Sewer upgrade flushes West Nile virus vector from Atlanta stream

May 21 2014, by Carol Clark

About 50 Emory students, mostly undergraduates, worked in the field to gather data for the stream monitoring project. Credit: Gonzalo Vazquez-Prokopec

Just 10 years ago, a heavy rain in Atlanta could turn Tanyard Creek into a river of raw sewage. "You would sometimes see toilet paper hanging from low branches along its banks," recalls Gonzalo Vazquez-Prokopec, a disease ecologist in Emory's Department of Environmental Sciences.

Few fish or turtles were evident in the stream, which flows alongside expensive Buckhead real estate. But larvae from the Culex quinquefasciatus mosquito, the main vector of West Nile virus in Atlanta, thrived in the polluted waters.

Today, that scene is largely reversed, following the remediation by the city of Atlanta of a combined sewage overflow (CSO) facility connected to Tanyard Creek. A five-year study led by Emory researchers gathered the before-and-after data to prove it.

"This is the first study that shows how the construction of a deep storage tunnel for a CSO system not only improves stream health and water quality but reduces the mosquitoes that spread West Nile virus," Vazquez-Prokopec says.

The journal *Environmental Research* published the study's results, which could help guide interventions for cities across the country dealing with problems of aging sewage systems and burgeoning populations.

"Our data provide evidence for how a particular cost-saving technology can work to significantly reduce both pollution and disease vectors," Vazquez-Prokopec says.

About 50 Emory students, mostly undergraduates, worked in the field to help gather the data for the project. "I now use the research in my 'Urban Ecology and Development Class' to introduce students to the levels of impairment that urban streams can suffer," Vazquez-Prokopec says.

In addition to Vazquez-Prokopec, the study's co-authors include Andrea Lund, Joseph McMillan, Shirin Jabbarzadeh and Uriel Kitron (all from Emory's Department of Environmental Sciences); Rosmarie Kelly from the Georgia Department of Public Health; Daniel Mead from the University of Georgia; and Thomas Burkot from James Cook University

in Australia.

Credit: Gonzalo Vazquez-Prokopec

Cities alter the natural environment in myriad ways, and one of the most obvious is water pollution. Sewage, chemicals and heavy metals wind up in creeks, streams and rivers.

More than a century ago, many cities in the United States combined their sewer lines from buildings with runoff from streets. When populations were smaller and fewer surfaces were paved, the sewage pipes were generally large enough to handle the combined flows, and the systems only rarely overflowed.

Today, however, many of the more than 700 cities across the country using CSO systems are facing an environmental crisis. During periods of heavy rain, the wastewater flows directly into natural waterways after only minimal chlorine treatment and sieving to remove large physical contaminants.

Congress had passed the Clean Water Act in 1972, calling for zero discharge of pollutants into fishable and swimmable waters by 1985. Atlanta was among the many cities that failed to achieve this goal even by the late 1990s. After heavy rains, federal water-quality monitoring stations along the Chattahoochee River have recorded as much as 20,000 colonies per liter of e-coli fecal chloroforms, essentially traces of human feces.

Under the pressure of lawsuits, and enforcement action by the U.S. Environmental Protection Agency, Atlanta began remediation efforts. The city eventually won an extension to 2027 to complete the system upgrades.

In June 2008, when Emory's Department of Environmental Sciences began its water quality study, Tanyard Creek was one of the most polluted streams in the city. "Just one-quarter-inch of rain was enough to initiate a sewage overflow," Vazquez-Prokopec says. "Tanyard Creek was subjected to more than 40 overflows per year, totaling about 150 million gallons of sewage."

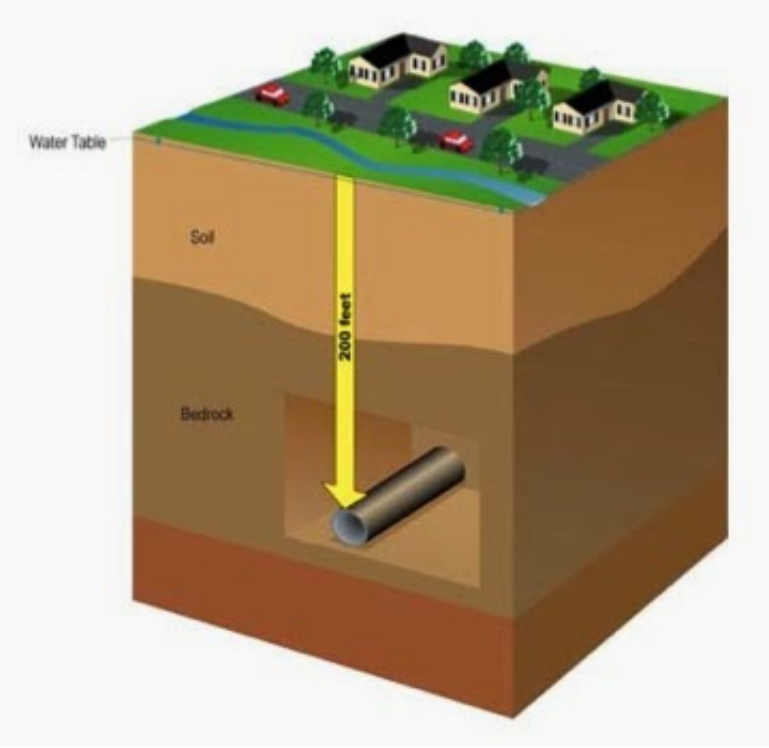
Toilet paper hangs from the underbrush alongside Tanyard Creek, following a heavy rain in 2008. Credit: Gonzalo Vazquez-Prokopec

Chemical analysis of water samples from the creek showed high levels of ammonia, nitrogen and phosphorus. Worms that thrive in this type of pollution were moving about Tanyard's waters, but most of the fish the researchers encountered were dead. "Ammonia, in particular, is food for bacteria and algae, which had overgrown and depleted oxygen levels to the point that fish couldn't breathe," Vazquez-Prokopec explains.

The researchers also recorded the amount and types of mosquito larvae and pupae in the water. Culex mosquitos, which can carry the West Nile virus and transmit it between birds and other animals and humans, were teeming in the polluted waters. Cup-sized Tanyard Creek water samples typically had more than 1,000 Culex larvae and pupae, compared to

almost none in samples from Peavine Creek. (Peavine, which flows through the Emory campus, is a healthy urban stream not subjected to CSOs, and was used as a control in the research.)

A new deep storage tunnel for the CSO facility connected to Tanyard Creek became operational in November of 2008. The tunnel was a less expensive fix than installing larger sewage pipes, and it is able to contain most of the CSOs coming from Midtown Atlanta. A total of 42 sewer discharges were recorded at the facility in 2008, none were recorded in 2009, and only one in 2011 and two in 2012. The total annual volume discharged from the CSO facility was reduced from 154 million gallons in 2008 to six million gallons in 2012.



City of Atlanta graphic of deep storage tunnel

The effects of the remediation effort were dramatic, Vazquez-Prokopec says. "From 2008 to 2009, it was like, 'Boom!'"

The before-and-after data showed the water quality continued to improve through October of 2012 when the study was completed. "The ammonia and nitrate levels were down, and the oxygen levels went from really low to normal," Vazquez-Prokopec says. "We're seeing an urban stream as healthy as an urban stream can be, with wildlife coming back, including turtles, tadpoles, frogs and water snakes. And the main vector of West Nile virus is disappearing."

A cup-sized dip of water from Tanyard Creek that previously contained hundreds of Culex mosquito larvae now may have 10 Culex larvae, Vazquez-Prokopec says.

Atlanta has about 40 different species of mosquitoes, he notes. The Culex is the main species that can carry the West Nile virus in the city, and it happens to prefer polluted waters, making the old CSO system and frequent heavy rains a perfect storm for an outbreak of the disease.

Rapid urban growth means rapid changes throughout an ecosystem, a fact that will increasingly present challenges to public health. "In 2007, the human world population shifted from primarily rural to more urban," Vazquez-Prokopec says. "That's a huge and important milestone in history. We have to understand that our own health is not separate from the health of the environment."

More information: "Long term impacts of combined sewer overflow remediation on water quality and population dynamics of Culex quinquefasciatus, the main urban West Nile virus vector in Atlanta, GA." Lund A, et al. *Environ Res*. 2014 Feb;129:20-6. DOI: 10.1016/j.envres.2013.12.008. Epub 2014 Jan 11.

Provided by Emory University