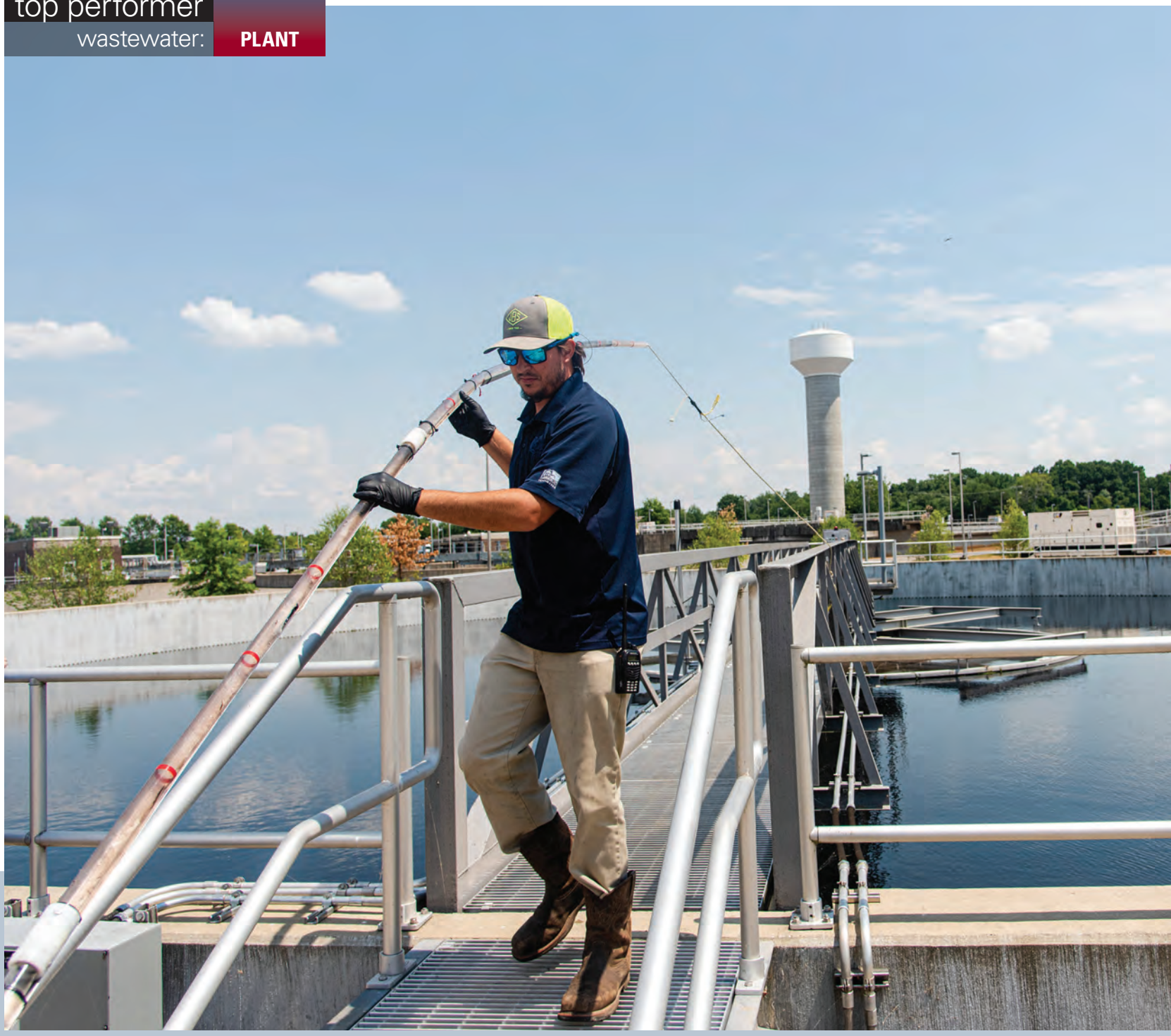


Doing the Impossible

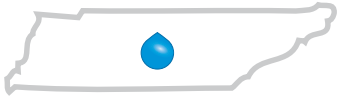
A TENNESSEE FACILITY TEAM REWRITES THE PLAYBOOK ON NUTRIENT REMOVAL TO CLEAR THE WAY FOR A PLANT EXPANSION ESSENTIAL TO ECONOMIC GROWTH IN ITS COMMUNITY

STORY: **Suzan Chin-Taylor** | PHOTOGRAPHY: **Martin Cherry**

> "One of the key things we did was to include [in expansion decisions] every single staff member, even those who were very new and only on the job a short time."
>
> **JOHN STRICKLAND**

Anthony Pollock, plant supervisor, samples the sludge blanket in a clarifier.

Effluent feeds the West Fork Stones River, helping to provide a healthy ecosystem for the wildlife.



Murfreesboro (Tennessee) Water Resources Recovery Facility

www.murfreesborotn.gov

BUILT:
2000 (expanded and upgraded 2017)

POPULATION SERVED:
160,000

TEAM MEMBERS:
30

FLOWS:
24 mgd design, 20 mgd average

TREATMENT LEVEL:
Tertiary

TREATMENT PROCESS:
Oxidation ditch; deep-bed mixed-media sand filtration

RECEIVING WATER:
West Fork Stones River, cropland irrigation

BIOSOLIDS:
Landfilled

ANNUAL BUDGET:
$9 million (operations)

When facing what seemed insurmountable odds to meet aggressive new effluent nutrient limits, the Murfreesboro Water Resources Department team members banded together.

They drew upon internal resources, skills and innovation to complete a treatment plant expansion that was financially viable, met the permit requirement, and provided a framework for capacity expansion and long-term reliability.

The Murfreesboro Water Resources Recovery Facility was built in 2000 and expanded by 50% in 2017 to a 24 mgd design capacity (average flow is 20 mgd). The plant culminates decades of diligent effort by the city staff and consulting engineers to achieve dramatic reductions in effluent nitrogen and phosphorus.

The plant has received four Peak Performance Gold Awards from the National Association of Clean Water Agencies. Closer to home, it has earned two Excellence in Beneficial Reuse Water Awards and eight consecutive Operational Excellence Awards from the Clean Water Professionals of Kentucky and Tennessee.

The Murfreesboro Water Resource Department team includes, from left, Anthony Pollock, plant supervisor; John Strickland, plant manager; Josh LeMay, assistant plant supervisor; Jelisey Russell, plant operator; and Terry Suber, senior plant operator.

REUSE AND RAINBOWS

To limit phosphorus in the effluent, the Murfreesboro Water Resource Department purchased two farms — 150 acres in 2001 and 425 acres in 2005 — for irrigation with recycled water.

The farms receive some of the effluent otherwise released to the West Fork Stones River. Diverting that water and the phosphorus it contains reduces phosphorus loading to the creek and helps the facility comply with its permit.

When the utility purchased the farms, neighbors at first were opposed. Now, they appreciate the farms for the open green space they provide in a community that is developing rapidly. The spray irrigators create rainbows that residents enjoy seeing.

The farms raise hay for sale to livestock farmers. This bonus crop comes in handy during periods of drought, providing feed that farmers otherwise would not have had. The farms are droughtproof, remaining lush and green regardless of the weather. So, what's not to love?

It won a 2014 Plant of the Year award from the Tennessee Water and Wastewater Association, and achieved STAR Operations Designation from the Tennessee Department of Environment and Conservation in 2014. The Water Resource Department has been recognized as a National Utility of the Future Today.

BACK THROUGH TIME

The original Murfreesboro treatment facility was built in 1961, discharging about 200,000 gpd to the West Fork Stones River, a small creek. A new oxidation ditch facility was completed in 2000 with a design capacity of 16 mgd (average flow 12 mgd).

Murfreesboro, a Nashville suburb that became one of the nation's fastest growing cities, eventually saw a need for even more capacity. However, the Tennessee Department of Environment and Conservation, "based on known plant performance," refused to grant a permit for an expansion, convinced that the larger facility could not meet new permit requirements of 520 pounds of nitrogen and 307 pounds of phosphorus per day.

"Those numbers were based on a flow of 16 mgd, and we had to demonstrate that we could achieve those numbers if the flow increased to 24 mgd," says John Strickland, plant manager.

The expansion was critical to the community's future prosperity: A study by the Smith, Seckman and Reid engineering firm found that a moratorium on new sewer connections, essentially stopping growth in the city, would cause an immediate negative financial impact to residential and commercial property values along with a loss of $695 million over approximately five years in underdeveloped property and future tax collections.

"When you're talking about that kind of economic impact, there was no way for us to accept TDEC's answer," says John Strickland, plant manager. "At the time of that requirement, the plant had been online for 12 years. We were unsure how we could double nitrate removal, and the facility was never designed for phosphorus removal. So we took all that we knew about operations and our plant, developed a very forward-thinking plan, and executed it."

DEVISING THE SOLUTION

The plan was to improve nitrogen removal and enable biological phosphorus removal (bio-P) by taking the existing oxidation ditches, with aerobic and anoxic zones for nitrification-denitrification, and creating two additional habitats — luxury phosphorus uptake and anaerobic — within the same structure.

> "You never know where nuggets of innovation or wisdom will come from. So consider the process of innovation and the process of problem-solving to be like gold mining."
> **JOHN STRICKLAND**

The three aerators on each of the facility's two oxidation ditches would be manipulated to create the different habitats. The sequence of habitats from raw water to secondary effluent was anoxic, anaerobic, luxury uptake, aerobic (for ammonia removal).

Since facility automation was extremely limited, the existing and new habitats would be created and sustained by operators manually adjusting the aerators to specific speeds. Strickland and his team had one year to document to TDEC that the changes in operation could achieve the needed nutrient reductions.

"No one had ever done this type of extra zone creation in oxidation ditches before, so we called in the gurus," says Strickland. "None of the national experts we spoke to could solve our problem, so we had to figure it out on our own."

Operators had to collect and analyze multiple samples from each zone daily for dissolved oxygen content. "To give you an idea of the difficulty we faced, we would receive test information days after the tests were taken. From

Jelisey Russell with the Water Resources Recovery Facility's SCADA system display.

an operator standpoint that's like riding a bull backward and blindfolded down a lightning bolt."

PLENTY OF STRESS

DO levels were taken with a single portable probe. Because of these delays in data after aerator adjustments, operators had to make anticipatory judgments on what was to happen and be extremely sensitive to the changes being made. They had to know hour-by-hour what was happening to stay on top of the needed adjustments.

The process subjected the operators to considerable stress and fatigue. "I had never seen a staff get battle-weary the way we were," Strickland says. But with stakes so high, failure was not an option, and the team kept pushing through: "We were creating a new playbook. Even if automatic control had been available, no one would have known what to set it to, so we still would have been playing by ear."

At the end of the year, the plant team had tripled nitrate-removal efficiency and increased phosphorus-removal efficiency by 100%. The changes also saved the plant $130,000 per year on electricity through the changed aerator operation. Based on the result, TDEC granted a permit for the plant expansion.

The biosolids produced at the high-performance Murfreesboro facility are dewatered on eight rotating sludge presses (Fournier Industries) and are currently being landfilled.

FAST FORWARD 2017

With the permit in hand, Murfreesboro went forward with design for the expansion with an eye toward customer service, constant innovation and financial viability. "As we designed the new plant, we were largely using the technology we had used before, because it had worked well," Strickland says. "But as a group, because we are under a constant innovation framework, we were going to kick the tires on everything again."

For example, the plan called for expanded sludge and biosolids handling facilities at a cost of $3.5 million. But the team determined that through a process redesign, the existing building could accommodate the higher demand.

In total, consulting engineers originally projected the cost of the plant expansion at $36 million. However, through the team's efforts to repurpose, reuse and redesign the solids-handling system, the sand filtration system and other components, and sludge handling components, the project came in $6 million under that figure.

"This financial consciousness, along with knowing the operation so well, resulted in no real impact on the ratepayers as a result of the expansion," Strickland says.

PLAYING A SYMPHONY

Throughout the expansion, decisions involved the entire staff. "One of the key things we did was to include every single staff member, even those who were very new and only on the job a short time," Strickland says.

Anthony Pollack inspects step screen equipment (WesTech Engineering) in the headworks building.

The 30-member facility team encompasses plant operations, maintenance, laboratory, instrumentation and control, and industrial pretreatment personnel. Key team members include: Josh LeMay, assistant plant manager; Anthony Pollock, plant supervisor; Steve Huffman, pretreatment coordinator; Mike McMurry, FOG program coordinator; James Ross, maintenance supervisor; Felicia Fletcher, laboratory supervisor; and Greg Hicks, biosolids supervisor.

Strickland notes that maintenance is gaining importance as the plant ages.

"With the maintenance team we've installed a mindset that I borrowed from the airlines," he says. "In the airline maintenance industry they have what they call a cannot-fail mindset, which means there is no circumstance in which the airplane can fall out of the sky due to a maintenance issue. We've adopted that same mindset. We've agreed we will never be out of compliance because of a maintenance issue. The team has stayed on top of it and has done very well with meeting that goal."

Instrumentation and control have become more essential as the facility has become more automated.

Murfreesboro Water Resources Recovery Facility
PERMIT AND PERFORMANCE

	INFLUENT	EFFLUENT	PERMIT
BOD	200 mg/L	2.0 mg/L	4.0 mg/L
TSS	650 mg/L	0.5 mg/L	32 mg/L
Nitrogen	4,800 lbs/day	250 lbs/day	520 lbs/day
Phosphorus	1,100 lbs/day	200 lbs/day	307 lbs/day

"We refer to this as the universal right to improvement. That means anyone can suggest an improvement. Regardless of title, position or longevity, anyone can put forward a proposal. We fostered a learning organization, and team members were buying textbooks and doing their own research because they were excited about being able to share ideas."

This open platform was of great value in determining the best way to automate the oxidation ditches. Manual operation had been successful, but was unsustainable; automation was essential to the expansion plan.

The oxidation ditches were automated by creating a three-way partnership of innovation involving Murfreesboro and two manufacturers. The Carrousel oxidation ditches (Ovivo USA) are fitted with Excell aerators and automated through the company's Oculus control system. Added control was achieved by incorporating Hach probe/sensor technology.

TEAM ENTERPRISE

All the teamwork, sharing, history, and hands-on experimentation led to a high-performance facility. The expanded plant consists of 17 buildings. The main pump station is equipped with three 500 hp and two 250 hp pumps from Hidrostal Pumps and Trillium Pumps USA Inc. - WEMCO. The headworks building has four step screens (WesTech Engineering) and two PISTA grit chambers (Smith & Loveless).

The six 2 million-gallon secondary clarifiers (Walker Process Equipment, A Div. of McNish Corp.) center-drive, spiral rake units. Tertiary treatment is provided by 13 deep-bed, mixed-media sand filters (De Nora Water Technologies). Two channels with TrojanUVSigna units provide disinfection units; water for reuse is chlorinated. The final effluent is enriched with oxygen by ABS TA submersible aerators (Sulzer Pumps Solutions).

Biosolids are dewatered on eight rotating sludge presses (Fournier Industries) to a minimum of 12.5% solids. The material is now being landfilled, but a small-scale test dryer unit (Gryphon Environmental) is operating as the team evaluates producing a Class A-EQ product.

BLAZING THE TRAIL

Murfreesboro achieved what many considered the impossible when facing restrictions and rejections from regulators. Trying something new, with a high risk of failure and permit violation, has brought many rewards.

"When accepting one award, the gentleman who presented it to me stated 'The most amazing thing about what you're doing is that this will be the way it will be done everywhere going forward,'" Strickland says. Murfreesboro's success with biological nitrate and phosphorus removal is spreading across the country and around the globe: Visitors have come from Egypt, Guam, and elsewhere around the world to see the innovations in treatment.

"You never know where nuggets of innovation or wisdom will come from," Strickland says. "So consider the process of innovation and the process of problem-solving to be like gold mining. Be willing to get in there and dig in the dirt to sift through all of the unusable to get to the golden nuggets that will bring about real impactful change." tpo

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