Hazen

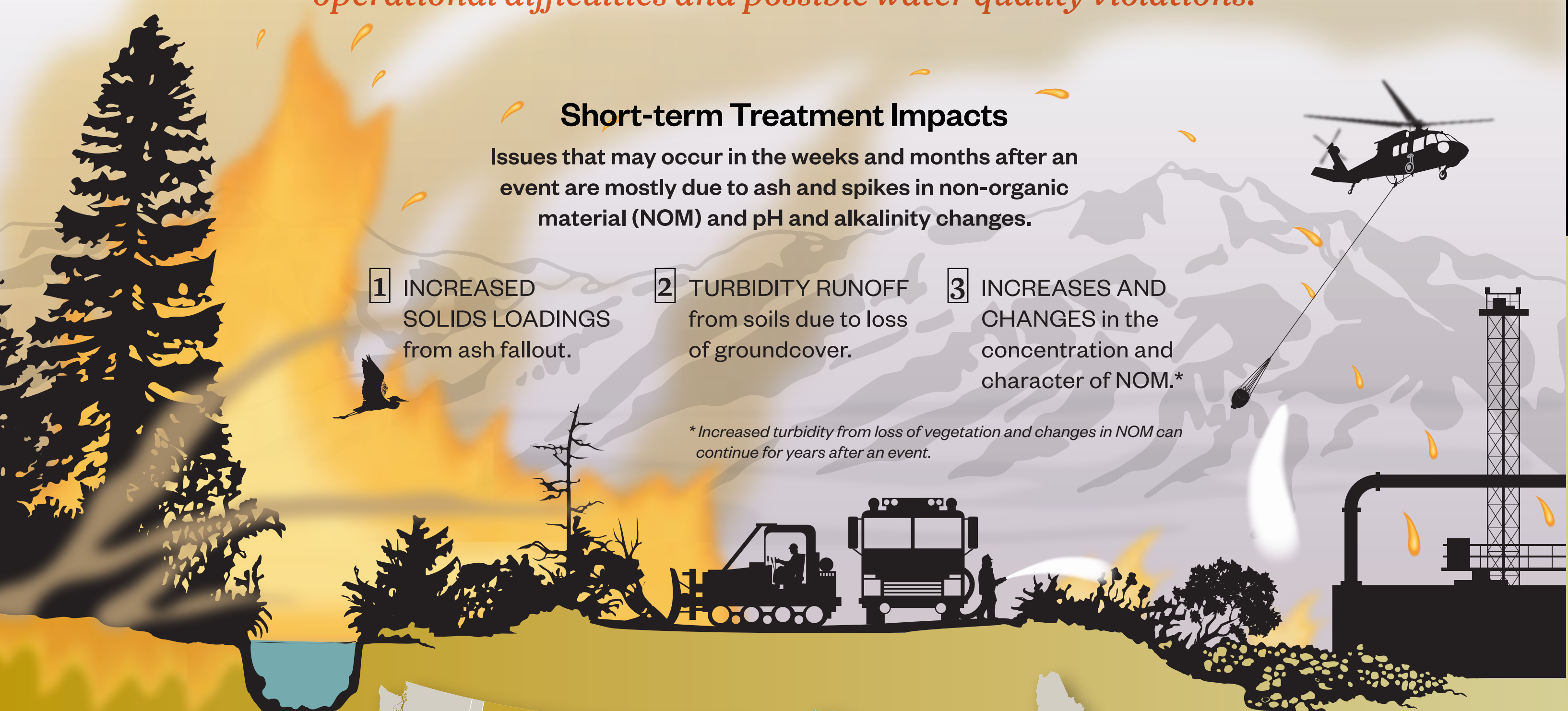
HORIZONS

water environment solutions

WINTER 2020

Impact of Wildfires on Treatment Plant Operations and Design

As the effects of climate change and population growth are felt worldwide, utilities are under pressure to prepare for the stress on water resources and drinking water supplies. Fires, floods, droughts, and tropical storms have caused treatment plants to either shut down, reduce flow, or deliver inferior quality water that failed to meet regulations. As the frequency of extreme weather events is expected to increase, many water utilities are at risk of operational difficulties and possible water quality violations.

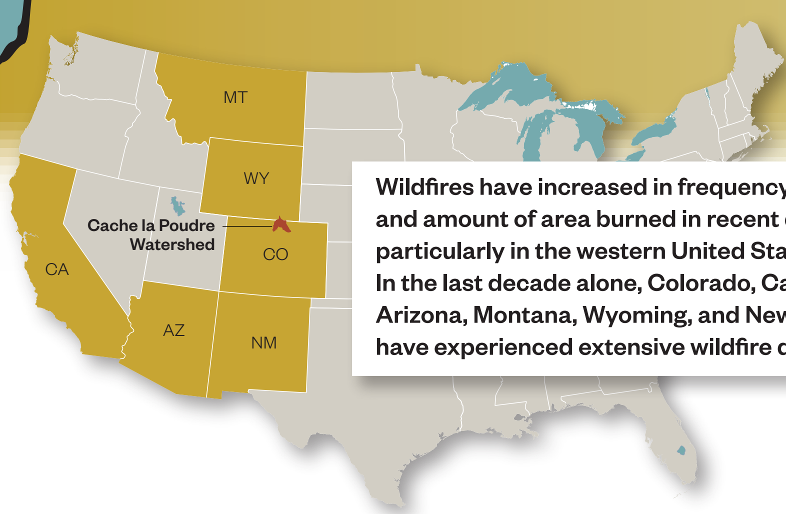


Short-term Treatment Impacts

Issues that may occur in the weeks and months after an event are mostly due to ash and spikes in non-organic material (NOM) and pH and alkalinity changes.

1. INCREASED SOLIDS LOADINGS from ash fallout.
2. TURBIDITY RUNOFF from soils due to loss of groundcover.
3. INCREASES AND CHANGES in the concentration and character of NOM.*

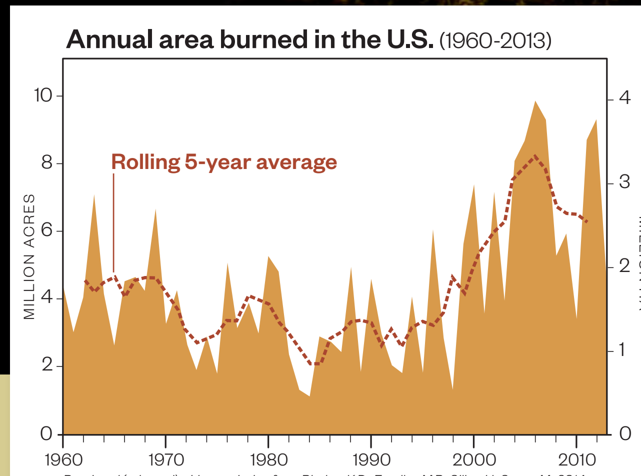
* *Increased turbidity from loss of vegetation and changes in NOM can continue for years after an event.*



Wildfires have increased in frequency, duration, and amount of area burned in recent decades, particularly in the western United States. In the last decade alone, Colorado, California, Arizona, Montana, Wyoming, and New Mexico have experienced extensive wildfire damage.

In 2012, the High Park Fire burned large sections of the Cache la Poudre Watershed—the main drinking water source for three northern Colorado communities—forcing the City of Fort Collins to shut down its water intake along the CLP River and rely on alternate water supplies for 100 consecutive days.

HIGH PARK FIRE PHOTO BY: SGT. JECCA GEFFRE/U.S. ARMY



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Utilities can better manage risk, resiliency, and emergency preparedness by both understanding the effects of wildfires on drinking water treatment and design changes that can be undertaken to mitigate them.

Wildfire's Wide-Ranging Effects on Drinking Water

Extreme droughts, higher temperatures, earlier snowmelt, and changes in precipitation patterns can all contribute to the likelihood of wildfires. Wildfires affect water quantity, water availability, water quality, and can significantly impact a utility's ability to effectively treat wildfire-impacted source water.

Forested watersheds serve as high-quality drinking water sources for many communities—making water quantity and quality inextricably linked to forest soil properties. Wildfire changes to those soils are critical to understanding watershed effects of fire.

In a 2018 WRF study, researchers at the University of Colorado at Boulder, with Hazen's Dr. William Becker, simulated post-fire runoff by collecting soil and litter samples from the watersheds serving four different utilities throughout the United States. The samples were air dried and heated at a temperature of 225°C, representing a medium temperature wildfire, and then leached into water. Evaluations of the water determined that litter tended to release more dissolved organic matter (DOM) following heating compared to soils, including an increase in sulfate, phosphate, iron, and manganese.

Although DOM is common and naturally occurring, in excess it can react with disinfectants to form disinfection byproducts (DBPs). The evaluation revealed the possibility of DBP maximum containment levels being exceeded, and exposure to DBP has been linked to cancer risks and reproductive developmental effects. Results of the evaluation also indicated that after a wildfire leachate will likely have a resistance to coagulation and require higher coagulant doses. These factors all have serious implications for operations and residual handling when treating water after a wildfire.

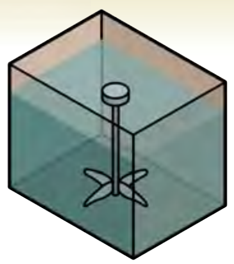
IMPACTS *of* WILDFIRES On Conventional Water Treatment Unit Processes

Each unit process in a water treatment plant is dependent on the upstream processes ability to perform properly. Poor influent water quality after a wildfire can cause cascading effects throughout a conventional treatment train, and in severe cases poor water quality can force plants to shut down completely.

Planning for the Future

With the increase in extreme weather events, planning for future water-related vulnerabilities is more important than ever before and is a requirement of the new America's Water Infrastructure Act. **The concepts and recommendations presented here can apply to any utility anticipating any type of extreme weather events that increase source water turbidity, NOM, or nutrient loadings.** Utilities under the threat of wildfires should consider the treatment implications specific to their watersheds.

COAGULATION

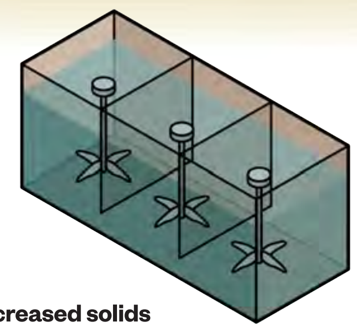


All downstream processes rely on proper coagulation. Improper dosage of coagulant can result in poor flocculation, high settled water turbidity, high filtered water turbidity, and inadequate disinfection due to pathogen shielding. With wildfire leachate resistant to coagulation and requiring higher coagulant doses, in extreme erosion conditions coagulation alone may not be effective for meeting turbidity and TOC removal requirements.

Develop operational protocols and train utility staff to conduct on-site jar tests to respond to increased turbidity and NOM during extreme weather events. Post-fire increases in raw water NOM concentrations will almost always require an increase in coagulant dose, leading to increased particulate loading that may require adaptation to downstream processes. Streaming current monitors or zeta potential analyzers can also be installed to help determine optimum coagulant doses.

Wildfires can also impact raw water pH and alkalinity, affecting coagulation—chemical feed systems can be installed to adjust pH or add alkalinity. When using chemical feed systems or chemical storage, ensure that that they can deliver the higher doses that may be needed after a wildfire. Polymer feed facilities may also be needed to treat high ash content.

FLOCCULATION

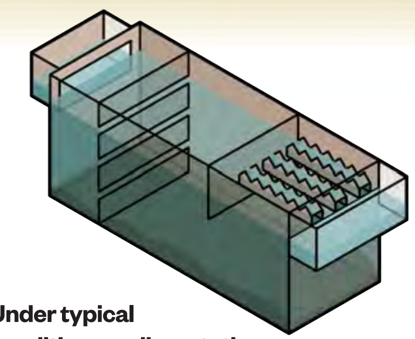


Increased solids loading to a filtration plant will not impact the design or operation of the flocculation process—with more particles, the flocculation process may even improve. But if the raw water turbidity increases dramatically, heavier particles may settle out in the flocculation basin, requiring more frequent periodic removal.

Flocculation (or slow mixing) promotes particle growth through particle on particle contact. In a conventional treatment plant, flocculation creates "settleable" floc that can be readily removed in a sedimentation basin. Changes in the concentration and character of NOM may also result in changes to floc formation.

This can be addressed by installing a means of removing silt settled at the bottom of the floc tanks and creating a plan to handle additional loads during high turbidity events. Train staff to monitor and adjust the mixing speed to prevent floc shear.

SEDIMENTATION

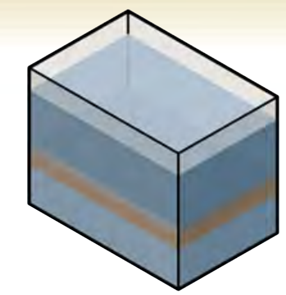


Under typical conditions sedimentation basins sufficiently remove nearly all applied turbidity. Conventional sedimentation basins can adequately treat raw waters with turbidity up to 100 NTU, while DAF and adsorption clarifiers are limited to 10 NTU. If after a wildfire raw water turbidity is consistently above a clarification processes normal upper limit—for both conventional sedimentation and high-rate clarification—a pre-sedimentation basin should be installed. The basin should be able to be bypassed during normal conditions.

If large conventional sedimentation basins are not practical, plate settlers can also be used. In areas where high turbidity will not likely reach the intake, consider dissolved air flotation to address algal bloom concerns.

Elevated turbidity or changes in NOM will also mean an increase in coagulant dose which will further increase the solids load. This can result in thousands of pounds per day of additional solids that must be removed, collected, processed, and disposed. An automated sludge removal system in the basins can be used to enhance solids removal.

FILTRATION

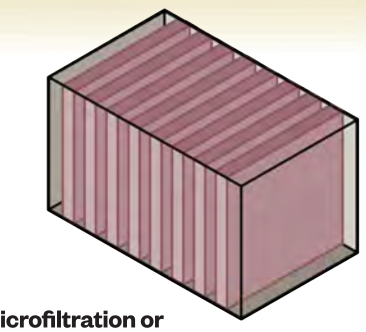


As the final particle removal process in drinking water treatment plants, granular media filters depend on effective coagulation to create particles large enough to be removed. Particles not removed earlier in the process by sedimentation enter the filters. As particles are removed in a granular media filter, head loss accumulates and eventually the filter must be backwashed. If the time between backwashes is too short, then the plant cannot produce enough water to meet demands and more waste backwash water may be produced than can be handled.

If coagulant doses are not increased enough to address an uptick of NOM after a wildfire, higher water turbidity would cause higher filter head loss, shorter filter runs and more frequent backwashes and waste backwash water. Utilities should consider having enough backwash water and waste backwash storage so that multiple filters can be backwashed simultaneously.

Inadequate coagulant dose can also lead to poorer particle removal in filters and higher finished water turbidity. Larger media filters with deeper beds can increase solids storage, and inspections should be conducted frequently to ensure the filters are in good condition. Inside the filters, granular activated carbon can be used instead of anthracite to help with taste and odor.

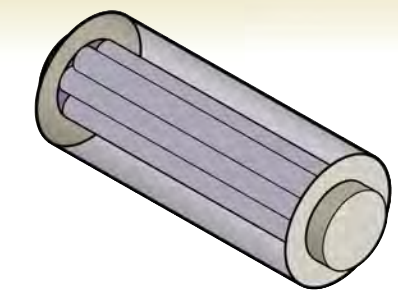
MEMBRANES



Microfiltration or ultrafiltration membranes, where particles are removed by straining, are a common alternative to granular media filters. Although finished water quality is not normally affected by changes in raw water quality, increased NOM can affect the rate of membrane fouling. When membranes become fouled, they need to be chemically cleaned.

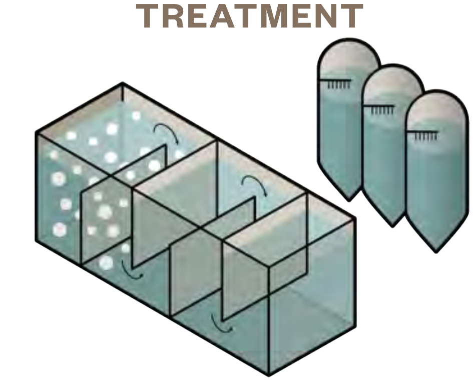
Water quality changes following fires can overwhelm and cause excessive fouling in membrane water treatment plants, especially when sedimentation is not practiced. Membrane-based treatment should not be used in areas where raw water will be subject to firefighting foams and other substances that could foul membranes. For those already using membranes, adding powdered activated carbon can help adsorb firefighting foams before they reach the membranes.

DISINFECTION



Higher levels of NOM can lead to exceeding DBP maximum containment levels. To prevent DBP compliance issues, maximize removal of NOM pre-disinfection or use alternative disinfectants like UV or ozone.

ADVANCED TREATMENT



After a fire, smoky tastes and odors can permeate water. Nutrient release from wildfires could also result in long-term eutrophication and increased algal growth in downstream reservoirs, leading to additional taste and odor issues and algal toxins. Installing powdered activated carbon, post-filter GAC contactors, or ozone/biofiltration can address these issues.

For more information on impacts of wildfires on water treatment processes contact:
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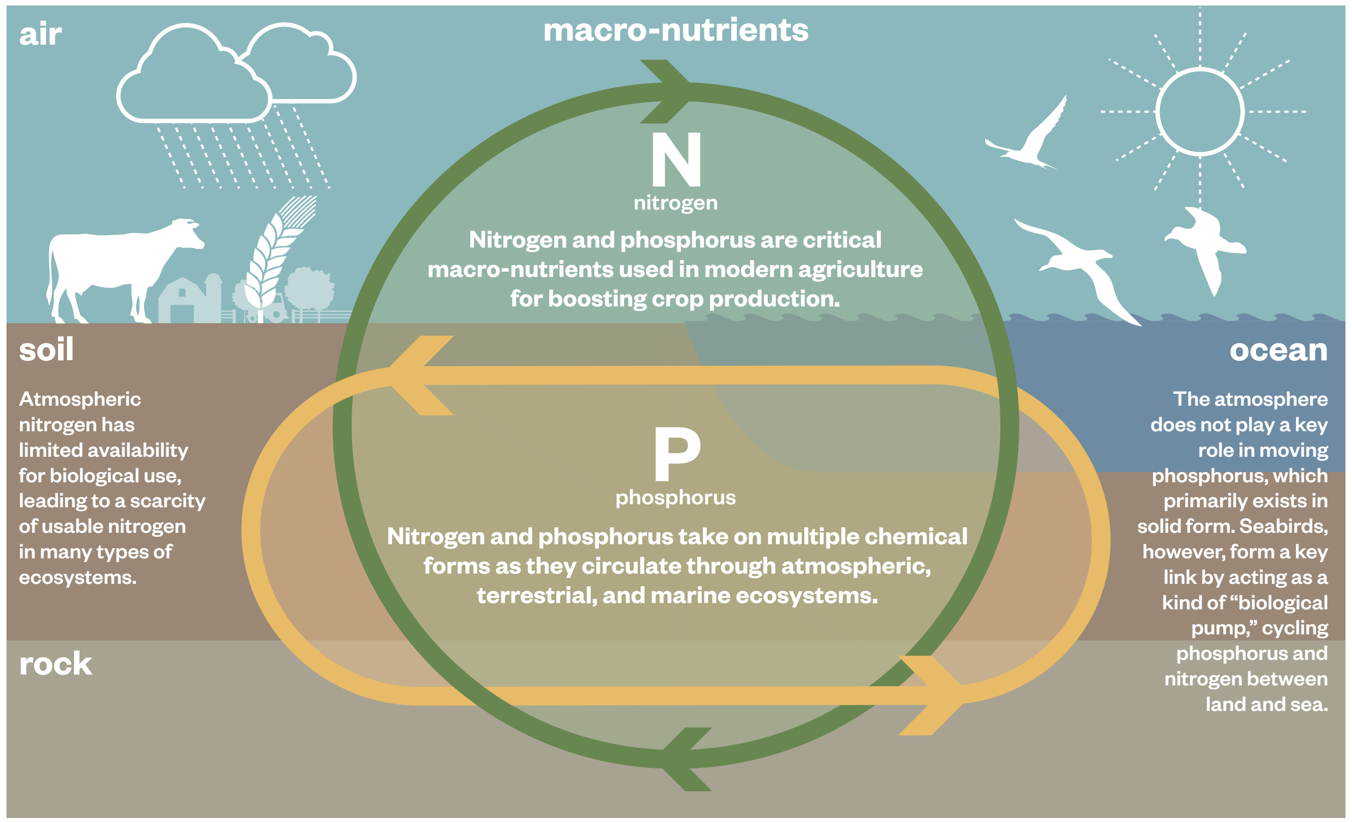
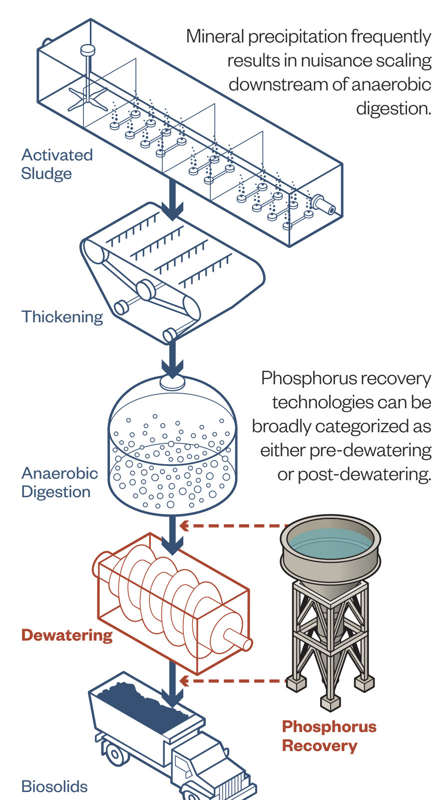
Realizing the Benefits of Nutrient Recovery at WRRFs



Every day across the country, significant masses of nitrogen and phosphorous are discharged to water resource recovery facilities (WRRFs). WRRFs use biological or physio-chemical means to remove nutrients from wastewater, which generates solids enriched with nutrients. These solids can be stabilized before being beneficially reused as fertilizer or disposed.

During anaerobic digestion, organic material is broken down to produce a bulk solution with high concentrations of ammonia (NH_3), phosphorous (P), magnesium (Mg), calcium, iron, hydrogen, and potassium, among other compounds. High concentrations of these compounds combined with high pH and temperatures can stimulate precipitation of minerals in the digested sludge matrix. Many of these minerals have a high specific gravity and can precipitate within digestion and dewatering facilities.



Mitigating Nuisance Struvite Formation

One of the most common precipitates formed in WRRFs using biological phosphorus removal (Bio-P) and anaerobic digestion is struvite (magnesium ammonium phosphate). Left unchecked, struvite precipitate can plug pipes and affect downstream processes. Nuisance struvite formation can be mitigated using a combination of multiple strategies.

1. Removal after precipitate formation
2. Chemical addition to prevent precipitate formation
3. Process changes to minimize precipitate formation
4. Resource recovery to harvest struvite


Struvite clogging a pipe.

Struvite crystal magnified 35x. (left). Struvite removed from pipe (below).

Nutrient Recovery Benefits

Implementing nutrient recovery can help utilities reduce costs associated with treatment while also allowing for the reuse of valuable resources within the agricultural sector as slow-release fertilizers.


Fertilizer pellets produced through post-dewatering technology.

PHOTO COURTESY OF OSTARA

- *Reduce operating costs by offsetting aeration, supplemental carbon, and metal salt coagulant (where applicable).*
- *Reduce sludge and biosolids production.*
- *Reduce nuisance precipitate scaling.*
- *Reduce the impact of sidestream nutrient loads on the mainstream biological process and increase reliability of meeting effluent nutrient limits.*
- *Regain tank, pipeline, and pump capacity by reducing scaling.*
- *Improve sludge dewaterability, reducing dewatering polymer demand and increasing the cake dryness.*
- *Offset operating costs by selling the recovered product.*
- *Alter the phosphorus and nitrogen content of the biosolids product to one that is more favorable in regions with land application limitations due to P-indexing.*

Nutrient Recovery Technologies

Phosphorus recovery technologies can be broadly categorized as either pre-dewatering recovery or post-dewatering recovery.

Struvite can be harvested from either system or it can be sequestered in biosolids and removed from the plant.

There are multiple commercially available options for phosphorus recovery in the United States. These technologies vary in reactor type, efficiency, and product formed, but the principle behind each are similar. In each system, struvite is precipitated in a dedicated reactor where the pH, conductivity, temperature, and chemical feed (e.g., magnesium, caustic) is used to stimulate supersaturated conditions that will promote precipitation. Although specific reactor configurations and control strategies vary among the different technologies, all can remove 80-90% of soluble phosphate and 10-30% of soluble ammonia.

Commercial companies offer a variety of options for purchasing recovered struvite, including buy-back of struvite and third-party purchasing.

Post-Dewatering | Gwinnett County Department of Water Resources F. Wayne Hill Water Resources Center

The F. Wayne Hill Water Resources Center (FWHWRC) is an advanced wastewater treatment facility with a capacity of 60 mgd. To address struvite issues and decrease the impacts of phosphorus recycle loads on the main liquid stream, while simultaneously recovering a sustainable fertilizer, Gwinnett County selected the OSTARA Pearl® nutrient recovery process coupled with WASSTRIP®.

The nutrient recovery system includes a WASSTRIP® tank, two nutrient recovery reactors, centrate and filtrate storage tanks, transfer pumps, a fertilizer product handling system, and chemical feed systems. The WASSTRIP® process consists of a holding tank where primary sludge and WAS react anaerobically for 3–6 hours. The combined sludge is then thickened by rotary drum thickeners and the filtrate that is rich in phosphorous and magnesium is fed to the two recovery reactors. Each reactor has a nominal capacity of 4,400 pounds of struvite production per day.

The additional benefits of nutrient recovery at the FWHWRC include:

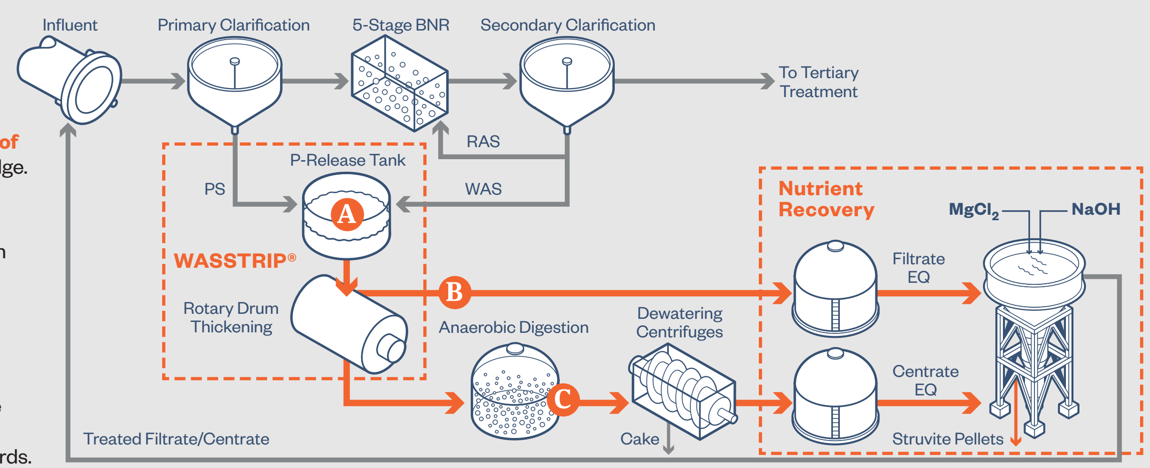
- *Reduced alum addition for struvite control by 75%*
- *Increased thickened solids 2% and dewatered solids 1.5%*
- *Decreased dewatering polymer by 7 active lb/DT*

FWHWRC PROCESS

A **WASSTRIP®** Anaerobic **release of P and Mg** from sludge.

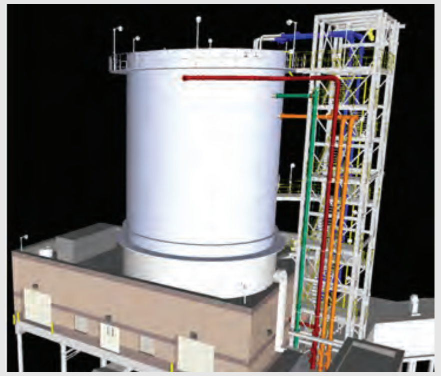
B **Send P and Mg** rich filtrate to recovery.

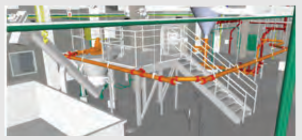
C **Lower P and Mg** content of sludge minimizes nuisance struvite formation from digester onwards.



Pre-Dewatering | Metro Wastewater Reclamation District Robert W Hite Treatment Facility

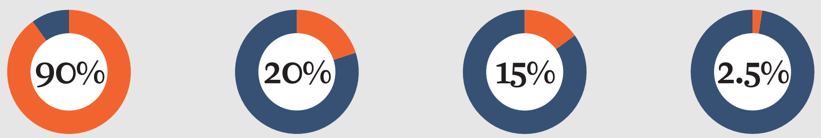
The Robert W Hite Treatment Facility (RWHTF) in Colorado is rated for 220 mgd and operates a Bio-P process. To manage nuisance struvite, ferric chloride is continuously dosed, pipelines are periodically pressure jetted, and two digesters are cleaned each year. The District evaluated pre- and post-dewatering recovery alternatives. Based on a comprehensive evaluation, the District decided to construct a pre-dewatering phosphorus recovery facility (PRF). The PRF measures 70 ft x 66 ft, which demonstrates that phosphorus recovery does not need to be a space intensive process. The reactor has an effective volume of approximately 378,000 gallons to provide a 7-10 hour hydraulic retention time to maximize struvite formation and recovery.





RWHTF Phosphorus Recovery Facility design.

The design team coordinated with the District and CNP AirPrex™ to perform pilot testing and use testing results to establish full-scale performance criteria. The PRF project is scheduled to be completed in August 2020, with the following benefits:



90%	20%	15%	2.5%
PO_4-P reduction via sequestration as struvite	Recovery of struvite	Reduction in dewatering polymer addition	Increase in cake total solids

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RESERVOIR MANAGEMENT

Combating Algae Growth and Increased Nutrient Loadings in Water Supply Reservoirs

Water supply reservoirs are a vital component of our nation's water supply systems, providing storage during droughts and improving resiliency. Off stream reservoirs can also provide improvement in raw water quality through settling of suspended solids and organic matter before treatment. Recently, many reservoirs across the country have been experiencing significant water quality problems due to increased nutrient loadings and associated changes in algae production.

The most recent U.S. Environmental Protection Agency (EPA) national lakes assessment found that of the most disturbed lakes around the country, 40.5% were disturbed due to phosphorus and 34.5% for nitrogen loading. This trend has continued over the last 5 years, with water utilities encountering issues treating reservoir raw water due to elevated algae levels that produce geosmin and MIB compounds, causing taste and odor problems in drinking water.

PHOTO BY DAVID ZAPOTOSKY/ TOLEDO WATER

The EPA has recognized the potential for impacts on human health associated with the cyanotoxins *(Cylindrospermopsin and Microcystin)* that are produced by some species of blue-green algae *(cyanobacteria)* and have developed health advisory concentrations for drinking water. As a result, water utilities are having to focus more attention on actively monitoring and managing their water supply reservoirs to minimize growth of these nuisances associated with blue-green algae.

Some species of cyanobacteria produce toxins that affect animals and humans. The most frequent and serious health effects are caused by drinking water containing the toxins or by ingestion during recreational water contact like swimming.

STRATIFICATION AND RESERVOIR MANAGEMENT

Water Layers & Algae Growth

In reservoir management, there are multiple approaches for oxygenation/aeration, with the most common being a free bubble plume with either a linear or circular diffusion. There are two general categories, with different objectives: hypolimnetic, which leaves the stratification intact; and destratification by mixing. Stratification isolates three environments—epilimnion, metalimnion, and hypolimnion—each with distinct characteristics.

T Temperature | N Nutrients | O Dissolved Oxygen (DO)

Normal

Epilimnion

Highest ↕ Lowest

T N O

When stratified, the epilimnion is a nutrient competitive environment, lending an advantage to buoyant-regulating cyanobacteria.

Metalimnion

Highest ↕ Lowest

T N O

Such cyanobacteria can drop down in the water column to utilize nutrients from the metalimnion or upper portion of the hypolimnion when nutrients are limited in the epilimnion.

Hypolimnion

Highest ↕ Lowest

T N O

* Possibly anoxic

This physiological advantage is ideal as it allows cyanobacteria to remain in a position in the water column where there is more light and higher temperature, both of which are ideal for growth.

Hypolimnetic Oxygenation System

Mixing, or destratification, is meant to disrupt that buoyant-regulating cyanobacteria and suppress growth—but buoyant-regulating cyanobacteria are not the only subset of primary producers (organisms like algae or phytoplankton that convert light into energy) that are of concern or warrant management.

PHOTIC ZONE

Mixing will not mitigate algae and cyanobacteria related issues, but it will change the appearance of the phytoplankton community.

Stressors such as mixing cause the phytoplankton community—largely buoyant-regulating cyanobacteria—to adapt to changing conditions and shift to an attached growth community, which typically synthesizes more geosmin and MIB.

Some buoyant-regulating cyanobacteria, like *Cylindrospermopsis,* even thrive with mixing and circulation. By mixing the water column more nutrients are put into the photic zone, especially problematic as mixing does not directly suppress growth. Mixing the water column also increases the temperature and oxygen demand in the hypolimnion, disrupting the fish population.

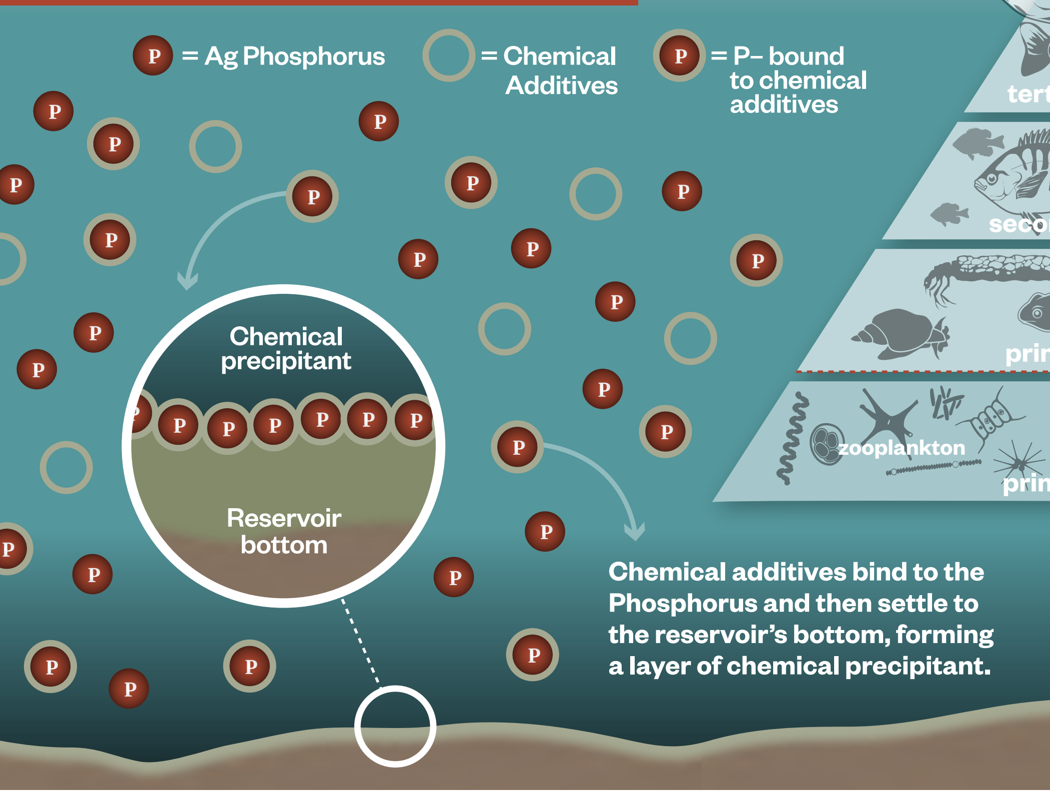
Oxygenation & Destratification

Another important aspect of destratification is the dilution factor that impacts the data attempting to assess population density of phytoplankton and the perceived benefit.

The phytoplankton community is normally concentrated in the photic zone, the surface layer of a lake where light penetration is optimal for phytoplankton growth.

Implementing hypolimnetic oxygenation can raise the barrier between the hypolimnion and metalimnion to ensure the water intake is in the oxic zone to significantly limit the iron and manganese that comes into the treatment plant. The precipitation of iron and manganese is governed by abiotic parameters, chiefly dissolved oxygen. Therefore, the optimal implementation for an oxygenation system, especially given the capital and OM costs, is to place a system at the water intake and maintain oxygen saturation.

Chemical Feed Stations



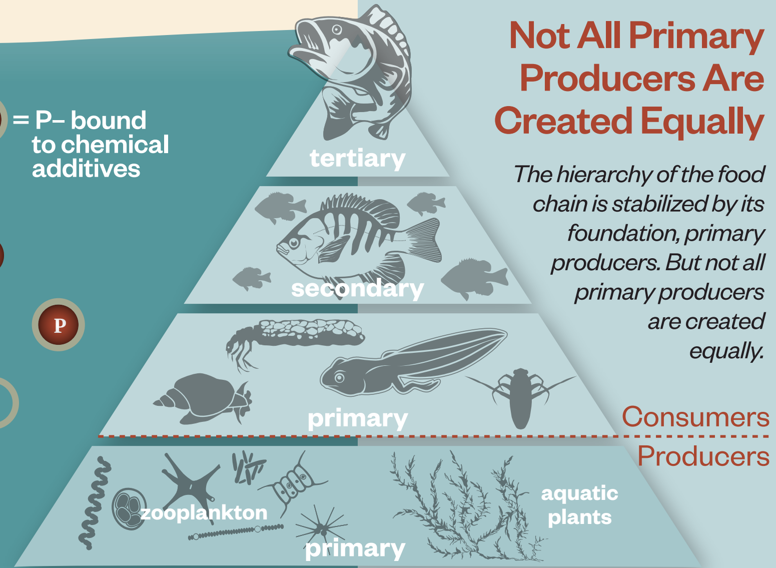
Typically, chemical feed stations are coupled with destratification and aeration/oxygenation to help further limit nutrient cycling. Chemical feed stations attempt to suppress cyanobacteria and algae growth by inactivating additional nutrients put into the photic zone by mixing, but this does not directly suppress cyanobacteria or algae. It further ensures cyanobacteria dominance, as they are more competitive organisms than eukaryotic algae and can capitalize on briefly lived, pulse inputs of common macronutrients.

The settled floc in a chemical feed station also drastically changes the biological community that resides at the sediment-water interface. The biological community adapts to the change in substrate and uses the settled floc in its metabolic processes. Research confirms phosphate solubilizing bacteria (PSB) liberates phosphate from insoluble aluminum phosphate. Current management plans that recommend chemical feed stations do not account for these changes.

Additionally, the chemical feed stations are placed just upstream of intense mixing to create a vortex, which destratifies the water column and the surrounding area. This increases temperatures in the hypolimnion, where the settled floc would reside. This is also important because ideal pH for alum treatment is between 6 and 7, and the addition of the coagulant itself reduces the population. Understanding physical and bio-chemical weathering of sediments (and minerals) and microbiology is imperative for proper source water management with minimal impact on the ecosystem.

Not All Primary Producers Are Created Equally

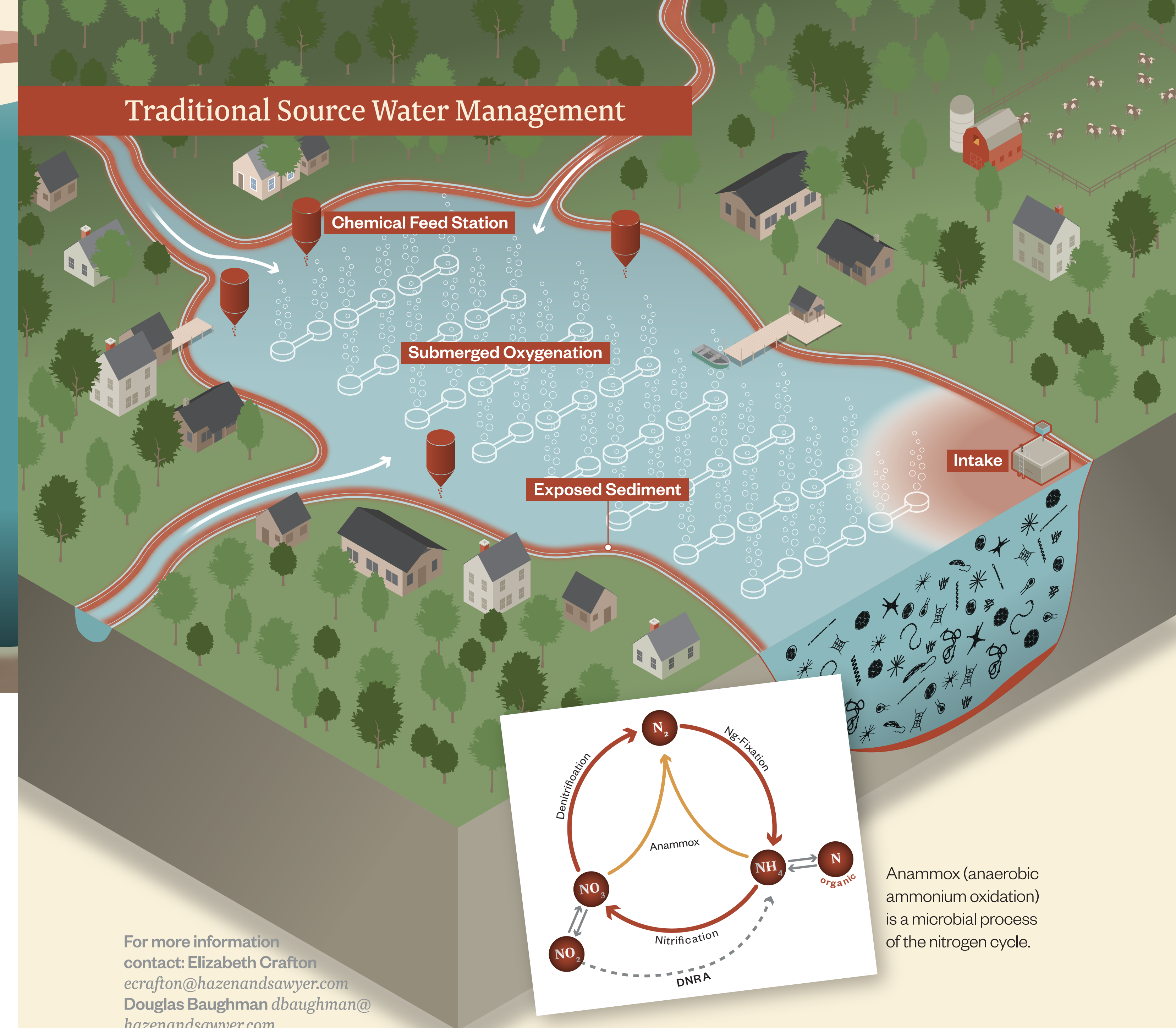
The hierarchy of the food chain is stabilized by its foundation, primary producers. But not all primary producers are created equally.



CYANOBACTERIA are not an ideal food source, so when they govern the primary producer population the rest of the food chain is unsteady. If the primary producer population is not as nutritional, then the primary consumers (zooplankton, insects, crayfish, freshwater mussels, tadpoles, and any other organisms that eat phytoplankton) are reduced. With the reduction in primary consumers, the secondary and tertiary consumer populations are unstable. When the food chain is unstable and imbalanced, nutrient cycling within the system is disrupted.

In an ideal system, much of the primary producers are grazed upon and nutrients and energy flow up the food chain. However, when the primary producer population is dominated by cyanobacteria, which are not subjected by the same grazing pressure, then more biomass accumulates at the sediment-water interface in the form of decaying cyanobacteria biomass. This creates more 'work' for the decomposers (bacteria) and reintroduces common macronutrients into the system, in turn promoting more primary producer growth dominated by cyanobacteria—continuing the 'broken' cycle. Nutrients and energy should flow up the food chain and ultimately leave the source water system by tertiary consumers, ideally terrestrial carnivores—bears, river otters, great blue heron, or humans.

Traditional Source Water Management



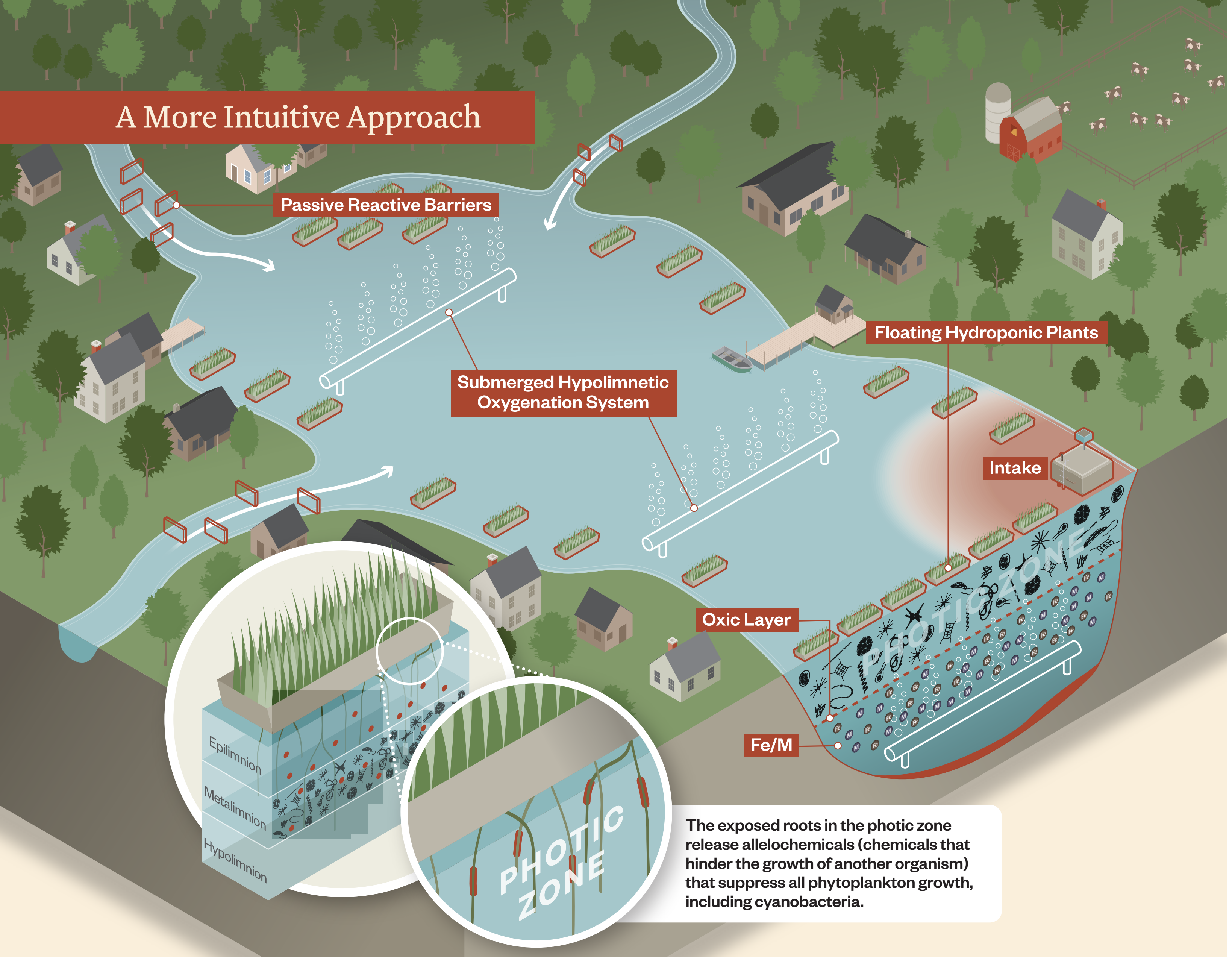
Anammox (anaerobic ammonium oxidation) is a microbial process of the nitrogen cycle.

For more information contact: Elizabeth Crafton *ecrafton@hazenandsawyer.com*
Douglas Baughman *dbaughman@hazenandsawyer.com*

Typical source water management consists of chemical feed stations and oxygenation/aeration with the intent of mixing and destratification. These management programs fail to restore the banks of the tributaries and the littoral zone of the source water, key factors needed to promote primary consumers and allow nutrients and energy to flow up the food chain and promote nutrient removal. The amount of oxygenation/aeration is usually excessive, and the aim is to promote aerobic respiration, which is only one segment of a metabolic pathway. This only accounts for one of the many metabolic pathways that are present at the sediment-water interface.

The intent is to promote the breakdown of decaying biomass from primary producers (typically cyano-bacteria) through aerobic respiration after glycolysis. This approach neglects numerous metabolic pathways and is especially inhibitory to the nitrogen cycle because there are key enzymes that cannot be synthesized in presence of oxygen. For example, anammox and fe-anammox, which promotes nitrogen losses from the internal cycles instead of conserving the nitrogen in the cycle as ammonia. It does not fix fundamental issues, but simply tries to work around them chemically and physically.

A More Intuitive Approach



The exposed roots in the photic zone release allelochemicals (chemicals that hinder the growth of another organism) that suppress all phytoplankton growth, including cyanobacteria.

Water supply reservoir water quality management is a complicated process driven by biological systems that are continually reacting to changes in physical and chemical conditions. Managing these systems requires an approach that recognizes these influences and facilitates proactive responses throughout the year. Management approaches should balance the benefit and impact of oxygenation and optimize the balance by strategic spatial implementation of restoration elements.

The ecosystem and habitats are reestablished to increase biodiversity and promote nutrient removal from internal overloaded cycles by promoting nutrient and energy migration up the food chain. It also optimizes nutrient removal from the photic zone with plants, which are more competitive with cyanobacteria than green algae.

This approach attempts to reestablish a balanced ecosystem by using natural purification processes that not only mitigate cyanobacteria related issues, but also increase overall water quality, especially with respect to emerging contaminants.

There will be times when conditions require more immediate measures for algae population reduction that involve algaecide application. Any use of algaecides must be focused on the key species of concern and prescriptions developed that are based on monitoring data to ensure effective algae reduction while protecting the aquatic resources in the reservoir. These approaches are long-term measures to effectively manage water supply water quality that can and should be coupled with a broad strategy for monitoring and watershed management for reduction of overall nutrient loadings.

Addressing Increasing TDS & nbDON at Water Resource Reclamation Facilities

Water conservation , expanding use of alternative source waters, and four prevalent factors shown at right, are driving increased concentrations of total dissolved solids (TDS) and non-biologically available dissolved organic nitrogen (nbDON) in wastewater.

Elevated TDS and nbDON concentrations can complicate permit compliance and ultimately limit the end use of effluent and biosolids, as well as damage infrastructure and impair the performance of many treatment process elements.

Understanding the strategies available to control the concentrations of TDS and nbDON in a wastewater resource reclamation facility (WRRF) collection and treatment system can minimize adverse impacts while avoiding the need for advanced removal technologies.

TDS Is a bulk water quality parameter that reflects the total concentration of organic and inorganic suspended solids dissolved in water passing through a 2 micron (μm) filter. In municipal water and wastewater, the primary components of TDS are sulfate, magnesium, potassium, sodium, chloride, calcium and bicarbonate.

nb DON Is the fraction of DON that is not oxidized in the activated sludge process and generally remains dissolved in plant effluent. nbDON is a component of total Kjeldahl nitrogen (TKN) and total nitrogen (TN).

What drives increasing TDS and nbDON at WRRFs?

Population growth, urbanization, and climate change are creating water scarcity in many parts of the world, forcing utilities to consider the use of alternative water supplies. These alternative water supplies, like seawater, brackish groundwater, surface water, stormwater, and reclaimed water, may be more difficult to treat than conventional supplies and also may be characterized by higher concentrations of TDS and/or nbDON.

Source water (i.e., raw drinking water) concentrations have a direct impact on influent and effluent wastewater concentrations. A study by the Southern California Salinity Coalition found that source water TDS was the primary driver for observed variability in influent and effluent wastewater at WRRFs. Wastewater nbDON concentrations are also impacted by source water concentrations, although the correlation is generally weaker because nbDON treatment barriers (floc/sed, activated carbon) are more common at water treatment facilities than TDS treatment barriers.

Drinking water treatment may increase the concentrations of TDS and/or individual TDS components. For example, anion exchange and cation exchange impact the composition of TDS replacing certain anions and cations with chloride and sodium, respectively. Metal salt coagulants also contribute to TDS. Sedimentation, adsorption, and biologically active filtration (BAF) can impact nbDON concentrations in finished drinking water.

Drinking water treatment facilities can also increase TDS and nbDON concentrations at WRRFs through the discharge of residuals to the collection system. Membrane concentration, exhausted ion exchange regeneration brine, settled solids, and other residuals can contain can contain high TDS and nbDON concentrations. Drinking water treatment residuals at the household level can also impact TDS and nbDON at WRRFs, such as the high chloride discharges that are produced by self-regenerating water softeners.

TDS and nbDON concentrations at WRRFs are highly dependent on how drinking water is used by residential, commercial, and industrial customers. Water conservation (passive and active) will continue to play an important role in water resource management as it acts to reduce the extent to which discharges are diluted by drinking water prior to arrival at WRRFs. The Southern California Salinity Coalition estimates that for every gallon per capita per day decline in indoor water use, there is a 1.2 to 1.7 mg/L increase in WRRF influent TDS.

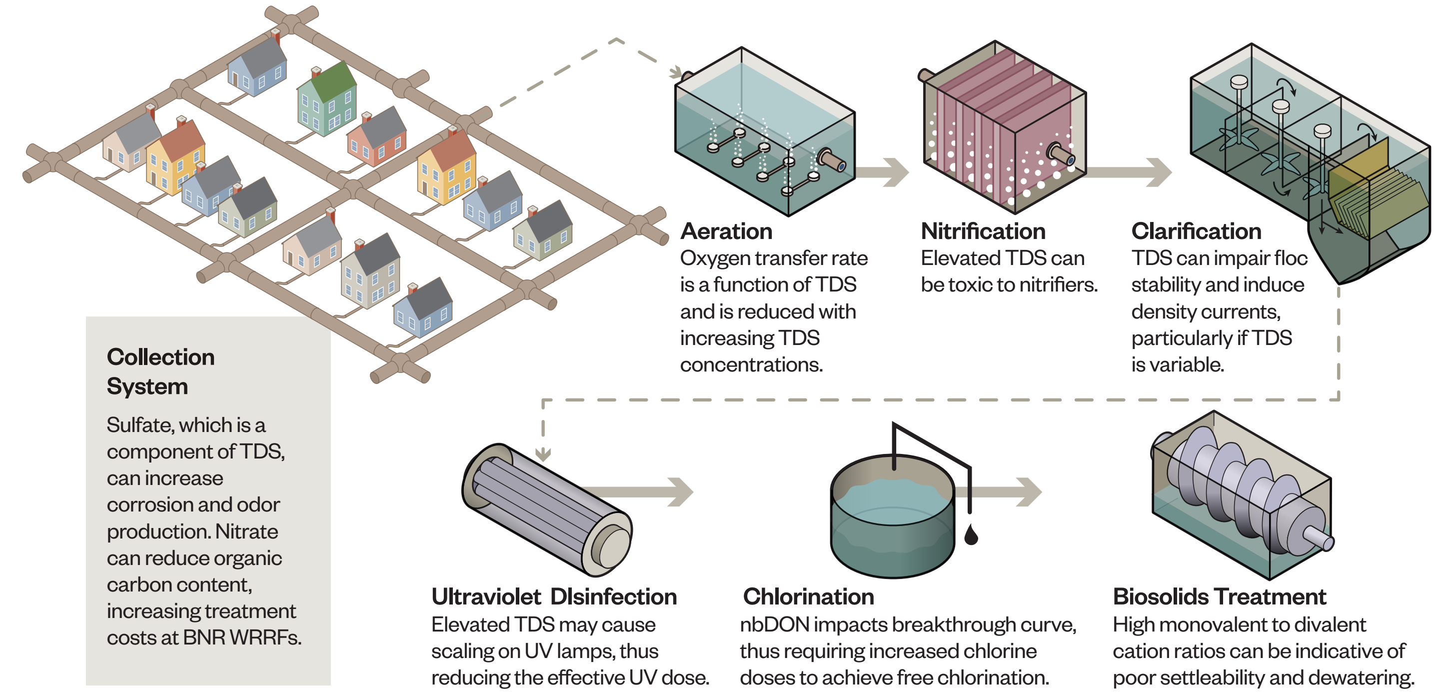
Sewershed management practices and wastewater treatment may increase TDS and nbDON concentrations in WRRF influent and effluent. Utilities may opt to add chemicals to the collection system to minimize odor production and/or corrosion. Additional chemical inputs may be dosed at the WRRF for pH control, biological and chemical nutrient removal, and other applications, all possibly increasing TDS.

Importantly, water conservation can exacerbate the need for chemical inputs in the collection system and thus the potential for TDS increases because reduced flows in the collection system lead to an increased potential for odors and corrosion. Biosolids treatment processes, such as thermal hydrolysis pretreatment ahead of anaerobic digestion, can also increase nbDON in return flows.

What Is It Doing To My System?

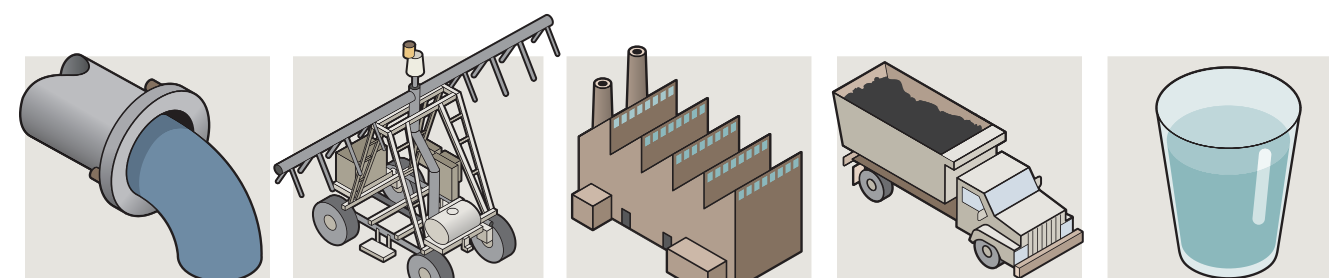
Impacts of Increasing TDS and NbDON Concentrations

A summary of WRRF infrastructure and treatment process sensitivities to TDS and nbDON.



Downstream Impacts

Elevated TDS and nbDON may limit effluent and biosolids management options.



Environmental Discharge of Effluent
Elevated nbDON concentrations may challenge compliance with effluent TKN and TN restrictions; elevated TDS concentrations may challenge compliance with conductivity, TDS, acute toxicity, and/or chronic toxicity restrictions; WRRF effluent may also be subject to restrictions on individual TDS components (e.g., sodium, metals, etc.).

Beneficial Reuse of Effluent via Irrigation
TDS limits for irrigation are crop dependent; elevated TDS concentrations and high sodium adsorption ratios can impair vegetation and soil health.

Beneficial Reuse of Effluent via Industrial Applications
Elevated TDS concentrations limit the extent to which cooling water can be recycled, thus increasing cooling water demand and discharge volumes; elevated TDS and nbDON concentrations can cause scaling and biological fouling, requiring further addition of chemicals and resulting in higher TDS.

Land Application of Biosolids
Elevated metals concentrations, which contribute to TDS, may exceed land application limits. Advanced biosolids treatment and the importance of high-strength waste may increase nbDON/ DOC concentrations in the liquid fraction of biosolids.

Beneficial Reuse of Effluent via Potable Reuse
Drinking water maximum contaminant levels for nitrate, nitrite, metals, chloride, sulfate, sodium, and TDS may be exceeded, thus requiring blending with other source waters and/or additional treatment; high nbDON can contribute to nitrogen cycling in ozone/biofiltration/GAC configurations, increasing treatment costs and disinfection byproduct formation potential.

How Can I Manage It?

MANAGEMENT STRATEGY: **Source Water Selection**

Purposeful selection and prioritization of source waters based on TDS and nbDON can minimize TDS and nbDON in finished drinking water, in turn minimizing these concentrations in WRRF influent and effluent.

CASE STUDY

Brick Township Source Water Modeling, Projections, and Adaptation Alternatives

For more information contact Eric Rosenberg: erosenberg@hazenandsawyer.com

The Metedeconk River is projected to become increasingly saline, rendering the intake structure unusable for a significant part of the year.

Brick Township, NJ is a coastal utility that relies on surface water as its primary source water. The surface water supply is subject to riverine salinity intrusion, as well as increasing levels of chloride from urbanization and road salt.

To avoid the need for TDS removal at the water treatment plant, the Township switches to the use of a reservoir when the salt front gets within 1,000 feet of the intake or the specific conductivity of the source water exceeds 1,000 µS/cm. Hazen worked with the Township to model future salinity-based reliance on the pumped storage reservoir and recommend adaptation strategies.

Modeled outputs showed that the river was projected to be unusable for 100 days per year by 2040 in the absence of adaptation strategies. Reservoir improvement, which would allow for additional pumped storage when river water is unusable, was ranked as the most effective adaptation strategy for increasing the safe yield of surface water supplies and avoiding adverse impacts from elevated salinity levels. This work demonstrates how a utility can proactively manage its source water to comply with drinking water limitations (e.g., chloride, TDS) without additional treatment, while also limiting the loads of those constituents that are delivered to WRRFs as wastewater.

MANAGEMENT STRATEGY: **Drinking Water Treatment Residuals Management**

Drinking water treatment residuals can be managed to minimize TDS and nbDON impacts at WRRFs. Strategies include the minimization of residuals production, pretreatment of residuals prior to discharge to the collection system, and alternative disposal options that do not involve the WRRF.

CASE STUDY

Town of Jupiter Nanofiltration Concentrate Management

For more information contact Janeen Wietgrefe: jwietgrefe@hazenandsawyer.com and Monica Pazahanick: mpazahanick@hazenandsawyer.com

The Town of Jupiter's nanofiltration building.

The Town of Jupiter, FL, treats their groundwater supply with nanofiltration, primarily for the removal of hardness and color. The Town has purposefully selected operational conditions and a concentrate management strategy to minimize water loss and avoid increasing TDS at the WRRF. The nanofiltration facility operates at a conservation recovery rate—approximately 80%—to manage TDS in concentrate, allowing the Town to supplement reclaimed water supplies with concentrate. The supplemented reclaimed water is fully used for non-potable applications, resulting in zero liquid waste from nanofiltration.

The Town's chosen mode of operation allows them to provide high quality drinking water, minimize water losses, and produce a concentrate that is suitable for reuse applications when blended with reclaimed water. The Town offset approximately $10 million of construction costs associated with installing deep injection wells for onsite concentration disposal.

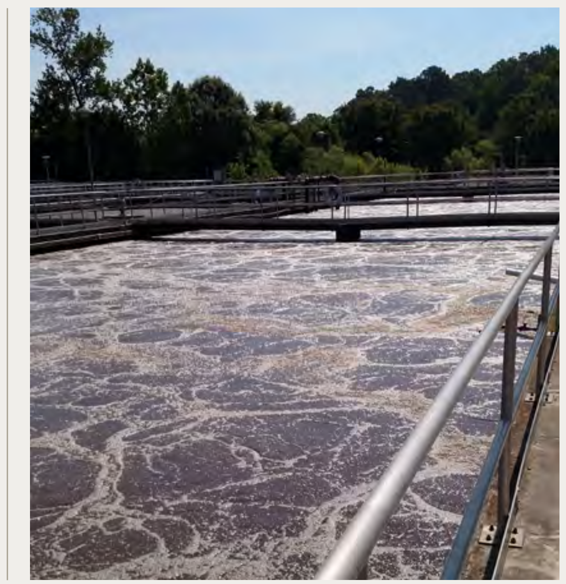
MANAGEMENT STRATEGY: **Sewershed Surveys and Headworks Analyses to Address TDS, nbDON at the Source**

Sewershed surveys, headworks analysis, and local limits evaluations are an opportunity for utilities to focus on the larger impact of individual discharges on wastewater treatment. These evaluations are particularly important when a utility receives a request to discharge pollutants that are not specifically regulated. A comprehensive understanding of the relative contributions of nbDON and TDS from sources upstream of the WRRF are required to evaluate management via pretreatment, collection system improvements, collection system flow splitting, and/or WRRF treatment enhancements.

CASE STUDY

Johnston County Headworks Analysis for TDS and nbDON

For more information contact Mary Sadler: msadler@hazenandsawyer.com



Johnston County Central Regional Wastewater Treatment Facility

Johnston County, NC was faced with the challenge of evaluating the potential impact of both TDS and nbDON from industrial sources. Hazen worked with Johnston County to better quantify the source of influent loads and determine the effectiveness of various management strategies.

The evaluation revealed a significant contribution of nbDON from industrial and domestic sources.To achieve compliance with stringent nutrient limits, the County is considering the purchase of additional nutrient credits, expansion of the reclaimed water program, and advanced treatment technologies (e.g., membrane filtration, advanced oxidation) for reducing nbDON in wastewater effluent.

Additionally, utilities may consider industrial partnerships for targeted pretreatment as compared with centralized treatment.

CASE STUDY

Wollongong Water Recycling Plant TDS Control

For more information contact Troy Walker: twalker@hazenandsawyer.com

Wollongong Water Recycling Plant in greater Sydney, Australia.

Sydney Water's Wollongong Water Recycling Plant includes conventional secondary treatment, tertiary filtration, dual disinfection, microfiltration, and reverse osmosis. The treated effluent is primarily used by an industrial customer for steel manufacturing, which requires consistently high-quality water. Increasing influent TDS concentrations at the plant were causing increased energy use and challenging the performance of existing equipment.

Sydney Water conducted a sewershed survey to determine the cause of increasing influent TDS. An open non-return flap in low lying sewer lines was identified as the major contributor. As a result of the sewershed survey, Sydney Water was able to forego treatment enhancements and maintain their existing water reuse agreements by pursuing targeted collection system improvements.

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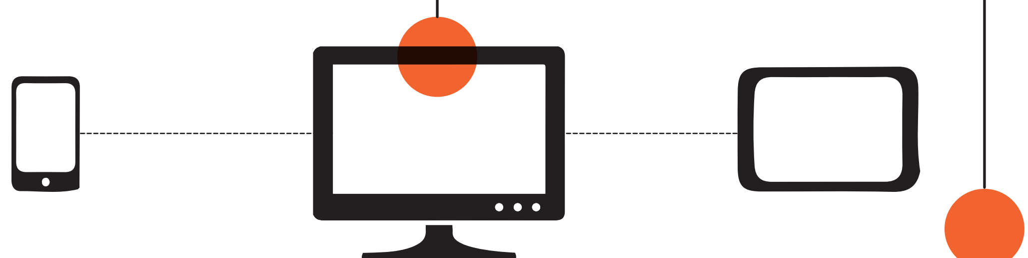

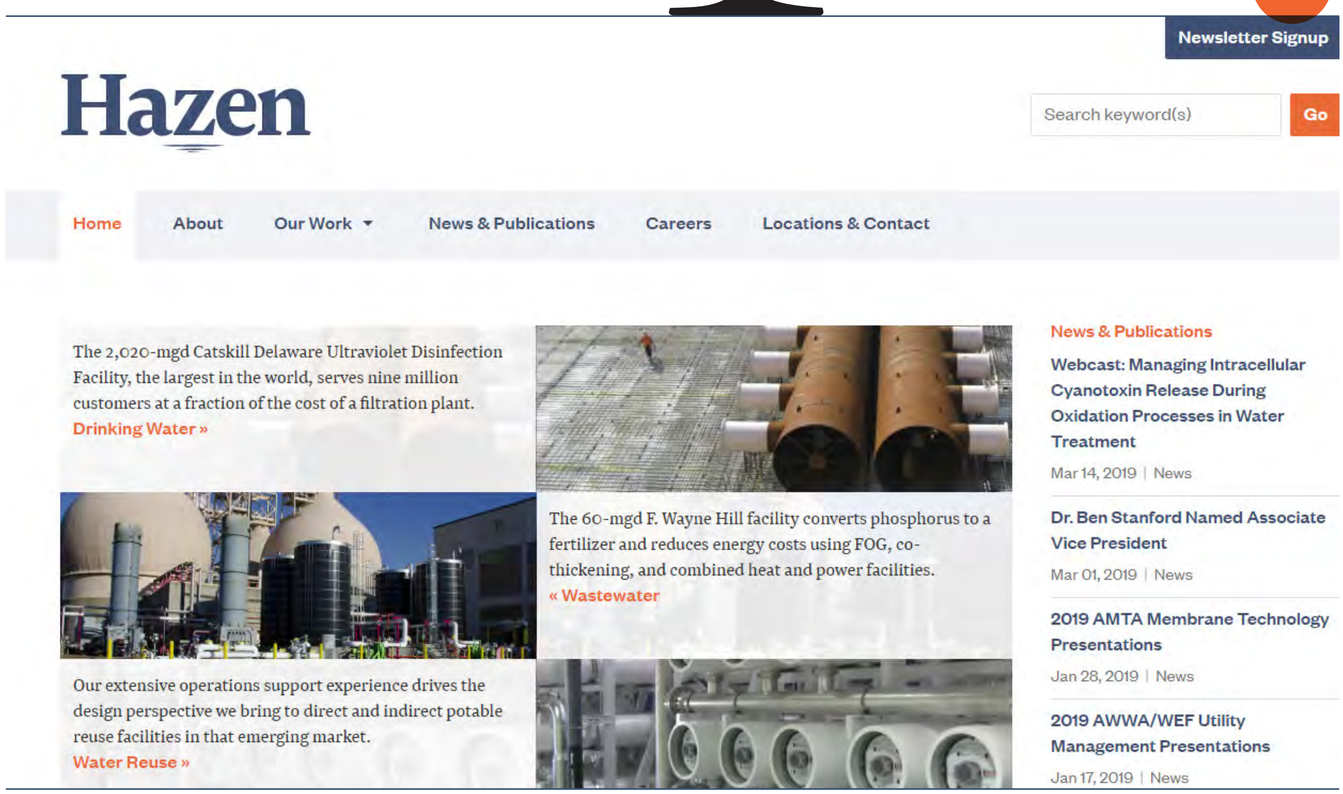

HORIZONS
water environment solutions

On the Cover:
Martins Fork River, KY
–Photo by Anthony Heflin

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