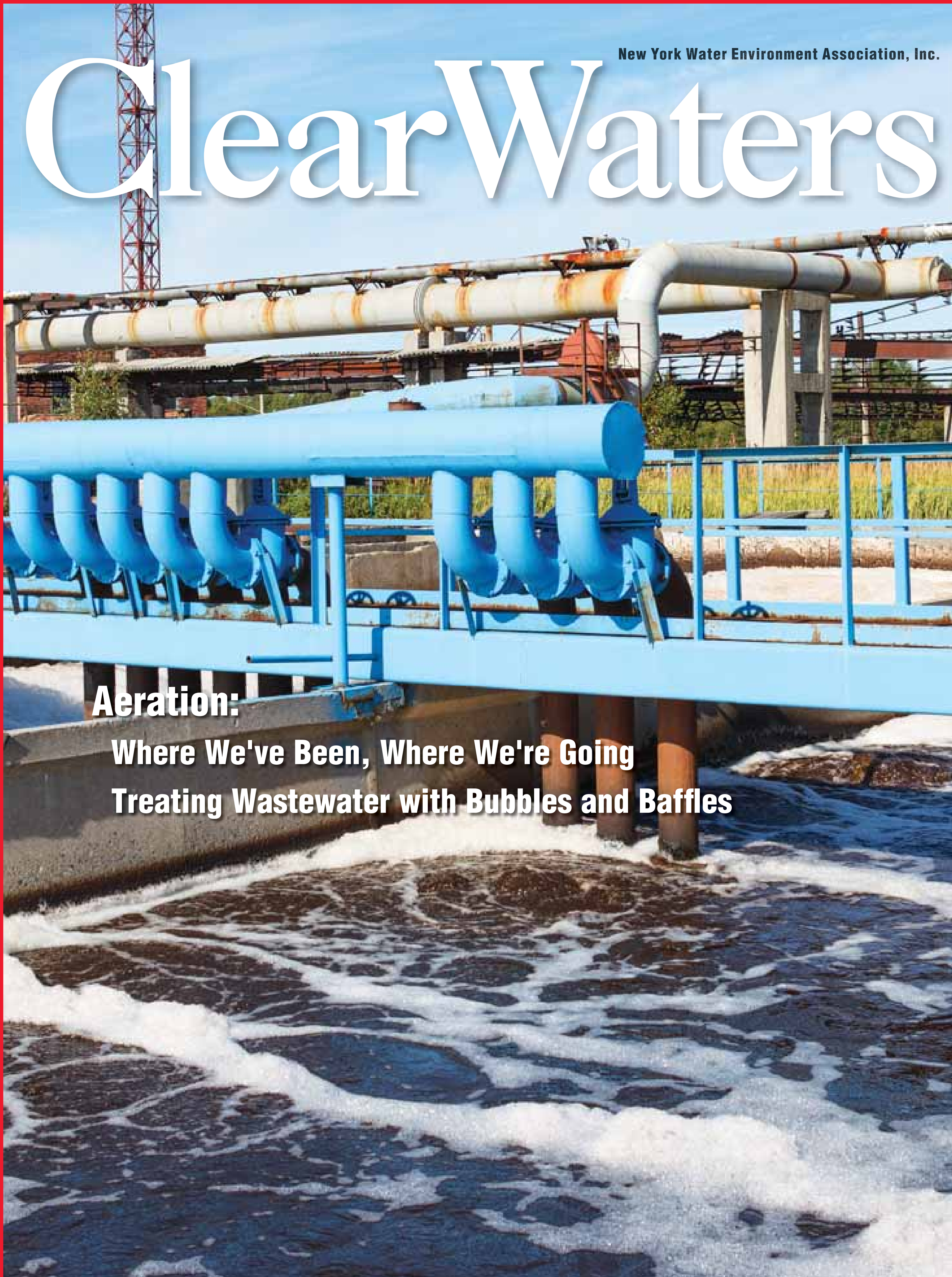
Winter 2018, Vol. 48, No. 4

New York Water Environment Association, Inc.

ClearWaters



Aeration:

Where We've Been, Where We're Going

Treating Wastewater with Bubbles and Baffles

NYWEA

Water Environment Federation
Preserving & Enhancing the Global Water Environment
MEMBER ASSOCIATION

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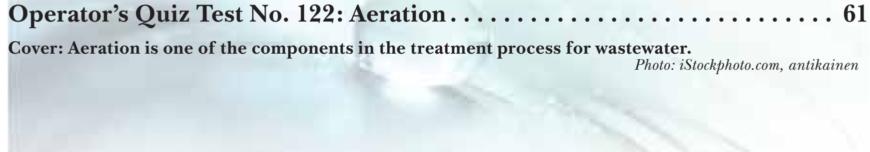

Cover: Aeration is one of the components in the treatment process for wastewater.
Photo: iStockphoto.com, antikainen

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President's Message | Winter 2018

As you may remember, I started this NYWEA year in February by declaring the "Year of the Water Superhero". Not only was this to recognize the hard work, passion and energy that all of you put into your daily actions protecting public health and enhancing the environment, but also to celebrate your efforts to save lives and the planet!

So, I was surprised and absolutely pleased to attend WEFTEC's opening session this past October to find that WEF leadership had picked up on our theme. WEF has introduced this year as the "Year of the Water Hero". They did us one better by bringing the author of *The Hero Effect,* Kevin Brown, to speak at the opening session. If you haven't heard him, he is worth checking into to get his unique take on what it means to be an "everyday hero." I think you will see many parallels between his core thesis and the way that you approach the world. (*https://www.micro.site/weftec.*)

> *"What I've learned on this journey is that heroes are not ordinary people doing extraordinary things. Not by a long shot. It's in fact the opposite. Heroes are extraordinary people who chose not to be ordinary.*
>
> *You see, doing what you do, you can't afford to be ordinary. Not one time. You show up and do your job in an ordinary way, people get sick; people die; communities don't run …*
>
> *If ever there was a time when this world needed to hear your voice and really understand what clean water and safe water is all about and what it does to the quality of their life, the time is now. The world needs water heroes. Ladies and gentlemen, I am here to tell you that what you do is brilliant, and there's nobody on the planet that tells the story like you do."*
>
> *Kevin Brown*
>
> *Excerpted from the WEFTEC Opening General Session, October 2018*

New York's Showing at WEFTEC 2018

On the topic of WEFTEC, we had an excellent turnout from our New York membership, including four Operations Challenge Teams. For the first time we had a team compete in the Division I category – the Jamaica Sludge Hustlers – and they made us proud. The Long Island Brown Tide team put on a good showing, taking 4th place out of 37 teams in Division II. Our two new teams did a great job as well: the Watershed Warriors came in 21st and Bowery Bay Coyotes were 31st overall. These teams gave it their all and were our New York Water Superheroes!

We are so proud of the students from Manhattan College who competed in the Design Competition. Our Sunday reception was jam-packed with members, friends and family. It was so nice to see all of you who could make it, including a large group of student members and new members. It bodes well for the future of this organization that we continue to attract new people. WEFTEC is the world's largest annual water quality event, with 20,740 people in attendance this year in New Orleans. It is a remarkable event to attend. This year's meeting featured 1,019 exhibitors and more than 170 top-notch technical papers. During Tuesday's Leadership Day, WEF rolled out the refreshed Water's Worth It Campaign along with a new set of resources we are looking forward to utilizing.

NYWEA's Upcoming Annual Meeting

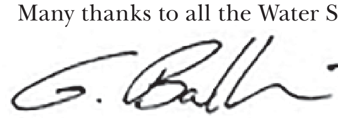
WEFTEC is a perfect prelude to NYWEA's 91st Annual Meeting that takes place at the New York City Marriott Marquis, February 4-6, 2019. Last year we had over 1,800 people in attendance, and we expect similar turnout this year. With over 120 technical papers to pick from, I am sure you will find several of interest. New this year is our pre-conference workshop on nutrients, geared especially for operators. We have also created a pilot Mobile Exhibitor Session, which will take place in the 5th floor ballroom. There's something for everyone at this meeting, and I hope to see you there.

In Closing …

As this is my final President's Message, I would like to once again thank the many volunteers that help us achieve our mission. These individuals are the backbone for identifying and mapping out the programs that are offered to our members. I'd also like to recognize Patricia Cerro-Reehil, Maggie Hoose, Tanya May Jennings, Maureen Kozol, Rebecca Martin, Kerry Thurston, Ken Skibinski, Leah Harnish and our newest executive team hire, Madison Quinn, for the excellent work they do on behalf of our members and the help they have given me over the last four years. They are true professionals.

This year we have had some great *Clear Waters* issues, covering a wide range of topics. The diversity of articles has been remarkable. This season, we move back into the deep end of the technical pool and discuss one of the most important parts of the treatment process: aeration. Another great topic and one we haven't covered in this much detail in recent memory. Again, it is amazing how much information is packed into this issue. It really should come as no surprise that the membership of NYWEA has so much talent in so many areas of endeavor, allowing us to create such an interesting publication four times each year. It is that willingness to volunteer that completely sets NYWEA apart from so many other industry organizations, and all the more proof that the "Year of the Water Superhero" was a fitting title.

Many thanks to all the Water Superheroes!



Geoffrey G. Baldwin, PE BCEE
NYWEA President

Students attending WEFTEC from Manhattan College, Clarkson University, and the State University of New York College of Environmental Science and Forestry. Front row (l-r): SUNY ESF professor Doug Daley, Briana Fitzgerald, Elena Araya, Isabelle Horvath and Megan Steward. Back row (l-r): Alex Hess, Mallory DeLanoy, Zach Patterson, Josh Crane, Casey Radomski, Geoff Baldwin, Shannon Vogt, Hannah Beebie, Maurice Peploski, and NYWEA Executive Director Patricia Cerro-Reehil.

In every issue of *Clear Waters* magazine, we try to share useful information about any number of current environmental issues and emerging technologies. This issue is a little different, as we only address one specific process, aeration. The idea for this came last spring when I received a phone call from David Railsback from Schnabel Engineering. He wanted to know how themes for *Clear Waters* were selected and if aeration could be a topic that we could cover. After presenting the idea to the Publications Committee, the answer was an overwhelming "yes!" – So David, here it is! I extend my appreciation to you for reaching out to us and sharing your idea.

This is an interesting story of how ideas that start with the input of an interested member can work their way through our committees and leadership to the benefit of all members. We hope you will find it interesting and relevant to your work. This is a great "by the members, for the members" example of how one member can make a difference. NYWEA is your organization! Our success depends on your interest and input to keep the organization relevant. To that end, keep your eyes peeled for our 2019 Membership Survey. This is one way we can keep our hand on the pulse and make sure you are getting everything you need out of your membership!

Inspired Volunteer Leadership

I had the privilege of participating in a couple of Lower Hudson and Metropolitan Chapter events recently. Not only did I have a great time, I met many people that I had previously only spoken to on the phone or had heard "stories" about. It was a pleasure to spend some quality time with members that I don't get to see and speak with often enough. As I traveled around to the chapters, I noticed they have something in common: people who give of their time to make the meeting a success. These individuals go the extra mile to make meeting attendees feel welcome. These are inspired leaders. Volunteers who diligently coordinate outstanding events help to keep the chapters vibrant and bring together so many interesting and forward-thinking individuals. Whether it's a social event or a technical meeting, chapter events bring the neighborhood of like-minded and hard-working stewards of our environment together to get to know each other better, and hopefully to create new and exciting relationships and collaborations – All in the name of water quality! I encourage you to connect with your local chapter as often as possible. From what I have witnessed, it is where some of the strongest relationships are built.

The Lower Hudson Chapter members "huddle" on the campus of West Point before the Army vs. LaFayette football game.

Social Media

We are looking for help promoting the organization's presence on social media. We would appreciate your assistance as we use electronic media to harness the energy of our membership, build stronger relationships, exchange ideas and advance water quality initiatives. Social media can connect us all in real-time and is a tremendously useful tool that has been underutilized for NYWEA. Our new Communications Manager, Madison Quinn, is working hard to help us get more environmental professionals connected by following us on various social media platforms, including LinkedIn, Instagram and others. We look forward to connecting with you on these platforms!

Instagram: @nywea
Twitter: @NYWaterEnviro
Facebook: www.Facebook.com/nywea/

— • —

Also, don't forget that you can download the *Clear Waters* App on your phone!

Thank you all very much for your work to improve water quality. Here's wishing you a healthy, happy and wonderful 2019!

Patricia Cerro-Reehil, pcr@nywea.org

Water Views | Winter 2018

Long-Term Action and Progress in the Long Island Sound

Recently, I presented testimony to the New York State Assembly on the Long Island Sound's water quality. It was gratifying to be able to report that New York and Connecticut have successfully achieved the Total Maximum Daily Load (TMDL) nitrogen pollution reductions in the Sound.

Nitrogen is typically the limiting nutrient for biological growth in marine systems. Low oxygen (hypoxic) zones are caused by nitrogen-induced algal blooms. Excess nitrogen also damages coastal marshes, which serve as critical habitat and a natural protective barrier against intensifying coastal storms.

Thanks to extensive investments and efforts by our communities, nitrogen in the Sound from human sources has been reduced by the TMDL's 58.5 percent target level, in large part through the installation of advanced nitrogen treatment systems at water resource recovery facilities.

In addition, New York has mapped and regulated the entirety of the Long Island Sound Watershed as a Municipal Separate Storm Sewer System (MS4). Municipalities are required to abate combined sewer overflow (CSO) discharges from outfalls in the state, including those in New York City that flow toward the Sound. Many New York City CSO projects are completed or underway, with many more to come.

There is also an important connection between air and water pollution, as New York's efforts to eliminate coal-fired boilers reduce nitrogen pollution from atmospheric deposition onto Long Island.

We are pleased to see a positive water quality trend, as our annual surveys show the size, duration and intensity of the hypoxic zone in the Sound decreasing. In 2015, for the first time since monitoring began 28 years ago, there were no severe hypoxic or anoxic conditions (e.g., dissolved oxygen readings below 1 mg/l) measured in the Sound. This trend has generally continued through 2018.

New York is committed to continuing efforts to improve and protect the Sound, including:

- Governor Cuomo's Long Island Shellfish Restoration Project, which has already resulted in the stocking of millions of clams and oysters to support optimal growth, reproduction and water filtration.
- Governor Cuomo's initiative to expand artificial reefs, which are undergoing the largest enhancement in state history.
- Continuing to implement the already successful Long Island Nitrogen Action Plan (LINAP), which includes an intensive focus on the Sound's North Shore bays.

As both a national and natural treasure, the Sound deserves the extensive efforts underway to restore and maintain its chemical, physical and biological integrity. This ongoing success story demonstrates how, by focusing on the issues facing our waters, developing solutions, and providing funding for implementation, we can work together to achieve highly positive outcomes.

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

Focus on Safety | Winter 2018

Hopefully, A Long Engagement

Workplace engagement has been a topic of interest for employers for the last several years. It doesn't matter if you are a water treatment plant, a manufacturer or a utility. We all need coworkers who are thoughtful and committed to our common goals, people who have "got our collective backs", not just timecard punchers going through the motions.

Safety engagement is the term most often used to describe a process where a culture-inspiring amorphous "thing" develops in an organization that strikes the right balance between employers and employees. When this happens, employees are actively involved in decision-making and in using their discretionary effort in ways that move the organization forward. These people are committed and motivated, and their personal goals are in good alignment with their organization's goals. The way to get this type of workforce is through a style of leadership that gives up control and embraces a participative management style. Sometimes, though, we as leaders behave exactly the opposite. We may believe that our future career path will be in jeopardy if others are involved in the decision-making process. We ask our workforce to contribute but ignore their suggestions; we make decisions without team input; or we fail to recognize or appreciate our employees' experience, knowledge and skill base. It becomes about the individual "me," not about the collective "us".

We can change how decisions are made by ensuring that the workforce has proper training; continuous opportunities for development; the appropriate tools, both physical and organizational; clear understanding of the organization's mission; and the freedom to take risks and to fail safely – both in an emotional/social sense and in a physical sense. As leaders, we need to make the decisions from where the information lies, right in the hands and minds of our engaged employees. The leader-follower dynamic is turned on its ear. Supervisors and managers become coaches and facilitators, not directors and enforcers. Employees are the experts, invested in their frontline decision-making, risk analysis and hazard assessment. These employees develop into leaders of their own section of the organization, taking responsibility for making their work efficient, accurate and safe.

This change won't happen overnight. This is a long march, whether with people who are on-board from the start, or with those who are not convinced and need to be brought along the way. Leadership in safety doesn't exist in isolation; it is influenced by decisions at all levels of the organization. By involving the frontline, making safety decisions their decisions, and by respecting and valuing ingenuity, experience and intellect, we can engage our workforce like no time previously. Our people are not just the means to get something done; they are the best resource of expertise in how it gets done, safely.

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


Aeration tanks at a wastewater resource recovery facility (WRRF), Westfield, MA. *Tighe & Bond*

Secondary Treatment Aeration Systems – Past, Present and Future

by Frederick Mueller and Cynthia Castellon

Abstract

Aeration for secondary treatment has historically focused on providing excess air to completely oxidize organic matter for Biological Oxygen Demand (BOD) removal. A typical plant is now faced with increasing challenges as the role of aeration in secondary treatment is changing. For example, processes for nitrification require more air, while denitrification and phosphorus removal require less or no air. Plants also must balance operation of non-aerated vs. aerated zones; hydraulic issues that may arise from baffled tanks; decouple mixing requirements from aeration requirements; and size equipment for realistic conditions rather than for 20-year projections that may never occur. This article will review the most prominent milestones in aeration; discuss recent technological improvements; and provide insight to the critical role aeration will play in meeting nutrient and emergent contaminant permit limits.

Introduction

Oxygen in the air we breathe makes life possible. It allows life forms to metabolize carbon, grow and reproduce. Prior to the advent of the wastewater treatment industry, oxygen diffusing into our streams and rivers provided the electrons that allowed microorganisms to oxidize the waste products entering that water. As human populations grew and concentrated in cities, the capacity of waterways to treat these wastes was exceeded, depleting the dissolved oxygen (DO) in waterbodies to low levels. The fish kills resulting from lack of sufficient oxygen, as well as the spread of disease-causing pathogens and excessive odors, led to the birth of our industry. Although the installation of sanitary sewer systems, primary treatment and disinfection helped to reduce odors, disease and waste loading to streams, the fish kills continued. More needed to be done. Systems that deliver oxygen to microorganisms in an engineered environment, rather than in our rivers and streams, became the focus of wastewater treatment.

Secondary treatment systems, such as trickling filters, rotating biological contactors and the activated sludge process were developed to fill this need. The first two technologies used simple mechanical means to deliver oxygen to microorganisms and were effective for the removal of BOD and ammonia (typically present as the ammonium ion NH_4^+). Trickling filters have an advantage that, with enough hydraulic head, oxygen could be delivered essentially for free. Even if pumping was required, it uses less energy than that needed for other secondary treatment options. Rotating biological contactors have an advantage in that they are simple to operate, but their energy input is essentially independent of load.

The activated sludge process traces its roots to 1914, in the work done by Edward Ardern and William Lockett in Manchester, England *(Ardern and Lockett, 1914(a), 1914(b), 1915)*. The process relies on one of two operations: either mechanical aerators that pump and spray the water into the air; or blowers that compress the air with diffusers to deliver it deep into the water column. Both operations are energy-intensive. A typical treatment plant, when upgraded to secondary treatment, may see its power consumption more than double as a result. When compared to today's standards, those upgraded plants' aeration systems did not operate as efficiently. To better understand why this was the case, consider the mindset of the 1960s and 1970s when many of the plants currently in existence were designed and constructed.

Early Treatment Plant Design

Early 1970s wastewater treatment facility with extended aeration lagoon and platform-mounted mechanical aerators.
Tighe & Bond, Erving, MA, WRRF

The post-World War II baby boom led to a significant growth in population, and there were high expectations that similar growth would continue for another 20 years. As a result, many treatment plants in the United States were designed for industrial and population expansion that ultimately did not materialize. The availability of 80-percent federal grant dollars for plant construction also encouraged municipalities and engineers to design for more growth, since there was little cost on their part to doing so. The result was oversized aeration systems designed for anticipated future loads. Additionally, hopes had been high that the nuclear power industry would grow, and power would become "too cheap to meter." Thus, there was little emphasis on energy efficiency.

continued on page 12

continued from page 10

The focus of treatment plant designs was on removal of BOD, which required oxygen. In some areas, ammonia nitrogen removal was also a concern. Since having too much oxygen did not inhibit the removal efficiencies for either of these target constituents, there was little downside to operating oversized aeration systems other than higher-than-necessary energy costs.

Dealing with Industrial Discharges

Toxic industrial discharges to the sewer were also prevalent. Many plant operators retiring today can still tell stories about how they knew a plating bath had been dumped because they could see the color of their tanks change. Engineers combatted the industrial discharges by designing aeration systems that would quickly mix and dilute the toxicity entering the biological process. This approach encouraged the use of fewer large aeration tanks together with simple high-energy mechanical aerators. Although this approach completely mixed the tanks, this resulted in less efficient treatment. Even in larger plants using blowers and diffuser systems, concerns over toxic industrial discharges led to the design of many aeration tanks that were relatively square, which were outfitted with only a single DO sensor, air control valve and single aeration diffuser grid per tank.

Air Diffusers

Air diffuser technologies were still developing in the 1960s and 1970s, and coarse-bubble systems were becoming more common. These systems were an improvement over the porous plates that had been used for decades. Fine-pore dome diffusers, capable of higher efficiencies than the coarse-bubble systems, were just being introduced from Europe, while the ceramic disk and membrane diffusers we see today were still years away from implementation.

Centrifugal Blowers

Many plants built in the 1960s and 1970s had only three centrifugal blowers: two duty and one standby. Centrifugal blower turndown, or its ability to reduce the air flow rate, was limited to start with as compared with other blower types. Since the anticipated design operating pressure did not match the actual operating conditions in many plants, the blower turndown was even more limited. The large diurnal air demand, often plus or minus 50 percent or more over the day's average, compounded the problem. One duty blower might run at its minimum and still over-aerate the process for portions of the day. Even some plants upgraded in the last 20 years have used these traditional two-three blower arrangements due to available space, economic concerns or continued use of overly conservative design guidelines. Fortunately, plant upgrades occurring today – especially those focused on nutrient removal – utilize three or four duty blowers and one standby blower to achieve the needed turndown.

Not that long ago, there were limited options for controlling blowers and mixer motors. The variable-frequency drives and the process instrumentation that we rely so heavily on today for precise aeration control did not exist, or were not yet as developed, reliable and customizable as they are today.

A Changing Landscape

Over the years, despite the limitations of existing aeration systems, operators have adapted to optimize their plants. Many operators whose plants have excess process capacity and oversized aeration systems learned that they could save energy by cycling their aeration systems on and off. For nitrifying plants required to remove ammonia, operators benefitted from denitrification and recovered alkalinity, which decreased the need for adding chemicals and further reduced operating costs. Many operators found that treatment did not suffer using this aeration on-and-off technique and the lack of mixing during the aeration-off times did not create operational problems.

Operators also learned that their plants could function periodically with much less air or mixing energy going into their tanks than what typical design standards, such as 10-States *(GLUMRB 2014)* and TR-16 *(NEIWPCC 2016)*, recommended. When optimizing operations in this manner, these plants also began to remove higher levels of nitrogen as well as, occasionally, phosphorus. Design engineers evaluating such plants for nutrient-related upgrades needed to carefully assess the level of biological nutrient removal that was already occurring, so that the scope of the upgrade would be accurately assessed.

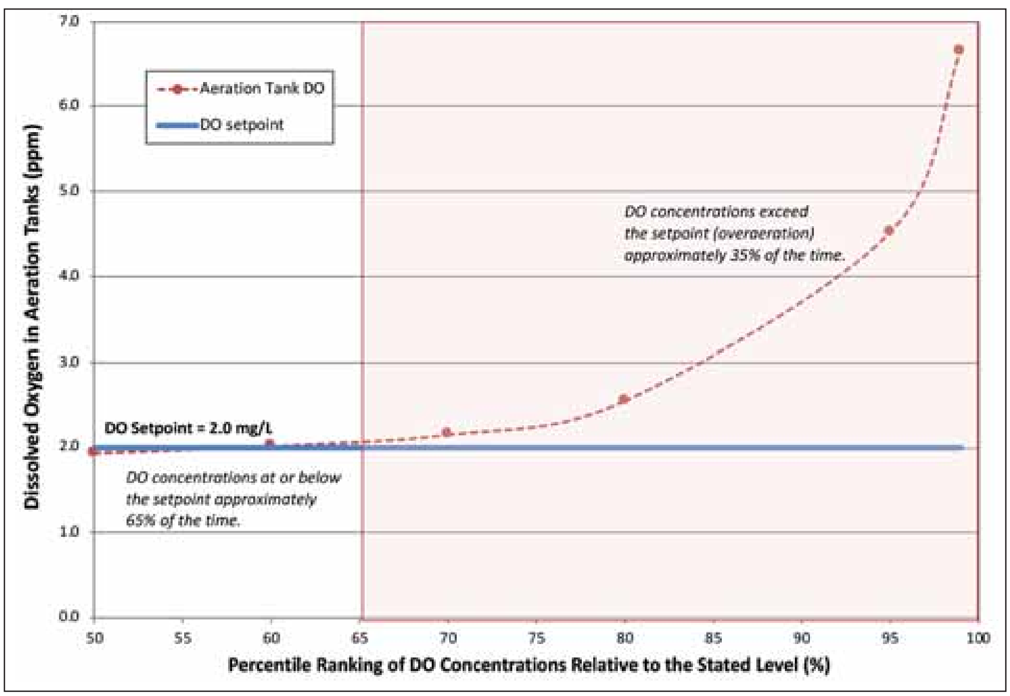


Figure 1. Westfield, Massachusetts, WRRF dissolved oxygen levels. Lack of blower turndown led to dissolved oxygen levels being higher than the setpoint 35 percent of the time. *Tighe & Bond, Westfield, MA, WRRF*

Some operators took advantage of energy efficiency incentives to convert coarse-bubble diffuser systems to fine-bubble diffuser systems. While this saved energy by reducing the volume of air required, many operators quickly observed a significant increase each day in the amount of time the blowers operated at their minimum. Additionally, the amount of time that oxygen levels in the aeration tanks were higher than desired also increased ***(Figure 1)***.

Computerized Oxygen Controls

Instrumentation and control systems with greater operational scope have been implemented to adjust oxygen delivery and match the oxygen supply to the load. Programmable logic controllers and SCADA systems made it easier to design, modify and adapt aeration control systems to the changing needs of the plant. Recently developed luminescent DO sensors were quickly adopted by many plants for ease of maintenance. Although these technological advances helped improve oxygenation performance, engineers in our industry were still upgrading smaller and medium-sized plants that have run effectively for years without a real-time DO monitoring and control system.

Other medium-sized and larger nitrifying plants have embraced more advanced ammonia-based control systems to adjust DO control setpoints in real time. These systems are most effective and appropriate when the aeration systems can be turned down all the way to match the low loadings to the plant. After years of operating with a DO setpoint of 2 mg/L, some plants have opted for advanced controllers with sophisticated models, which look at influent and effluent ammonia; nitrate; mixed liquor suspended solids (MLSS) concentrations; return activated sludge (RAS) rates; and more. These are available from some vendors to optimally adjust the DO setpoint to minimize both energy usage and the DO levels leaving the process. Other smaller plants have taken a simpler approach, utilizing the ammonia levels in the secondary treatment influent to scale the DO setpoint up and down between two setpoints. This latter approach can still save energy but likely not to the extent that the sophisticated model-based system can.

Nutrient Permit Limits

In New York, communities discharging to New York City's watershed and Great Lakes are required to meet nutrient permit limits. Many other inland plants discharging to smaller impounded waterbodies also have nitrogen and phosphorus permit limits to protect the local water quality from eutrophication. Communities in New England and New York are working to improve water quality in Long Island Sound by optimizing their plant operations to reduce nitrogen discharges. In many cases, to meet permit limits operators need to modify plant operations, using up as much of the excess capacity in the plant's secondary aeration systems as they can to nitrify and then denitrify. Plants with a phosphorus permit may find more of their excess capacity consumed with inert solids from chemical precipitation of phosphorus, which would need to be carried in their aeration tanks. Excess capacity may also be used for the creation of anaerobic zones for the biological removal of phosphorus. For some plants that are already nitrifying, this means cycling aeration on and off, putting aside fears that equipment wear might increase.

For plants with long and narrow tanks, options to meeting permit limits include increasing RAS rates and blocking off aerators in the head of the aeration tanks. This allows for creation of anoxic zones where nitrate can be converted to nitrogen gas. Most plants have RAS pumps with a capacity to match the plant design flow. This means that they should be able to reduce their effluent total nitrogen by about 50 percent during normal dry weather flows. Of course, this reduction in nitrate means that less oxygen is needed in the aerobic zones, which in turn means that if the plant was nitrifying before the optimization, their oxygen demand will decrease further.

Year-Round Nitrification

To allow for year-round nitrification, some operators have found they need to increase the MLSS concentrations in their plants to achieve the desired aerobic solids residence time. This residence time is typically as high as 10 days in the winter since autotrophic organisms grow slowly. Operators quickly learned that the wet weather flow capacity of the final clarifiers limited their plant's ability to increase the solids residence time. Therefore, techniques were needed to reduce the solids loading to the clarifiers during wet weather flows. Operators lucky enough to have plants with piping, channels and gates already in place to operate in a "step-feed mode" could store solids in a portion of the aeration tanks. Other operators could simply shut off their plant's aeration systems, allowing solids to settle to the bottom of the tanks until high wet-weather flows subsided. Normal operations could then resume, without violating effluent permit limits.

Assessing Aeration System Performance

With the advent of modern SCADA-based control systems, we now have more data available to analyze the performance of aeration systems. Such data has shown that even plants recently upgraded were constructed with "oversized" blowers. This has led to the implementation of energy-efficiency projects to install "right-sized" blowers for both current conditions and for more practical future conditions.

Historical data from SCADA systems, such as DO concentrations and actual air flows delivered, can be used to glean information regarding the time of day and days of the year that oxygen levels rise because the blower is at its minimum turndown. By applying oxygen transfer models to this data, estimates can be developed of what the actual air flows and oxygen demand would have been at the desired DO concentration – typically 2 mg/L – as opposed to the elevated concentrations recorded by the SCADA system. Comparing these data to actual plant loads has shown that blowers are oversized, as we have observed in several different communities (Waterbury, Connecticut; Westfield, Massachusetts) during the preliminary design evaluation.

Engineers tend to be conservative in their designs and, lacking data to the contrary, tend to select oxygen demand factors at the higher end of design guidelines ***(Table 1)***. The 10-States guidance *(GLUMRB 2014)* is more conservative by factors of 10 to 35 percent than the TR-16 guidance *(NEIWPCC 2016)*. New York participates in the use of both design guides.

Table 1. Oxygen Demand Factors Based on Design Guidance.

Design Guidance	O_2 per pound BOD	O_2 per pound NH_4-N
TR-16	0.85 to 1.2	4.2
10-States	1.1 to 1.5	4.6

Notes: TR-16 (NEIWPCC 2016). 10-States (GLUMRB 2014).

Based on the authors' experience, calibrating SCADA data based on actual influent loadings has shown that actual oxygen demand factors were lower than the guidelines. This is true even after taking into account assimilation of ammonia due to the growth of heterotrophic organisms removing BOD and depletion of BOD by facultative aerobes due to denitrification in anoxic and anaerobic zones in the plant ***(Figure 2,*** *see page 16)*.

TR-16 includes guidelines for minimum airflows to aeration tanks intended to maintain proper mixing, which can lead to

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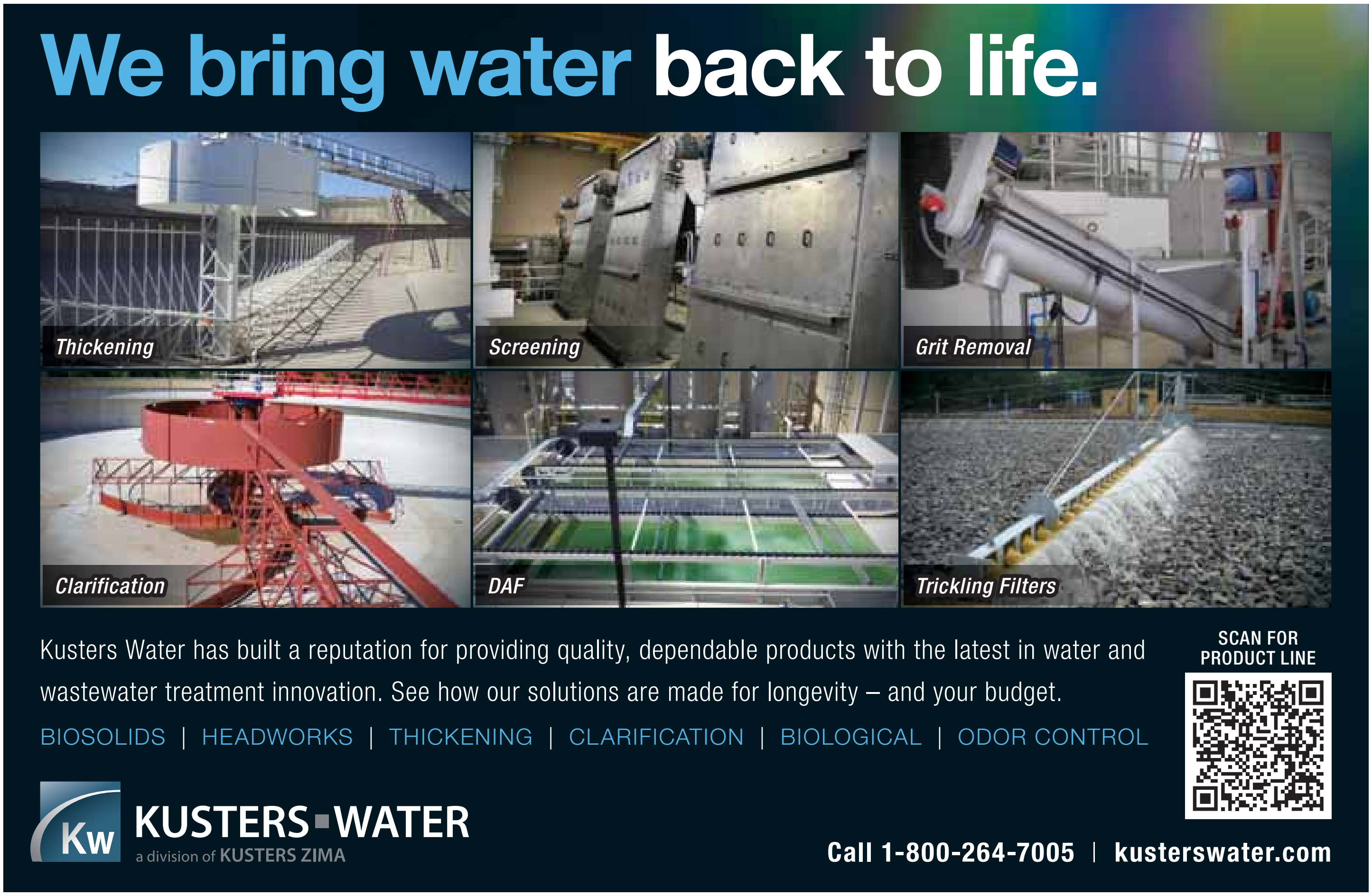
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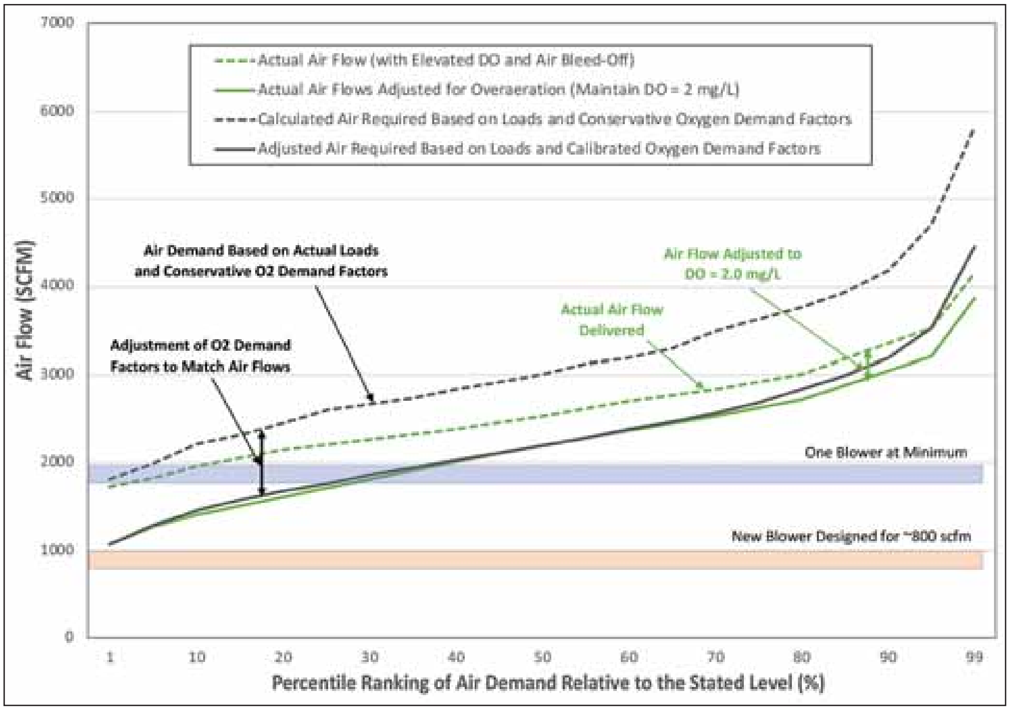

Figure 2. Aeration tank air demand analysis. SCADA data and oxygen transfer models to correct for elevated dissolved oxygen readings can be used to better evaluate diurnal loadings and blower turndown requirements. Data also suggests oxygen demand factors can be too conservative (see black line).
Tighe & Bond, Westfield, MA, WRRF

process issues if applied rigorously. To be compatible with biological nutrient removal, treatment plants may need to routinely operate at lower air flows for prolonged periods of time, often lower than the guidelines for minimum mixing. In practice, many plants can do so with limited negative side effects. Periodically bumping the blowers to a high air flow rate for a short period of time while exercising the diffusers is a great way to re-suspend solids that may have settled. An alternate approach implemented as part of a nutrient-related upgrade is to decouple aeration from mixing by including mixers in the aeration tanks or by designing the plant with large diameter low speed mixers and sparge rings.

Evolving Treatments

Looking forward to the future, those in our industry are in the midst of a battle to do more with less. While grant funding opportunities have improved recently, we will never see a return to those 80-percent federal grant days. The need to upgrade plants for nutrient removal has driven – and will continue to drive – the design of treatment plant upgrades into the future.

Advanced Controls and Instrumentation

Nutrient removal brings its own challenges in the design of aeration and secondary treatment systems, as biological nitrogen and enhanced biological phosphorus removal rely on creating anaerobic and anoxic conditions that will be poisoned by excess oxygen. Smaller plants that for years functioned adequately with high oxygen levels and high RAS rates are now being driven to remove nutrients while minimizing chemical usage. The result is that many of these plants will need a higher level of process sophistication, including advanced controls and instrumentation. Many larger plants have already implemented these changes, due to the economic scale of resultant energy savings.

Plug-Flow Configurations

Advances and changes continue to occur that impact the role of aeration in water resource recovery facilities (WRRF). For example, industrial pretreatment has done much to reduce influent toxicity to our plants and activated sludge plants are more frequently designed as plug-flow plants with longer, narrower and deeper tanks. Plug-flow configurations ***(Figure 3)*** allow for installation of more efficient, multistage, tapered fine-bubble aeration systems. Long and narrow plug-flow tanks also significantly improve the kinetics of BOD oxidation and nitrification processes, allowing successful operations at lower solids residence times than the older, completely mixed systems. With plug-flow configurations and baffle design, consideration must be given to mechanisms that allow scum build-up to flow through the reactor, and prevent backflow mixing and density currents due to underflows and overflows.

Oxidation-Reduction Potential

In biological nutrient removal plants that need to create anaerobic, anoxic and oxic conditions, DO concentrations no longer tell the entire story. Many operators are discovering first-hand that, although not commonly used for real-time control, oxidation-reduction potential (ORP) can be a more useful tool to understand what is happening in the process. Rather than measuring

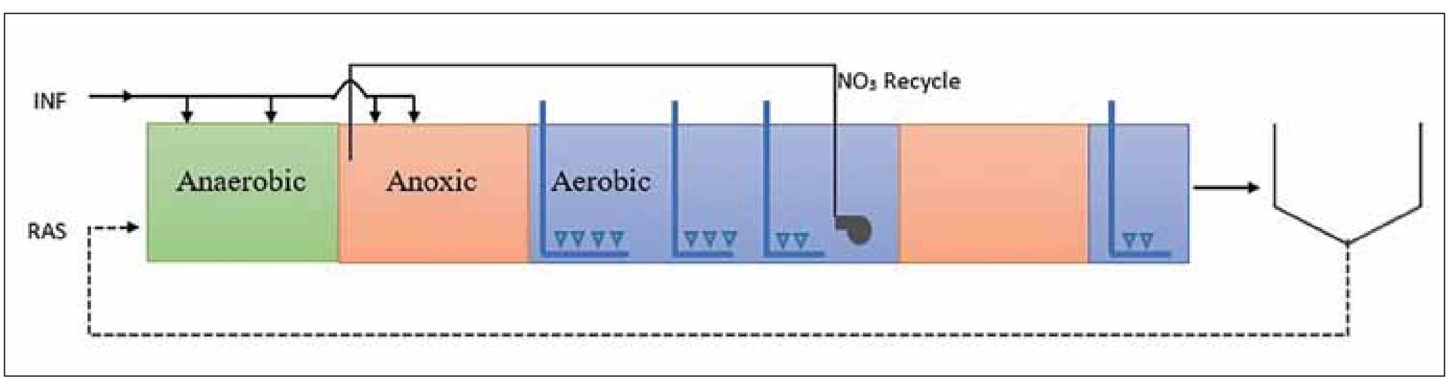

Figure 3. Long plug-flow tanks with many baffled stages and more advanced tapered aeration systems help provide the conditions for efficient oxygen delivery and effective nutrient removal.
Tighe & Bond

DO at various locations and depths in their secondary process tanks, operators are measuring ORP to determine whether the conditions are right for these processes:

- Enhanced biological phosphorus release: occurs under anaerobic conditions with DO concentrations near 0 mg/L and ORP in the range of -250 to -100 millivolts (mV).
- Denitrification: occurs under anoxic conditions of DO less than 0.5 mg/L and ORP of -50 to +50 mV.
- Enhanced biological phosphorus luxury uptake: occurs under aerobic conditions of DO greater than 0.5 mg/L and ORP of +25 to +250 mV.
- Nitrification: occurs under aerobic conditions of DO equal to 2 mg/L for maximum growth rates and ORP of +100 to +350 mV.

High-Efficiency Blower Technology

In the past ten to 15 years, advances in high-efficiency blower technology have gained acceptance in our industry. High-speed, direct-drive centrifugal turbo blowers and screw-type, positive-displacement blowers have both been adapted from other markets to serve the needs of the wastewater treatment industry. These advances often lead to significant energy savings compared to the previous generations of blower technologies.

On the Horizon

What else might the future bring that will impact our aeration systems? Innovations and challenges will be driven by the need to do more with less, be it energy, space, labor or some other constraint.

High efficiency blowers have made substantial penetration into the wastewater market over the last 10 years.

Tighe & Bond, North Attleborough, MA, WRRF

Consider, for example, combining our aeration tanks and clarifiers into one tank, much like the design for a sequencing batch reactor. Then modify that design so the aeration systems and sludge-wasting systems work together to retain in the reactor denser, more rapidly settling sludge, while wasting the lighter, less desirable sludge, thus creating just the right environment to promote biological nutrient removal in less space. These newer granular-activated sludge processes, whether implemented for main-stream or side-stream treatment, have been developed in Europe and are being introduced into the United States, showing great promise for reducing costs and/or footprint. Expect some of these technologies to gain traction over the coming years. Perhaps when it is time to replace your aging infrastructure or to plan for increasing the capacity of your plant, it will be time to consider the applicability of these new systems.

While oxygen makes life possible, the key to future treatment will be to deliver just the right amount of oxygen at the right time and for the right conditions to produce clean, low-nutrient treated water.

Frederick Mueller, PE, is a Principal Engineer with Tighe & Bond. He has nearly 30 years of experience managing and implementing projects related to wastewater, environmental remediation and regulatory compliance. His expertise includes: municipal and industrial wastewater treatment systems; pumping systems; energy conservation and management; soil and groundwater remediation systems; air emissions compliance; odor control; electrical systems; SCADA systems; hazardous waste; and petroleum and chemical storage systems. Cynthia Castellon, PE, is a Project Engineer with Tighe & Bond. She has ten years of experience specializing in water and wastewater treatment process optimization; facility planning; design and construction; water supply planning and drinking water master plans; environmental permitting research; cost analysis; and preparation of state revolving fund applications and documents. For questions regarding this article, she may be reached at CMCastellon@TigheBond.com.

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Operator Certification and Aeration Principles

by Robert Wither

The certified wastewater treatment plant operator needs a broad knowledge of the proper operation of a water resource recovery facility (WRRF). For the activated sludge operator, maintaining sufficient levels of oxygen throughout the facility is a major focus of activated sludge process control. Sufficient oxygen is necessary to prevent the generation of odors and ensure proper biomass growth to remove BOD and nutrients. Because aeration systems are used to supply the oxygen or air, the operator needs to understand both the principles of aeration and aeration systems operation for pre-aeration, grit removal, secondary treatment processes, sludge stabilization and effluent re-aeration.

Operators who obtain a New York "A" certificate have demonstrated basic to advanced levels of understanding of aeration principles. Operators demonstrate their knowledge to achieve certification by passing an Association Board of Certification (ABC) wastewater exam. ABC developed Need-to-Know criteria for each certification grade exam to identify knowledge areas that support the performance of the job tasks for which the operator may be tested. ABC uses the terms Basic, Intermediate and Advanced to describe the level of knowledge needed for a task at each exam grade level. These are defined as follows:

- Basic: A fundamental or lower level of knowledge is required. Lack of knowledge at this level by the operator will result in minimal impact or significance on the performance of the tasks listed in the content area, or on public safety and welfare.
- Intermediate: A level of knowledge beyond the basic level is required. Lacking this level of knowledge will have a significant impact on the performance of the job and on the public safety and welfare.
- Advanced: A very high level of knowledge/job experience is required, and the operator will be functioning at an expert level. Operators lacking this level of knowledge will have a serious impact on the performance of the job and will be very harmful to public safety and welfare.

The ABC Need-to-Know criteria identifies aeration principles, such as mixing, mechanical and diffusers, as an area that they will test an operator's knowledge. Using the Need-to-Know criteria, ABC modifies the complexity of the questions based on the level of knowledge they expect an operator to have for a specific grade level. ABC rates the level of knowledge for Aeration Principles at each grade level ***(Table 1)***.

Table 1 shows that ABC expects the operator who completes the Grade 4/4A exam to be an expert on aeration principals as they relate to operation, monitoring, evaluation and adjustment of aeration systems.

New York requires the operator to complete a specified amount of hands-on operations experience and pre-certification training to qualify to take the ABC certification exam, which is the final step

Working in the laboratory gives operators hands-on experience at the Environmental Training Centers facility at Morrisville State College.
Stephen Sanders

for certification. The training components of the pre-certification courses provide a basic understanding of the principles of aeration. The Basic Operations course covers aerated grit removal; secondary treatment processes (primarily fixed film process) and odor control; aerobic digestion; and pumps and blowers. This program provides an overview of equipment and support systems for aeration with a primary focus on blowers. The operator is expected to gain an understanding of operational concepts; be able to make routine adjustments; recognize performance problems; troubleshoot operational problems; implement corrective action; and identify and perform routine maintenance upon completion of the Basic Operations course.

The major overview of aeration principles occurs in the Activated Sludge course. This program reviews the aeration system components, as well as the advantages and disadvantages of mechanical and diffused aeration systems at maintaining the two goals of aerations systems: mixing and a minimum level of dissolved oxygen in the aeration tank. The first day's course materials review operational parameters for activated sludge, including aeration system monitoring for each operational mode; how to use the observations of aeration patterns (in the case of diffused aeration systems); and

Table 1. Levels of Knowledge Required at Grade Levels for Aeration Principles.

Grade Levels	Equipment Evaluation & Maintenance	Equipment Operation	Treatment Processes Monitoring, Evaluation & Adjustment	Safety, Security & Administrative Procedures
1 / 1A		Basic	Basic	
2 / 2A	Basic	Basic	Basic	Basic
3 / 3A	Intermediate	Intermediate	Intermediate	Basic
4 / 4A	Intermediate	Advanced	Advanced	Basic

detection of odors to help monitor aeration system performance. Day two of the course reviews the control tests for activated sludge, including where to monitor for dissolved oxygen and proper dissolved oxygen levels; how changes in dissolved oxygen levels can manifest themselves in the type of organisms present in the activated sludge; and the overall performance of the process. The attendees learn the calculations necessary to determine the amount of air required; how to use the efficiencies of the aeration system to determine the amount of air that is necessary to meet these air requirements; and troubleshooting techniques for the activated sludge process. Sufficient oxygen in the aeration tank is always one of the first questions asked by the troubleshooter.

The final pre-certification course addressing aeration principles is the Technical Operations Module. Objectives of this one-hour portion of the program are for the operator to understand principles for the additional oxygen required to achieve nitrification and removal of oxygen for denitrification.

These pre-certification courses provide the basic understanding of aeration principles. More advanced knowledge is achieved through work experience. As the above discusses, the level of knowledge increases with the higher grade of certification. By the time the operator achieves their Grade 4A certification, they are considered an expert in aeration principles.

This article is a quick overview of New York's wastewater operator pre-certification training program and the ABC certification exam for aeration principles. The course curricula for the pre-certification programs is available on the New York State Department of Environmental Conservation's website at *www.dec.ny.gov/chemical/8707.html*. References used to develop the course curricula and the ABC certification exams are:

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As always, please contact Tanya May Jennings *(tmj@nywea.org)* with questions on how to become a certified wastewater treatment plant operator and an aeration principles expert.

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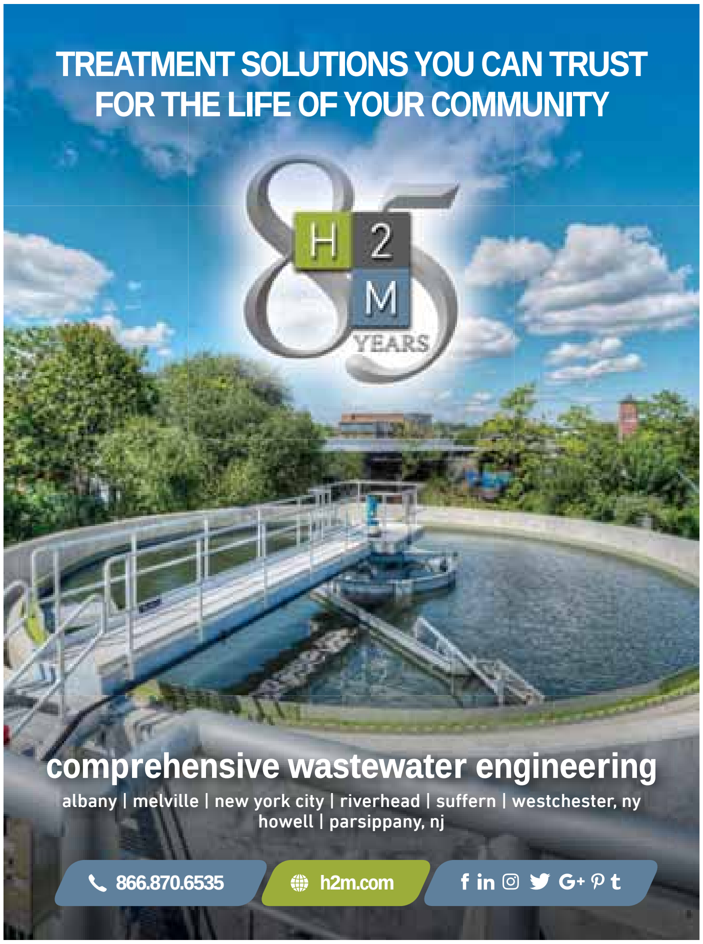
Operators also receive training on-site at an actual activated sludge plant, such as the one in Waterville, New York. *Stephen Sanders*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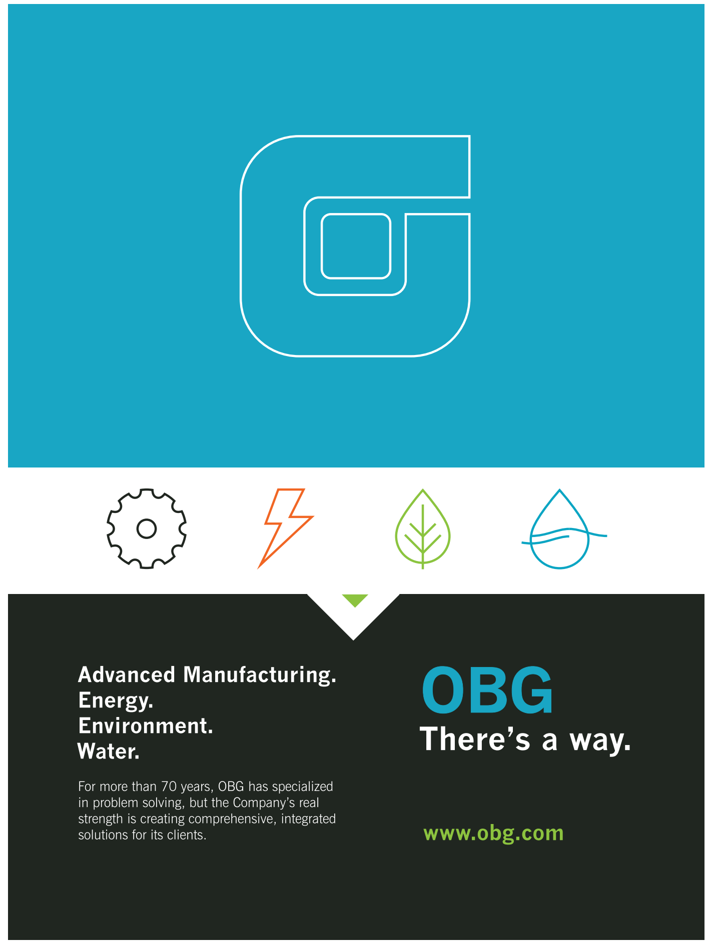
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Final Settling Tanks: The Nexus of Geometry, Solids Properties and Hydraulic Loading Performance

by Savvas Xanthos, Krish Ramalingam, Alan Alleyne, John Fillos, Allen Deur and Mauro Orpianesi

New York City Department of Environmental Protection (NYCDEP) along with The City College of New York (CCNY) has developed a comprehensive 2D and 3D computational fluid dynamics (CFD) model to improve the performance of the final settling tanks (FSTs) at the water resource recovery facilities (WRRFs) in New York City. The model development was initiated more than a decade ago and was necessitated because the WRRFs were being upgraded for nitrogen removal due to new permit regulations. One of the consequences of nitrogen removal is the higher solids inventory in the aeration tanks to enable the nitrification/de-nitrification operation, which results in higher solids loading to the FSTs. The mandate given to the CCNY team was simple yet complex in nature and execution and comprised of two phases:

I. Develop a model that was as comprehensive as possible to incorporate recent modeling advances, calibrated by multiple experimental data sets and validated against existing FST performance data. With this tool in hand …

II. Perform an overall assessment of the current performance of the FSTs, identify any limitations in design and recommend feasible modifications to optimize the performance of the tanks for biological nitrogen removal (BNR) under regular and high flow conditions.

Introduction

FSTs have traditionally been the weakest link in a treatment process train *(Ekama et al. 1997, Ekama and Marais, 2002)*, and the ability of the tanks to handle higher solid loading rates has been questioned. Tools such as the state point analysis (SPA) have been shown to be practical in the assessment of clarifier performance but have serious shortcomings especially with regard to hydrodynamic loading characteristics and geometry permutations. Daigger and others *(Daigger et al. 2018)* presented the importance of understanding how particles settle, the factors of their formation (granular vs. flocculent) and the relationship of these factors to achieving the best water quality. Li and others *(Li et al. 2014)* highlighted the importance of sedimentation and how this process determines the performance of the activated sludge process in secondary settling tanks (SSTs).

The use of CFD, while traditionally prevalent in the aerospace, chemical and mechanical industries, is now a rapidly emerging field in wastewater treatment and applied to almost all unit processes. Samstag and others *(Samstag et al. 2016)* provided an overview of CFD on water and wastewater treatment, articulating the state of practice, research and development needs for each of these applications. Special attention was given to the biological processes (suspended growth) systems and secondary sedimentation, with a comprehensive CFD review provided by Karpinska and Bridgemen on activated sludge reactors and Gong, Xanthos and others on rectangular settling tank modeling and optimization *(Karpinska and Bridgeman 2016; Gong et. al. 2011; Xanthos et al. 2011; and Xanthos et al. 2013)*.

The first part of this paper will focus on presenting several of the field experiments performed and how the results gave rise to input parameters for different models. These experiments aimed to answer the following challenges:

a. Develop a "discrete particle" measurement technique to carry out the fractionation of the solids in the FST, which has critical implications in the prediction of the effluent quality.

b. Identify the floc aggregation (K_a) and floc break-up (K_b) coefficients that are found in Parker's flocculation equation *(Parker et al. 1970, 1971)* and used for the flocculation submodel in the CFD model based on a series of flocculation jar tests on a range of mixed-liquor suspended solids (MLSS) concentrations.

c. Bridge the mean velocity gradient "G" value from the laboratory scale jar test (manufacturer's curves) to its applicability to the full-scale FST by using a jar test CFD model.

d. Briefly address Type III (zone settling) occurrence and choice of model, as well as address the choice of the rheological model used.

The second part of this paper will include a brief description of the modeling software used for the simulation, followed by a third part that will detail optimization results based on different loading conditions, geometry configurations and baffle additions.

Field Tests

Discrete Settling

Discrete settling occurs at low concentrations of suspended solids (SS) and, in the absence of interference from hydrodynamic flow field, of other particles in the suspension. Ramalingam and others outlined the overall measurement technique developed, and the different settling regimes typically found in secondary clarifiers *(Ramalingam et al. 2012)* ***(Figure 1)***. The authors emphasized that sludge flocs are complex bodies consisting of both flocculent and filamentous microorganisms. Consequently, it is difficult to classify sludge flocs in terms of size, shape and density except when they are granular and in effect ideal in shape. However, since the purpose of the field testing was to determine their capture efficiency, it was convenient to classify the sludge flocs in terms of their average settling velocity, V_{as}.

Activated sludge was categorized into an arbitrary number of groups: (L) for large, (M) for medium and (S) for small-size flocs ***(Table 1)*** with tabulated fraction results based on eight different

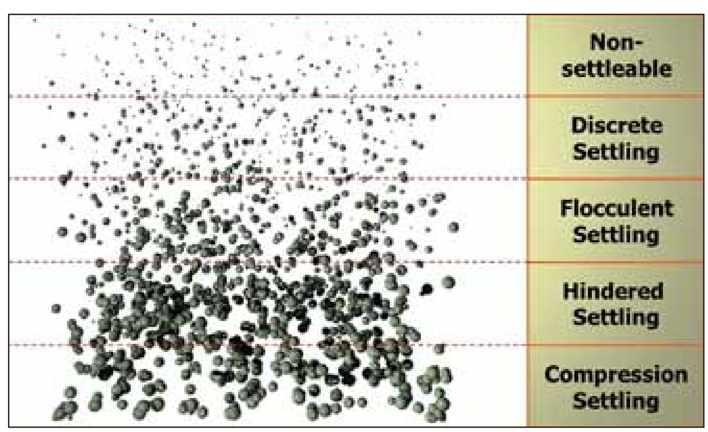

Figure 1. Settling regimes in clarifiers. *Savvas Xanthos*

continued on page 23

continued from page 21

experiments ***(Table 2)***. These can be split into two sub-sets, one that would exhibit enhanced "good" settling vs. one that would demonstrate "bad" settling characteristics.

Table 1. Discrete Settling Velocity Groups and Settling Velocity Magnitudes.

Floc Size	Apparent Settling Velocity (m/hr)
Small (S)	$V_{as} < 1.5$
Medium (M)	$1.5 < V_{as} < 6$
Large (L)	$V_{as} > 6$

Flocculation

Flocculation in activated sludge influences many factors, including biological activity and overall settling characteristics. In simple terms, flocculation is the growth of smaller particles into larger aggregates and the net flocculation in an FST is the total sum of floc aggregation and breakup. There has been extensive work over the last two decades to develop techniques to quantify flocculation such as the population balance model (PBM) *(Nopens 2005)*. The modeling of flocculation is reviewed by Thomas and others *(Thomas et al. 1999)* and the current understanding of these aggregation phenomena has been discussed in detail by Maximova and Dahl *(Maximova and Dahl 2006)*. Laboratory jar tests have also shown that the flocculation rate is directly related to the hydrodynamic shear in the range that is typically achieved in the inlet region of the FST. This suggests that shear-related orthokinetic coagulation, where the spatial and temporal velocity gradients in the liquid cause particles in a region of higher velocity to overtake those moving at slower velocity, is the major mechanism for flocculation.

The model developed by Parker and others (*Parker et al. 1970, 1971)* has been widely used and is described by ***Eq. 1***:

$$(dX_i)/dt = K_b \cdot X_o \cdot G^2 - K_a \cdot X_o \cdot X_i \cdot G \ldots \textit{(Eq. 1)}$$

where:

X_i - concentration of i^{th} sized particle group (g/L).
X_o - MLSS initial concentration (g/L).
G - root mean square velocity gradient (s^{-1}).
K_a (L/g) and K_b (s) - experimentally determined coefficients for the floc aggregation and break-up, respectively.

Eq. 1, which sums the potential floc formation due to turbulent mixing and floc breakup due to the stress tensor applied on the floc, has been widely used in FST modeling *(McCorquodale and Zhou 1993, Griborio 2004, Gong et al. 2011 and Ramalingam et al. 2012)*.

Definition of G

The velocity gradient G in ***Eq. 1*** has not yet been defined rigorously. The most frequently cited study was by Camp and Stein *(Camp and Stein 1943)*, where the root-mean-square velocity gradient was proposed as an approximation to the fluid shear velocity G. This parameter has been used to characterize mixing in a range of applications and especially in flocculation basins (*Crittenden et al. 2005)*. Several researchers *(Graber 1994; Kramer and Clark 1997)* have shown that the traditional definition of G should be modified to ***Eq. 2*** since that would take into account particle collisions caused both by shear and normal strain rates with G defined by ***Eq. 3***

$$\mu \cdot G^2 = \mu \cdot \left[(\partial u/\partial x)^2 + (\partial v/\partial y)^2 + (\partial w/\partial z)^2 + (\partial u/\partial y + \partial v/\partial x)^2 + (\partial u/\partial z + \partial w/\partial x)^2 + (\partial w/\partial y + \partial v/\partial z)^2\right] \ldots \textit{(Eq. 2)}$$

$$G=\sqrt{(P/(V \cdot \mu))} \ldots \textit{(Eq. 3)}$$

where,

P - power dissipated in the fluid domain.
V - volume of the domain.
μ - dynamic viscosity of the fluid.

In theory, velocity gradients can be calculated at any point within mixing vessels, provided that the power dissipated at each of those points is known. Experiments *(Ducoste and Clark 1998, 1999)* have shown that while a constant power input is applied to a stirrer in a jar, turbulence intensity and local turbulent energy dissipation rates vary and are dependent on the impeller type, jar size and rotational speed. Velocity gradients have a spatial and temporal response and given the difficulty associated with the calculation of G at a local level, researchers have opted to replace ***Eq. 3*** with the following approximation outlined by ***Eq. 4a***, where the average power consumption is acquired by ***Eq. 4b***.

$$\bar{G} = (\sqrt{(P_{ave}/(V \cdot \mu)} \ldots \textit{(Eq. 4a)}$$
$$P_{ave} = P_o \cdot \rho \cdot N^3 \cdot D^5 \ldots \textit{(Eq. 4b)}$$

where:

P_o - impeller power number.
ρ - fluid density.
N - impeller rotational speed.
D - impeller effective diameter.

Multiple authors *(Bridgeman, J. et al. 2009)* have argued that this assumption is inherently flawed as it attempts to represent a complex flow field with a singular value. G is not a conservative variable

continued on page 24

Table 2. Tri-column Classification Results, Based on "Good" or "Bad" (n = 8).

Tank No.	Average Large V_{as} (m/hr)	Average Medium V_{as} (m/hr)	Average Small V_{as} (m/hr)	MLSS (mg/L)	Temp °C	Large Floc Fraction	Medium Floc Fraction	Small Floc Fraction
1	-	-	-	1183	26.3	0.77	0.12	0.11
2	-	-	-	1196	26.3	0.68	0.14	0.18
3	-	-	-	1683	26.4	0.73	0.20	0.07
4	-	-	-	898	25.0	0.52	0.35	0.13
Avg. "Good"	> 6	~ 3.75	~ 1.13	-	-	**0.68**	**0.20**	**0.12**
5	-	-	-	607	18.5	0.15	0.53	0.34
6	-	-	-	722	21.4	0.22	0.49	0.29
7	-	-	-	823	21.4	0.28	0.48	0.24
8	-	-	-	1077	27.3	0.25	0.45	0.30
Avg. "Bad"	> 6	~ 3.75	~ 1.13	-	-	**0.23**	**0.49**	**0.29**

continued from page 23

and thus cannot be simply averaged out. However, using CFD it is possible to quantify the impact of the mean flow and turbulence using a local velocity gradient G_l, presented by ***Eq. 5*** *(Mei and Hu 1999)*.

$G_l = \sqrt{(\varepsilon/\nu)}$ … *(Eq. 5)*

where:

ε - energy dissipation rate per unit mass.
ν - kinematic viscosity of the fluid.

Identification of Coefficients in Parker's Model

The flocculation coefficients K_a and K_b in ***Eq. 1*** are typically determined using jar test experiments with the value of $\bar{G}$ calculated by ***Eq. 4a***. This value is usually provided by the manufacturer in the form of a chart that plots $\bar{G}$ vs. the RPM of the stirrer. Researchers have provided a detailed methodology on the determination of the coefficients of ***Eq. 1*** by the use of a nonlinear regression *(Moruzzi and de Oliveira 2013)*. Given the challenges faced by the interpretation of G – i.e., the average value in ***Eq. 4a*** or local value in ***Eq. 5*** – the development team elected to apply the k-ε turbulence model on the jar test equipment traditionally used (Phipps & Bird 900 Series Programmable Jar Testers) by CFD, both using the multiple reference frame (MRF) model and the more computationally demanding sliding mesh (SM) model as described in the literature *(Deglon and Meyer 2006)*.

Numerical simulations have shown that the value of the mass weighted average $\bar{G}$ ***(Eq. 4a)*** is approximately 40 percent lower at impeller rotational speeds ranging from zero to 90 RPM. G_l varied significantly within the jars, with the largest values found near the paddles and particularly in the turbulent wake area behind the impeller. All modeling efforts herein use the in-house developed calibration curves.

Model Selection

Zone Settling Model Selection

Zone settling characteristics can be well-predicted using the sludge volume index (SVI) of the sludge *(Daigger and Roper 1985)*. Moreover, equations such as the Vesilind ***Eq. 6*** and Takacs *(Vesilind 1968* and *Takacs et al. 1991)* can be used when batch activated sludge settling column tests are performed. Researchers have advocated that for the prediction of sludge blanket dynamics, the Takacs equation can be simplified to the Vesilind equation *(Watts et al. 1996)*. In view of these reflections ***Eq. 6*** has been predominantly used for these simulations.

$V_j = V_o \cdot e^{-r_j \cdot X}$ … *(Eq. 6)*

where:

V_o (m/hr) - the maximum settling velocity.
r_j *(j = h, c)* - relate the hindered and compression decay rate indices (L/g).
X - the sludge concentration (g/L).
V_j *(j = h, c)* - the settling velocity (m/hr).

These batch tests typically exhibit three different types of settling regimes: hindered, transient and compression *(Ekama et al. 1997)*. Multiple zone and compression settling experiments were conducted on-site, year-round. For each experiment, several dilutions of the mixed liquor were tested and the settling velocities corresponding to each concentration of MLSS were determined via linear regression to distinguish the settling characteristics of the subject sludge.

Table 3 tabulates recent batch experiments at one specific WRRF with calculated values of V_j and r_j along with the operating conditions of MLSS concentration, temperature, and sludge volume index (SVI).

Table 3. 26th Ward WRRF – Zone Settling Data (n=5).

No.	MLS (mg/L)	Temp (°C)	$V_{h,c}$ (m/hr)	$r_{h,c}$ (L/g)	SVI
1	609	19.0	11.7	0.38	69
2	773	22.0	12.5	0.49	68
3	954	24.0	14.3	0.57	55
4	1140	26.0	14.9	0.42	59
5	1680	23.8	13.3	0.52	53

Throughout the year, more than 100 zone/compression settling experiments were performed in just one of the WRRFs (data not shown). It appeared that all data fit ***Eq. 6*** with an R^2 of 0.9563 for SS concentrations up to 12 g/L. Therefore, a single equation was used.

Rheological Model Selection

There are multiple proposed empirical formulations in literature *(Eshtiaghi et al. 2013; Ratkovich et al. 2013)* that describe the rheological behavior of activated sludge. There is a lack of agreement in the research community on the best model when rheology is incorporated. Some argue that the Bingham and Herschel-Bulkley model should be used when modeling raw and anaerobically digested sludge *(Monteiro 1997)* while the Bingham model is ideal on thickened sludge *(Sozanski et al. 1997)*. Bokil *(1972)* proposed an experimental exponential function of plastic viscosity ***(Eq. 7)***.

$$v = \begin{cases} 1 \cdot 10^{-6} \cdot e^{(1.386 \cdot X)} & X < 1\ g/L \\ 2.9 \cdot 10^{-6} \cdot e^{(0.322 \cdot X)} & X > 1\ g/L) \end{cases} \dots \textit{(Eq.7)}$$

where:

v - effective molecular kinematic viscosity (m^2/s).
X - the sludge concentration in g/L.

DeClercq also proposed a modified version of the Herschel-Bulkley equation *(DeClercq 2003)*. When compared in the prediction of the sludge blanket height (SBH), however, it was determined that the two-parameter Bokil model provided the best overall fit. It should be noted that even though the current numerical code offers a choice of both the Bokil and the Herschel-Bulkley models, the former was used in this study due to the ease of use in the numerical computation sense. The new settling and rheology model proposed by Ramin and others *(Ramin et al. 2014)* should also be considered for future simulations.

Numerical Implementation – Turbulence Modeling

The standard turbulence model k-ε *(Launder and Spalding, 1972)* was chosen due to its popularity and effectiveness. It is a two-equation model, in which two separate transport equations are solved for the turbulence kinetic energy and its dissipation rate.

The model is coupled with scalable wall functions *(ANSYS 2013)*, avoiding deterioration at the wall when grid is highly refined. The effective viscosity of the sludge is given by ***Eq. 8***.

$v_{eff} = v + v_t$ … *(Eq. 8)*

where:

v_t - the turbulent eddy viscosity calculated directly by the k-ε model.
v - the kinematic molecular viscosity given by Bokil *(Eq. 7)*.

Discretization/Solution

FLUENT® software by ANSYS, Inc. was utilized for the geometry generation and the development of the simulation and results presented herein *(ANSYS 2013)*. All the sub-models described were implemented with user-defined functions (UDFs). A geometry generator was used to create the geometry from which the computational domain (grid) was extracted. The domain was divided into a finite number of control volumes and, with the use of a cell-centered finite volume approach, the governing equations for fluid flow and solids concentration were discretized. Because of the intricate geometries of the rectangular clarifiers and the anticipated presence of a wide range of turbulence-length scales in the domain, mesh generation was particularly challenging. High-quality mesh generation was of paramount importance, focusing on all critical regions. This was especially important near wall surfaces, where very refined boundary layers were utilized. Mesh independence tests were also performed to assure that the discretization method did not interfere with the results that were performed on personal computer (PC) clusters.

Case Study: 26th Ward WRRF

The CFD modeling effort results focused on the 26th Ward WRRF in Brooklyn, New York ***(Figure 2)***. The facility processes 85 million gallons per day (MGD), or 4.5 cubic meters per second (m^3/s). Two sets of four final clarifiers are present, whose size details are given in ***Table 4***. Even though the two types exhibit some differences, including energy-dissipating baffle, RAS withdrawal type and location, and distance of effluent weir from the end wall, the most significant difference lay in the total length of the tank ***(Figure 3)***. Tanks 1 through 4 were approximately 32 feet longer than Tanks 5 through 8. In addition to the length, the tanks are fitted with different types of energy-dissipating baffles as shown in ***Figure 4*** and ***Figure 5***. The discretized domain, representing the existing FSTs, is depicted by ***Figure 6*** and ***Figure 7*** *(see page 28)*.

Table 4: Geometrical Characteristics of Clarifiers at the 26th Ward WRRF.

Parameter	Tank Set *1 through 4*	Tank Set *5 through 8*
Length	232 ft 8 in	200 ft
Width	71 ft	71 ft
Depth	13.5 ft–14.5 ft	13.5 ft-14.5 ft
RAS Withdrawal	Center	Side
Sluice Gate	24 in x 24 in	24 in x 24 in
Energy-dissipating Baffle	Tank Length x 30-in Slot	60 in x 72 in

Figure 2. Three-dimensional (3D) view of the 26th Ward WRRF. *Google Earth*

Simulation Conditions/Results

The permutation of simulations was based on the parameters and flow conditions tabulated in ***Table 5*** *(see page 28)*. Two sets, defined as "good" and "bad," are outlined and will be used to present the results based on hypothetical questions that a stakeholder might raise. These hypothetical questions are:

i. What is the effect of solids loading rate on the clarifier's performance (i.e., increased MLSS)?

continued on page 28

Figure 3. Plan view of clarifiers: Tanks 1 through 4 (left) and Tanks 5 through 8 (right). *Google Earth*

Figure 4. Energy-dissipating baffle along the width, 30-inch opening at the bottom, in Tanks 1 through 4. *Krish Ramalingam*

Figure 5. Energy-dissipating baffle, with dimensions of 60 inches by 72 inches, in Tanks 5 through 8. *Krish Ramalingam*

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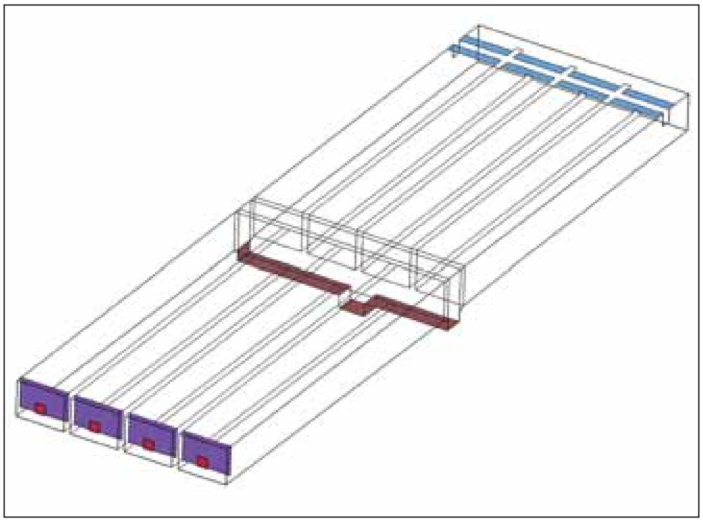

Figure 6. Current geometry of Tank Set 1 through 4. *CCNY*

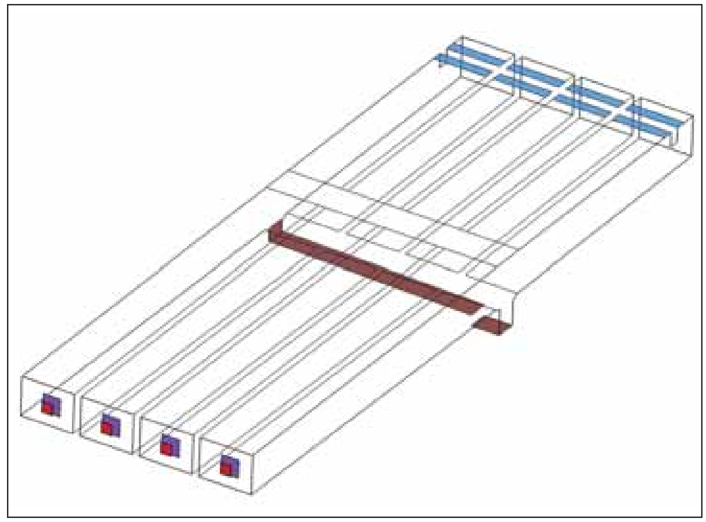

Figure 7. Current geometry of Tank Set 5 through 8. *CCNY*

ii. What is the effect of the surface overflow rate on the clarifier's performance (i.e., increased flow rate)?

iii. Could additional baffles be added? If yes, where?

The range of MLSS and flow-rate values was chosen between 2100-2500 mg/L and 6.0-15.8 MGD, respectively. The choice of baffle type (Secondary Baffle (SB) and In-Tank Baffle (In-TB)) and position are tabulated in ***Table 6***. Close up images of these proposed baffles are depicted in ***Figure 8*** and ***Figure 9***. The SB consists of 12-inch by 12-inch openings, while the In-TB measures 8-inch by tank width. The placement choice is not arbitrary but the result of a long sensitivity study by the authors (results not shown).

Table 5: Typical Model Input Parameters for "Good" and "Bad" Conditions.

Description			Variable	Value
Influent MLSS (g/L)			X_{MLSS}	2100-2500
Design Flow Multiplier	0.55X	1.0X	1.25X	1.5X
Effluent Flow, Q_{EFF} (MGD)	6.0	10.6	13.25	15.8
RAS, Q_{RAS}, (MGD)	4.0	4.0	6.6	8.0
Floc Characteristics			**Good**	**Bad**
Large Fraction	L		0.70	0.30
Medium Fraction	M		0.20	0.40
Small Fraction	S		0.10	0.30
Max. settling Velocity (m/hr)	V_o		14.9	14.3
Decay rate index (L/g)	r_j		0.42	0.67
Floc aggregation coefficient (L/g)	K_a		5.31xE-03	
Floc breakup coefficient (s)	K_b		4.62xE-06	

The discretized domain, representing the existing FSTs with baffles, is described by ***Figure 10*** and ***Figure 11***. Results of 18 permutations of runs are presented in ***Table 6***. Runs 1 through 4 show that the longer battery of tanks outperformed the shorter one. A close image at the effluent from Run 4 ***(Figure 12**, see page 30**)*** explains why this clarifier failed. ***Figure 13*** *(see page 30)* identifies asymmetry in the profile concentration; note the bottom effluent weir concentration. This could be attributed to the fact that the RAS withdrawal is located at one side, which would result in a "clockwise" 3D flow.

Comparing CFD effluent suspended solids (ESS) predictions for runs 1 through 10, it appears that even at 0.55 times the design flow, with "bad" settling conditions, failure will inevitably occur. This failure is due to either thickening or clarification, or both. With the assumption of "good" settling conditions, the FSTs can handle

Figure 8. Secondary baffle (SB) type, with 12-inch by 12-inch openings. *Krish Ramalingam*

Figure 9. In-tank baffles (In-TB), 8-inch wooden planks evenly spaced at 8 inches. *Krish Ramalingam*

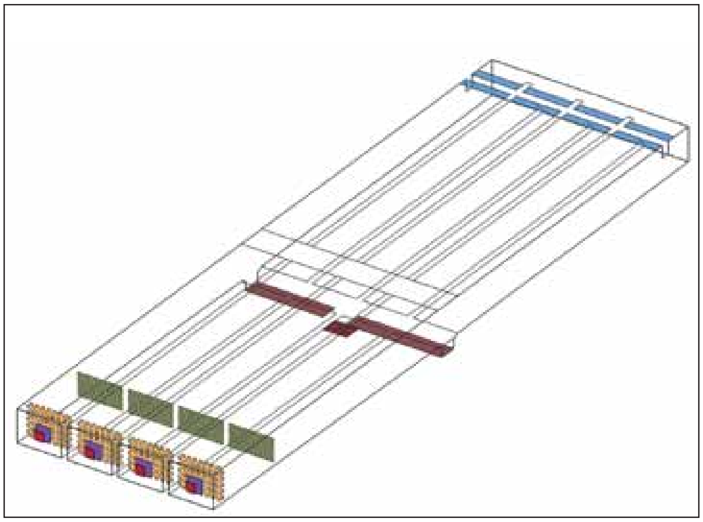

Figure 10. Geometry with SB and In-TB baffle addition, Tanks 1 through 4. *CCNY*

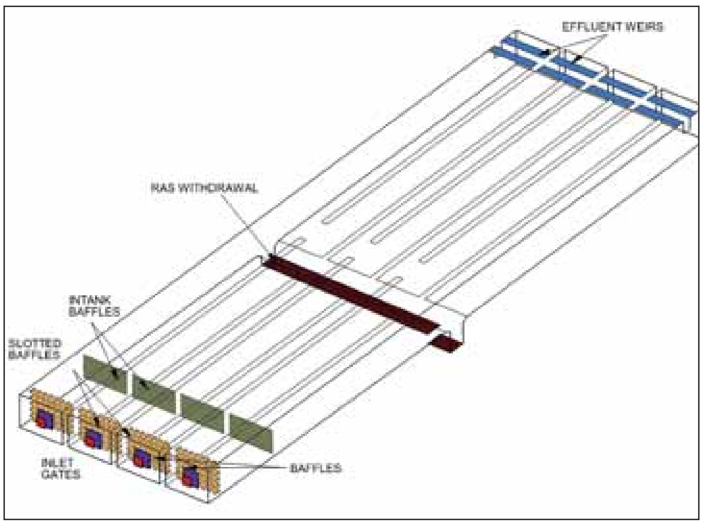

Figure 11. Geometry with SB and In-TB baffle addition, Tanks 5 through 8. *CCNY*

up to 1.25 times design flow at a MLSS of 2,100 mg/L (Run 5). The addition of baffles (Runs 13 and 15) postulates that with "good" settling conditions, both tanks will have no issue handling 1.5 times design flow at a MLSS of 2,500 mg/L. Contours of solids concentration along two planes and velocity streamlines are illustrated in ***Figures 13, 14*** and ***15*** *(see pages 30 and 31)*. Contours of the sludge concentration of a well-performing tank (Run No. 13) is shown in ***Figure 16*** *(see page 31)*.

Conclusions

Two of the important parameters of this CFD modeling endeavor were:

a. Identifying the initial fractionations of the solids categorized by settling velocity thresholds.

b. Developing a methodology in the identification of the floc aggregation (K_a) and floc break-up (K_b) coefficients.

There are primarily three mechanisms that sum up aggregation. The first is Brownian coagulation and applies to the smallest of particles present. The second is shear stress that increases the collision frequency and the third is sedimentation if particles are of different size. Particles are continuously in a process of aggregation and break-up, and floc size relies on the balance between the hydrodynamic forces exerted and the strength of the floc. This in turn correlates to the local turbulent energy dissipation rate within the FST. Energy-dissipating baffles combined with in-tank baffles can, through hydrodynamic modification, promote FST settling.

In this study, two baffle types were proposed that created a recirculation region within a defined space. In effect, re-entrainment of already clarified liquid into the inlet zone was averted, improving the overall fluid velocity and providing zones of further flocculation. Settling characteristics used as input parameters to the model were divided into "good" and "bad." Tanks 1 through 4 were superior to Tanks 5 through 8 in clarification under existing conditions. Yet if fitted with baffles, the modeling results show that both tank sets can exceed their design capacity.

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continued on page 30

Table 6: CFD ESS Prediction Based on Flow, MLSS, Baffle Addition and Settling Condition (18 CFD runs).

Run No.	Tank No.	MLSS (mg/L)	Q_{EFF} (MGD)	Q_{RAS} (MGD)	SB (5 FT)	In-TB (30 FT)	Predicted TSS (mg/L)		Baffle Comment
							Good	Bad	
1, 2	1-4	2100	6.0	4.0	no	no	5.6	37.0	As Is
3, 4	5-8	2100	6.0	4.0	no	no	8.9	44.2	As Is
5, 6	5-8	2100	10.6	4.0	no	no	17.4	94.0	As Is
7, 8	1-4	2500	15.87	8.0	no	no	38.8	349.0	As Is
9, 10	5-8	2500	15.87	8.0	no	no	46.6	852.6	As Is
11	5-8	2100	6.0	4.0	yes	no	–	27.8	1 Baffle Set
12	1-4	2100	6.0	4.0	yes	yes	–	28.6	2 Baffle Sets
13, 14	1-4	2500	15.87	8.0	yes	yes	11.6	301.0	2 Baffle Sets
15, 16	5-8	2500	15.87	8.0	yes	yes	11.8	744.2	2 Baffle Sets
17, 18	5-8	2500	13.25	6.6	yes	yes	9.59	168.8	2 Baffle Sets

Note: The shading for runs No. 11 and No. 12 in the "Good" column indicates that since the "Bad" column value satisfies the criteria (e.g., less than the permit limit of 30 mg/L), these "Good" runs were not made.

continued from page 29

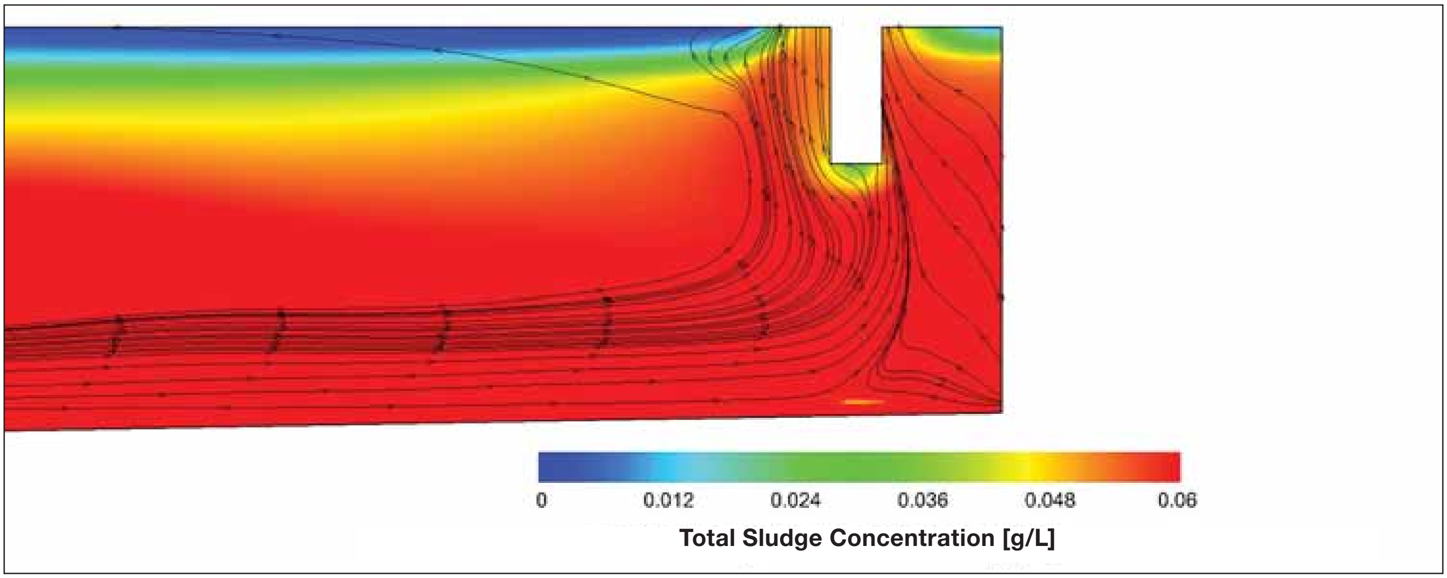

Figure 12. Sludge concentration contours (xy plane) at effluent with streamline overlay. Tanks 5 through 8, Run No. 4. *CCNY*

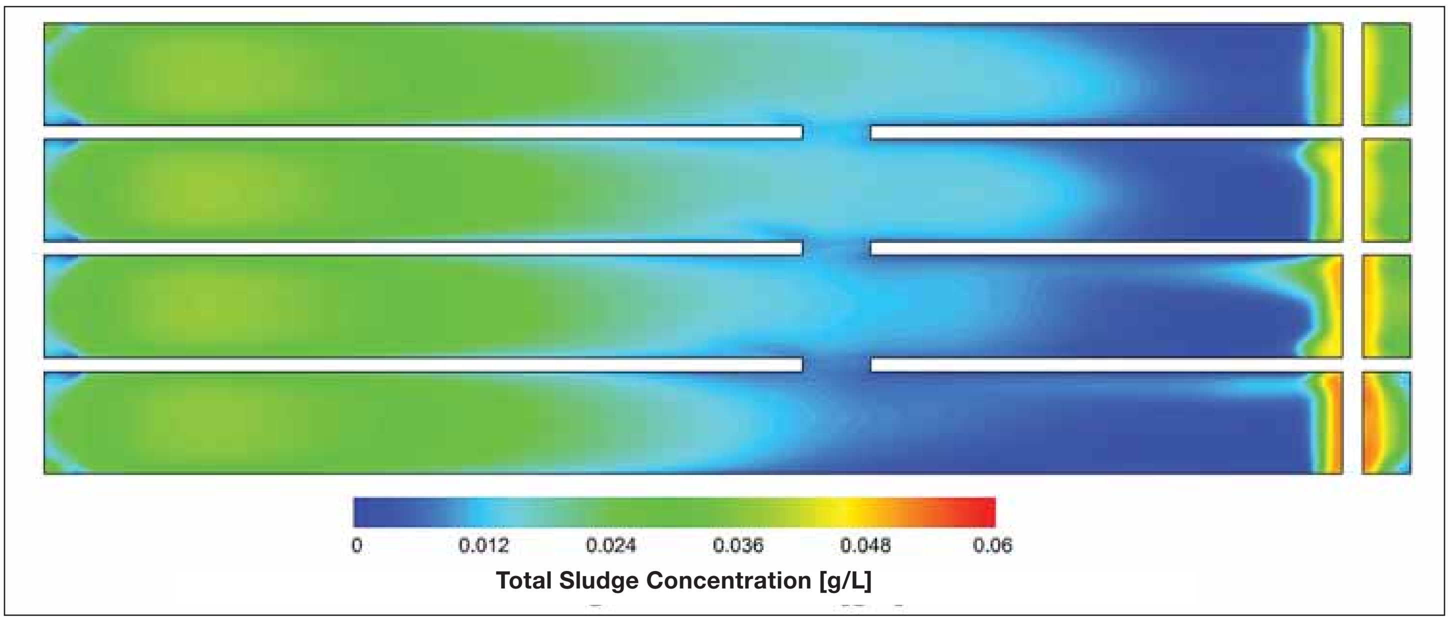

Figure 13. Sludge concentration contours (xz plane). Tanks 5 through 8, Run No. 4. *CCNY*

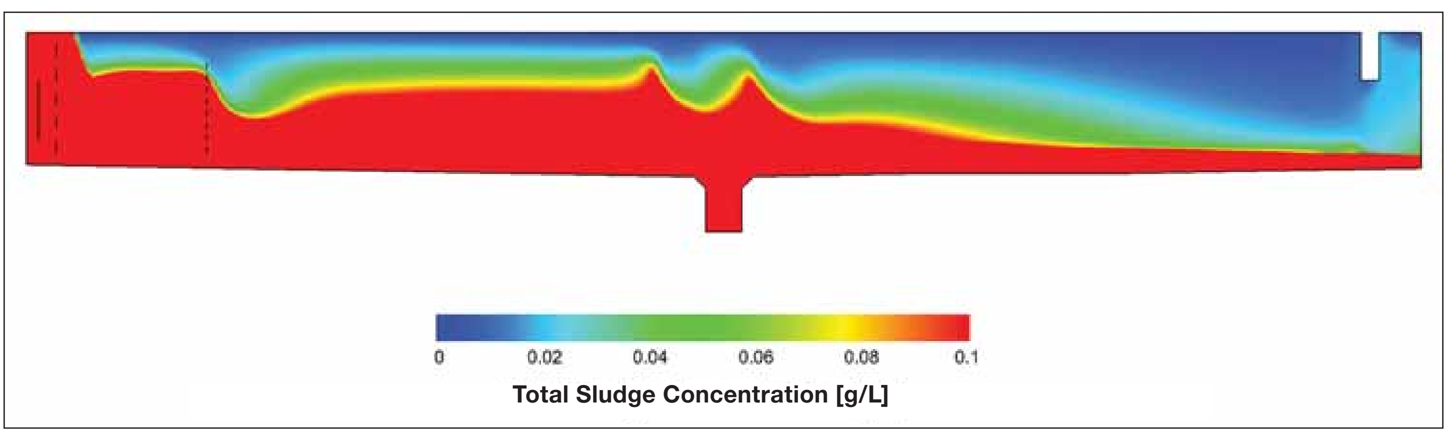

Figure 14. Sludge concentration contours (xy plane). Tanks 5 through 8, Run No. 18. *CCNY*

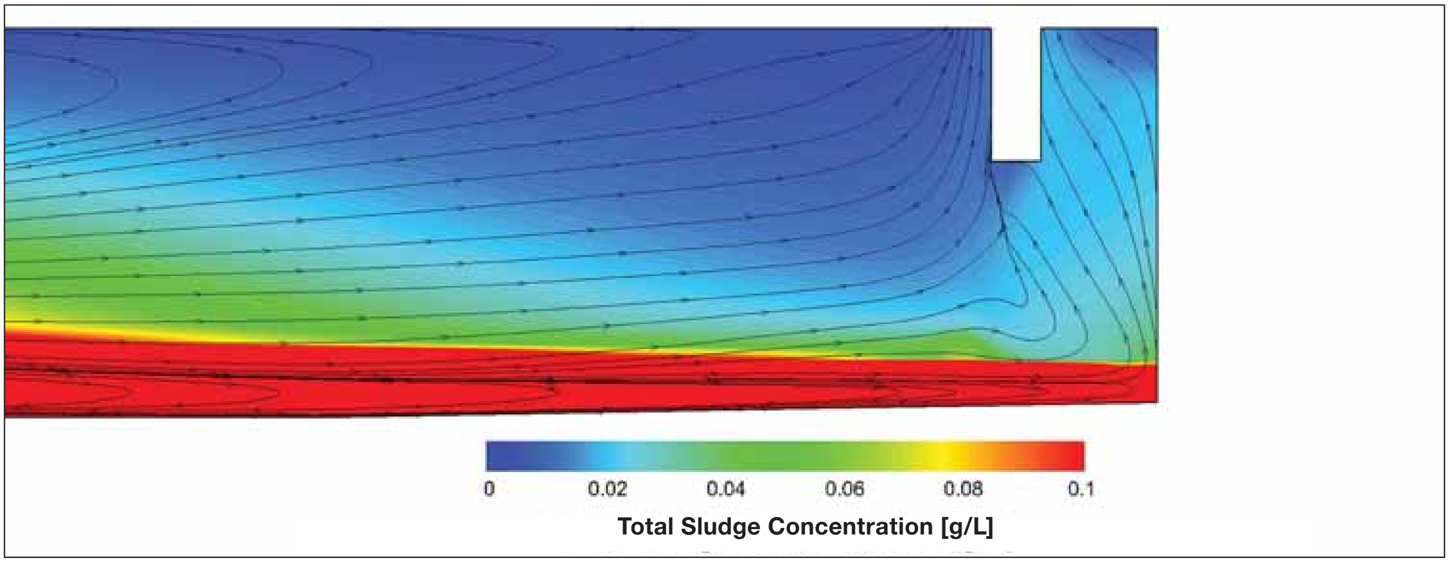

Figure 15. Sludge concentration contours (xy plane) at effluent with streamline overlay. Tanks 5 through 8, Run No. 18. *CCNY*

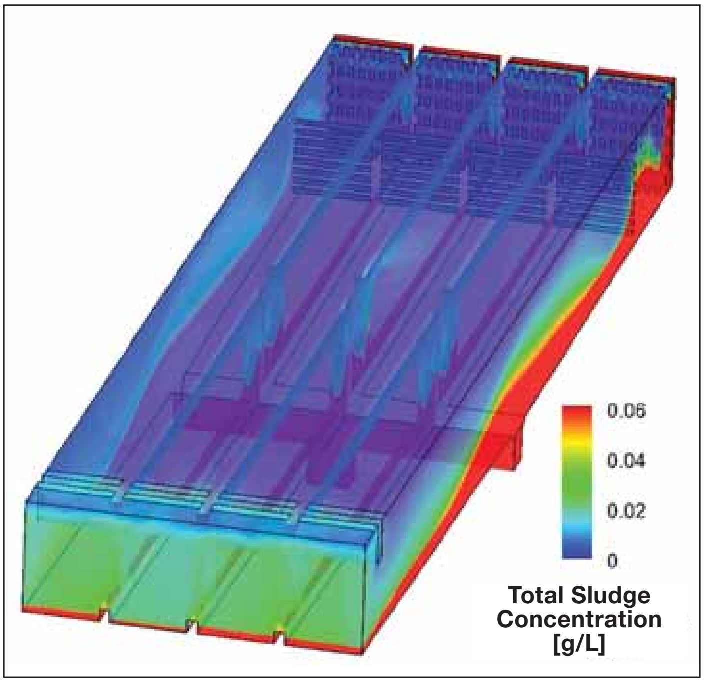

Figure 16. Sludge concentration, volume based, for Tanks 1 through 4, Run No. 13. *CCNY*

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A Baffling Hydraulics Problem

by David M. Railsback, Gregory J. Daviero and John Wendelbo

Here is a hydraulic design riddle. Imagine that you are the new senior operator of a water resource recovery facility. It is your first day of work at the facility, and you are making the rounds through secondary treatment. Your plant has two aeration basins: one is relatively old, while the other, added in a recent expansion, is relatively new. You walk by the old tank and everything looks good. You continue by the new tank, but something catches your eye: there is a foam blanket covering much of the tank's surface. The amount of foam is somewhat surprising, especially since this is the newer tank. You are eager to learn the ins-and-outs of this facility, so you stop for a closer look.

As illustrated in ***Figure 1***, both tanks are four-pass aeration basins, with alternating zones of aerated and non-aerated water. The tanks are running in step-feed mode, so the primary effluent is distributed equally at the head of each pass such that each pass receives one-eighth of the primary effluent. The aerated and non-aerated zones are separated by baffle walls.

In the new tank, the baffle walls are constructed from fiberglass-reinforced plastic (FRP). For water to travel from one zone to the next, flow passes either over or under the baffle. From your vantage point, a walkway above the tank, you can see flow passing over the weir that is notched out of the baffle near the surface of the tank. The weir crest is submerged a few feet below the water surface. Although you cannot see it, you know that a low-level orifice is cut out of the baffle near the floor of the tank. This typical baffle configuration is shown in ***Figure 2***.

Aeration Tank: Plan View.

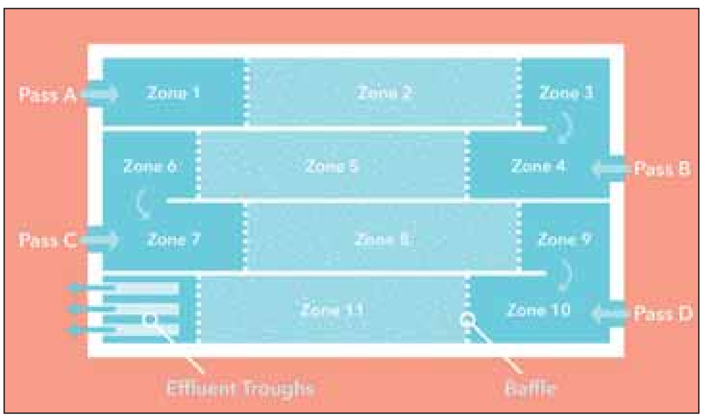

Figure 1. An Aeration Tank with alternating aerated and non-aerated zones separated by baffle walls. The tank is operating in step-feed mode, where primary effluent flows are distributed equally at the head of each pass. *Schnabel Engineering*

Key Features of Baffle Walls.

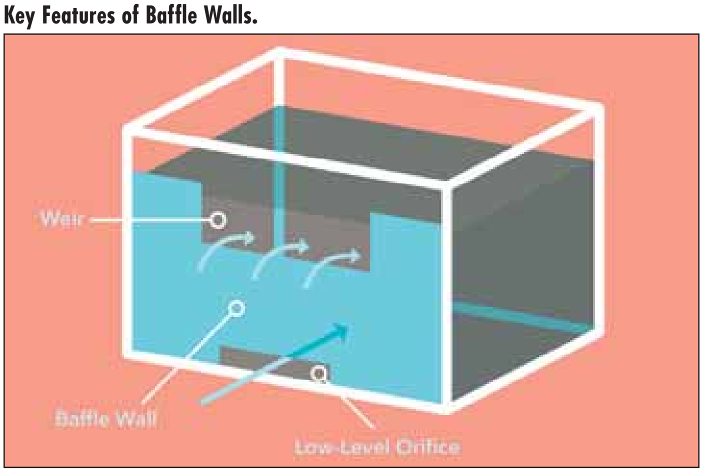

Figure 2. A typical baffle wall configuration, where flow can pass over the weir or through the submerged low-level orifice. *Schnabel Engineering*

As you inspect the new tank more closely, you notice that flow appears to travel backwards at the surface of the tank near some – but not all – of these baffle locations. This backflow is trapping foam and floating debris at the surface within the upstream zones, hindering its passage through the tank. The foam has built up significantly in some zones. The foaming appears heaviest in Passes A and B, less noticeable in Pass C and there is no foam in Pass D. You are concerned, and rightfully so. On a windy day, the foam could make a mess of walkways, handrails and instrumentation panels or – worse yet – upset the process performance.

You return to the old tank to see if the backflow is occurring there as well, and you observe that it is not. There must be some difference between these tanks. The new tank was built to be very similar to the old tank; both are four-pass aeration basins with identically arranged zones of aerated and non-aerated water and both are operating in step-feed mode. The air diffusers and the aeration rates are also identical between the tanks. The only noticeable difference is that the zones in the old tank are separated by structural concrete baffle walls. When the new tank was built, FRP baffles were used to reduce cost. The baffle geometry is the same, including the configuration of the weir and low-level orifice. However, the structural concrete baffle walls in the older tank have a slide gate over the low-level orifice, and the gates are currently in the closed position. You are a curious person, so you cautiously crank open one of the low-level gates in Pass A. Even before you have fully opened the gate, the forward flow over the baffle weir slows, comes to a stop, and then reverses.

What has been causing the backflow and foam accumulation at the new tank? Go ahead and have a guess.

Here is the situation, boiled down. Our trouble spot is a baffle that separates an upstream non-aerated zone from a downstream aerated zone. The upstream non-aerated fluid has greater bulk density than the downstream aerated fluid. The water surface elevations are nearly equal throughout the tank, so the density variation causes a pressure differential across the low-level opening between the two zones. The pressure differential drives flow forward through this orifice. Near the surface of the tank, the pressure differential is minimal. Near the floor of the tank, the pressure differential is more pronounced. The flow rate through the orifice depends on the dimensions of the orifice and the tank depth, as well as the degree of aeration and resulting pressure differential. In some circumstances, the forward flow through the low-level orifice may exceed the forward flow rate through the tank. If that occurs, then flow will return to the upstream zone by passing back over the weir in reverse. The ideal condition and the backflow condition are illustrated in ***Figure 3*** and ***Figure 4***, respectively. In a nutshell, there is the answer to the riddle. Did you solve it? If you knew the answer, bravo! If not, you have a chance for redemption in the Bonus Round.

Aeration Tank – Section View: Ideal Operation.

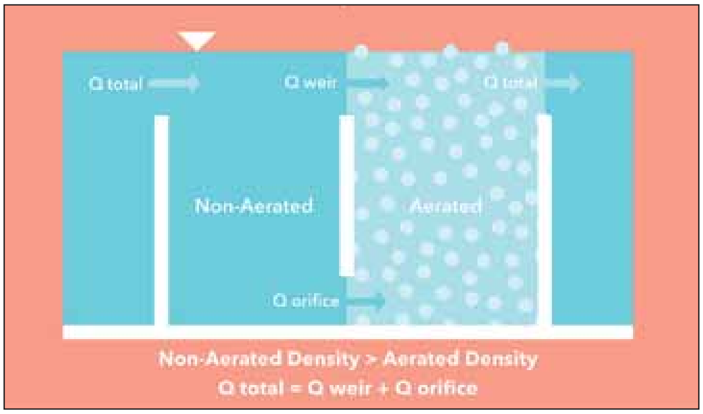

Figure 3. Under ideal conditions, flow moves gradually forward at all locations in the tank: over the weir and through the low-level orifice. *Schnabel Engineering*

Aeration Tank – Section View: Backflow Condition.

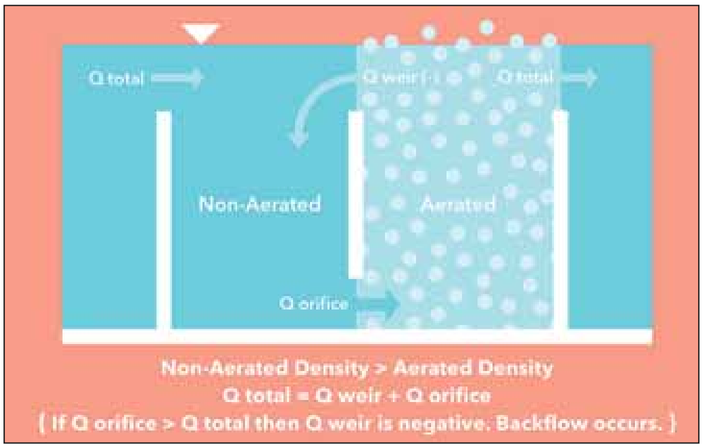

Figure 4. In some circumstances, the forward flow through the low-level orifice may exceed the forward flow rate through the tank. If that occurs, then flow will return to the upstream zone by passing back over the weir in reverse. *Schnabel Engineering*

Bonus Question 1

Why is the foam buildup greatest in Passes A and B, less evident in Pass C and not noticeable in Pass D?

Answer: Recall that the tank is operating in step-feed mode, so a quarter of the tank's flow is fed to each of the four passes. In other words, one eighth of the total primary effluent is fed to each pass, because there are two tanks. The overall forward flow in the tank is lowest in Pass A, so the relative impact of flow through the low-level orifice is greater and the backflow is very noticeable. The overall forward flow is highest in Pass D, so backflow is less likely to occur, and it will be less powerful if it does occur.

Bonus Question 2

How do you resolve the backflow problem?

Answer: The simplest way to minimize backflow in a tank is to limit the size of the low-level orifices. Reducing the orifice size will reduce the flow through the orifice, and subsequently reduce the backflow. The answer is as simple as that. However, there is a trade-off. A small low-level orifice might resolve the backflow condition, but it can cause other operational issues. We will cover one in detail: filling and draining the tank. A large low-level orifice will quickly equalize the water levels across the tank zones as you fill or drain the tank, reducing pressures across the baffle walls and minimizing the risk of breaking a baffle. With a large low-level orifice, you can fill a tank more quickly, with less risk. In contrast, it may take a long time to safely fill or drain a tank with small low-level orifices. If you fill the tank too quickly, the water will fill up one zone before the others, creating an unsafe condition and potentially breaking a baffle wall. Baffle failures like this have happened before and it is an expensive error! If a baffle fails under pressure, a wave of water and debris will travel through the tank, potentially causing a sequence of domino-style baffle failures, along with damage to diffusers, mixers and instrumentation.

A small low-level orifice plays a part in reducing the backflow and foaming issue, but a large low-level orifice may be preferred for O&M purposes. The engineer should be familiar with these design considerations to strike an appropriate balance. The owner and operator should be aware of the trade-offs.

Bonus Question 3

Why was backflow occurring at the new tank with the FRP baffles, and not at the old tank with the concrete baffles?

Answer: Some facilities have structural concrete baffles, with mechanically gated low-level orifices, allowing the best of both worlds. At our hypothetical facility, the low-level gates in the old tank are left closed during normal operations. All forward flow must pass over the weir, and this eliminates the backflow issue. During filling and draining of the tank, and during tank cleaning, the low-level gates can be opened. If one of these gates is accidentally left closed during filling or draining, hopefully the structural wall has been designed to withstand the differential hydrostatic pressures that would occur. A structural concrete baffle with low-level gates is expensive, and not a luxury that all treatment plants can afford.

Design Process

With all these competing design elements, the engineer will need to make delicate compromises. The site-specific solution must strike a balance between a facility's numerous operational requirements, and the intent must be passed down from the designer to the operator. Of course, cost is a factor.

The process sounds complicated, but there is good news! Engineers have been solving this design problem analytically for many years. The appropriate design process is neither fancy nor expensive; in fact, it can be performed in a somewhat detailed Excel spreadsheet. If you recognize similar hydraulic symptoms at your facility, there is likely a cost-effective solution.

Computational Fluid Dynamics

Our industry has some new tools that are allowing us to take a closer look at the hydraulic conditions in aeration tanks. Within the last few years, Computational Fluid Dynamics (CFD) has grown to incorporate entrained air, and these models are more accessible than ever to the water and wastewater treatment industry. Schnabel Engineering, Inc. recently collaborated with Flow Science, Inc. (Flow Science) to examine the backflow conditions within aeration tanks, and we are excited to share a few new findings.

Modeling Aerated Flows

Modeling aerated flows is currently one of the most interesting and rapidly growing areas of activity within the CFD modeling practice, and it is not just aeration tanks: consider air entrain-

continued on page 38

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continued from page 35

ment in drop structures; air entrainment in stepped chutes; and air entrainment in conveyance applications. Modeling "dispersed phase" flows such as water-plus-air can now be done on regular workstations using modern, advanced CFD tools. Not only can we model how the flow acts on the bubbles, we can also fully couple the effects that bubbles have on the flow itself.

Stepping back just for a moment, it has been several decades now that the Volume of Fluid (VOF) method was successfully deployed by Flow Science to accurately model complex free-surface flows in any number of water infrastructure applications, from flow over weirs and through orifices, to retention tanks and everything in between. The "water only" solutions (sometimes we call this the "straight hydraulics") is now a mature application for CFD practitioners. More recently we have been able to add additional elements to these analyses. For instance, for clarifiers we are able to model the settling of particles and formation of sludge, all tightly coupled to the hydraulics. For reaction tanks, chemistry is coupled with the hydraulics. Indeed, it is often the case that the complexities of wastewater applications require modelers to include many additional physics beyond the mere flow of water in and around hydraulic structures.

FLOW-3D®

For this application, we were particularly interested in trying out a completely new approach to modeling aeration. Where the practice has been to use dispersed phase models, sometimes called mixture models or drift-flux models in the literature, Flow Science has recently added a new approach using gas particles to the FLOW-3D tool box.

For many years, a particles-based approach to modeling air bubbles had been viewed as impractical simply because of the sheer number of gas particles that exit diffusers at any given time – numbers in the billions! How can they all be tracked? Advances with both hardware and numerical algorithms and methods have overcome these old perceived limitations.

Putting this new gas particle approach to the test, could we reproduce in the CFD world the backflow observed in the laboratory and in the field? We benchmarked our CFD results against some experimental work done in the hydraulics laboratory *(Daviero and Sturm 1996)*.

Methods

In the modeling world we always like to start simple: can we reproduce the flow conditions in the absence of aeration? The diffusers are turned off, flow is moving through the tank. Some of the water flows over the baffle weir, whereas some of the flow travels at depth through the submerged low-level orifice. In the absence of air diffuser action, both flows travel in the same direction downstream towards the next tank; this was the first step in our modeling sequence. A CFD model must capture the simple before attempting the complex, and our model accomplished that based on straight hydraulics.

Step 2: turn on the air! As air is turned on in the CFD model, millions of particles are released through the diffusers. ***Figure 5*** shows a snapshot of early bubble rise with the diffusers turned on.

Results

What is observed: just like in the experiments, upon exit from the diffuser pinholes the gas particles adjust very quickly to the local hydrostatic pressure by expanding from microns to millimeters in scale. There is a brief pause, followed by the much faster rise of the particles as they escape up to the surface. The numerical behaviors of the particles reproduce the qualitative observations of the experiment.

In FLOW-3D gas particles are fully coupled with the water, so that when a particle rises, it entrains some surrounding fluid along with it. Collectively, particles then can drive bulk circulations in the flow. Even if the patterns are not obvious to the eye because of the very turbulent nature of the flow, CFD can extract the time-averaged circulations from the instantaneous and chaotic velocity field. An example of the CFD results for backflow are shown in ***Figure 6***.

Ultimately, the key was to determine whether the CFD model was predicting the reverse flow over the weir. The hydraulic laboratory experimental results offered a range of flow and aeration conditions that we were able to test our model against. The conditions we reproduced in the CFD model had 5 percent bulk aeration, and backflow above the weir was measured for a range of inlet flow rate conditions. ***Figure 7*** shows that CFD does a good job at capturing the backflow trends, and even matches well with respect to the quantitative metrics.

Conclusion

In summary, there are fascinating physics and fluid dynamics at play in this backflow scenario, and we have been using it to test the capabilities of newly-released CFD tools that address gas particles and air entrainment. We are pleased with the preliminary results, and we are excited about the evolution of this particle-based approach to modeling aerated systems. We expect to continue seeing improved results across a range of cases as we continue to explore this set of modeling applications.

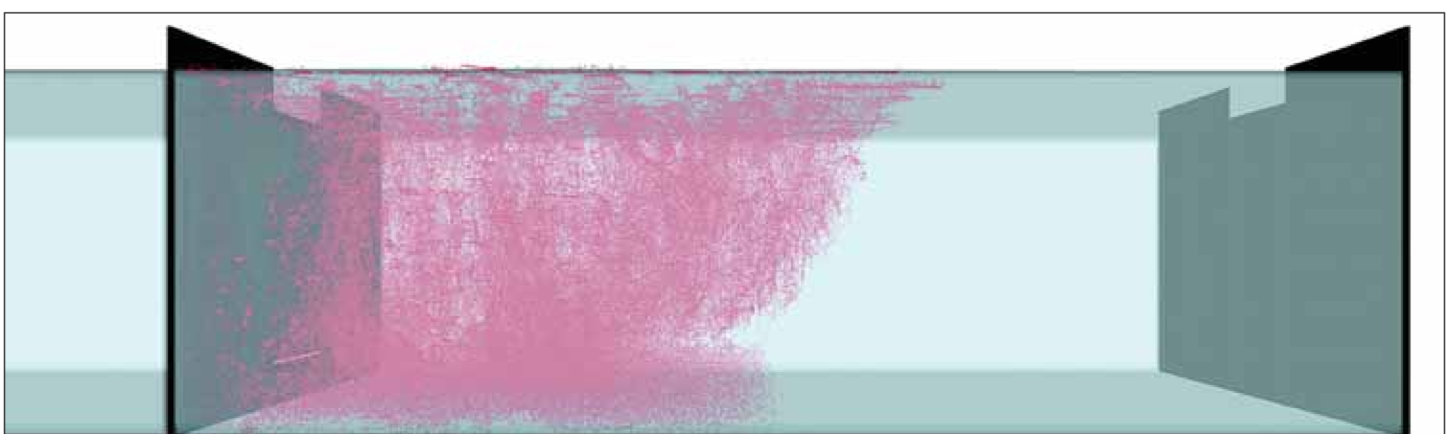

Figure 5. Gas particles in CFD. With the diffusers just turned on, a cloud of gas particles (millions of them) rise towards the free surface. *Flow Science*

Aeration Tank - Section View: CFD Rendering of Backflow Condition

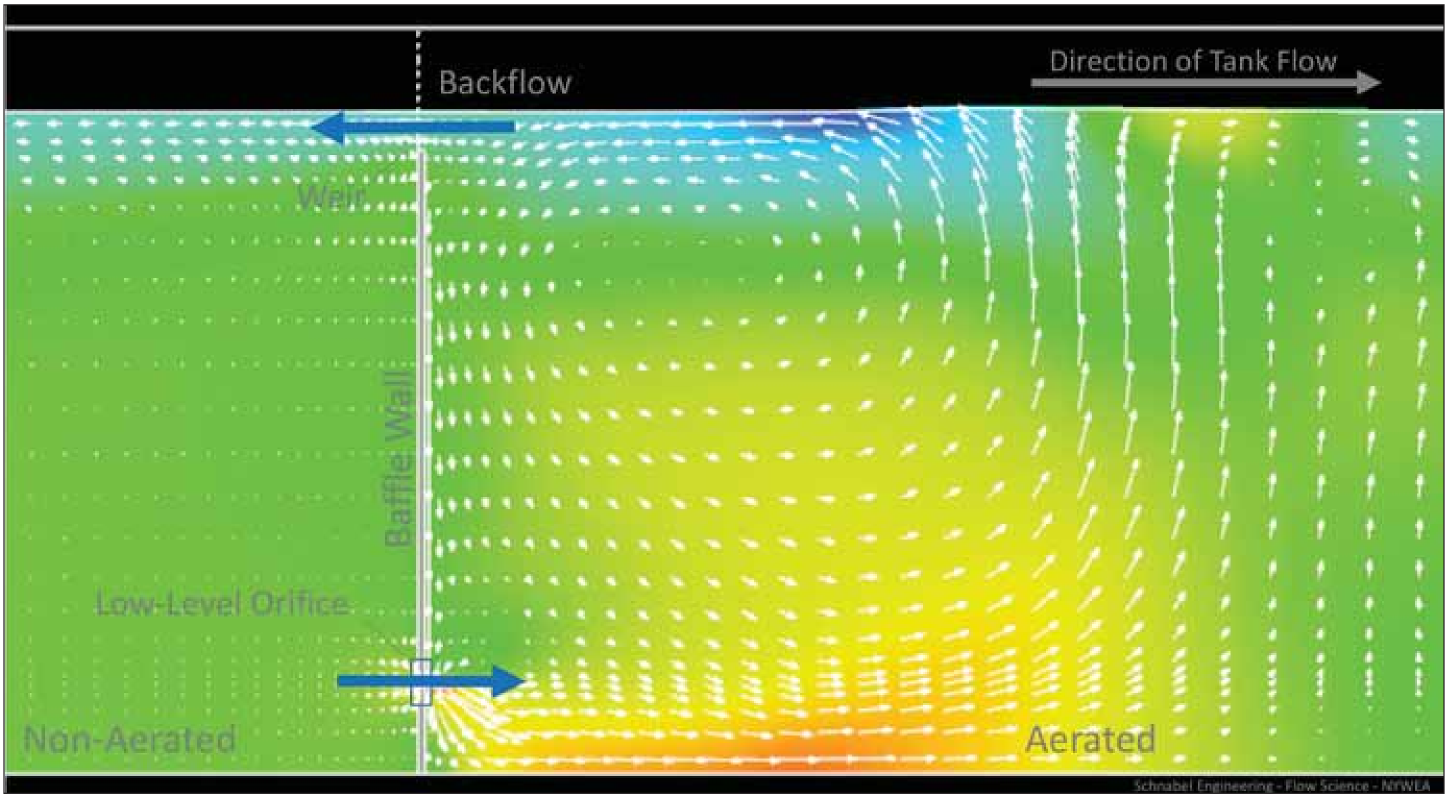

Figure 6. This baffle wall simulation in CFD demonstrates backflow characteristics, and the results are consistent with previous experimental data. CFD also offers a glimpse at internal flow characteristics, which are typically obscured by turbulent conditions in the field and in the lab.
Schnabel Engineering and Flow Science

Backflow Condition: Comparison of CFD and Experimental Results.

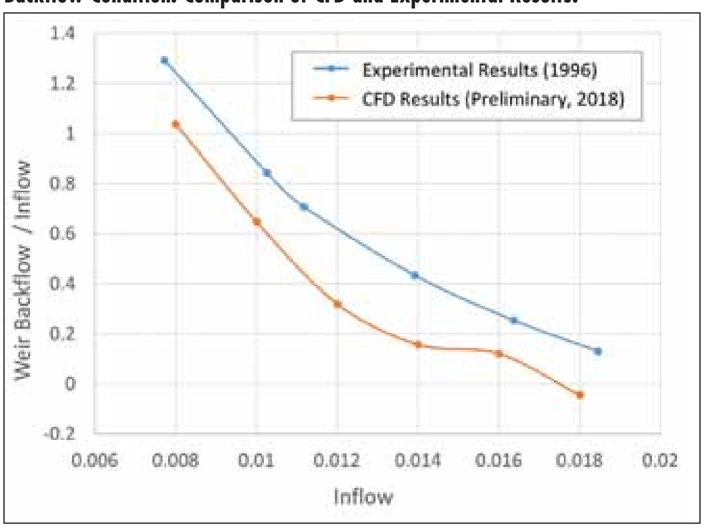

Figure 7. Preliminary CFD modeling, plotted against experimental results, for various inflow rates and a fixed 5 percent bulk aeration. Both methods illustrate the backflow condition, with similar quantitative metrics. *Schnabel Engineering and Flow Science Dimensions*

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Now Available in the United States and Canada: Aerobic Granular Sludge

by Brian Bates

Developments in wastewater treatment processes and products are happening around the world. Aerobic granular sludge (AGS) is a novel microbial community that allows simultaneous removal of carbon, nitrogen, phosphorus and other pollutants in a single sludge system (*Nancharaiah and Kiran Kumar Reddy 2018*).

The key difference between AGS and conventional biological nutrient removal is the granule itself. Within the granule ***(Figure 1)***, the DO concentration drops off as you move towards the center, thereby creating an aerobic zone (outside layer), anoxic zone (intermediate layer) and anaerobic zone (middle of the granule) as opposed to multiple tanks found within a conventional system to create those same zones.

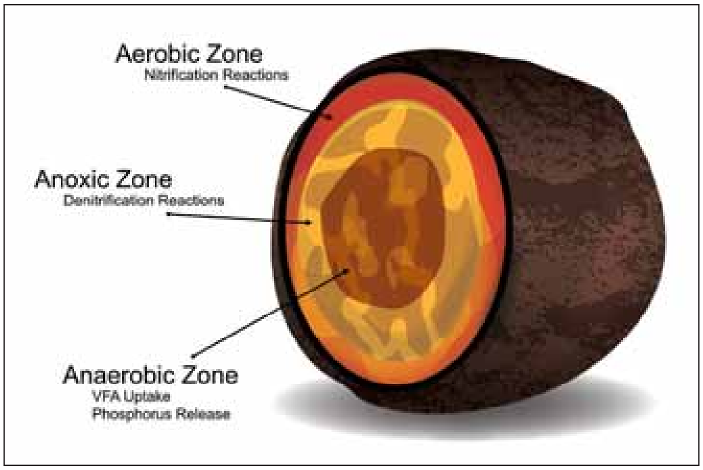


Figure 1: AquaNereda granule illustration shows three zones with different oxygen levels.

Research has demonstrated that AGS technology can effectively be implemented for the treatment of domestic wastewater *(Pronk et al 2015)*. AGS technology, under the brand name Nereda®, is a biological wastewater system that provides advanced treatment using the unique features of aerobic granular biomass.

The Nereda Process

The Nereda process was created by a public-private partnership with Delft University, Dutch Water Authorities and Royal HaskoningDHV in the Netherlands. In 2016, Aqua-Aerobic Systems, Inc. signed an agreement with Royal HaskoningDHV to become the exclusive provider of the Nereda granular biomass wastewater treatment system in the United States and Canada, where it is marketed under the brand AquaNereda® Aerobic Granular Sludge Technology *(Royal HaskoningDHV 2016)*.

The technology has been used successfully for more than 12 years in full-scale wastewater treatment facilities, with over 50 plants currently in operation or under design and construction. This experience has demonstrated that the technology offers several advantages when compared to conventional activated sludge systems, including:

- Significant footprint reduction in terms of the space occupied in the treatment facility.
- Energy and chemical savings under a wide range of influent characteristics, applications and climates.

Pilot Study

To introduce the technology to the North American market, Aqua-Aerobic Systems planned to build a demonstration facility.

continued on page 42

Full-scale installation of Nereda AGS technology, Epe, Netherlands, June 2015. *Royal HaskoningDHV*

continued from page 41

First, however, a four-week AGS pilot study was completed at Rock River Water Reclamation District (RRWRD) in Rockford, Illinois, in the spring of 2017. The pilot unit was equipped with two independent AGS reactors. Both reactors were seeded to a mixed liquor suspended solids (MLSS) strength of 8 g/L with aerobic granules shipped from a full-scale Nereda aerobic granular sludge plant overseas.

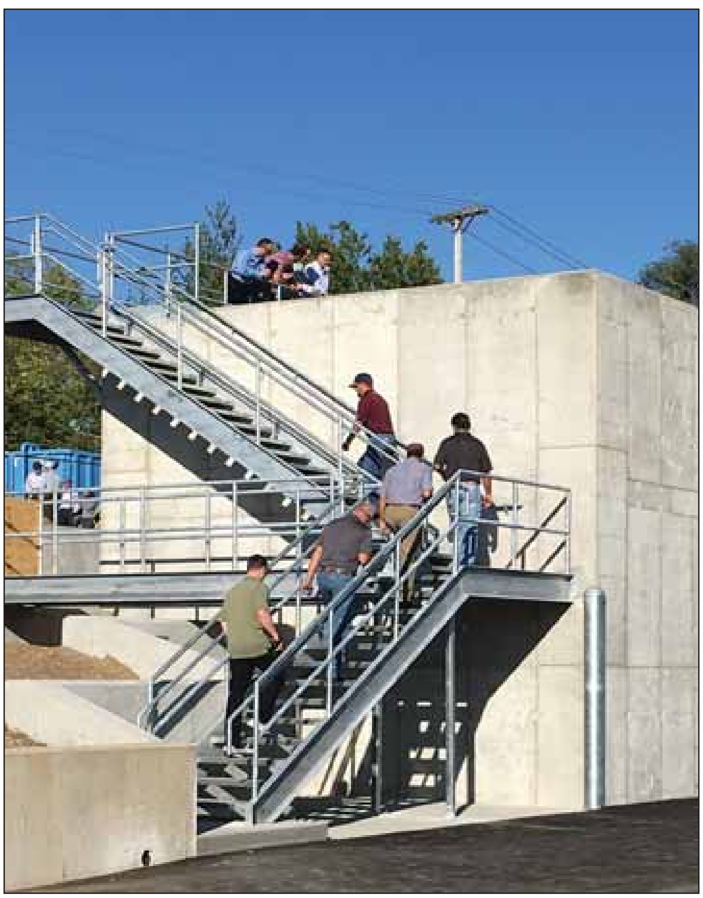
One of the primary objectives of the pilot was to demonstrate the rapid acclimation of granules that had been dormant in shipping containers for three months. Nitrification was observed within two and a half weeks of start-up. Within four weeks, BOD_5 and total suspended solids (TSS) were both reduced to less than 10 mg/L, total nitrogen (TN) and total phosphorous (TP) were reduced to less than 3 mg/L and 0.8 mg/L, respectively. The pilot study performance was comparable to the performance of existing full-scale plants.

Demonstration Project

Following the pilot study, Aqua-Aerobic Systems built a 757 m^3/d (200,000 gpm) demonstration facility at the RRWRD in Rockford, Illinois. This fully automated system was put into operation in January 2018.

The AquaNereda demonstration facility is unique in that it is capable of operating at a range of process water level depths. This allows the distinctive advantages of AGS to be demonstrated at the various process depths often seen in retrofit applications. The demonstration facility also provides Aqua-Aerobic Systems with two additional functions:

- The facility is a North American site to grow and store seed granules for plants in the United States and Canada that need to accelerate biological nutrient removal during commissioning of new plants.
- The facility is an easily accessible aerobic granular sludge site for engineers and plant operators in North America to visit and learn more about the technology.



Visitors at the AquaNereda demonstration plant (RRWRD) in Rockford, Illinois, September 2017. *Aqua Aerobic Systems Inc.*

The analytical results obtained from the demonstration plant at start-up ***(Table 1)*** exhibited the same performance as the initial pilot studies, showing that pilot studies are representative of full-scale performance.

Table 1. AquaNereda® Demonstration Plant (RRWRD) Effluent Results.

Parameter	Influent (mg/L)	Effluent (mg/L)
COD	262	18
BOD_5	116	2
TSS	128	8
TN	30	2.6
NH_4-N	11	<0.1
TP	2.6	0.9

Overall, the RRWRD demonstration plant produces the same effluent quality as seen at more than 50 full-scale Nereda installations around the world. Operation at this demonstration facility is now focused on varying process water depths, increased MLSS strength, solids handling, and various process control strategies.

Should you implement this technology at your plant? There are many factors to consider. This is a custom-engineered plant, so footprint requirements, energy needs, capital investment, and operation and maintenance costs for each implementation are assessed on a case-by-case basis., For more information about the AquaNereda process, visit the web site at *www.aquanereda.com*.

Brian Bates, MBA, B.Sc. is a Product Channel Manager with AquaNereda® Aqua-Aerobic Systems Inc. He may be reached at bbates@aqua-aerobic.com.

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Ultrafine Bubble Diffused Aeration System Reimagined

by Roberta Gaiek, Julie Le, Timothy Blake, Oluwole (OJ) McFoy, Jamie Johnson and Andrew Casolini

Introduction

The Buffalo Sewer Authority (Buffalo Sewer), a public benefit corporation, was created in 1935 by an Act of the New York State Legislature to provide effectual means of relieving the Niagara River and other tributary streams from pollution by sewage and waste. Buffalo Sewer's Main Office is located in downtown Buffalo, New York, and the authority serves more than 550,000 people, 24 hours a day, 365 days a year. Buffalo Sewer is deeply committed to maintaining high levels of public trust and environmental protection services. Its primary responsibility is to protect public health and the Great Lakes waterways from pollution, and its goal is to continually invest and improve both infrastructure and efficiency to ensure the quality of water resources throughout western New York.

Aeration at the Bird Island WRRF

Buffalo Sewer owns and operates a Water Resource Recovery Facility (WRRF) located on Bird Island, which is located within the City of Buffalo in the Niagara River. The Bird Island WRRF is designed to handle a peak flow of 563 million gallons per day (MGD); a flow of 360 MGD is expected to go through the secondary treatment. To better meet the needs of Buffalo Sewer's customers while managing available resources, Buffalo Sewer is driven to improve operations and energy efficiency within its facilities.

The aeration system, one of the most important treatment processes within the plant, is reaching the end of its useful life. If no action is taken, the oxygen transfer efficiency (OTE) will suffer, which correlates to increased energy usage and uneven air distribution in the aeration tanks. As the aeration and mixing are not optimized, dead zones with low dissolved oxygen will form in the aeration tanks. With poor OTE, the blowers that supply air to the aeration tanks will work harder to deliver the same volume of oxygen to meet the treatment demands of the system.

Buffalo Sewer's leadership has long suspected that energy efficiency could be gained by using higher efficiency diffusers within the aeration system. Based on the New York State Energy Research and Development Authority's (NYSERDA) *Water & Wastewater Energy Management: Best Practices Handbook* (2010), savings from 30 to 70 percent of total aeration system energy consumption are typical when coupling the diffused aeration system upgrades with the on-going aeration blower upgrades at the WRRF.

Planning for the Future

Before the OTE of the existing fine-bubble ceramic diffuser system is compromised, Buffalo Sewer began actively planning ahead for the replacement of the aging aeration system. Working with its consulting engineer and local manufacturer's representative, a pilot study program has been designed to benchmark aeration improvements to the existing system. The end goal is to create a business model for the proposed aeration system improvements that will qualify and quantify the energy and operations and maintenance (O&M) savings potential.

Buffalo Sewer's leadership, recognizing the importance of this capital improvement project, assembled the "dream team" that included various experts in the engineering field:

- Sanitaire®, a Xylem, Inc. brand, is a leader in diffused aeration technology and manufacturing. Sanitaire offers a tilt-up diffuser design for the ease of cleaning and maintenance activities in the aeration tanks.
- Mollenberg-Betz is a century-old, Buffalo-based mechanical contractor specializing in process piping.
- Wendel, the consulting engineer, manages the overall project and ensures effective communication of the project's vision on behalf of Buffalo Sewer.

Existing Configuration and Pilot Study Program

There are 16 aeration tanks at the Bird Island WRRF ***(Figure 1)***. Each tank is currently equipped with a Sanitaire fine-bubble ceramic diffused aeration system, which was installed in 1995. Currently, 14 tanks are in operation to provide adequate aeration to the secondary treatment system.

Bird Island WRRF Existing Ceramic Diffusers Design Parameters

- Type: Fine-Bubble Ceramic
- Disc diameter: 9 inches
- Number of passes per tank: 4
- Approximate dimension of each pass (L x W x H, in feet): 160 x 30 x 15
- Number of zones per pass: 2
- Total number of diffusers: 57,000 in 16 tanks

A gas cleaning system was installed at the same time as the ceramic diffuser system so that the diffusers can be regularly cleaned. Buffalo Sewer cleans the Bird Island WRRF ceramic diffuser system every spring at an estimated annual cost of $110,000. The regular gas cleaning is a significant maintenance activity and cost for the plant.

Tank Nos. 3B and 4B at the facility were once used as holding tanks for an in-situ grit removal process. When the in-situ grit removal process was no longer needed, Tank Nos. 3B and 4B were drained and cleaned out completely. With proactive planning for the diffuser system improvements at the WRRF, Buffalo Sewer selected Tank Nos. 3B and 4B for the installation of the new ultrafine bubble membrane diffusers for the aeration pilot study program, before proceeding with the plant-wide diffuser system upgrades. The diffusers will be studied for a one-year period under the pilot study program to compare the performance between the existing and the new aeration systems, including energy efficiency and ease of operation and maintenance of each system for the plant's personnel.

The following objectives were identified with this pilot and design project for the Bird Island WRRF's diffused aeration system:

- Critical asset renewal to maintain continuous operation at the WRRF.
- Protect human and environmental health.
- Reduce energy costs associated with the aeration system by improving the OTE of its diffusers.
- Eliminate the need for costly gas cleaning as it will no longer be required for the membrane diffusers.
- Qualify and quantify whether full scale implementation of aeration diffuser upgrades will result in an ideal return on investment when comparing capital construction cost to energy and O&M savings.

Figure 1: Bird Island WRRF Project Site Plan. *Wendel Companies*

How is Aeration "Reimagined"?

For the ultrafine bubble membrane diffused aeration system pilot study program, a strip diffuser type ***(Figure 2)***, instead of the traditional disc type, was selected. The strip geometry and advanced micro-punched membrane for high-density, full-floor coverage and low head loss, is expected to provide higher oxygen transfer, maintain uniformity and require less energy from the aeration blowers. During the design phase Buffalo Sewer, the consulting engineer and the manufacturer worked closely to create an optimal diffuser layout for each pass of Aeration Tank Nos. 3B and 4B.

According to the WRRF personnel, the second zone of the first pass (Zone No. 2 of Pass No. 1) in each Aeration Tank accumulated a noticeable volume of solids as compared to other zones within the same tank. Therefore, a tilt header concept, with headers that can be rotated on the manifolds, was designed specifically to facilitate cleaning of these accumulated solids and for maintenance activities within the second zone. Four headers are tied together, sharing the same support structure so that four headers can be rotated vertically at one time.

In each Aeration Tank, Zone No. 2 of Pass No. 1 will have 78 headers, corresponding to approximately 20 grouped headers for rotating. In order to tilt one header group, loosening the anchor bolt and support structure in the basin will be required. Once loosened, the operator can use a hoist from the operating deck level to lift from the center of the group header up towards the outer wall of the Aeration Tank ***(Figure 3)***. With the headers tilted up and secured in place with provided eyehooks and cables, maintenance personnel can easily access and remove accumulated grit.

FUN FACT:

Buffalo Sewer's Bird Island WRRF will be the first facility in New York to install and operate a tilt header design!

Another notable design feature addresses the high velocity problems of the influent wastewater flow in Zone No. 1 of Pass No. 1. Historically, Buffalo Sewer has experienced issues with damage to the diffusers and manifolds in the direct flow path due to the

Figure 2: Sanitaire® Gold Series strip diffusers delivered to the Bird Island WRRF. *Wendel Companies*

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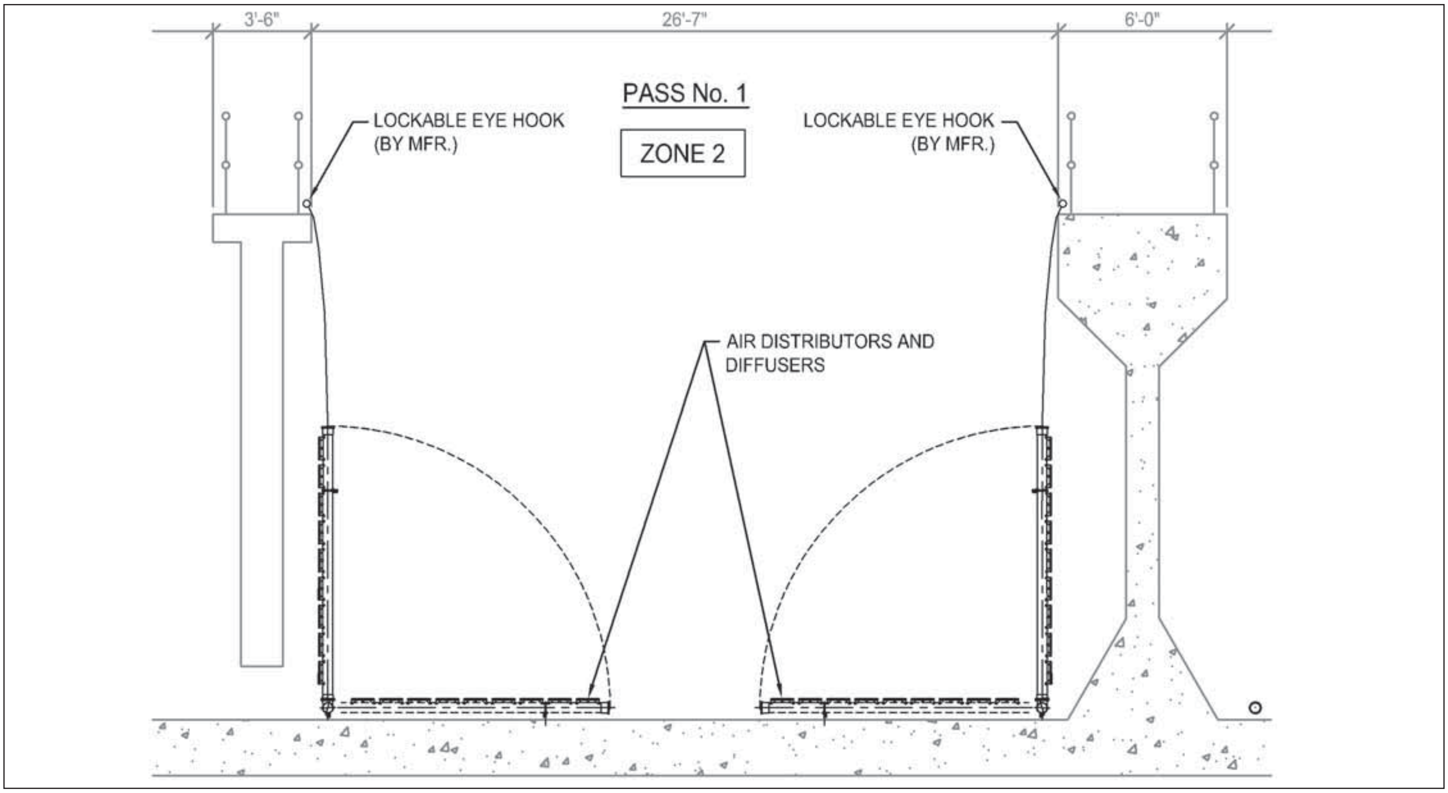

Figure 3. Tilt header design schematic. *Sanitaire®*

high velocity. To compensate for this issue, more rigid anchorage and additional supports will be provided to mitigate damage and increase longevity of the new diffusers.

The system design and layout optimization ***(Figure 4)*** will maintain uniform airflow, preventing hot spots, dead zones and areas for spiral roll currents, each which can degrade OTE within any given zone or pass of the Aeration Tanks.

New Ultrafine Bubble Membrane Diffusers Design Parameters

- Type: Ultrafine Bubble Membrane, Strip Diffuser
- Strip length: 59 inches for medium strips and 90 inches for long strips
- Total number: 1,170 diffusers per aeration tank
- Design Standard Oxygen Transfer Efficiency (SOTE): 33.5 percent

The strip membrane diffusers are easy to install and are shipped from the factory with as much pre-assembly as is feasible. With proper maintenance, it is projected that the ultrafine bubble diffused aeration system will last upwards of 30 years without the need for harsh chemical cleaning. The anticipated improvement in OTE, ease of maintenance and lack of harsh chemicals is expected to result in real energy and O&M savings for Buffalo Sewer.

What's Next?

The pilot study program elements are coming together. The upcoming activities in the program are:

- Receipt of delivery of Tank 3B diffuser equipment; Tank 4B diffuser equipment was delivered in October 2018.
- Storage of diffuser equipment through March 2019.
- Contractor to mobilize for installation in March 2019.
- Pilot study system start-up anticipated in June 2019.
- Pilot study program and data analysis to start in June 2019 and continue into 2020.

Conclusion

Through this project, Buffalo Sewer is demonstrating its thought leadership when it comes to capital planning and investment. By working collaboratively with its team of consulting engineers, equipment manufacturers and installing contractors, Buffalo Sewer is striving to ensure an end product tailored to meet its specific goals and requirements. Doing so in a small-scale installation via a pilot study program verifies that future capital spending is fact-based. Using real comparative data, Buffalo Sewer can assess whether the energy and O&M savings realized will result in a favorable payback when factoring in the total capital investment for full scale implementation. This forward thinking shows Buffalo Sewer's efforts to address the needs of its customers in a manner that is responsible and transparent.

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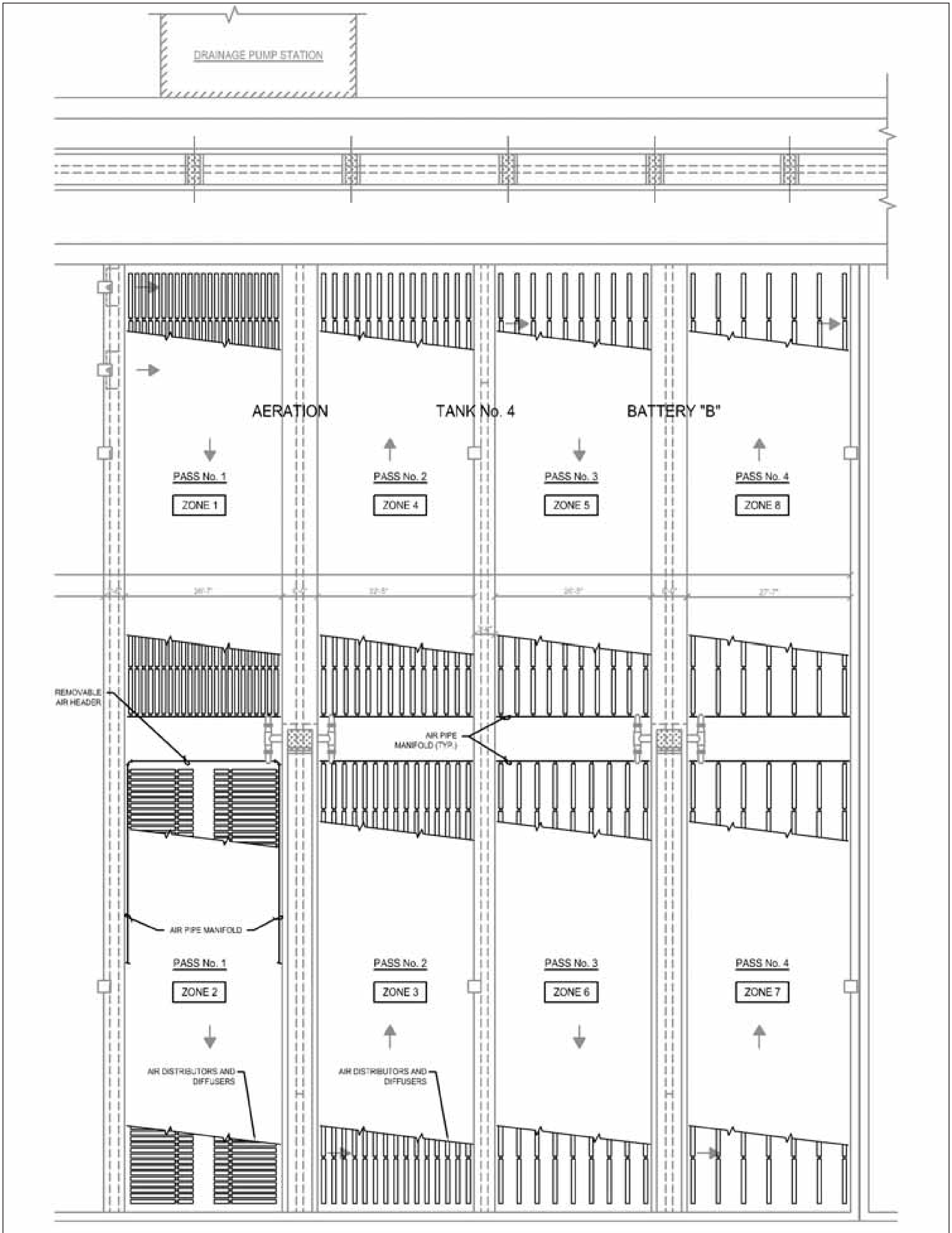

Figure 4. Strip diffuser layout schematic in Aeration Tank No. 4B. *Wendel Companies*

Nutrient Removal Impacts on Other Treatment Processes: Understanding the Effects of Nutrient Removal on Dewatering

by Patrick Dube

As states push nutrient discharge limits lower for water resource recovery facilities (WRRFs), utilities must implement different technologies to make sure they comply. While many different nitrogen (N) and phosphorus (P) removal technologies can help meet these limits, WRRFs must carefully select them to avoid unintended consequences on dewatering processes and costs.

Nitrogen Removal

When it comes to nitrogen removal from waste streams, two methods are typically used, physicochemical (ion exchange, air stripping, etc.) and biological. Although both methods can remove nutrient, biological nutrient removal often makes more fiscal sense.

By using the natural nitrogen cycle of the bacteria in a WRRF, nitrogen is removed via nitrification-denitrification. Ammonia is transformed to nitrite (NO_2-) and then nitrate (NO_3-) during nitrification before a different set of bacteria transforms nitrate into nitrogen gas (N_2) during denitrification. The gas escapes into the atmosphere.

The entire process is driven by bacteria under either anaerobic or aerobic conditions. Oftentimes, these processes occur in separate tanks as nitrification is an aerobic process while denitrification is an anaerobic process, but it can all be completed in one tank if anaerobic zones exist. Aside from aeration, nitrification-denitrification requires ample carbon for the bacteria to use as building blocks. Optimization of the process, important to achieve high removal, requires balancing temperature, dissolved oxygen, pH and solids retention time. As shown in ***Figure 1***, balancing carbon also is important. The carbon used for nutrient removal lessens the amount available for anaerobic digestion to generate biogas, and therefore, energy.

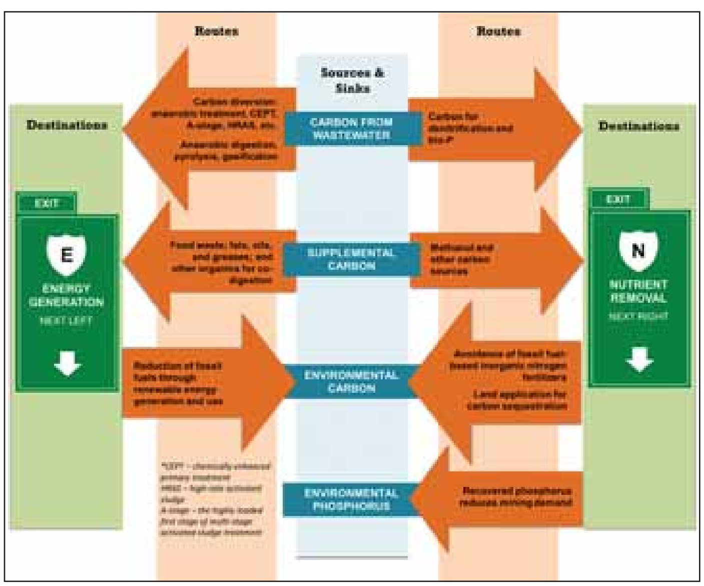

Figure 1. Both energy generation and nutrient removal require carbon.
Water Environment Federation (2015)

Phosphorus Removal

Phosphorus removal presents a different challenge. Unlike nitrogen, phosphorus cannot be removed as a gas; instead, it must be removed as a solid. Many methods can remove phosphorus such as chemical, biological, combined chemical and biological and nano processes. Membrane filtration – including reverse osmosis, nanofiltration and electrodialysis reversal – all fall under the nano process category. Chemical methods rely on such chemicals as alum or ferric chloride to bind to phosphorus and precipitate it out as a solid, which can be collected. The quality and type of phosphorus precipitate is dictated by optimizing wastewater pH, chemical addition, mixing and other factors.

Biological phosphorus removal uses anaerobic conditions followed by aerobic conditions to promote phosphorus uptake by phosphorus-accumulating organisms (PAOs). Anaerobic conditions promote the consumption of volatile fatty acids (VFAs) by the PAOs, which forces them to release phosphorus. Once the PAOs switch to aerobic conditions, they uptake the released phosphorus as they replenish stores and multiply, resulting in more phosphorus removed than was released. The phosphorus-rich PAOs are then removed as settled solids, resulting in a low phosphorus liquid wastewater effluent.

Effects on Dewatering

It turns out that nitrogen and phosphorus removal also effect solids dewatering quite a lot. ***Figure 2*** shows that nutrient removal can hinder dewatering. This means using more polymer to get the same dewatering results; and increased costs for one of the most cost-intensive parts of treatment. A decrease in solids dewaterability by as much as six percent total solids leads to two to three times the polymer needed. Decreased dewaterability also means more cost to haul away the solids to landfills or composting or more fuel needed to incinerate the solids.

Nutrient removal in and of itself is not the cause of poor dewatering performance as some methods, such as nitrification–denitrification, have no negligible effect. Studies and real-world performance show that specific types of phosphorus removal can directly affect dewatering. For example, chemical phosphorus removal can help with dewatering, while biological phosphorus removal hinders it.

When biological phosphorus removal is combined with anaerobic digestion and low-metal ions (iron and aluminum), dewatering efficiency decreases. This causes higher polymer demand and, therefore, increased costs ***(Figure 3)***.

Other studies have investigated the effect of biological phosphorus removal on dewatering and identified extracellular polymeric substances (EPS) as the culprit. EPS are released by anaerobic microbial communities. Dewatering decreased as the EPS content increased after anaerobic digestion, showing a correlation between the two and leading researchers to conclude that removing EPS may increase dewaterability.

Anaerobic digestion followed by aerobic treatment, using zero valent ions and other technologies, has minimal effects on dewaterability.

Legend: Strong Positive Impact; Positive; Negative; Strong Negative Impact

	Nitrogen Removal	Phosphorus Removal	Energy Usage	Supplemental Carbon Requirements	Dewatering	Biogas Production
MAINSTREAM TREATMENT TECHNOLOGIES						
Conventional Nitrification-Denitrification (e.g., Modified Luszack Ettinger, Bardenpho etc.)	Strong Positive Impact	Negative		Strong Negative Impact		Negative
Nitritation-Denitritation = "Nitrite Shunt"	Strong Positive Impact	Negative	Positive	Negative		Positive
Partial Nitritation-Anammox = "Deammonification"	Strong Positive Impact	Positive / Negative	Strong Positive Impact	Positive		Strong Positive Impact
Chemical Phosphorus Removal (e.g., iron (FE) & aluminum (Al) addition)	Negative	Strong Positive Impact			Positive	Positive
Biological Phosphorus Removal (e.g,, Virginia Initiative Plant, University of Cape Town, and Anaerobic/Oxic processes)	Negative	Strong Positive Impact		Negative	Strong Negative Impact*	Negative
SIDESTREAM TREATMENT TECHNOLOGIES						
Sidestream Deammonification			Positive	Positive		
Struvite Precipitation & Recovery		Strong Positive Impact		Positive	Negative	

Figure 2. Interrelationships between N and P removal and other WRRF operations. *Water Environment Federation (2015)*

**The negative relationship between biological phosphorus removal and dewatering is affected by the presence of anaerobic digestion and low metal ions.*

The research is not completely settled, and it is up to WRRFs to investigate the wide range of nutrient removal technologies available and see which can help meet their goals while maintaining high dewaterability.

Balancing the Scales

Nitrogen and phosphorus removal are necessary for WRRFs to meet discharge limits and keep our environment safe and healthy. However, tradeoffs exist, such as the effects these technologies can have on dewatering. Each of these financial and operational implications must be considered. Each WRRF is a unique system and nutrient removal technologies must be chosen based on a such factors as influent flow and loading, economic considerations, and permit limits.

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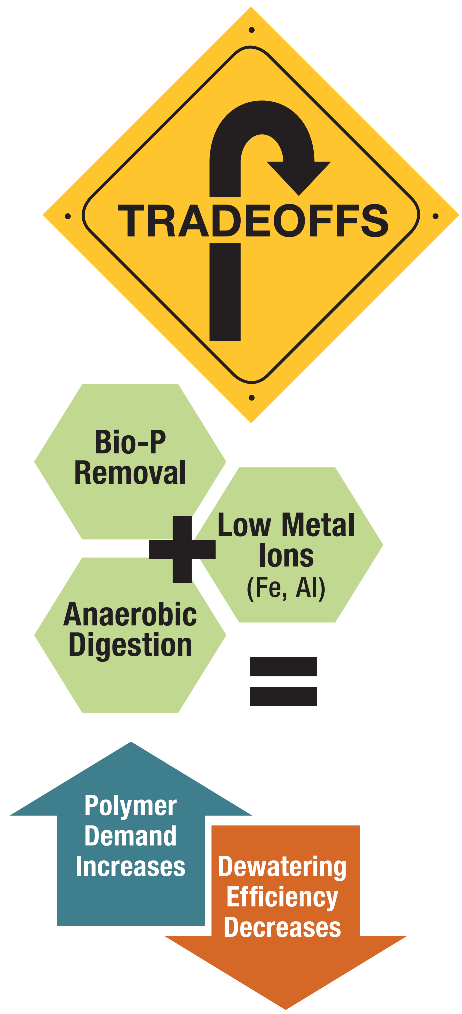

Figure 3. Biological phosphorus removal increases dewatering polymer demands. *Water Environment Federation (2015)*


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From **wef hq** Leading-edge updates from the Water Environment Federation

Thriving Despite Low Numbers

by Katherine Saltzman

The water sector employs significantly fewer women than the national average of all workers, according to the report, *Renewing the Water Workforce: Improving Water Infrastructure and Creating a Pipeline to Opportunity,* published in June 2018 by The Brookings Institute (Washington, D.C.)

According to the report, 46.8 percent of workers across the U.S. are women, though women "only account for 14.9 percent of the water workforce." Furthermore, the occupational breakdown of women in water is skewed. "While women make up a majority of water workers in certain administrative positions – including 95 percent of secretaries – they only account for a fraction of employment in some of the largest water occupations overall, including plumbers (1.4 percent) and water treatment operators (5.2 percent)," the report says.

Successful Women on the Job

Joanna Healy, a Grade 4 certification operator at the McDowell Creek Wastewater Treatment Plant, which is operated by Charlotte Water in North Carolina, began her career in the mailroom at the Hoover Dam in Nevada. Soon a position testing water and wastewater samples opened, and she took it. Later she moved into compliance reporting. Healy then transferred to a community college where she received an associate degree in Applied Science in Wastewater Treatment before moving to North Carolina.

"Usually there aren't a whole lot of us in the classes," Healy said. "In the maintenance tech class there were over 60 students and I was one of two females."

Healy attained her Grade 4 certification in 2.5 years by earning her associate degree. She also received a Pretreatment and Maintenance Tech 1 certification and plans to get a Pretreatment and Maintenance Tech 2 certification.

Despite few women in her classes, Healy said that she has received support and mentorship from trainers and colleagues throughout her training and career in the water sector.

"I think it's really neat that women can do anything men can do," Healy said. "That's what I tell my daughter. You can do all the things the guys can do, but you don't have to prove yourself to anyone."

Tara Romine started working at Charlotte Water in October 1990 as a laborer. An operator position later became available and she received on-the-job training to become qualified; more formal training was not readily available then, Romine said. By July 1998 she had received her Grade 4 certification and in 2000 took on the responsibility of first chief operator at Mallard Creek Water Reclamation Facility for Charlotte Water. When the facility became the first ISO-certified plant in Charlotte Water, she assisted with the development and creation of the ISO program. In her role, Romine helps implement standard operating procedures and create work instructions and procedures for new operators, among many other responsibilities.

Romine said her career in water has been filled with strong relationships and rewarding opportunities.

"I was always treated well," Romine said. "The gentlemen that I train have given me the utmost respect. It has been a very good working environment for me. I feel like I have really been given a gift to serve the community."

Barriers to Entry

The Brookings Institute's report includes overall recommendations on improving gender and racial diversity in the water sector. These include:

- Increasing the visibility of the sector for younger students.
- Creating more opportunities for workforce training.
- Expanding career paths for professionals in the water workforce.

However, the report stops short of forming conclusions on why so few women are in the water workforce.

Kalpna Solanki, CEO of the Environmental Operators Certification Program, suggests that Canada faces similar obstacles to the U.S. in terms of recruitment, training and retention, especially for female employees. Solanki's non-profit organization classifies water and wastewater facilities in British Columbia and Yukon and certifies the operators who work in those provinces.

"Very often people literally fall into the career. It wasn't necessarily a planned path. It would be better if it was proactive rather than reactive," Solanki said.

Often information on these water jobs are heard about at the Canadian equivalent of city or state departments of parks and recreation or departments of sanitation with majority male staff, she said

"[Men] get into the [water/wastewater] workforce because they happen to be there," she said. "There are not many women [here], so the result is fewer women going into the field from that point."

Solanki echoed the message of The Brookings Institute's report that women's job descriptions within water sector are skewed. While things are changing, and most female operators love their jobs, she said that she is aware of some situations of discrimination and harassment in the workforce.

If 10 percent of the water workforce is female, their numbers

Women account for only a fraction of employment among operators.

iStockphoto.com, SeventyFour

are not spread evenly among the four major area specialties: water treatment, water distribution, wastewater collection and wastewater treatment, she said.

"I would be surprised if more than 1 percent is female in wastewater collection and 1 percent to 2 percent of women in water distribution," Solanki said. "Within that 10 percent of female operators, there are some specialties that have almost no women at all."

Overcoming Entrenched Attitudes

Even though Canada has workforce standards in place at public utilities, each employer at the utility must reinforce rules and guide employees on proper workplace behaviors. This is especially true if women have historically been underrepresented in the specialty area, Solanki explained.

"Some of the feedback I have received from women, especially in water distribution and wastewater collection, [is that] the problem often lies at the employer level," she said. "The support mechanisms are not in place in where women are just parachuted into the workforce. The men are not prepared for this change [and] are not educated with regards to workplace harassment. The women are not properly trained in terms of what is acceptable and what is not acceptable behavior and what resources are available to them," Solanki said.

In June 2018, Solanki participated on a panel discussion during a workplace diversity workshop at the Canadian Water Summit. Topics included how to promote the field in general as well as to women; it also dealt with how to better recruit and integrate women in areas of the water sector where they are currently underrepresented.

"Most of the women that I meet like the work, are good at it, and like the variability of the job — there are no two days that are the same," Solanki said. "We do hear of a few women who face harassment but, in general, most of the women are happy and really enjoy being in the field."

Amanda Schuffels serves as an example of a happy newcomer to the water sector. In January 2018, she took on the role of full-time Grade 1 wastewater operator at the Kelowna Wastewater Treatment Facility in British Columbia, Canada. Previously she had worked in co-op training positions and part-time roles at the utility.

"A lot of men and women have taken me under their wing and have taught me what I needed to learn so that I can strive in my position," she said. "I love the job and industry."

Despite their lower numbers, female operators and utility leaders are at the forefront of the sector. These women prepare and train new employees, support innovations and technologies, manage the day-to-day operations of their facilities and support the environment and public health for communities across the world.

Katherine Saltzman is a publications assistant at the Water Environment Federation (Alexandria, Va.) where she works on WEF's Operator Initiative programs.

From wef hq — Leading-edge updates from the Water Environment Federation

U.S. EPA Office of Inspector General Releases Biosolids Report

by Patrick Dube

A routine investigation by the U.S. Environmental Protection Agency (EPA) Office of Inspector General (OIG) has concluded that EPA's controls over the land application of biosolids were incomplete or had weaknesses and may not fully protect human health and the environment. However, the EPA Office of Water, which operates the biosolids program, disagrees with the findings and states that presence of pollutants does not automatically pose a risk to public health and the environment.

Throughout 2017 and 2018, OIG investigated whether EPA "has and implements controls over the land application of sewage sludge that are protective of human health and the environment." On Nov. 15, 2018, OIG released a report based on its investigation titled, *EPA Unable to Assess the Impact of Hundreds of Unregulated Pollutants in Land-Applied Biosolids on Human Health and the Environment.*

OIG Process and Findings

OIG is an independent office that helps the agency protect the environment in a more efficient and cost-effective manner. OIG's main activities include performing audits and investigations of EPA to prevent and detect fraud, waste and abuse. Following an audit or investigation, OIG typically releases a report of findings.

In the report on the biosolids investigation, OIG found 352 unregulated pollutants in biosolids and stated that EPA lacked the data or risk assessment tools to decide safety. These 352 pollutants are in addition to the nine regulated pollutants that EPA consistently monitors.

The report pointed to a steady reduction in staff and resources in the EPA biosolids program as a cause of many of these weaknesses. The OIG recommended that the EPA Office of Water "address control weaknesses in biosolids research, information sharing with the public, pathogen control and training" and implement corrective actions with milestones to fix these issues.

The report and related materials can be viewed on OIG's website at *http://bit.ly/EPA-OIG-biosolids2018*.

Office of Water Response

OIG provided the Office of Water the chance to comment on the report; this response is included in Appendix D of the report. The Office of Water took issue with how the science was presented in the report and stated that "there is no attempt to make it clear to the reader that the occurrence of pollutants in biosolids does not necessarily mean that those pollutants pose a risk to public health and the environment."

The response also states that a top priority for the biosolids program will be to address the uncertainty of potential risk posed by pollutants found in biosolids but uncertainties in science does not mean that they are threats to human health and the environment.

The OIG report resulted in 13 recommendations for the Office of Water to consider. The Office of Water response provides corrective actions and milestone dates for eight of them with resolution efforts underway for the remaining five.

The Office of Water conducts biennial reviews of biosolids that include a full literature review of potential toxic pollutants and determines if the pollutants detected pose "potential risk to human health or the environment." The 2015 report analyzed peer-reviewed journal articles from January 2013 through December 2014 to determine the articles' relevance to biosolids and potential pollutants. Overall, 46 articles met the eligibility criteria. Once analyzed, the biosolids program identified 29 new chemical pollutants. Following a risk assessment of these new chemicals, the Office of Water determined that no additional pollutants needed to be regulated. A 2017 report following the same intensive analysis is expected to be released in the coming months.

WEF Actions

During the OIG investigation, WEF staff members were interviewed and have since been tracking the report and working with other biosolids partners to coordinate responses after the release. It is WEF's position that decades of science have shown that biosolids are a safe, renewable resource that improves our environment, lowers costs to consumers and strengthens our farming communities.

Biosolids undergo a rigorous set of treatment processes that include physical, chemical and biological processes to aid pathogen reduction. Utilities across the country have been safely recycling biosolids for decades while delivering innovative solutions that lead to stronger, more sustainable and resilient communities.

WEF supports continued research on biosolids to ensure regulatory requirements continue to be based on the latest science. The WEF Residuals and Biosolids Committee (RBC) is committed to developing and promoting cost-effective practices and policies in biosolids and energy technologies associated with municipal, agricultural and industrial wastewater residuals for the protection of the environment. Through education of WEF members, the public and policymakers, RBC aims to serve the public interest regarding scientifically sound residuals and biosolids environmental practices and regulation. To learn more, visit the RBC page – *www.wef.org/biosolids* – to download fact sheets, white papers and technical reports.

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LEADING THE WAY IN WATER QUALITY MANAGEMENT

Defining "Waters of the United States": A Moving Target

by Kerry A. Thurston

From the federal regulatory perspective, defining the waters of the United States (WOTUS) for permitting purposes has been a particularly contentious issue. While the nation has established clean water as a priority through federal legislation, the jurisdiction over waterways at the federal level has been the proverbial football, passing from Congress to the agencies to the courts and back again. This is a matter of interest for landowners with wetlands and other water resources present on their properties. Does the landowner need a federal permit for a project on their property? The answer depends on whether the water resources are considered jurisdictional based on the definition of WOTUS.

North Branch of the Moose River in autumn, Adirondack Park, New York. *Kerry A. Thurston*

A Little History

The earliest federal water pollution control legislation in the United States, the 1899 Refuse Act, was an amendment to the Rivers and Harbors Act. Under this act, the Army Corps of Engineers was given jurisdiction over activities resulting in dumping in and obstruction of navigable waterways *(Black 1991)*. With this precedent established, Section 404 of the Federal Water Pollution Control Act amendments of 1972 and 1977 (collectively known as the Clean Water Act), gave the Army Corps of Engineers authority to establish a permit system for dredging and filling of materials in the "waters of the United States." *(Mitsch and Gosselink 1986)*. The 1975 court decision *Natural Resources Defense Council v. Calloway,* along with Executive Order 11990 on Protection of Wetlands, explicitly included wetlands in the definition of WOTUS *(Mitsch and Gosselink 1986)*.

Over time, challenges to the definition of WOTUS – and the Army Corps of Engineers' jurisdiction for permitting activities in these waters – have been brought to the courts. Several pivotal cases include:

- Solid Waste Agency of Northern Cook County (SWANCC) v. United States Army Corps of Engineers (531 U.S. 159, 2001) – "In this decision, the Court held that the Corps of Engineers could no longer require Clean Water Act (Section 404) permits based upon the use of isolated ponds and other waters by migratory waterfowl alone. The Court distinguished but did not overrule an earlier Supreme Court decision – Riverside Bayview – in which the Court unanimously held that the Clean Water Act broadly applied to wetlands adjacent to navigable waters. The Court concluded in SWANCC that the Clean Water Act did apply to traditionally navigable waters and other, adjacent waters with a 'significant nexus' to traditionally navigable waters. However, the Court did not make clear what tests for navigability are to be applied for the purposes of the Clean Water Act, nor the meanings of the terms 'adjacency', 'tributary', or 'significant nexus.'" *(Kusler 2005)*.
- Rapanos vs. United States, and Carabell vs. U.S. Army Corps of Engineers (known collectively as *Rapanos*) – "In 2006 the Supreme Court issued a consolidated decision in which the Court vacated two lower appellate court decisions upholding Clean Water Act jurisdiction for wetlands which were separated by a berm from ditches or drains leading into navigable waters (Carabell) and for wetlands linked to navigable waters through a system of small natural drainageways, ditches and drains (Rapanos). … [Justice Kennedy's] opinion set forth the 'significant nexus' test." *(Kusler, Parenteau and Thomas 2007)*

The significant nexus test provided a mechanism by which agencies gather information to determine whether wetlands and waters have a nexus to navigable waterways, and if impacts would therefore be significant. This entails assessment of the functions and values of wetlands and other waters in a watershed context. The results of this assessment guide the decisions to issue permits, determine whether an Environmental Impact Statement is warranted, and review the adequacy of proposed mitigation measures. (*Kusler, Parenteau and Thomas 2007)*

Fast-Forward to 2015

On June 29, 2015, the USEPA and the Army Corps of Engineers published in the Federal Register (80 FR 37053) a final rule defining the scope of waters protected under the Clean Water Act, responding to the court rulings, the statute and science *(USEPA 2015)*. This rule – the 2015 Clean Water Rule – established three broad categories of waters:

- *Waters that are jurisdictional in all instances.* These include traditional navigable waters, interstate waters and the territorial seas. Impoundments of jurisdictional waters are also jurisdictional by rule in all cases. "Tributaries" and "adjacent" waters are jurisdictional by rule, as defined, because the science confirms that they have a significant nexus to traditional navigable waters, interstate waters, or territorial seas. For waters that are jurisdictional by rule, no additional analysis is required.
- *Waters that are excluded from jurisdiction.* These include prior converted cropland; waste treatment systems; ditches with ephemeral flow that are not a relocated tributary or excavated in a tributary; ditches with intermittent flow that are not a relocated tributary, or excavated in a tributary, or drain wetlands; groundwater; erosional features; stormwater control features constructed to convey, treat, or store stormwater; and cooling ponds that are created in dry land.
- *Waters subject to case-specific analysis to determine whether they are jurisdictional.* The rule provides for case-specific determinations under narrowly targeted circumstances based on the agencies' assessment of the importance of certain specified waters to the chemical, physical, and biological integrity of traditional navigable waters, interstate waters, and the territorial seas. These water bodies are considered "similarly situated" for a significant nexus determination. Similarly situated waters that are within the 100-year floodplain of a jurisdictional water or within 4,000

continued on page 56

continued from page 55

feet of a high tide line or ordinary high-water mark of a jurisdictional water are subject to a case-specific significant nexus determination. Specific waters identified as "similarly situated" are called out in the rule, including prairie potholes, Carolina and Delmarva bays, pocosins, western vernal pools in California, and Texas coastal prairie wetlands.

The 2015 Clean Water Rule went into effect on August 25, 2015. There were immediately multiple filings against the rule in federal district and appeals courts, which were consolidated before the Sixth Circuit Court of Appeals. On October 9, 2015, the Sixth Circuit Court stayed the implementation of the 2015 Clean Water Rule, leaving the rule in a state of suspension. (*Hackney and Barsh 2015)*

On February 28, 2017, the President of the United States issued Executive Order 13778 (82 FR 12497) that directed the agencies to review and revise the 2015 Clean Water Rule, to narrow the definition of WOTUS *(Seby and Tieslau 2018)*. The Executive Order specifically called on the USEPA Administrator and the Army Corps of Engineers Assistant Secretary to consider interpreting the term "navigable waters" in a manner consistent with the opinion of Justice Antonin Scalia in the 2006 *Rapanos* decision *(President of the United States 2017)*.

Justice Scalia's opinion in *Rapanos,* by contrast to Justice Kennedy's "significant nexus" test, draws a narrower interpretation of WOTUS:

> "In sum, on its only plausible interpretation, the phrase "the waters of the United States" includes only those relatively permanent, standing or continuously flowing bodies of water "forming geographic features" that are described in ordinary parlance as "streams[,] … oceans, rivers, [and] lakes." See Webster's Second 2882. The phrase does not include channels through which water flows intermittently or ephemerally, or channels that periodically provide drainage for rainfall." *(Scalia 2006)*.

This Just In…

Dateline December 11, 2018: The USEPA and the Army Corps of Engineers issued a press release proposing a "clear, understandable and implementable definition" of WOTUS. According to the press release *(USEPA 2018),* the agencies believe that this proposed definition will serve several purposes:

- Provide clarity, predictability and consistency so that the regulated community can easily understand where the Clean Water Act applies – and where it does not.
- Appropriately identify waters that should be subject to regulation under the Clean Water Act while respecting the role of states and tribes in managing their own land and water resources.
- Result in significant cost savings, protect the nation's navigable waters, help sustain economic growth, and reduce barriers to business development.

The December 11, 2018 press release (Press Release) stated that more than 6,000 pre-proposal recommendations from a wide range of stakeholders were received by the agencies. Once the proposed definition is published in the Federal Register, the agencies will take comments on it for 60 days. The USEPA and Army Corps of Engineers will hold an informational webcast on January 10, 2019 and will host a listening session on the proposed rule in Kansas City, Kansas, on January 23, 2019. More information, including the supporting analyses and fact sheets, are available at: *https://www.epa.gov/wotus-rule.*

So, What Does It All Mean?

The proposed revision of the federal definition for WOTUS is not yet, as of this writing, official nor finalized. However, a quick review of the pre-publication proposed version of the rule from the Press Release against the 2015 Clean Water Rule shows that the definition of WOTUS would be narrowed. For example, those waters "subject to case-specific analysis to determine whether they are jurisdictional" in the 2015 Clean Water Rule have been dropped from the pre-publication proposed rule. Language that called out the prairie potholes, Carolina and Delmarva bays, pocosins, western vernal pools in California, and Texas coastal prairie wetlands in the 2015 Clean Water Rule was also dropped from the pre-publication proposed rule.

Another difference between the 2015 Clean Water Rule and the pre-publication proposed rule is use of the term "adjacent." In the 2015 Clean Water Rule, the term "adjacent" is also defined by the terms *bordering, contiguous* or *neighboring,* including waters separated by constructed dikes or barriers, natural river berms, beach dunes and the like. A wetland or other water resource is defined as "neighboring" if one of the three following definitions is met *(USEPA 2015)*:

- The water resource falls within 100 feet of the ordinary high-water mark of a water identified as WOTUS.
- The water resource falls within the 100-year floodplain and less than 1,500 feet from a water identified as a WOTUS.
- All waters located within 1,500 feet of the high-tide line and all waters within 1,500 feet of the ordinary high-water mark of the Great Lakes.

The pre-publication proposed rule defines "adjacent" differently:

- Wetlands that abut, meaning to touch at least at one point or side of a WOTUS, are adjacent.
- Wetlands that, in a typical year, have a direct hydrologic surface connection to a water identified as a WOTUS. A direct hydrologic surface connection occurs as a result of inundation from a WOTUS to a wetland or via perennial or intermittent flow between a wetland and a WOTUS.

Under the pre-publication proposed rule's definition of "adjacent", wetlands that are separated from a WOTUS by upland or by dikes, barriers, or similar structures and also lacking a direct hydrologic surface connection to such waters are not adjacent *(USEPA 2018)*.

Based on this quick review, it appears that some wetlands that would have been jurisdictional under the 2015 Clean Water Rule would not be jurisdictional under the pre-publication proposed rule.

Stay Tuned

The December 11, 2018 press release was a pre-publication announcement of the proposed revisions to the definition for WOTUS. At the time of this writing, it is anticipated that the proposed rule will be published in the Federal Register sometime in the coming weeks.

Bear in mind, however, that the definition of WOTUS is a federal-level regulatory definition that sets the jurisdictional limits for the Army Corps of Engineers in administering the Section 404 permit program under the Clean Water Act. At the state level, there are other permit and regulatory requirements for the protection of water resources which do not rely on the definition of WOTUS.

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Warner Bay in autumn, Lake George, Adirondack State Park, New York.
iStockphoto.com, Rick Sause

Looking for Project Funding? Try One of These Opportunities

by Kerry A. Thurston

There are several funding opportunities available in New York. On these pages are listed a few of the grant opportunities and deadlines that may interest readers of *Clear Waters*. The Editor extends thanks to NYSDEC Great Lakes Program for sharing their compiled list of Great Lakes and Watershed Restoration Grants that got this article started. The information presented here has been collected from the grant application websites.

Grant Applications without Specific Deadlines

Great Lakes Restoration Initiative (USEPA)

The Great Lakes Restoration Initiative (GLRI) allocates up to $300 million per year in interagency agreements, fund transfers, competitive grants and capacity-building grants. Funding and initiatives are for projects supporting one of the GLRI focus areas. These areas are:

- Toxic substances and areas of concern.
- Invasive species.
- Nonpoint source pollution impacts on nearshore health.
- Habitat and species.
- Foundations for future restoration actions.

Agencies provide notice of funding opportunities in accordance with their regular practices, such as posting competitive announcements through *grants.gov. (https://www.glri.us/funding)*.

Great Lakes Protection Fund

The Great Lakes Protection Fund (GLPF) welcomes ideas for projects that will create and advance the next generation of actions to protect and restore the ecological health of the Great Lakes. There is no specific funding program or formal deadline. GLPF is always open to discussing ideas and can be nimble (e.g., funding vehicles, timeframes) when an opportunity presents itself. *(http://glpf.org/get-funding/projects-wanted/)*.

Grant Applications Due in January 2019

Great Lakes Research Consortium Small Grants (GLRC)

This small-grants program provides seed funding for new, cooperative projects that improve our understanding of, and/or management of, New York's Great Lakes basin. The program supports collaborative projects and grant awards can be used for basic or applied research and project planning that will lead to larger projects. Routine monitoring and one-time site-specific infrastructure projects are not appropriate topics for this RFP. Deadline for applications is January 23, 2019. (*https://www.esf.edu/glrc/documents/RFP-NYGLPF.pdf)*

Coastal and Marine Habitat Restoration Project Grants (NOAA)

Restoration includes activities that return degraded or altered marine, estuarine, coastal, and freshwater migratory fish habitats to functioning conditions, and techniques that return National Oceanic and Atmospheric Administration (NOAA) trust species to their historic habitats. The deadline for required pre-proposals is January 14, 2019. The full proposal deadline in April 2019 will be sent to eligible applicants that were successful in the pre-proposal process. *(https://www.fisheries.noaa.gov/grant/coastal-and-marine-habitat-restoration-grants)*

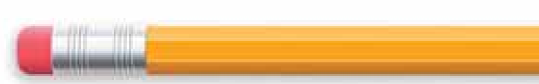
Great Lakes Fish and Wildlife Restoration Act Grants (USFWS)

Under the Great Lakes Fish and Wildlife Restoration Act, the U.S. Fish and Wildlife Service (USFWS) is accepting Fiscal Year 2019 project proposals through January 7, 2019. to protect, restore and enhance Great Lakes fish and wildlife habitat. *(https://www.fws gov/midwest/fisheries/glfwra-grants.html)*

Grant Applications Due in February 2019

Great Lakes Habitat Restoration Partnership Grants (NOAA)

The objective of the Fiscal Year 2019 NOAA Great Lakes Habitat Restoration Partnership Grants solicitation is to provide federal financial and technical assistance to habitat restoration projects that both meet NOAA's mission to restore coastal habitats and support the Great Lakes Restoration Initiative goal to protect and restore habitats to sustain healthy populations of native fish species in the eight U.S. Great Lakes states (New York,



Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, and Minnesota). The application deadline is February 4, 2019. *(http://www.federalgrants.com/2019-NOAA-Great-Lakes-Habitat-Restoration-Regional-Partnership-Grants-74463.html)*

North American Wetlands Conservation Act Standard Grants (USFWS)

The Standard Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in Canada, the United States, and Mexico. These projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. Grant deadlines are February 22, 2019 for Cycle 1 and July 3, 2019 for Cycle 2 grants in the U.S. *(https://www.fws.gov/birds/grants/north-american-wetland-conservation-act/standard-grants.php)*

Grant Applications Due in April 2019

Environmental Literacy Grants (NOAA)

NOAA's Environmental Literacy Program provides grants and in-kind support for programs that educate and inspire people to use Earth systems science to improve ecosystem stewardship and increase resilience to environmental hazards. NOAA's Office of Education regularly offers the Environmental Literacy Grants competition. This competition focuses on helping communities build the environmental literacy necessary for resilience to extreme weather events and other environmental hazards. The deadline for the Fiscal Year 2018-2019 is closed. Check in with their website for updates on the Fiscal Year 2019-2020 opportunities. *(https://www.noaa.gov/office-education/elp/grants/apply)*

Chautauqua County's 2% Occupancy Tax for Lakes and Waterways Grant Program (Chautauqua County)

Chautauqua County has a five percent occupancy or "bed tax" for the rental of lodging units within the County. Two-fifths of this bed tax is utilized solely for the enhancement and protection of lakes and streams in Chautauqua County. The Occupancy Tax Grants for Lakes and Waterways offers financial assistance to efforts that enhance and protect the lakes and waterways of Chautauqua County, and may be used by public agencies, private organizations, or residents of Chautauqua County. Completed applications are due by April 1, 2019 for projects that will be finished by December 31, 2020. *(http://chautauqua.ny.us/519/Project-Funding)*

Grant Applications Due in May 2019

Great Lakes Basin Small Grants Program (New York Sea Grant)

New York Sea Grant (NYSG) in partnership with the New York State Department of Environmental Conservation (NYSDEC) created the New York's Great Lakes Basin Small Grants Program to support stakeholder-driven efforts to restore and revitalize the state's Great Lakes region and demonstrate successful application of ecosystem-based management (EBM). As part of the larger, multi-year partnership that continues through at least 2022, the purpose of these projects is to help Great Lakes coastal communities enhance their resiliency to events like severe storms and protect water quality. *(https://seagrant.sunysb.edu/proposals/)*

Grant Applications Due in July 2019

Consolidated Funding Application (CFA)

Access multiple economic development funding opportunities from multiple New York state agencies through a single application. Grant opportunities include:

- Water Quality Improvement Project (WQIP) Grants (NYSDEC)
- Green Innovation Grant Program (GIGP) (Environmental Facilities Corporation)
- Wastewater Infrastructure Engineering Planning Grant (NYSDEC/EFC)
- Climate Smart Communities (CSC) Grant Program (NYSDEC)
- Local Waterfront Revitalization Program Department of State (DOS)
- EPF Municipal Grant Program Office of Parks, Recreation and Historic Preservation (OPRHP)

The CFA solicitation will be open for 88 days – from May 1 until the application due date of 4:00 pm July 27. *(https://apps.cio.ny.gov/apps/cfa/)*

Grant Applications Due in September 2019

Trees for Tribs Small Grants (NYSDEC)

The Trees for Tribs Grant Program supports efforts to reforest New York's tributaries, or small creeks and streams, which flow into and feed larger rivers and lakes. The goal of the program is to support communities in planting young trees and shrubs along stream corridors, also known as riparian areas, to prevent erosion, increase flood water retention, improve wildlife and stream habitat, as well as protect water quality. Grant applications are accepted in the month of September. *(https://www.dec.ny.gov/animals/113412.html)*

Clean Energy Communities Program (NYSERDA)

Cities, counties, towns and villages that complete at least four of 10 high-impact clean energy actions are designated Clean Energy Communities and are eligible to apply for funding of up to $250,000 with no local cost share with the option of receiving up to 25 percent paid in advance to support additional clean energy projects. Those with fewer than 40,000 residents are eligible to apply for up to $100,000. At least two of the four actions must have been completed after August 1, 2016. New York State Energy Research and Development Authority (NYSERDA) is accepting applications for funding on a rolling basis through September 30, 2019 or until funds are exhausted, whichever comes first. Funds are being provided through the Clean Energy Fund and the Regional Greenhouse Gas Initiative.

Once all funding is exhausted for large or small/medium categories in a region, local governments designated a Clean Energy Community are eligible to apply for a $5,000 grant, on a first-come, first-served basis until such funds are exhausted. *(www.nyserda.ny.gov/cec)*

Grant Applications Due in October

North American Wetlands Conservation Act – Small Grants (USFWS)

The Small Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in the United States that further the goals of the North American Wetlands Conservation Act. These projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds. Grant deadline is October 18, 2018. *(https://www.fws.gov/birds/grants/north-american-wetland-conservation-act/small-grants.php)*

Operator Quiz Test No. 122 – Aeration

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. Which of the following is not a form of a diffused aeration system?
   a. Ultrafine bubble
   b. Fine bubble
   c. Course bubble
   d. Surface aerator

2. The growing or coming together of small scattered particles into larger particles, also known as floc, is called?
   a. Agglomeration
   b. Algorithm
   c. Aerobic digestion
   d. Anaerobic digestion

3. Aeration tank diffusers are most commonly found:
   a. Upstream of the blower discharge valve
   b. Downstream of the blower discharge and near the surface
   c. At the bottom of the aeration tank
   d. At the surface of the aeration tank

4. Calculate the pounds of solids under aeration within an aeration system that has a volume of 2.5 MG and an MLSS of 1500 mg/L.
   a. 28,050
   b. 31,275
   c. 12,510
   d. 3,750

5. An aeration tank is showing characteristics of white sudsy foam. This is an indication of which of the following?
   a. The MLSS is too low
   b. The MLSS is too high
   c. The WAS rate is too low
   d. The RAS rate is too high

6. Which of the following most accurately describes the stages in a sequencing batch reactor (SBR)?
   a. Fill, Suspend, Digest, Incinerate, Chlorinate
   b. Empty, Fill, Aerate, Decant, Chlorinate
   c. Fill, Aerate, Settle, Decant, Idle
   d. Remove FOG, Aerate, Decant, Fill, Repeat

7. The typical MLSS concentration range of an SBR is:
   a. 100 to 1,000 mg/L
   b. 1,000 to 2,000 mg/L
   c. 2,000 to 6,000 mg/L
   d. 6,000 to 10,000 mg/L

8. These common protozoa, found in activated sludge, possess one or more long hair-like appendages used to propel themselves. Also known as Mastigophora, they are called:
   a. Amoebas
   b. Free-swimming ciliates
   c. Stalked ciliates
   d. Flagellates

9. What is the procedure for finding the weight of volatile solids of an MLSS sample?
   a. Find the amount of total solids, ignite dried solids at 550°C, cool in desiccator, weigh remaining white ash and calculate
   b. Evaporate water from dried total solids sample, ignite at 103°C, measure wet sludge sample
   c. Find the amount of total solids, cool sample in desiccator, ignite sample at 550°C, calculate the amount of MLSS
   d. Find the amount of total solids, ignite sample at 103°C, cool in desiccator, weigh remaining white ash and calculate

10. When using the Off-Gas test method to determine the OTE of an aeration system, the OTE is known as:
    a. Organically Tested Element
    b. Oxygen Theoretical Equation
    c. Operator Tested Efficiency
    d. Oxygen Transfer Efficiency

Answers and explanations on page 62.

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.

Winter 2018, Vol. 48, No. 4

Clear Waters

New York Water Environment Association, Inc.

ADVERTISER	PAGE
AECOM	50
Aftek, Inc..	Back Cover
Aqua-Aerobic Systems	43
Barton & Loguidice, D.P.C.	53
C&S Companies	19
CDM Smith	27
D & B Consulting Engineers & Architects	27
DN Tanks	20
Franklin Miller Inc..	40
GA Fleet	8
Gartner Equipment Co, Inc.	14
GHD	60
GP Jager Inc.	32
Greeley & Hansen	14
H2M architects + engineers	20
Harper Control Solutions Inc.	22
HDR	22
Holland Company, Inc..	39
J. Andrew Lange Inc.	51
Koester Associates, Inc.	Inside Front Cover
Kusters Water	15
Lakeside Equipment Corporation	11
Medora Corporation	7
Mixing Systems, Inc.	Inside Back Cover
Mott MacDonald	26
OBG	20
Pumping Services	33
Siewert Equipment Co.	36
Smith & Loveless, Inc..	51
SolSystems	6
Statewide Aquastore, Inc.	15

Answers from page 61: 1D, 2A, 3C, 4B, 5A, 6C, 7C, 8D, 9A, 10D

Operator Quiz Test No. 122 "Aeration" Answers Explained

1. A surface aerator is an example of a mechanical aeration system.
2. (b) an algorithm is a procedure for solving a mathematical problem; (c) aerobic digestion breaks down waste solids in the presence of oxygen; (d) anaerobic digestion breaks down waste solids in the absence of oxygen.
3. Aeration diffusers are located at the bottom of the aeration tank to allow for necessary contact time of air bubbles with the mixed liquor and to allow for mixing within the tank.
4. Solids (lbs) = 2.5 MG x MLSS of 1,500 mg/L x 8.34 lbs/gal
5. Thick billowy foam is indicative of low MLSS, reduce wasting to increase MLSS and MCRT.
6. The typical sequence of operation of an SBR includes filling the tank; aerating the tank for a reaction period; settling the MLSS; decanting or withdrawal of clarified effluent; and idling the tank.
7. MLSS of 2,000 to 6,000 mg/L is common in an SBR as well as a sludge age between 25 and 45 days and a F/M ratio of 0.02 to 0.05 lbs BOD/day/lb MLVSS.
8. (a) amoebas use a flexible cell membrane or false foot to move; (b) free-swimming ciliates possess many short hair-like extensions to move; (c) stalked ciliates are tulip-shaped and grow on a flexible stalk.
9. Total solids are first analyzed by drying sample in a drying oven set to between 103°C to 105°C. The remaining sample is then ignited in a muffle furnace set to 550°C.
10. (d) The Oxygen Transfer Efficiency can be used to determine localized diffuser performance data. The other answers are made-up terminology.