Division of Science, Research and Environmental Health

Research Project Summary

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Continuous Monitoring For Total Chlorophyll-A and Four Classes of Algae and Analysis of Water Samples For Dissolved Organic Carbon at Passaic River Below Two Bridges, NJ

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Abstract

This project was a joint funding agreement between the NJ Department of Environmental Protection, Division of Science, Research, and Environmental Health; the USGS New Jersey Water Science Center; Passaic Valley Water Commission; North Jersey Water Supply Commission; and Rutgers University. This objective of this study was to test two new field-deployable technologies that together provide nutrient and dissolved organic carbon data along with classification of algae type by correlation to the chlorophyll responses. The BBE AlgaeGuard meter is a highly sensitive, submersible spectrofluorometer with automatic algae classification and chlorophyll analysis. The second sensor platform tested at the monitoring station was an S::SCAN unit. The S::SCAN Spectrolyzer is a miniature ultra-violet/visible light spectrophotometer that estimates the concentration of dissolved organic carbon and nitrate plus nitrite. This study was conducted at the Two Bridges USGS surface water monitoring station located in Wayne Township, Passaic County, NJ. Since two major drinking water purveyors withdraw raw water in the vicinity of this station, the location provides the opportunity to evaluate the ability to accurately measure continuous nitrate+nitrite levels, as well as assess beneficial and harmful algae blooms; two factors that impact the water treatment operations at both facilities. Concentrations of measured real-time data from the BBE and S::SCAN sensors calibrated well to the concentrations of lab-analyzed grab samples.

Introduction

Previous research conducted by the NJ Department of Environmental Protection and the USGS New Jersey Water Science Center has identified the Passaic River basin as one of the most complex watersheds in the state due to the extensive water allocations and discharges. This river system supplies drinking water to the North Jersey District Water Supply Commission (NJDWSC) and Passaic Valley Water Commission (PVWC). In addition, groundwater discharges from three sewer treatment plants are also located in this area and contribute groundwater to the total flow of the rivers. Contributions from a variety of wastewater treatment facilities augment the flow of the river by an estimated 70%. The highly urbanized environment also contributes nutrient runoff that is conducive to algae formation.

Passaic Valley Water Commission's Little Falls drinking water treatment facility has implemented an enhanced coagulation processes (activeflow) to enhance the removal of algae from their influent supply at this facility. North Jersey District Water Supply Commission can select when they pump from the Two Bridges location and has reservoirs that effectively buffer against algae blooms through the use of depth selectable intake structures. Elevated concentrations of diatoms can aid in the filtration process at the water treatment facilities. Other algae classes may complicate the water treatment process by requiring more frequent filter back flushing, by forming objectionable taste and odor compounds that affect the aesthetic quality of the finished drinking water, and forming precursory organic matter that produces undesirable disinfection byproducts.

The objective of this study was to calibrate near-real-time data from the Two Bridges monitoring station for dissolved organic carbon (DOC), nitrate+nitrite, algae class, and chlorophyll analysis by comparing lab analyses of grab samples to real-time measurements from BBE and S::SCAN meters. DOC and nitrate+nitrite are important to monitor because they affect the downstream removal efficiency of precursory material responsible for the formation of regulated disinfection byproducts. Excessive nitrate is very difficult to treat with conventional water treatment processes. In addition, determining the various chlorophyll concentrations provides insight into the types of aquatic organisms that may affect filtration processes at the treatment facility or may cause poor aesthetic quality (taste and odor) of the delivered potable water. Results of the calibrations were applied, where necessary, to adjustments of the sensor estimates for real-time data availability.

Methods

Water-quality sensors installed at the USGS continuous monitoring station at the Passaic River below Pompton River at Two Bridges NJ (USGS Station # 01389005) measured the characteristics of water pumped sequentially from three separate intakes. Looking downstream, the left, middle, and right intakes are approximately 70, 160, and 220 feet, respectively, from the left bank. The location of the USGS monitoring station near the confluence of the Pompton and Upper Passaic Rivers is shown in Figure 1.

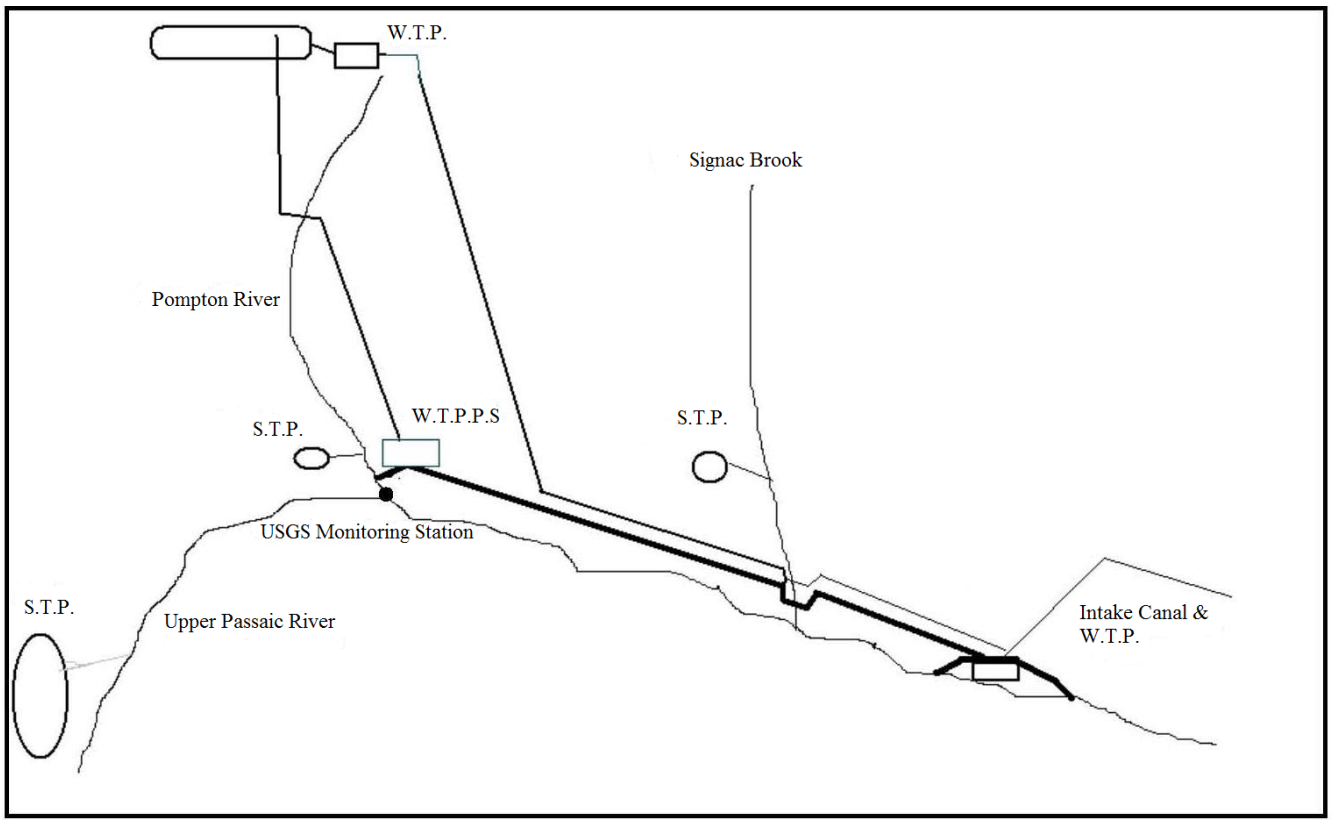

Figure 1. Location of key water supply infrastructure at the confluence of the Pompton and Passaic Rivers. NJDWSC treatment plant (W.T.P) is shown at the top of the illustration. NJDWSC pump station (W.T.P.P.S.) is adjacent to the USGS station. Locations of the sewer treatment plant discharge locations (S.T.P.) are shown as well

A comparison between the grab samples and the real time data for DOC, nitrate+nitrite, chlorophyll-a, and algae class collected from the Passaic and Pompton Rivers intakes were evaluated. This statistical information was incorporated to produce a local calibration of the responses from a submersible spectrofluorometer BBE AlgaeGuard meter and an S::SCAN Spectrolyzer (Gullick and Schorr, 2014).

A highly sensitive submersible spectrofluorometer BBE meter was utilized at this station for automatic algae classification and chlorophyll analysis. It quickly and reliably determines chlorophyll concentration and detects the presence of algae followed by spectral algae classification (i.e. blue-green algae/cyanobacteria, green algae, diatoms/ dinoflagellates/chrysophytae, and cryptophytae). This enables the instrument to analyze the occurrence and distribution of algae on site without the necessity of a grab sample and laboratory analysis. Initial calibration of the BBE AlgaeGuard instrument was completed at the factory using pure algal cultures.

An S::SCAN Spectrolyzer was also installed at the Two Bridges site. The S::CAN Spectrolyzer is a miniature ultra-violet/visible light spectrophotometer with a bandwidth of 2 nanometers (nm) with a microprocessor that deconvolutes the absorption spectra from 220 to 720 nm. Various ultra violet (UV) and visible spectral regions are utilized to determine water quality parameters of interest for this study. The UV wavelength range from 200 to 250 nanometers is utilized to quantify nitrate+nitrite. The UV range from 250 to approximately 375 nanometers quantifies chemical oxygen demand (COD), DOC, various aromatic organic compounds, and the algae classification chlorophyll response region. The visual range from 375 to 750 nanometers identifies color, turbidity, total suspended solids, and total dissolved solids parameters. For further information see Environmental Technology Online, 2011.

The raw data output from each instrument was processed in accordance with the continuous calibration procedures following the methods for real-time water-quality data published in Wagner and others, 2006. Initial validation between the grab samples and nitrate+nitrite, DOC and Chlorophyll-a sensor data was evaluated using this protocol. This information was incorporated to produce a parameter-specific calibration of DOC and Chlorophyll-a sensor response for real-time deployment.

A list of the available real-time water quality parameters at the Two Bridges monitoring station (USGS Station #01389005) are listed in Table 1. Both instruments (BBE and S::SCAN) provide continuous data for each parameter and are currently available online at http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01389005&agency_cd=USGS.

Results

The field sensors proved to accurately represent the in-stream conditions. Where necessary, parameter values were calibrated by applying regression analysis of in-stream sensor measurements to lab-analyzed grab samples. Ongoing calibration of the in-stream sensor values to lab-analyzed data is critical for maximum reliability of the sensor-generated data.

Table 1: List of parameters at Passaic River below Pompton River at Two Bridges NJ (USGS Station Number 01389005).

65	Gage height
10	Temperature, water (from right, middle, and left intake)
95	Specific conductivity at 25°C (from right, middle, and left intake)
300	Dissolved oxygen (from right, middle, and left intake)
301	Dissolved oxygen, percent saturation (from right, middle, and left intake)
400	pH (from right, middle, and left intake)
99133	NO3+NO2, water, insitu (from right intake)
99133	NO3+NO2, water, insitu (from middle intake)
99133	NO3+NO2, water, insitu (from left intake)
99134	DOC, water, insitu, est (from right, middle, and left intake)
32284	Chlorophyll 'a' (from right and left intake)
32285	Green Chlorophyll 'a' (from right and left intake)
32286	Cyanobacteria Chlorophyll 'a' (from right and left intake)
32287	Cryptophytes Chlorophyll 'a' (from right and left intake)
32288	Diatoms Chlorophyll 'a' (from right and left intake)
32289	DCOM (right and left intake)
63680	Turbidity, nephelometric turbidity units, (from right, middle, and left intake)

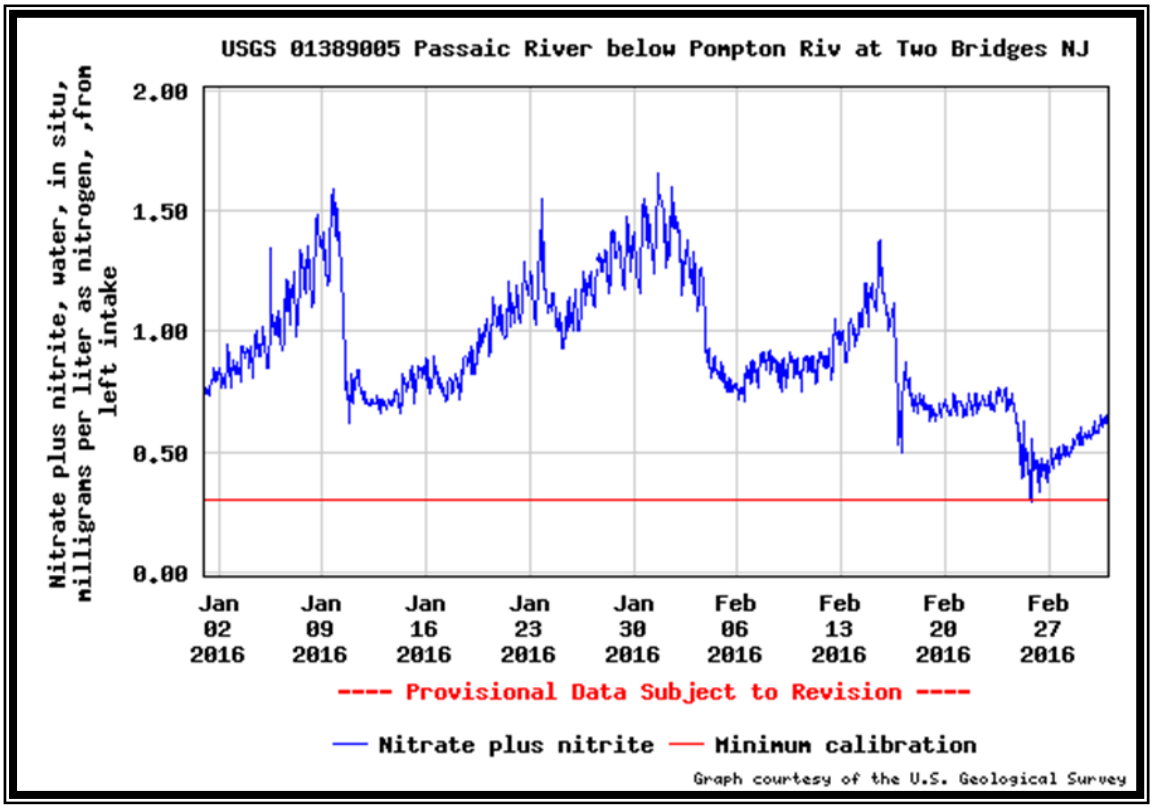

Figure 2. Presentation of continuous nitrate+nitrite data from the left intake at the Two Bridges monitoring station.

Examples of real-time data following validation between the bench scale tests and “raw” sensor data are presented for nitrate+nitrite (NO_3+NO_2) from the left and right intakes, respectively (Figures 2 and 3). Similarly, Figure 4 shows real-time date for chlorophyll-a, diatom, and dinoflagellate sensor data following validation and calibration with regression analysis between the bench scale tests and “raw” sensor data. This data has been continuously available to the public and drinking water purveyors since the system was brought on-line in 2010.

Discussions and Conclusions

The principal investigator and research project participants have a high level of confidence in the calibration and quality of continuous-monitoring data

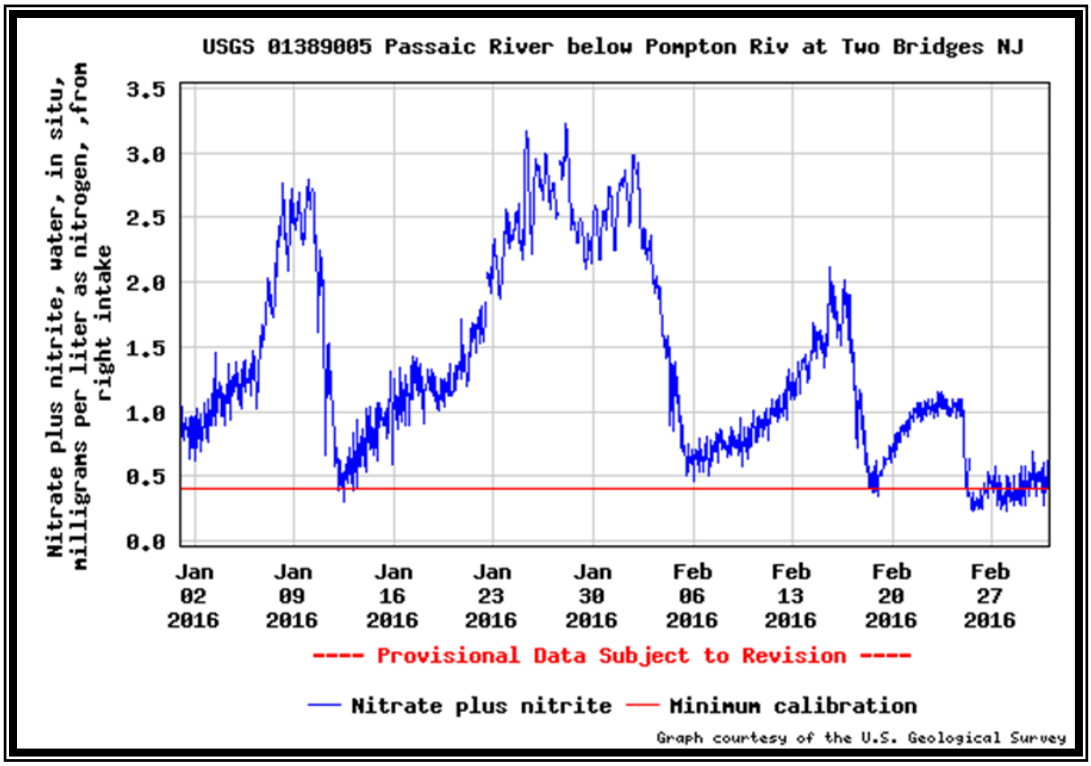

Figure 3. Presentation of continuous nitrate+nitrite data from the right intake at the Two Bridges monitoring station.

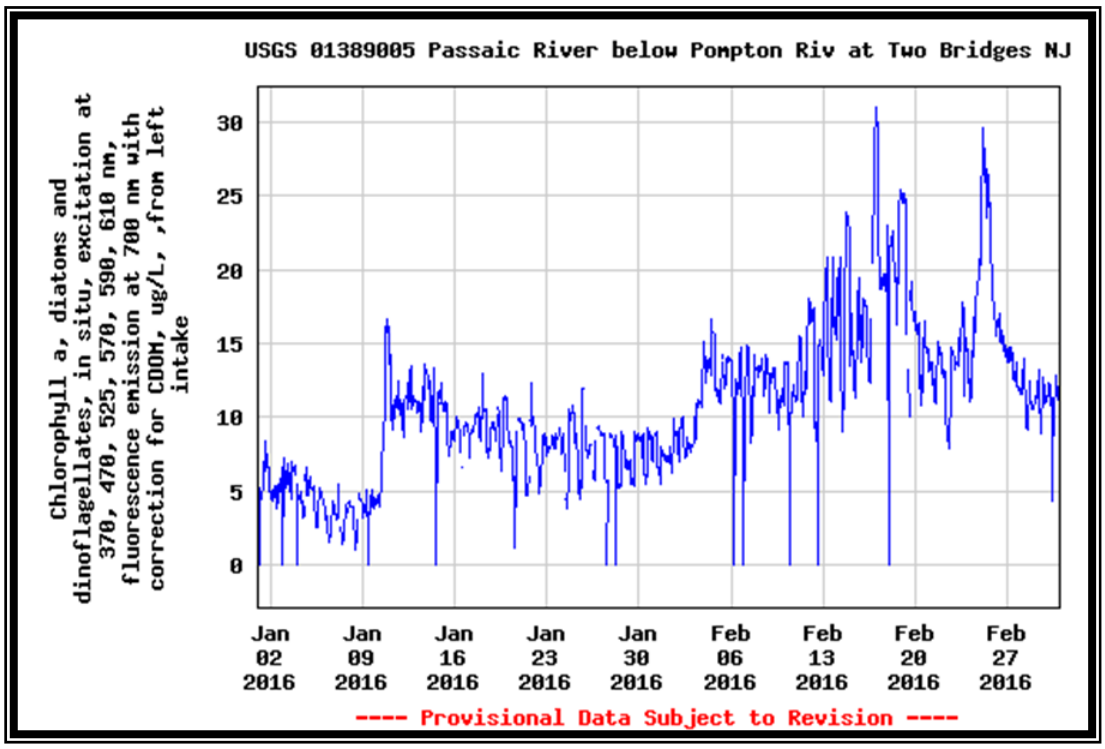

Figure 4. Presentation of continuous chlorophyll-a, diatom, and dinoflagellate sensor data from the left

collected for these parameters. The sensor data met the objectives for USGS real-time data needs and were subsequently made available to the public over the internet beginning in September 2010. The validation of this technology is beneficial because it provides for early warning of potentially disruptive water-quality conditions and allowing for maintenance of successful drinking water plant operations. Results of this investigation have been presented at two national annual meetings of the American Chemical Society (Gullick and Schorr 2014; and Schorr and Lippincott 2014).

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