

**Water Resources Research Institute of the University of North Carolina  
North Carolina State University**

**Annual Technical Report  
2019**

## General Information:

### Introduction:

During 2019-20 (Fiscal Year 2019), the NC Water Resources Research Institute (WRI) continued a program of excellence for fostering research, training and information dissemination efforts that are responsive to the water problems of the state and region. To develop its programs, the Institute maintains a proactive effort to interact and communicate with federal, state, and local water managers and other relevant stakeholders.

WRI interacts closely with state agencies such as the NC Department of Environmental Quality, water and power utilities, and an array of research and outreach programs within the UNC system and at private higher educational institutions across North Carolina. The Institute utilizes an advisory committee that provides input, guidance, and review of the research priorities that are used in developing our Requests for Proposals (RFPs) and directing other institute activities.

WRI leverages USGS funds with a variety of sources including state funds received through the UNC System and NC State University, our two Consortiums (the Urban Water Consortium and the Stormwater Consortium), and extramural grants received by Institute staff.

This report provides details on the three research projects supported by 104b funds as noted below as well as the Institute's Information Transfer activities.

- Improving Performance And Examining Expansion Of Constructed Wetlands For Tertiary Treatment Of Nitrogen From Domestic And Municipal Wastewater, PI Mike Burchell, NCSU.
- Hidden Sediment Sources: Locating And Studying Road-draining Gullies Using A Geospatial Model And Field Measurements, PI Diane Styers, Western Carolina University
- Occurrence Of Pesticides In North Carolina Private Drinking Water Wells And
- Identification Of Point-of-use Treatment Options, PI Detlaf Knappe, NCSU.

### 1) Products

The following products were reported to WRI during FY19.

Aziz, Tarek N.; Obenour, Daniel R. *Predicting the Effectiveness of Artificial Mixing for Controlling Algal Blooms in Piedmont Reservoirs*. Final report submitted June 2019 to WRI for funded project 2016-0466.

Burchell, M.R. and Hunt, W.F. *Natural and constructed wetlands in North Carolina: An overview for citizens*. North Carolina Cooperative Extension Publication AG-856. 9 pp.

Di Giulio, Richard T.; Lindberg, Casey D.. *The Impacts of Multiple Environmental Stressors on Fish Populations Native to Estuaries along the Eastern Shore of the United States*. Final report submitted March 2019 to WRI for funded project 2016-0454-05.

Ducoste, Joel J.; Pour-Ghaz, Mohammad; Kusum, Samrin Ahmed. *Evaluation of Alternative Binder Material to Reduce Sewer Collection System Infrastructure Maintenance and Enhance Sustainability*. Final report submitted July 2019 to WRI for funded project 2016-0453.

Keen, Olya; Munir, Mariya; Meyer, Michael; Brown, Xueying; Park, Sol; Zagade, Minal; House, Brittany. *The Role of Environmental Buffers in Potable Water Reuse*. Final report submitted April 2019 to WRI for funded project 2017-0356-01.

Kurki-Fox, Jack; Burchell, Michael R. II. *Field testing of mesocosm-scale derived nitrate removal models to verify water quality improvement potential of restored coastal forested wetlands and Enhanced monitoring to assess the nitrogen dynamics of a wastewater treatment wetland*. Final report submitted April 2019 to WRI for funded project 2017-0757.

Maxwell, Bryan; Winter, Dani; Birgand, François. *Quantifying Treatment Potential of Floating Treatment Wetlands to Benefit North Carolina Waters Using Improved Methodology and Novel Technology*. Final report submitted May 2019 to WRI for funded project 2016-2372.

Schnetzer, Astrid. *Cyanobacteria Blooms in North Carolina Lakes and Reservoirs: Examining Drivers of Bloom Patterns and Testing for Cyanotoxin Presence*. Final report submitted December 2019 to WRI for funded project 2017-0358.

Stillwell, Charles; Hunt, William F. III. Stormwater Management in nutrient-sensitive water supply watersheds: A case study at the Life Time Athletic facility in Raleigh, North Carolina. Final report submitted March 2019 to WRI for funded project 2015-3063.

Sun, Mei; Pulikkal, Vivek Francis. *Electrochemical Mineralization of Perfluorooctanoic Acid*. Final report submitted August 2019 to WRI for funded project 2016-0454-06 & 2016-1887-11.

Wang, Ling; Hossen, Elvin; Aziz, Tarek; Ducoste, Joel; de los Reyes, Francis. *Increased loading stress leads to convergence of microbial communities and high methane yields in adapted anaerobic co-digesters*. *Water Research*, 169 (2020) 115155.

<https://unctv.pbslearningmedia.org/resource/watershed-wisdom/lesson-plan-unc-tv-science/>

Wake Green Schools Partnership, Teaching Students Outdoors fact sheet and starter resources at <https://sites.google.com/wcpss.net/wakegreenschools/>

## 2) Information Transfer Program:

WRI has four main arms of the information transfer programs. The first is focused on disseminating results of sponsored research and providing information on emerging water issues, solutions, and regulations. Results of research are disseminated by publication of technical completion reports, peer reviewed manuscripts, summary articles and blogs on the WRI website, and presentations by investigators at the WRI Annual Conference and individual group meetings. The list of publications is noted in the above section. The second arm is the WRI Annual Conference. This signature event is hosted annual in Raleigh NC, brings together state-federal agencies, counties and municipalities, students and faculty, consulting and engineering firms, and professional organizations for multiple days of water-themed sessions. The third is based on extension activities conducted and coordinated by WRI staff. The fourth is our engagement with our two Consortiums. Each of these arms is described in detail below. A full list of information transfer activities is included in Table 1 (see below).

Annual Conference:

WRI's signature training and outreach event, the WRI Annual Conference, was all prepared for its 22nd hosting in March 2020. However, due to the Covid Pandemic, the classic in-person conference had to be cancelled. Rather than lose all the preparation and great talks, WRI pivoted portions of the conference into three online virtual forums. These forums were hosted in April, May, and June 2020. Similar to the in-person annual conference, these crossed multiple sectors, including academia, private consulting, local, state and federal government, non-profits and many others, and touched on the wide variety of disciplines surrounding water resources.

Extension activities:

Community leadership and participation in watershed efforts are critical to protecting waters, and WRI partners with groups across NC to provide services and support for these efforts. WRI's Sustainable Waters and Communities Coordinator continues to coordinate the North Carolina Watershed Stewardship Network (WSN) and manage community watershed restoration efforts funded and supplemented by EPA 319 grants, foundation grants, and cost-sharing contributed by partnering organizations. This includes the following initiatives: the Black Creek Watershed Association; the Walnut Creek Wetland Community Partnership and associated Parks with Purpose

Community Task Force in southeast Raleigh, the Coastal Landscaping Initiative, and a newly formed effort, the Wake Green Schools Partnership. These projects involve engaging local municipal, community-based and national non-profits in education, watershed planning, and community development. An additional \$63,770 of external grants were received during FY2019 to support watershed stewardship activities. At the end of the year, a NCWSN team released the Watershed Wisdom Lesson Plan on PBS Learning Media.

WRRRI continued to partner with the North Carolina Water Resources Association (NCWRA) to host community forums and webinars. The NCWRA is the North Carolina state section of the American Water Resources Association (AWRA) and has been a non-profit organization for over 30 years. NCWRA serves the water resources community in North Carolina by fostering the exchange of ideas and approaches from research to policy to practice. The WRRRI and NCWRA partnership collaborated to host three well-attended forums and webinars in FY19. Speakers presented information on the effects of climate change and resulting catastrophic storm events our state is facing, new methods of stream restoration geared toward urban environments, and improving storm assessment and response in coastal NC.

Other key extension information transfer highlights for WRRRI include the annual Local Programs Erosion and Sedimentation Control Workshop. This workshop, hosted in partnership with the NC Division of Energy, Mineral, and Land Resources and the Sedimentation Control Commission, provides an opportunity for staff of local governments that have been approved by the NC Sedimentation Control Commission to administer the NC Sedimentation Pollution Control Act to receive training on erosion and sedimentation control and enforcement issues. Similar to the annual conference, this workshop was all scheduled to occur in April 2020, and then had to be cancelled due to the Covid pandemic. It was too late to convert this workshop into an online activity, but the workshop is already on the books as an online activity for April 2021.

| <b>Event Date</b>                                | <b>Event Title</b>  | <b>Location</b> | <b>Adult Participants</b> | <b>Youth Participants</b> | <b>Event Description</b>  |
|--|---|-----------------|---------------------------|---------------------------|---|
| 6/23/2019  | Stream Monitoring methods for community scientists workshop   | Swannanoa       | 12                        |                           | Training workshop in partnership with NC Aquatic Data Hub partners  |
| 7/16/2019  | Wake Green Schools Environmental Literacy planning  | Cary, NC        | 10                        | 1                         | New partnership kick-off to enhance environmental literacy efforts in Wake County School District. (then met monthly- not reporting every meeting here)   |
| 7/24/2019  | NC Watershed Stewardship Network meeting  | Raleigh         | 25                        |                           | Watershed professionals gathered to share efforts.  |
| 8/19/2019<br>10/7/2019<br>12/2/2019<br>1/27/2020 | Parks with Purpose Community Task Force meetings (4), a Walnut Creek Wetland Community Partnership subcommittee | Raleigh         | 25                        | 2                         | Facilitated community task force meetings to identify a space and ideas for providing nature park and green stormwater infrastructure amenities accessible to majority African American subdivisions along Walnut Creek |

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|---------------|--|---|-----|----|--|
| 9/7/2019      | Meet the Bailey Drive Greenspace event   | Raleigh   | 28  | 22 | Environmental education event held to activate a space selected for new nature park and GSI facilities.  |
| 9/23/2019     | NCWRA Forum & Webinar: "So, It Rained Two Feet, Now What?"   | Raleigh, NC   | 115 |    | Hurricane Florence and her predecessors have brought into question the size of storms for which we should be designing. Is the status quo sufficient or should we rethink the location and types of development in the face of what might be the "new" normal for rainfall?      |
| 9/24/2019     | SciREN Triangle Educator Open House  | Raleigh   | 50  |    | Shared soon to be completed Watershed Wisdom lesson plan with educators.   |
| 10/5/2019     | Big Sweep for Black Creek  | Cary, NC  | 8   |    | Volunteer stream clean-up  |
| 10/14-15/2019 | Demonstration of Watershed Wisdom lesson plan activities with 4 <sup>th</sup> graders                    | Raleigh   | 1   | 41 | A science teacher was filmed demonstrating two watershed lessons with 4 <sup>th</sup> grade students.  |
| 10/28/2019    | Community canvassing*  | Rochester Heights & Biltmore Hills neighborhoods, Raleigh | 430 |    | Parks with Purpose team provided fliers about project and upcoming event   |
| 11/9/2019     | Parks with Purpose Community Design meeting  | Raleigh   | 20  |    | Community feedback event for designing new nature park facilities.   |
| 11/13/2019    | Advancing Water Loss Control & Improving System Viability: A Summit for North Carolina's Water Utilities | Greensboro, NC  | 50  |    | This program was hosted by the North Carolina Division of Water Infrastructure (DWI), in partnership with the NC WRI and Cavanaugh & Associates. The program provided water loss technical assistance utilizing the AWWA M36 Methodology to 10 rural utilities across the state. |
| 11/15/2019    | NC Science Teachers Association  | Charlotte   | 50  |    | UNC-TV partners presented Watershed Wisdom fliers to teachers in advance of lesson plan release.   |

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| 11/19/2019 | Presentation on Watershed Wisdom  | Wilmington        | 30  |    | At NC Coastal Conference   |
| 12/2/2019  | NCWRA Forum & Webinar: "Guiding Stream Management Using Biological Potential"                         | Raleigh, NC       | 63  |    | This forum focused on the theory and application behind the concept of biological potential, to define interim targets for the adaptive management of urban stream protection and recovery using existing biological assessment tools, and implications for policy.            |
| 12/13/2019 | Presentation on One Water to Wake Water Partnership   | Raleigh, NC       | 20  |    | Walnut Creek Watershed efforts shared with county-appointed board.   |
| 1/18/2020  | Black Creek Greenway invasive plant removal   | Cary              | 5   | 4  | Volunteer event to remove invasive plants along creek.   |
| 2/3/2020   | NCWRA Forum & Webinar: "Storm Events and the North Carolina Coast: Improving Assessment and Response" | Raleigh, NC       | 62  |    | This forum focused on novel storm events (including extreme events such as hurricanes) data collection approaches and the need for quantitative data for microbial and chemical contaminants in order to make positive improvements in coastal water quality in North Carolina |
| 2/19/2020  | Career week presentation  | Raleigh           |     | 80 | Talk about water career with kindergarteners.  |
| 2/27/2020  | SciREN Coast Educator Open House  | Pine Knoll Shores | 60  |    | Shared Watershed Wisdom lesson plan with educators.  |
| 3/5/2020   | Triangle Water Collaborative Presentation   | Durham            | 14  |    | Talked about GSI in schools with municipal staff and officials   |
| 3/9/2020   | Wake Green Schools Event  | Apex              | 170 | 20 | Presentations and networking between teachers and community partners about schools sustainability.   |
| 4/20/2020  | NC Museum of Natural Sciences Science Café  | Virtual           | 48  |    | Landscaping with Nature presentation   |
| 4/23/2020  | Annual Conference Virtual Session 1   | Virtual           | 220 |    | Wastewater Treatment Along North Carolina's Changing Coast   |
| 5/1/2020   | Walnut Creek Partnership  | Raleigh           | 50  |    | Sent face masks made by local Black-owned  |

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|------------|---|---------|-----|--|---|
|            | Newsletter and face mask mailing                        |         |     |  | business and newsletters to community members.  |
| 5/19/2020  | Annual Conference Virtual Session 2                     | Virtual | 281 |  | Wetlands Research in North Carolina   |
| 6/15/2020  | Wake Green Schools meeting                              | Virtual | 37  |  | Updates and discussions about environmental literacy during Covid with educators.   |
| 6/19/2020  | Annual Conference Virtual Session 3                     | Virtual | 241 |  | Awareness, Action and Engagement Around Water   |
| 7/14/2020  | Clean Water Education Partnership presentation          | Virtual | 36  |  | Presentation to local governments on green schools efforts.   |
| 9/24/2020  | SciREN Triangle Educator Open House                     | Raleigh | 50  |  | Shared soon to be completed Watershed Wisdom lesson plan with educators.  |
| 9/20/2020  | Presentation to Brunswick Co Master Gardeners           | Virtual | 25  |  | Nature-friendly landscaping talk.   |
| 9/21/2020  | NC Watershed Stewardship Network meeting                | Virtual | 35  |  | Watershed group presentations and discussions.  |
| 11/9/20    | Parks with Purpose Community Design meeting             | Raleigh | 20  |  | Community feedback event for designing new nature park facilities.  |
| 11/13/2020 | Conservation workforce training                         | Raleigh | 12  |  | Provided training on watershed science and stormwater mgt to participants. Partners provided career skills, environmental justice, and natural vegetation mgt training. |
| 11/16/2020 | Walnut Creek Wetland Community Partnership meeting      | Virtual | 28  |  | Partner updates and networking meeting.   |
| 12/18/2020 | Parks with Purpose ACE conservation crew work (4 weeks) | Raleigh | 11  |  | Conservation crew removed 4 truckloads of invasive plants and planted 3,000 native plants in Walnut Creek wetlands.   |

#### NC Urban Water Consortium

WRRI administers the NC Urban Water Consortium (UWC) and meets with the members quarterly. The consortium was established in 1985 by the Institute, in cooperation with several of North Carolina's larger cities to provide a

program of research and development, and technology transfer on water problems that urban areas share. Through this partnership, WRRI and the State of North Carolina help individual facilities and regions solve problems related to local environmental or regulatory circumstances. Participants support the program through annual dues and enhancement funds and guide the program through representation on an advisory board, selection of research topics, participation in design of requests for proposals, and review of proposals. There are 12 member cities/special districts in North Carolina, and members hosted six quarterly meetings throughout the state during the reporting cycle. Through these activities, this group is able to jointly fund research projects to address drinking and wastewater needs across the state at the same time, advise each other on new issues the utilities must deal with and best practices to adhere to the legal conditions of their various permits.

#### NC Stormwater Consortium

In 1998, several members of the NC UWC partnership formed a special group to sponsor research and technology transfer on issues related to urban stormwater and management. Subsequently this group has formed their own Consortium, administered by WRRI, to continue their focus on stormwater management. Participants support the program through annual dues and enhancement funds. They guide the program through selective representation on the WRRI advisory board, determining stormwater-related research priorities, participation in the design of requests for proposals and review of proposals submitted to WRRI directly or to the SWC. Six meetings were hosted by rotating SWC members throughout the state and virtually during the reporting cycle. Through these activities, this group is able to jointly fund research projects to address stormwater needs across the state at the same time, advise each other on new issues the utilities must deal with and best practices to adhere to the legal conditions of their various permits.

### **3) Student Support**

Through the WRRI projects supported by only USGS funds in FY19, 7 students were supported. These include 4 undergraduate students, 2 graduate students (both Ph.D.), and one post-doctoral trainee. Not captured in this tally are the students that received training through our information transfer activities - see above.

### **4) Notable Achievements and Awards:**

The following achievements and awards occurred during the reporting period

- PhD student on 18-09-W submitted a successful student award proposal that was later funded with NC WRRI funds.
- PhD student on 18-07 obtained full time employment at engineering consulting firm.
- Undergraduate student on 18-07 obtained full time employment at renewable energy firm.
- Former WRRI fundee, Yara Yingling, professor of materials science and engineering and undergraduate program director in the College of Engineering, NCSU, received the NCSU Alumni Association Outstanding Research Award in 2020.

# Improving Performance And Examining Expansion Of Constructed Wetlands For Tertiary Treatment Of Nitrogen From Domestic And Municipal Wastewater

**Project Type:** Annual Base Grant

**Project ID:** 2019NC195B

## **Project Impact:**

This research was aimed at improving existing and future constructed wetlands used in tertiary wastewater treatment in N.C. In WRRRI project #18-07-W, our continuous flow, water quality monitoring, and hydraulic tracer tests in two research treatment wetland cells in Walnut Cove, N.C. revealed nutrient treatment limitations due to 1) 25 years of wetland plant detrital build-up and 2) lack of nitrification pre-treatment of wastewater. Funds from a NCSG Community Collaborative Research Grant were used to remove the detritus from one of the 2-acre wetland cells. Data collection and analysis is ongoing but results appear promising. Tracer studies confirm that hydraulic retention time within the wetland doubled. Water quality monitoring was suspended by University order due to COVID-19 March 2020 – August 2020. The flow and water quality monitoring data we were able to collect through December 2020 did show enhanced treatment of NH<sub>4</sub>-N in the rejuvenated wetland cell. Although overall influent NH<sub>4</sub>-N concentrations were relatively low (6 mg/L), effluent from the rejuvenated wetland cell 1 was on average 2 mg/L less than wetland cell 2, and removed 5x more NH<sub>4</sub>-N load during the period of data collection. However, since valuable data was missed during the more biologically active summer season of 2020, water quality effects are not completely understood. However, the Town has reported NH<sub>4</sub>-N values far below their permit during this period and are pleased with the results. We continue to use our experience to help other small facilities in NC improve their constructed wetlands.

# Hidden Sediment Sources: Locating And Studying Road-draining Gullies Using A Geospatial Model And Field Measurements

**Project Type:** Annual Base Grant

**Project ID:** 2019NC196B

## **Project Impact:**

The purpose of our study is to 1) develop a method to remotely detect gullies created by road runoff in steep, forested areas, and 2) provide open-access on-line maps of verified roaddraining gullies through an interactive web portal. Though drainage gullies are excluded from jurisdiction of the Clean Water Act, they potentially contribute a large amount of sediment to streams of western North Carolina. Using a high-resolution DEM derived from recently released 1 m LiDAR data, we created a data set for Jackson County comparing road-side gully sites and non-gully sites. Initially, gullies were remotely, visually identified using a DEM map. Field work was used to verify remotely identified gullies and collect data on traits of gullies and local topography. Overall, there is one road-side gully per 10.3 km of paved road. To develop an automated model, multiple landscape indices were extracted from the 67 field verified gully points and 100 randomly generated points within the same area. We then developed a model using multivariate logistic regression to predict the probability that any given cell in the DEM was a gully. The model was successful in that it identified all known gullies, but did overpredict road-side gullies. Improved pre- or post-processing of data would help improve the models practicality. To disseminate our findings to land managers and citizens, we have built user-friendly draft version of an interactive story map on ArcGIS Online; it shows gully, stream, and road locations with clickable access to site traits of all gullies.

# Occurrence Of Pesticides In North Carolina Private Drinking Water Wells And Identification Of Point-of-use Treatment Options

**Project Type:** Annual Base Grant

**Project ID:** 2019NC197B

## **Project Impact:**

The overarching objective of this study is to assess the quality of private well water in North Carolina. We developed a new analytical method using high-resolution mass spectrometry for the identification of pesticides, which enables us to perform non-targeted analysis and more comprehensively assess well water quality. Samples from 78 wells in three counties were analyzed using both the developed non-targeted method as well as additional methods to determine the occurrence of volatile organic contaminants, metals, anions, and total/fecal coliforms. In 14 of the 80 wells at least one analyte was identified above maximum contaminant level (MCL) goals, primary MCLs, secondary MCLs, and/or action levels. Lead and copper were the two analytes most commonly found above their action levels. Following a 5-minute flush, lead and copper levels decreased by an average of 67% and 73%, respectively. Currently, reports containing private well water quality results are being developed using Silent Spring Institute's Digital Exposure Report-Back Interface (DERBI). These reports will contain participants' individualized water quality information and comparisons to the results of other identified wells included in our study. Each report will also contain background information on each group of contaminants, an explanation of how the group of contaminants may have ended up in their well, and recommendations to reduce exposure to each group of contaminants. We are hosting a Stakeholder meeting in February 2021 to obtain feedback on the reports. Reports will then be finalized and shared with study participants.