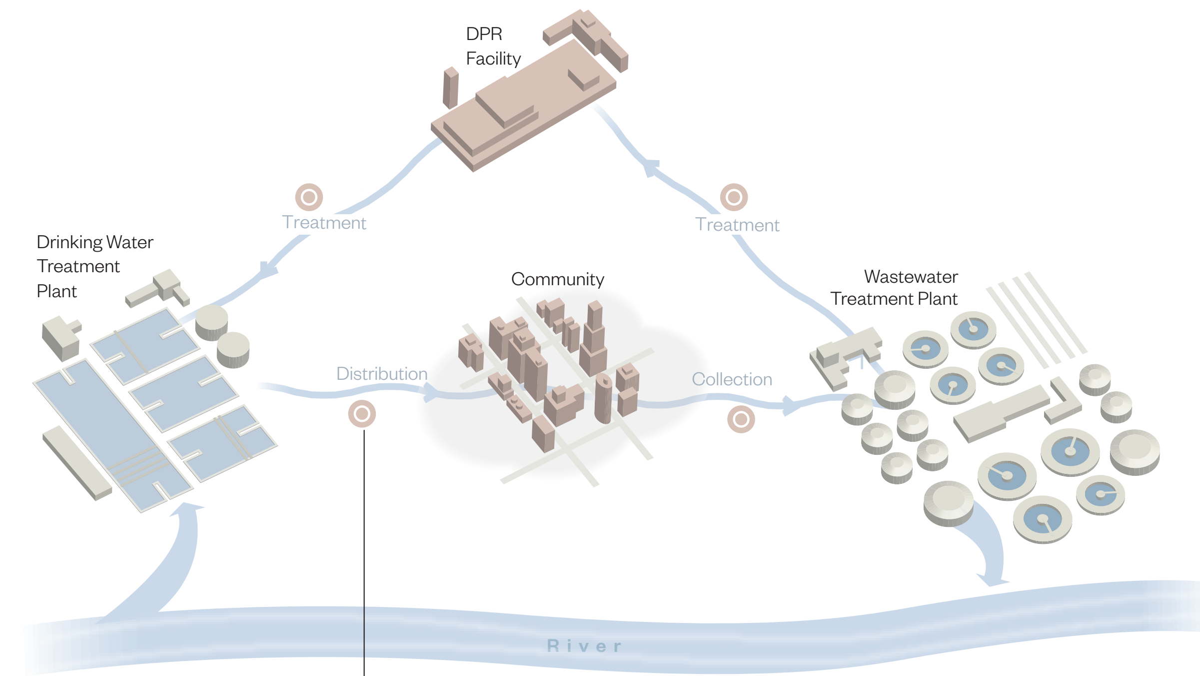


Inherent Risk			Risk Mitigation-Treatment	Post-Treatment Risk	
Contaminent	Likelihood	Risk	Treatment Barriers	Likelihood	Risk
Microbial	Almost Certain	Very High	UF, RO, UV, Chlorine	Rare	Low
Organic Chemical	Almost Certain	Very High	UF, RO, UV, Chlorine	Rare	Low
Inorganic Chemical	Unlikely	Very High	UF, RO, UV, Chlorine	Rare	Low

Through work at DPR facilities with our clients and cutting-edge research, Hazen and Sawyer is developing the training and certification programs to help ensure operations staff have the tools and information they need to produce high-quality, reliable water for their community. With appropriate development of critical control points (CCPs), response procedures, alarm management, and proper training, staff can be prepared to handle all levels of operation at DPR facilities.

Operating PROCEDURES

The operations, maintenance, and monitoring plan (OMMP) for a facility identifies the risks to successful system operation, how the system should mitigate those risks, and what procedures should be followed in the event of system failure. It will include dedicated response procedures at each critical process barrier or CCP to ensure a consistent approach for managing health risk. Emergency response procedures and emergency response communication requirements must also be clearly established.



Operational INTERFACES

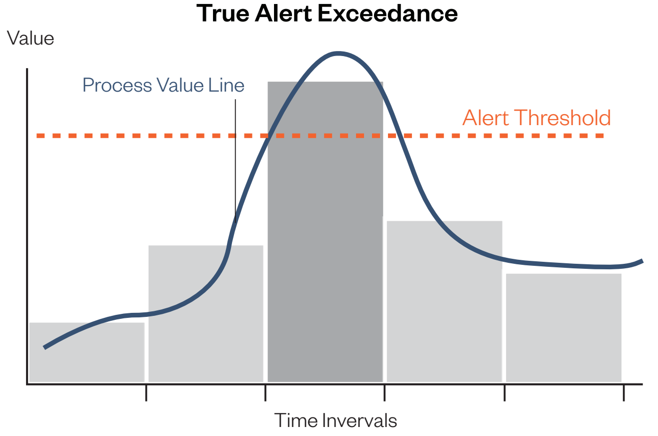
Operational interface protocols should provide detail on the water quality and monitoring requirements for upstream and downstream entities, such as wastewater and drinking water treatment plants, as well as collection and distribution systems. Historically, recycled water plants operate independently from upstream wastewater plants. In the DPR scenario, the protocol will detail cooperative operating procedures, communications protocols, data sharing, and other elements necessary to integrate multiple entities in the one DPR scheme. This requires DPR operators to understand essential elements of wastewater treatment, while focusing on finished water production and distribution system management.

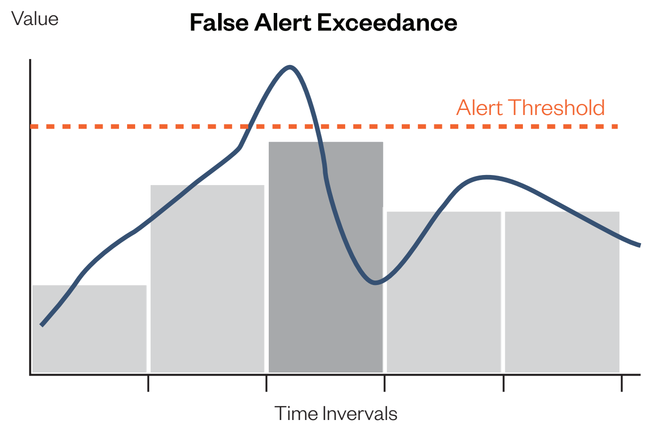
Operational **MONITORING**

The high level of automation in DPR facilities requires that information be strategically managed. Alarm flooding poses a significant risk, with the acute possibility of far too many alarms being generated, leading to overwhelmed operations teams overlooking important alarms. Development of effective and realistic performance monitoring, trending, and alarming is critical to anticipating performance risks and taking preventative action before a problem occurs. Dashboard reports are particularly useful for operations teams to clearly keep their eye focused on operational targets.

It's All About Timing

Several alarm types are available with strategically managed alarm thresholds. One example is a Block Average Alarm, depicted below. The alarm is set to the average value over a pre-determined time period, rather than a single input, within the alert period. In this example, the alarm notification (when Block Average exceeds Alert Threshold) would only occur for block 3 of the true example, since the Process Value average of the time block is above the alert threshold.





Operator **SKILLS + TRAINING**

Operator training should include risk management, understanding of regulations, CCPs, understanding of upstream and downstream interfaces, and sampling and analysis.

Relative to existing water and wastewater treatment systems, DPR operations teams are under much greater scrutiny for performance and must therefore have adequate training and certification processes in place to provide a framework for developing and evaluating the necessary skills for successful operation and management of water recycling systems.

Appropriately developed training and certification is critical to support this requirement. But certification programs can only develop a minimum standard for operations. Beyond this, each facility will require a thorough ongoing training program that is tailored to that facility and includes items such as:

- Demonstrated knowledge of operational response procedures, with appropriate testing and "fire drills."
- Detailed monitoring of operator competence, with demonstration of knowledge and experience in the field.
- Effective knowledge of performance monitoring and trending – making sure to anticipate performance and meet performance targets.
- Good understanding of regulatory and permit targets, with regular updates as these develop.

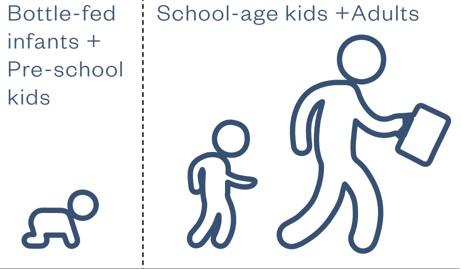
A **GROWING** CONCERN

Harmful algal blooms pose new concerns for water utilities nationwide.

Date of satellite image: March 21, 2012
Source: NASA

The wall poster on the following two pages can be used as a guide to develop algae monitoring and treatment. At hazenandsawyer.com, you can also access the Hazen-Adams Model that estimates the amount of cyanotoxins that will be removed during oxidation by ozone, permanganate, chlorine, chlorine dioxide, or chloramine.

Microcystins and Cylindrospermopsin EPA 10-day Health Advisory Levels
by age groups (Initial 10-day)



Bottle-fed infants + Pre-school kids	School-age kids + Adults	
0.3ppb	1.6ppb	Microcystins
0.7ppb	3.0ppb	Cylindrospermopsin

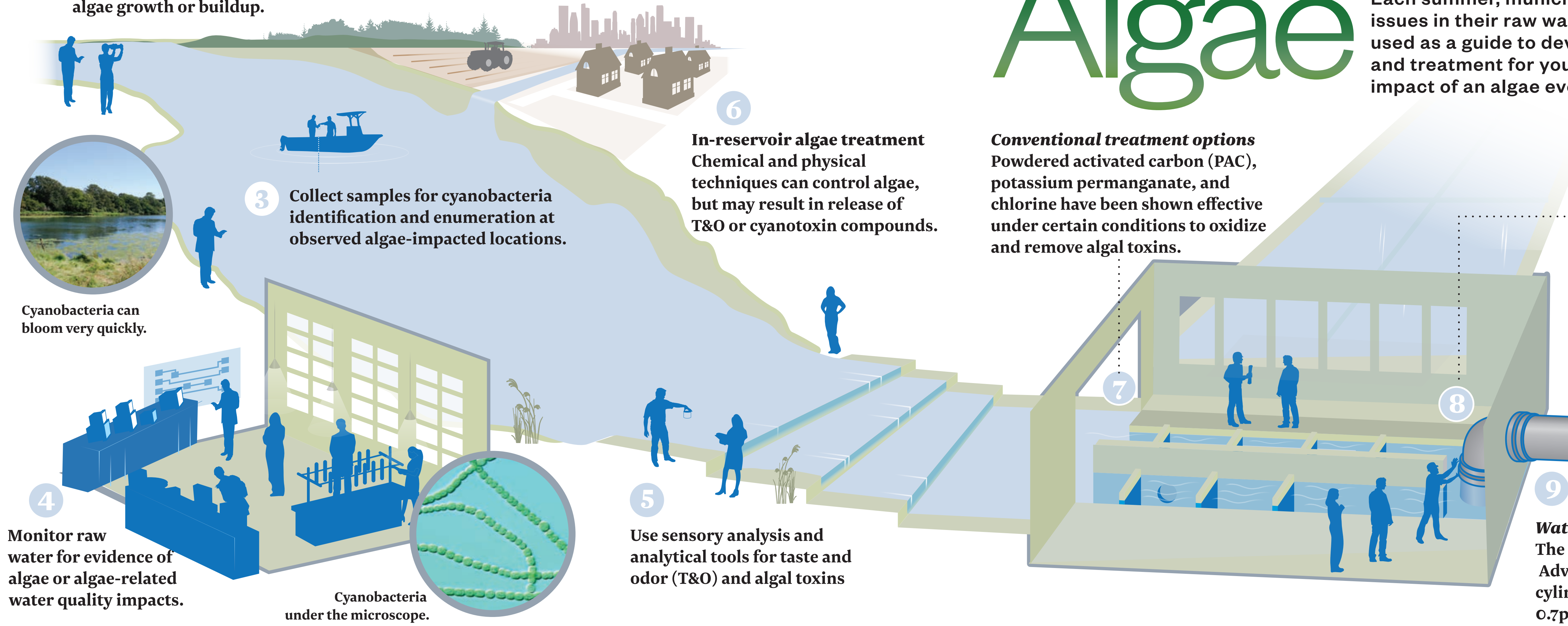
Despite efforts to control nutrients in surface waters, algal blooms in raw water supplies have increased in frequency and severity in recent years. Of particular concern are blooms of cyanobacteria, naturally occurring organisms similar to algae. These organisms can appear in fresh water and may rapidly multiply causing "blooms" under favorable conditions, which are most prevalent in the summer months. Conditions that enhance bloom formation and persistence include light intensity and duration, nutrient availability (such as nitrogen and phosphorus), water temperature, pH, and water column stability. Some blooms produce cyanotoxins such as microcystins, cylindrospermopsin, and anatoxin-a, which can be of health concern.

In August 2014, the City of Toledo reported elevated microcystin levels in their finished water. Even though microcystin was not regulated anywhere in the United States, residents were warned to not drink the water or use it to cook or brush their teeth for two days. The water emergency in Ohio's fourth-largest city put a spotlight on harmful algal blooms (HABs) in Lake Erie and throughout the country.

The seemingly ubiquitous and expanding nature of HABs in the United States, coupled with the well-publicized Toledo event, has raised the profile of the issue of algal toxins for water utilities. Consequently, the US EPA has reacted swiftly to the issue. In June 2015, the EPA announced 10-day Health Advisory Levels for several algal toxins. These Health Advisories are informal non-regulatory guidance for unregulated drinking water contaminants to assist federal, state, and local officials, and public water systems in protecting public health.

Algae
Alert & Action Plan

Each summer, municipalities are faced with algae-related issues in their raw water supplies. This wall poster can be used as a guide to develop preventative algae monitoring and treatment for your facility, as well as minimize the impact of an algae event.



1. Regular visual checks are performed to identify signs of algae growth or buildup.
2. Monitor for algae-favoring conditions (nutrients, water temperature, stratification).
3. Collect samples for cyanobacteria identification and enumeration at observed algae-impacted locations.
4. Monitor raw water for evidence of algae or algae-related water quality impacts.
5. Use sensory analysis and analytical tools for taste and odor (T&O) and algal toxins
6. In-reservoir algae treatment
   Chemical and physical techniques can control algae, but may result in release of T&O or cyanotoxin compounds.
7. *Conventional treatment options*
   Powdered activated carbon (PAC), potassium permanganate, and chlorine have been shown effective under certain conditions to oxidize and remove algal toxins.
8. *Advanced treatment options*
   Ozone, granular activated carbon (GAC) filtration, and UV advanced oxidation provide effective barriers to algal toxins. These high-energy and cost technologies represent significant investments for addressing intermittent water quality issues.
9. *Water Regulations*
   The EPA has released draft "10-day Health Advisory Levels" for total microcystin and cylindrospermopsin as low as 0.3ppb and 0.7ppb for children younger than school age.
10. Proactively prepare a public notification plan in case it is ever needed.

Cyanobacteria can bloom very quickly.

Cyanobacteria under the microscope.

ALERT LEVEL	LOW	MEDIUM	HIGH	VERY HIGH
Conditions	• Non-favorable algae growth conditions	• Favorable growth conditions • Potential presence of cyanobacteria • Potential for algae-related treatment challenges such as pH, DO swings, low level taste and odor (T&O) or toxins in raw water	• Confirmed cyanobacteria growth • Likely algae-related treatment challenges • Potential for algae-related toxins and T&O	• Confirmed cyanobacteria blooms • Confirmed presence of T&O or toxins in raw water
Monitoring Actions	• Regular visual inspection for algae • Monitoring of conditions • Weekly algae intake sample during growth season	• Bi-weekly to weekly visual inspections with cyanobacteria identification at observed impacted locations • Weekly review of raw water quality • Weekly odor sensory analysis of raw water • Daily algae intake sample	• Vigilant visual inspections and sampling at confirmed bloom location(s) • Daily review of raw water quality • Daily odor sensory analysis of raw and treated water • Weekly testing for T&O compounds and/or cyanotoxins in raw and treated water	• Continue daily visual inspection until algae eliminated • Daily review of raw water quality • Twice daily odor sensory analyses of raw and treated water • Daily testing for T&O compounds and/or cyanotoxins in raw and treated water
Response Actions	• Evidence of algae in reservoir or raw water = move to Medium Alert Level	• Evidence of cyanobacteria observed = move to High Alert Level • Prepare for control of observed algae/ cyanobacteria via targeted control methods • Prepare for in-plant treatment of T&O or cyanotoxins	• Evidence of odor or T&O/cyanotoxins in raw or treated water = move to Very High Alert level • Treat confirmed bloom location and consider whole-reservoir treatment • Prepare for in-plant treatment for T&O or cyanotoxins on standby or precautionary implementation	• Alert public as appropriate and advise about treatment strategies in place • If not already done, treat bloom or whole reservoir • Implement in-plant treatment of T&O or cyanotoxins
Step-up Triggers	• Favorable algae growth conditions • Evidence of cyano-bacteria in sampling	• Confirmed cyanobacteria growth (2000 - 5000 cells/mL) • Evidence of algae raw water quality impacts • Detection of algae-related odors in raw water	• Cyanobacteria bloom conditions (>10,000 - >50,000 cells/mL) • Detection of algae related T&O and/or toxins in raw and/or treated water	• Chemical algae control in-reservoir often results in T&O or cyanotoxin release into water column, so analysis of compounds should continue even after bloom controlled

SOURCES:

International Guidance Manual for the Management of Toxic Cyanobacteria, Global Water Research Coalition Water Quality Research Australia, 2009; "EPA Health Advisories for Cyanotoxins" Presented at the May 11, 2015 Cyanotoxins in Drinking Water Stakeholder Meeting

USEPA
Algal Toxins
Frequently **A**sked **Q**uestions

What is a Health Advisory?

Health advisories describe non-regulatory concentrations of drinking water contaminants at or below which adverse health effects are not anticipated to occur over specific exposure durations (e.g., one-day, 10-days, several years, and a lifetime). HAs are not legally enforceable federal standards and are subject to change as new information becomes available.

What are the health effects from exposure to cyanotoxins in drinking water?

Effects including gastroenteritis and liver and kidney damage have been reported in humans following acute or short-term exposure to high levels of cyanotoxins in drinking water. However, the Health Advisory levels for microcystins and cylindrospermopsin reflect concentrations in drinking water at which adverse health effects are not anticipated to occur over a 10-day exposure period.

Are immunocompromised individuals or infants fed by nursing mothers at risk?

Populations such as nursing mothers and pregnant women, the elderly, and immunocompromised individuals or those receiving dialysis treatment may be more susceptible than the general population to the health effects of microcystins. As a precautionary measure, immunocompromised individuals and nursing mothers may want to consider following the recommendations for bottle-fed infants and young children of pre-school age.

What about using water with elevated algal toxins for showering and other uses?

The Health Advisory values for microcystins and cylindrospermopsin are specifically for consumption of drinking water. Exposure to cyanobacteria and their toxins may also occur by ingestion of toxin-contaminated food, including consumption of fish, and by inhalation and skin contact during bathing or showering. While these types of exposures cannot be quantified at this time, they are assumed to contribute less to the total cyanotoxin exposures than ingestion of drinking water and EPA expects that it is unlikely that showering or bathing in water with cyanotoxin levels near or below the Health Advisory will present a health risk.

Where in the country are harmful algal blooms a problem?

Harmful algal blooms (HABs) are a national concern. HABs have impacted waters across many regions of the country. EPA recommends that drinking water systems in all areas of the country that use surface water sources, such as lakes and reservoirs, assess their water source's vulnerability to HABs. EPA estimates that lakes and reservoirs serving as sources of drinking water for between 30 and 48 million people may be periodically contaminated by algal toxins.

Adapted from "EPA 2015, Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water". For more recommendations and guidance from the EPA, visit http://www2.epa.gov/sites/production/files/2015-06/documents/cyanotoxin-management-drinking-water.pdf

Good from the First Drop

Teamwork and planning laid the groundwork for a new 18-mgd WRF to meet its permit on day one.

Water from the new WRF discharges into the Cape Fear River basin. Effluent from the plant was compliant with permit requirements from day one of operations.

The challenges of start-up can be nerve-wracking for operators and managers, particularly when the start-up requires immediate compliance with strict permit regulations. For the Western Wake Regional Water Reclamation Facility, the challenges were considerable, as start-up not only included the entire plant and conveyance systems, but it occurred during the summer when stricter nutrient removal permit requirements were in effect. By establishing a knowledgeable team with a start-up plan backed by process modeling, the plant came online efficiently with impressive results. On the very first day of discharge, the facility's effluent not only met monthly permit limits, it surpassed what are commonly accepted as the limits of conventional wastewater treatment technology.

Project Background

The population of Western Wake County (NC) has grown steadily, drawing increasingly from the Cape Fear River Basin for potable water supply, while discharging most of its treated wastewater to the adjacent Neuse River Basin. The Interbasin Transfer Certificate was renewed in 2001, but with the condition that water had to be returned to the Cape Fear River Basin. Studies determined that a new water reclamation facility and a significant amount of new infrastructure was required – including nine miles of influent pipeline, a new influent pump station, upgrades to an existing influent pump station and conveyance, an effluent pump station, and 11 miles of effluent pipeline. The Towns of Apex, Cary, and Morrisville, with the Town of Cary being the lead, form the Western Wake Partners and now manage the new facilities. Hazen and Sawyer was the design engineer for five of the eight design contracts, and provided program and construction management for all eight construction projects.

As construction proceeded, the Town of Cary began staffing the new plant several months before anticipated start-up. During this time, operations staff attended training sessions and became familiar with the plant. Concurrently, Hazen and Sawyer created a start-up plan that incorporated a Biowin™ model to identify operational recommendations for the system during start-up, predict initial nitrogen removal rates, and ensure that biological process and construction schedules were in sync.

*Limitations of Conventional Technology

Conventional technology can reliably achieve annual average effluent TN concentrations of 2.2 to 3 mg/L and TP concentrations of 0.03 to 0.08 mg/L, depending on influent characteristics and the treatment approach. One limitation of biological nutrient removal processes and conventional technology is that they are not physical barriers capable of removing all species of nitrogen and phosphorous. While microfiltration (MF) membranes are considered conventional technology, they are designed to remove particulate material only and do not remove ions such as ammonium, nitrate, nitrite, and orthophosphate. Advanced treatment technologies, such as MF followed by Reverse Osmosis (RO), are required to meet nutrient standards that are beyond the Limits of Conventional Technology (LOCT). The anticipated capital cost of adding MF + RO to a LOCT plant is approximately $10 to 15 per gallon with the design flow peaking factor being one of the most sensitive variables to price. The carbon footprint of the MF + RO process is also orders of magnitude greater than that of the LOCT plant.

Nutrient	Influent mg/L	Required monthly avg	Limits of Conventional Technology*	Effluent on day one
Nitrogen	30.4	5.0	2.2 – 3.0	2.02
Phosphorus	4.17	0.75	0.03 – 0.08	0.10

The Plan
Working closely together, the staffs of Hazen and Sawyer and the Town of Cary had a clear understanding of the anticipated start-up. Initial flows to the plant were expected to be very low (<1 mgd) so excess basin capacity was earmarked to hold flow until the biological nutrient removal process was operating efficiently to allow initial discharge within permit limits. Chemical feed systems were also available in the event that they were needed. Due to the variability inherent in construction schedules, the exact date of start-up could not be defined. Therefore, it was necessary to plan to meet permit limits right from the start of operations.

During the testing phase of the project, Hazen and Sawyer and facility personnel worked side-by-side. This established a cohesive team with a keen understanding of plant functionality and a marked ownership of the plant before the first flow arrived.

Seeding and Batch Testing
Establishing a healthy biological population is one of the most crucial elements to successful start-up of a new WRF. Timing the growth of that population so that the process would provide adequate treatment upon the start of flow required seeding with solids from another plant more than 10 miles away.

Batch testing was conducted concurrently with the seeding process (July 21-25, 2014) to compare actual nitrification with expected performance, quantify the degradation of the seeded bacteria, and confirm that seeding needs were being adequately met. This testing showed acceptable nitrification rates on July 22nd and July 25th. Though flow to the plant began on the 28th, it took a few days for clean water to be flushed out of the system, due to the significant length of the influent pipeline. This starved the microorganisms and resulted in a decline in nitrification rate, which was confirmed with additional batch testing on July 29th. An additional solids seeding was performed on July 30th, which successfully restored the target nitrification rate. The results of this second seeding enabled the cancellation of a planned third seeding, saving time and money.

Operational Flexibility
The initial, intermittent flow of 0.75 mgd to the 18-mgd facility - including periods of up to five hours with no flow at all - created challenges. Low alkalinity was identified as a concern during the basin

The flow of water from the influent pipeline, through the plant (which includes eight biological reactor basins, eight filters, and UV disinfection), and into the effluent pump station.

profile and a caustic feed drip was set up into the first cell. Due to the initial low intermittent flow, the caustic was not pushed through the system fast enough and pH levels in the first few cells got too high. The caustic feed was stopped and recycle flow was increased to distribute the caustic through all the cells in the basin. This successfully lowered the pH back down to an acceptable level between 7 and 8 in all cells and got nitrification efforts back on track.

During no-flow periods, dissolved oxygen (DO) control also presented a significant challenge. When the microorganisms in the online basin consumed all the available ammonia, the demand for oxygen sharply decreased, resulting in a spike in DO levels in the basin. By diverting air to the basins holding both clean water from testing plus the initial treated wastewater, easier modulation of airflow to the online basin was achieved, thus reducing severe oscillations in DO.

The intermittent influent flow also caused challenges establishing denitrification. Initially, full aeration was employed to maximize nitrification time. Nutrient profile sampling revealed that ammonia was consumed by the halfway point of the aerated volume, so the focus shifted to denitrification. Supplemental carbon was dosed to provide a food source in the pre-anoxic and post-anoxic zones to encourage the denitrification process. Further, the final re-aeration cell was run anoxically to provide a larger postanoxic zone and the coarse air bubble diffusers in the basin effluent channel were enough to bring DO back up before entering the clarifier.

Lessons Learned
The challenges of start-up were made significantly easier to address thanks to the extraordinary collaboration and cooperation amongst all parties. The Town's staff, hired and trained well in advance of facility completion, had a deep understanding of the facilities, and their involvement in equipment testing and input on start-up contributed greatly to the project success. Process modeling outlined an initial start-up strategy, and bench testing and nutrient profile sampling verified the process model and identified areas of focus. Options in the plan allowed the team to quickly resolve issues and make efficient process adjustments. Each of these elements played a key role in getting the plant to surpass the strict summer monthly average permit limits on day one and far into the future.

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