

**South Carolina Water Resources Center
Annual Technical Report
FY 2017**

Introduction

The South Carolina Water Resources Center (WRC) is South Carolina's representative to the National Institutes for Water Resources (NIWR) and serves as a liaison between the U.S. Geological Survey, the university community and the water resources constituencies of those institutions. This is accomplished by serving as a water resources information outlet through the WRC website, serving as a research facilitator through an annual grants competition, and by operating as a catalyst for research and educational projects and programs across South Carolina. WRC also serves as a conduit for information necessary in the resource management decision-making arena, as well as the water policy arena of the state. A critical component of the conduit is the S.C. Water Resources Conference held every two years and managed by Clemson Public Service and Agriculture through the S.C. Water Resources Center.

To fulfill the need for continuous assessment of South Carolina's water resource capacities, Clemson University has proposed to the SC General Assembly the creation of a comprehensive science-based water resources program. Clemson University's goal is to create a comprehensive science-based Water Resources Program to continuously assess South Carolina's capacity to provide water with regard to demand and availability. The program will support the assessment procedures and management guidelines outlined in the South Carolina Water Plan and will provide an objective source of data for projecting future needs, capacity, and impacts to continue the ongoing efforts of implementing a 'comprehensive' statewide water management plan. The new Water Resources Program will be based in Clemson University's South Carolina Water Resources Center which is housed in a 34,200 square foot facility offering spacious office, meeting and laboratory space.

Clemson University is ideally positioned to lead effort statewide water resources assessment effort. As a land-grant institution, it is the University's mission to solve problems associated with natural resources through research, education, and extension. Clemson Public Service and Agriculture (PSA) has an array of statewide programs that address a wide-range of agriculture and natural resource issues including water resources for agriculture, forested watershed management, and numerous other water-related natural resource topics.

Creating a complete and integrated water resources program Clemson University has already committed major capital and personnel investment to understanding and conserving the state's water resources. While existing University water programs and research infrastructure address many aspects of the state's water resources, this proposal seeks the funding necessary to secure the additional expertise and program support to unify the individual programs into a complete and integrated Water Resources Program. The creation of this premier Program will establish South Carolina as a national leader in science-based water resources management. The resulting research and resources will guide the efforts of state and federal agency collaborators to implement sound water-based policy making for the benefit of the state and region.

Water Resources Resiliency: The S.C. Water Resources Center will unite existing successful water-based programming and research efforts with faculty support and need-based hires. By way of this strategy, and with feedback from engaged statewide stakeholders, expertise will be sought in agricultural water use, water quality and treatment, crop production, soil science and hydrogeology, water and soil informatics, biofuels (including Algal-Based Biofuels) production, decision support systems and systems modeling, resource management, policy and economics, sustainability and life cycle assessment and public perception and acceptance of water use and policy.

Integrated Watershed Management Assistance to South Carolina Communities: Water touches every natural resources management, engineering, and agriculture systems management concern, research effort, and outreach mechanism. The proposed program will connect research with applied instruction and assistance to

more proactively meet stakeholder needs. Water pollution prevention outreach, typically conducted in the state's more urban centers, will be expanded to include a 'whole systems' approach - increasing the number of programs and instructional resources for better management decision making and implementation of water-protective best management practices. Due to water's crosscutting nature, these programs will provide interdisciplinary training to all natural resources and 4-H Extension program teams. Strategic placement of Clemson Extension agents to engage agricultural sectors in water reuse, water management, pollution prevention, and ecosystem services in a changing climate will unite downstream urban educators for comprehensive, basin-driven programming.

The biennial South Carolina Water Resources Conference (SCWRC) is sponsored by Clemson University Public Service and Agriculture (PSA) and coordinated by the SC Water Resources Center staff, in conjunction with a planning committee made up of statewide water resource professionals. The conference purpose is to provide an integrated forum for discussion of water policies, research projects and water management in order to prepare for and meet the growing challenge of providing water resources to sustain and grow South Carolina's economy, while preserving our natural resources.

In spring 2007, Clemson University first announced that it would establish a biennial conference on water resources in South Carolina to be held in even-numbered years, with the first slated for October 2008. The conference goals are to: (1) communicate new research methods and scientific knowledge; (2) educate scientists, engineers, and water professionals; and (3) disseminate useful information to policy makers, water managers, industry stakeholders, citizen groups, and the general public.

Each of the four previous conferences brought together over 300 registered attendees, featured over 120 presenters and hosted popular plenary speakers. A wider public audience was reached in 2012 and 2014 with live streaming video of the plenary sessions through the conference website. Conference attendees have included those from colleges and universities; municipal water authorities and entities; environmental engineering, consulting and law firms; state and federal agencies; nonprofit organizations; economic development associations; utility companies and land trusts. Participants have responded in an overwhelmingly positive manner about the organization of the conference, the speakers, and the information that has been presented and shared. The conference web site, www.scwaterconference.org, provides up to date information for all conference audiences from contributors to presenters and exhibitors and houses the archives for all proceedings to date, including manuscripts and posters. Due to its success and popularity, the conference has become self-sustaining financially.

The most recent conference marked the fifth occurrence of the biennial event. The program schedule featured four plenary sessions, six tracks, 35 breakout sessions, and 108 oral presentations. The conference was held at the Columbia Metropolitan Convention Center in Columbia, SC for the fourth time in a row due to its central location in the state and accommodating venue space. In the wake of last year's severe impact on the state's water resources due to drought and flooding, the theme of this past year's conference was "SC Water Resources at a Crossroads: Response, Readiness and Recovery".

Research Program Introduction

SCWRC Research Overview: The SC Water Resources Center has recently been placed under the Vice-President Public Service and Agriculture (PSA). Clemson University PSA is part of a national network of 50 major land-grant universities - one in each state - that work in concert with the USDA National Institute of Food and Agriculture. Clemson PSA has state and federal mandates to conduct research, extension and regulatory programs that support economic growth in South Carolina and improved, sustained management solutions of one of our state's most important natural resources – water.

Current programs of the SC Water Resources Center include: The S.C. State Water Assessment and Planning Program: involves working with the S.C. Department of Natural Resources (S.C. DNR), S.C. Department of Health and Environmental Control (S.C. DHEC), U.S. Army Corps of Engineers, USGS and CDM Smith (an engineering consulting firm) to develop the first complete river basin plans for all eight major river basins. The U.S. Geological Survey National Competitive Grants Program: provides research infrastructure and funding for water scientists at Clemson and across South Carolina in cooperation with the National Institutes for Water (NIWR). The Sustainable Water Resources Program is an international effort with Clemson University and Linnaeus University in Kalmar, Sweden. Current efforts include a study abroad program hosted by Linnaeus University with shared faculty as well as a new research effort aimed at cross cultural student led projects. Future plans include an internship program with students shared between institutions. The S.C. Sea Grant Consortium Stormwater Ponds Research and Management Collaborative: is an initiative to compile background data and information on stormwater pond policy for a state-of-the-knowledge report. The Savannah River Assessment: utilizes remote sensing and other modeling data to understand the impacts of changing land use to the Savannah River. The U.S. Army Corps of Engineers Lower Savannah Economic Study: utilizes the Regional Economic Modeling System to understand how changing flow regimes affect the regional economy of the Lower Savannah River Basin.

The Clemson University Intelligent River® Research Enterprise: has successfully developed a range of buoy sensor technologies and remote data collection systems that enable advanced environmental and hydrologic monitoring to improve scientific-based decision making. Cost-effective and reliable monitoring of water quantity and quality at nearly any location in South Carolina is now possible through the Intelligent River® system of data acquisition, transmission, archiving and analysis. By storing this data at a central server in a standard format, long-term monitoring and analysis is possible. Examples of successful and ongoing Intelligent River® projects include:

The Savannah River Project: is the first real-time river monitoring system that accurately monitors water quality throughout the basin by using custom buoy technology to place sensors within the river channel. It does this through multiple sub-networks formed by wireless devices that sense, process, and communicate environmental stimuli including: temperature, conductivity, pH, depth, turbidity, and dissolved oxygen from 27 stations. The project uses a web browser-based portal for access to observation data and infrastructure diagnostics, as well as a user interface for deploying new low-power environmental monitoring computers.

The City of Aiken stormwater monitoring project: uses continuous monitoring of storm drain flow within the city to quantify hydrologic flows during storm events, evaluate and optimize potential locations for further green infrastructure, enhance site-level remote data acquisition capabilities throughout the Sand River watershed, and inform stakeholders, policymakers and planning agencies. Furthermore, the Intelligent River® program has the ability to deploy small UAVs (drones) to quickly image water bodies and after-flood events, develop high-resolution 3D models, and help quickly evaluate infrastructure status and damage. Researchers are also developing a small bridge-based sensor pack that will enable scientists to monitor in near real-time water levels and status under bridges.

Research Program Introduction

Clemson University Center for Watershed Excellence: In 2007 the U.S. Environmental Protection Agency Region 4 Office created the Centers of Excellence for Watershed Management in order to utilize the diverse talent and expertise of colleges and universities from across the Southeast. The Centers and provide hands-on practical products and services to help communities identify watershed-based problems and develop and implement locally sustainable solutions. The Clemson University Center for Watershed Excellence received its designation in 2008 and takes a leadership role in water resources and watershed issues in South Carolina by collaborating with other state agencies, organizations, and institutions to provide education and outreach to residents. The Center has an ongoing partnership with the U.S. EPA and S.C. DHEC to help new MS4 communities gain a better understanding of the permit and compliance process. The Center also collaborates on workshops to give community staff an overview of their responsibilities under Phase II of the National Pollutant Discharge Elimination System (NPDES) stormwater program and gain feedback on how agencies can assist them under this new designation. South Carolina Adopt-a-Stream (SC AAS) creates a network of watershed stewardship, engagement, and education through involvement. SC AAS volunteers can play an important role in monitoring and tracking water quality while sharing information about local water resources with their communities. In providing baseline information about stream conditions, volunteers, local communities, educators, and local government agencies can partner to protect and restore our waters. Microbial Source Tracking is an emerging technology to source the species of bacteria loading and cause for failure to meet state and federal thresholds. Specifically, Clemson University is piloting a technical service using qPCR, or quantitative polymerase chain reaction, to quantify loading from warm-blooded mammals. Species available for detection are swine, bovine, human, and dog.

USGS Funding: The past year the Water Center oversaw the funding of two research studies: 1) “Phosphorus Removal from Nutrient Enriched Agricultural Runoff Water” with Sarah White (Clemson University) as principal investigator and John Majsztrik (Clemson University) and William Strosnider (Saint Francis University, PA) as co-principal investigators; and 2) “Endemic Bartram’s Bass as a Sentinel Species to Prioritize Restoration in the Upper Savannah River basin of South Carolina” with Brandon Peoples (Clemson University) as principal investigator and Yoichiro Kanno (Clemson University) as co-principal investigator.

This coming year the Water Center will oversee the funding of two research studies: 1) “Statewide survey of irrigation source water quality and water use techniques in the specialty crops production industry” with Sarah White (Clemson University) as principal investigator; and 2) “Monitoring Distribution and Toxicity of Coal Tar Chemicals in the Congaree River Using Passive Samplers” with Peter van den Hurk (Clemson University) as principal investigator.

Endemic Bartram

Basic Information

Title:	Endemic Bartram
Project Number:	2017SC105B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	SC-003
Research Category:	Water Quality
Focus Categories:	Ecology, Management and Planning, None
Descriptors:	None
Principal Investigators:	Brandon Peoples, Yoichiro Kanno

Publications

There are no publications.

Endemic Bartram's Bass as a Sentinel Species to Prioritize Restoration in the Upper Savannah River basin of South Carolina

Brandon Peoples, Ph.D. (Clemson University) principal investigator and Yoichiro Kanno, Ph.D. (Clemson University) as co-principal investigator

Garnering public support for watershed restoration projects aimed to improve water quality and aquatic life can be difficult. However, relating key *sentinel species* to watershed- scale processes can be an effective tool for conveying the importance of restoration projects to the public. Bartram's Bass (*Micropterus sp. cf. cataractae*) is endemic to the Savannah River basin; it occurs nowhere else in the world. Unfortunately, this unique fish is threatened by invasive species and landscape alteration. Because it is (a) sensitive to water quality and habitat degradation, and (b) a popular gamefish, Bartram's Bass is an ideal sentinel species for monitoring water quality and instream habitat in the Savannah River basin and garnering public support for restoration efforts. This project will leverage support from (a) currently-funded research on Bartram's Bass in the PIs' labs, and (b) a collaborative agreement between South Carolina Dept. of Natural Resources (SCDNR) and the PIs' labs. The proposed project will: (1) Quantify variation in growth rates (a key component of individual fitness) of Bartram's Bass throughout the Savannah River basin; (2) identify the watershed-scale factors that control growth rates of Bartram's Bass, and (3) identify key locations and implementation strategies for stream restoration, using the South Carolina Stream Assessment (SCSA) decision support tool and information from objectives (1) and (2).

To accomplish these objectives, we will first collect adult Bartram's Bass from at least 30 sites representing the range of water quality and instream habitat conditions found in the Savannah River basin. In the lab, we will use *otoliths* (a bone in the fish's head that accumulates growth rings similar to trees) to estimate growth rates. Using remotely sensed data, we will then use mixed effects modeling to identify the most important watershed-scale predictors of Bartram's Bass growth rates. Based on the mixed model results, we will use the SCSA tool to model potential restoration alternative scenarios that maximize key locations and strategies for improving growth of Bartram's Bass.

This project is an important step toward implementing conservation strategies that will benefit Bartram's Bass, as well as overall water quality and aquatic ecosystems as a whole. The proposed research takes an innovative approach of using detailed life history parameters of key species to define priorities for land restoration and conservation. Moreover, it will fill in critical knowledge gaps in the life history and ecology of a species that lives nowhere else in the world but in the Savannah River basin.

To date the project team has collected approximately 800 black bass individuals from approximately 50 sites in tributaries to the Savannah River. The team has

extracted otoliths from all individuals, and are in the process of conducting age and growth analyses.

Phosphorus removal from nutrient enriched agricultural runoff water

Basic Information

Title:	Phosphorus removal from nutrient enriched agricultural runoff water
Project Number:	2017SC106B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	SC-003
Research Category:	Water Quality
Focus Categories:	Agriculture, Geochemical Processes, None
Descriptors:	None
Principal Investigators:	Sarah White, John C Majsztrik

Publications

There are no publications.

Title: Phosphorus removal from nutrient enriched agricultural runoff water

Drs. Sarah A. White, William R. Strosnider, and John C. Majsztrik

A pilot scale phosphorus (P) removal system was installed at a nursery production facility. The P removal system (Figure 1) received water from a nursery tailwater recovery pond. The water was pre-filtered to minimize substrate pore clogging. Pre-filtered water flowed through 3, 102-liter containers filled with approximately 75-liters of substrate (either calcined clay or iron oxide). Two internal baffles were installed within each filter to increase contact time and minimize channeling. Water samples were collected pre- and post-filtration from each unit. Water was pumped through the filters for 12 hours per day and then the filters were drained, to prevent formation of anoxic conditions. Five composite samples (100 ml each) were collected daily. Every 2 weeks, composite samples were filtered (0.45 μm) and submitted for ICP analysis through the Clemson University Agricultural Services lab. Phosphorus filtration capacity was evaluated first for iron oxide and then for calcined clay.

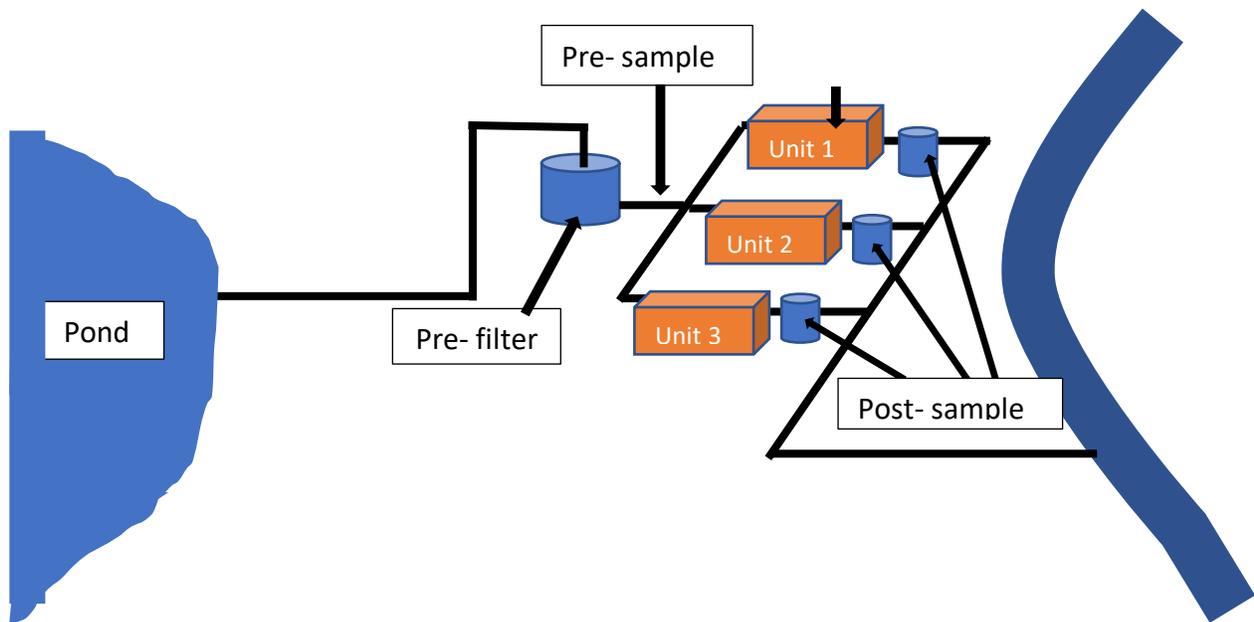


Figure 1. Schematic drawing of experimental setup. Water was pumped from a pond receiving runoff from irrigation of container-grown nursery plants, prefiltered, and then traveled through three identical bins filled with substrate. Water samples were collected pre- and post-substrate filtration for analysis.

Results

Iron oxide

The iron oxide study was initiated early February and ran 8 weeks. At that time the grower was using a minimal amount of fertilizer, and as a result there was a low amount of phosphorus in the pre-sample water (Figure 2, blue line). The iron oxide reduced the amount of P exiting the

filter, regardless of the concentration from 0.02 ppm (detection limit) to 0.5 ppm. From day 23-37, some P was released from the filter back into the surface water, this P release could be due to pH mediated desorption of P from iron oxide, channeling (and subsequent reduction in contact time), or measurement error.

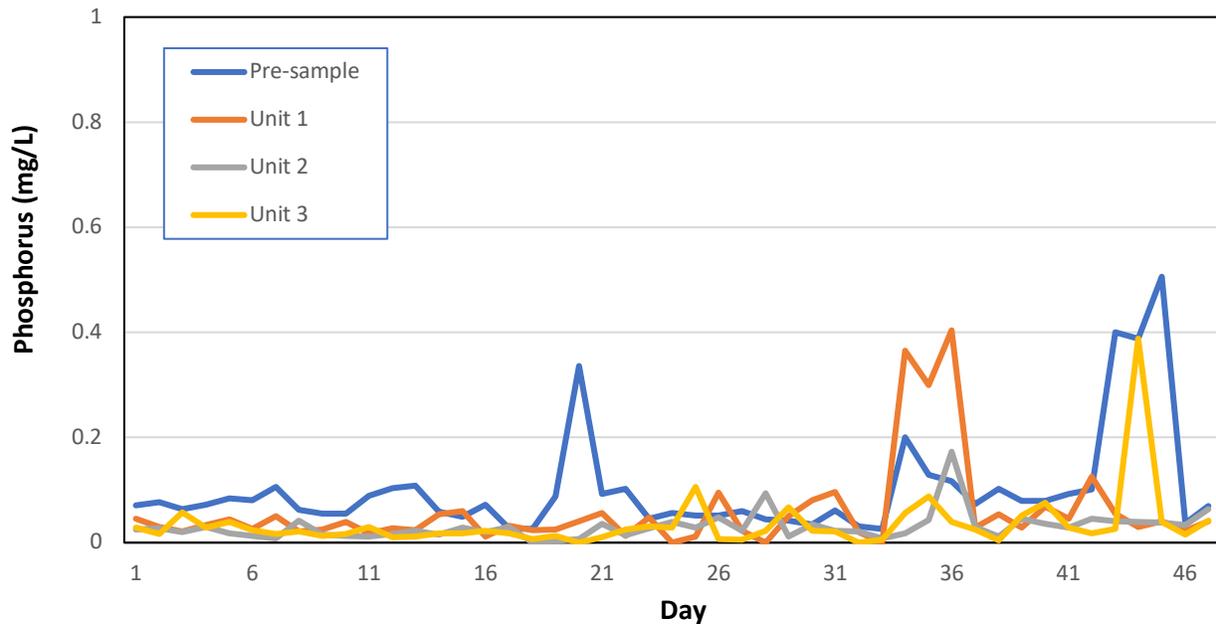


Figure 2. Continuous monitoring of phosphorus removal using an iron oxide substrate. Nutrient enriched pond water was pumped from an irrigation pond at a partner nursery, particulates were filtered out, and water was then run through three bins of iron oxide substrate in parallel. Five composite samples were collected per day for each sample location (before and after the iron oxide substrate).

Calcined clay

The calcined clay study was initiated in early April and ran for 8 weeks. Phosphorus concentrations in the pre-sample increased over time, indicating an increase in fertilizer use and runoff at the operation (Figure 3). Not all samples are presented, as sample processing is not yet complete. The calcined clay reduced the amount of P compared to the presample, with a few instances of a single unit reporting P levels at or higher than the presample. Phosphorus removal efficiency by calcined clay did not appear to be dependent on the concentration of P in incoming water.

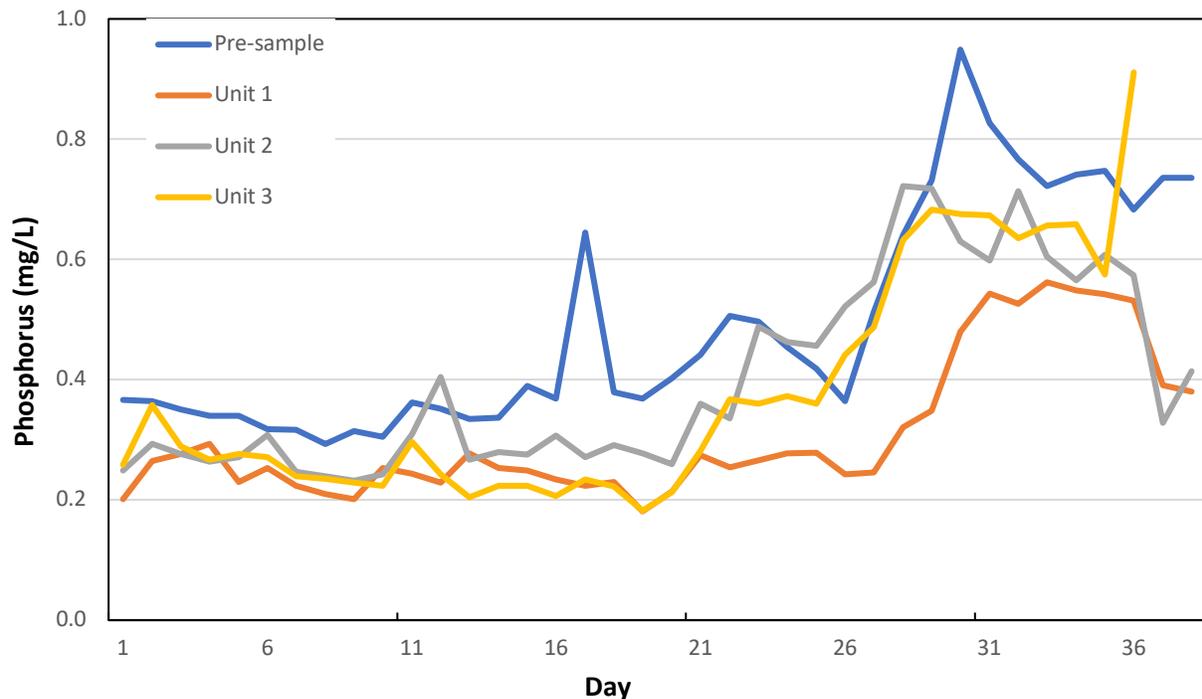


Figure 3. Continuous monitoring of phosphorus removal using a calcined clay substrate. Nutrient enriched pond water was pumped from an irrigation pond at a partner nursery, particulates were filtered out, and water was then run through three bins of calcined clay substrate in parallel. Five composite samples were collected per day for each sample location (before and after the calcined clay substrate).

Conclusions

These two studies showed that both iron oxide and calcined clay are able to remove P from container-plant nursery runoff. These results are likely applicable to most types of agriculture where P in runoff can potentially be captured and treated before it reaches surface waters. Future work should focus on the effect of flow rate (contact time), inflow pH, and particle size on P removal, as these factors may impact P removal efficiency. Flow rate and particle size were not varied in these experiments. Additional work is needed to determine system sizing, substrate P-binding longevity, and uses for P-saturated materials (recycling or reuse options).

Information Transfer Program Introduction

None

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	1	0	0	0	1
Ph.D.	2	2	0	0	4
Post-Doc.	0	0	0	0	0
Total	3	2	0	0	5

Notable Awards and Achievements

Worked with the S.C. Sea Grant Consortium on incorporating the policy and management chapter for the South Carolina Storm-water Pond State of the Knowledge Report into a potential RFP

Completed report for work on funded project to conduct stakeholder engagement meetings for the SCDNR sponsored South Carolina River Basin Surface Water Assessment.

Secured additional funding for the SCDNR sponsored South Carolina Groundwater Assessment to conduct stakeholder meetings. Held and facilitated initial Groundwater Assessment meetings

Continued work on project funded through U.S. Department of Agriculture for a project to analyze land use changes and associated water consumption using multiple remote sensing platforms in the Savannah River Basin

Continued work on project funded from U.S. Army Corps of Engineers to conduct an economic analysis of changes to flow regimes in the lower Savannah River Basin

Initiated program to survey agricultural producers across South Carolina in order to gain a more complete understanding of agricultural irrigation and water use.

Initiated a study abroad program with Linnaeus University in Kalmar Sweden to share students and resources in an international sustainable water resources program.

Successfully conducted SCWRC statewide research solicitation under the guidelines of USGS.

Served as chairman of the Planning Committee of the S.C. Water Resources Conference to be held in 2018

Served on editorial committee for the Journal of South Carolina Water Resources

Planned and conducted workshop with SC Water Resources Conference Planning Committee on drought and drought response by state agencies in S.C.

Planned and conducted workshop with SCDNR and USC-CISA on drought emergency response

Planned three workshops with SCDNR and USC-CISA on climate connections and roles of agencies and academia in climate change response

Served on the Savannah River Basin Advisory Council.

Served on the Carolinas Integrated Sciences & Assessments Advisory Board

Served on the SC Sea Grant Consortium Coastal Communities Advisory Board

Served on SCDNR State Water Plan Advisory Committee

Served on the SC Sea Grant Consortium Program Advisory Board

Served on the Science Advisory Committee of the Catawba Wateree Water Management Group

Served on the Selection Committee of the Duke Energy Water Fund

Served on the Science Advisory Committee of the Savannah River Clean Water Fund

The 2018 S.C. Water Resources Conference, sponsored by the S.C. Water Resources Center is planning for:
300+ Participants 100+ Groups represented 50+ Students 108 Oral presentations 45+ Posters on display 20+ Exhibitors 7+ Major financial contributors 10+ Supporting financial contributors

The 2018 S.C. Water Resources Conference, sponsored by the S.C. Water Resources Center – Media Coverage will produce: Impacts from earned print and broadcast media Unique visitors to web site @SCWaterNews Twitter impressions for October