CAROLLO ENGINEERS VOLUME 1 2022 / SPECIAL EDITION

currents

BACK TO THE FUTURE 2022

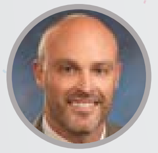
The Future of Wastewater Treatment Starts Now

Aerobic Granular Sludge
Energy Management
Control and Management of Wet Weather
Suboxic Nutrient Removal
Advanced Process Control
Emerging Contaminants in Biosolids

THIS ISSUE'S EDITORIAL

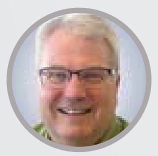
TANJA RAUCH-WILLIAMS

We are excited to celebrate the **5-year anniversary of Carollo's Strategic Wastewater Innovation Program**. In 2016, we initiated this program in partnership with the Carollo Research Group and Wastewater Technical Practice to advance technology developments that will define the future of wastewater treatment as we know it.



JESS BROWN

In early 2021, a team of Carollo's wastewater engineers and scientists completed an industry-wide reconnaissance effort to reassess our wastewater innovation focus areas. The group decided on seven **wastewater innovation initiatives** that Carollo will support over the coming years through strategic investments, applied research, technology development, and industry collaborations.



JOHN FRASER

In this Special Edition of ***Currents***, you will find practical applications and examples of these initiatives. With each project, the future of wastewater treatment is one step closer to the present. We hope you enjoy the issue!

IN THIS ISSUE

carollo
Engineers...Working Wonders With Water®

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DESIGN TOOLS for GRANULAR SLUDGE SELECTION and WASTING DESIGN

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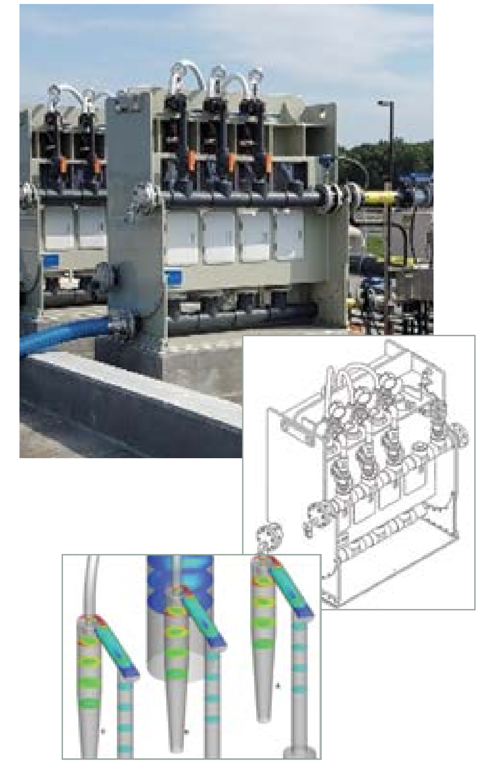
Granular activated sludge (GAS) is an innovative biological treatment process that, when compared to conventional activated sludge (CAS), enables higher settling rates and enhanced nutrient removal in a smaller reactor footprint. One popular GAS technology, inDENSE™, manufactured by Water Works, Inc., utilizes hydrocyclones as selectors to separate and select densified or granular activated sludge from light, fluffy mixed liquor flocs.

USE OF HYDROCYCLONES

To date, inDENSE™ hydrocyclones have been successfully designed and implemented at US wastewater facilities for physical selection similar to commonly used surface wasting systems. With performance largely based on empirical field data from these installations, we still lack a detailed understanding of how GAS particles differ between facility sites and how those differences influence the design and operation of physical selectors, such as hydrocyclones.

To fill these decisive gaps, Carollo's Innovation Leadership Initiative entered into a partnership with DC Water, HRSD, and NEWhub Corp. to develop a dynamic computational fluid dynamic (CFD) model that can simulate physical GAS selection in hydrocyclones and improve the design and operation of these systems.

As a first step, we required field data to calibrate the CFD model and describe the behavior of normal, densified, and granular flocs in a highly dynamic and nonlinear flow field. At the time of this effort, no facilities operating inDENSE™ in the US had adequate data for model calibration. We were thankful when our partners, the Virginia-based utility UOSA and the Colorado-based MWR, committed to collecting the field data necessary to calibrate the CFD model (Figure 1). UOSA operates a CAS plant with anoxic selectors while MWR operates biological nutrient removal (BNR) for phosphorus and nitrogen removal that accumulates larger densified flocs compared to UOSA.



This project began in 2020 with Carollo building the CFD model. Since the hydrocyclone geometry is rather complex, World Water Works helped build an accurate physical model using 3-D scans of a standard hydrocyclone unit's inlet nozzle, outlet arrangement, and vortex finder.

In the following steps of the project, particle size analysis and microscopy proved to be robust tools for comparing the CFD model's output to hydrocyclone data from both UOSA and MWR sites. Figure 2 shows the capture rate of the actual measured particles by size in the hydrocyclone underflow at UOSA and MWR against the capture predicted by each utility's respective CFD model.

The figure makes it apparent that hydrocyclones at UOSA captured a much larger fraction of small and medium dense flocs than those at MWR's facility. This is believed to be a result of the different process conditions: MWR's BNR process produces large and dense sludge. While CFD modeling was able to simulate the capture efficiency accurately across the spectrum of floc sizes, UOSA's model required changes to the particle density for different size ranges during the model calibration. UOSA's CFD model indicates that the specific particle density decreases with increasing particle size and that this process accumulates what NEWhub terms "baby granules."

HOW CAN THIS UNDERSTANDING HELP UTILITIES?

To increase the capture efficiency of medium-sized dense flocs in the underflow, UOSA's CFD model recommended increasing the nozzle size of the hydrocyclones. A switch to larger nozzles in the field subsequently confirmed this prediction, highlighting the CFD model's productivity and accuracy.

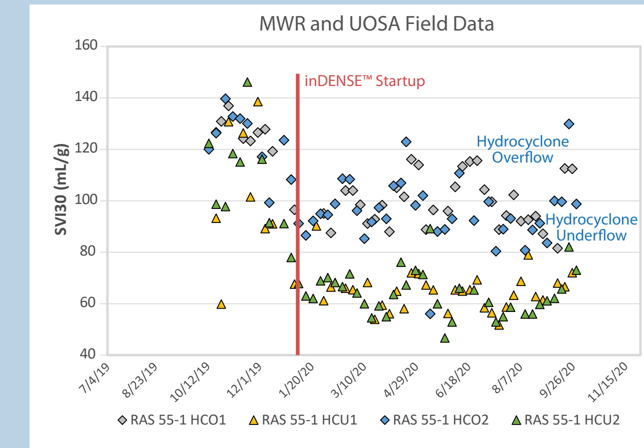


Figure 1. *inDENSE™ successfully improves sludge settling at MWR and UOSA, whose data is shown here. Through CFD modeling, we can better understand the differences in granule make-up and their implications for selector design and operation at both sites.*

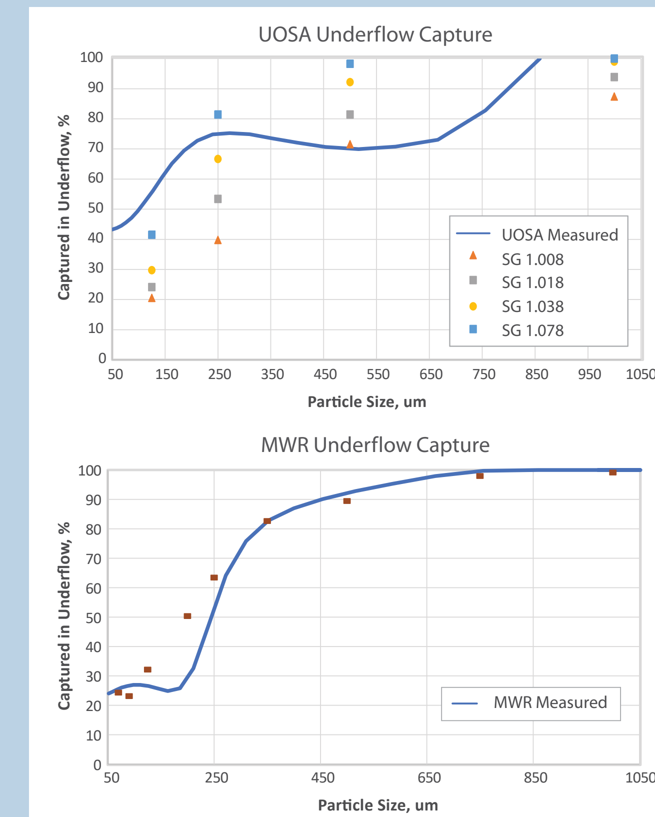


Figure 2. *CFD model prediction and measured capture of particles by size at UOSA (top) and MWR (bottom).*

HOW CAN CFD MODELING SUPPORT YOUR GRANULAR SLUDGE NEEDS?

CFD modeling of GAS informs utilities on optimal design and operation as well as cost-effective opportunities for optimization. For instance, CFD models can answer a utility- and region-specific question such as: How many cyclones must be in operation to best meet seasonal wasting needs?

Carollo is dedicated to meeting your GAS modeling needs. Please contact **Tanja Rauch-Williams** at **trauch-williams@carollo.com** or **720-670-0479** or **Ed Wicklein** at **ewicklein@carollo.com** or **206-538-5166** for more information on this evolving technology and Carollo's CFD modeling services.

A HOLISTIC LOOK AT ENERGY INFRASTRUCTURE REPLACEMENT

The Madison Metropolitan Sewerage District's Energy Management Master Plan

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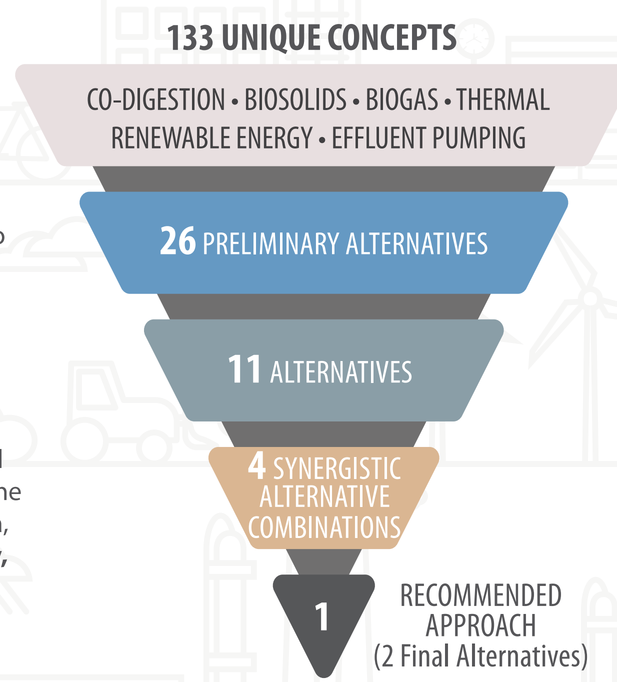
Supported by our nation-wide Carbon and Energy Management Innovation Initiative, Carollo is tackling today's energy challenges by leading a growing number of energy management and renewable energy planning and design projects. One such effort is our development of the Madison Metropolitan Sewerage District's (District's) *2020 Energy Management Master Plan* (Plan), a comprehensive roadmap that recommends targeted improvements to the Wisconsin-based utility's energy infrastructure and energy-management approaches over the next two decades.

The Plan was born out of the District's need to replace aging energy-producing and -consuming infrastructure at the Nine Springs Wastewater Treatment Plant (NSWTP), an effort with an estimated life-cycle cost of $93 million without explicit process or energy performance improvements. To make strategic use of these investments, the District decided to pursue improvements that not only rehabilitate the NSWTP's existing infrastructure but also meet the following energy goals **by 2030**:

MADISON'S ENERGY GOALS BY 2030	
Reduce **fossil-fuel-based greenhouse gas (GHG) emissions** by	**-10%**
Reduce **the cost of peak electricity demand** by	**-5%**
Reduce **operational energy consumption** by	**-10%**
Use **renewable energy** to meet	**50%** ENERGY DEMANDS
Reduce **Class B biosolids processing energy demand**	
Improve **the resiliency and reliability** of **energy supply sources**	
Improve **the reliability of energy-using** and **-consuming infrastructure**	

The wastewater industry is rapidly transforming into an energy-efficient and energy-producing business. Utilities across the country are departing from energy-intensive processes in favor of innovative approaches that recover clean water and nutrients while creating renewable energy for their communities.

In collaboration with the District, Carollo convened an industry-wide energy expert panel that identified numerous technology and energy concepts, which were grouped into six major improvement categories: **co-digestion, biosolids, biogas, thermal, renewable energy, and effluent pumping**. Using a systematic screening process, Carollo and the District then pared down these concepts into two final recommended alternatives using the District's specific evaluation criteria, which included: **energy efficiency, resilience, reliability, cost, and operation and maintenance.**



Following thorough business case evaluations and sensitivity analyses, Carollo recommended that two scenarios be further evaluated against the Baseline Scenario:

BASELINE SCENARIO
Maintains the status quo with necessary future infrastructure upgrades. Status quo includes:

- Acid phase, mesophilic and thermophilic digestion.
- Land-application of liquid biosolids.
- Combined heat and power cogeneration system.

COMMUNITY ENERGY PARTNERSHIPS CAN PAVE A NEW FUTURE

The Plan was crucial in proving that, by establishing partnerships with local electric utilities or other entities, the District can share the cost and responsibility of owning and operating innovative renewable energy infrastructure.

ALTERNATIVE 1 - BASELINE SCENARIO WITH SOLAR
Modifies the Baseline Scenario as follows:

- Discontinue thermophilic digestion.
- Land-application of dewatered cake biosolids.
- Install new cogeneration similar in size to existing.
- Partner with Madison Gas and Electric (MGE) to procure solar energy through their Renewable Energy Rider (RER) program.

ALTERNATIVE 2 - REDUCED INFRASTRUCTURE COMPLEXITY
Modifies the Baseline Scenario as follows:

- Discontinue thermophilic digestion.
- Land-application of dewatered cake biosolids.
- Export renewable natural gas (RNG) to the renewable fuels market.
- Partner with Madison Gas and Electric (MGE) to procure solar energy through their Renewable Energy Rider (RER) program.

WINS FOR THE DISTRICT, RATE PAYERS, AND THE ENVIRONMENT

Both Alternatives 1 and 2 replace the NSWTP's aging energy infrastructure and beneficially use all biogas produced for either on-site electricity generation or RNG production **at life-cycle costs similar to or lower than that of the baseline**. Table 1 exemplifies how the two alternatives stand up against the Baseline Scenario.

Of the two, Alternative 1 is appealing in that it maintains the District's current operational philosophy (i.e., cogeneration and renewable electricity production) and **robustly meets all seven of the Plan's energy goals**, as shown in Table 2.

Alternative 2 offers a lower life-cycle cost, simplified infrastructure, and lower operational complexity, but does not meet the District's goal of reduced peak demand costs, since it converts biogas to RNG rather than on-site electricity. However, this scenario promises high revenues following the value of renewable identification numbers in the EPA's Renewable Fuel Standard program. In fact, revenues from RNG sales are projected to offset this scenario's increased costs in peak energy demand.

TABLE 1 • Comparison of Final Scenarios Recommended for Further Consideration

Comparison Criteria (based on projected 2040 values)	Baseline	Alt 1 - Baseline Scenario With Solar	Alt 2 - Reduced Infrastructure Complexity
Electricity purchased (kWh/d)	86,400	37,800 (-56%)	101,300 (+17%)
Renewable electricity generation (% of total on-site electrical demand)	32%	70%	15%
GHG emissions ($MT\ CO_2e/yr$)	34,340	20,320 (-41%)	27,420 (-20%)
Reliability impacts	No Improvement	Improved (Replaces cogeneration equipment, boilers, heat loops)	Improved (Replaces boilers, eliminates use of cogeneration equipment and associated equipment)
20-year life-cycle costs	$93 M	$83-93 M (89-100% of baseline)	$67-87 M (72-94% of baseline)

TABLE 2 • Energy and Infrastructure Goals Achieved with Recommended Alternatives 1 and 2

District Project Goals	Final Recommended Alternatives	
	Alt 1	Alt 2
Reduce **GHG emissions** by 10% within 10 years.	+ +	+
Reduce **peak demand costs** by 5% within 10 years.	+	–
Reduce **energy consumption** by 10% within 10 years.	+	+
Use **renewable energy** to meet 50% of energy demands within 10 years.	+ +	+
Reduce **Class B biosolids processing energy demand.**	+	+
Improve the resiliency and reliability of **energy supply sources.**	+	+
Improve the reliability of **energy-using and -consuming infrastructure.**	+	+ +

WHAT'S NEXT?

The District will engage stakeholders and community partners to further assess the final two recommended alternatives and earn public support for an effective, responsible, and transparent infrastructure project that delivers sustainable benefits in the long term.

AGS forms dense granules that include aerobic, anoxic, and anaerobic layers to provide nitrogen and phosphorus removal. The dense "bio-BBs" shown in the gloved hand provide rapid settling.

AEROBIC GRANULAR SLUDGE TODAY AND TOMORROW

JOHN FRASER, PE (jfraser@carollo.com)

A QUICK LOOK AT THE AGS PROCESS

AGS is one of the most intriguing emerging technologies introduced to the wastewater industry over the last decade. With a compact footprint for site intensification, this effective treatment process is known to remove nutrients at high mixed liquor concentrations by creating dense granules that boast superior settling characteristics.

These AGS granules are formed through a combination of biological and physical selection pressure. Biological conditions that promote granulation include a repeated feast/famine cycle with a high food to microorganism (F:M) gradient across the reactor. Meanwhile, physical conditions include movements through the water column that create the granule's semi-spherical, rapidly settling shape. The granules are kept in the reactor through an internal physical selector.

THE AEROBIC GRANULAR SLUDGE PROCESS OF TODAY

Today, aerobic granular sludge (AGS) is commercially available using sequencing batch reactors (SBRs). In the US, the patented process is known as AquaNereda® and licensed through Aqua-Aerobic Systems, Inc.

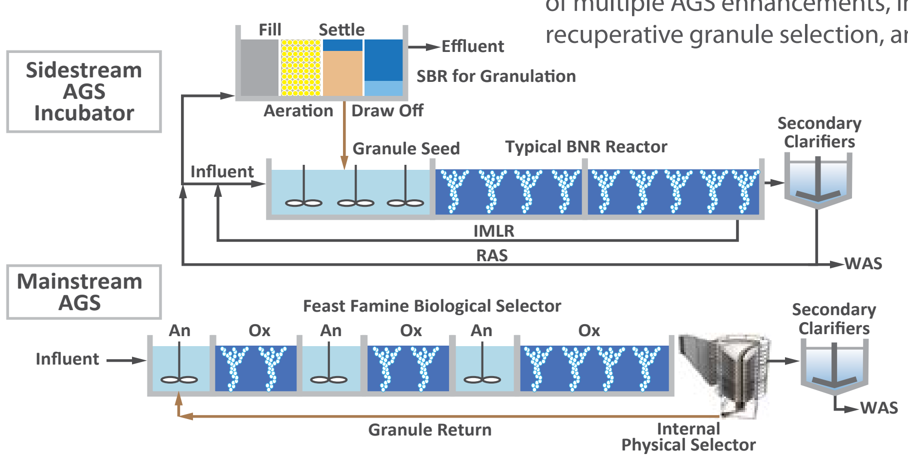
In a continuous-flow SBR configuration, each parallel reactor goes through fill-draw, aerate/react, and settling sequences. A minimum of three reactors is recommended for AGS with the exact number and size depending on average and peak flow and loads, as well as the available space at the plant site.

The US market has generally used AGS as SBRs at smaller plants with capacities of less than 5 million gallons per day (mgd). The large number of reactors, additional piping and ancillary equipment, and complexity of controls may limit the AGS use as an SBR for larger installations. Despite potential limitations, the interest in AGS continues to grow, and the capacity of AGS plants in the US and worldwide is getting larger.

AGS in SBRs may be a good fit for a facility that meets most of the following criteria:

- The capacity is less than 20 mgd.
- The facility is located on a "greenfield" site that does not have an existing water reclamation facility (WRF).
- The facility uses a process other than activated sludge (e.g., trickling filters or lagoons).
- The facility uses an activated sludge process that can be decommissioned, and a new process can be built alongside the obsolete aeration basins and clarifiers.
- Staff can handle the complexity and/or operations and maintenance (O&M) cost of operating multiple SBR reactors in parallel.

Several powerful innovations are being developed to improve the AGS process in an SBR format. Carollo is actively evaluating the process benefits of multiple AGS enhancements, including granular contact stabilization, recuperative granule selection, and A-stage AGS.



There are two approaches to flow-through AGS. The first approach includes a sidestream incubator for granule seeding to the mainstream. The second approach, which is currently being advanced by Carollo, employs a mainstream reactor that mimics both the biological and physical selection pressure of an SBR for continuous granule formation.

THE AGS PROCESSES OF TOMORROW

Created over 100 years ago, activated sludge first started out as a batch process and eventually evolved into the flow-through reactors we know today. Flow-through reactors are less costly and can handle larger capacities than batch processes.

Over time, AGS will also likely evolve into a flow-through configuration. Carollo is actively developing mainstream AGS. We have focused our efforts on designing mainstream flow-through AGS reactors without the use of an incubator.

CURRENT CAROLLO INNOVATIONS FOR AGS IN SEQUENCING BATCH REACTORS

Granular Contact Stabilization

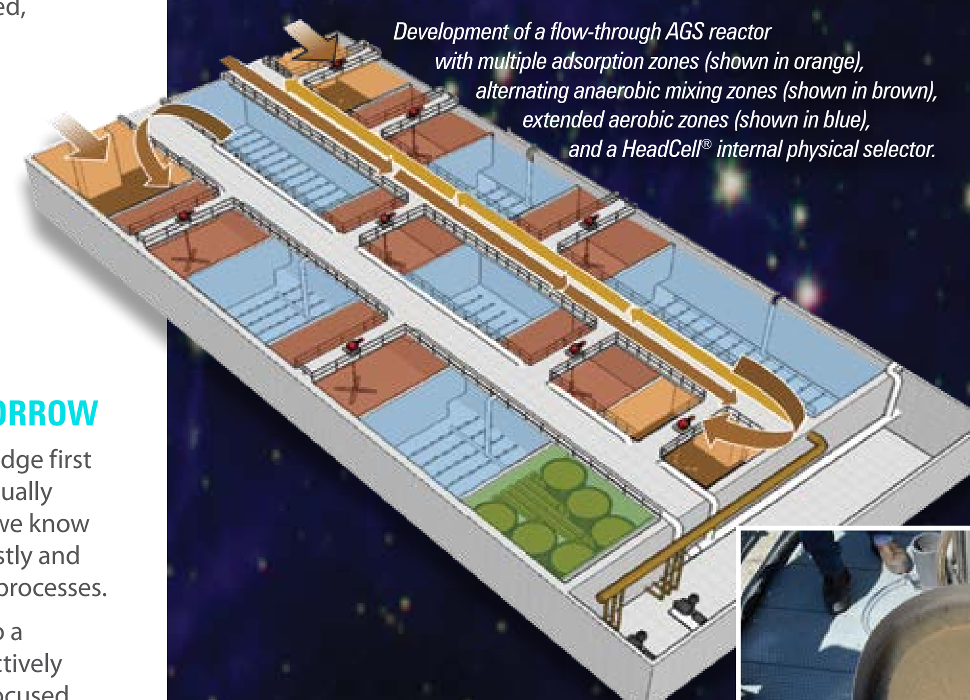
AGS can handle large storm flows by reducing aeration as the peak flow increases. Granules are retained even at high overflow rates and can provide contact stabilization to meet most biological treatment standards.

Recuperative Granule Selection

In an SBR, non-granule associated floc can be washed out in the effluent. Continuous circulation of AGS through a HeadCell® selector retains the best granules.

A-Stage AGS

Starved granules under anaerobic conditions in the AGS fill/draw sequence have the ability to adsorb large amounts of biochemical oxygen demand (BOD). This BOD can be diverted to biogas through anaerobic digestion similar to other Adsorption-Bio Oxidation (A-B) processes.



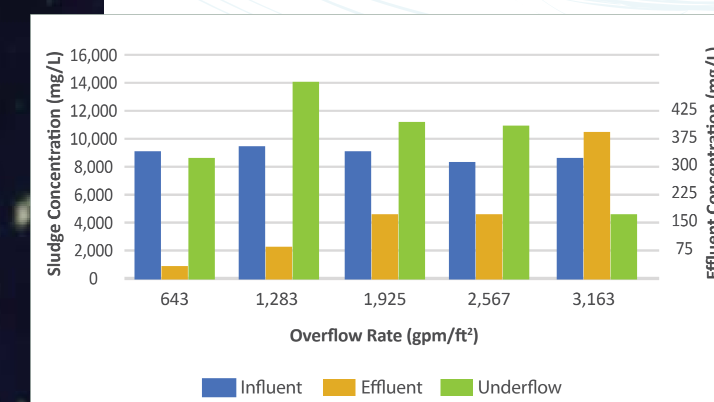
Development of a flow-through AGS reactor with multiple adsorption zones (shown in orange), alternating anaerobic mixing zones (shown in brown), extended aerobic zones (shown in blue), and a HeadCell® internal physical selector.

Photos taken during proof-of-concept testing using a HeadCell® selector to separate granules at the AGS demonstration facility in Rockford, Illinois.

To mimic an SBR, a flow-through AGS reactor must possess the following four components:

1. **An anaerobic adsorption zone** that passes influent through a bed of settled and starved granules to provide the "feast" conditions.
2. **Alternating anaerobic/aerobic zones** that provide both gentle mixing to shape the granules and create "famine" conditions.
3. **Repeated biological selection pressure** using multi-pass reactors configured for step feed to repeated feast/famine cycles.
4. **A flow-through granule selector** using an internal physical selector, such as Hydro International Inc.'s HeadCell®, at the end of the basin. Captured granules are returned to the adsorption zone for the "feast."

Thus far, Carollo has conducted proof-of-concept testing of the HeadCell® selector and developed design concepts for a flow-through AGS reactor with supporting process simulation modeling. We are currently working in partnership with agencies interested in pilot- or demonstration-scale testing of future flow-through AGS configurations. We welcome further discussion of our research on this innovative technology and the opportunity to collaborate on further testing.



Data gathered during HeadCell®'s proof-of-concept testing shows good selector performance at high overflow rates.

COST-EFFECTIVE Post-Long-Term Control Plan Approaches for WET WEATHER MANAGEMENT

(WRF Project #4849)

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Wet weather can compromise collection systems as well as the reliability of process operations at treatment facilities. For over 30 years, utilities and municipalities across the country have been required to develop and implement long-term control plans (LTCPs) to adequately handle combined sewer overflow (CSO) discharges and improve water quality in local waterways.

In recent years, wet weather collection and treatment challenges have only increased due to climate change and competing costs for needed infrastructure upgrades, affecting regions in the US that had previously given little consideration to intense rain events. And, despite the high costs to meet LTCP compliance, ranging from $5 million to over $4.5 billion, these investments do not guarantee that water quality objectives will be met. In fact, many utilities who have followed through with their LTCPs report continued challenges in meeting receiving water quality standards despite significant progress in controlling pollution from bacteria, nutrients, and organic pollutants or solids.

Recognizing these continued challenges, Carollo established a Wastewater Innovation Leadership Initiative focused on developing and promoting the most cost-effective technologies for low-strength/high-flow wet weather treatment. Carollo is currently leading a study examining cost-effective wet weather management strategies following LTCP implementation, under The Water Research Foundation (WRF) Project 4849, "Exploring Cost-Benefit Analysis of Post-Long-Term Control Plan (LTCP) Approaches to Wet Weather Management."

Through this WRF project, Carollo provides guidance to utilities on the following two tasks:

- Synthesizing existing practices for controlling CSO discharges.
- Evaluating the costs and benefits of implementing different compliance approaches within the current CSO regulatory framework.

The Carollo team completed a comprehensive literature review of surveyed US- and Canada-based utilities. In September 2021, the team conducted an industry expert workshop with nearly 20 US and Canadian utilities, along with the US Environmental Protection Agency (EPA), to share and receive feedback on the following topics:

- **Preferred solutions:** The EPA has recently been promoting alternative CSO control technologies, such as green infrastructure and smart sewers (e.g., real-time monitoring and control). However, survey results shown in Figure 1 illustrate that many utilities still rely heavily on gray infrastructure (e.g., pipes, pumps, tunnels) to provide additional treatment capacities and tunnel storage that achieve the compliance objectives outlined in the 1994 EPA CSO policy.

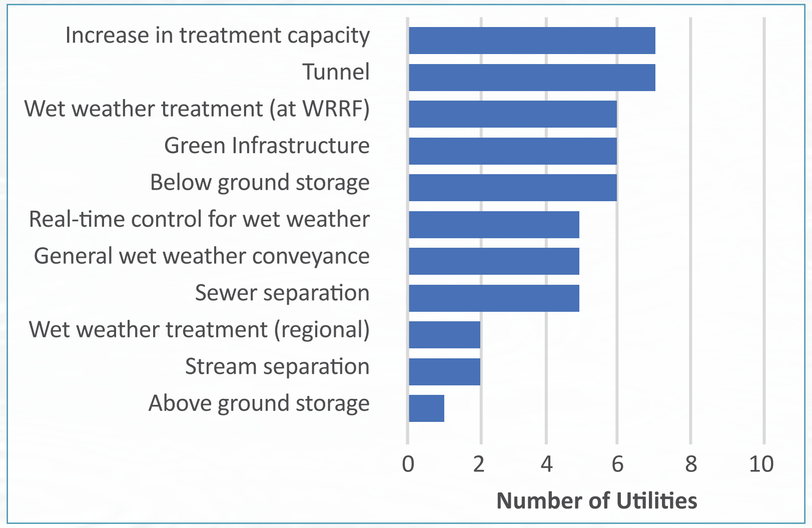


Figure 1. Although utilities have implemented a variety of solutions, survey results indicate that increased treatment capacities and tunnel storage are the most frequently used compliance approaches.

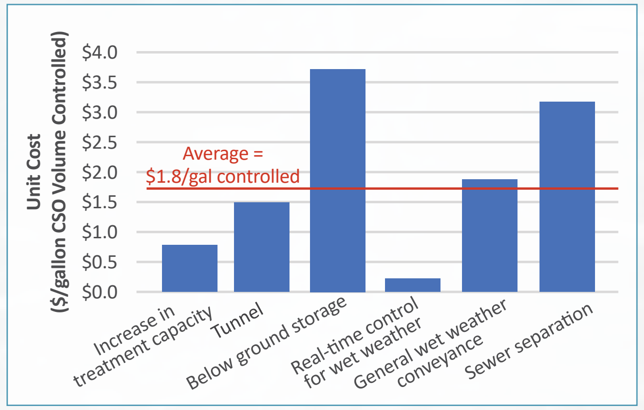
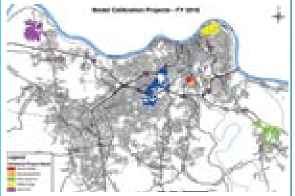


Figure 2. Unit costs of CSO control technologies implemented by utilities. Includes data adapted from the Massachusetts Water Resource Authority's Combined Sewer Overflow Control Plan Annual Progress Report 2015 (March 2016).

- **Cost and benefit comparisons:** While national cost data specific to CSO control is limited, some utilities document control-specific costs and benefits that will provide insights into the future of wet weather management. According to this project's review, utilities expend a wide range of costs, depending on the CSO control technology or strategy they employ.
- **Innovative solutions:** Most CSO communities with compliance challenges are currently subject to consent decrees under the EPA, a process that provides little collaborative compliance support. Instead, utilities want creative solutions that allow them to more dynamically adapt to continuously changing conditions. This project highlights examples of creative solutions, including use attainability analyses (UAA), integrated planning, watershed-wide approaches, adaptive management, and One Water planning, all of which are described in Table 1.
- **Affordability and social justice:** Both of these factors are critical to future CSO compliance planning, particularly for urban areas with higher populations that are disproportionately affected by utilities' financial decisions.
- **Climate change:** Very few utilities have systematically considered the potential impacts of climate change on programs and funding.

The results of this project provide utilities with guidance on the cost-effectiveness of specific LTCP approaches and case study examples of innovative regulatory programs that foster collaboration between facilities and regulators. Further action is needed through national policy initiatives and funding programs to implement long-term successful wet weather management strategies.

Table 1. Innovative compliance approaches and case study examples

Innovative Regulatory Approaches	Description	Case Study Example
Integrated Planning	A process that identifies efficiencies from separate wastewater and stormwater programs to best prioritize capital investments and achieve human health and water quality objectives.	 Metropolitan Sewer District of Greater Cincinnati (OH)
Watershed-scale Planning	An approach that evaluates all sources of pollution and determines technical solutions to address which source(s) contribute to exceedances of receiving water quality.	 EPCOR (Edmonton, Alberta, Canada)
Adaptive Management	An iterative project implementation to reduce uncertainty in environmental management via system monitoring.	 Sanitation District No. 1 of Northern Kentucky (Covington, KY)
One Water Planning	A holistic system's approach that engages multiple stakeholders. What affects water resources, the holistic system or the stakeholders?	 City of Los Angeles, CA
Use Attainability Analysis (UAA)	A structured scientific process to review and potentially modify designated uses of a waterbody when the uses are not existing or attainable.	 Citizens Energy Group (Indianapolis, IN)

SUBOXIC NUTRIENT REMOVAL

Chico, CA, Case Study: Less Aeration Energy Without the Struvite Nuisance

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While most facilities must search for ways to improve nitrogen and phosphorus removal with as little energy input as possible, what do you do when biological nutrient removal (BNR) is *too* good?

The City of Chico's (City) Water Pollution Control Plant (WPCP) was faced with this unusual problem. First constructed with a conventional activated sludge process, this facility was equipped with a sludge retention time (SRT) control system in 2014, called SRTmaster™ by Ekster & Associates (Ekster). Four years later, Ekster and Carollo added an advanced predictive aeration controller, DO/Nmaster™.

Since spring 2020, the WPCP's activated sludge process has been operated under suboxic activated sludge conditions, fully nitrifying at average dissolved oxygen (DO) concentrations of less than 0.7 milligrams per liter (mg/L) throughout its aeration basins. As a result, the City achieved even greater energy savings while effectively removing nitrogen and phosphorus.

HOW TO MAINTAIN ENERGY SAVINGS WHILE PREVENTING STRUVITE FORMATION

After operating under suboxic conditions for approximately 6 months, City staff observed struvite scaling in the plant's pipes and dewatering centrifuge as a result of *biological phosphorus removal.* Thus, Carollo and Ekster teamed up with the City once more to address this unusual question: **How can we maintain the exceptional energy savings earned through suboxic operation while adjusting the efficiency of phosphorus removal to prevent struvite formation?**

DO/Nmaster™ ammonia-based aeration control (ABAC) has considerably improved the WPCP's aeration control accuracy, producing the following plant-wide benefits:

- 47% of energy saved.
- Greater than $100k per year in electricity cost savings.
- 30 to 40% nitrate reduction without mixed liquor recycle pumping.
- A payback period of less than 2 years.

Water & Waste Digest's 2020 Top Project of the Year award, presented to the City of Chico and Ekster & Associates, for Automatic Ammonia Control.

Between February and November 2021, our team completed the following process changes:

1. **Remote, online process monitoring:** Installed online probes and analyzers to remotely monitor nitrate and phosphorus in the aeration basins (DO and ammonia monitoring was already in place).
2. **Outcompete phosphorus removal:** Adjusted the aeration and nitrate profile in the aeration zones to prevent biological phosphorus removal.
3. **Optimization:** Re-tuned the DO profile throughout the three-pass aeration basin zones to maintain full nitrification, maximize nitrate removal and minimize aeration energy use.

The team succeeded in providing the City with important process flexibility. Suboxic process operation had achieved total phosphorus concentrations of less than 0.5 mg/L year-round, at average DO concentrations below 0.7 mg/L throughout the aeration basins, all while maintaining good sludge settling qualities. Plus, phosphorus removal can now be turned off to prevent struvite scaling with equal or better aeration efficiencies through DO and nitrate profile adjustments in the aeration basin zones.

EXPANDING SUCCESS TO OTHER US FACILITIES

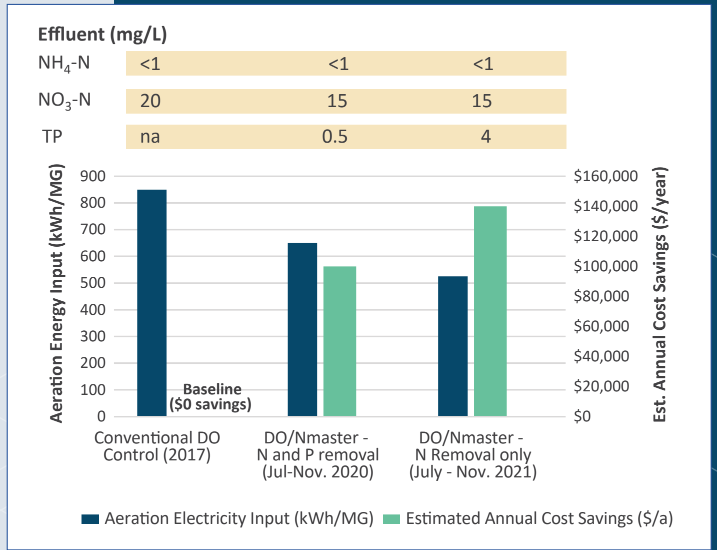
In 2021, a Carollo-led research team received a $2-million research grant from the Department of Energy to make suboxic nutrient removal accessible to the broader US wastewater industry. Project partners include: Los Angeles County Sanitation Districts (LACSD), Hampton Roads Sanitation District (HRSD), Ekster & Associates, APG-Neuros Inc., NEWhub Corp, University of Wisconsin, Columbia University, the Water Research Foundation, and the University of California, Irvine. As part of this project, the team will also commercialize the integration of DO/Nmaster™ into the APG-Neuros's blower technology, which will accelerate the WPCP's success to be replicated at other water resource recovery facilities (WRRFs).

If your utility is interested in saving on aeration power and improving nutrient removal, or using aeration control to avoid nuisance struvite formation, contact **Tanja Rauch-Williams** at **trauch-williams@carollo.com** or **720-670-0479** to learn about Carollo's services with suboxic nutrient removal.

ACKNOWLEDGMENTS

Thank you to Brendt Thompson at S-can who provided the S:Scan nitrate probe at no cost for the duration of this project. Additionally, thanks to Raul Baca, the WPCP's Electrical & Environmental Supervisor for his help installing the monitoring equipment, and Carol Reilly, WPCP's Laboratory Manager, who supported testing.

Carollo & Ekster optimized the suboxic BNR process remotely through online instrumentation to prevent struvite formation while attaining award-winning energy savings.



The WPCP's suboxic nutrient removal, empowered by DO/Nmaster™, controls struvite formation and saves the City more than $140,000 in annual electricity costs. The control system upgrades paid back in less than two years.

Understanding the Impacts of EMERGING CONTAMINANTS on BIOSOLIDS

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Understanding the commonalities of PFAS, microplastics, and other emerging contaminants is important for holistic strategies to protect biosolids management programs.

TEAM MEMBERS:
Mike Luers, Chad Burrell, and
Marlo Davis (Snyderville Basin Water Reclamation District)
Charles Gerba (University of Arizona)

Biosolids have long been beneficially used as nutrient-rich fertilizers and soil amendments. However, we cannot ignore concerns about emerging contaminants in land-applied biosolids. Two specific contaminant groups have garnered considerable attention: per-and polyfluoroalkyl substances (PFAS) and microplastics.

PFAS & MICROPLASTIC COMMONALITIES

- PFAS and microplastics are co-occurring, chemically connected, and ubiquitous.
- Analysis, detection, and treatment methods (e.g., thermal processing), as well as the fate/transport and risk of PFAS and microplastics in wastewater and biosolids, are still being researched.
- PFAS precursors can transform into perfluoroalkyl acids (PFAAs) and microplastics can break-down into nanoplastics during treatment.
- PFAS and microplastics present in treatment plant influent can accumulate in biosolids.
- Source control can prevent more PFAS and microplastics from entering wastewater, biosolids, and ultimately, the environment.

PFAS SNAPSHOT

In Winter 2022, the EPA expects to leverage National Pollutant Discharge Elimination System (NPDES) permitting to reduce PFAS discharges, including actions that "require pretreatment programs to include source control and best management practices to protect WWTP discharges and biosolid[s] applications."

The EPA anticipates finalizing its risk assessment for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) in biosolids by Winter 2024. The risk assessment will then be used to determine whether regulating PFOA and PFOS in biosolids is appropriate. Additional research into fate and transport, plant uptake, measurement of PFAS precursors and PFAS destruction are also ongoing.

TRACKING MICROPLASTICS DURING WASTEWATER TREATMENT

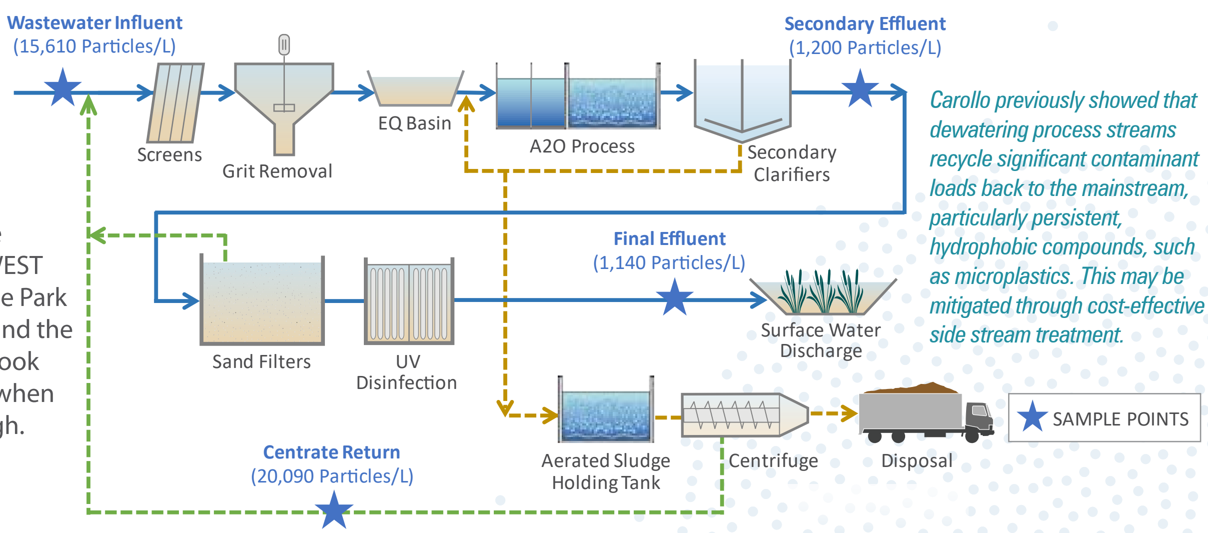
Carollo recently conducted a study at the East Canyon Water Reclamation Facility in collaboration with the Snyderville Basin Water Reclamation District (SBWRD) and the University of Arizona's WEST Center. SBWRD serves the Park City, UT, ski resort area, and the first round of sampling took place during ski season when hotel occupancy was high.

The team tracked the microplastics through the treatment process down to a size range of 10 micrometers using the laser direct infrared (LDIR) method. The treatment process successfully removed more than 90% of microplastic particles during the liquid stream treatment, as illustrated in the figure below.

Most particles in this size range were removed upstream of the tertiary sand filters. Interestingly, polytetrafluoroethylene (PTFE), a microplastic and PFAS compound, was among the least removed through liquid stream treatment. Data indicates that approximately 70 to 90% of microplastics were captured in the solid stream. An additional round of sampling was recently completed in a non-ski season for comparison of microplastics quantities and types during high and low resort occupancies.

CONCERNED ABOUT EMERGING CONTAMINANTS?

If your utility is seeking support to better understand how emerging contaminants could impact your biosolids program, please contact **Rashi Gupta** at **rgupta@carollo.com**.



Carollo previously showed that dewatering process streams recycle significant contaminant loads back to the mainstream, particularly persistent, hydrophobic compounds, such as microplastics. This may be mitigated through cost-effective side stream treatment.