New Hope for Tar Creek

By Chip Minty

Courtesy of Tulsa Historical Society and Museum

In June 2016, OU students seine for fish in an unnamed tributary to Tar Creek. In the five years since this photo was taken, water quality has improved and fish have returned to the tributary, marking a major milestone in reclamation efforts at Oklahoma's oldest Superfund site.

An OU environmental scientist's career-long dedication to a doomed creek in Northeastern Oklahoma is showing promise in remarkable ways.

When they hear scientific explanations for what happened to a once-productive mining town, many residents of Ottawa County, Okla., stare back with eyes glazed over, ready to fall asleep. Going on 40 years now, they've heard the story many times before.

Their grandfathers and great-grandfathers worked in the lead mines near Picher, Okla., to produce raw materials for the ammunition that helped win two world wars. As a result of their heroism, the fish in Tar Creek died, water runs orange, and a big chunk of the county is deemed a man-made environmental disaster area.

But nowadays, talk about Tar Creek sounds different. There is still a lot of scientific discussion and it's easy to get lost in the engineering jargon, but there is one key phrase that everyone in Northeastern Oklahoma can latch onto.

The fish are coming back.

The fish population in a small Tar Creek tributary is growing because of water remediation work by University of Oklahoma environmental scientist Robert Nairn, who heads OU's Center for Restoration of Ecosystems and Watersheds.

Numbers have grown from near zero to 15 species. Bass and catfish are back, and beaver have moved in as well, building dams, having kits, and helping the small stream look normal again.

Tar Creek is still laden with pollution from untreated water spilling in from other tributaries. But results Nairn and his team have seen in the waterways near their reclamation ponds give them hope.

Nairn, who serves as the Sam K. Viersen Family Presidential Professor for OU's School of Civil Engineering and Environmental Science, has been working for nearly 25 years to achieve what many have considered the impossible—bringing fish back to the tributary. While that may seem like a small accomplishment, it is a giant first step for Nairn, who is on a career-long journey to restore an environmental disaster so severe that even the EPA has turned away. If they can clean up a small tributary, he reasons, why can't they remediate polluted waters throughout the Tar Creek Superfund site?

Nairn doesn't fault the government for surrendering to the crisis nearly 40 years ago. Any reclamation project they might have considered would have taken decades to manage and would have cost hundreds of millions of dollars to fund.

Nairn's approach to the problem is much different than conventional remediation methods. He and his students have designed passive treatment systems composed of "human-made ecosystems" that clean the water. They use renewable energy from the sun and wind and the principles of chemistry. The result: clean water at an affordable cost. But his work is far from finished. The environmental wounds across the 40-square-mile Superfund site will require multiple remediation systems.

Tar Creek's slowly unfolding environmental disaster began in the 1970s and 1980s, when vestiges from the mines first surfaced, Nairn says.

"When the mining was occurring through the first half of the 20th century, they pumped water out of the mines to keep things dry, so the men could work. They were actually mining through an aquifer.

"It wasn't until late in the process that those pumps were shut off and natural groundwater began to recharge those massive holes the mining had created," Nairn says. "We estimate there are about 100,000 acre-feet of water in those abandoned mines. To put that into context, that's a little bit bigger than Lake Eucha, a municipal water reservoir east of Tulsa."

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Environmental scientist Robert Nairn, who heads OU's Center for Restoration of Ecosystems and Watersheds, wades into Little Elm Creek to take samples from the healthy stream for comparisons with Tar Creek and its tributaries.

Nairn and students designed and built a custom solar system to power the passive treatment at the Southeast Commerce site. Energy from the solar panels is stored in batteries inside the shed. The batteries power blowers that force air into aerators in the treatment ponds, oxygenating the water.

Once the groundwater began interacting with minerals left exposed by the mining, chemical reactions ensued, producing an orange soup containing dissolved iron, zinc, lead, cadmium and other elements. Eventually, the pollution found its way to the surface and into Tar Creek and other tributaries in the Tri-State Mining District, which includes portions of southeast Kansas and southwest Missouri.

Mother Nature will eventually heal herself, Nairn says, but that is likely to take centuries or perhaps a millennium.

To make matters worse, the EPA ruled in 1984 that the waters were irreversibly damaged and resolved to take no further action to clean them up, he says. They declared that the problem was too big to fix and too expensive to pay for.

"The irreversible damage thing struck me as inappropriate," he says, "not only as a scientist, but as a citizen. I thought, 'we can do something about this. Let's figure out what we can do.' "

So, Nairn began his Tar Creek journey in 1997, accompanied by a talented group of OU undergraduate students.

"They were doing research with me that really generated our original data, the kind of 'getting started' work," Nairn says, "then it just snowballed from there."

Student research projects accumulated over time until Nairn and his lab got to a point when they were ready for a full-scale implementation in 2008 at the Mayer Ranch site between the towns of Miami and Commerce, Okla. Today, Nairn and his team are operating two passive treatment systems—the Mayer Ranch system and a newer one they call the Southeast Commerce system, established in 2017.

OU student Nicholas Shepherd, who is working on a Ph.D. in environmental engineering, was among students who helped build the second system. Born and raised in Miami, Shepherd joined Nairn's research team when he was an OU freshman in 2011. Having spent his childhood around Tar Creek, Shepherd had met Nairn when he was still at Miami High School and decided to attend OU for the opportunity to help with the Tar Creek cleanup.

Only a year away from finishing his doctorate, the 28-year-old says it was great to see the positive impact the Southeast Commerce system has had.

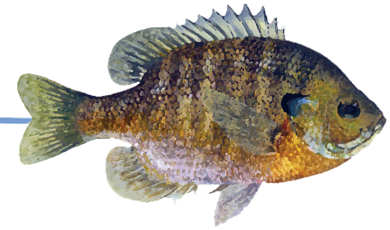
"There is always more work to be done, and we're still figuring out ways to make the system better," Shepherd says.

"Despite all this work, we haven't gotten up to scale to make Tar Creek clean," he says. "It's cleaner, but it's still not clean, and that is a matter of resources. From a technology standpoint, the problem is fixable, but now we're working on getting the resources."

Nairn and Shepherd are pioneering new technology customized for Tar Creek's unique characteristics. Environmental science and engineering are well-traveled paths, but the OU team is taking a different course, the only one that they believe can remediate one of the worst Superfund sites in the country.

In tackling pollution problems, environmental engineers have many great solutions, Nairn says. They can create wastewater treatment plants that are made of steel and concrete and use fossil fuels to run pumps and blowers. These are efficient, but they're also expensive and must be managed. The same type of active treatment technology could be used to clean up waters at Tar Creek, but it would require massive capital investment, energy, labor and a significant operation and maintenance commitment.

Instead, he says, the Tar Creek project's passive treatment systems use natural processes that are physical, chemical, ecological and microbial and can effectively improve water



An aerial view from 2018 shows the passive treatment system Nairn and students designed at the Mayer Ranch. The V-shaped pond receives contaminated water from the underground mines. Above, on left and right, are parallel trains of identical treatment units where the scientists can experiment by changing the flow rate, water depth and level of contamination.

Fish communities have returned to the receiving stream, including warmouth (top left and right), bluegill sunfish (bottom left) and green sunfish (bottom right).

quality at a fraction of the cost. Polluting contaminants include iron, zinc, lead, cadmium, arsenic, sulfate, manganese and nickel. Those elements are not being broken down, Nairn says. They are being sequestered before they get into the creek and into the larger environment, where they can cause problems downstream.

"Within the treatment ponds, we create the right conditions for specific processes to happen. Some of them are oxidative," he says. "Our major workhorses in the system include oxidation ponds, where we make rust. The iron is going to oxidize, hydrolyze and form an oxide that precipitates out as a solid."

With wind and solar power, Nairn runs large fans that aerate the water, which speeds the oxidation process. Meanwhile, they create conditions for indigenous microbes to do their job. That requires sulfate, which is already in the water, and carbon, which they add in the form of mushroom compost acquired from a nearby mushroom farm.

With ingredients in place, the ponds were engineered and designed to maintain enough retention and contact time to allow processes to happen. Through metabolism, these ponds use the carbon and sulfate to produce hydrogen sulfide, which is very reactive with the zinc, cadmium and lead. That forms a solid sulfide mineral that gets retained within a compost matrix. Contaminants are separated from the water, which eventually flows clean into the creek.

"We talk with a lot local folks," Nairn says. "There's an annual nonprofit-led conference up there, and you can get up and talk about the chemistry all day long and everybody's eyes glaze over and they fall asleep. But when you show the fact that fish have recovered in the stream, that's one of the most exciting things, I think, from a public perception perspective.

"We have data from several years that show the fish population had fallen, there were just a couple of species, low numbers. And now that we've cleaned up the water flowing into the stream, we've increased those species numbers by about four times and we've seen big increases in biomass," he says.

So far, the two cleanup projects have cost a little more than \$2 million to design and build, but those were isolated research efforts. A complete system designed and built to clean up water throughout the Superfund site could take \$20 million or more, but Nairn says that is a rough estimate still needing refinement.

Meanwhile, he is continuing to talk with officials about the success of his systems, hoping to attract federal or state funding to support continued development. But progress has been slow and the dynamics are complicated.

"The EPA is well aware of the work that we've been doing," Nairn says. "We've given them tours. We've taken them out there. We've done the dog and pony show, walking them through and explaining how things work. There's no doubt that to effectively treat all the waters, it's going to take some resources."

But for now, the agency is not willing to change its 1984 ruling that the waters were irreversibly damaged, so the talks will continue, he says.

Shepherd says he's been studying Tar Creek and doing school projects on the site since he was a sophomore in high school. If their cleanup efforts receive funding, he hopes to continue working there after he completes his doctorate. Ottawa County is his home.

"When people walk up on the street, they want to know when Tar Creek will be less orange," Shepherd says. "What matters is that the fish are coming back. To the locals, it's all about the fish."

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