Application Note, A622
August 2015
By: Trevor Gauron

YSI
a xylem brand

State Promulgates TMDL's Based On Sporadic Grab Sampling

SOUTH CAROLINA, USA

Continuous monitoring provides a more comprehensive view of the state of water quality in a waterbody than traditional grab sampling methods, offering a more reliable understanding of water quality in the Gills Creek watershed located in Columbia, South Carolina, United States. Woolpert Project Manager Trevor Gauron explains the positive changes this new monitoring method brought to the area.

The ability to accurately assess water quality in a watershed is largely dependent on the monitoring programs cities and state agencies implement. While grab sampling can provide a picture of the health of a watershed, it inherently leaves large gaps in the data that can lead to unreliable conclusions.

If grab sampling is like taking a picture, then continuous monitoring is recording an uninterrupted video. Instead of recording the information about a specific moment in time without seeing the larger picture surrounding it, continuous monitoring captures not only the events before and after that moment, but also many more moments that together tell a much broader story, as was the case for the Gills Creek Watershed in the US state of South Carolina.

Located just east of downtown Columbia, the 47,000-acre Gills Creek Watershed starts at the spacious Sesquicentennial State Park and includes approximately 113 kilometers of streams and lakes reaching all the way to Congaree Swamp National Park. As with any large body of water, the watershed plays a vital role in the area's environmental health, both affecting and being affected by the citizens and communities within its boundaries.

Over the course of several years in the early 2000s, the South Carolina Department of Health and Environmental Control (SCDHEC) collected sporadic samples from monitoring stations within the watershed, including one—the C-017 station—on Gills Creek within the City of Columbia's municipal separate storm sewer system (MS4) area. During this time, the SCDHEC recorded violations of dissolved oxygen (DO) levels in 13 percent of the samples at the C-017 station. Based on these recordings, along with levels recorded at a station further upstream and outside of the Columbia MS4 jurisdictional boundary, the state listed the watershed as impaired for DO and issued a total maximum daily load (TMDL) limit.

Knowing the discrete sampling method used by the SCDHEC limited the amount of collected data and reduced the reliability of the results, city officials worked with engineers at Woolpert—a design, geospacial, and infrastructure management engineering firm—to launch a more fully rounded monitoring program. This was done to not only determine whether the levels captured by the SCDHEC painted an accurate picture, but also to better determine the causes of the low DO levels.

The GIL-B Monitoring Station

In February 2013, engineers installed continuous water quality monitoring stations at three locations within the Gills Creek Watershed: the GIL-A station, located upstream of Lake Katherine; the GIL-B station, located between the lake and a wetland; and the GIL-C station, located at the city's

jurisdictional boundary next to the state-run C-017 monitoring station.

Over the course of one year, the in-stream monitoring stations collected a variety of data—including stage, water temperature, turbidity, specific conductivity, pH, and dissolved oxygen levels—with the goal of providing a more accurate representation of the health of the watershed as well as an indication of what might be causing any impairments.

Deeper Understanding of Water Quality

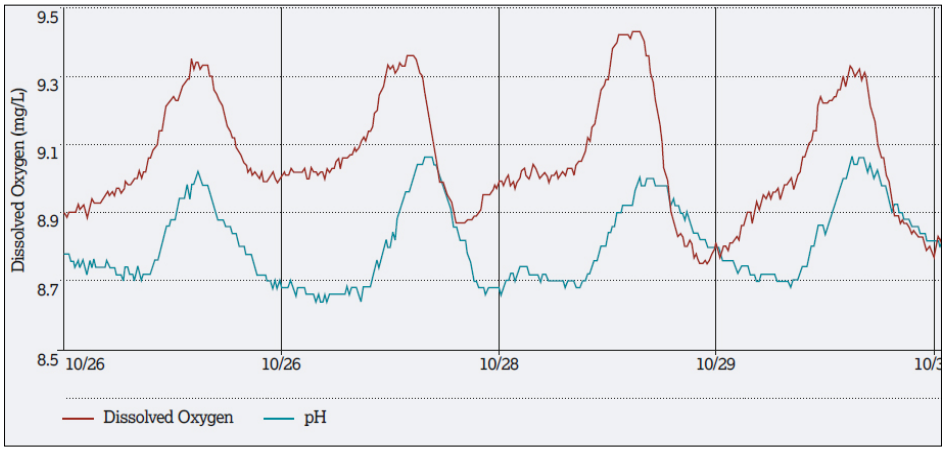
Using datasondes and remote telemetry, continuous monitoring stations provide the ability to respond to events in real time, whether from illicit discharges or severe weather. Monitoring stations can send texts or emails to personnel when an alarm signals an event. The sheer amount of data captured can also better indicate short-and long-term trends associated with ambient, storm event, and seasonal conditions.

In the case of the Gills Creek Watershed, while real-time alerts for events allowed city engineers to more quickly respont to illicit discharges, the real value of the program was in the amount of data recorded at the stations. The SCDHEC collected a relatively small number of grab samples, which were used as the basis for the promulgated TMDL requirements in Gills Creek. The infrequent nature of grab sampling methods often implies a lower degree of accuracy in assessing ambient water quality conditions in a stream, and spurred the following question: Did the number of DO violations recorded at the SCDHEC monitoring station accurately reflect the water quality conditions of Gills Creek?

When the city looked at the data collected over the year-long period at all three of its continuous monitoring stations, they found a much lower percent of violations than the SCDHEC's numbers suggested. Even more importantly, the dataset revealed correlations between the DO levels and other parameters that started to indicate causes for why the DO levels dropped during certain times and at certain locations.

Factor	Description	Degree of Influence
Seasonal Temperature	Water temperature influences the dissolved oxygen saturation level of a water body, with colder water holding more oxygen than warmer water. This manifests as seasonal variations in average DO values.	High. DO values fluctuate seasonally by approximately 4 mg/L in Gills Creek.
Diurnal Solar Radiation Cycle	Photosynthetic biological processes produce oxygen. These processes are dependent upon sunlight. In the afternoon, oxygen production is at a maximum.	Moderate. DO values fluctuate daily on the order of 0.5 mg/L.
Local Weather Conditions	Both the local temperature and cloud cover can impact DO. Higher temperatures can decrease the saturation DO level in the stream, and heavy cloud cover can reduce oxygen production from photosynthesis.	Low. These minor impacts are difficult to separate from other factors.
Surrounding Land Use	Slow-moving, wetland waterways typically have lower dissolved oxygen values. SLow-moving water provides less opportunity for air entrapment, is typically associated with larger amounts of deposited organic matter, and has a longer residence time, allowing for the amplification of inpacts from aerobic digestion.	High. This appears to be a driving factor in water quality, based upon the observed water quality differences between the GIL-B and GIL-C stations.
Illicit Sewage	Sewage waste from both SSO's and Sanitary sewer line leaks can contribute a load of organic matter to the stream which can result in increased aerobic digestion, decreasing DO.	High.
Storm Events	Stormwater can have at times unpredictable impacts on DO. When stormwater transports organic matter to a water body or causes an SSO, the dissolved oxygen in a stream can be negatively impacted.	Moderate.

A color-coded table summarizing factors that influence dissolve oxygen in the Gills Creek Watershed in South Carolina, United States. (Low Medium High)



Diurinal Cycles in Water Quality

Data is Only as Reliable as the Collection Method

Because the SCDHEC collected only 96samples between 2002 and 2006, with 12 samples (just over 13 percent) violating the standard, they determined the need for TMDL. Over the course of the 2013 monitoring year, 30,000 DO measurements were made with the city's continuous monitoring methods, and, in contrast to the SCDHEC data, just two percent of the data from the location downstream of the wetland violated the state standard. The continuous monitoring data collected by the city undoubtedly provides a clearer picture of water quality in Gills Creek.

In addition, the surplus data collected at the monitoring stations explains why

the DO levels fell below the TMDL standard. When engineers investigated a direct correlation between pH and DO measurements, they found DO levels were affected by natural photosynthesis and respiration cycles on a diurnal and seasonal scale.

Additionally, storm events were found to impact DO in the creek, but in an unpredictable manner—with some storm events causing an increase in DO levels and other events causing depressed concentrations. Impacts from sanitary sewage were also suggested by the data; specific conductivity levels were found to increase as water moved downstream from the GIL-A station to the GIL-C station, pointing to the possible addition of substances with high ion concentrations (such as sanitary sewage) between these stations. Finally, the wetlands located between the GIL-B and GIL-C stations appeared to be a strong influencer of DO concentrations, as suggested by changes in turbidity levels and pH between these two stations.

While the GIL-C station, closest to the state-run monitoring station, showed six occurences when the daily average DO concentration fell below five milligrams per liter, the GIL-B station recorded just one occurrence and the GIL-A station remained within the established DO standards throughout the year. Based on this data and the correlation between the changes in specific conductivity and DO, the engineers believe the wetland plays a significant role in the depression of DO in surface waters, with some contribution to these numbers coming from illicit discharges through sewer leaks.

The GIL-C Monitoring Station

Guide for Stormwater Management and Regulation

At this time, the SCDHEC's TMDL is still in place for the city's MS4. The city hopes, however, that continued monitoring over time will help them better understand the cause for the occasional low DO levels and show the impairment in the lower portion of Gills Creek is inappropriate and unnecessary. The monitoring program will also help clarify if any stormwater runoff is a source of these infrequent low DO concentraions.

This program also has implications for watersheds across the world, where grab sampling is still giving communities scattered and partially accurate pictures of their water quality. Following in Columbia's footsteps, these communities could gain a more accurate picture by implementing a similar continuous monitoring program.

Author's Note

Trevor Gauron is the project manager at Woolpert, headquartered in Dayton, Ohio, United States.

The GIL-A Monitoring Station