Fall 2014, Vol. 44, No. 3

New York Water Environment Association, Inc.

Clear Waters

Nutrients: Monitoring and Removal

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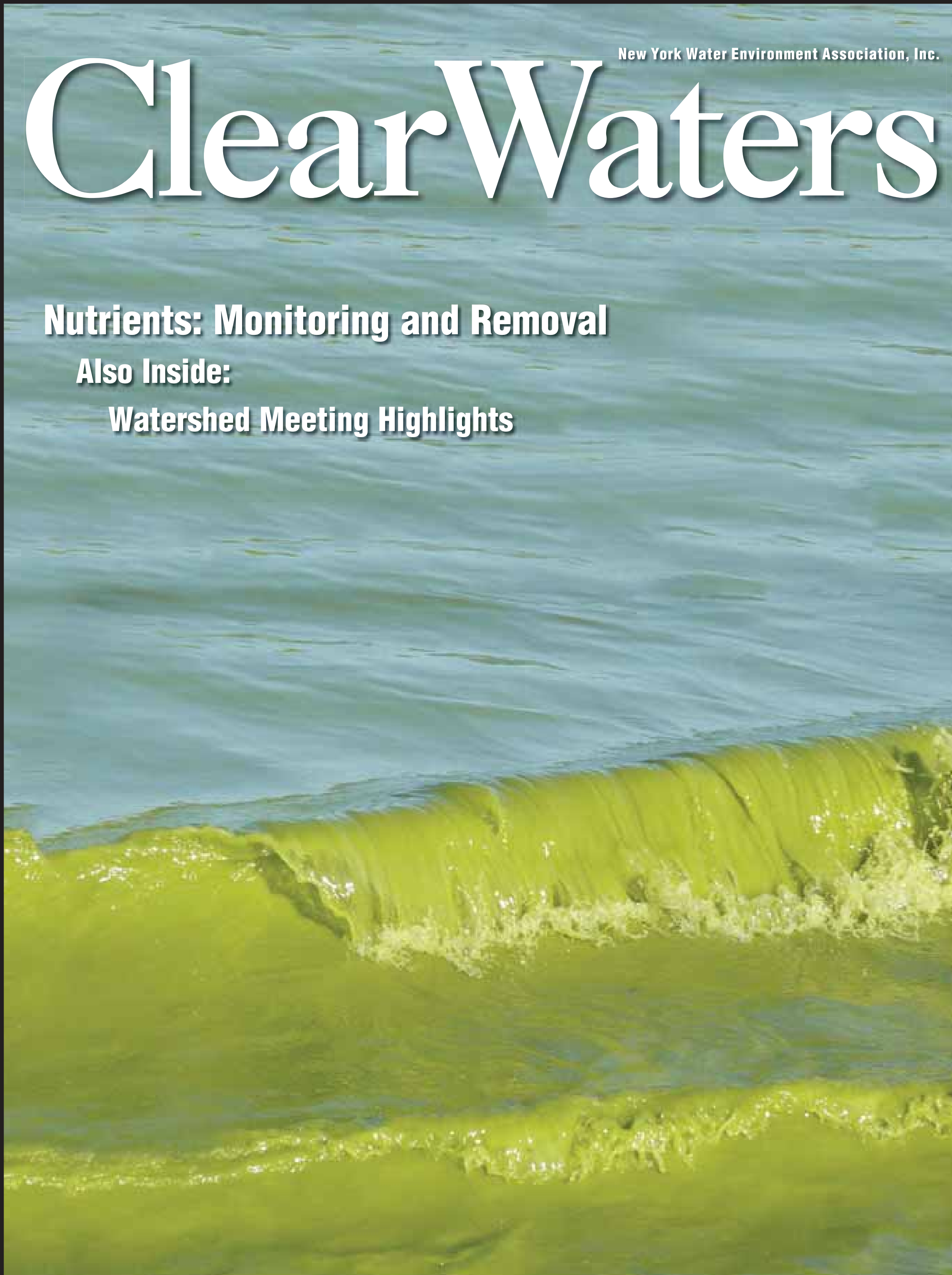

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Clear Waters

New York Water Environment Association, Inc.

Cover Image: A harmful algae bloom, Pelee Island, Ohio, Lake Erie. *Photo by T. Archer, courtesy NOAA*

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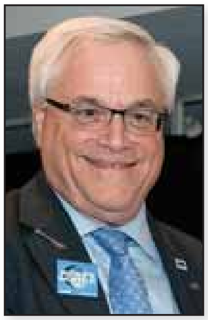
President's Message | Fall 2014



NYWEA's Grassroots

The Summer of 2014 passed quickly, but there was no vacation for NYWEA and its chapters. The work of NYWEA and its various state committees which take on the hot issues of the day – Government Affairs, Utilities Executive, Member Education and the Nominating committees, just to name a few – are all coordinated from the association's executive office so that everything keeps flowing.

The chapters also run some fantastic events over the summer and I attended a few, from the Metropolitan Chapter's Annual Golf Event, the Long Island Chapter's Annual Clambake, to the end-of-the-summer Genesee Valley Chapter Annual Steak Roast. I was gratified by how well each event was run and by the enthusiasm shown by members across the state. One of the events I attended for the first time, and another I've been going to since the 80s. This year, I was able to attend these events as NYWEA president!

The NYWEA is a remarkable organization where so much occurs at the grassroots, or the local chapter level, and which translates up to the state level with information exchange back through our technical conferences, as well as legislative, regulatory and operations training and competitions. My main impression of our organization is that everyone possesses a passion for our bottom line issue – water quality and quantity protection – while also having fun networking on both the chapter and state levels. So, ***VOLUNTEER!*** It's what keeps all this going!

Chapter Exchange – CHAPEX 2014

Every year, NYWEA holds a webcast with its chapters on financial, legal and insurance matters including the chapter officers involved with those subjects. Taking the lead from the Water Environment Federation (WEF), NYWEA broadened its approach to introduce the first Chapter Exchange or CHAPEX, which is an exchange focused on success stories from the local chapters to other chapters with NYWEA's assistance. This event was held in August, and the results were great! The feedback will lead to additional time allowed at future CHAPEX meetings for individual chapter success stories and unique programs. This chapter exchange of ideas added some "spice" to the usual financial discussions and all seven chapters participated. Follow-up on information is ongoing. I am happy to report a second CHAPEX is planned for 2015. Send your ideas and possible presentations to Patricia Cerro-Reehil (*pcr@nywea.org*).

Water Resources Reform and Development Act (WRRDA)

The Water's Worth It! advocacy campaign in Washington has assisted in both the passage and signing into law of the WRRDA bill. This was many years in the making and after many visits to The Hill by members of organizations such as WEF, the National Association of Clean Water Agencies, the Water Environment Research Foundation and your own NYWEA, the bill passed and was signed into law. The Clean Water Act was amended to allow for 30-year loans under the State Revolving Fund (SRF) provisions; the Clean Water and Drinking Water SRF's were extended by two years; and, a Water Infrastructure Finance and Innovation Act (WIFIA) provision was added. Besides the renewal and enhancements to the SRF program, the WIFIA provision provides an additional level of funding for larger projects. Finally, an Integrated Funding Pilot was added to the legislation, something pursued for many years, which recognizes that watersheds do not receive pollution from point sources alone, but that stormwater and farm runoffs, and other sources of pollution must be considered together for mitigation in order to see long-term results. The WRRDA bill now lays all this out for actual implementation. Draft guidelines are in review and funds must yet be appropriated, but the first step was taken by enacting this bill. With the present Congress labeled as gridlocked, this was a unique success story. The NYWEA thanks all participants of the "Fly-Ins" to Washington over the last few years and all organizations that have pushed for this. There is much more work to do because Water *IS* Worth It!

As a sidebar, the NYS Environmental Facilities Corporation (NYSEFC) must continue to stress New York State's needs for these funds, reflect their importance in the state priority lists of projects, and ensure that funds available are being used. Otherwise, Congress will shift these funds to other states that indicate higher priorities. The NYSEFC has done a great job of leveraging the funds provided to them by the federal government and additional capital from Washington is necessary for New York's long-term needs. Consider NYSEFC when funding your projects.

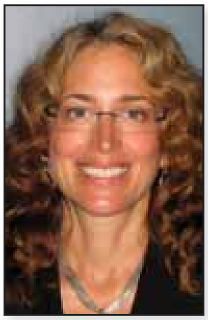
Watershed Science and Technical Conference at West Point

The NYWEA watershed conference was held in a new one-day format and the results were again amazing. Over 200 registrants and 30 papers made the technical program a value in and of itself. Our co-sponsors, including the New York City Department of Environmental Protection (NYCDEP), the Watershed Protection and Partnership Council and the NYS Department of State, delivered outstanding efforts to make it a successful conference. The Lower Hudson Chapter setting – West Point on-the-Hudson as viewed from the Thayer Hotel – was an added enhancement to the gathering. The panels focused on one of the most important watersheds on Earth which provides over one billion gallons of safe drinking water to the residents of New York City and its surrounding areas. Thanks to all from NYWEA and its partners in making this a successful conference once again. Look for the next watershed conference in September 2015.

Nutrients: Monitoring and Removal

This issue of *Clear Waters* offers articles on various aspects of nutrient removal, including some of today's technologies. Modeling, monitoring and reporting on nitrogen reduction verification and the operation of nutrient removal facilities and their watershed impacts, are also covered. Be sure to read through this information in order to keep up to date on this important topic.

Steven A. Fangmann



Administration of NYS Operator Certification Program

In 2012, NYWEA entered into a five-year cooperative agreement with the NYS Department of Environmental Conservation on the administration of the Wastewater Operator Certification program. We have just completed the third year administering the wastewater operator certification program. I am pleased to report that during the three year timeframe, 486 people became certified operators, and 880 individuals renewed their licenses. A total of 309 people sat for the ABC exams with 173 passing, and 136 failing. The members of the Wastewater Operator Certification Governance Council are working to increase the number of people who pass the exams. Several tools are available on the NYWEA website for that purpose, including Morrisville College's Study Guide for this certification. We express our many thanks to Van Bartlett from Morrisville, who has shared this important guide which includes lecture contents, practice problems and exams.

November Energy Conference

Together with NYS Energy Research and Development Authority and the NYS Department of Environmental Facilities, NYWEA is sponsoring an Energy Specialty Conference on November 20 at the Desmond Hotel in Albany, NY. This conference will feature 19 presentations by industry leaders and will focus on the transition and economics needed to move your utility from a traditional wastewater treatment plant to a water resource recovery utility. Ed McCormick, WEF president and editor of WEF's Energy Roadmap, will be the keynote luncheon speaker. I hope to see you in Albany.

Help Shape Future of NYWEA – Participate in the *Just One More* Membership Campaign

Under the leadership of President Steven Fangmann and the Membership Committee, we have a campaign underway titled the *"Just One More"* program. Every member who sponsors a new member receives a NYWEA microfiber t-shirt. The new member is given a t-shirt as well. This program was met with success a number of years ago. We hope that each and every one of you, *our members,* will continue to help shape the future of the New York Water Environment Association by recruiting the next generation of environmental professionals to carry on the great work of what the membership accomplishes every day to improve water quality.

Posters: In conjunction with the *Just One More* membership campaign, we have developed posters for corporations, municipalities and colleges that can be displayed to promote the benefits of joining NYWEA *(see them below).* Please let me know if your company or utility has not yet received a copy of both posters. We hope you'll be pleased with their visual appeal and will post them in the lunchroom or common area of your building.

The new members who join today will become the future leaders of this organization. Help us define NYWEA's future by sponsoring more new members!

As we experience autumn in New York, enjoy the vibrant colors of the season – it's one of the many rewards of living in the Northeast.

Patricia Cerro-Reehil
pcr@nywea.org

The Hotel Thayer, West Point, NY

Highlights of Watershed Science & Technical Conference

September 10, 2014

NYWEA President Steven Fangmann addresses the attendees during the Opening Session.

William C. Harding, Executive Director of Watershed Protection and Partnership Council, welcomes everyone to the conference.

Matt Millea in his new position as Deputy Secretary of State for Planning and Development speaks on behalf of Governor Cuomo.

Tim Ramirez of the San Francisco Public Utilities Commission

Dwayne Myers, of CDM Smith, talks about Philadelphia's Green City, Clean Water Program.

William Nylic introduces the next speaker, Richard Vandreason.

Klaus Albertin talks about climate change and TMDL tools.

NYCDEP's Mark Zion speaks to members about climate change and turbidity.

Opening Session panelists Jeff Graf and Elizabeth Reichheld of NYCDEP

Karen Sklenar of the Cadmus Group speaks about source water protection.

The Thayer Hotel monument with Hudson River in background

Nick Bello (left) of Cullen Company and Paul McGarvey of GHD

L–r: Steven Fangmann, Patricia Cerro-Reehil, Matt Millea and William C. Harding

Above: Lisa Melville and William C. Harding of the Watershed Protection and Partnership Council

Above: Attendees enjoy lunch overlooking the Hudson River.

Above: Syd Harris of Koester Associates

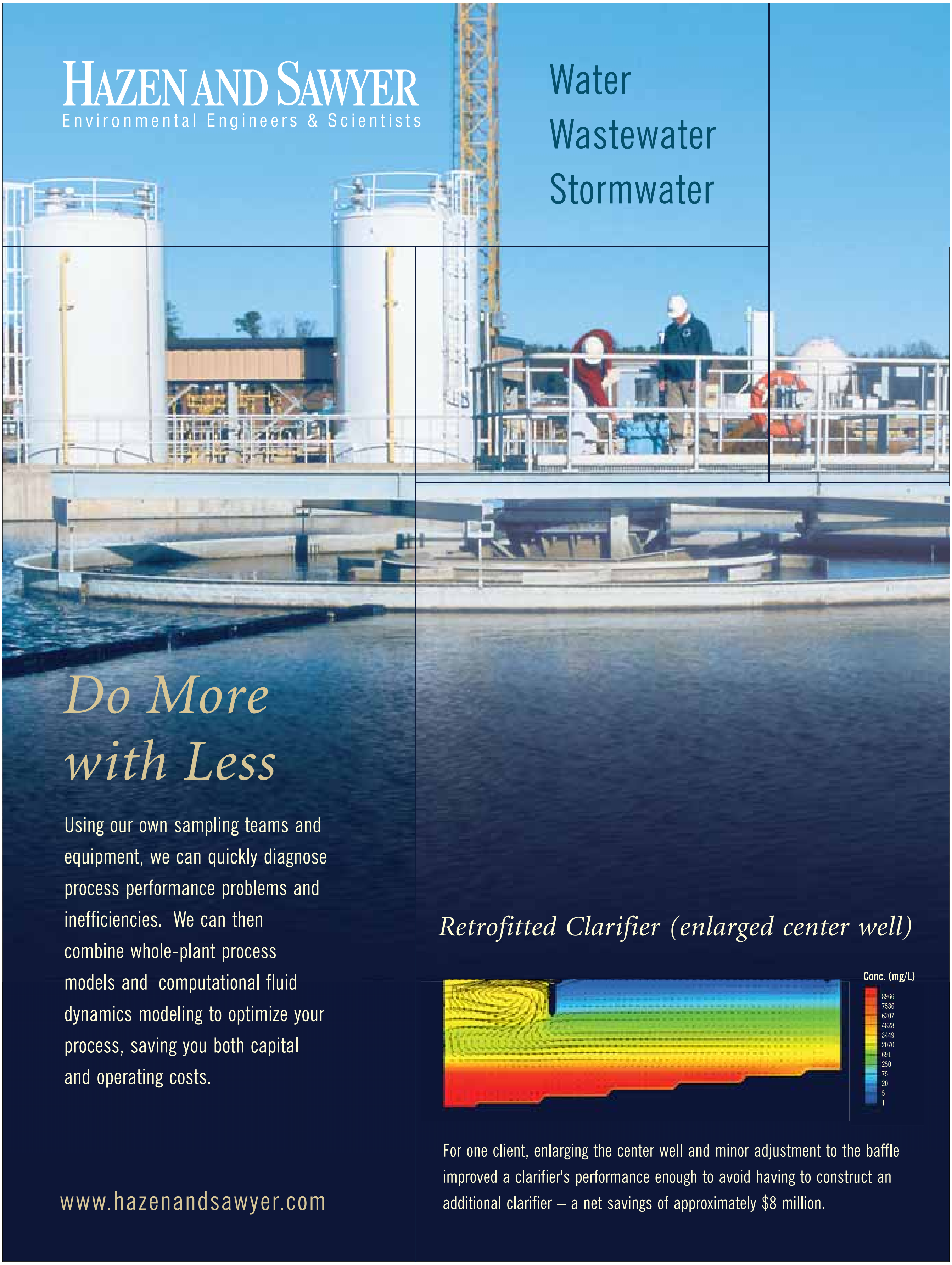
Above: Michael Principe and Kerri Alderisio

Janice Whitney, right, of USEPA speaks with attendees.

Right: President Steven Fangmann inducts Matt Millea into the Select Society of Sanitary Sludge Shovelers.

Rich Fiedler (left) and Joe Habib from G.P. Jager & Associates

Attendees mingle in Exhibit Hall.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Water
Wastewater
Stormwater
Do More with Less
Using our own sampling teams and equipment, we can quickly diagnose process performance problems and inefficiencies. We can then combine whole-plant process models and computational fluid dynamics modeling to optimize your process, saving you both capital and operating costs.
Retrofitted Clarifier (enlarged center well)
Conc. (mg/L)
8966
7586
6207
4828
3449
2070
691
250
75
20
5
1
For one client, enlarging the center well and minor adjustment to the baffle improved a clarifier's performance enough to avoid having to construct an additional clarifier – a net savings of approximately $8 million.
www.hazenandsawyer.com

Water Views | Fall 2014

Importance of Minimizing Nutrients

Phosphorus and nitrogen are vital nutrients that all plants and animals need to grow. However, excessive levels of nutrients can also harm the environment. When the nutrient levels in water are high, aquatic plants (including harmful algae blooms) grow. Their overabundance can clog water intakes, discourage recreation and alter habitat. When the plants die, they decompose, making the water oxygen poor. Fish and other aquatic life cannot survive without enough oxygen, so it must either leave the area, or die.

There are many sources of nutrients, the most common being: human waste from treatment plant discharges and inadequate septic systems; animal manure and other fertilizers; stormwater runoff that transports pet and animal wastes; and some industrial discharges. Because there are many sources, one single solution is not going to address the entire problem. New York is working to control nutrients in a number of ways.

Wastewater Treatment Facilities – all have permits that require effluent to not compromise water quality standards. If nutrient pollution is impairing recreation or other uses of a water body, permits for dischargers to those waters restrict the allowable amount of nutrients.

Concentrated Animal Feeding Operations (CAFO) – larger farms must also comply with state water pollution discharge permits, so the farmer must develop and implement a Comprehensive Nutrient Management Plan to mitigate sources of nutrient pollution with farm-specific best management practices.

Municipal Stormwater, Stormwater from Construction Sites and Certain Industrial Activities – NYSDEC permits require various practices to control the amount of nutrients and other pollutants from entering waterways from these potential sources.

Dishwasher Detergent and Nutrient Runoff Law – passed in 2010, this law prohibits (with some exceptions) the use of lawn fertilizer with phosphorus and the sale of dishwashing detergent containing phosphorus, reducing the amount of nutrients into waterways.

Watershed Plans – developed for a number of nutrient-impacted watersheds across the state, these plans outline multi-pronged strategies to control nutrient sources.

Green Infrastructure – an effective technique to control stormwater and reduce the transport of nutrients to waters, NYSDEC has been promoting GI through its stormwater permits and grant programs.

Combined Sewer Overflows or CSOs – can be significant sources of nutrients and where they occur, NYSDEC has been working with the municipalities to reduce CSOs and limit their impact on waterways.

Though nutrient pollution remains a challenge, progress is being made. For examples: 95 percent of the nutrient reductions outlined for the Long Island Sound has been achieved; phosphorus levels in the Cannonsville Reservoir have been reduced due to public investment to upgrade wastewater treatment facilities and whole farming planning initiatives; and, NYSDEC is working hard to identify and address sources of nutrient-driven harmful algal blooms.

While nutrient sources are numerous, so are the effective actions to limit them. I encourage you to look for ways that you can help solve this widespread problem.

– James Tierney, Assistant Commissioner for Water Resources
NYS Department of Environmental Conservation

Focus on Safety | Fall 2014

When Working with Methanol

Denitrification is a method to eliminate or reduce the amount of nitrogen in a waste stream. One of the ways to denitrify is to add another source of carbon so that the bugs will work on that and emit gaseous nitrogen. Probably the most common source of this additional carbon is methanol, otherwise known as wood alcohol. Most of us drive around all day with some in our car – that blue stuff in a gallon jug – windshield washer fluid. However, instead of this diluted version, the methanol used in wastewater treatment is full-strength.

Both the NFPA (National Fire Protection Association) and OSHA (Occupational Safety and Health Administration) consider methanol to be a Class 1B Flammable Liquid, falling within the guidelines of NFPA 30 *Flammable and Combustible Liquids Code* and OSHA 1910.106 Flammable Liquids. Operations that involve the presence of 10,000 lbs. of methanol (or any other hazardous chemical) also fall under OSHA 1910.119 *Process Safety Management of Highly Hazardous Chemicals* (also known as PSM). There is also a Methanol Institute to provide technical information specific to the transport, storage and handling of methanol in its *Methanol Safe Handling Manual*.

Make no mistake about this: working with methanol is a hazardous operation!

A wastewater treatment plant using methanol must make the process as safe as possible. The first step is to create the PSM document, even if your facility does not have the requisite volume necessary under the PSM standard. The information and processes developed are invaluable and provide responsible control methodology. They are also a royal pain in the neck in time and effort because this is an in-depth undertaking. While many organizations use consultants to help guide this process, staff personnel are generally very capable in developing a PSM manual themselves, given sufficient time and resources. At least one person developing the PSM manual and safety procedures should take a PSM class. The better PSM manuals are those that are developed by the people who are integrated in the denitrification system. However, the manual should not be a requirement to check off and leave on the shelf. It is a living document to be used daily and refined periodically as the organization becomes more familiar with the requirements, their responsibilities and lessons learned.

Do not allow yourself or others on your team to become blasé about using methanol. It is not just juiced up windshield washer fluid. It is a valuable part of wastewater treatment and can be used very safely by those who learn about it, and respect it.

– Eileen M. Reynolds, Certified Safety Professional
Owner, Coracle Safety Management

Wastewater Treatment Plant Operator Tips for Nutrient Removal

by Sandra Lizlovs

Not too long ago, NYSDEC asked you – plant operators – to fill out a full SPDES (state pollutant discharge elimination system) permit application and it did a full technical review of your permits (after all, it's been over 20 years since NYSDEC took a look). Opening your mail one day, each of you found a copy of a draft SPDES permit for your treatment plant. Among the changes, you see that NYSDEC is proposing new limits for ammonia, total nitrogen and phosphorus!

What's an operator to do?

Background

Why is nutrient removal important? Nutrients have a negative effect on water quality in the form of algal blooms and toxicity. ***Table 1*** shows some of these effects. Naturally occurring microorganisms can oxidize ammonia to nitrite, then nitrate. This reduces dissolved oxygen (DO) concentrations in receiving waters and may impact aquatic life. The magnitude of DO depletion is impacted by receiving water characteristics, wastewater discharge loadings and environmental conditions. Nitrification rates increase significantly with increasing water temperature. As a result, impacts are most severe during summer when stream flows are low and temperatures are high.

Table 1. Effects of Nutrients on Receiving Waters

Nutrient	Effect
Phosphorus	Algal blooms in fresh water. Blooms may be a toxic form such as blue-green algae, or result in aesthetic problems, such as odor or reduced clarity May cause low dissolved oxygen levels Increased aquatic vegetation
Nitrogen	Algal blooms in salt water Increased aquatic vegetation in salt water
Ammonia	Toxic to fish, reduces dissolved oxygen levels
Nitrate, nitrite	In drinking water, linked to methemoglobinemia, a sometimes fatal blood disorder affecting infants

Nitrification Basics

What are the typical concentrations of nitrogen compared to BOD5 (biochemical oxygen demand over a five-day period) in the plant influent? ***Table 2*** provides a quick summary.

Table 2. Typical Concentrations

Influent BOD_5	100–200 mg/L
Influent Ammonia	10–25 mg/L
Influent TKN	15–45 mg/L

These concentrations vary depending on inflow and infiltration rates in a collection system. If there are industrial discharges or there is septage, concentrations in a facility may be greater. Unique systems such as schools, ski resorts or rest areas may also have higher concentrations of specific parameters.

How do things differ between carbon (BOD) removal and ammonia (nitrification)? As ***Table 3*** shows, there are several differences.

Nitrification requires:

- Longer MCRT (mean cell residence time)
- More oxygen
- More alkalinity
- Care taken on inhibitory compounds
- Water temperature with more impact

Table 3. BOD and Ammonia Requirements

Process Control Parameter	Carbon (BOD) Removal	Ammonia Removal (Nitrification)
MCRT	0.5–1 day	4–15 days
pH	5–9	6.5–8 (optimal)
Temperature	Above freezing	25°C (optimal)
D.O.	>0.5 mg/L	> 2 mg/L
Alkalinity	No impact	Need 7 mg/L alkalinity per 1 mg/L ammonia

Here is a review of some of the parameters:

Mean Cell Residence Time (MCRT): The MCRT of an activated sludge process can be calculated by dividing the pounds of suspended solids, or MLSS (mixed liquor suspended solids), in the activated sludge process by the pounds of suspended solids leaving the activated sludge process. The pounds leaving the process include both the pounds of solids wasted and the pounds of solids in the effluent. For ammonia removal, you need a much longer MCRT, in other words, your plant will be operating with an older sludge. The MCRT that is required is very dependent on temperature. As temperature increases, nitrifier growth rate increases (within the range of 4° C to 35° C). And, as nitrifier growth rate increases, required MCRT decreases.

Operator Rules of Thumb:

- o For every 10°C increase in temperature, nitrifier growth rate doubles, required MCRT is cut in half, and required MLSS (mixed liquor solids) concentration is also reduced.
- o Use a running average approximately equal to the MCRT.

Dissolved Oxygen: The DO requirements can double when it must be nitrified. Why? Below are the two reaction equations that happen when the biologicals, *nitrosomonas* and *nitrobacter,* convert ammonia first to nitrite, and then to nitrate.

Ammonia + Oxygen + biology yield nitrite (NO_2) and acid
Nitrite + more oxygen + more biology yield nitrate (NO_3)

The total oxygen required is 4.55 lb of oxygen per lb of nitrogen (N).

When a plant is required to remove only carbon (BOD_5), the biology needed is roughly one pound of oxygen per pound of BOD_5. What does this mean in terms of how much more oxygen will be needed?

Let's assume a plant receives an influent BOD load of 200 lb/d (day) and an influent ammonia load of 40 lb/d. The amount of oxygen needed for carbon removal is 200 pounds, and for nitrification, it's 182 pounds! The oxygen requirements have nearly doubled! Better check the aeration system and make sure that there is enough air.

Operator Rule of Thumb:

- o Maintain DO concentration at 2.0 mg/L or higher for optimum nitrification. As dissolved oxygen increases, nitrifier growth rate increases up to DO levels of about 5 mg/L.

Alkalinity: Looking at the nitrification equations, an operator may notice that during the conversion to nitrate, the biology generates acid. This, in turn, is using up alkalinity. In fact, it's using up 7.14 lb alkalinity per lb of N! You'll need to check the influent alkalinity concentrations and determine whether or not there is enough buffering capacity. If not, add a source of alkalinity, such as sodium bicarbonate.

Operator Rule of Thumb:

- o Nitrification will use up 7 mg/L of alkalinity per 1 mg/L of ammonia. Make sure to have at least 50 mg/L of extra alkalinity as a buffer in the effluent.

Denitrification: This occurs when nitrogen in the nitrate (formed when the plant nitrified) is converted to nitrogen gas. To do this, the plant must operate in an anoxic zone (i.e., DO < 0.3 mg/L) so that the biology will scavenge the oxygen from the nitrate molecule. The same biology also needs a carbon source. The reaction is:

Nitrate + Carbon Source Carbon Dioxide + Nitrogen Gas + Water + Hydroxide

To have the plant denitrify, the following is needed:

- • Carbon source
- • Anoxic conditions
- • Mixing

A commonly used carbon source is methanol, however, there are other sources of carbon such as the treatment plant influent or commercial products such as MicroC.

Carbon Source: How much carbon is needed is dependent on how easily the plant biology assimilates the form of carbon the operator is adding. Methanol has been the industry standard for use as a carbon source as it is easily assimilated. In general, the actual methanol dose that is required is 2.5 to 3.0 lbs methanol per lb nitrate-N denitrified. There are safety considerations for methanol. There are specific handling and storage requirements, including grounding tanks and taking precautions to prevent fires, so an operator may want to look at other sources of carbon. If the operator decides to look at other chemicals, he or she should consult with the vendor to help determine the correct feed rate.

Anoxic Conditions: To denitrify, maintain a DO of <0.3 mg/L. The tank volume that is needed for denitrification depends on the mass of nitrates that are recycled and the estimated denitrification rate (which is dependent on the carbon source). The anoxic zone must be mixed without air to maintain the low DO. While an operator will need to work with a consultant to determine the actual conditions, a few rules of thumb that will help are:

Operator Rules of Thumb:

- o Required anoxic zone volume will be about one-third of the aerobic volume
- o Required mixing power will be about 1 HP per 15,000 gallons of anoxic zone volume
- o Maintain DO < 0.3 mg/L (DO inhibits denitrification)
- o If pH is in the recommended range of 6.5 – 8 for nitrification, there will be no pH effects on the denitrifiers.
- o Denitrifiers are less sensitive to pH than nitrifiers

Benefits of Denitrification: Denitrification has some benefits. Notice that DO and some alkalinity are recovered:

- • Oxygen recovered = 2.86 lbs per lb nitrate-N denitrified
- • Alkalinity produced = 3.57 lbs as $CaCO_3$ (calcium carbonate) per lb nitrate-N denitrified

continued on page 13

Credit: Sandra Lizlovs

The buildup of nontoxic algae mires this otherwise clear lake.


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Phosphorus Removal

Phosphorus may be removed both biologically as well as using chemical precipitation. This only focuses on chemical precipitation removal.

There are two steps to chemical phosphorus removal:

1. The adsorption of soluble ($PO^{4\;3-}$) phosphate into the metal hydroxide floc.
2. The subsequent separation of the metal hydroxide/phosphate floc from the liquid phase by settling/clarification or filtration

Note that this is NOT precipitation of a phosphate. Iron phosphate and aluminum phosphate only exist at a pH that is less than 5. The treatment plant is most likely operating at a pH between 6 and 8.

Most commonly used metal salts are: ferric chloride, ferrous sulfate, ferrous chloride, alum (aluminum sulfate) and polyaluminum chloride (PAC).

So, what happens? Metal hydroxide flocs form by the bonds between the metal and oxygen. Phosphate can replace this bond and be adsorbed into the floc. As the floc size increases, the ability of iron to bond with phosphate is reduced.

Because phosphate is adsorbed onto the floc particle, the plant must remove the floc by settling, or in some cases, by tertiary filtration. If the solids floc is not removed, the effluent will have a higher phosphorus level.

Which one is an operator to use? The answer is – it depends. Operators need to look at their budgets, chemical storage space, and addition points. In addition to these chemicals, adding a polymer may be needed to help the solids floc together and settle out better. One thing that operators frequently do NOT anticipate is that their sludge production will increase dramatically. If the effluent limit is > 0.5 mg/L total phosphorus, chances are it'll be fine with just chemical addition. However, if a lower limit must be met, then probably one should install some form of tertiary filtration.

A general comparison of iron salts and aluminum salts is in ***Table 4***. Keep in mind that prices and dosage rates vary. Work with the chemical supplier to jar test and develop the correct metal salt and polymer combination for the plant.

Where should you add the salts? There are many places in a plant where salts can be added. With iron salts, ferric chloride immediately allows for the phosphate to adsorb on to the particle. Ferrous chloride or ferrous sulfate – first they need to be oxidized, either in the aeration tank or in another aerated tank before they will work.

Often, a rapid sand filter may be used in lieu of adding chemicals, or in addition to adding them. Sand filters remove fine particulate matter from the effluent which is the carrier of the phosphorus. A cleaner effluent means fewer solids and, ultimately, less phosphorus being discharged.

This was a broad overview for operators. If your facility's permit requires you to remove nutrients, then work closely with your consultant, the NYSDEC representative and, quite possibly, the chemical vendor, to understand what physical and operational changes will need to be made at the plant in order to meet the permit limits. You will also need to work with local elected officials to educate them as to why these changes need to be made at your plant. The NYSDEC has some resources available online regarding nitrogen removal. These may be found at *http://www.dec.ny.gov/chemical/83360.html*. The Water Environment Federation and the USEPA also publish a number of guidance manuals. A list may be found here: *http://www.dec.ny.gov/chemical/8708.html*.

Table 4. Metal Salts Comparisons

Chemical	Tips & Things to Look For
Iron Salts: • Ferric Chloride • Ferrous Sulfate • Ferrous Chloride	■ Ferrous chloride and ferrous sulfate must be oxidized to the ferric form before they will work. This means they must be added to the wastewater in a location where they will be aerated. ■ May cause staining ■ Corrosive ■ Watch addition rates: too much may cause lowering of the pH to where it violates the permit and/or causes plant upset ■ If have UV disinfection system, the iron will coat the bulbs, resulting in decreased disinfection ■ Be careful with an effluent iron limit. The extra iron may cause violations to the permit. ■ Provides odor control ■ Ferrous sulfate is made as a by-product of titanium dioxide production or from scrap iron, possibly containing undesirable levels of heavy metal contaminants. ■ Ferrous sulfate does not form a good floc for settling so may need to add a polymer ■ 1 mg/L of an iron salt will generate 2 mg/L of solids ■ May improve solids dewaterability
Aluminum Salts: • PAC • Alum	■ Do not interfere with UV system ■ Lower dosage requirement ■ No requirement for any neutralizing agent (soda, lime) ■ Shorter flocculation time ■ Smaller amount of sludge ■ Higher quality of the treated water ■ 1 mg/L of aluminum salt generates 2.9 mg/L TSS (aka sludge) ■ Decrease dewaterability of sludge ■ No odor control

continued on page 15

Sandra Lizlovs is an Environmental Engineer for NYSDEC-Region 7 in Syracuse, NY (sandra.lizlovs@dec.ny.gov).

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Preparing Data for DMR Reporting

This was first published in the NYSDEC technical bulletin, Operator Facts (Summer/Fall 2006).

Whether the data we collect is to be used to evaluate process performance, determine design requirements, or report on the Discharge Monitoring Report (DMR), it may require simplification before its use. The objective of data simplification is to reduce the raw data to more manageable forms while making sure the information is not changed or masked.

All measuring devices have some uncertainty in a measurement. Each analytical measurement has accuracy limitations because of the chemical nature of the procedure, instrumentation and/or methodology. The objective is to report as many digits as were accurately measured while avoiding reporting digits not known. When this is accomplished, meaningful information is not lost, and the data does not suggest greater accuracy than is warranted. The significant figures for any measurement include all digits known with certainty plus the last digit. This last digit is an approximation.

Reporting sample results and calculations on the DMR requires using the number of significant figures of the raw data and that specified by the SPDES permit limit or action level. If the permit does not clarify the number of significant digits, sample measurements must be reported in two significant digits, except in the cases of effluent TSS or BOD where single digit effluents are achieved. In these cases, single digits can be reported.

The DMR Manual outlines the rules for significant figures, and uses the terms significant figures and significant digits interchangeably.

Rules for Significant Figures:

1. All non-zero digits (1–9) are to be counted as significant.
2. All zeros between non-zero digits are always significant. Both 4308 and 40.05 contain four significant digits.
3. For numbers that do not contain decimal points, the trailing zeros may or may not be significant. The number 470,000 may have two to six significant digits. The number of digits that are significant depends on the accuracy of the measurement.
4. For numbers that do contain decimal points, the trailing zeros are significant. Both .360 and 4.00 have three significant digits.
5. If a number is less than 1, zeros that follow the decimal point and are before a non-zero digit are not significant. Both 0.00253 and .0670 contain three significant digits.

When reporting results on your DMR, rounding the data to the same number of significant figures specified by the permit limit or action level or raw data may be necessary. All calculations *(i.e.,* averaging and multiplying) are completed before any rounding is done.

Rules for Rounding:

1. If the digit being dropped is 1, 2, 3, or 4, leave the preceding number as it is. For example, 20.3 rounded to the nearest whole number is 20.
2. If the digit being dropped is 5, 6, 7, 8, 9, increase the preceding digit by one. For example, 26.5 and 26.9 rounded to the nearest whole number is 27 in both cases.

Beyond using the number of significant figures specified by the SPDES permit, sample measurements must be reported with the same degree of precision achieved in the analysis or measurement. This means that numbers resulting from calculations cannot be more precise than the raw data used in the calculations.

Rules for Precision:

1. For addition or subtraction, the answer can contain no more decimal places than the least precise measurement. Example: 13.681 - 0.5 = 13.181 should be rounded off to the tenths place, with a correct result of 13.2.
2. For multiplication or division, the least number of significant digits in any of the measurements determines the number of significant digits in the answer. Example: 2.5 x 3.42 = 8.55 should be rounded off to two significant digits, with a correct result of 8.6.
3. Numbers such as conversion factors or number of days are counted numbers and are not considered when determining the number of significant digits or decimal places in the calculation.
4. If both addition/subtraction and multiplication/division are used in a calculation, follow the rules for multiplication/division.

Example 1:

Report the annual total mass loading for phosphorus using the monthly mass loadings: 250.2 lb, 101.0 lb, 135.0 lb, 180.0 lb, 159.0 lb, 225.9 lb, 258.0 lb, 237.0 lb, 202.5 lb, 210.0 lb, 246.3 lb, 236.4 lb. The permit limit is 3125 lbs/yr.

Annual Mass Loading = 250.2 + 101.0 + 135.0 + 180.0 + 159.0 + 225 .9 + 258.0 + 237.0 + 202.5 + 210.0 + 246.3 + 236.4 = 2441.3 lbs/yr.

The permit limit specifies four (4) significant figures and the data has four (4) significant figures. Precision Rule #1 applies. Therefore, the number 3 (in the tenths place) in the result is rounding down. Leave preceding number as is; enter 2441 in the Sample Measurement Box on the DMR.

Example 2:

Calculate the 7-day average for ammonia using the four (4) sample results collected during the week: 0.56 mg/L, 0.93 mg/L, 2.53 mg/L, 6.92 mg/L. The Permit Limit is 4.5 mg/L.

$$\textbf{Average} = \frac{0.56 + 0.93 + 2.53 + 6.92 = 2.735 \text{ mg/L}}{4}$$

The ‘0’ before the sample results 0.56 and 0.93 are not significant figures (Significant Figures Rule #5). Two (2) significant figures are specified by the permit limit and raw data. Following Precision Rules 2, 3 and 4, the numbers 2 and 7 in the result are the two significant digits. The number 3 (in the hundredths place) in the result is rounding down. Leave the preceding number as is; enter 2.7 in the Sample Measurement Box.

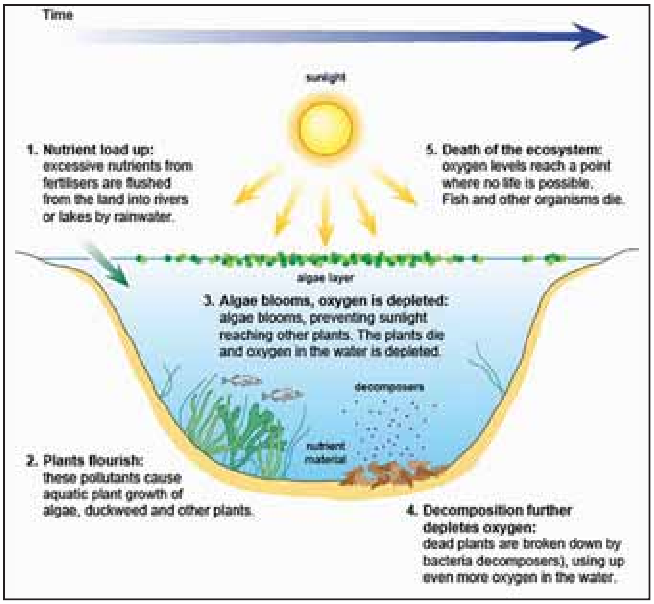
More information on data reporting can be found in the DMR Manual. The manual is available from the NYSDEC website at: http://www.dec.ny.gov/docs/water_pdf/dmrmanual.pdf

Nutrient Reduction Programs and Their Impact on Credit Analysis

by Eva D. Rippeteau

Municipal water and sewer utilities are fee-based long-term enduring monopolies that provide highly essential services to the general public. Provision of these services is generally carried out by local governmental entities which are, in turn, heavily regulated by state and federal environmental and public health agencies with primary oversight conducted by the federal United States Environmental Protection Agency (USEPA). The total maximum daily load (TMDL) component of the USEPA's Clean Water Act of 1972 (amended in 1977, 1981 and 1987) specifies the allowable pollutant loading from contributing sources and assigns numerical limits to the permissible concentrations of nutrient discharges. Nutrient reduction programs address concentrated volumes of naturally occurring nutrients that enter natural waterways and water bodies from various manmade municipal and rural sources and cause ecological harm.

Figure 1. Eutrophication and Its Impact on Natural Water Bodies



Excess concentrations of nitrogen and phosphorus in water cause eutrophication – a process shown in this diagram. *Source: BBC Bitesize, Eutrophication, 2008.*

As demonstrated in ***Figure 1***, and according to the USEPA, "pollutants often enter upstream waters like creeks and streams and then flow into larger water bodies like lakes, rivers and bays. Excess nitrogen and phosphorus can travel thousands of miles to coastal areas where the effects of the pollution are felt in the form of massive dead zones, such as those in the Gulf of Mexico and Chesapeake Bay. More than 100,000 miles of rivers and streams, close to 2.5 million acres of lakes, reservoirs and ponds, and more than 800 square miles of bays and estuaries in the United States have poor water quality because of nitrogen and phosphorus pollution."[1]

An assessment of nutrients and regulations, including Fitch Ratings' (Fitch) overview of water and sewer utilities as they face regulatory mandates to address nutrient loading, follows. The credit quality of two Fitch-rated utilities under consent orders for nutrient reduction is also explored.

What are Nutrients and How Do They Affect the Environment?

Nutrients are naturally occurring elements that exist in the air we breathe, the water we drink, and the soil we till and on which we walk. Specifically, nitrogen and phosphorus are two very common nutrients relevant to the treatment and protection of water and wastewater. When in perfect balance, nitrogen and phosphorus are critical components of healthy ecosystems; however, when a high concentration of either nutrient exists in natural water bodies, the aquatic ecosystem becomes impaired. The most likely result of overloading of nutrients is the process of eutrophication, which is the formation of algal (algae) blooms. These blooms grow, spread and consume much of the water's dissolved oxygen, leading to hypoxia. The blooms shade the benthic (bottom) zone of a sea bed, blocking off vital sunlight needed for photosynthesis.

According to the USEPA, the sometimes toxic nature of algal blooms can lead to illnesses and death in fish, and can even be harmful to humans. Further, the USEPA indicates there are significant monetary costs associated with poor water quality as a result of nutrient loading. The smells and appearance of algal blooms may decrease the value of waterfront homes and detract tourism; fish stocks may diminish and negatively impact the fishing industry; and the high costs of completing mandated capital programs and paying back associated debt burdens compels utilities to increase customer charges.

Concentrated nutrients enter natural water bodies in a variety of ways. The most readily measurable way is from wastewater treatment plant (WWTP) effluent. Wastewater is full of nitrogen from human waste, street runoff, industrial chemicals, and more. The resulting effluent product, unless otherwise treated, and after controlling for pathogens, bacterial and solid material, contains the bulk of this nitrogen. Another common municipal source of nutrients is the overflow of combined storm and sanitary sewers during periods of high precipitation into natural water bodies. These combined sewer overflows (CSOs) are combinations of street runoff and untreated sanitary flows that would otherwise flow toward a WWTP. Sanitary sewer overflows (SSOs) occur when the sanitary sewer becomes overwhelmed and spills a high concentration of untreated sewage into streets or waterways. The SSOs often point to greater infrastructural deficiencies as sanitary sewers are strictly meant to convey untreated sanitary flows and should not be affected by changes in precipitation.

The USEPA indicates that the largest contributor of nutrients to natural water bodies is from agricultural sources. Heavy concentrations of nitrogen and phosphorus found in farm animal waste and agricultural pesticides, respectively, are extremely harmful when they runoff or are discharged into natural water bodies. Other sources include: contaminated municipal stormwater runoff; airborne nitrogen particles from the burning of fossil fuels at coal-powered electric plants; industrial, commercial and transportation emissions; and the residential use of chemicals and fertilizers around the house.

Nutrient Reduction's Regulatory Framework

The USEPA's National Pollution Discharge Elimination (NPDES)

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Challenges that face natural water systems – this impaired water body showing ducks maneuvering through the algal blooms – can result from an over-accumulation of nutrients.

permits are issued to industrial, municipal and other wastewater treatment facilities and dictate the TMDLs for water bodies based on their flushing and dilutive propensities. Most states, through their respective environmental protection agencies, are authorized by Section 303(d)(1)(C) of the CWA to identify water bodies that do not meet CWA water quality standards. States must prove that their TMDL requirements are sufficiently stringent to comply with the goals of the CWA, and then monitor the compliance activity of NPDES permit holders.

A number of utilities and cities across the country are facing mandated programs and consent orders from state environmental agencies and the USEPA to address persistent nutrient overloading violations and to reduce their nitrogen output. The utility or city will work closely with the regulator and a judge to agree on a program that specifically addresses local contextual needs and best practices to reduce nutrients from entering waterways. A common nutrient reduction approach is the mitigation of CSO and SSO occurrences which are very prevalent in older, larger cities that have very old (and possibly clogged) combined storm and sanitary sewer systems that overflow during extreme wet weather. Since the early 2000s, the USEPA has engaged the cities of New York City, Boston, Philadelphia and Washington, DC (to name a few) in mandated CSO reduction programs, and is progressively targeting smaller-sized cities that are also consistently polluting waterways.

Evaluating Impacts of Nutrient Reduction Programs for Credit Rating

Fitch Ratings (Fitch) is a credit rating agency that assigns ratings to entities that issue debt to fund capital programs, in some cases initiated by regulatory action. Fitch's methodology for assessing the credit quality – or the ability for an entity to repay its debts to investors (outlined in the ***Table*** on next page)– hinges on a multi-faceted assessment of that entity, including its compliance with relevant regulatory standards. The key attributes on which Fitch relies in order to assign long-term bond ratings and succinctly describe the

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credit quality of an individual issuer to the investment community are: the efficacy and professionalism of the entity's governance and management team; the past, current and projected future financial performance; the management of the system's capital program and the overall debt burden; and the quality of the utility's operational and regulatory compliance profile.[2]

Fitch's Water & Sewer Rating Criteria

Governance & Management
• Leadership
• Policies & Forecasts
• Political Impartiality
Operations
• Customers & Service Area
• Water & Sewer Statistics
• Regulatory Compliance & Climate
Debt & Capital
• Capital Improvement Plan
• Funding Sources
• Leverage and Debt Structure (Fixed vs. Variable)
• Legal Bond Covenants
Financial
• Billing & Collections
• Rates & Charges
• Audited Financial Trends & Performance
• Stress Test Performance

Fitch Ratings evaluates these four key qualitative and quantitative criteria points to assess a borrower's expected ability to meet financial debt repayment obligations in full and on schedule. The degree to which certain credit factors are emphasized – especially nonfinancial factors – will vary depending on the levels of credit stability and competitiveness observed within the sector and for individual borrowers.

Consent order mandates have been a dominant factor for sector credits since passage of the federal CWA and SDWA (Safe Drinking Water Act), and the costs of implementing mandated programs can be tremendous. In many cases, the scope of these programs extends beyond the purview of a utility's standard capital improvement plan (CIP) and the added costs may necessitate additional leveraging (borrowing). Fitch has found that the greater extent to which a utility proactively stays ahead of anticipated state and federal requirements, the greater the utility can minimize its costs and more effectively plan and implement regulatory requirements, ultimately reducing credit risk.

Fitch's 2014 water and sewer sector outlook[3] cautions that the capital outlays necessary to adhere to nutrient reduction standards can be costly and have a direct bearing on a utility's credit quality. However, enforcement actions may also reflect underlying credit weaknesses that extend beyond actual violations (e.g., management issues). Regulatory enforcement does not necessarily preclude a utility from a high credit rating, nor does it necessarily dictate immediate rating action. Weaker existing credit quality that may render a utility more vulnerable to rating action should it face regulatory enforcement can be due to multiple factors, such as a systematic political unwillingness to raise rates to pay for needed capital improvements, or due to a lack of planning to identify and address shortcomings within the system. In such cases, enforcement action likely would put increased downward pressure on a rating, as opposed to being the explicit cause for such action. The following examples describe the costs, projects and plans of two large utilities addressing nutrient-oriented mandates and consent orders, and how these factors contributed to Fitch's rating assessment.

From the viewpoint of operating stability, anticipating and financing improvements over time are generally preferable than doing so under the threat of orders and fines from regulatory bodies or the courts. Fitch qualitatively evaluates the events leading to enforcement, the scope of the corrective plan, the current stage of the corrective plan, and the projected timeline for completion. It focuses also on the expected quantitative impact on ratepayers and management's commitment to meeting the set milestones and returning to compliance, as substantial debt issuances often imply significant utility customer rate increases. Utilities with aging infrastructure or annual capital spending that regularly falls below the amount of annual depreciated assets may require substantial upgrades in the near term to maintain regulatory compliance.[2]

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Degraded water conditions resulting from nutrient overload

Nutrient Reduction in NYC: Long Island Sound Study and CSO Consent Order

The New York City Department of Environmental Protection (NYCDEP) has actively addressed nutrient reduction from a number of sources over the past three decades. In 1985, the Long Island Sound Study (LISS), which was created by the USEPA and New York State Department of Environmental Conservation (NYSDEC) provided guidelines for how to improve poor water quality in the Long Island Sound. The LISS concluded that the leading cause of the LIS's degraded condition was hypoxia, primarily linked to an overabundance of nitrogen. The greatest sources of nitrogen were attributed to municipal and industrial WWTPs, CSOs, and nonpoint and atmospheric depositions.[4] The New York City Department of Environmental Protection, which operates four Upper East River/LIS WWTPs, was required by the NYSDEC to implement nutrient reduction programs at these plants. In May 2014, NYCDEP announced the completion of a $230 million nutrient-related upgrade at the Tallman Island WWTP in College Point, Queens. Overall, NYCDEP estimates that it has invested more than $1.5 billion in similar nitrogen reduction upgrades elsewhere over the last 10 years, and that these improvements have resulted in a reduction of more than 3,500 pounds of nitrogen per day (nearly 1.3 million pounds each year). The NYCDEP projects that it will continue to reduce excessive nitrogen discharges from these plants by nearly 60 percent by 2017.[5]

In addition to implementing nutrient reduction programs at its WWTPs, NYCDEP entered into an order of consent in 2005 with the USEPA and NYSDEC to address CSOs. The agency's most recently updated Long Term Control Plan outlines a hybrid approach of using both green and gray infrastructure to capture, contain and treat excess precipitation that would otherwise overwhelm the combined sewer network. Over the next 10 years, NYCDEP has budgeted over $1.1 billion towards the implementation of this combined green/gray plan.[6]

The NYCDEP is one of the largest environmental protection agencies in the United States and frequently accesses the municipal bond market to fund its multi-billion five-year CIP, including the projects mentioned above. The New York City Municipal Water Finance Authority (NYW) is the entity responsible for issuing debt on behalf of the NYCDEP and is currently rated AA+ by Fitch. Similar to many large urban utility systems, NYW's capital needs are significant, principally the result of state and federally mandated projects. The capital program for fiscal years 2014-2023 includes an estimated $13.4 billion in water and sewer projects, funding for which will continue to come almost entirely from long-term debt issuance.

As of June 2014, NYW's forecast shows additional bond issues through fiscal 2018 totaling $5.5 billion, or an annual average of approximately $1.4 billion. Debt levels are high and escalation beyond what is currently forecast could pressure NYW's rating over the medium term. Total outstanding debt to net plant assets now stands at about 100 percent, indicating that the utility has just as much debt outstanding as its entire system asset base is worth. Also, leverage as measured on a per capita basis, approximates $3,000. By comparison, Fitch's AA category median ratios for debt to net plant and debt per capita are 49 percent and $492, respectively.[2] Fitch believes that NYW's highly levered position and extensive capital needs, both mandated and otherwise, are mitigated in part by the system's demonstrated commitment to raising rates as well as the system's strong financial management. These factors will be key to preserving operating margins and meeting the continued growth in debt service costs included in NYW's current financial forecast. Other credit attributes include sound legal covenants, the essentiality of the service, and the strong and diverse economic status of the service territory.

Nutrient Reduction in Chesapeake Bay: Hampton Roads Sanitation District

The Hampton Roads Sanitation District (HRSD/the district) in the Hampton Roads region of Virginia (which holds wastewater revenue bonds rated AA+/AA on senior/subordinate liens), is currently assessing a massive strategy to reduce nutrient loading from CSOs into and around the ecologically sensitive and heavily protected Chesapeake Bay. In 2007, the district, together with 13 of the municipalities it serves (the localities) entered into a regional consent decree with the state of Virginia (and the federal government in 2009) to reduce SSOs in the Hampton Roads region. In 2010, the district and the localities developed a regional wet weather management plan (RWMP) to collectively address the SSO violations and the district's strategy is still under consideration.

During fiscal 2013, HRSD's outstanding debt totaled approximately $799 million. Debt to net capital assets was an above average 82 percent in that year, but at $1,738 debt per customer remains just below the median for AA category water and sewer utilities. Debt carrying costs are also on the rise, but still comprise a manageable 24 percent of fiscal 2013 gross revenues. The district's $500 million five-year capital plan is expected to be roughly 50 percent debt-funded through fiscal 2018, yet the system's pro forma debt burden is projected to increase only modestly with key ratios remaining close to the AA rate medians.

Longer-term capital needs remain significant; the HRSD's 10-year, $1.14 billion CIP will address regulatory requirements associated with nutrient reduction standards and SSOs, as well as fund system-wide renewal and rehabilitation of aging infrastructure. The HRSD anticipates it will issue additional bonds totaling approximately $350 million between fiscals 2019–2023 primarily to offset the costs associated with the consent order projects. Another roughly $800 million in projected debt will be issued thereafter, as the 20-year CIP is closer to $3 billion. Fitch is concerned that the significantly higher longer-term projected debt needs will lead to a significantly higher future debt profile.

Fitch believes these concerns are currently mitigated by the extended time horizon for project implementation, HRSD's role as a large and important regional wastewater service provider with broad powers and authority, and a proven proactive and diligent management team. Fitch will continue to monitor capital spending needs and other related developments regarding the implementation of the RWMP, including potential regionalization, as they progress.

As demonstrated by these examples, regulatory enforcement does not implicitly lead to immediate rating action. The existence of weaker credit quality may render a utility more vulnerable to mandated nutrient reduction programs if elevated debt loads and capital needs lead to deteriorated financial positions and unaffordable customer charges. There are many examples of utilities and communities around the country that are ill equipped to implement the requirements of a consent order in addition to meeting existing needs. These entities would benefit greatly from replicating the qualities observed in more highly rated credits, including: proactively anticipating the capital implications of upcoming regulatory changes; incrementally and consistently addressing structural deficiencies that may assist with or even preclude eventual large capital projects; and strategically planning funding options and rate increases needed to repay debt. A strong operational and financial management team will not only achieve the aforementioned goals, but also transparently engage with the customer base in order to successfully implement necessary rate increases.

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Framework for Collecting, Reporting and Verifying Agriculture Conservation Practice Data in the Chesapeake Bay Watershed

by Mollie Putzig and Ben Sears

The Chesapeake Bay is impaired by excess nitrogen, phosphorus and sediment from its 64,000 square mile watershed, including portions of six states (Delaware, Maryland, New York, Pennsylvania, Virginia and West Virginia) and Washington, DC. New York's portion of the Chesapeake Bay watershed is made up of the Susquehanna River and Chemung River watersheds, which together form the northern headwaters of the Chesapeake Bay and cover much of New York's Southern Tier.

In 2010, the US Environmental Protection Agency (USEPA) established a total maximum daily load (TMDL) for the Chesapeake Bay to address water quality problems caused by the excess nitrogen, phosphorus (nitrogen and phosphorus together are commonly called "nutrients") and sediment. The TMDL, often called a "pollution diet," defines the amount of nutrients and sediment that can enter the bay, while still allowing the bay to meet water quality standards. Specifically, the TMDL sets a watershed-wide limit of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus, and 6.45 billion pounds of sediment per year that can enter the bay. This means, to be restored, the bay needs a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus, and 20 percent reduction in sediment from the 2009 baseline levels. The TMDL compels Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and Washington DC, collectively called the Chesapeake Bay watershed *jurisdictions,* to work together toward the TMDL's water quality goals. The TMDL requires that all pollution control measures needed to meet water quality goals will be in place by 2025.

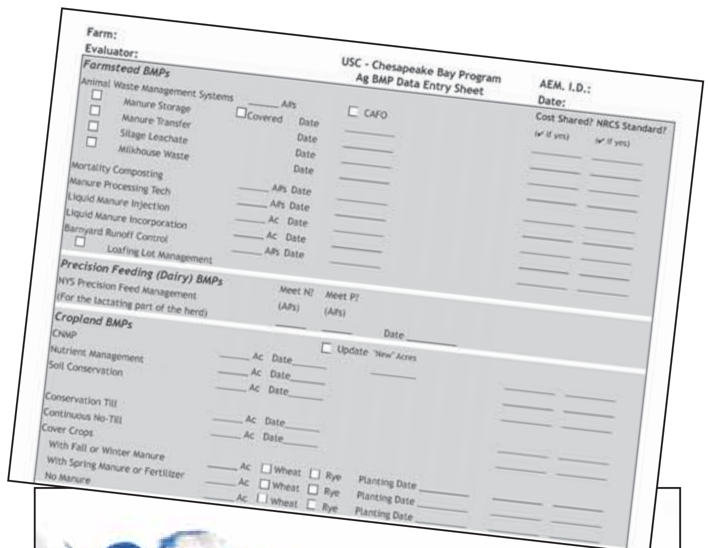
The Chesapeake Bay and its watershed are large and complex, so USEPA relies on computer models to simulate the characteristics of the bay's ecosystem and the effects of the jurisdictions' work to protect and restore water quality. This modeling allows USEPA to monitor progress toward TMDL goals.

When the TMDL took effect, water quality in New York's Southern Tier was already good, with the majority of water bodies in the region not impaired by nutrients or sediment. In fact, only two water bodies – Whitney Point Reservoir and Patterson Creek – are listed with nutrient impairments attributable to agricultural sources.[1] To further improve water quality and assist in bay restoration, New York developed a Watershed Implementation Plan outlining steps to reduce nutrient and sediment loads from major sources including agriculture, wastewater and urban runoff. Achieving these reductions is a challenge that requires collaboration by all New Yorkers in the watershed to plan, implement, maintain and track best management practices (BMPs) for each source.

In all of the jurisdictions, agriculture is a leading force in bay restoration. According to USEPA models, New York agricultural operations reduced nitrogen by 27 percent between 2002 and 2009.[2] Building on this momentum, New York continues to reduce nutrient and sediment loads from agriculture, as it is the largest source of nitrogen, phosphorus and sediment from New York's portion of the watershed. Based on 2013 model simulations, agriculture is the source of 38 percent of the nitrogen, 52 percent of the phosphorus, and 39 percent of the sediment delivered to the bay from New York. It is essential that farm data are accurately collected and reported to quantify nutrient and sediment reductions accomplished by agricultural BMPs. The data will demonstrate the contributions of New York's farmers to Chesapeake Bay restoration and protection of the good water quality found in the Southern Tier.

Data Collection and Reporting

In New York, agricultural BMP data is collected and aggregated by the Upper Susquehanna Coalition (USC is a coalition of Soil and Water Conservation Districts in New York and Pennsylvania) and reported to USEPA by the New York State Department of Environmental Conservation (NYSDEC).


Farm:
Evaluator:
USC - Chesapeake Bay Program
Ag BMP Data Entry Sheet
AEM. I.D.:
Date:

Farmstead BMPs
Animal Waste Management Systems ______ AUs
☐ Manure Storage ☐ Covered Date ☐ CAFO
☐ Manure Transfer Date
☐ Silage Leachate Date
☐ Milkhouse Waste Date
Mortality Composting
Manure Processing Tech ______ AUs Date
Liquid Manure Injection ______ AUs Date
Liquid Manure Incorporation ______ Ac Date
Barnyard Runoff Control ______ Ac Date
☐ Loafing Lot Management ______ AUs Date
Cost Shared? (✔ if yes) NRCS Standard? (✔ if yes)

Precision Feeding (Dairy) BMPs
NYS Precision Feed Management (For the lactating part of the herd) Meet N? (AUs) Meet P? (AUs)

Cropland BMPs
CNMP Date ______
Nutrient Management ______ Ac Date ______ ☐ Update "New" Acres
Soil Conservation ______ Ac Date ______
______ Ac Date ______
Conservation Till
Continuous No-Till ______ Ac Date ______
Cover Crops ______ Ac Date ______
With Fall or Winter Manure ______ Ac ☐ Wheat ☐ Rye Planting Date ______
With Spring Manure or Fertilizer ______ Ac ☐ Wheat ☐ Rye Planting Date ______
No Manure ______ Ac ☐ Wheat ☐ Rye Planting Date ______


Photo by Troy Bishopp, grazing specialist, Madison SWCD

The Upper Susquehanna Coalition collects BMP data, such as prescribed grazing, using worksheets (above) to ensure New York farmers receive credit for their good work.

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The USC relies on the statewide Agricultural Environmental Management (AEM) program as the framework for data collection and verification. AEM provides a consistent format to identify and address environmental concerns through a comprehensive assessment of participating farms. Farmer participation in the AEM program is voluntary and designed to be highly interactive. One provision of AEM is the inventory and documentation of existing BMPs. Building on the AEM process, the USC developed additional procedures specifically to collect and report BMP data to USEPA for the Chesapeake Bay TMDL. The USC formed an "Agriculture Team," which consists of a team leader, coordinator, GIS specialist, data collectors and technicians. While performing on-farm conservation work, members of the Agriculture Team consult with farmers to complete worksheets that describe management of resources on their farm.

This approach, along with data from NYSDEC's Concentrated Animal Feeding Operation (CAFO) program, the NYS Agricultural Nonpoint Source Abatement and Control Grant Program, and federal funding programs through the US Department of Agriculture, provides a comprehensive structure for BMP data collection and reporting in New York. The USC approach encourages farmer participation, increases farmer awareness of the impact their farm activities have on the environment, and seeks behavioral changes, which are all important for achieving New York's Chesapeake Bay restoration goals.

Photo by Troy Bishopp, grazing specialist, Madison SWCD

Cover crops, such as winter wheat planted after corn, can be credited toward New York's nutrient and sediment reduction goals.

Under the AEM framework, conservation professionals in the individual Soil and Water Conservation District (SWCD) offices track implementation and enter the BMP information into a database developed by the USC. The database is used by the SWCDs to plan and evaluate BMPs and has the capability to track practice implementation on individual farms, although individual farm information is not sent to NYSDEC or USEPA. Data is collected on BMPs for farmsteads, cropland, pasture and riparian areas, including manure storage, barnyard runoff control, precision feed management, livestock mortality composting, nutrient management, prescribed grazing, conservation till and no till, cover crops, stream restoration and access control, tree planting, and stream buffers. These and other practices reduce nutrient and sediment runoff into rivers and streams from New York's agricultural land.

Each year, the USC aggregates this BMP data on a county scale and formats it for reporting to the Chesapeake Bay Program for annual model simulations, known as *Progress Runs*. County scale data is sufficient for the Chesapeake Bay Program to model reductions in nutrients and sediment achieved by BMP implementation without compromising the privacy of farmers participating in federal and state programs. The aggregated data, with farm names and locations removed, is sent to NYSDEC, which is responsible for TMDL compliance in New York, including submission of BMP data. The NYSDEC uploads the data files to the National Environmental Information Exchange Network (NEIEN), USEPA's national data network. The Chesapeake Bay modeling tools draw information from NEIEN and other sources to produce the annual simulations that estimate progress toward meeting bay restoration goals.

Data Confidentiality

Protecting the privacy of farmers is an important aspect of New York's data collection and reporting efforts and is required by both state and federal laws. In New York, state law protects the confidentiality of AEM information provided to the Department of Agriculture and Markets and county SWCDs. At the federal level, Section 1619 of the Food Conservation and Energy Act of 2008 (the 2008 Farm Bill) limits disclosure of farm-specific information to organizations that have a "Conservation Cooperator" agreement with USDA's Natural Resources Conservation Service (NRCS). The USC has a Conservation Cooperator agreement, also known as a "1619 Agreement," that allows it access to BMP information for use in its database. Having the USC collect and aggregate all data before sending it to NYSDEC complies with state and federal laws and assures farmers that their privacy is protected.

Data Reliability and Accuracy

One of the challenges faced by the Chesapeake Bay jurisdictions and USEPA is data accuracy and reliability. Modeling tools are only as accurate as the incoming data, so demonstrating progress in Chesapeake Bay restoration relies on accurate and reliable input data. New York has achieved this by assembling a team of trained agricultural technicians from SWCDs, the state Department of Agriculture and Markets, and USDA (NRCS and FSA) to implement and collect BMP information. The expertise and experience of these technicians increases data reliability and accuracy. Because of the strong working relationships among these organizations, data is readily shared, allowing the USC to cross reference the information in its database with information from the other organizations to improve the accuracy of data used for Chesapeake Bay modeling. Reliable and accurate data about existing BMPs also helps New York organizations determine which additional BMPs are needed and leverage other sources of funding to implement those BMPs.

New York continues to work to improve data collection and reporting. The USC has developed its own worksheet to supplement the AEM worksheets that provides more information about BMPs, including acreage and number of animals affected. The USC worksheet is continually updated as Chesapeake Bay BMP definitions and verification protocols evolve. This will allow the Chesapeake Bay model to more accurately quantify New York's contribution toward restoring bay water quality.

Next Steps – Collecting Non-Cost Shared Practice Data

To-date, New York has focused its efforts on practices that are cost-shared by the farmer through a state or federal program, or are implemented under a CAFO permit because these data are the most cost effective to collect and verify. As New York continues working toward its Chesapeake Bay restoration goals, more data about non-cost-shared practices will need to be collected and verified too. This includes practices that are implemented voluntarily and paid for fully by the farmer. As with cost-shared BMP data, the USC's Agriculture Team will lead the collection of non-cost-shared BMP data within the framework of New York's AEM program.

New York has begun a new initiative for collecting non-cost-shared BMP data, by having NYSDEC and SWCD staff collaborate during inspections of CAFO farms in the Chesapeake Bay watershed and complete the same USC worksheet used for cost-shared practices. Including a greater breadth of data in the Chesapeake Bay model will provide a more thorough picture of the efforts of New York farmers to reduce nutrient and sediment loads going into the bay.

Positive Mechanism

Data suggest New York is well positioned to achieve our restoration goals while continuing to conserve local water quality. Accounting for all the good work that New York farmers are achieving already is critical to meeting these goals. The collaboration of local, regional and national organizations to relay information accurately and confidentially is crucial to this process. The data collection and reporting framework described here provides a dynamic mechanism to account for agricultural conservation efforts while protecting farmer privacy and demonstrating New York's contribution to restoration of the Chesapeake Bay.

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Disproving Perceived Barriers in Utilizing Anammox for Full-Scale Wastewater Treatment

Six-Year Pilot Study with Constructed Wetlands

by Wendong Tao and Douglas J. Daley

Traditional Approach to Biological Nitrogen Removal

Ammonia-rich wastewater is generated in a variety of sources such as animal feeding operations, food processing facilities, municipal landfills, and anaerobic digesters. Discharge of ammonia-rich wastewater poses health concerns and ecological impacts, such as toxicity to aquatic organisms, oxygen depletion and eutrophication. Biological nitrogen removal is one of the most commonly used methods to remove nitrogen from wastewater. Traditionally, biological nitrogen removal is accomplished by a combination of nitrification and denitrification in various designs and operating modes. Complete nitrification includes two steps of biochemical processes under aerobic conditions, i.e., nitritation or partial nitrification of ammonium to nitrite by aerobic ammonium-oxidizing bacteria (AOB) and nitratation or nitrite oxidation to nitrate by nitrite-oxidizing bacteria (NOB) as shown in ***Equations 1 and 2***, respectively. Nitrate is further reduced to nitrogen gas by heterotrophic denitrifying bacteria under anoxic conditions as shown in ***Equation 3***.

1. NITRITATION:

$$55NH_4^+ + 76O_2 + 5HCO_3^- \xrightarrow{AOB} C_5H_7O_2N + 54NO_2^- + 57H_2O + 104H^+$$

2. NITRATATION:

$$400NO_2^- + 195O_2^+ NH_4^+ + 4H_2CO_3 + HCO_3^- \xrightarrow{NOB} C_5H_7O_2N + 400NO_3^- + 3H_2O$$

3. DENITRIFICATION:

$$10CH_2O + 5NO_3^- \xrightarrow{\text{Denitrifying bacteria}} C_5H_7O_2N + 2N_2 + 5CO_2 + 13OH^-$$

Based on the above reactions reflecting both bacterial respiration and biomass growth, 3.16 grams (g) O_2 is required for oxidation of 1g ammonium-N and 1.11 g O_2 is required for oxidation of the nitrite produced by nitritation of 1 g ammonium-N. Oxygen required for nitrification is supplied by artificial aeration, which can account for approximately one-half of the total operational cost of biological wastewater treatment processes. Heterotrophic denitrifying bacteria require organic carbon for biomass growth. Where wastewater does not have sufficient organic substrates for complete denitrification, organic substrates such as methanol are supplemented. Supplementation of organic substrates increases operational costs. On the downside, organic carbon of the added substrates is converted to greenhouse gases – CO_2 and CH_4. Meanwhile, both nitrification and denitrification may produce greenhouse gas as N_2O, which has a global warning potential of 310 times that of CO_2. Lastly, nitritation, nitratation, and denitrification produce 0.15 g, 0.02 g, and 1.61 g of microbial biomass ($C_5H_7O_2N$), respectively, for complete removal of 1 g ammonium-N via the nitrification-denitrification process ***(Equations 1–3)***. The waste sludge needs to be thickened and dewatered before final disposal or beneficial reuse, increasing operational cost by approximately one-third.

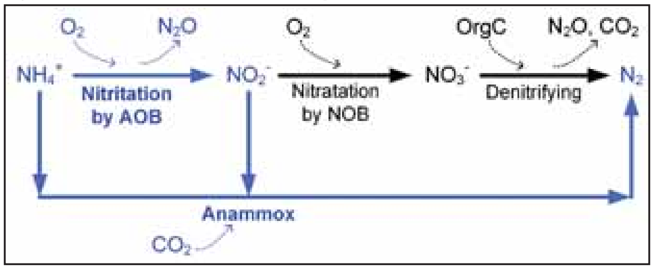
Alternative Biological Pathway

Because of these drawbacks associated with the traditional nitrification-denitrification process, alternative biological pathways under anaerobic and low-oxygen conditions have been intensively explored in the last two decades. Anaerobic ammonium oxidation (anammox), as shown in ***Equation 4***, is the only alternative pathway that has reached full-scale application for biological nitrogen removal. Anammox is either directly used to simultaneously remove both ammonium and nitrite, or coupled with nitritation for complete conversion of ammonium to nitrogen gas. Integration of nitritation and anammox creates a shortcut for nitrogen removal ***(Figure 1)***. The novel nitritation-anammox process occurs as 57 percent of ammonium is oxidized aerobically to nitrite via nitritation, while the remaining ammonium and the nitrite produced are converted to nitrogen gas via anammox. Compared stoichiometrically (calculated by exact chemical reactions) with the nitrification-denitrification process ***(Equations 1-3)***, the nitritation-anammox process ***(Equations 1 and 4)*** requires only 1.80 g O_2 for converting 1 g NH_4^+-N to N_2 and produces 0.08 g AOB and 0.048 g anammox biomass, thus decreasing oxygen demand by 58 percent and waste sludge by 93 percent. Moreover, both AOB and anammox bacteria are autotrophic, thus eliminating the requirement for organic substrate supplementation. The autotrophic bacteria use inorganic carbon as carbon source for biomass growth and N_2O is not produced by anammox. Consequently, the nitritation-anammox process decreases greenhouse gas emissions by 40 percent compared with the nitrification-denitrification process *(Joss et al., 2009)*.

4. ANAMMOX:

$$NH_4^+ + 1.32NO_2^- + 0.066HCO_3^- + 0.13H^+ \xrightarrow{anammox} 1.02N_2 + 0.26NO_3^- + 0.066CH_2O_{0.5}N_{0.15} + 2.03H_2O$$

Figure 1. Anammox as a Shortcut in N Cycle



Misconceptions and Slow Application of Anammox Processes in US

Anammox has been used for nitrogen removal alone, with nitritation, or with nitritation and denitrification at more than 100 full-scale installations, mostly in Europe, China and Japan *(Lackner et al., 2014)*. Fewer large research and development projects have been funded in the United States. The first full-scale treatment system adopting nitritation-anammox in the US began to operate in 2013 by the Hampton Roads Sanitation District in Virginia. DC Water is

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in the development stage of full-scale nitritation-anammox. In New York, feasibility study and pilot tests were conducted at wastewater treatment plants in New York City.

Misconceptions about anammox have retarded adoption of anammox for wastewater treatment in North America. The concerns that became barriers of anammox application in the US often include:

1. Lack of an anammox seeding source
2. Slow growth of anammox bacteria, consequently slow startup
3. Strict operating conditions required for reliable operation
4. Useful only for low C/N (carbon-nitrogen)wastewater

As intense research has been greatly funded in Europe and China over the past decade, these concerns have proven to be misconceptions. Anammox bacteria have been found in marine and lake sediments, natural and constructed wetlands, and various types of activated sludge under various environmental conditions. In 2011, a study found surprisingly high abundance of anammox bacteria in anaerobically digested dairy manure *(Xia et al., 2012)*, which could serve well as a seeding source. Although there are optimum ranges of temperature, pH, dissolved oxygen, and wastewater C/N ratio for nitritation and anammox, anammox has been successfully utilized for nitrogen removal under wide ranges of environmental conditions and various types of wastewater. The doubling time of anammox bacteria has been reported mostly to be from 8 to 11 days, which is longer than denitrifying bacteria. However, stoichiometrically, anammox bacteria have a biomass growth rate in the same magnitude of order as that of AOB. The much lower biomass growth rate of anammox bacteria relative to denitrifying bacteria is preferred because less sludge needs to be wasted. There is a trade-off between the traditional nitrification-denitrification process featuring fast recovery from mishaps plus costly sludge processing and the novel nitritation-anammox process featuring slower recovery plus less waste sludge. The slower recovery of anammox is now minimized with the discovery of more readily available seeding sources and reversible inhibitions of oxygen and nitrite. Co-existence of anammox and denitrifying bacteria has been observed in natural environments and treatment processes with a wide range of wastewater C/N ratios, suggesting broader applicability of anammox.

Pilot Study of Anammox in Constructed Wetlands

Nitritation-anammox has been accomplished in several types of bioreactors through high energy and material inputs with automated control of operating conditions. In the past decade, constructed wetlands have also been explored to nurture anammox along with nitritation and/or denitrification. By incorporating nitritation-anammox with denitrification and the other treatment mechanisms, nitrogen removal rates have been increased in constructed wetlands. Constructed wetlands are designed with emphasis on the use of natural processes, self-organization and sustainable energies. Development of constructed wetlands utilizing nitritation-anammox will contribute to the global endeavor of making wastewater treatment energy neutral and climate friendly.

Constructed wetlands are low-energy alternatives to conventional energy-dependent treatment methods *(Kadlec and Wallace, 2009)*. There are several advantages to use nitritation-anammox in constructed wetlands. First, nitratation has to be inhibited to enhance the nitritation-anammox process. Constructed wetlands provide a low-oxygen environment to favor AOB over NOB, using such natural processes as surface re-aeration, plant transport, photosynthesis, and passive air pump. Second, nitratation may not be completely inhibited and nitrate shall be produced more or less. In addition, nitritation-anammox also converts about 11 percent ammonium to nitrate. Simultaneous nitritation, anammox and denitrification (SNAD) presents a greater potential for complete nitrogen removal. The root exudates of growing plants and leachate from senescent plant tissues can supplement organic substrates for heterotrophic denitrifying bacteria in constructed wetlands. Third, autotrophic AOB and anammox bacteria are usually retained as biofilms or granules in bioreactors due to their lower growth yield coefficients. Both surface and subsurface flow constructed wetlands have solid surfaces such as submerged plant stems, roots, rooting medium and porous packing materials to carry biofilms. Due to microbial reactions in and mass transfer resistance through biofilms, vertical microgradients of oxygen, pH, bacterial substrates and metabolic products usually exist in biofilms, allowing nitritation in the outer layers and anammox and denitrification in the inner layers of biofilms in single wetlands. Compared with highly-controlled bioreactors, the ecologically engineered constructed wetlands provide additional ecosystem services, such as wildlife habitat and aesthetics.

Because of the varying environmental conditions in wetland ecosystems and the ecological design principles, creative design considerations are required to promote nitritation-anammox and inhibit NOB in constructed wetlands. At SUNY College of Environmental Science and Forestry, faculty with students have been pioneering enhancement of simultaneous nitritation and anammox (SNA), as well as simultaneous nitritation-anammox-denitrification (SNAD) in both free water surface and submerged bed constructed wetlands in a greenhouse year-round since 2008. The research was initiated with four wetland treatment trains or systems with free water surface wetlands and pea pebble biofilters (submerged beds) in series ***(Figure 2)*** to examine the effects of limestone addition, vegetation, and aeration on SNAD *(Tao and Wang, 2009)*. These treatment trains were seeded with soil/sediment collected at a local forest lake and operated weekly by batch with

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Photo by Wendong Tao

Figure 2. First generation of wetland treatment systems to initiate simultaneous nitritation, anammox and denitrification. Four systems were operated in parallel (from left to right) for treatment of ammonia-rich wastewater. Each system included two free water surface wetlands (back) and one biofilter packed with pea pebbles (front) in series. Six free water surface wetlands had broadleaf cattails.

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Table 1. Performance of Constructed Wetland Systems: Enhancing Nitritation and Anammox

	Free Water Surface Wetlands			Gravel Biofilters (submerged beds)		
YEAR	**Influent NH_3-N (mg/L)**	**NH_3 removal rate (g N/m^3/d)**	**TIN removal rate (g N/m^3/d)**	**Influent NH_3-N) (mg/L)**	**NH_3 removal rate (g N/m^3/d)**	**TIN removal rate (g N/m^3/d)**
2008	53–58	4.7–7.7	4.6–6.9	7–33	0.7–4.4	0.7–2.4
2009–2010	42–116					
248–293	8.8					
10.6	13.3					
12.3	176–202					
378–413	11.4–15.8					
18.2–22.3	5.2–8.5					
7.6–13.0						
2010–2011	258	22.8	22.0	309	7.6	7.5
2011	144	4.9	5.4	202	9.2	9.5
2012	144	3.7–11.6	2.2–8.8	210	9.7–10.1	9.6–10.1
2013	183	9.4–10.6	8.5–9.2	200	3.6–4.0	3.7–4.1
Review[a]	1–406	≤ 4.5	≤ 5.1	0.3–230	≤ 2.4	≤ 3.2

[a]*For ≥80% constructed wetlands reviewed by Kadlec and Wallace (2009)*

synthetic ammonia-rich wastewater.

The **second generation** of pilot systems was operated in 2009 and 2010 to compare pea pebble and marble chips packed in two series, respectively, each having two gravel biofilters and one free water surface wetland in series *(Tao et al., 2011)*. The pea pebble biofilters failed because of decreasing pH, while the marble chip biofilters had increasing N removal rates until stabilized after 26 weeks of batch operation.

The **third generation** of wetland treatment systems was operated in 2010 and 2011 to test the low-cost pH controls and investigate the effects of pH and seasonal temperature variation on SNA *(He et al., 2012; Tao et al., 2012)*. The systems were seeded with anaerobically digested dairy manure and activated sludge, and operated weekly by batch with dairy wastewater. Likely due to increased water depth in the biofilters, N removal rates were lower than those in the second generation setup, while N removal rates of the free water surface wetlands were more than doubled from the preceding setup due to the improved pH control. The microbial communities in the wetlands were examined with fluorescence *in-situ* hybridization technique and found that AOB and anammox bacteria accounted

Photo by Wendong Tao

Figure 3. Current settings of the third generation of wetland treatment systems which are enhancing nitritation and anammox for treatment of dairy wastewater. Two vegetated submerged beds (left photo) packed with marble chips and planted with papyrus (left) and broadleaf cattails (right), respectively, were operated in series with free water surface wetlands (above) planted with papyrus.

for 69–74 percent of all bacteria in the marble chip biofilters and 42–73 percent in the free water surface wetlands, being the highest reported in the literature for constructed wetlands. The third generation of systems was operated after Fall 2011 at modified water depths and different plant species including *Typha, Phragmites,* and *Papyrus* ***(Figure 3)***. Two types of biofilter packing materials (marble chips and rubber mulch) were compared in biofilters and an insignificant difference was found. In general, the pilot studies showed that ammonium and total inorganic nitrogen (TIN) removal rates were higher at higher ammonium mass loading rate and influent concentration. Maintaining pH in the optimum ranges for nitritation and anammox is important for efficient nitrogen removal in the constructed wetlands.

As a whole, these constructed wetlands designed and operated to enhance SNA and SNAD achieved higher nitrogen removal rates compared with the typical values reviewed on earlier constructed wetlands ***(Table 1)***. The yearly variations in N removal performance are associated with the different designs and operating conditions during each experimental period. The design and operating parameters may affect factors such as pH, concentrations of free ammonia and nitrous acid, dissolved oxygen concentration, and biofilm biomass which regulate the activities of AOB and anammox bacteria. Under given conditions, the startup period was 26 weeks initially with limited seeding and 16 weeks when seeded with anaerobically digested dairy manure *(Tao et al., 2012; Tao and Wang, 2009)*. When operating conditions were changed, it took approximately one to three weeks to see stable performance. Over the six years of pilot operation, no clogging was noticed, which could occur in constructed wetlands using the nitrification-denitrification process. Seasonal temperature variation had little effect on SNA. In 2011, recirculating vertical flow subsurface wetlands were set up and they achieved much higher nitrogen removal rates with the liquid portion of anaerobically digested dairy manure. The design is continuously improved using experimental and modeling approaches.

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Development and Use of a Basin-Scale Hydrologic Model for the Onondaga Lake Basin

by William F. Coon

The water quality of Onondaga Lake, which was once identified as one of the nation's most polluted lakes *(Effler, 1996)*, has greatly improved over recent years in response to pollution control measures to reduce industrial and sanitary sewer discharges and to control nonpoint sources of stormwater pollution. These measures include, but are not limited to, upgrades to the Metropolitan Syracuse Wastewater Treatment Plant, cleanup of industrial pollution sites, control of stormwater runoff from agricultural and urban areas, reduction in the number of combined sewer overflows (CSOs), mitigation of sediment loads from the Tully mudboils ***(Figure 1)***, and implementation of green infrastructure alternatives and agricultural environmental management plans *(New York State Department of Environmental Conservation, 2010).*

The planning and implementation of stormwater runoff controls is a complex problem. Potential sources of contamination – both point and nonpoint sources – first need to be identified and loads (the mass of the contaminant being transported per unit time) estimated. Then the sources need to be assessed as to their respective contributions to a receiving water body, which can vary depending on the source's location in the watershed and its distance from the water body. Finally, estimates of load reductions need to be allocated to these sources and mitigative measures implemented to achieve these reductions. A tool that can assist water resources managers in this task is the creation of a basin-scale precipitation runoff model, which can be used to simulate and better understand the processes responsible for the generation of loads of sediment and nutrients that are transported to the receiving water body.

Photo by William M. Kappel, USGS, Ithaca, NY

Figure 1: Mudboils – volcano-like cones of clay, silt and fine sand brought to the land surface by groundwater under artesian pressure – are a source of turbidity to Onondaga Creek.

Onondaga Lake Basin Model

During 2003 to 2007, the US Geological Survey (USGS), in cooperation with the Onondaga Lake Partnership, developed a model of the Onondaga Lake Basin (***Figure 2***; *Coon and Reddy, 2008)*, which was based on the computer program, Hydrological Simulation Program–FORTRAN *(Bicknell et al., 2001)*. The model simulated overland flow to, and streamflow in, the four major tributaries to Onondaga Lake – Onondaga Creek, Harbor Brook, Ley Creek and Ninemile Creek. The model also simulated water temperature, concentrations of dissolved oxygen, and concentrations and loads of sediment, orthophosphate, total phosphorus, nitrate, ammonia and organic nitrogen.

The 285-square-mile Onondaga Lake Basin was divided into 107 sub-basins, and within these sub-basins, the land area was apportioned among 19 pervious and impervious land types on the basis of land use and land cover, hydrologic soil group (HSG), and aspect. Simulated flows were calibrated to data from nine USGS streamflow monitoring sites. Simulated nutrient concentrations and loads were calibrated to data collected at six of the nine monitoring sites, most of which were located near the downstream ends of the tributaries. Several time series of flow and sediment and nutrient loads were generated for known sources of these constituents, including the Tully Valley mudboils (flow and sediment), Otisco Lake (flow and nutrients), the Village of Marcellus Water Pollution Control Plant (flow and nutrients), and springs from carbonate bedrock (flow). The mitigative effects that the Onondaga Reservoir (upstream from the Onondaga Creek Flood Control Dam) and Otisco Lake were presumed to have on loads of sediment and particulate constituents were simulated by adjustment of parameter values that controlled sediment settling rates, deposition, and scour in the reservoir and lake.

Comparisons of model results indicated that simulated daily and monthly streamflows were generally within 10 percent of observed flows. Simulated monthly loads of total phosphorus were within 15 percent of loads computed by the Onondaga County Department of Water Environment Protection using a multiple regression model *(EcoLogic, LLC, 2003)*. No observed data were available by which to directly assess the model's simulation of suspended sediment loads.

Collection of New Data for Model Calibration

One of the shortcomings of any modeling project is the paucity or lack of adequate data with which to calibrate the model. The model results are only as good as the data on which the model is developed and when calibration data are absent or inadequate, assumptions based on hydrologic "good sense" must suffice. Modelers and users accept this shortcoming and use the model results with this understanding. In the case of the Onondaga Lake Basin model, data for calibration of the model were available from monitoring sites only at or near the mouths of the major tributaries to Onondaga Lake; no calibration data from headwater subbasins, where the loads originated, were available.

To address this limitation and thereby decrease the uncertainty in the simulated results associated with headwater processes, the USGS, in cooperation with the Onondaga Lake Partnership, conducted a three-year (2005–2008) basinwide study to assess the quality of surface water in the Onondaga Lake Basin *(Coon et al., 2009)*. The study quantified the relative contributions of nonpoint sources associated with the major land uses in the basin and also focused on known sources (streams with large sediment loads) and presumed sinks (Onondaga Reservoir and Otisco Lake) of sediment and nutrient

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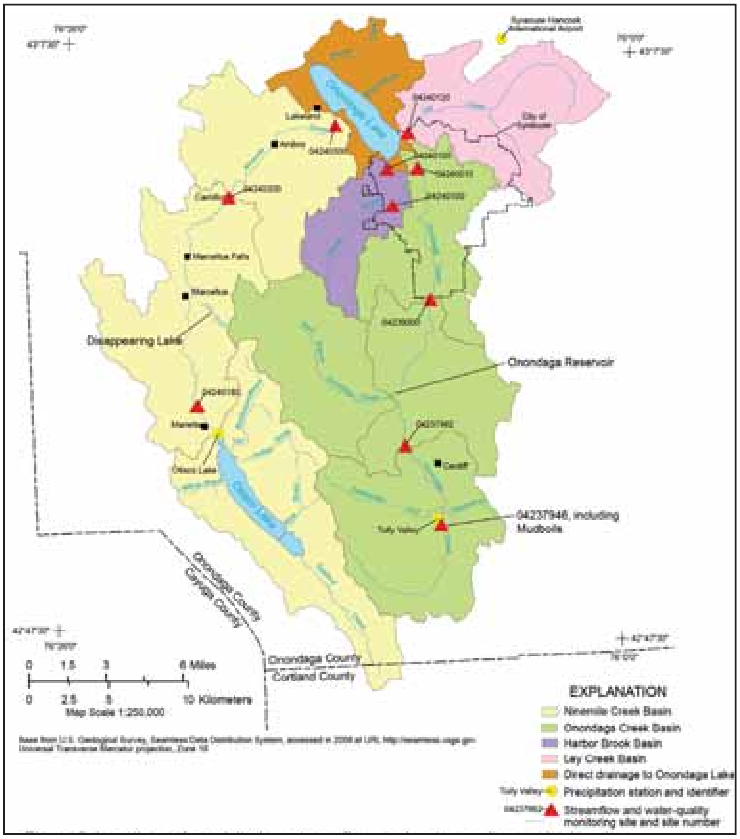
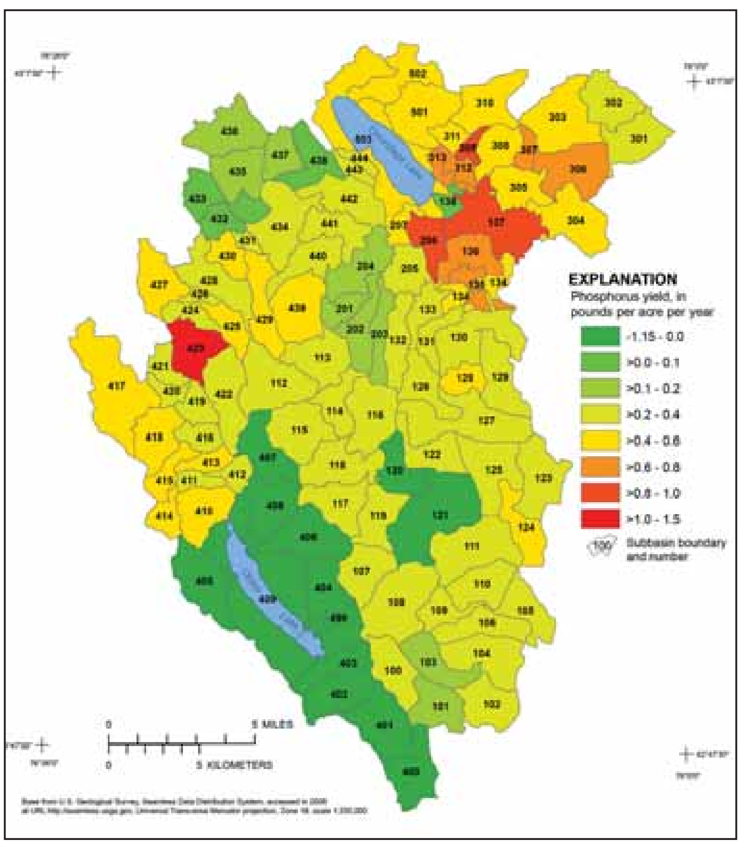


Map courtesy of USGS

Figure 2. Locations of precipitation, streamflow and water quality monitoring sites in the Onondaga Lake Basin, Onondaga County, NY *(Coon and Reddy, 2008)*



Map courtesy of USGS

Figure 3: Estimated sub-basin phosphorus yields that enter Onondaga Lake, Onondaga County, NY *(Coon, 2011)*

loads, which previously had not been evaluated. Water samples were collected and analyzed for nutrients and suspended sediment at 26 surface water sites and four springs in the basin. More than 1,060 base-flow, stormflow, snowmelt, spring water, and quality assurance samples collected during the study were analyzed for ammonia, nitrite, nitrate plus nitrite, ammonia-plus-organic nitrogen, orthophosphate, phosphorus, and suspended sediment. The concentration of total suspended solids was measured in selected samples and nutrients were analyzed in precipitation and snowpack samples. Specific conductance, salinity, dissolved oxygen, and water temperature were also measured in the field.

Recalibration of Onondaga Lake Basin Model

The Onondaga Lake Basin model was recalibrated on the basis of these newly acquired data *(Coon, 2011)* and improvements in the simulation of processes in the headwater sub-basins, including suspended sediment, orthophosphate, and phosphorus generation and transport, were noted. The use of suspended sediment concentrations rather than concentrations of total suspended solids resulted in substantial increases in the simulated low-flow sediment concentrations and, in most cases, decreases in the simulated peak flow sediment concentrations. The mitigative effects of the Onondaga Reservoir and Otisco Lake, which had not been previously quantified, were incorporated into the revised model.

The calibrated model was used to:

1. Compute loading rates of sediment and nutrients for the various land types that were simulated in the model
2. Conduct a watershed management analysis to identify sub-basins that generated disproportionately large loads of sediment and phosphorus and, subsequently, to estimate the portions of the total loads that were likely to be transported to Onondaga Lake from each of the modeled sub-basins ***(Figure 3)***
3. Compute and assess chloride loads to Onondaga Lake from the Onondaga Creek Basin
4. Simulate precolonization (forested) conditions in the basin to estimate the probable minimum phosphorus loads to the lake
5. Compute the total maximum daily load for phosphorus in Onondaga Lake and to allocate these loads among the many contributors in the Onondaga Lake Basin by the New York State Department of Environmental Conservation *(2012)*.

Use of Calibrated Model to Manage Nutrient Loads

In addition to the uses listed above to which the Onondaga Lake Basin model was applied, a calibrated model can be used to assess many "what-if" scenarios. These scenarios reflect before and after conditions and the model results indicate the effects that a given activity is likely to have on streamflow and sediment and nutrient loads. In this way, the effects of urbanization and other land-use changes, agricultural activities, best management practices, detention basins, and even zoning laws can be assessed before a given activity occurs in a basin. Model results could be used to prioritize areas of the basin where mitigative measures to decrease sediment and nutrient loads could provide the greatest benefits. If interested in probable future conditions that might develop as a result of climate change, the meteorological datasets that drive the model can be extended into the future with predicted climate data. The results of such a modeled scenario could guide decision makers on measures to take in the present to prevent negative impacts in the future. These analyses provide water resources managers with the information needed to make informed decisions before incurring the expense and time associated with actual implementation of a given activity.

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Innovative Nitrogen Removal in New York City

by Allen Deur, Keith Beckmann, Vin Rubino, Peter Young, Sarah Galst, Robert Sharp and Melissa Motyl

Jamaica Bay, a 28,000 acre estuary, is an important ecological resource in New York City with a vast network of open waters, salt marshes, woodlands and fresh water wetlands. It holds the distinction of being the only United States National Park reachable by subway, and serves as a vital source of recreation and leisure for thousands of local residents and visitors. The bay supports numerous species of fish, birds, and is an important habitat for many species of reptiles, amphibians and mammals. The bay's proximity to New York City's ultra-urban environment produces unique environmental protection challenges.

Courtesy of Hazen and Sawyer

A view of the complex Jamaica Bay ecosystem

Over the past century, Jamaica Bay water quality has been degraded by the nitrogen-heavy discharge of wastewater treatment plant (WWTP) effluent. Nitrogen is a naturally-occurring element found in food and other organic materials and present in wastewater when it enters treatment plants. The nitrogen prevalent in the WWTP effluent acts as a fertilizer for algae in the bay. The overabundance of nitrogen fosters an overabundance of algae, which restricts the oxygen available to other aquatic life and leads to violations of state water quality standards and loss of biodiversity.

Courtesy of Hazen and Sawyer

An aerial view of the 26th Ward WWTP located in Brooklyn, with Jamaica Bay in the background. The newly built and first-in-the-nation separate centrate treatment (SCT) wastewater facility that operates a glycerol storage-and-feed system is reducing effluent nitrogen by 67 percent.

Numerous efforts are underway to mitigate the effects of human-caused stressors on this vital resource and restore the water quality and biohabitat diversity of the bay. One such effort is the New York City's Department of Environmental Protection's (NYCDEP's) Research and Development (R&D) Project for Nitrogen Removal. This project pilot tested and implemented an innovative wastewater treatment technique, placing into service the first separate centrate treatment (SCT) wastewater facility in the nation at the 26th Ward WWTP.

Courtesy of Hazen and Sawyer

The glycerol addition system that services the SCT process consists of three progressive cavity pumps, a network of piping, various meters and sensors, and two storage tanks (one storage tank is visible in right background).

The 26th Ward Wastewater Treatment Plant went into operation in 1944 and serves more than 283,000 residents. Located in eastern Brooklyn, it treats up to 85 million gallons of wastewater a day and up to 170 million gallons during wet weather events.

SCT Break-through Process Using Glycerol

The nitrogen reduction technology at the 26th Ward Wastewater Treatment Plant removes nitrogen from the treated water by adding glycerol, a high-strength carbon byproduct of biodiesel production that is non-hazardous and non-flammable, to a dedicated separate centrate tank at the plant. The more commonly used chemical, methanol, is highly toxic, flammable and can be hazardous to wastewater treatment plant operators.

The SCT facility is designed to reduce nitrogen from the plant's centrate, a high-strength ammonia wastewater stream. As part of the biological nitrogen removal, a supplemental chemical (or carbon source) can be used to enhance the nitrogen removal process. The SCT process (with glycerol as a stimulus) converts nitrogen in its liquid form to harmless nitrogen gas, which naturally constitutes 78 percent of the air we breathe. The glycerol addition facility – the subject of this breakthrough project – was placed in operation on

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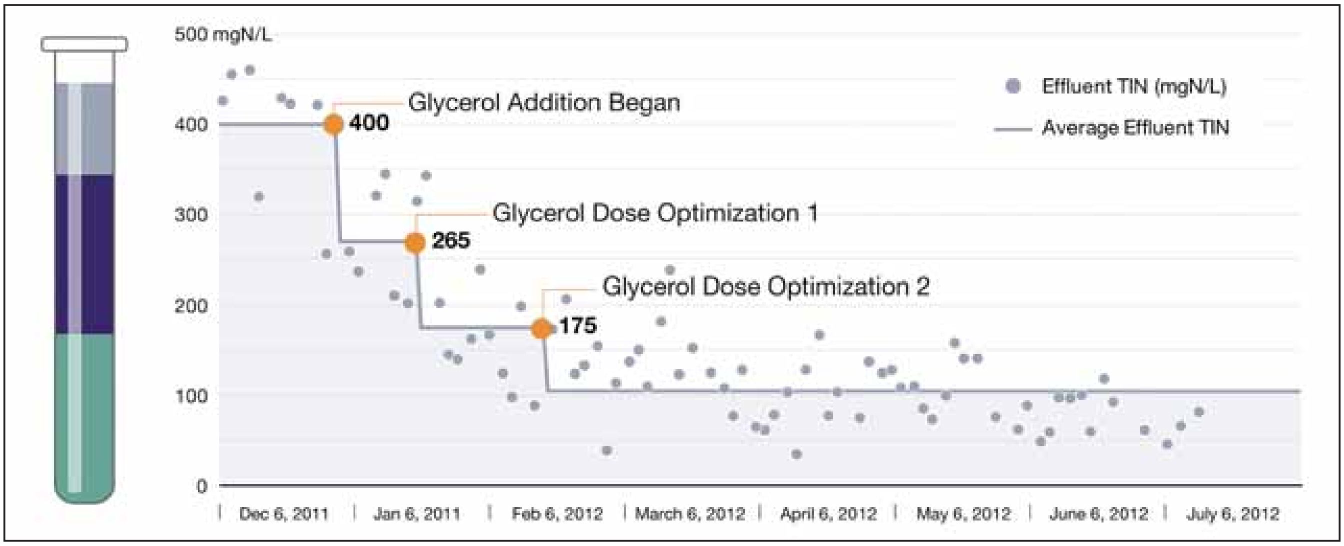
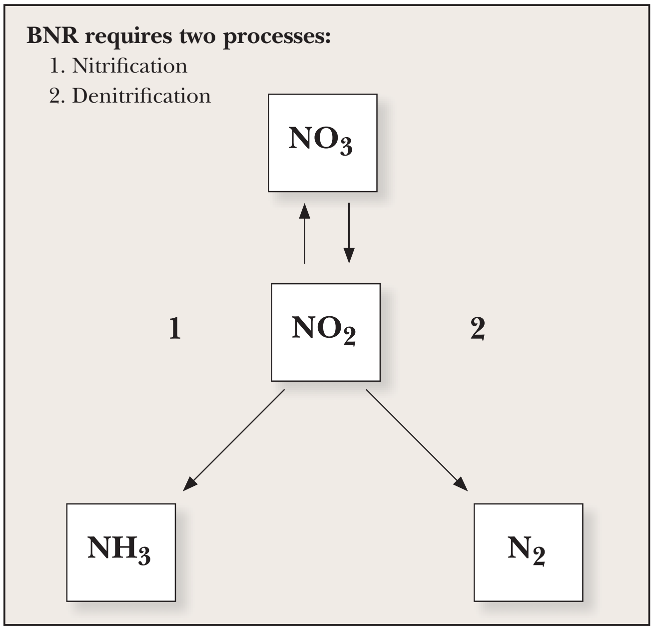
Glycerol Reduces Pollution of Jamaica Bay



December 31, 2011 and has successfully produced a significant reduction in nitrogen discharge. Hazen and Sawyer completed the design and process monitoring of the glycerol facility at 26th Ward Wastewater Treatment Plant in joint venture with CH2M HILL.

As the first application in the United States to employ glycerol to denitrify a high strength ammonia waste stream in a SCT process, the project demonstrates a breakthrough in wastewater treatment. The glycerol facility has resulted in 67 percent reduction in the effluent nitrogen, decreasing discharges from 5,800 lb/day of total inorganic nitrogen in December 2011 to 1,900 lb/day of total inorganic nitrogen today (graph above). Due to the outstanding performance of the facility, New York City was able to eliminate the need for additional treatment at 26th Ward. A $30 million procedure known as the ammonia recovery process (ARP) was being contemplated, however, the $1.5 million glycerol facility achieved the goal of nitrogen reduction, allowing the city to negotiate the elimination of the ARP process with the state regulatory authority.

By substituting glycerol, wastewater operators are not exposed to the health and safety concerns of methanol. Methanol or methyl alcohol is highly toxic and flammable and must be handled and stored safely. Designing a supplemental carbon facility that can safely store, pump and utilize methanol can add 10 to 30 percent to the capital construction cost, which can translate to more than a million dollars at large-scale WWTPs. In contrast, glycerol is not flammable and does not have the handling and storage concerns of methanol.



Glycerol is also a more sustainable chemical than methanol. Glycerol is a natural byproduct of biodiesel production, with a production rate of about one gallon of the byproduct produced per 10 gallons of biodiesel. The recent increase in the production of biodiesel has led to an interest in recovery and beneficial use of this glycerol. In 2011, more than 1 billion gallons of biodiesel were produced as part a federally-sponsored effort to reduce the US reliance on foreign oil imports. New York City's glycerol is obtained from local biodiesel producers, which further reduces transportation and environmental costs. Several years ago, the "crude" glycerol byproduct was typically incinerated by biodiesel producers due to lack of a market for the product, but today it is a large part of the growing biodiesel industry.

How It Works: The nitrogen removal process is traditionally a two-step process of nitrification and denitrification ***(diagram left)***.

In the nitrification process, ammonia (NH_3) is oxidized to nitrite (NO_2) and then to nitrate (NO_3) in the presence of oxygen and with sufficient alkalinity, as shown in ***Equation 1***. The second step to nitrogen removal, denitrification, is the reduction of NO_3 and NO_2 to nitrogen gas (N_2) under anoxic conditions and in the presence of a carbon source, as shown in ***Equation 2***.

Equation 1: $NH_4^+ + 2\ O_2 \quad NO_3^- + 2H^+ + H_2O$

Equation 2: $6NO_3^- + 5CH_3OH \quad 3N_2 + 5CO_2 + 7H_2O + 6OH^-$

There are several operating conditions that are essential to the success of overall nitrogen removal. The nitrification process is reliant upon a bacterial population that is slow growing and very sensitive to dissolved oxygen (DO) concentrations and pH. In order to optimize nitrification, a sufficiently high population of the nitrifying biomass must be available, and the DO concentrations and pH values must

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be held in an optimum range. The pH can be controlled through the use of supplemental alkalinity. The denitrification process is conducted by bacteria commonly found in the activated sludge system; however, it does require a readily biodegradable carbon source. If sufficient carbon does not exist inherent to the wastewater then, in most cases, supplemental carbon must be added. Common supplemental carbon sources include methanol, ethanol and glycerol.

Cost Considerations: Glycerol features steady pricing and availability, offering municipalities a safe and reliable supplemental carbon source to help them meet their permit regulations to remove nitrogen. Since methanol – the current industry standard for supplemental carbon – has a wide variety of industrial uses, its price and availability experiences high volatility, even during good economic conditions. During the economic boom of 2007–08, methanol prices doubled in a few months and large industrial consumption made it difficult for wastewater plants to receive deliveries.

Future Applications in NYC and Beyond

New Yorkers produce, and the NYCDEP treats, an average of 1.3 billion gallons of wastewater every day. The wastewater is collected through 7,400 miles of sewers that ultimately carry this flow to one of the city's 14 wastewater treatment plants.

With six of the city's wastewater treatment plants requiring more stringent nitrogen removal over the next few years, the results of this R&D project led the city to re-evaluate its selection of a supplemental carbon source. Nearly 200 wastewater treatment plants in the United States use methanol to denitrify their wastewater; it is this wide and successful use that drove New York City's Nitrogen Program to consider the use of methanol initially. After the R&D project, however, the city selected glycerol to use at all of its plants because it was proven to be safer to handle and more sustainable than methanol.

The NYCDEP has committed more than $100 million to reduce nitrogen discharges from the four wastewater treatment plants along Jamaica Bay by 50 percent over the next 10 years and nearly $20 million to wetland restoration projects.

The NYCDEP is also investing more than $1 billion to reduce nitrogen discharges from the four Upper East River wastewater treatment plants – Bowery Bay, Hunts Point, Tallman Island and Wards Island – which will reduce total nitrogen discharges from the four plants by more than 52 percent. Based on the work of New York City's R&D contract, the NYCDEP will utilize glycerol throughout the East River plants, treating more than 700 million gallons per day and saving up to $13 million per year in reduced chemical purchasing costs. The work is being funded by NYCDEP and is the result of an agreement between it, and the Office of the New York State Attorney General and the New York State Department of Environmental Conservation (NYSDEC).

Global Implications: Many municipalities are faced with more stringent wastewater effluent permit requirements to reduce their discharge of nitrogen. This study demonstrates that glycerol is a feasible alternative to the traditional use of methanol, and that major cities can use it as a cost-efficient alternative. Major initiatives to reduce nitrogen loading to the Long Island Sound, Chesapeake Bay and Gulf of Mexico are underway to improve water quality in these high nutrient, low oxygen water bodies. The results of the city's research can be applied to hundreds of wastewater facilities that discharge to these and other water bodies where the oxygen content is depleted by organic nutrients.

In the United States, the last major paradigm shift in wastewater treatment was the passage of the Clean Water Act in 1972, which required secondary treatment for WWTPs. It authorized $24.6 billion in immediate research and construction grants to achieve this treatment standard. Forty years later, it is estimated that utilities have spent more than $100 billion (inflation adjusted) toward Clean Water Act compliance.

Regulatory trends indicate more and more utilities will face stringent nutrient limits in the coming decades. The American Society of Civil Engineers estimates a $380 billion need in the US over the next 20 years for utilities to comply with regulations currently being phased in, a figure that will only increase as additional nutrient limits are promulgated. Using the work of New York City as a guide, using glycerol as an alternative to methanol has the potential to save America's wastewater utilities upwards of $100–$200 million per year.

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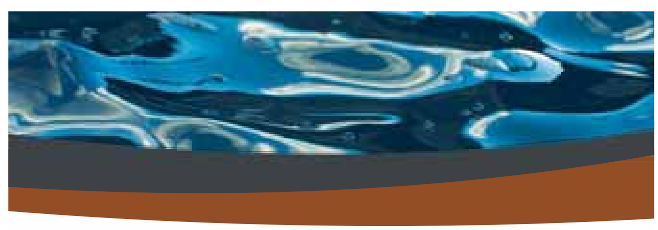

Suffolk County Sludge Odor Control Program at Bergen Point Wastewater Treatment Plant

by Sean Murtagh, Paris Neofotistos and Doug Haussel

A field demonstration was initiated in February 2014 by the Suffolk County Department of Public Works (SCDPW) to quantify the impacts of Peroxide Regenerated Iron-Technology (PRI-TECH™) as a more economic approach in maintaining odor control in the solids handling phase of the wastewater treatment plant (WWTP) Bergen Point.

For approximately the last 30 years, the SCDPW Bergen Point WWTP has treated H_2S (hydrogen sulfide)and reduced sulfur compound-based odors in the sludge handling phase at the facility with potassium permanganate ($KMnO_4$). The sludge handling phase includes sludge waste from three locations: sludge from the primary clarifiers; thickened waste activated sludge from the aeration basins; and chemical sludge from the facility's scavenger sludge collection system. The three streams have been co-mingled in a 0.25 million gallon capacity sludge blend tank that is turned over approximately every 24 hours. Suffolk County explored a PRI-TECH™ demonstration program in an effort to achieve equal to or better performance than the current odor control program while reducing operating costs.

Figure 1: Diagram of Pilot Odor-Control Process

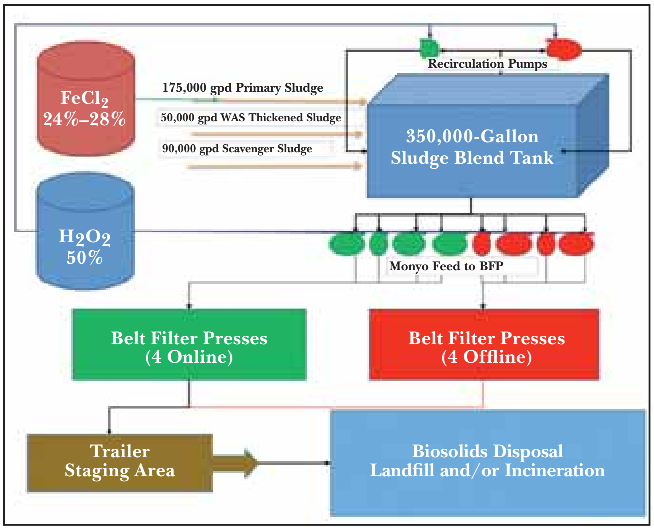

Image courtesy of Suffolk Co. DPW

Program Approach

This demonstration evaluated the use of PRI-TECH™ for controlling sludge odors, composed mainly of hydrogen sulfide gas and reduced sulfur compounds (mercaptans, etc.), while maintaining the belt filter press operation. The product is a proprietary odor and corrosion control program that utilizes iron salts and oxidants in a fashion that reduces sulfides to elementary sulfur and reduced sulfur compounds to non-odorous compounds. This program was implemented by adding ferrous chloride ($FeCl_2$) as the primary sulfide control agent into the primary sludge line upstream of the sludge blend tank. Hydrogen peroxide (H_2O_2) was added downstream at the sludge blend tank recirculation pumps to regenerate iron from ferrous sulfide (FeS) to either free ferrous and/or ferric iron. The H_2O_2 was also added to the online belt press feed pumps discharge piping to provide additional iron regeneration and durational odor control ***(Figure 1)***. The iron also acts as a catalyst to allow the hydrogen peroxide to more efficiently and quickly oxidize reduced sulfur compounds such as mercaptans.

Results of Field Demonstration

Odor control was analyzed by measuring liquid sulfide and mercaptan levels through a "shake" test in which sulfide and mercaptan compounds are oxidized and analyzed with either Odalog portable gas detection instruments or colorimetric tubes. Vapor phase sulfides and mercaptans were analyzed by the same methods. After program optimization during the demonstration period, there were no recorded sulfides or mercaptans in either the treated sludge or the sludge blend tank headspace ***(Table 1)***.

An additional opportunity to expand the program beyond the plant to the outside disposal sites was evaluated. Analytical methods for evaluating specific odor compounds were not available at any of the disposal sites. Durational odor control has been evaluated based on subjective experiences of the operators at the disposal sites. Optimization of the program, including the use of targeted dosing with weekend and holiday modes profiles ***(Figure 2)***, produced a reduction in odors at the disposal sites, according to the operators.

Table 1: Sludge Blend Tank Shake Test

Phase	Average H2S (ppm)	Maximum H2S (ppm)	Average RSH (ppm)	Maximum RSH (ppm)
Transition Period	6.0	7.0	5.3	10.0
Field Trial (Start)	0.0	0.0	0.0	0.0
Optimization	0.1	1.0	0.6	3.0
Post Field Trial				
Weekend Profile	0.0	0.0	0.0	0.0
Weekday Profile	0.0	0.0	0.0	0.0
Carrier Water Install				
Weekend Profile	0.0	0.0	0.0	0.0
Weekday Profile	0.0	0.0	0.0	0.0

The demonstration program was shown to have positively benefited the operation of the belt filter presses and the filter cake generated. An indirect benefit of the PRI-TECH™ program is the potential to generate ferric iron (Fe^{3+}), which could assist in sludge dewatering and in producing higher percent solids in the pressed solids. Ferric iron is generated through the reaction of ferrous iron and hydrogen peroxide. During the demonstration period, polymer use was unaffected and an increase in percent solids was noted in the

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filter cake from a comparable period the previous year.

Costs: Based on the current use of $FeCl_2$ and H_2O_2, the average daily operating cost was $5,080. Compared to the previous three-year average $KMnO_4$ usage program, there was an average savings of $1,150 per day for a projected total yearly chemical cost savings of over $400,000.

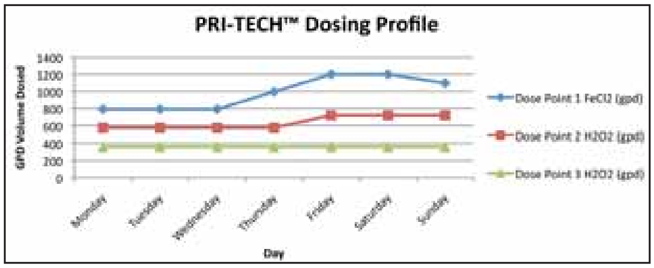

Figure 2: 7-Day Dosing Profile at Disposal sites

Figure courtesy of Suffolk Co. DPW and US Peroxide

Table 2: Field Demonstration Cost Savings Summary

	$KMnO_4$	PRI-TECH™ Ongoing
Daily Average	$6,230[1]	$5,080
Yearly Average	$2,273,950	$1,854,200
Projected Yearly Savings		$419,750

[1] *Three year average*

As the program continues to be optimized, additional savings may be expected. Not captured in the chemical cost savings are additional savings realized from decreased operator labor hours required to maintain the $KMnO_4$ system and slightly higher belt filter press percent solids which result in lower trucking costs and disposal fees *(Table 2)*.

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Photo courtesy of Bergen Point WWTP

Aeration basins are seen in operation at the Suffolk County Bergen Point Wastewater Treatment Plant.

Utilizing Extractive Nutrient Recovery to Effectively Manage Nutrient Rich Sidestreams

by Wendell O. Khunjar, Katya Bilyk, Ron Latimer, Laurissa Cubbage, Paul Pitt, Bill Balzer, Rick Baumler and Charles Bot

Wastewaters are increasingly being viewed as a renewable resource whereby value added products (e.g. water, nutrients, energy, carbon, other resources) can be recovered and reused. This shift in focus from removal to extractive recovery whereby a chemical product that is distinct from biosolids is recovered, can reduce energy consumption, improve treatment efficiency, reduce nuisance scaling and provide utilities with alternative revenue streams with which to offset operational and capital costs. Within this context, both nitrogen (N) and phosphorus (P) have been identified as ideal candidates for extractive recovery from water resource reclamation facilities (WRRFs). A review of the extractive nutrient recovery concept, and a case study facility that has successfully practiced extractive nutrient recovery are provided here.

Making the Case for Extractive Nutrient Recovery

The nutrient concentration in the influent to municipal WRRFs typically ranges from 10 to 50 mg N/L for N, and from 1 to 10 mg P/L for P *(Latimer et al., 2012)*. Since the efficiency of extractive nutrient recovery technologies is low at these concentrations, N and P must first be concentrated. This can be accomplished using a combination of existing biological and chemical treatment technologies.

For instance, up to 20 percent of the influent N load will be assimilated into biomass in activated sludge systems. Similarly, up to 90 percent of the influent P load can be accumulated into the solids fraction through use of enhanced biological phosphorus removal (EBPR), or chemical precipitation with metal salts.

Once accumulated into the solids phase, a large faction of these nutrients can be released into a low volume stream via solids stabilization processes like anaerobic digestion. One important exception is the fraction of P that is removed via metal salt addition. Metal associated phosphorus complexes are not solubilized during conventional solids removal processes and require further processing for extractive nutrient recovery.

For plants that do not practice chemical P removal, the P and N load of the nutrient rich sidestream resulting from the solids stabilization process can represent between 10 and 30 percent of the total nutrient load to WRRFs. These nutrient rich loads can compromise the mainstream EBPR performance as well as increase nuisance scaling potential within solids handling processes.

Importantly though, these low flow nutrient rich streams represent an ideal feedstock for extractive nutrient recovery processes like struvite crystallization, which is the most commonly applied technologies. In the crystallization process, P can be recovered from sidestream flows as struvite ($NH_4MgPO_4{\bullet}6H_2O$) or hydroxyapatite ($(Ca_5(PO_4)3(OH)$) within designated reactors in which the precipitation potential in the reactor is controlled by sodium hydroxide (NaOH) addition while limiting reagents, typically magnesium (Mg)

Table 1. Overview of Phosphorus Recovery Alternatives

Application	Principle Behind Recovery	Chemical Additions Needed	Recovered Element	Examples of Technology	Reuse Potential
Wastewater and Sludge	A concentration step (e.g., EBPR or adsorption onto selective media) acts to remove P from the mainstream flow. P is then released into a smaller stream via anaerobic digestion, VFA stripping or media regeneration. This stream is then subjected to chemical precipitation and crystallization under alkaline conditions.	Mg, Ca, NaOH	P, N, Mg	Pearl®, Multiform Harvest (MH) process, PHOSPAQ™, Crystalactor™, NureSys™	Fertilizer
		Ca, NaOH	P, Ca	P-ROC™	Replacement for P rock
		Quartz (sand) NaOH, Ca	P, Ca, trace metals	Crystalactor™	Replacement for P rock
	Acid addition to digested sludge re-dissolves nutrients. The sludge is then dewatered to generate a nutrient rich stream which is then subjected to chemical precipitation at alkaline pH.	H_2SO_4, H_2O_2, Na_2S, Mg, NaOH	P, N, Mg	SEABORNE™ E™	Fertilizer
Sludge Ash	Acid addition to sludge ash re-dissolves nutrients. Selective precipitation of phosphate complexes is performed at pH 3.5.	H_2SO_4, Ca	P, Ca, Al	SEPHOS™	Replacement for P rock; coagulant
	Potassium or magnesium chlorides are added to the ash. This mixture is then heated to > 10000 C to remove heavy metals chlorides. Potassium and magnesium phosphates can then be recovered directly from the residue.	P, K, Mg	P, K, Mg	SUSAN™	Replacement for P rock

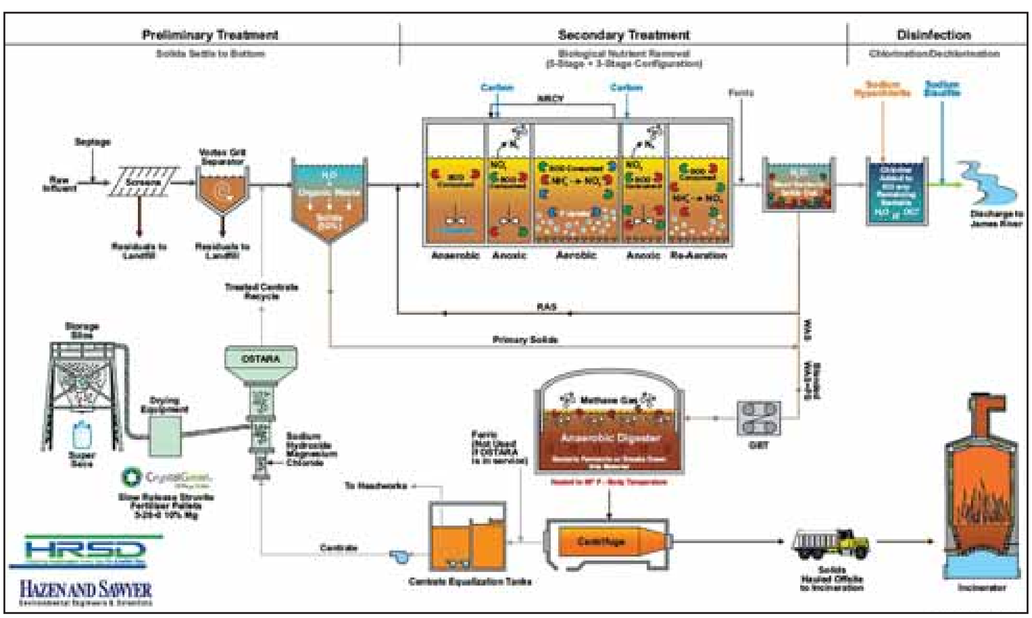
and calcium (Ca), are added to the nutrient rich stream. Effluent from this recovery process can then be recycled within the crystallization reactor or directly returned to the head of the plant. During this crystallization process, between 80 and 90 percent of the soluble phosphorus and 20 and 30 percent of the nitrogen from the side-stream flow can be recovered as products that can then be reused as slow release fertilizers (struvite) or feedstock (hydroxyapetite) for other industries. A general overview of technologies that are available for extractive nutrient recovery is provided in ***Table 1***.

Implementation and Successful Operation of an Extractive Nutrient Recovery Facility

The Nansemond Treatment Plant (NTP) in Suffolk, Virginia, is operated by the Hampton Roads Sanitation District (HRSD) and discharges treated effluent into the Chesapeake Bay ***(Figure 1)***. The 30 mgd NTP uses a modified 5-stage biological nutrient removal (BNR) secondary process to achieve annual average total phosphorus and total nitrogen effluent limits of 2.0 mg/L and 8.0 mg/L, respectively ***(Figure 2)***. The facility's influent contains high nitrogen (43 mg/L) and phosphorus (8.2 mg/L) concentrations due to industrial contributions.

Backus Aerial Photography

Figure 1: Nansemond Treatment Plant in Suffolk, VA.



Hazen and Sawyer, PC

Figure 2: Overview of Nansemond Treatment Plant Process

Solids handling consists of anaerobic digestion of separately thickened primary and waste activated sludge followed by centrifuge dewatering. Prior to the most recent upgrade, dewatering centrate contributed an abnormally high phosphorus loading on the main-stream process (30 percent of total load), resulting in frequent process upsets to the EBPR process. Process modeling performed by Hazen and Sawyer indicated that side stream treatment of the P rich centrate would increase the reliability of EBPR *(Cubbage et al., 2011)*. Two options were considered for controlling P recycle loads:

1. **Ferric chloride precipitation**
2. **Extractive nutrient recovery from the centrate via OSTARA Pearl® Process**

A cost evaluation was performed to compare the cost of P recovery with that of side-stream ferric chloride removal. For the ferric alternative, it was assumed that the precipitate would ultimately be processed through centrifuges and disposed of through incineration. For the P recovery option, two different scenarios were evaluated. In the first, the equipment would be purchased from the manufacturer, and operation and maintenance of the facility would be the responsibility of the utility (capital option). In the second option, the utility would provide a monthly fee in exchange for the manufacturer providing the facility and equipment (fee option). In both options, recovered product would be purchased by the manufacturer to offset the operation costs borne by the utility (electricity, chemicals, etc.).

Present worth analysis indicated that both extractive nutrient recovery options would be less expensive than using ferric for P removal. A comparison between capital and treatment fee recovery options indicated that the capital purchase option was superior to the fee option. As a consequence, the HRSD chose to construct the nutrient recovery facility using this option.

Construction of the nutrient recovery facility began on November 11, 2009, and the project was completed by the end of May 2010 ***(Figure 3)***. The system was started up soon thereafter, and has resulted in an average 84 percent reduction in soluble phosphorus content in the centrate. Nitrogen content of the centrate also has dropped by an average of 24 percent. As of August 2014, approximately 835 US tons of Crystal Green® product (specialty struvite blend fertilizer ***(Figure 4)*** have been produced to date at the facility. Since startup, ferric addition at the facility has been limited to one three-week event, due to an EBPR upset event.

Results from this work represent a unique scenario where extractive nutrient recovery was shown to be the lower cost alternative for reducing sidestream phosphorus loading versus conventional ferric addition. Factors that were determined to positively contribute to a favorable outcome for nutrient recovery included the amount of nutrient that

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Laurissa Cubbage

Figure 3: Nansemond Treatment Plant Nutrient Recovery Facility

must be removed or recovered; the degree to which infrastructure could be repurposed; the business model employed by the struvite recovery technology provider; and, the offset in chemical and energy costs associated with nutrient removal and reduced sludge production.

Wendell Khunjar

Figure 4: Struvite Product

Wendell O. Khunjar is Director of Applied Wastewater Research; Katya Bilyk is an associate; Ronald Latimer is a senior associate; Laurissa Cubbage is a senior principal engineer; and, Paul Pitt is a vice president and Director of Wastewater Technology for Hazen and Sawyer, PC in Raleigh, NC. Bill Balzer is Plant Manager for the Nansemond Treatment Plant in Suffolk, VA. Rick Baumler is Chief of North Shore Treatment and Charles B. Bott is Chief of Special Projects at the Hampton Roads Sanitation District in Virginia Beach, VA.

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Nitrogen Reduction in North Hempstead Treatment Plants

by Roger W. Owens

On August 13, 2014, an article appeared in Newsday discussing the installation of the Great Neck Water Pollution Control District's (GNWPCD/district) new BNR (biological nutrient removal) facility. This system came on line in January 2013, and is the last of the major treatment plant upgrades on the north shore of Long Island installed to significantly reduce nitrogen discharges into Long Island Sound. This facility was constructed to treat the wastewater from the GNWPCD and the Village of Great Neck. With the installation of this plant, the original treatment plant at the Village of Great Neck was decommissioned.

The original plants at both sites were designed around trickling filter technology. The new BNR facility replaces the trickling filters with an activated sludge oxidation ditch. The oxidation ditch was selected because of its ease of operation, relatively low operating costs and proven performance at numerous installations. In addition to the replacement of the trickling filters, the district also replaced the existing wastewater chlorination system with a new UV (ultraviolet) disinfection system. The district is very energy conscious, one of the reasons for selecting the oxidation ditch and for installing microturbines this fall to operate in conjunction with the existing anaerobic sludge digestion system. Use of the oxidation ditch and the addition of the microturbines are expected to result in using less power than the two replaced trickling filter plants combined, saving the district approximately $1 million per year in operating costs.

Great Neck WPCD Plant: The ***Figure 1*** map shows the location of this north shore BNR plant located in the Village of Great Neck along with the other two described in this article. This facility's WPCD is located within the Town of North Hempstead and ***Figure 2*** is an aerial view of the plant. Unit operations at the facility consist of influent screening with automatic self-cleaning, one-quarter-inch screens followed by vortex grit removal. The screened and degritted sewage flows to four primary settling tanks followed by the oxidation ditch influent pumping station. Three final settling tanks receive the effluent from the oxidation ditch. The oxidation ditch consists of three channels. An outer channel, the largest, is operated as an aerobic/anoxic reactor in which the DO (dissolved oxygen) is maintained below zero. The middle channel serves as a swing channel that can handle any increasing influent loads. The final inner channel serves as an effluent polish, removing any residual ammonia. Following the final settling tanks is the UV disinfection system and plant effluent pumping station. Waste activated sludge is thickened in a gravity belt thickener (GBT) and together with primary sludge is fed to the anaerobic digesters. The effluent from the digesters goes through a belt filter press and then trucked from the site.

Courtesy of Town of North Hempstead

Figure 2. Great Neck Water Pollution Control District BNR plant

Port Washington WPCD: Great Neck has a sister plant also located in North Hempstead on another peninsula, operated by the Port Washington Water Pollution Control District. This plant was the first to be converted from a trickling filter facility to a BNR using the oxidation ditch. In operation since October 2009, it has been producing excellent results. An aerial view of the plant is shown in ***Figure 3***. Similarly to Great Neck, the influent flow is screened and degritted, followed by primary settling. The primary settled effluent flows by gravity to the oxidation pumping station. The effluent from the oxidation ditch flows to four final settling tanks, followed by UV disinfection. Unlike Great Neck, there are no anaerobic digesters. The waste activated sludge is mixed with primary sludge and pumped to a gravity thickener from which it flows through a belt filter press and is trucked to a landfill.

Belgrave WPCD: The third BNR facility located in the same town, is the Belgrave Water Pollution Control District. This is the smallest of the three plants and uses a different technology to achieve the requisite nitrogen removal. The plant, shown in ***Figure 4***, underwent start-up in January 2012. It uses trickling filters to remove BOD (biological oxygen demand) and to nitrify the ammonia to nitrate and denitrification filters to remove the nitrate. Methanol is added to the influent of the denite filters to provide a source of carbon for the organisms that remove the nitrate. The methanol dose is controlled automatically by using the influent and effluent nitrate concentrations around the filter, measured by on line instrumentation and the influent flow rate. Flow entering the plant passes through influent

Source: Google Maps

Figure 1. Map of the North Shore locations of BNR plant upgrades described

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Source: Google Maps

Figure 3. Port Washington Water Pollution Control District plant

Source: Google Maps

Figure 4. Belgrave WPCD

screens and a grit removal system. Primary settling tanks follow the degritting system. The primary effluent is pumped to a lead trickling filter which is used primarily to remove BOD from the influent. The effluent of the lead trickling filter is pumped to a second trickling filter which oxidizes the ammonia present to nitrate. Following the trickling filters, the flow is pumped to the inlet of the denitrification filters, and then by gravity into a UV disinfection system. This system is capable of achieving very low levels of nitrate in the effluent. Secondary sludge is pumped to the primary tanks and co-settled in the primary. The settled sludge is pumped to anaerobic digesters from which the stabilized sludge is hauled away.

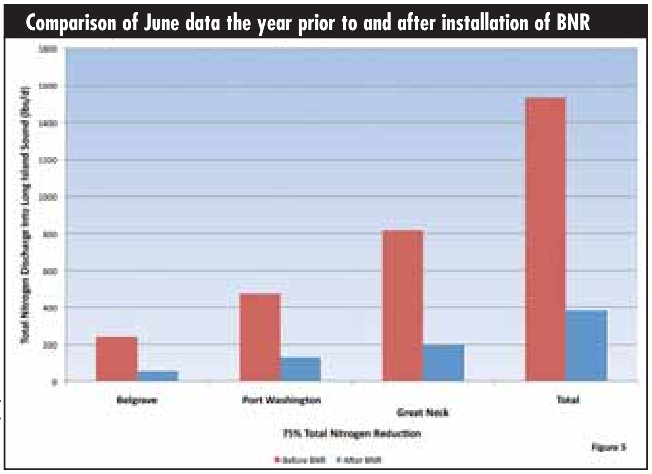
Table 1. No. Hempstead Treatment Plants Performance Data from June 2014

PLANT	Belgrave	Port Washington	Great Neck
Flow Rate (mgd)	1.53	2.8	3.2
Influent BOD (mg/L)	192	135	154
Effluent BOD (mg/L)	16	2	5
Influent TSS (mg/L)	324	409	158
Effluent TSS (mg/L)	10	1	6
Influent TN (mg/L)	50	72	41
Effluent TN (mg/L)	4.5	5.5	7.4

Courtesy of D&B

Goals Met

Table 1 shows the performance data from the three plants for June 2014, along with the plant flow rates. As shown, the plants remove over 90 percent of the major pollutants for the most part, and achieve total nitrogen in the effluent below their permitted effluent concentration, based on flow. Port Washington and Great Neck are similar in size, treating approximately 3 mgd each; while the Belgrave plant treats approximately half of that flow rate, or 1.5 mgd.



Courtesy of D&B

Figure 5. Comparison Nitrogen Data

Figure 5 shows a comparison of the total nitrogen discharged in each plant's effluent in the month of June, prior to the BNR modifications coming on line, with the current total nitrogen discharged by the plants in June of this year. The Long Island Sound Study required these plants to achieve an overall reduction in effluent total nitrogen of approximately 64 percent by July 31, 2014. As can be seen in the chart, the plants have achieved an overall reduction of 75 percent, exceeding the required reduction by over 15 percent.

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Chautauqua Lake

My Poor Little Lake

by Scott Kishbaugh and Karen Stainbrook

A previous version of this article appeared in the April 2014 issue of Conservationist *magazine (www.TheConservationist.org).*

Jane and Doug Conroe call Chautauqua Lake home. Not as a place to receive mail or store stuff, but as a special place to dream of a future, build memories, and protect everything they hold dear. Yet Jane often refers to Chautauqua Lake as "my poor little lake," and laments that "she [the lake] needs our help." Jane and Doug often speak about how much "she" has given to those who love her – and that it is time to help her.

Across the state, some lakes like Chautauqua are showing colors caused by algal blooms. Some of these blooms may appear light green, blue-green, have white streaks, or can look like paint spills or pea soup, and they indicate a problem. Though algae are one of the first essential building blocks of all life in lakes, in excess they can create a host of issues, from generating an off-putting color to presenting significant health risks for those who swim in or drink untreated water.

Harmful Blue-green Algae

Algae blooms color the landscape throughout the world, and are not new to lakes and rivers. Harmful blue-green algae have existed for at least 3.5 billion years, and blooms have killed fish as well as a wide range of mammals, from elk to manatee.

Not all blue-green algae blooms produce toxins. However, exposure to any blue-green algae can cause negative health effects, specifically if people and animals come into contact with dense blooms, swallow them, or if they inhale airborne droplets. For some people, direct contact with a bloom may cause allergic reactions such as irritation of the skin, eyes, nose, throat and respiratory tract. Swallowing water with blue-green algae blooms or toxins can cause nausea, diarrhea and vomiting; reports suggest that ingesting water with high levels of blue-green algae toxins over long time periods can affect the liver and nervous system.

Children and pets are most susceptible to toxins associated with harmful algal blooms (HAB) because their behaviors are more likely to place them in contact with dense blooms. Additionally, children weigh less, which means they are more likely to be affected by a smaller amount of toxin. Dogs can magnify their exposure because in addition to drinking contaminated water, they can ingest it when grooming after wading. Algae nerve toxins likely killed dogs in Lake Champlain in 1999 and 2000, and were suspected in dog deaths elsewhere in New York in 2012.

Blooms also affect lake ecosystems by reducing oxygen levels, which can result in fish kills and prevent the growth of beneficial algae. Luckily, there have been no reports of people becoming sick from eating fish caught during a bloom. To help reduce any potential risk, anglers can limit their consumption of fish organs, and rinse and/or freeze fillets before cooking. The New York State Department of Health (DOH) also recommends avoiding eating fish caught from areas with water that looks like thick paint or pea soup.

While HABs can cause problems with our waters, studies to date indicate that public water treatment systems effectively remove algal toxins. In fact, there haven't been any human illnesses in New York that could be attributed to drinking algae-tainted water.

Blooms: Then and Now

Some New York lakes have historically been plagued with blooms, but recently, government officials are fielding more complaints about surface scums and heavily discolored water. In 2013, a National Wildlife Federation survey turned up reports of blue-green algal blooms in at least 150 waterbodies in 21 states – more than one-third were in New York, which has a large number of lakes and one of the most active monitoring programs.

In Chautauqua Lake, the Conroes first observed persistent late-summer blooms during the 1970s. Back then, the blooms were isolated, but now blooms are visible at more locations along the north basin shore and have spread throughout much of the southern basin. In addition, green water now extends into November, even coloring winter ice.

The NYS Department of Environmental Conservation (DEC), DOH, and the NYS Office of Parks, Recreation and Historic Preservation are working together to identify and respond to blue-green algae concerns. DEC and DOH have collected information about blooms for the last several years, and are conducting research to evaluate the risks to public health and the environment. Much of this information is collected by volunteers from the Citizens Statewide Lake Assessment Program, a lay monitoring program run by DEC and the NYS Federation of Lake Associations.

Dealing with HABs

Just as "location, location, location" is the mantra for realtors selling homes, "phosphorus, phosphorus, phosphorus" is the mantra for lake managers and DEC when addressing HABs. As phosphorus is the primary "fuel" for an algal bloom, large persistent blooms are generally limited to lakes with high phosphorus content.

DEC evaluates data to determine how much phosphorus is too much. In waterbodies affected by algal blooms, DEC identifies the sources of phosphorus entering the lake. Phosphorus can enter the water from septic systems, stormwater, municipal wastewater treatment plants, agriculture and waterfowl. DEC regulates some of these sources of phosphorus, such as municipal wastewater treatment plants and stormwater.

The solution seems simple: reduce phosphorus and blooms go away. But reducing phosphorus is complex and can be costly. In addition to phosphorus levels, many other factors, such as water depth, wind, nitrogen content, and "good" algae removal by zebra mussels can trigger or concentrate blooms. Blooms often come and go in lakes, sometimes showing up only in the morning or afternoon, sometimes staying for weeks. They can move within a lake or linger like a green cloud.

While DEC, DOH and their partners work to understand how HABs develop, both agencies are focused on public awareness and safety. DOH closes regulated beaches where an HAB is visually identified. This is a proactive approach that deals with sensitive individuals and the transient nature of blooms.

Throughout the summer, the public can view a list of lakes with current blooms on DEC's website (see "Additional Resources" sidebar). DEC and DOH recommend avoiding contact with floating rafts, scums and discolored water. The best advice is: If you see it, avoid it and report it!

Blue-green Harmful Algae Blooms (HABs)

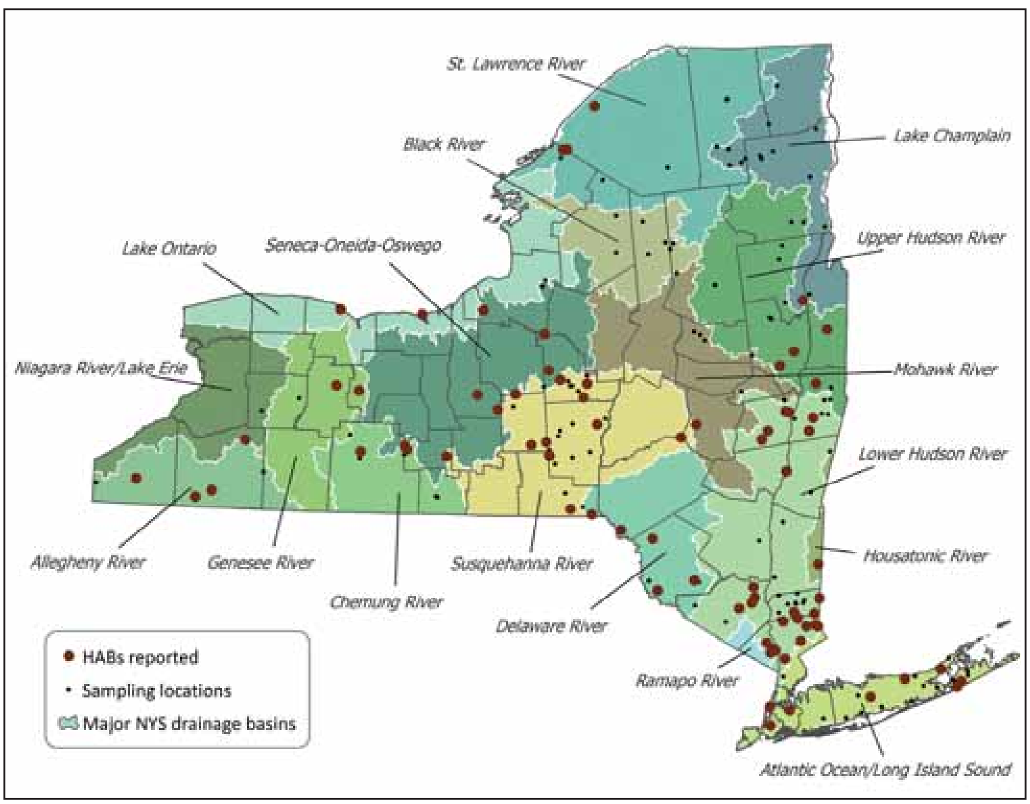
- Blue-green algae are photosynthetic bacteria (cyanobacteria) that are naturally present, in low numbers, in lakes, ponds and rivers.
- Excess nutrients, warm temperatures, and other environmental conditions promote the growth of blue-green algae, forming visible, dense build-ups (blooms) that discolor the water or form surface scums.
- Some types of blue-green algae produce toxins that can be harmful to people and animals. These blooms are collectively called blue-green harmful algal blooms.
- The first official report of dead livestock associated with a blue-green algae bloom occurred in Australia in 1878. The suspicious death of a Wisconsin swimmer in 2005 may have been due to blue-green algae exposure in a golf course pond.

Photo by Carrie Buetow

Take Action and Reduce Blooms

Everyone can help keep our lake systems healthy. Proper care of septic systems, limiting use of fertilizers, and planting shoreline buffers can have profound effects on an adjacent water body, and can limit nutrients that fuel HABs. Local government plays a role, through zoning and development decisions. A helpful reference for lake users is the publication Diet for a Small Lake (available online at *www.dec.ny.gov/chemical/82123.html*), which includes information on the ecology, monitoring and management of lakes and watersheds throughout New York.

continued on page 56



The accompanying map shows locations where blue-green algae blooms were confirmed or strongly suspected in 2013, and additional sampling locations where blooms were not found.

continued from page 55

People love swimming in NYS lakes and ponds, but should avoid any areas with an active blue-green algal bloom.

In Chautauqua Lake, the solutions are neither clear nor simple. The Chautauqua Lake Association and the Chautauqua Watershed Conservancy lead the effort to identify what is literally a clearer path. Their many partners include the county Department of Health and state Office of Parks and Recreation, which actively monitor conditions and close public swimming beaches when appropriate. DEC oversaw a study that identified the sources of phosphorus entering the lake.

It is tempting to seek a magic bullet – a simple and cheap solution – but the algae did not start blooming yesterday and will not stop blooming tomorrow. It is important for overwhelmed lake residents to realize that each action makes a difference, but bloom management can only work when government, organizations, and individuals roll up their sleeves and work together.

Future of Blue-green Algae in New York

Are blue-green algae blooms getting worse? A Conservationist article in 1985 suggested a relatively low level of concern about blooms, mostly because "people are not prone to drink or swim in water covered with blooming algae." Our evaluations and DOH protocols show that the precautionary message implicitly heeded in 1985 – avoiding blooms and highly discolored water – still applies today.

However, with global climate change resulting in warmer air and water, more drought and extreme storms, and with more nutrients to feed blooms, the problem with blue-green algae blooms is likely to worsen. Nutrient and algae levels currently appear to be increasing in many lakes. Blue-green algae are known to thrive in warmer conditions, and the longer ice-free seasons experienced over the last 100 years is allowing these blooms to start earlier and last longer.

So what does the future hold for Chautauqua Lake? The Conroes are optimistic. They are continually energized by a lake community frustrated by blooms but fiercely and passionately loyal to their home. They are also encouraged by many lake residents stepping up to give back to the lake that has given them so much. These blooms may be just the latest lake problem that demands great effort but offers great opportunities for lasting improvements. The local community, DEC, DOH and others have worked on this issue for years, and are committed to finding a solution.

Scott Kishbaugh and Karen Stainbrook work in DEC's Division of Water in Albany.

Editors Note: DEC and the editors would like to thank DOH staff for their assistance on the above article.

Additional Resources

DEC posts blue-green algae notices on its website at *www.dec.ny.gov/chemical/83310.html* that show locations of current blooms. The site is updated weekly, and includes a map to help swimmers, parents, and pet owners make informed decisions before recreating. Note: The notification system is only as good as the information it contains. Blooms may also occur in locations not reported to DEC; please report any suspected blooms at *www.dec.ny.gov/chemical/77118.html*.

Be sure to visit DOH's blue-green algae webpage at *http://bit.ly/1mZGiCw* for further information. Also, don't forget to sign up for DEC's Division of Water's newsletter Making Waves to receive weekly updates on blue-green algae bloom notices; visit *http://bit.ly/1ignXz7* to sign up.

Buffalo Receives $500,000 USEPA Great Lakes Grant for Green Infrastructure to Improve Water Quality in Lake Erie

The US Environmental Protection Agency recently announced the award of a $500,000 Great Lakes Restoration Initiative grant to the City of Buffalo to fund green infrastructure projects to improve water quality in Lake Erie. Cameron Davis, Senior Advisor to the USEPA Administrator for the Great Lakes, along with Congressman Brian Higgins and Buffalo Mayor Byron Brown gathered at the offices of the Buffalo Niagara Riverkeeper to announce the projects.

"Lake Erie's health and Buffalo's resurgence are tied together. Neither can exist without the other," said Davis. "This project will result in cleaner water, reduced flooding, and a more resilient shoreline in the face of climate change."

"Through this USEPA grant, the City of Buffalo will be able to use green infrastructure to prevent stormwater from carrying contamination into Lake Erie," said USEPA Regional Administrator Judith A. Enck. "Green infrastructure projects make both fiscal and environmental sense, especially for communities that need to adapt to the growing effects of climate change."

"Through continued collaboration, this project will invest in Niagara Street, creating a more attractive gateway to our city and continuing our ongoing momentum to preserve and enhance our waterfront," said Congressman Brian Higgins.

"We applaud the USEPA and Congressman Higgins for supporting the City of Buffalo as a Great Lakes shoreline city that values and protects its fresh water resources through green infrastructure projects," said Jill Jedlicka, Buffalo Niagara Riverkeeper Executive Director. "The Niagara Street corridor continues toward a major transformation that will showcase Buffalo as an innovative leader in Great Lakes protection and urban waterfront revitalization."

Photo by Margaret Wooster

The Scajaquada Creek, a waterway flowing into the Niagara River, has five combined sewer outfalls from the City of Buffalo's combined system, with one outfall that has additional inputs from upstream systems of Cheektowaga and Depew, NY.

Courtesy of Buffalo Niagara Riverkeeper

The Windsor Avenue rain gardens are part of a green streets demonstration project through a partnership with the Buffalo Sewer Authority and Buffalo Niagara Riverkeeper.

The City of Buffalo and the Buffalo Sewer Authority will use the $500,000 USEPA grant, along with $500,000 in funding from Empire State Development to construct green infrastructure projects along a one-mile section of Niagara Street. The projects include the installation of porous asphalt, stormwater planters, rain gardens and the reduction of impervious pavements. This section of roadway, which is a part of the Great Lakes Seaway Trail/National Scenic Byway, currently generates untreated stormwater that drains directly to the Black Rock Navigation Channel and the Niagara River. The green infrastructure projects will capture stormwater from approximately 15 acres along the Niagara Street right of way, resulting in the control of up to 4.9 million gallons of stormwater runoff per year and a significant reduction in the amount of road salt, nutrients, oil and grease, and sediment flowing into the Niagara River.

Buffalo is one of 16 cities to receive funding in the initial round of the USEPA's new GLRI Shoreline Cities grant program, which is designed to improve water quality in the Great Lakes basin. These grants can be used to fund up to 50 percent of the cost of green infrastructure projects on public property.

Some 30 million Americans get their drinking water from the Great Lakes, and the lakes also support a multi-billion dollar economy based on fishing, boating and recreational activities. The lakes face significant challenges, including pollution and the threat of harmful species that threaten their health.

Information provided by USEPA Communications

Of Interest

CRA and GHD Join Forces

Conestoga-Rovers & Associates (CRA) and GHD have joined to create a global leader in engineering, environmental consulting, architecture and construction services. The result is a company of more than 8,500 employees, with 4,000 in North America. The merger includes all of CRA and its family of companies, including Inspec-Sol and eSolutions. The companies have officially merged, with all ongoing employee shareholders in CRA becoming shareholders of GHD. This unique feature of the merger makes it one of the largest private stock transactions in the engineering and environmental consulting industry.

The combined business, known as GHD, now operates across a network of 200+ offices with 130 located in North America.

CPE Acquires Burgh & Schoenenberger Associates

CPE President Rob Tortorella announced this summer that CPE had acquired the assets of Burgh & Schoenenberger Associates, Inc. of Pavilion, NY. CPE, which is a leader in the Northeast in fluid handling and process equipment distribution and specialty construction services, has acquired Burgh & Schoenenberger, a fluid handling instrumentation distributor and repair house.

Burgh & Schoenenberger was founded in 1972 and provides liquid flow monitoring equipment including flow meters, instrumentation and data loggers to the clean water and wastewater markets. The company also conducts flow data studies and offers installation, calibration and repair services. Along with Hans Schoenenberger, the entire staff of repair technicians and customer service support will join CPE at the Elmgrove Park headquarters.

Dredging OK'd to Help Restore Oswego Co. Lake to Health

The state Department of Environmental Conservation recently determined that the proposed dredging project of Lake Neatahwanta, located in the vicinity of the City of Fulton and Town of Granby in Oswego County, will not have an adverse environmental impact. The project is a big step in returning the fresh water body to a healthy condition through "phased hydraulic dredging of about 400,000 tons of material," (sludge and silt) from the bottom of the lake, according to NYSDEC. Dewatering will occur on agricultural lands and will be used as a soil amendment or for mine reclamation.

Cleanup through dredging has been a goal to restore the lake to swimmable health since the closure of its beaches 26 years ago because of high levels of fecal coliform bacteria, and because later studies also found the lake overloaded with phosphates contributing to the growth of blue-green algae *(OswegoCountyToday.com)*. It was reported that a pet dog died in 2004 after swimming in the algae-rich water, which prompted the city to post signs along the beach warning visitors that it was not safe for them or their pets to enter the water. Fulton city officials received the state permit July 25. A $200,000 state grant received this September along with private donations to help with the lake's rejuvenation are pushing the community ahead on the long-term project dredging the first 10,000 cubic yards.

Green roof at Oncenter's Nicholas J. Pirro Convention Center

Green street on Harrison Street in Syracuse

Onondaga County's Save the Rain Project Wins Award

The Water Environment Federation presented the national winners of its 2014 StormTV Project competition at its WEFTEC annual technical conference held September 29 in New Orleans. The competition was held in an effort to collect and share innovative stormwater videos and to recognize the work of stormwater professionals. Over 220 videos were submitted in four categories. The winner of the Nonprofit and Government Programs category was Onondaga County's Save the Rain program which is a comprehensive stormwater management plan to reduce pollution to Onondaga Lake and its tributaries. Save the Rain applies green and innovative technologies to mitigate stormwater runoff and prevent combined sewer overflows.

"This award will help us spread the word about how stormwater infrastructure can be an environmentally friendly solution," said County Executive Joanie Mahoney.

Operator Quiz Test No. 105 – Wastewater Potpourri

The following questions are designed for trainees as they prepare to take the ABC wastewater operator test. It is also designed for existing operators to test their knowledge. Each issue of *Clear Waters* will have more questions from a different section of wastewater treatment. Good Luck!

1. The main cause of most odors in wastewater systems is due to:
   a. Hydrogen sulfide
   b. Hydrogen peroxide
   c. Hydrogen gas
   d. Nitrous oxide

2. Chlorination of waste streams is an effective means of odor control because:
   a. Chlorine is very reactive and oxidizes many chemical compounds in water
   b. Chlorine can destroy bacteria that can convert sulfate to sulfide
   c. Chlorine can destroy hydrogen sulfide at the point of application
   d. All of the above

3. Ozone as a means of odor control may be disadvantageous because:
   a. Ozone is a powerful oxidizing agent
   b. Ozone is able to remove odors from air collected over sources of odor
   c. Ozone can be manufactured onsite
   d. The effective concentrations of ozone at large plants may be too costly to use

4. A common means of phosphorus removal is:
   a. Microorganisms in a state of endogenous respiration
   b. Lime precipitation
   c. Aluminum sulfate flocculation followed by precipitation
   d. Hypochlorite dosing followed by precipitation

5. What is the name of the bacteria that converts nitrite to nitrate during the nitrification cycle?
   a. Nitrobacter
   b. Nitrosomonas
   c. Nocardia
   d. Thiothrix

6. Of the following, the most precise piece of lab equipment for measuring liquid would be:
   a. Beaker
   b. Graduated cylinder
   c. Erlenmeyer flask
   d. Volumetric pipette

7. An effective velocity for a grit removal channel would be:
   a. 1.2 feet per second
   b. 0.3 feet per second
   c. 2.1 feet per second
   d. 3.0 feet per second

8. The most commonly known disinfection byproducts found in water/wastewater treatment are:
   a. Oxidized metals
   b. Trihalomethanes
   c. Phosphates
   d. Weak organic acids

9. What is the purpose of a vacuum relief valve on your anaerobic digester?
   a. To add air to the digester
   b. To remove excess air
   c. To decrease the pressure
   d. To prevent liquid from leaving the digester

10. Using only a single aliquot from a bacteriological sample, the probability of accurately estimating the coliform density is
   a. High - because of the sampling techniques involved
   b. Low - because of the lack of an appropriate culture media
   c. High - because of the refined analytical technique
   d. Low - because of the distribution of bacteria in the sample

Answers on page 61.

For those who have questions concerning operator certification requirements and scheduling, please contact Tanya May Jennings at 315-422-7811 ext. 4, tmj@nywea.org, or visit www.nywea.org/OpCert.

November 20, 2014, Desmond Hotel, Albany, NY

Energy Specialty Conference

"Accelerating the Transition of Wastewater Treatment Facilities into Water Resource Recovery Facilities"

Many of New York State's water resource recovery facilities (a.k.a., wastewater treatment plants) are moving in the direction of becoming Utilities of the Future (UotF). This conference will highlight some of these facilities, individual projects and technologies that can be components of UotFs, as well as mechanisms for funding such projects.

Utilities of the Future go far beyond traditional public health and environmental objectives by:

- Generating renewable energy using open space and other horizontal assets;
- Capturing waste heat and latent energy from biosolids and liquid streams;
- Reclaiming and finding commercial uses for nutrients and other constituents;
- Using green infrastructure to manage stormwater and protect urban waterways; and
- Reclaiming and reusing water.

Resources

To advertise or to become a member, contact Rebecca Martin at 315-422-7811 ext. 5 or e-mail her at rebecca@nywea.org.

Visit www.nywea.org for information or see us on Facebook.

Answers from page 59: 1 A, 2 D, 3 D, 4 C, 5 A, 6 D, 7 A, 8 B, 9 A, 10 D

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