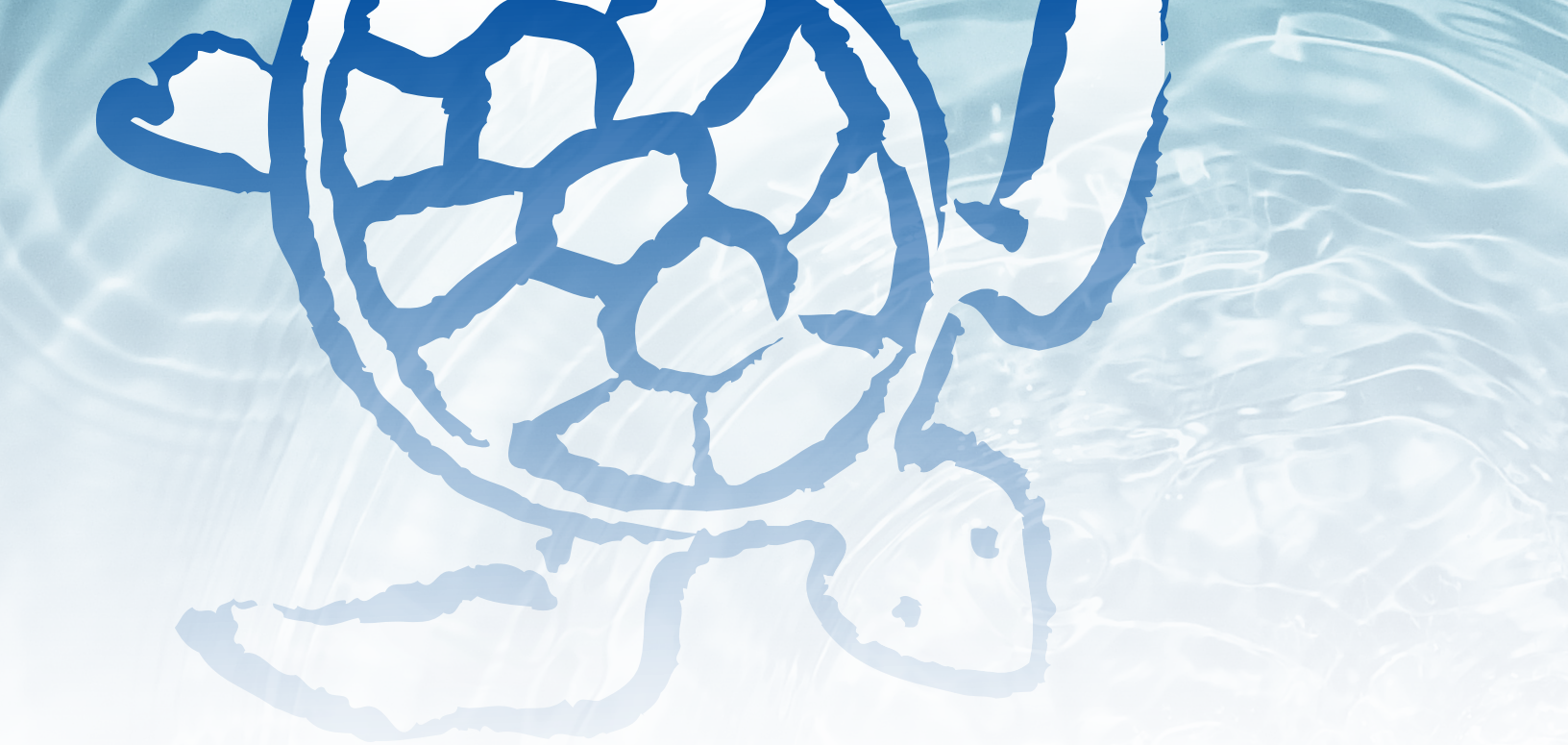


The Tennessee Story

Optimizing Nutrient Removal at Municipal Wastewater Facilities

Reduced Operating Costs, Capital Savings, Better Treatment & Sustainable Operations 2017

THE WATER PLANET COMPANY

www.cleanwaterops.com

Optimizing Tennessee Municipal Wastewater Treatment Facilities:

Nutrient Removal, Cost Savings & Sustainable Operations 2017

During 2015 and 2016, The Water Planet Company trained and provided on-site technical support to optimize the day-to-day operations of nine Tennessee municipal wastewater facilities.

Plants realized significant O&M savings.

Treatment is now more sustainable.

Operations led to improved nitrogen and phosphorus removal.

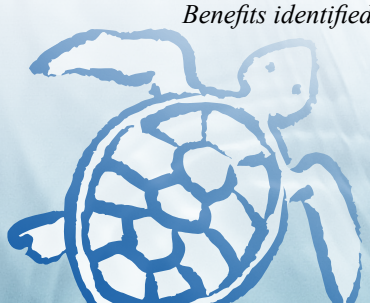
Tennessee municipal wastewater staff used newly acquired knowledge and challenged themselves to operate standard equipment differently. This ingenuity has enabled plants to exceed design expectations and meet anticipated nitrogen and phosphorus nutrient limits.

Tennessee's approach to optimization was one of common sense. A river modeler researched wastewater's effect on state waterways and came to an unexpected conclusion: while nutrient removal was proven essential to wastewater treatment, there was not enough data to accurately determine what the most ideal nitrogen and phosphorous levels should be. Therefore, priorities shifted away from making large upgrades and toward making the most of existing infrastructure.

The most critical factor in improving operations was the engagement of regulatory personnel. Their willingness to make changes to long-running protocol led to an ideal environment for plant staff to fully employ their extensive abilities.

Treatment Plant	Nitrogen Removal	Phosphorus Removal
Cookeville		
Baileyton		
Norris		
Millington		x
Collierville Shelton Road		
Athens North Mouse Creek	x	
Athens Oostanaula	x	W/O Chemicals
Nashville Dry Creek		x
Lafayette	x	W/O Chemicals

Plants that were removing nitrogen or phosphorus before the optimization effort are noted with an X.
Benefits following optimization: solid blue box
Benefits identified but not yet realized: shaded blue box



The plants are now operating more sustainably.

Treatment Plant	Environmental Benefits		
	Reduced Electricity	Reduced Chemicals	Less Sludge
Cookeville	■		■
Baileyton	■		
Norris	■		▒
Millington			▒
Collierville Shelton Road			
Athens North Mouse Creek			▒
Athens Oostanaula		■	▒
Nashville Dry Creek	▒		
Lafayette		■	

Benefits following optimization: solid blue box
Benefits identified but not yet realized: shaded blue box
Increases are shown in teal

Most of the facilities have reduced operating costs.

Dollar Savings: Reduced Operating Costs	
Cookeville	■
Baileyton	■
Norris	■
Millington	■
Collierville Shelton Road	■
Athens North Mouse Creek	▒
Athens Oostanaula	■
Nashville Dry Creek	■
Lafayette	■

Cost savings resulting from nutrient optimization: solid blue box
Cost savings but not yet realized: shaded blue box
No cost savings: orange

Cookeville

Optimization efforts enacted by Water Department Director Ronnie Kelly, Wastewater Superintendent Tom Graham, and Assistant Superintendant John Buford resulted in significant nitrogen and phosphorus reductions while providing electrical savings of nearly $200,000 per year. Total-nitrogen is now averaging 5 mg/L versus 20+ before the optimization effort. Total-phosphorus has been cut in half.

By reducing the operation of the plant's 24 40-horsepower oxidation ditch aerators from continuous to eight hours daily, Cookeville is treating wastewater more sustainably and saving nearly enough electricity each day to power a residence for a year. Ammonia removal occurs in the aeration zone and nitrate is removed in the anoxic, air-off zone. Fermentation occurs in the depths of the air-off zone and biological phosphorus removal is completed in the aerobic zone.

Aeration in the sludge holding tanks is also cycled on and off. Doing so works as a selector to provide better settling of sludge.

A $4 million nutrient removal facility upgrade is no longer under consideration, due to these operational changes. The plant now treats wastewater just as well as, if not better, conventional treatment did before the upgrade. During a 2016 heavy rain event, the 15 MGD plant processed a record 30 MGD without incident.

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Tom Graham and John Buford

Baileyton

With the support of Water Planet, TDEC's Johnson City Field Office (Bryan Carter, Sandra Vance, Jason Benton and Robert Tipton), and Brett Ward of the University of Tennessee, Baileyton successfully reduced nitrogen to low concentrations. They first addressed the problem by cycling aeration equipment on and off throughout the day; this change created alternating aerobic conditions for ammonia conversion to nitrate (nitrification) and anoxic conditions for nitrate conversion to nitrogen gas (denitrification). The one in-service blower operates approximately 11 hours per day for a monthly electrical savings of close to $500. Effluent nitrogen is consistently below 10 mg/L; this stands out from before optimization when it was typically greater than 50 mg/L.

It was more difficult to achieve phosphorous removal. The pre-aeration tank was converted to a pre-anaerobic tank and mixed liquor piped into it for VFA (volatile fatty acid) production and uptake by PAOs (phosphate accumulating organisms), but effective biological phosphorus removal has not been realized and Baileyton staff are using chemicals to meet their phosphorus limit.

Meanwhile, Baileyton staff continue to experiment with biological phosphorus removal. The pre-aeration tank has been restored to aerobic conditions and a 330-gallon tote is being used as a fermenter. Bacteria from the plant's main aeration tank is pumped into the tote at a slow rate. The contents of the tote become anaerobic and flow into the highly aerobic pre-aeration tank and back into the main aeration tank.

Given these changes and plant staff's commitment to optimization, Baileyton's wastewater treatment facility is now operating more sustainably at a reduced operating cost. The facility is now expected to meet anticipated nitrogen and phosphorus limits without a full upgrade.

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Norris

TDEC's Knoxville field office actively participated in optimizing nutrient removal at the Norris wastewater treatment plant; participants included Greg Mize, Rob Ramsey, and John West. The City of Norris is lucky to have enthusiastic, talented wastewater staff, particularly Tony Wilkerson and Doug Snelson. Brett Ward of UT provided a kick-start to the nitrogen removal and his help was invaluable.

The Norris wastewater treatment facility is a plate steel pre-fabricated plant that is 30 years old. A plug flow aeration tank surrounds a circular clarifier. Sludge is digested in a nearby concrete tank. The facility was designed for neither total-N nor total-P removal.

By cycling aeration equipment in the plug flow treatment facility, Norris staff reduced effluent total-N to below 5 mg/L by mid-summer. Since then, plant staff have been working on a mechanism to reduce total-P. The first attempt at biological phosphorus removal proved ineffective and detrimental to total-N removal.

The current strategy involves the use of two used totes as 330-gallon chemical fermenters. Mixed liquor is pumped into the totes and allowed to sit overnight before being returned to the aeration tank.

By the project's end, Norris' small staff gained an incredibly strong understanding of nitrogen removal, and is able to operate the facility for the effluent to be very low in nitrogen. A creative effort to biologically remove phosphorus using totes has been unsuccessful so far, but staff continue to work with Water Planet to achieve the desired level of phosphorus removal.

Given plant staff's interest, commitment, and intellect – as well as their informed use of TDEC supplied equipment – Norris is certain to produce fantastically clean water once it is optimized for no facility upgrade to be required to meet anticipated nutrient limits.

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Millington

Eddy Bouzeid of TDEC's Memphis field office worked closely with Millington Superintendent David Dunn and staff (Chris Max, Shane Swindle, and Dave Wolle). Brett Ward of the University of Tennessee and Larry Moore of the University of Memphis have both contributed their expertise and joined Water Planet in assisting with the optimization of Millington's oxidation ditch wastewater treatment facility.

Plant staff have cycled aeration rotors on and off at Millington's unique oxidation ditch plant to improve nitrogen removal by creating alternately high dissolved oxygen conditions for ammonia removal and low dissolved oxygen conditions for nitrate removal. Biological phosphorus removal has historically ranged from good to excellent thanks to incomplete mixing and the creation of anaerobic sludge blankets in the oxidation ditches.

With TDEC's technical support, Millington should be able to meet upcoming nitrogen and phosphorus limits without a facility upgrade.

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Collierville

City staff are fully engaged in optimizing nutrient removal at the Shelton Road treatment plant, and they are applying the knowledge gained at the 3.5 MGD facility to the similar, 6.0 MGD Northwest treatment facility (both plants are oxidation ditch facilities). At Shelton Road, plant staff have installed an in-line ORP probe connected to a SCADA system, tracking conditions in the oxidation ditches. With this tool, they are learning how to control both ammonia-nitrogen and nitrate-nitrogen to optimize total-nitrogen removal.

Years ago, plant staff realized that they could recover alkalinity lost during aeration by cycling the rotors in their oxidation ditches on and off. During the optimization effort, Water Planet guided plant staff in adjusting the cycles to create optimal conditions for ammonia removal during the air-on cycles and nitrate removal during the air-off cycles. Conditions continue to be tracked using an in-line ORP probe and plant staff are working to establish optimal cycles.

At the recommendation of University of Memphis professor Dr. Larry Moore, plant staff have creatively reduced the RAS (return activated sludge) pumping rate to create anaerobic conditions in the plant's gravity thickener. These conditions will ferment sludge for biological phosphorus removal. Despite ongoing monitoring and considerable effort from the participants, phosphorus removal is not as effective as desired. Optimization efforts are ongoing.

Nitrogen removal is well understood and controlled by plant staff: David Harrison and Jennifer Benjamin. Collierville's Utilities Engineer Clay Holabird and Utilities Division Director Tim Overly are well informed as to the scince and are fully supportive of staff efforts. Phosphorus removal continues to be a struggle. But given the competency and intensity of Collierville's effort, performance at its treatment facilities is being fully optimized.

With the steadfast effort, and the ongoing support of TDEC's Eddy Bouzeid, this facility will surely be producing an effluent with low nutrient levels. Apart from some chemical phosphorus polishing, it is unlikely that the Shelton Road plant will need any upgrades to meet forthcoming nutrient limits.

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Athens

Led by Manager Greg Hayes, Athens has undertaken a comprehensive effort to collect and analyze data to optimize biological phosphorus removal. In the summer of 2016, for the first time in its history, the Oostanaula wastewater treatment plant complied with its total-phosphorus limit without the need for chemical addition.

With the full engagement of Superintendent Jill Davis, Chief Operator Russell Coleman, Chief Operator John Sullivan, Consultant Stefanie Farrell, and Water Planet, Athens staff found that their orbital ditch treatment facility was effectively removing nearly all organic waste before aeration, providing an improper environment for phosphorus uptake during the summer months. The recycling of fermented waste sludge to the plant's inlet was marginally successful. Bypassing flow around the pre-anoxic tank did not provide the anticipated improvements in phosphorus removal, but it has allowed the plant to be permit compliant without the need for chemical addition for the first time in a decade.

Lessons learned at the city's bigger wastewater treatment facility (Oostanaula) are being implemented at the smaller North Mouse Creek facility. Manager Greg Hayes has traveled to plants across the state to support their optimization efforts by sharing his experiences.

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Metro Nashville Dry Creek

Jordan Fey of TDEC's Nashville field office was an effective, active participant in the optimization program, as were Metro Nashville plant Assistant Director (Operations) David Tucker, Manager Johnny McDonald and other members of Metro's staff including Jeff McGuire, Carl Marsh, Dave Tucker, and consultant Ken Schnaars.

Given the large size of the facility (24 MGD), and the fact that none of the aeration valves are automated, Water Planet suggested that Nashville staff seek to optimize one of six parallel trains. The air in the first one-third of the first pass of the two-pass, plug-flow aeration tank is always off. Designed as a biological selector for filament control, the zone provides anaerobic conditions for bio-P removal. The remainder of the first pass is continuously aerated to provide biological phosphorus uptake. The air in the second pass is cycled on and off rather than the conventional practice of having it always on. The operational strategy is intended to preserve the facility's historically excellent total-P removal (effluent averages 0.2-0.3 mg/L) while providing alternating aerobic conditions for ammonia conversion to nitrate and anoxic conditions for nitrate conversion to nitrogen gas in the second train.

In optimizing nutrient removal, Metro took primary clarifiers off line in an effort to beneficially increase the organic loading on aeration tanks. Plant staff also incorporated step feed to send a portion of the primary effluent flow to the second pass of aeration, boosting denitrification when the air is cycled off. These actions yielded encouraging results. Total-nitrogen dropped by approximately 50% in the optimized train. During the trial, electrical savings on the order of $25,000 per month were observed.

Metro is considering investing in equipment that will allow all six passes to be operated automatically to provide complete nitrogen removal and save electricity. Thanks to the willingness of Metro (with the support of their design consultant!) to make the process changes described above, Metro is saving millions of dollars on future upgrades. Not only will the Dry Creek facility be made to remove nutrients to low concentrations with minimal investment, the lessons learned at Dry Creek have been incorporated into the upgrade of Metro's 37.5 MGD Whites Creek treatment plant.

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Lafayette

Using two portable ORP probes and meters, plant staff collected data which was formatted, tabulated and distributed by Water Planet and shared with TDEC's Oakley Hall and plant staff – Jack Hauskins and Rocky Hudson – for weekly review and discussion. The data were used to maintain excellent nitrogen removal while improving biological phosphorus removal. All involved gained a strong awareness of the conditions that support and hinder phosphorus removal. Notwithstanding a number of actions, the high influent-dissolved oxygen concentration and the small size of the pre-selector have limited plant staff's ability to create sufficiently anaerobic conditions in the selector to provide the desired level of biological phosphorus removal.

The weekly emails between the three parties (Lafayette, TDEC and Water Planet) empowered plant staff to the point that their facility is optimized. They went on to reach out to the plant designer and discuss its limitations with them; additionally, they are looking forward to operating the soon to be installed pre-equalization tank to improve biological phosphorus removal. The use of this tank will make it unnecessary to ever add ferric chloride to maintain compliance with effluent phosphorus limits.

Given the staff's commitment, it appears likely that Lafayette will be able to dial in nutrient removal for the facility to meet all anticipated limits without further facility upgrades.

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Rocky Hudson

The Water Planet Company

Education and empowerment are at the forefront of our approach to wastewater treatment. We believe that operational expertise is every bit as important as having the right equipment, and that the ingenuity of wastewater operators is the driving force behind better water quality at cost savings. Our training philosophy centers on empowering operators in client facilities and expanding on their vast potential. We seek these objectives in classroom settings and through in-plant support.

Water Planet staff have provided in-plant technical support to 60 municipal wastewater treatment facilities in the New England states (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine), Pennsylvania, Montana, Texas and Tennessee.

Company President Grant Weaver, a licensed Professional Engineer with top wastewater licensing in multiple states, has made many scholarly contributions: he authored a chapter of the Water Environment Federation's Nutrient Roadmap, was a review author of the Water Environment Federation's Operation of Nutrient Removal Facilities Manual, and has authored numerous trade journal articles. Grant has been a presenter/lecturer at meetings and conferences in New Hampshire, Massachusetts, Connecticut, Pennsylvania, Wisconsin, Montana, Utah, Colorado, Louisiana, and Missouri. He resides in Groton, Connecticut.

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