Water Resources Center
Department of Civil and Environmental Engineering

Annual Technical Report
2019

Products

Project 2019RI231B: Decreasing trihalomethanes In the Providence drinking water system

Goodwill J., Ray, P., Nock, D., and Miller C., "Moving Beyond Resilience and Toward Antifragile Potable Water Systems" Submitted to Environmental Science: Water Research & Technology, January 2021.

Franco, P., Spellman, C., Addison, E., and Goodwill, J., “Measuring and Managing Trihalomethanes with Novel Gas Chromatography and Aeration Approaches” Submitted to: 2021 UCOWR/NIWR Annual Water Resources Conference. (in preparation)

Project 2019RI232B: Providing a new perspective on groundwater hydrometry using thermal infrared sensor equipped unmanned aerial vehicle

Young, K.S.R., & Pradhanang, S. M. 2021 Small Unmanned Aircraft (sUAS)-Deployed Thermal Infrared (TIR) Imaging for Environmental Surveys with Implications in Submarine Groundwater Discharge (SGD): Methods, Challenges, and Novel Opportunities” Remote Sensing (under review)

Young, K. S. R., Pradhanang, S. M., Robinson, R, Boving, T, Kelly, R.P., Kmetz, J. 2021 Shallow Groundwater Discharge Plumes Across Salt ponds using Drone-based Thermal Infrared: Comparison and Regression against SGD flux via Rn222 /RAD7. Remote Sensing and the Environment (in preparation)

Project 2019RI233B: Clean drinking water in Rhode Island

Not applicable, this project funded an outreach activity with high school students.

Information Transfer Program

Project 2019RI231B: Decreasing trihalomethanes In the Providence drinking water system

The uSAS equipped with TIR needed proper training. The main operator of this unit was a licensed pilot in the Pradhanang Lab. The flight manual was created and used by other students and operators. The PIs and students engaged with homeowners of the Salt Pond areas in the Ninigret and Green Hill Pond on drone demonstration and sharing results.

Project 2019RI232B: Providing a new perspective on groundwater hydrometry using thermal infrared sensor equipped unmanned aerial vehicle

The PI had weekly meetings with Providence Water and quarterly meetings with INFICON (the THM analyzer instrument supplier) during the course of this research. The results will be disseminated in a peer reviewed journal article and a regional drinking water community conference (in November 2021).

Project 2019RI233B: Clean drinking water in Rhode Island

Summer day camp for high school students learn concepts with regard to clean water from presentation and hands-on activities. Ten high school students from underrepresented groups in STEM field from the Providence school system participated in the summer camp.

Program administration

Two graduate students were partially supported to aid the Director managing the Center’s activity.

Student Support

Project 2019RI231B: Decreasing trihalomethanes In the Providence drinking water system

This project funded one graduate student and one undergraduate student participate in the research activities. Additionally, five undergraduate students participated on the drone training activities.

Project 2019RI232B: Providing a new perspective on groundwater hydrometry using thermal infrared sensor equipped unmanned aerial vehicle

This grant supported one graduate and one undergraduate student. Additional three graduate students participated in activities related to the project.

Project 2019RI233B: Clean drinking water in Rhode Island

One graduate/undergraduate student during the activity

Program administration

Two graduate students were partially funded to support the Director with administrative activities

Overall supported with annual base (104b) and required matching funds:
Undergraduate: 8
Graduate: 4
Postdoc: 0

Notable Achievements and Awards

Project 2019RI231B: Decreasing trihalomethanes In the Providence drinking water system

Nothing to report

Project 2019RI232B: Providing a new perspective on groundwater hydrometry using thermal infrared sensor equipped unmanned aerial vehicle

The PI has been invited to publish research results as part of the Royal Society of Chemistry's Emerging Investigator Series in Environmental Science: Water Research & Technology

Project 2019RI233B

Nothing to report

Clean Drinking Water In Rhode Island

Project Type: Annual Base Grant
Project ID: 2019RI233B

Project Impact:
This project consisted of a one-week summer camp for ten high school students from the Providence School District. In this activity, the students participate in lectures and hands-on activities related to clean water concepts.

The students' activities involved eight science presentations, four experiments, field trips to water treatment, and a wastewater treatment facility. The concepts explored in the presentations were: the water cycle, the chemistry of water, water quality and treatment, sewage treatment and biological technology, runoff, and stormwater, industrial water pollution, pollution prevention. Laboratory activities included water quality sampling and testing, settling, and filtration experimentation. Fieldwork consisted of collecting samples at the 30 Acre Pond at URI, where students were allowed, with guidance and observation, to enter into the shallow areas of the pond to sample for macro-invertebrate life in the pond. Hunter was in the pond as well at the point where they were not to go beyond, and they did not have to go in the pond. We provided waders, nets, and buckets in the process. The students also were exposed to some simple coding efforts for a morning to look at collected water data from various collection points in Rhode Island. Field trips were taken to the Holton Water Purification Facility at the Scituate Reservoir and the Warwick Advanced Wastewater Treatment Facility, with a final trip to the Boston Science Museum.

The impacts from these activities were numerous. Student were exposed to sampling processes and general data collection. They were asked to write one report of a lab that they did during the first or second day, and they were shown an example of the expectation of a college-level lab report. We hoped that this would impress upon them the importance of performing good lab work and reporting it well being important. With the sampling from the pond, it was important to recognize that the field work would lead to further analysis when brought back to the lab and getting good field collections was important.

We added a session exposing them to MATLAB for using data capture, data entry, analysis, and plotting. We wanted them to have a minor exposure to some level of software that we used for analysis in our College of Engineering, and we gave them a little background in some basics for coding and then allowed them to access data online to use for the overall process.

The visits to various sites such as the Water Treatment facility in Scituate and the Advanced Wastewater Treatment Facilities were important for students to hear about and see the process for delivering clean water to Providence, since all of them lived there and various biology and chemistry related processes involved.

Other important events included a visit from a former an alumnus of the URI Civil Engineering program, Mr. Iziarh Roberts who worked at another water treatment facility in the Providence area, who shared his story of living in Providence and going to URI and then landing a job. An existing student from URI visited with the program the same afternoon to share with the students. He had been a student from a Providence High School, and he was currently studying electrical engineering, but wanted to share with the students about the Water Camp because he had attended a few years previous to that. These interactions were very impactful

as both the URI alumnus and the URI student, were students from underrepresented groups in STEM as were all of the students who participated in the program.

The students were also exposed to the URI Talent Development program, which is a special admissions program for students of color and disadvantaged students from Rhode Island. The impact of this was to allow them to see the space at URI for support and meet a staff person who could potentially be an advisor and answer questions about levels of service offered to students for retention and persistence.

Most of the students were stronger students with at least one student taking AP calculus and most interested in math and science. I think the impact was that they were exposed to one other path in potential science and engineering careers.

Dr. Hunter, from URI, was responsible for most of the presentations and establishing the activities.

Decreasing Trihalomethanes In The Providence Drinking Water System

Project Type: Annual Base Grant
Project ID: 2019RI231B

Project Impact:
The aim of the project was to (1) monitor THM concentrations at a site for Providence Water, (2) to create trends and correlations between THM concentrations and temperature, day of the week, etc., and (3) evaluate the effectiveness of an aeration-stripping process for THM mitigation.

Total trihalomethane (TTHM) concentrations were measured for Providence Water at 265 Ridge Road in Smithfield, Rhode Island (Figure 1). This site was of particular interest because of the regularly high concentrations of THMs that occur at this location. THM concentrations are generally high due to the long hydraulic residence time (6-12 days) between the clear well at Providence Water and the storage tank at Ridge Road. The long residence time is due to the distance in which the water must travel (approximately 9.5 miles).

Raw and effluent water quality characteristics entering and leaving the Providence Water treatment facility from 2010 to present day were generously provided by Providence Water. Water quality characteristics included pH, temperature, free chlorine, UV254, total organic carbon (TOC), color, chloroform, DCBM, DBCM, bromoform, and TTHMs. Effluent water quality characteristics at the Ridge Road site were also provided. The water quality parameters monitored were pH, temperature, total alkalinity, color, chlorides, iron, fluoride, free residual chlorine, turbidity, chloroform, DCBM, DBCM, bromoform, and TTHMs.

Total trihalomethane concentrations at Ridge Road were measured using two different instruments utilizing two different techniques, in order to ensure accurate measurements. Monitoring of THM concentrations began in November 2019.
Trihalomethane concentrations were continuously monitored on an hourly basis at Ridge Road using a gas chromatograph with a micro argon ionization detector (MAID) (CMS5000, INFICON). Effluent water at Ridge Road constantly flowed through the detector at approximately 1 L/min to allow for hourly measurements. Data was collected from the instrument on a bi-weekly basis.

Providing A New Perspective On Groundwater Hydrometry Using Thermal Infrared Sensor Equipped Unmanned Aerial Vehicle

Project Type: Annual Base Grant
Project ID: 2019RI232B

Project Impact:
Shallow groundwater discharge (SGD) exhibits high spatial variability, and the empirical and modeling methods commonly used to assess SGD at regional scales are unable to adequately quantify this variability. Additionally, the temporal variability of SGD and its environmental controls are poorly constrained. Use of thermal infrared (TIR) imaging can detect and quantify SGD surface plumes at high spatial and temporal resolutions. Terrestrial-derived fresh SGD is fresher, and therefore of lower density, than the saline or brackish estuarian background waters. Additionally, groundwater is well-insulated from seasonal temperature variations and therefore fresh SGD retains a relatively constant year-round temperature. Consequently, if the total SGD flux into the estuary comprises ample terrestrial fresh SGD component, the SGD will buoy to the surface of the estuary where its thermal signature can be detected by airborne TIR imaging.

When deployed from small Unmanned Aircraft Systems (sUAS) TIR can provide continuous coverage of large areas at low operating expense, offering a cost-effective means of conducting high resolution, regional-scale assessments of SGD. sUAS-TIR also enables geostationary time series assessments of SGD TIR plumes, otherwise impractical using manned aircraft. The unique capabilities of sUAS-TIR can therefore facilitate novel studies into the spatial and temporal characteristics of SGD, and their environmental controls.

This study employed sUAS-TIR to conduct surveys of the northern shore of two coastal estuaries in southern Rhode Island – Ninigret and Green Hill Ponds – in order to identify estuarian SGD TIR plumes and assess their spatial and temporal variability. In doing so, this study helped improve our understanding of estuarian SGD fluxes, sources, and their environmental controls and in future will also advance sUAS-TIR technology and science applications.