

**South Carolina Water Resources Research
Institute
Annual Technical Report
FY 2010**

Introduction

The South Carolina Water Resources Center uses its operating funds to carry out its mission as a liaison between the US 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 our web site, by serving as a research facilitator through our annual grants competition and by operating as a catalyst for research and educational projects and programs across South Carolina. The Water Center 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.

While continuing to be involved with numerous water issues across the state including membership on an ad-hoc statewide committee identifying policy issues related to primary water concerns and analyzing population growth impacts on water resources, the Water Center is collaborating with multidisciplinary teams investigating natural system/social system interactions. The SCWRC has embarked upon a cooperative study with the US Army Corps of Engineers and six counties surrounding Lake Hartwell in the Savannah River Basin to determine economic impacts of changing lake levels due to drought and other circumstances. Duke Energy has also agreed to collaborate on further economic impact studies for reservoirs they manage within the Savannah River Basin.

The SCWRC has been involved with key individuals from the South Carolina Department of Natural Resources, the South Carolina Department of Health and Environmental Control and South Carolina Sea Grant that produced a working group that has funded and undertaken a multi-disciplinary research program for assessing management strategies along the South Carolina coast. As an outcome of those meetings, the SCWRC has completed work as a committee member of the SCDHEC-Ocean and Coastal Resource Management (OCRM) Shoreline Change Advisory Committee. That committee work has resulted in a report made to SCDHEC-OCRM with recommendations and potential input into a new beachfront policy. SCDHEC-OCRM has now formed a blue-ribbon committee that will make recommendations potentially leading to revisions of South Carolina's Beachfront Management Act.

The Water Center has worked closely on human population growth management issues in several areas of South Carolina including intensive land cover change and water quality studies in the Saluda/Reedy watershed. The SCWRC completed work on the Upstate South Carolina urban growth prediction model in 2009 and continue to be asked to discuss the model with various groups. The results of the model have been presented to numerous city and county councils, water and waste-water districts as well as chamber's of commerce. Numerous civic leaders have commented on the importance of the model in regard to both managing growth and development and protecting natural resources, especially receiving waters. Numerous water utilities in the Upstate have asked the SCWRC to propose a water budget analysis for the Upstate based upon the results of the urban growth model.

Research Program Introduction

SCWRC Research Program Overview

While continuing to be involved with numerous water issues across the state including membership on an ad hoc statewide committee identifying policy issues related to primary water concerns and analyzing population growth impacts on water resources, the Water Center is collaborating with multidisciplinary teams investigating natural system/social system interactions. Foremost among these projects is a cooperative study with the US Army Corps of Engineers and six counties surrounding Lake Hartwell to determine economic impacts of changing lake levels due to drought and other circumstances. Results of the study were controversial, particularly for lake dependent businesses, as the analysis revealed only minimal impacts to the local economy as a result of lake levels dropping. This study has already led to funding by Duke Energy to look at similar economic impacts of changing flows both upstream and downstream from Lake Hartwell within the Savannah River Basin. An additional highlighted project is the "Pickens County Water Supply Plan" funded by the Pickens County Water Authority. The SCWRC will provide a plan for water use for the twelve water purveyors within Pickens County. The South Carolina Department of Health and Environmental Control is particularly interested in the process we have undertaken for the Pickens County Water Supply Plan. If the results of the planning process are suitable, SCDHEC intends to partner with the SCWRC to undertake water supply planning initiatives in numerous other counties and sub-basins across the state.

Two SCWRC/USGS funded projects are finishing up in 2010: 1) "Sediment Pollution Potential Assessment of Abandoned Developments Using Remote Sensing and GIS " with Elena Mikhailova as principal investigator and Christopher Post as co-principal investigator; and 2) "Developing a Theoretical Framework for Water Quality Trading in the Saluda-Reedy Watershed, South Carolina" with Michael Mikota as principal investigator and Jeffrey Parkey as co-principal investigator.

This year the Water Center is funding two research studies through its 2010-2011 USGS competitive research program: 1) "Sediment Phosphorus Flux Measurement in Lake Wateree, SC " with Daniel Tufford (University of South Carolina) as principal investigator and Dwayne Porter (University of South Carolina) as co-principal investigator; and 2) "Effects of Water Pollution on Fish Health in the Saluda River " with Peter van den Hurk (Clemson University) as principal investigator and Dennis Haney (Furman University) as co-principal investigator.

Sediment Pollution Potential Assessment of Abandoned Developments Using Remote Sensing and GIS

Basic Information

Title:	Sediment Pollution Potential Assessment of Abandoned Developments Using Remote Sensing and GIS
Project Number:	2009SC66B
Start Date:	3/1/2009
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	3rd
Research Category:	Not Applicable
Focus Category:	Non Point Pollution, Sediments, Water Quality
Descriptors:	
Principal Investigators:	Elena Mikhailova, Christopher Post

Publications

There are no publications.

Sediment Pollution Potential Assessment of Abandoned Developments
Using Remote Sensing and GIS

Submitted to the South Carolina Water Resource Center: 12/2008

Dr. Elena Mikhailova
Assistant Professor of Soil Science
Clemson University
261 Lehotsky Hall
864-656-3535
eleanam@clemson.edu

Dr. Christopher Post
Associate Professor of
Environmental Information Science
Clemson University
261 Lehotsky Hall
864-656-6939
cpost@clemson.edu

Graduate Student Project Assistant: Joshua. D. Werts

Executive Summary

The current economic crisis has left numerous residential developments in the Southeastern United States in various states of construction. Many of them are currently graded and essentially abandoned creating a major source of sediment runoff to waterways. Residential development locations with significant bare soil areas were identified through classification of Landsat 5 TM satellite imagery and subsequently verified from high-resolution county aerial photographs.

Initial GIS identification indicated 301 sites with a total bare soil area of 2,378 hectares over three counties in upstate South Carolina. A random sample of 153 sites was visited and results indicate that 77.8% of the sites were classified correctly (residential construction sites in varying stages of completion); 88.3% of identified areas were less than 25% built compared to the previous year; 47.9% were categorized as moderate to severe problems. Abandoned and unfinished developments in upstate South Carolina may represent a major source of sediment pollution to streams and this study indicates maintenance of erosion control devices and establishment of ground cover as possible solutions.

Introduction and Background

Over recent years the upstate region of South Carolina has experienced an unprecedented amount of growth in population and in the area of developed land (Allen and Wyche, 2008). Residential housing construction in the upstate often involves the conversion of forest or pasture to low-density housing developments. During the development process, careful management of exposed soil and storm runoff is necessary to prevent sediment from being transported to nearby water bodies. Best management practices (BMPs), when properly installed and maintained, can minimize the amount of sediment pollution, but research has shown that even with BMPs sediment runoff can occur (Goddard et al., 2008). The environmental impact of sediment runoff is well known and can devastate aquatic ecosystems (Sciera et al., 2008).

The current economic crisis has left numerous residential developments in the Southeastern United States in various states of construction. Anecdotal evidence suggests that many of these development sites in the upstate region of South Carolina are currently graded and essentially abandoned. Even if BMPs and sediment/water quantity control structures were properly installed during active development, they will not continue to function if they are not maintained. To further exacerbate the potential environmental impact of these developments, the long-standing drought has prevented ground cover crops from being established, leaving even more soil surfaces exposed to the environment.

Methodology

Identification of abandoned developments. Initial identification of bare soil areas was determined using a 30m resolution Landsat 5 TM satellite image from June 2, 2009 for WRS-2 path 18, row 36 (scene center: 34°37'N, 82°48'W). This image was selected as the most recent haze/cloud free image for the study area at the time of analysis. Atmospheric and radiometric corrections were performed in ERDAS Imagine 9.3 (ERDAS 2008) using the Chavez cost model (Chavez 1996). A supervised classification was performed in Imagine to determine locations of bare site areas. Training sites were selected in Microsoft Bing Maps (<http://maps.bing.com>) by drawing polygons around sites using tools provided by

the interface. Two bare soil classes representing bare developments were used in the classification. Initial sites were selected from those classes where pixel groups were greater than 2 acres in area. Selected pixel groups were converted to vector polygons in ESRI ArcGIS 9.3 (ESRI 2009) to represent initial bare soil areas. Polygons were overlaid on recent high resolution county aerial photos and systematically verified visually as barren residential sites. Commercial sites, residential sites greater than approximately seventy-five percent complete, and areas whose status was unable to be determined visually were excluded from the study. Sites were typically easy to identify based on the characteristic red hue of the clays prevalent in the region and cul-de-sacs surrounded by bare soil.

Soil loss risk analysis. The revised universal soil loss equation (RUSLE, Renard et al. 1997) model was selected to quantify risk of soil loss for each site based on its ease of use, and readily available data.

Random Selection of Sites. A proportional stratified random sample was used to select approximately fifty percent of the 301 sites. Sites were stratified according to area (ha). Fifty percent of each strata were randomly selected for validation site visits

Site Visits. Typical site visits durations were between thirty minutes and two hours depending on the size of the site and extent of problems. All of the sites in the random sample were visited in seventeen days averaging nine sites per day. Data were collected at each site utilizing a tablet computer with ESRI ArcPad 8.0 mobile GIS software, digital camera, and GPS unit (small number of sites). Each site was visually inspected to identify erosion related problems. Points or polylines were collected on each site to represent erosion related problems such as buried or destroyed silt fences and catch basin protection, evidence of sediment output from sediment basins, and erosion features such as gullies or off-site sediment deposits. On each site, the location of off-site storm water outlets was determined and evaluated based on evidence of sedimentation and erosion at outlets (visual inspection).

Results and Conclusions

Out of the 153 sites in the random sample, 34 were deemed as a misclassification meaning that sites were determined to be commercial or private residences during field verification (includes 3 sites that were not able to be accessed due to gate or other barrier). Over three quarters (119 sites, 77.8%) of sites in the sample were correctly classified as residential developments in varying stages of construction. The misclassified sites (34 sites, 22.2%) were outside of the scope of this study and were not evaluated for erosion and sedimentation problems.

It is evident that very little construction has occurred in the study area within the time period between the aerial photographs and field verification (approximately 1 year for Spartanburg and Greenville counties; approximately 2 years for Pickens). Of the 119 correctly classified sites, 88.3% were less than 25% built in the identified areas; 59.7% had zero new houses or buildings. Over half of the sites showed evidence of sediment leaving the site, and nearly half directly entered a stream. Typically, sediment loss was due to bare lots eroding to catch basins and carrying sediment to unmaintained sediment basins which have filled with sediment, are undersized, or have damaged control structures. Several sites exhibited buried, damaged, or otherwise ineffective silt fence that was not holding back sediment from directly leaving the site.

The classification success rate for the techniques we developed for rapid location and verification of abandoned and unfinished residential developments was greater than 75%. This would likely be improved based upon the experience of the individual performing the aerial photo verification process. This study also considered commercial sites and private residences to be misclassifications despite their potential to yield similar problems. GIS mapping suggests that the sites are highly clustered at the urban-rural interface surrounding large population centers (cities of Spartanburg and Greenville in this study). Further research is necessary to quantify this clustering and determine its usefulness as a predictor for locating and prioritizing these sites.

Over the area encompassing three counties, very little construction has occurred in over a year. Our study suggests that nearly half of all unfinished residential construction sites pose a moderate to severe problem in terms of erosion and offsite

sedimentation. This study also suggests the importance of performing erosion control maintenance and establishing ground cover as a long-term solution on abandoned or unfinished sites.

Literature Cited

- Allen, J., and B. Wyche. 2008. Growth projections for upstate South Carolina. Available at http://www.upstateforever.org/newsviews_other/ProjectedGrowth.pdf (accessed 1 May 2009). Upstate Forever, Greenville, SC.
- Chavez, P.S. Jr. 1996. Image-based atmospheric corrections—revisited and revised. *Photogrammetric Engineering and Remote Sensing* 62(9): 1025-1036.
- ERDAS, Inc. 2008. *Imagine 9.3*, Norcross, GA.
- ESRI, Inc. 2009. *ArcGIS 9.3.1*, Redlands, CA.
- Goddard, M.A., C.P. Post, W.R. English, and J.W. Pike. 2008. Examining the impacts of changing land use on biological integrity in streams using geographical information systems and statistical modeling. *Aquatic Ecosystem Health and Manag.* 11(2):230-242.
- Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. 1997. Predicting soil erosion by water—a guide to conservation planning with the revised universal soil loss equation (RUSLE). United States Department of Agriculture, Agricultural Research Service (USDA-ARS) Handbook no. 703. United States Government Printing Office, Washington, DC.
- Sciera, K.L., J.A. Smink, J.C. Morse, C.J. Post, J.W. Pike, W.R. English, T. Karanfil, M.A. Schlautman, and S. J. Klaine. 2008. Impacts of land disturbance on aquatic ecosystem health: quantifying the cascade of events. *Integrated Environmental Assessment and Management* 4(4):431-442.

Effects of water pollution on fish health in the Saluda River

Basic Information

Title:	Effects of water pollution on fish health in the Saluda River
Project Number:	2010SC71B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	3rd and 4th
Research Category:	Not Applicable
Focus Category:	Water Quality, Toxic Substances, Surface Water
Descriptors:	None
Principal Investigators:	Peter Van Den Hurk, Dennis C. Haney

Publications

There are no publications.

Progress Report, May 17, 2011

“Effects of Water Pollution on Fish Health in the Saluda River.”

Dennis Haney, Furman University, Peter van den Hurk, Clemson University

Funded by:

South Carolina Water Research Center

Introduction

In 2009 the Saluda River was ranked as # 6 of America’s Most Endangered Rivers by American Rivers, a leading conservation organization. The sole reason for this status is the excessive phosphorous levels in the river, which originate mostly from wastewater treatment plant effluents. The Saluda River watershed is home to more than 350,000 residents, and provides drinking water for more than 500,000 inhabitants of the Upstate and Piedmont of South Carolina. As a result of the elevated phosphorous levels regular algal blooms and occasional fish kills have been observed in Lake Greenwood, one of the major reservoirs in the Saluda River. With the human population rapidly growing in the Saluda watershed, protecting clean drinking water supply and preservation of fishing and other recreational activities on the river and reservoirs is of crucial importance.

Despite the accumulated knowledge on the concentrations and effects of elevated phosphorous levels in the Saluda River and Lake Greenwood, nothing was known about the effects of other contaminants in the Saluda River. Not only does the river receive phosphorous-rich effluents from wastewater treatment plants, there are also several other industrial point sources along the river. Over the last two decades more than 500 violations of NPDES permits have been documented for facilities that discharge effluents on the Saluda River. In addition, pollution from non-point sources in the rapidly urbanizing watershed contributes to the total contaminant load in the river.

Because virtually nothing is known about the biological effects of pollutants (other than nutrients) in the Saluda River, and because of the elevated current public attention for the water quality effects in the river, it is urgent that more scientific data are collected on the health of the aquatic ecosystem in the river. We initiated a study in which fish were collected from the river and are being analyzed for health status and pollution effects. The overall goal for this project is to investigate exposure and effects of anthropogenic pollutants on fish in the Saluda River. We will achieve this goal by collecting fish from a variety of sites along the river, and measure a suite of health parameters, among which: somatic indices, tissue histology, blood and bile analysis and expression of detoxifying enzymes and proteins in liver.

Field collections and biomarker assays

Fish were collected at 13 sites along the Saluda River, ranging from the North Saluda Reservoir in the mountains north of Greenville, down to the upper reaches of Lake Greenwood. We collected around 170 fish in total, most of them were sunfish species in addition to a dozen or so largemouth bass. Of all the fish we collected a blood sample, liver, gall bladder and spleen samples, and a piece of muscle tissue. Bile was collected from the gall bladders, and was analyzed for fluorescence as a measurement for metabolites of polynuclear aromatic hydrocarbons (PAHs). To normalize these data the total protein content was also measured in the bile samples. We are in the process now of analyzing the bile samples for estrogenic compounds, using an estrogen receptor binding assay after deconjugating these compounds through an enzymatic reaction, followed by extraction. The liver samples were homogenated and analyzed for cytochrome P450-1A activity, using the EROD assay. In addition glutathione-S-transferase (GST) activity was measured in the liver homogenates as a general indication for oxidative stress. A limited number of liver samples were also analyzed using the TBAR assay, which is indicator for cell membrane damage as a result of oxidative stress.

Preliminary Results

The results of the bile fluorescence and EROD assays show both that in the middle part of the river significantly higher concentrations of PAHs are found. This is clearly related to higher urbanization in this area, and may be related to road run-off. Recent findings have demonstrated that especially run-off from parking lots and driveways that have been treated with seal coats contribute large amounts of PAHs to receiving urban creeks. An interesting observation is that the PAH responses appear to be diminishing downriver, with Lake Greenwood samples having comparable background levels as the samples in the North Saluda Reservoir. The input of PAHs is obviously less in this rural area, and PAHs from upstream sources are degraded or removed on the way down river.

The GST and TBAR assays did not show any significant differences along the river gradient. Analysis of habitat types (main river, reservoir, upstream vs. downstream of dams) did not show any significant differences for the parameters analyzed so far. At the moment we are analyzing the estrogenic compounds in the bile samples, which will be followed by vitellogenin analysis in the blood plasma samples. Vitellogenin is a yolk protein which should not be present in male fish, but when found indicates that these male fish have been exposed to estrogenic compounds. Other analyses that will be performed are metallothionein expression in liver samples, as an indication for heavy metal exposure and acetylcholinesterase inhibition as an indicator for pesticide exposure. Muscle samples will also be analyzed for heavy metal accumulation.

Products

So far the obtained results have been presented in two forms: Peter Calomiris (undergraduate student at Furman University) wrote a paper as part of the requirements for the BIO 502 class (River Basin Research Initiative); Jessica Mierzejewski (graduate student at Clemson University) presented a poster with the results at the Carolina SETAC meeting in Boone, NC (March 2011).

Personnel involved

In addition to the principal investigators (Haney and Van den Hurk) and the two students mentioned above, two more undergraduate students from Furman University were involved in the field work and sample analysis (Lindsay Gerzel and Sawin Gunesekura), together with one high school student from the SC Governor’s School for Sciences and Mathematics (Katie Bradley).

Introduction

•The Saluda River watershed, in the Upstate and Piedmont regions of South Carolina, provides drinking water for more than 500,000 inhabitants, as well as providing an area for fishing and other recreational activities.

• In 2009 the Saluda River was ranked 6th of America's Most Endangered Rivers by American Rivers, due to its high levels of phosphorous which is assumed to mostly originate from wastewater treatment plant effluents.

•There are several other industrial point sources along the river, as well as many non-point sources from the urbanizing watershed.

•Little is known about the ecological health of the river. In this study, health effects from pollutants on fish in the Saluda River were examined through the application of biomarkers.

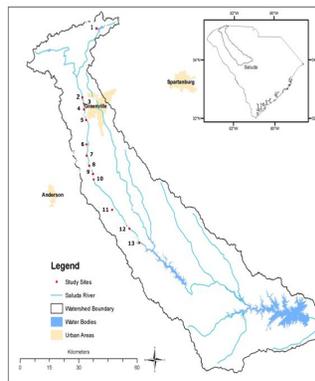


Figure 1: Sampling Sites along the Saluda River, SC.

OBJECTIVES

•To analyze the health of the Saluda River Watershed through the use of fish biomarkers.



Large Mouth Bass
www.dec.ny.gov



Bluegill Sunfish
coast2coastfishing.com

METHODS AND MATERIALS

Using electrofishing techniques, 159 fish from the *Centrarchidae* family (*Lepomis* spp. and *Micropterus salmoides*) were collected during June and July 2010, at 14 sampling sites along the Saluda River, located in northwestern South Carolina, USA (Figure. 1). Lake Greenwood was chosen as a reference site as samples from this location exhibited consistently low toxicity responses. The fish were anesthetized in a 1g/L Tricaine methanesulfonate (MS-222) solution prior to field dissection. Weight, length and sex were recorded and liver, gall bladder, spleen, gonad, blood and muscle tissue samples were harvested.

Bile fluorescence was measured for the presence of PAH compounds in the gall bladder. Fluorescence of diluted (50:50 MeOH:H₂O) bile samples was measured at 290/335 nm (2 ring compounds), 241/383 nm (4 ring compounds), and 380/430 nm (5 ring compounds), and fluorescence was normalized using total bile protein (Pierce BCA protein kit).

Liver S-9 fractions were prepared by homogenizing liver tissue in 0.05 M Tris buffer, pH 7.4 with 1.0 mM EDTA, 0.25 M sucrose, 1.0 mM DTT and 0.2 mM PMSF. Total protein was measured using the Pierce BCA protein kit.

Ethoxresorufin O-deethylase (EROD) activity was measured as indicator for cytochrome P450-1a (CYP1A) in liver S9 fractions. The reaction mixture (250 ul) consisted of: 0.1M Tris (pH 7.8), 0.2% BSA, 5 mM MgCl₂, 2 uM ethoxresorufin, 100 ug S9 protein, 0.5 mM NADPH. The formation of resorufin was measured at intervals over 30 min at 530/585 nm on a Spectramax Gemini fluorescent plate reader (MTX Lab systems Inc.).

Glutathione S-transferase (GST) activity in liver S9 fractions was measured using 1-chloro-2,4-dinitrobenzene (CDNB) as a substrate. The reaction mixture (250 ul) consisted of: 100mM HEPES buffer (pH 7.6), 1 mM glutathione, 50 ug S9 protein, 1 mM CDNB. The reaction kinetics were measured over 2 min by UV absorption at 344 nm.

ThioBarbituric Acid Reactive Substances (TBARS) (modified from Ohkawa *et al.* 1979) were measured to indicate levels of lipid peroxidation in liver tissues. Only those samples that had liver tissue remaining after creating the S9 fractions were used, resulting in an incomplete data set. A 10% (w/v) liver tissue homogenate was made in buffer containing potassium chloride and BHT. A TMP standard curve was prepared and was diluted as the samples in 20% acetic acid (adjusted to pH 3.5) with 0.8% aqueous TBA solution, and 8.1 % SDS solution. The samples were heated at 95 °C for 30 minutes, then cooled, after which the TBARS were extracted with 15:1 butanol:pyridine solution. Fluorescence of the supernatant was measured at 155/553 nm using a Spectramax Gemini ultraviolet fluorescent plate reader (MTX Lab systems Inc.).

All data sets were statistically analyzed using a Kruskal-Wallis statistic test and a Dunn's Multiple Comparison Test using the GraphPad Prism 4 software (GraphPad Software, Inc., 1995-2005). In the post test all other sample sites were compared to sample site 13, Lake Greenwood.

RESULTS

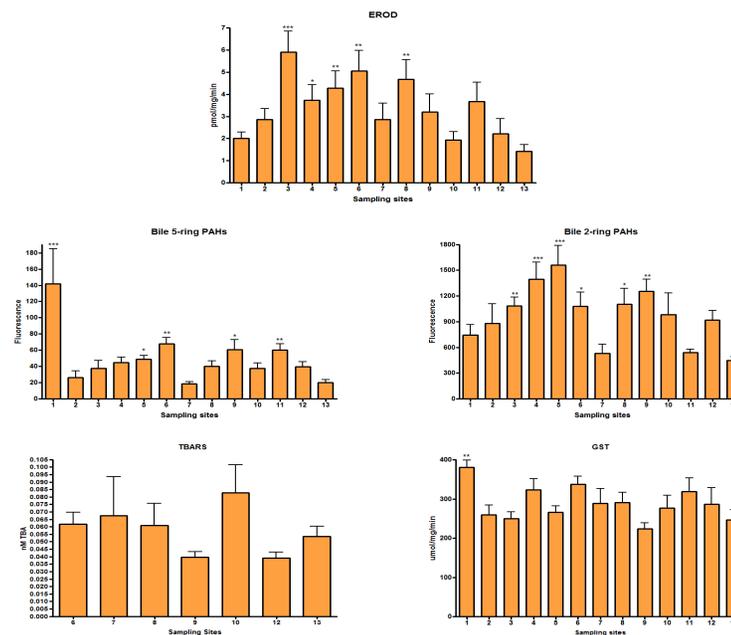


Figure 2: GST, EROD, TBARS and bile fluorescence results, organized by site.

•In general, highest responses were observed at the sampling sites in the center of the watershed, with lower responses seen at both the upstream and downstream ends of the watershed. Lake Greenwood exhibited consistently low responses.

•The most statistically significant data is found in the EROD and bile fluorescence assays, few or no statistical differences were found among sites in the TBARS and GST assays.

CONCLUSIONS

•Multiple sites along the Saluda River exhibit increased toxicity responses as compared to Lake Greenwood, the reference site. This may indicate decreased health of the river system and merits further research.

•Future investigations will include estrogenic effects, acetylcholinesterase inhibition analysis, metallothionein analysis and metal accumulation in tissues.

ACKNOWLEDGEMENTS

Thanks goes to the SC DNR for their support and the Greenville Water System Authority for assisting us at the North Saluda Reservoir. Special thanks goes to Dr. Haney's summer 2010 research team for all their hard work and support. Funding provided by the SC Water Resources Center.

REFERENCES

- America's Most Endangered Rivers, 2009 Edition. American Rivers. 2009. www.upstateforever.org/programsCAW/CAW_SavingLakeGreenwood.pdf
- Upstate Forever. 2009. Saving Lake Greenwood. An action plan for restoring and protecting water quality. Saluda-Reedy Watershed Consortium. www.saludareedy.org

Sediment phosphorus flux measurement in Lake Wateree, SC

Basic Information

Title:	Sediment phosphorus flux measurement in Lake Wateree, SC
Project Number:	2010SC73B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	6th
Research Category:	Not Applicable
Focus Category:	Water Quality, Nutrients, Sediments
Descriptors:	None
Principal Investigators:	Daniel Tufford, Dwayne Porter

Publications

There are no publications.

Title: Sediment phosphorus flux measurement in Lake Wateree, SC

Date submitted: May 22, 2011

Principle investigators: Daniel Tufford, Research Associate Professor
University of South Carolina
Department of Biological Sciences
715 Sumter St
Columbia, SC 29208
Phone: 803-777-3292 E-mail: tufford@sc.edu

Dwayne Porter, Associate Professor, Chair
University of South Carolina
Department of Environmental Health Sciences
921 Assembly St
Columbia, SC 29208
Phone: 803-777-4615 E-mail: porter@sc.edu

Abstract / summary: For many decades the Catawba River has been a source of excessive nutrient loading to the reservoirs at the lower end of the watershed. As a result, Lake Wateree is eutrophic and appears on the South Carolina 303(d) list

(http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_08-303d.pdf) for water quality impairment from total phosphorus. Work is in progress by the SC Department of Health and Environmental Control (SCDHEC) to develop a total maximum daily load (TMDL) for the lower Catawba River because of this impairment. The results of the work in this project will fill a gap in the information SCDHEC has about phosphorus loading to Lake Wateree. If significant internal loading is observed it will affect the estimates of the sources of current total loading and how reductions of external point and nonpoint source loading will impact lake recovery over time. If significant loading is not observed this will justify greater confidence in total loading estimates from external sources. During the summer of 2009 preliminary data collection took place in Lake Wateree where it was found that the reducing conditions necessary for sediment release of phosphorous do develop. Prior analysis of nutrient inflow-outflow using EPA/STORET data showed that more nutrients enter the lake than leave it on an annual basis. This project follows-up on that work to measure phosphorous stocks in the lake and sediment phosphorous flux. This will occur over a several month period with emphasis on the growing season.

Methodology / results: This project is still in progress with a planned completion date of 31 October 2011. There are two primary areas of activity at this stage. The first is water column and sediment sampling at seven stations throughout Lake Wateree. Thus far these sampling events occurred in January, March, and May. The next one is scheduled for June. Laboratory analysis is incomplete.

The second active part of this project involves the benthic chambers to measure sediment phosphorous flux. Design is complete and construction and laboratory testing of one chamber is complete. Field testing of the chamber is scheduled for the week of May 23. Once we are satisfied with the first chamber we will construct the second one. First field deployment is scheduled for June.

Information Transfer Program Introduction

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	3	0	1	0	4
Masters	3	0	0	0	3
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	7	0	1	0	8

Notable Awards and Achievements

SC WRC organizes annual NIWR meeting for 2011

The South Carolina Water Resources Center (SC WRC) at Clemson University is part of a national organization called the National Institutes for Water Resources (NIWR). NIWR is made up of 54 different institutes, including centers at all 50 states and a few U.S. territories. Dr. Jeff Allen served as the President-Elect for NIWR for 2010/2011. One of the responsibilities of the NIWR President-Elect is to plan the annual meeting held in Washington D.C. The 2011 NIWR meeting was held from February 14-16, 2011 at the Liaison Hotel.

Planning for the 2011 NIWR meeting was a process that took many months. Since Dr. Allen was tasked with planning the annual meeting, the SC WRC was responsible for hosting the meeting webpage and arranging the details for the gathering in Washington, D.C. Starting in September 2010, a team at the SC WRC began creating the content for the webpage that would be hosted by the center. On the webpage, attendees could register for the meeting, pay registration dues, and find information for the hotel. Also in September, a working agenda for the meeting was created, detailing the various speakers the SC WRC hoped to invite and topics of interest to cover at the meeting in February.

In December 2010 and January 2011, invitations to speakers were sent out. Some of the speakers who came to the meeting included John Schefter (Chief, Office of External Research, USGS), Dr. Joe Manous (US Army Corps of Engineers), David Trimble (US Government Accountability Office), Anne Castle (Assistant Secretary for Water and Science, Department of the Interior), Margaret Davidson (Director, NOAA Coastal Services Center), and Dr. Tim Kratz (Division of Environmental Biology). These speakers were chosen because their various perspectives on water research could give the institute leaders guidance and perspective on research and funding needs across the country.

In addition to inviting speakers, there were small details that the SC WRC had to attend to for the annual meeting. Part of planning for the meeting included gathering speakers' biographies. Agendas also had to be finalized and printed out. Nametags had to be created for every attendee. Also, gifts for attendees and speakers had to be ordered and assembled – in this case, the gifts were Strom Thurmond Institute mugs filled with orange M&Ms.

Planning for the meeting also included working with Van Scoyoc Associates. Van Scoyoc is a federal government affairs firm that lobbies on behalf of NIWR at the federal level. In addition to the lobbying duties, Van Scoyoc helps negotiate the contract with the hotel every year for the NIWR meeting. Working with Van Scoyoc, the SC WRC made sure audio-visual (AV) equipment was available at the meeting and gave the hotel the details needed to provide food for all the attendees.

A team from the SC WRC drove to Washington, D.C. two days before the meeting occurred to make final preparations. The team brought back-up AV equipment in addition to all the prepared materials for the meeting. At the meeting, the SC WRC set up and managed the registration table, set out materials in meeting rooms, made sure AV equipment was operating properly, and addressed attendees' needs.

After the meeting, the SC WRC sent out thank you letters to all of the speakers. The SC WRC also surveyed members of NIWR who were in attendance at the annual meeting and those who were unable to come to the 2011 gathering. Additionally, the SC WRC prepared a guide for next year's meeting and compiled survey responses to help improve the 2012 meeting.

Overall, planning and preparing the 2011 annual NIWR meeting was an eventful and rewarding experience for the SC WRC. The SC WRC was glad to be a key part in the national organization in 2011 and is willing to share their experiences with institutes that host the annual meeting in the future.

During the FY 2010, the South Carolina Water Resources Center sponsored the following lectures and seminars:

“From Silent Spring to Silent Night: A Tale of Toads and Men,” featuring Dr. Tyrone Hayes.

On January 28, 2011, the SC WRC cosponsored a lecture that featured Dr. Tyrone Hayes. Dr. Hayes is currently a professor in the Department of Integrative Biology at the University of California at Berkeley, where he has been internationally recognized for his research on endocrine disrupting chemicals.

Dr. Hayes’ lecture was focused on his research relating to the herbicide known as atrazine. Through his research, Dr. Hayes was able to determine that atrazine has led to an array of health problems in amphibian populations, including: retarded growth and development, immuno-suppression (which leads to increased disease rates and mortality), and reproductive difficulties. By identifying the ways in which atrazine has impacted the health of amphibians, Dr. Hayes has demonstrated that pesticides have a direct impact on environmental health. Due to the fact that atrazine and similar chemicals have such a substantial negative impact on the environment, Dr. Hayes has suggested that the use of these chemicals may also pose a significant risk to public health. However, Dr. Hayes has suggested that government agencies (such as the EPA) are ill-equipped to deal with the emerging scientific literature on chemicals such as atrazine and have been somewhat unable to translate this research into meaningful and effective public health policies.

“Assessing Aquatic Ecosystems: Small Streams to Great Lakes and Harbors,” featuring Dr. Allen Burton.

On April 2, 2010, the SC WRC cosponsored a seminar that was conducted by Dr. Allen Burton. Dr. Burton is a Professor and Director of the Cooperative Institute for Limnology and Ecosystems Research at the University of Michigan.

The seminar highlighted and discussed a wide variety of research projects ranging from ecological forecasting and multi-stressor integrated assessments in the Great Lakes, to in situ approaches from better linking exposure with effects in streams and coastal harbors in the U.S. and in Europe. The in situ approaches that were described by Dr. Burton delineate sediment from surface water and runoff-associated stressors and link species with population and community responses. Dr. Burton also provided examples of how sediment quality guidelines are being developed for Europe using bioavailability models, and how dominant stressor effects can be separated.

Publications from Prior Years

1. 2002SC1B ("Using Remote Sensing and GIS Technology to Assess the Relationship of Land Cover to Watershed Impairment for the Saluda River Basin South Carolina") - Conference Proceedings - Lu, Kang S. and Jeffery S. Allen. 2003. Animal Agriculture and Watershed Impairment in South Carolina: A GIS-based spatial assessment. In Ninth International Symposium on Animal, Agriculture and Food Processing Waste (ISAAFPW 2003), Durham, NC.
2. 2002SC4B ("Renovating Water for Conservation and Reuse: Developing Design Parameters for Constructed Wetlands for Domestic Wastewater Treatment and Mitigation") - Water Resources Research Institute Reports - Rodgers, Jr., John H., Kristina V. Garber, Jeffery S. Gallagher, Camille L. Stagg. 2002. Renovating Water for Conservation and Reuse: Developing Design Parameters for Constructed Wetlands for Domestic Wastewater Treatment and Mitigation, South Carolina Water Resources Center, Clemson University, Clemson, South Carolina, 28 pages
3. 2003SC7B ("Real-time Water Quality Monitoring for Education and Stakeholder Feedback in the Saluda-Reedy Watershed") - Conference Proceedings - Post, C.J., M. Goddard, S. Klaine, J. Smink, R. Otter and J. Hayes. 2003. Real-Time Water Quality Monitoring of Nonpoint Source Pollution in the Saluda-Reedy Watershed, South Carolina in USVI Water Quality Conference, December 4.
4. 2003SC8B ("Toxicological Effects of Environmental Pollutants in Lake Conestee") - Dissertations - Schreiber, E.A. A biomarker approach to measure biological effects of contaminant exposure in largemouth bass from Lake Conestee and nearby reservoirs. Masters Thesis, August 2005.
5. 2003SC7B ("Real-time Water Quality Monitoring for Education and Stakeholder Feedback in the Saluda-Reedy Watershed") - Other Publications - Post, C.M., M. Goddard and S. Klaine. 2003. Real-Time Water Quality Monitoring in the Saluda-Reedy Waterhshed. South Carolina Environmental Symposium, Oct. 15-17, Myrtle Beach, SC.
6. 2003SC8B ("Toxicological Effects of Environmental Pollutants in Lake Conestee") - Dissertations - Otter, R.R. Spatial Characterization of Biomarkers in a Contaminated Watershed: Usefulness in Ecological Risk Assessments. Dissertation. May 2006
7. 2004SC9B ("Modeling the Impact of Reservoir Management Regimes on Important Ecosystems in the Santee River Basin") - Dissertations - Cai, Zongshou. 2005. Multiple Input Transfer Function Model with Missing Data, MS Thesis. Statistics, College of Arts and Sciences, University of South Carolina, SC, 63 pp.
8. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Other Publications - Otter, RR, Schreiber, EA, van den Hurk, P, Klaine, SJ. Watershed scale application of biomarkers to assess ecosystem health. Poster presentation at the 25th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Portland, OR Nov 14-18, 2004.
9. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Other Publications - Schreiber, E.A., R.R. Otter, S.J. Klaine, and P. van den Hurk. The Use of Biomarkers to Evaluate Contaminant Effects on Largemouth Bass from Lake Conestee, SC, USA. Poster presentation at the 25th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Portland, OR, Nov. 14-18, 2004.
10. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Other Publications - Schreiber, E.A, R.R. Otter, S.J. Klaine, P. van den Hurk. Effects of Legacy Contaminants on Largemouth Bass in the Saluda Watershed. Poster Presentation at the Annual Meeting of the Carolinas Chapter of SETAC. April 2005, Raleigh, NC.
11. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Other Publications - Otter, R.R., E.A. Schreiber, P. van den Hurk, S.J. Klaine. Watershed scale application of biomarkers to access contaminant exposure in largemouth bass. Oral platform presentation at the 26th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Baltimore, MD. Nov 13-17, 2005.

12. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Dissertations - Schreiber, E.A. A biomarker approach to measure biological effects of contaminant exposure in largemouth bass from Lake Conestee and nearby reservoirs. Masters Thesis, August 2005.
13. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Dissertations - Otter, R.R. Spatial Characterization of Biomarkers in a Contaminated Watershed: Usefulness in Ecological Risk Assessments. Dissertation. May 2006.
14. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Other Publications - Schreiber, E.S., Otter, R.R., Van den Hurk, P. (2006) A biomarker approach to measure biological effects of contaminant exposure in largemouth bass from Lake Conestee, SC, USA. *Environ. Toxicol. Chem.*
15. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Dissertations - Truman, Pamela. 2006. Toxicological effects of endocrine disrupting compounds in the Reedy River watershed [electronic resource]: A biomarker approach using Bluegill (*Lepomis macrochirus*), "M.S. Dissertation", Department of Environmental Toxicology, College of Agriculture, Forestry and Life Sciences, Clemson University, Clemson, SC, pp. 116.
16. 2005SC11B ("Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River") - Water Resources Research Institute Reports - Truman, Pamela S., Peter van den Hurk, Stephen J. Klaine and David L. Hargett. 2006. Toxicological effects of endocrine disrupting compounds in Lake Conestee and the Reedy River. South Carolina Water Resources Center, Clemson University, Clemson, SC, pp. 7.
17. 2005SC13B ("Contaminant Transfer among Sediments, Water Column, and Atmosphere in Reservoirs") - Dissertations - Sivey, John D. 2005. Comprehensive Congener-Specific Analysis as an Assessment Tool for Polychlorinated Biphenyl Contamination Trends in Lake Hartwell, SC. "MS Thesis," Department of Environmental Engineering and Science, School of the Environment, College of Engineering and Science, Clemson University, Clemson, SC, 137 pp.
18. 2005SC13B ("Contaminant Transfer among Sediments, Water Column, and Atmosphere in Reservoirs") - Conference Proceedings - Sivey, John D.; Brothersen, Tess, and Lee, Cindy M. 2005. Comprehensive congener-specific analysis as an assessment tool for polychlorinated biphenyl (PCB) contamination trends in Lake Hartwell, SC. In *Proceedings of the 230th ACS National Meeting, Division of Environmental Chemistry, Washington, DC, August 28-September 1, 2005, Volume 45, Number 2*, 83-88.
19. 2005SC13B ("Contaminant Transfer among Sediments, Water Column, and Atmosphere in Reservoirs") - Conference Proceedings - Pac, C.R., A.J. Jones & E.R. Carraway. 2005. Metal Toxicity to *Ceriodaphnia dubia* as a Probe of the Kinetic Lability of Metal Complexes. Society of Environmental Toxicology and Chemistry (SETAC) North America 26 Annual Meeting, Baltimore, MD (November 13-17, 2005).
20. 2005SC15B ("Environmental Predictors of Mercury Methylation Potential and Fish Tissue") - Conference Proceedings - Jones, A.J., C.R. Pac & E.R. Carraway. 2005. Alkalinity Effects on Metal Speciation and Toxicity to *Ceriodaphnia dubia* in Waters of Varying Hardness. Society of Environmental Toxicology and Chemistry (SETAC) North America 26th Annual Meeting, Baltimore, MD (November 13-17, 2005).
21. 2006SC29B ("A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina") - Other Publications - Jones, AJ, Carraway, ER, Klaine, SJ, Scott, MC. (2007). A statewide sediment and water quality approach to characterize pollution in wadeable streams of South Carolina. Poster presented at the joint Carolinas and Southeastern Regional Meeting of the Society of Environmental Toxicology and Chemistry, Athens, GA, April 11-13.
22. 2006SC29B ("A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina") - Other Publications - Jones, A.J., Carraway, E.R., Klaine, S.J., Scott, M.C. (2007). A statewide sediment and water quality approach to characterize pollution in

- wadeable streams of South Carolina. Poster presented at Clemson University Restoration Institute Water Forum, Clemson, SC, April 5.
23. 2006SC30B ("A Statewide Biomarker Approach to Investigate Pollution Effects on fish in Wadeable Streams of South Carolina") - Other Publications - Keaton, Molly. (2007). Biomonitoring in South Carolina wadeable streams: Biomarkers of PAH exposure in sunfish species. Poster presented at Clemson University Restoration Institute Water Forum, Clemson, SC, April 5.
 24. 2006SC30B ("A Statewide Biomarker Approach to Investigate Pollution Effects on fish in Wadeable Streams of South Carolina") - Dissertations - A statewide biomarker approach to estimate contaminant effects in the wadeable streams of South Carolina. MS Dissertation, Environmental Toxicology, Clemson University, Clemson, SC, August 2007.
 25. 2007SC49B ("A Statewide Biomarker Approach to Investigate Pollution Effects on Sunfish (*Lepomis* sp.) in Wadeable Streams of South Carolina") - Water Resources Research Institute Reports - van den Hurk, Peter, Andrew Sayer, Stephen J. Klaine and Marc C. Scott. 2008. A Statewide Biomarker Approach to Investigate Pollution Effects on Sunfish (*Lepomis* sp.) in Wadeable Streams of South Carolina. South Carolina Water Resources Center, Clemson University, Clemson, South Carolina, (July 2008), 6 pp.
 26. 2007SC49B ("A Statewide Biomarker Approach to Investigate Pollution Effects on Sunfish (*Lepomis* sp.) in Wadeable Streams of South Carolina") - Dissertations - Keaton, Molly, 2007, A Statewide Biomarker Approach to Estimate Contaminant Effects in the Wadeable Streams of South Carolina, MS Thesis, Graduate Program in Environmental Toxicology, Department of Biological Sciences, College of Agriculture, Forestry & Life Sciences, Clemson University, Clemson, SC, 115 pp.
 27. 2007SC50B ("A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina (Phase 2).") - Water Resources Research Institute Reports - Carraway, Elizabeth R., Alan J. Jones, Stephen J. Klaine and Mark C. Scott, 2008, A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina. South Carolina Water Resources Center, Clemson University, Clemson, South Carolina, 16pp.
 28. 2007SC50B ("A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina (Phase 2).") - Dissertations - McNaughton, Christina. 2007. The Influence of Mercury-Dissolved Organic Matter (DOM) Complexation on Toxicity in Natural Waters, Environmental Toxicology, Department of Biological Sciences, College of Agriculture, Forestry & Life Sciences, Clemson University, Clemson, SC, 225 p.
 29. 2007SC50B ("A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina (Phase 2).") - Other Publications - Jones, Alan, Elizabeth Carraway and Steve Klaine, 2007, A Statewide Sediment and Water Quality Approach to Characterize Pollution in Wadeable Streams of South Carolina, Poster presented at the SETAC (Society of Environmental Toxicology and Chemistry) North America 28th Annual Meeting, 43. Milwaukee, WI, November 11-15, 2007.
 30. 2008SC55B ("Assessing suspended sediment transport potential and supply in an urbanizing coastal plains stream") - Conference Proceedings - Owens K. J., and A. D. Jayakaran. 2008. Modeling Channel Maintenance Strategies in a Coastal Plain Watershed, in South Carolina Water Resources Conference 2008. North Charleston, South Carolina (October 2008).
 31. 2008SC55B ("Assessing suspended sediment transport potential and supply in an urbanizing coastal plains stream") - Water Resources Research Institute Reports - Jayakaran, Anand D., Susan R. Libes, and Kelly J. Owens. 2009. Assessing suspended sediment transport potential and supply in an urbanizing coastal plains stream. South Carolina Water Resources Center, Clemson University, Clemson, South Carolina, August, 50 pp.
 32. 2008SC55B ("Assessing suspended sediment transport potential and supply in an urbanizing coastal plains stream") - Other Publications - Owens, Kelly J. and Anand D. Jayakaran. 2008. "Modeling Channel Maintenance Strategies in Coastal Plan Watershed." Poster presentation at the South Carolina Water Resources Conference, North Charleston, South Carolina, October 14-15.

33. 2008SC58B ("Improved Early Detection Methods for Microcystin-Producing Cyanobacteria") - Water Resources Research Institute Reports - Johnson, Alan R. and Yanru Yang. 2009. Improved Early Detection Methods for Microcystin-Producing Cyanobacteria. South Carolina Water Resources Center, Clemson University, Clemson, South Carolina. August 10.
34. 2009SC67B ("Developing a theoretical framework for water quality trading in the Saluda-Reedy watershed, South Carolina") - Water Resources Research Institute Reports - Robert T. Carey, G. Michael Mikota, Jeffrey R. Parkey. 2009. South Carolina Water Resources Center, Clemson University, Clemson, SC. 50pp.