P R O G R A M

2019 GEORGIA WATER RESOURCES CONFERENCE

April 16 & 17, 2019 • The University of Georgia • Athens, Georgia

EDITED BY

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Special Events

- Plenary Speakers (Tuesday)
  - Glen Daiger, University of Michigan
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  - Daniel Rochberg, Emory University (Tuesday)
  - Mary Walker, US EPA (Wednesday)
  - Richard Dunn, GA EPD (Wednesday)
- Evening Events
  - Little Kings Happy Hour (Monday)
  - Creature Comforts Happy Hour (Tuesday)
  - Hidden Rivers, Premiere at Ciné (Tuesday)

The 2019 GWRC is coordinated by Duncan Elkins, with Katie Hill and Wendy Paulsen of the UGA River Basin Center

River Basin Center
UNIVERSITY OF GEORGIA

History of the Georgia Water Resources Conference

The Georgia Water Resources Conference has been held biennially since May 1989. The inaugural conference included 76 oral presentations and nine posters, with an increasing number of participants and attendees at every succeeding conference. This year's conference has over 100 presentations and 36 posters.

Each conference has also seen new opportunities for workshops and training sessions. The steering committee includes representatives of the conference sponsors: U.S. Geological Survey, Georgia Department of Natural Resources, Natural Resources Conservation Service, UGA, and Georgia Institute of Technology - Georgia Water Resources Institute. The co-sponsors include federal and state agencies, professional associations, and citizen organizations.

The idea for the first Georgia Water Resources Conference came from discussions of Dr. Robert Pierce, Alec Little, and Kathy Hatcher, and stemmed from an initial statewide water conference led by Dr. Ram Arora (GSU) in 1984. The steering committee for that first conference was composed of Jeffrey Armbruster (USGS), Kathy Hatcher (UGA), Vernon Henry (GSU), Jim Kundell (UGA), Alec Little (UGA), Bob Pierce (USGS), Harold Reheis (GA EPD), and Bernd Kahn (Georgia Tech-GWRI).

The GWRI (state water research institute program, through USGS) provided grants for the first and later conferences to prepare the proceedings, which were edited by Kathy Hatcher. The complete set of conference proceedings (1989-2007) is available to the public online at www.gwri.gatech.edu.

Since its inception, the goal of the Georgia Water Resources Conference has been to provide an open forum for the discussion of current water policies, research, projects, and water management in Georgia. Papers on topics related to water policies, legislation, research, on-going studies, technical innovations, issues and concerns, current situation and trends, new approaches, management programs, data and information, education, public participation, institutional and financial arrangements, history, culture, future needs and solutions, and other topics related to water management have been encouraged and actively solicited.

This collaborative effort by water professionals has led to the advancement of water science and management in the state by providing a neutral and open forum for diverse perspectives to be presented and discussed.

James (Jim) Kundell's Legacy

For more than 30 years, Dr. James E. Kundell dedicated his career to serving the state of Georgia through research, service, and outreach. As the founding Director of the Environmental Policy Program at the Carl Vinson Institute of Government at the UGA, Dr. Kundell's scientific expertise branched far and wide -- from water management and land conservation to academic instruction at the Odum School of Ecology.

Jim served under three Governors, was appointed as a board chairman with the U.S Army Corps of Engineers, and authored or co-authored over 150 books on subjects of environmental policy. Dr. Kundell's gift for scientific research was complemented by a talent for communicating science to decision-makers and the public. He was also a gifted photographer, often capturing Georgia's natural beauty as he conducted site visits and field work.

Today, his contributions to natural resource management continue to influence students, policymakers, and professionals across the country. Indeed, readers of water resource management research and policy will often find the phrase "Courtesy of Jim Kundell" appearing repeatedly, an acknowledgement that illustrates the continued importance of his work – it is a lovely and lasting reminder of the lives he's touched and the environmental perspectives he's shaped. In short, Dr. Kundell went above and beyond the calling of most researchers, teachers, and public servants. In many ways, honoring him is honoring the beautiful and resource-rich state of Georgia and the decades of work he put into preparing us for its future. Dr. Kundell's work, his commitment to this state, and his legacy is everlasting.

As artifacts that demonstrate both his passion and expertise, Dr. Kundell's photographs remain with us as meticulously detailed living records of Georgia's natural beauty. The steering committee is honored to present a copy of his work to Dr. Mark Masters and Dr. Glen Daigger as we honor his legacy at this year's conference. Dr. Kundell was a fixture at the Georgia Water Resources Conference since its inception in 1984 until his passing, ironically as the conference convened, on April 19, 2017.

"Boneyard"

"Brunswick Port 6-28-05"

Glen T. Daigger, Ph.D., P.E., BCEE, NAE

Dr. Daigger is currently Professor of Engineering Practice at the University of Michigan and President and Founder of One Water Solutions, LLC, a water engineering and innovation firm.

He previously served as Senior Vice President and Chief Technology Officer for CH2M HILL where he was employed for 35 years, as well as Professor and Chair of Environmental Systems Engineering at Clemson University.

Actively engaged in the water profession through major projects, and as author or co-author of more than 100 technical papers, four books, and several technical manuals, he contributes to significantly advance practice within the water profession.

He has advised many of the major cites of the world, including New York, Los Angles, San Francisco, Detroit, Singapore, Hong Kong, Istanbul, and Beijing. Deeply involved in professional activities, he is currently a member of the Board of Directors of the Water Research Reuse Foundation (TWRF), and a Past President of the International Water Association (IWA).

The recipient of numerous awards, including the Kappe, Freese, and Feng lectures and the Harrison Prescott Eddy, Morgan, and the Gascoigne Awards, and the Pohland Medal, he is a Distinguished Member of the American Society of Civil Engineers (ASCE), a Distinguished Fellow of IWA, and a Fellow of the Water Environment Federation (WEF). A member of a number of professional societies, Dr. Daigger is also a member of the US National Academy of Engineers.

Mark Masters, GA Water Planning & Policy Center

Mark Masters serves as Director of the Georgia Water Planning and Policy Center at Albany State University and is a leading expert in agricultural water use and policy in the Southeastern US Throughout his career, Mark has led numerous research and outreach projects related to water resources in Georgia and has positioned the Center as a trusted technical resource for the State and its water planning efforts.

Beyond our borders, he's recently supported development of the Potomac River Basin Comprehensive Plan and, as a founding member and Executive Manager of the ACF Stakeholders, Inc, was instrumental in helping the group reach consensus on a Sustainable Water Management Plan for the entire ACF Basin.

Mark is active on a number of local, state and national advisory boards including the American Farm Bureau Water Advisory Committee, Governor's Soil and Water Advisory Committee, Institute for Georgia Environmental Leadership Board of Directors and as a Supervisor for his local Soil and Water Conservation District and Board of the Georgia Association of Conservation Districts.

When he's not busy professionally, Mark stays out of trouble volunteering at church and raising grass-fed beef with his family on their farm in Terrell County. Mark and his wife Amy also enjoy watching their three beautiful daughters make other kids look foolish on the soccer field.

Daniel Rochberg, Emory University

Daniel Rochberg is Chief Strategy Officer of Emory University's Climate@Emory initiative, an Instructor in Emory's Departments of Environmental Health and Environmental Sciences, and a co-founder of the Georgia Climate Project.

He spent seventeen years with the US Department of State, where he served as Special Assistant to the lead US climate negotiators under Presidents Bush and Obama and was a member of US delegations to multiple UN conferences, including the 2002 World Summit on Sustainable Development in Johannesburg and the 2009 UN Climate Conference in Copenhagen, and helped shape the President's Global Climate Change Initiative and the US-India Partnership to Advance Clean Energy.

Daniel participated in the 2018 class of the Institute for Georgia Environmental Leadership, was a term member of the Council on Foreign Relations, and has received the State Department's Superior and Meritorious Honor Awards and Emory University's Sustainability Innovator Award. He holds a B.A. in Human Biology with honors in environmental science, technology, and policy and an M.S. in Earth Systems, both from Stanford University.

Mary S. Walker, Acting Regional Administrator, Region 4

Mary S. Walker is the Acting Administrator for EPA's Southeast Region (Region 4). In this capacity, she leads EPA's efforts to protect human health and the environment in the eight southeastern states of Alabama, Florida, Georgia, Kentucky, North Carolina, Mississippi, South Carolina and Tennessee, as well as six federally-recognized tribes. Mary previously served as the Deputy Regional Administrator and Water Division Director in the Region 4 office. In these roles, she worked cooperatively with states to improve coordination and the timeliness of EPA actions, actions she will continue as Acting Regional Administrator.

Prior to her work at EPA, Mary served as the Assistant Director and Chief Operating Officer for the Georgia EPD (EPD), where she oversaw policy development and rulemaking for all media, permitting and compliance programs, and for general agency operations.

Mary is a graduate of the Institute for Georgia Environmental Leaders, served on the EPA/State E-Enterprise for the Environment Leadership Council, and represented Georgia on the Southern States Energy Board. She earned an undergraduate degree from Tulane University and a master's degree in Public Administration from the UGA. Mary is an Alabama native and currently lives in the Atlanta area with her husband and two children.

Richard E. Dunn, Director, Georgia EPD

Dunn was appointed Director of the EPD (EPD) of the Georgia Department of Natural Resources effective June 16, 2016. Georgia EPD is the state agency charged with protecting Georgia's air, land and water resources through the authority of various state and federal environmental statutes. These laws regulate air quality, water quality, hazardous waste, water supply, solid waste, surface mining, underground storage tanks and others.

Dunn was the former deputy director of the Governor's Office of Planning and Budget (OPB). He has also served as director of OPB's Health and Human Services division where he worked closely on the implementation of the Affordable Care Act, the behavioral health settlement agreement with the US Department of Justice, state health care programs, and child welfare. Prior to joining OPB in 2011, he worked for the Department of Behavioral Health and Developmental Disabilities where he served as the deputy chief of staff. He has also served as the acting director of the Governor's Office for Children and Families and chairman of the Georgia Occupational Regulation Review Council. Prior to his career in public service, Dunn taught courses on politics and public policy at Dickinson College and College of Charleston.

Dunn earned a bachelor's degree from Emory University and a master's degree from the UGA.

He and his wife, Susan, have one son. They reside in Atlanta.

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Conference website: www.georgiawaterconference.org/

2019 Conference Committees, Volunteers, and Exhibitors

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- Bill Bailey, USACE
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- Steve Golladay, Jones Center
- Gary Hawkins, UGA Crop & Soil Sciences
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- Scott Raulerson
- David Richards
- Jenny Sanders
- Jon Skaggs
- Ed Stowe
- Caleb Sytsma
- Maria Teresa Tancredi
- Elizabeth Tuttle
- Carol Yang

Exhibitors

- American Rivers
- Georgia Environmental Protection Division
- Greater Apalachee River Community
- Jacobs
- Oconee River Greenway Commission
- Upper Oconee Watershed Network
- USDA, Natural Resources Conservation Service
- USGS, South Atlantic Water Science Center
- YSI - A Xylem Brand

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The organizing and steering committees would like to thank the following sponsors (Champions, Advocates, and Supporters) for their generous support of the 2019 Georgia Water Resources Conference:

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TROUTMAN SANDERS

Schedule At-A-Glance

TUE	TRACK 1 (Masters Hall)	TRACK 2 (Room Q)	TRACK 3 (Room R)	TRACK 4 (Room K)	TRACK 5 (Room L)
8:30 - 10:00	1.1 Flint River	2.1 Computer Modelling	3.1 Research & Education	4.1 GA Aquatic Connectivity Team (offsite)	5.1 Speaker Practice Room
10:00 - 10:15	**BREAK**				
PLENARY 10:20 - 11:50	"Closing the Gap on One Water and Resource Recovery" by Glen Daigger, *Professor, U of Michigan, President & Founder of One Water Solutions* "Agricultural Water Use in Georgia: 2018 and Beyond" by Mark Masters, *Georgia Water Policy & Planning Center, Albany State University*				
LUNCH 12:00 - 1:15	"The Georgia Climate Project: What Does a Changing Climate Mean for Water in Georgia and What Do We Do About It?" by Daniel Rochberg, *Chief Climate Strategy Officer, Emory University*				
1:30 - 3:00	1.3 Water Management I	2.3 Groundwater	3.3 Agricultural Wetlands	4.3 Preventing Lead in Schools	5.3 Lake Lanier & Septics
3:00 - 3:15	**BREAK**				
3:20 - 4:50	**POSTER SESSION**				
WED					
8:30 - 10:00	1.5 Water Management II	2.5 Urban Infrastructure	3.5 Ecosystems	4.5 Surface Water Quality	5.5 Student Career Panel
10:00 - 10:15	**BREAK**				
10:20 - 11:50	1.6 Water Management III	2.6 Hurricanes/Flooding	3.6 Stream Health	4.6 Erosion & Nutrients	5.6 Hydrologically Connected Groundwater
LUNCH 12:00 - 1:15	Mary Walker, *Acting Regional Administrator, Region 4, US Environmental Protection Agency* Richard Dunn, *Director, Georgia EPD*				
1:30 - 3:00	1.7 Water Management IV	2.7 Forecasting/Treatment	3.7 Restoration	4.7 Agricultural Modeling	5.7 Nutrient Trading
3:00 - 3:15	**BREAK**				
3:20 - 4:50	1.8 Green Infrastructure	2.8 Climate & Drought	3.8 Wetlands	4.8 Vegetation & Hydrology	5.8 Conasauga River

TRACK 1

1.1 Flint River

1.1.1 “Restoring environmental flows in Flat Creek, Fayette County, Georgia”, by Elliott Jones, Flint Riverkeeper

1.1.2 “Evaluating effects of low streamflow on biotic components in the Upper Flint River” by Laura Rack, UGA

1.1.3 “Where has all the water gone: Examining hydrologic change in the Upper Flint River, GA?” by Stephen Golladay, The Jones Center at Ichauway

1.1.4 “Collaborative efforts toward drought resilience for people and nature in the Upper Flint River Basin” by Ben Emanuel, American Rivers

1.3 Water Management I

1.3.1 “Locals vote to lead Indian River Lagoon restoration” by Marcy Frick, Tetra Tech, Inc.

1.3.2 “Georgia CoCoRaHS: The first decade” by Christine McGehee, SERFC/NWS

1.3.3 “Planning for future generations in the Upper Oconee watershed by engaging in scenario development for desired outcomes in 2080” by Amy Rosemond, UGA Odum School of Ecology

1.3.4 “Assessing water quality from highway runoff at selected sites in North Carolina with the Stochastic Empirical Loading and Dilution Model (SELDM)” by J. Curtis Weaver, USGS

1.3.5 “A web-based information management system for environmental data” by Martin Kistenmacher, Georgia Water Resources Institute, Georgia Tech

1.5 Water Management II

1.5.1 “Comprehensive watershed management decision support system development with hydro-geospatial models integration - Lake Lanier Watershed, The case study” by Sudhanshu Panda, University of North Georgia

1.5.2 “Can Georgia Power mitigate the ACF conflict?” by Frederick Gordon, Columbus State University

1.5.3 “2019 update to the statewide nonpoint source management plan” by Anna Truszczynski, Georgia EPD

1.5.4 “Considerations for emergency action plans for high hazard dams in Georgia” by Kristin Ray, Hazen and Sawyer

1.5.5 “Rainwater harvesting: A self-funded stormwater utility” by Steve Williams, Steven Williams LLC

1.6 Water Management III

1.6.1 “Groundwater litigation: Recent cases, new strategies”, Douglas Henderson, Troutman Sanders

1.6.2 “Including groundwater users into future irrigation buy-out auctions in the FRB” by Jeffrey Mullen, UGA

1.6.3 “Pilot study on alternative instream flow considerations” by Wei Zeng, Georgia EPD

1.6.4 “Protecting and restoring flows in our Southeastern Rivers: State policies and partnerships for water security and sustainability” by April Ingle, River Network

1.6.5 “Demonstrating progress toward improving water supply efficiency” by Johanna Smith, Georgia EPD

1.7 Water Management IV

1.7.1 “Lake management strategies for source water quality improvement” by Elizabeth Crafton, Hazen and Sawyer

1.7.2 “Conservation easements are effective in maintaining ecosystem services in the Upper Chattahoochee Watershed in the Southern United States” by Fabio Jose Benez Secanho, UGA

1.7.3 “Managing forested wetlands in Georgia as a public good” by John Paul Schmidt, UGA Odum School of Ecology

1.7.4 “Oconee Confluence Clean Water Alliance (OCCWA): Forested watershed protection to improve drinking water source quality and quantity in the Upper Oconee River Basin” by Cassidy Lord Upper Oconee Watershed Network

1.7.5 “Economic drivers make the case for reuse” by Marilyn Hall, Athens-Clarke County Public Utilities Dept

1.8 Green Infrastructure

1.8.1 “Cumulative effects of Green Infrastructure (GI) on watershed hydrology: A case study and future directions” by Nahal Hoghooghi, UGA Institute for Resilient Infrastructure Systems

1.8.2 “Green infrastructure, stormwater planter bulb-outs and modular rainwater storage as part of a triple-bottom-line solution for an urban environment” by Alex Logan, Jacobs Engineering Group

1.8.3 “Atlanta's green infrastructure: Initiatives and impediments to just sustainability” by Lacey Davis, Georgia State University

1.8.4 “Stormwater management through potable use of harvested runoff at the Georgia Tech Kendeda Building for innovative sustainable design” by David Bell, Jacobs Engineering Group

1.8.5 “Rules of thumb for considering rainwater harvesting on jobs large or small” by Richard Hanson, Georgia Water Tanks

TRACK 2

2.1 Computer Modeling

2.1.1 “Evaluation of mixing capability for different nozzle configurations inside a circular water storage tank using Computational Fluid Dynamics” by Tien Yee, Kennesaw State University

2.1.2 “Revisiting the Longest Flow Path Algorithm” by Huidae Cho, Institute for Environmental and Spatial Analysis, University of North Georgia

2.1.3 “Growing application of hydraulic modeling and increasing reliance on simulation results” by. Rasheed Ahmad, WSP USA

2.1.4 “Climate change impact on crop yield and irrigation demand in the Apalachicola-Chattahoochee-Flint (ACF) River Basin” by Husayn El Sharif. Georgia Water Resources Institute, Georgia Tech

2.3 Groundwater

2.3.1 “A metric for assessing groundwater sustainability: Case study, Well Field 3, Augusta-Richmond County area, Eastern Georgia” by Gerard Gonthier, USGS

2.3.2 “Fiber optic distributed temperature sensing: An emerging groundwater monitoring technology” by Kristen Bukowski McSwain, USGS

2.3.3 “Simulation of groundwater flow in the Brunswick area, Georgia, for 2015 Base Case and selected groundwater-management scenario” by Gregory Cherry, USGS

2.3.4 “Guidance for regulation of aquifer storage and recovery” by Gail Cowie, Georgia EPD

2.5 Urban Infrastructure

2.5.1 “Long-term responses of a Piedmont headwater stream to the rapid urbanization of Its watershed” by Ted Mikalsen, Georgia EPD (Retired)

2.5.2 “Water supply forecasting as a tool for regional planning and utility management” by John Clayton, Hazen and Sawyer

2.5.3 “Effect of freshwater pollution on the integrity of bridge structures in the State of Georgia” by Saman Hedjazi, Georgia Southern University

2.5.4 “Analysis of quality-control split-replicate discrete water-quality samples on an urban water-quality program in Gwinnett and DeKalb Counties, Georgia” by Andrew Knaak, USGS

2.6 Hurricanes & Flooding

2.6.1 “Historic flooding in North and South Carolina following Hurricane Florence” by Toby Feaster, USGS

2.6.2 “Response of stressed marsh following Hurricane Irma” by Jacque Kelly, Georgia Southern University

2.6.3 “Effects of storm surge on coastal storm water systems in Georgia” by Zhongduo Zhang, School of Civil and Environmental Engineering, Georgia Institute of Technology

2.6.4 “Informing floodplain management and hazard communication through probabilistic flood inundation maps” by Brian Bledsoe, UGA Institute for Resilient Infrastructure Systems

2.6.5 “Obtaining event-based flood data through the USGS Flood Event Viewer” by Tony Gotvald, USGS

2.7 Forecasting & Treatment

2.7.1 “Stakeholder's perceptions of a small-scale wastewater treatment facility in DeKalb County” by Leesi Barinem, Dept of Geosciences, Georgia State University

2.7.2 “Uncertainty in demand forecasting: Tampa Bay Water case study and relevance to regional planning in Georgia” by John Clayton, Hazen and Sawyer

2.7.3 “The role of location cost considerations of firms on water pollution” by Temitope Arogundade, Clemson University

2.7.4 “Residential water efficiency in Georgia: Opportunities for further leadership, impact, and research” by Andrew Morris, Metropolitan North Georgia Water Planning District

2.7.5 “Updating flood-frequency statistics and regional regression equations for rural basins in the Southeastern United States” by Toby Feaster, USGS

2.8 Climate & Drought

2.8.1 “Simulated water availability in the Southeastern US for historical and potential future climate and land cover conditions” by Jacob LaFontaine, USGS

2.8.2 “Drought vulnerability model development of Georgia using updated geospatial data for management decision support” by Sudhanshu Panda, University of North Georgia

2.8.3 “Resilience of the Middle Oconee River to anthropomorphic watershed impacts and precipitation extremes” by Emad Ahmed, UGA

2.8.4 “Climate-related variability in streamwater solute concentrations and fluxes at Panola Mountain Research Watershed, Georgia” by Brent Aulenbach, USGS

2.8.5 “Low flow trends at Southeast US streamflow gages” by Tim Stephens, UGA Institute for Resilient Infrastructure Systems

TRACK 3

3.1 Water Research & Education

3.1.1 "Private well water program to educate UGA Extension Agents and homeowners" by Gary Hawkins, UGA Crop and Soil Sciences

3.1.2 "Water education and incentives for Murray 4-H'ers" by Brenda Jackson, UGA Extension - Murray County

3.1.3 "Educational materials and demonstration site designed to better educate on the management of on-site wastewater" by Beth Lunsford, UGA

3.1.4 "Gwinnett Water Innovation Center" by Melissa Meeker, Gwinnett County DWR

3.3 Agricultural Wetland Policy & Practices

Moderated by Jenny Pahl, Corblu Ecology Group

3.5 Ecosystems

3.5.1 "The creation of macroinvertebrate performance standards for a South Georgia stream restoration project" by Sean Miller, Mitigation Management

3.5.2 "Of Limpkins and Apple Snails: Invasive species, novel ecosystems, and an uncertain future" by Chelsea Smith, The Jones Center at Ichauway

3.5.3 "Wading through Georgia's oyster regulations – Shucking our way to a vibrant half-shell industry" by Danielle Goshen, UGA Law/Georgia Sea Grant

3.6 Stream Health

3.6.1 "Stream health analysis using geospatial data to assist in further in-situ water quality analysis: Lake Lanier Watershed, a case study" by Michael Mirroli, University of North Georgia

3.6.2 "Mowers versus growers: Riparian buffer management in the Southern Blue Ridge Mountains, USA" by Jenny Sanders, UGA Warnell School

3.6.3 "Knickpoints, undercuts, and slumps: Stream habitat monitoring at Chattahoochee National Recreation Area" by Jacob M. McDonald, UGA

3.6.4 "An assessment of water quality along the Appalachian Trail in Georgia" by Caleb Sytsma, UGA Warnell School

3.7 Restoration

3.7.1 "Improving fish habitat below impoundments using alternative discharge structures" by Jay Shelton, UGA Warnell School

3.7.2 "White Dam removal: Lessons learned", by Jay Shelton, UGA Warnell School

3.7.3 "Uniting stormwater management and stream restoration strategies for greater water quality benefits" by Roderick Lammers, UGA

3.7.4 "Shore protection for a sure tomorrow" by Julia Shelburne, UGA School of Law

3.7.5 "The effects of beaver dams on bioavailable organic carbon in urban streams" by Elizabeth Sudduth, Georgia Gwinnett College

3.8 Wetlands

3.8.1 "Multiscale assessment of estuarine water and sediment quality in National Park Units within the Southeast Coast Network" by Eric Starkey, National Park Service - Southeast Coast Network

3.8.2 "Using satellite data to develop wetland hydrologic models" by Courtney Di Vittorio, Georgia Tech

3.8.3 "Comparative metabolism of wetland-dominated estuaries" by Charles Hopkinson, UGA Marine Sciences

3.8.4 "Determination of predominant water source(s) to a Georgia Piedmont wetland using hydrologic modeling" by Bruce Pruitt, US Army Corps of Engineers, Engineer Research and Development Center

TRACK 4

4.1 Georgia Aquatic Connectivity Team Working Group

Moderated by Sara Gottlieb, The Nature Conservancy (offsite)

4.3 Preventing Lead in School Drinking Water

Moderated by Shannon Evanchec, with Samantha Becker, Herb Johnson, Paul Schwartz

4.5 Surface Water Quality

4.5.1 "Source water optimization: How CCWA is combatting taste and odor issues with aggressive in-lake and watershed improvements" by Roger Scharf and Kelly Taylor, Jacobs Engineering

4.5.2 "Predicting harmful algal blooms in Middle Chattahoochee reservoirs" by Wesley Gerrin, UGA Warnell School

4.5.3 "Microbial source tracking in the Chattahoochee River National Recreation Area" by Anna McKee, USGS

4.5.4 "Tracking and managing non-point source pollution in the Lake Herrick Watershed, Athens, Georgia" by Ashwini Kannan, UGA College of Engineering

4.5.5 "Strategic grazing for resistance to extreme weather events" by Subash Dahal, UGA Crop and Soil Sciences

4.6 Erosion & Nutrients

4.6.1 "Geospatial model development to analyze the reservoir volume change with the soil erosion model perspective" by Sidney McVay, University of North Georgia

4.6.2 "Identifying the impacts of prescribed fire on nutrient erosion into aquatic ecosystems utilizing lake sediment records from the SE USA" by Matthew Waters, Auburn University

4.6.3 "Strategic rotational grazing reduces sediment and sediment carbon in runoff" by Anish Subedi, UGA Crop and Soil Sciences

4.6.4 "Removal of nutrients from agricultural wastewater using modified biochar" by Jared Conner, UGA Geology

4.6.5 "The Mosaic Reservoir Process in sediment transport in large river systems" by Benjamin Webster, Auburn University

4.7 Agricultural Modeling

4.7.1 "Geospatial technology supported environmental impact assessment of historical gold mining in North Georgia" by Jeffery Robertson, University of North Georgia

4.7.2 "Projecting future agricultural water use under varying climate scenarios" by Jeffrey Mullen, UGA Agricultural and Environmental Sciences

4.7.3 "On-farm evaluation of dynamic variable rate irrigation" by Vasileios Liakos, UGA Crop and Soil Sciences

4.7.4 "ET-based smartphone applications for irrigation scheduling in corn, cotton, and soybean" by George Vellidis, UGA Crop and Soil Sciences

4.7.5 "Comparative study of estimation methods for determining soil carbon and nitrogen content in right-of-way areas in the State of Georgia" by David Penn II, Georgia Southern University

4.8 Vegetation & Hydrology

4.8.1 "Applying isotopes, mass balance, and xylem deuterium correction to water use and sourcing of two biomass tree species" by Lauren Gill, UGA Warnell School

4.8.2 "Influence of forest and vegetation type on annual evapotranspiration estimated by water budgets across 46 rural basins in the Southeastern US" by Seth Younger, UGA Warnell School

4.8.3 "Simulated Longleaf Pine restoration increased streamflow -- A case study in the Lower Flint River" by (Jill) Ji Qi, Jones Center at Ichauway

4.8.4 "Spatial and temporal dynamics of groundwater uptake by riparian vegetation at the Panola Mountain Research Watershed" by Jeffrey Riley USGS, Georgia State University

TRACK 5

5.3 Lake Lanier & Septic Systems

5.3.1 "An assessment of septic system nutrient contributions to Lake Lanier" by Brigette Haram, Gwinnett County Dept of Water Resources

5.3.2 "Assessment of septic system impacts on Lake Lanier" by Aris Georgakakos, Georgia Water Resources Institute, Georgia Tech

5.3.3 "Preliminary assessment of shoreline septic system impact on Lake Lanier water quality" by Samuele Ceolin, UGA Crop and Soil Sciences

5.3.4 "Advances in modeling the influence of onsite wastewater treatment systems on water quantity and quality" by Nahal Hoghooghi, UGA Institute for Resilient Infrastructure Systems

5.3.5 "Septic system impact to surface water quality study" by Daniel Johnson, Atlanta Regional Commission

5.5 AWRA Student Career Panel

Ridwan Bhuiyan (Jacobs), Amber Ignatius (University of North Georgia), Cody Hale (Nutter & Associates), and Jacob LaFontaine, USGS

5.6 Clean Water Act Regulation of Hydrologically Connected Groundwater: Supreme Court and EPA Actions

Moderated by Houston Shaner, Troutman Sanders

5.7 Nutrient Trading

Moderated by Laurie Fowler, UGA River Basin Center

5.8 Conasauga River

5.8.1 "Range-wide declines and spatial synchrony in Amber Darter (*Percina antesella*) populations identified with multivariate analysis" by Edward Stowe, UGA Odum School of Ecology

5.8.2 "Establishing a fish and mussel monitoring program in the Holly Creek Watershed" by Phillip Bumpers, UGA River Basin Center, Odum School of Ecology

5.8.3 "Evidence of spatial and temporal changes in benthic habitat conditions in the Conasauga River Mainstem" by Mary Freeman, USGS

5.8.4 "Genetics and the conservation status of the Trispot Darter, *Etheostoma trisella*, a recently federally listed species endemic to the Coosa River drainage" by Bernie Kuhajda, TN Aquarium Conservation Institute

POSTER PRESENTATIONS

P.01 "A comparison of benthic invertebrates in the Etowah River, 1958 & 2018" by Margi Flood, University of North Georgia – Gainesville

P.02 "Gene flow among fish populations spanning the continental divide in Gwinnett County" by Jacobo Rivera, Georgia Gwinnett College

P.03 "Gene migration of sunfish (*Lepomis spp.*) populations across the Southeastern Continental Divide" by G. Amanda Haney, Georgia Gwinnett College, School of Science and Technology

P.04 "Investigating coliform bacteria ratios relative to rainfall and stream stage in the Upper Chattahoochee River" by Kristina J. Ashe, College of Coastal Georgia, Dept of Natural Sciences"

P.05 "Assessing coliform ratios in depressional wetlands as potential indicators of hydrologic connectivity" by Catherine Wang, Cedar Shoals High School

P.06 "Field methods and photogrammetric techniques for generating maps of invasive aquatic vegetation using unmanned aerial system imagery" by Philip Ashford, UGA Geography Department

P.07 "Predicting future potential resistance and resilience of river ecosystem function to altered hydrology" by Caitlin Conn, UGA River Basin Center

P.08 "Impacts of understory rhododendron removal on Southern Appalachian Mountain stream temperatures" by Scott Raulerson, UGA Warnell School

P.09 "Comparing rate of soil moisture loss for conventional and conservation tillage systems" by Rachel Collier, UGA College of Engineering, College of Agricultural and Environmental Sciences

P.10 "Comparing LiDAR to standard field survey methods for wetland mapping in three geographically isolated wetland types" by Brian Clayton, The Jones Center at Ichauway

P.11 "Water quality monitoring in an urban nature preserve undergoing stream restoration" by Michael Kshatri, Georgia State University

P.12 "Prioritization of subwatersheds in the Upper Coosa River Basin for freshwater habitat protection" by Jon Skaggs, UGA River Basin Center, Odum School of Ecology

P.13 "Assessment of the fate of anthropogenic nitrogen and phosphorus compounds in the Ogeechee River eight years after the fish kill event" by Sumaia Islam, Georgia Southern University

P.14 "Georgia Adopt-A-Stream: Citizen science and water quality monitoring", by Harold Harbert, Georgia EPD

P.15 "Implementation guide to West Atlanta Watershed Alliance Community Science Program", by Tori Mister, Emory University, Rollins School of Public Health

P.16 "Twenty years of community stream monitoring in Athens, GA: Analysis and policy recommendations" by Luke Marneault, Oconee County High School

P.17 "Ecological restoration student design projects" by Jon Calabria, UGA College of Environment and Design

P.18 "Native salt-tolerant landscaping for Georgia's coastal hazards" by Rachel Smith, UGA Marine Extension and Georgia Sea Grant

P.19 "A spatial model to identify and prioritize potential oyster reef restoration sites along the Georgia Coast" by Cameron Atkinson, College of Coastal Georgia, Dept of Natural Sciences

P.20 "Coastal geomorphology change and spatial characterization using airborne LiDAR along the Southeast Florida Coastline" by David Richards IV, UGA Geology Department

P.21 "Modeling small order watershed freshwater contributions to estuaries along the Georgia Coast" by Isabelle McCurdy, College of Coastal Georgia, Dept of Natural Sciences

P.22 "Modeling potential hurricane storm surge flooding in the Lower Satilla River" by Sabrina Hodges, College of Coastal Georgia, Dept of Natural Sciences

P.23 "Using tidal stage to model hurricane storm surge inundation risk to development along the Georgia Coast, USA" by Clayton Davis, College of Coastal Georgia

P.24 "Water quality of a small, semi-isolated freshwater wetland on the Georgia Coast, USA" by Summer Wright, College of Coastal Georgia

P.25 "Comparison of radon-derived groundwater discharge fluxes from Georgia tidal creeks" by Katherine Curran, Georgia Southern University

P.26 "Groundwater conditions in Georgia, An interactive website" by Debbie Gordon, USGS

P.27 "Investigating subsurface flow in a karstic system considering the potentiometric surface" by Coleman Barrie, The Jones Center at Ichauway

P.28 "Impact of land cover on groundwater quality in the Upper Floridan Aquifer in Florida, United States" by Ranjit Bawa, UGA Warnell School

P.29 "Investigating the relationship between water flow path and contaminant risk from Georgia coal ash ponds in the Piedmont" by Claire Mathis, Georgia State University

P.30 "Flood-inundation maps for the Yellow River from River Drive to Centerville Highway, Gwinnett County, Georgia" by Jonathan Musser, USGS

P.31 "A hybrid approach of analyzing urban flood risk: A case study in the City of Atlanta, GA" by Nirajan Dhakal, Spelman College

P.32 "Relationships between discharge and land use / land cover in the Altamaha watershed" by Kimberly Takagi, Cedar Shoals High School

P.33 "Land use and land cover change in the Caloosahatchee River Basin in Southern Florida" by Melissa Creviston, UGA Geology Department

P.34 "Discharge distributions in the Satilla River: Relationships between discharge metrics and land use / land cover" by James Deemy, College of Coastal Georgia, Dept of Natural Sciences

P.35 "Multi-decadal forest streamflow behavior in Falling Creek, Georgia" by Todd Rasmussen, UGA Warnell School

P.36 "Comparative analysis of water-storage dynamics and storage-discharge relations among variably-urbanized catchments within the South River Watershed, Dekalb County, GA" by Jefferson Ibhagui, Georgia State University, Dept of Geosciences

P.37 "Assessing geophysical methods to detect nutrient movement from septic systems to Lake Lanier' by Maria Teresa Tancredi and Nandita Gaur, UGA Crop and Soil Sciences

TRACK 1

1.1 Flint River

1.1.1 Restoring environmental flows in Flat Creek, Fayette County, Georgia

L. Elliott Jones , *Flint Riverkeeper*

A hydrologic assessment of the Flat Creek Watershed in Fayette County, Georgia, was made to quantify releases from two water-supply reservoirs to restore environmental flows to Flat Creek. Streamflow-hydrograph analysis was performed on streamflow data from a gaging station on nearby Line Creek (Flat Creek is a tributary of Line Creek) that has more than 30 years of record. Eighteen surrogate gaging stations throughout the Georgia Piedmont were selected for comparison to the Flat Creek watershed to identify long-duration records that most closely mimic the characteristics of Flat Creek. Geographic, precipitation, land-use, and hydrologic characteristics were compared for each watershed. Hydrograph-separation analyses of streamflow data from select surrogate streamgaging stations allowed comparison of long-term average streamflow and baseflow, and temporal trends in annual flows. Paired boxplots of monthly-mean streamflows and baseflows at selected gaging stations for pre- and post-developments periods (1975 and before and after 1975), indicated reductions in seasonal streamflow and baseflow due to urbanization. Environmental-flows analyses were used to compute two suites of hydrologic parameters (1) Indicators of Hydrologic Alteration and (2) Environmental Flow Components for select surrogate streamgaging stations. The resulting parameters, which represent the entire range of streamflow conditions from low to high and quantify both streamflow extremes and the duration of high and low streamflows, can be related by the influence of various flow conditions on a broad array of ecosystem characteristics pertaining to aquatic flora and fauna and the riverine environment. The Fayette County Water System, aided by this hydrologic analysis, intends to codify a new management regime for the long term to improve environmental flows in this small watershed across a wide range of hydrologic conditions, not only during dry periods.

1.1.2 Evaluating effects of low streamflow on biotic components in the Upper Flint River

Laura Rack [1], Mary Freeman [2], Seth Wenger [1,3], Ben Emanuel [4]; [1] *UGA Odum School of Ecology,* [2] *USGS, Patuxent Wildlife Research Center,* [3] *UGA River Basin Center,* [4] *American Rivers*

The increasing frequency and persistence of droughts is becoming a greater concern with a changing climate. Prolonged and more frequent droughts result in low flow conditions that can reduce the health and function of river systems. Drought can also impact water availability for municipalities that rely on rivers for water supply. The Upper Flint River Basin in Georgia provides an important water source for multiple municipalities and supports a diverse aquatic ecosystem that offer multiple services, including recreation and biodiversity. The Upper Flint originates near the Hartsfield–Jackson Atlanta International Airport and runs south through suburban and rural areas towards the Fall Line, with urban pressures and water demand concentrated near the headwaters. Droughts occurred historically in the system, although low flow events appear to be increasing in severity. We have limited information on the effects of low flows on the biotic components specifically in the Upper Flint River. To help water managers quantify consequences of alternative management options affecting flows in the Upper Flint mainstem, we have identified biotic components of the system, including macroinvertebrates, small fishes, shoal bass, aquatic plants, and algae, that are of management interest and likely affected by more frequent and prolonged low flows. We are compiling observations and studies from other river systems to characterize potential impacts of low flow on these organisms, and to identify the types of data collection that could most effectively reduce uncertainty regarding low-flow effects. We intend this synthesis to identify components of the Upper Flint system that could act as ecosystem health indicators during low flow periods, as well as potential mechanisms of ecological resilience or recovery from prolonged drought.

1.1.3 Where has all the water gone: Examining hydrologic change in the Upper Flint River, GA?

S.W. Golladay [1], B. Emanuel [2], G. Rogers [3]

[1] *The Jones Center at Ichauway,* [2] *American Rivers,* [3] *Southern Environmental Law Center*

Recent droughts have elevated concerns about water security, i.e., the ability to provide for public supply and support in stream requirements for healthy biota and associated ecosystem services. These concerns are amplified in Georgia and the southeastern US by projections of increasing population, increasing temperatures, and uncertain precipitation. Given uncertainty, there is a need for systematic assessment of hydrologic change and recognition of biological responses. Human water use in the upper Flint is mostly municipal and commercial. Surface waters are the primary supply source in the Upper Flint and returns are much less than withdrawals. We used long term climate and stream flow data to assess hydrologic change in the upper Flint mainstem based on a period of 1940 to 2016. Annual rainfall averaged 55-56 inches per year and did not show a consistent trend during the record. However, the frequency of severe droughts was greater after the mid 1970's. Interestingly, evidence suggests an increase in the intensity of rainfall, when it occurs. Like annual rainfall, annual average stream flow did not show consistent trends. However, metrics of minimum flows (1-day, 7-day, 30-day) did show significant declines since the mid-1970's. Median monthly flows were also reduced throughout the year since the 1970's. While understanding of specific biological responses is incomplete, enough is known to suggest that major faunal groups including freshwater fishes, mussels, and crayfishes are at risk. Biota and ecological processes depending upon growing season flows may be most affected. Sufficient technical information exists to guide initial management responses and a monitoring network is in place to provide feedback. The challenge lies with engaging diverse social and economic interests in a process leading to stream flows that provide supply while sustaining ecological structure and function.

1.1.4 Collaborative efforts toward drought resilience for people and nature in the Upper Flint River Basin

Ben Emanuel, *American Rivers*

This session will summarize the 2019 publication *Ensuring Water Security for People and Nature: A Status Report from the Upper Flint River Working Group*. The report describes Working Group efforts to enhance drought resilience in Georgia's upper Flint River basin. The Working Group is a voluntary collaborative made up of the staff leadership of all the large water utilities in the upper basin, local conservationists, non-profit conservation organizations, and sustainability staff of Atlanta's international airport. From its outset in 2013, the Working Group has provided a forum for new conversations about the upper Flint River system's future and its role in the communities that depend on it. Group members share a vision of a river system healthy enough to maintain the many social, ecological, recreational and economic values that the Flint River system provides—values such as water supply, recreation, fisheries, property values and a healthy river ecosystem. Since the year 2000, four droughts have struck the Flint basin in the Georgia Piedmont. Each has brought on low river flows that are unprecedented in the historical record of flows on the Flint. The report details the Working Group's consensus-based goals and strategies for river system resilience. These goals fall under an over-arching common vision that the upper Flint River system has the capacity to meet human and ecological water needs, now and in the future. In addition, the report looks ahead to enhanced cross-sector collaboration between water managers, conservationists, river stakeholders and research scientists to improve understanding of environmental water needs and hydrologic trends in the basin. Researchers seek to inform efforts at goal-setting for river flows and drought resilience, and some are working to develop key indicators of ecological function, focused on main stem shoals, to improve understanding of the ecosystem impacts of hydrologic change in the basin.

1.3 Water Management I

1.3.1 Locals vote to lead Indian River Lagoon restoration

Marcy Frick [1] and Virginia Barker [2], [1] *Tetra Tech, Inc.,* [2] *Brevard County Natural Resources Management Department*

The Indian River Lagoon (IRL) in Florida is an Estuary of National Significance, supporting one of the greatest diversity of plants and animals in the nation. However, the IRL has been degraded because urban stormwater runoff has increased pollutant loading, causing turbid conditions and algal blooms which negatively affect the aquatic community. These pollutants also contribute to muck accumulation, which releases nutrients, depletes oxygen, and creates a lagoon bottom that is not hospitable to marine life. The municipalities located in the IRL basin, led by Brevard County, decided to work together to restore and protect the IRL system. Brevard County, working with Tetra Tech, developed and adopted the Save Our Indian River Lagoon Project Plan – a multi-pronged approach to Reduce, Remove, Restore, and Respond: reduce pollutant and nutrient inputs to the lagoon though cost-effective projects, remove the accumulation of muck, restore oysters and living shoreline ecosystem services, and measure progress to respond to changing conditions and new information. To implement the plan, the City Councils and County Commission approved a referendum for a ½ cent sales tax, which was included on the November 8, 2016 ballot. The sales tax passed by 62.4% of the votes and provides a dedicated funding source for IRL restoration projects throughout Brevard County over 10 years. To ensure the sales tax funding is used responsibly, the plan is adaptively managed through annual updates with input from an appointed Citizen Oversight Committee. During plan development, it was estimated that the benefit of restoring the lagoon has a present value of $6 billion and a cost of $300 million. In 2019, the plan will be entering the third year of implementation and projects in all categories are underway, with 12 projects completed and 38 additional under contract.

1.3.2 Georgia CoCoRaHS: The first decade

Christine McGehee, *SERFC/NWS*

The Community Collaborative Rain, Hail and Snow Net-work (CoCoRaHS) was started in Colorado in 1998. Georgia joined CoCoRaHS in 2008; since then, more than 1000 stations across the state have submitted observations. Numerous significant precipitation events have been documented, including Hurricane Matthew (2016) and Tropical Storm Fay (2008), and the September 2009 extreme rain event in the metropolitan Atlanta area. CoCoRaHS observations more than doubled the number of manual precipitation observations available for these events. CoCoRaHS data are available via the CoCoRaHS website (www.cocorahs.org), as well as in the Global Historical Climatology Network archived data set maintained by the National Centers for Environmental Information. The National Weather Service's Southeast River Forecast Center uses CoCoRaHS data to perform quality control on gridded multisensor precipitation estimates which are key forcings to the river forecast model.

1.3.3 Planning for future generations in the Upper Oconee watershed by engaging in scenario development for desired outcomes in 2080

A.D. Rosemond, S.J. Wenger, P.M. Bumpers, *UGA River Basin Center, Odum School of Ecology*

People in the Upper Oconee watershed depend on the river system for many ecosystem services, including drinking water, waste dilution, wildlife habitat, and recreation. Proactive management is critical to ensure these services will continue to be provided in the future. Currently, many streams are impaired due to fecal coliform contamination, and the biological condition of many streams is declining. Increased population growth and associated land use change, as well as climate change, will stretch the capacity for continued provisioning of ecosystem services. Scenario-building is a compelling tool that brings many stakeholders together to engage in decision-making frameworks. The approach uses input from people with diverse perspectives, values, and views of desired outcomes, and incorporates different possible events, conditions, and alternative decision-making structures. Specific outcomes are simulated using biophysical models and are synthesized and brought to life using visual art and storytelling. Alternative scenarios are useful to guide decision-making, as they lead to alternative outcomes, but can be adaptively changed as values, desires, and watershed conditions change. Such a scenario-building exercise would complement the existing sustainability and stormwater management plans of Athens Clarke-County (ACC), which are geared towards planning for a sustainable and desirable future in ACC. Models for scenario development and application exist in other rapidly growing areas in the US We will describe how these efforts could be successfully emulated by stakeholders in the Upper Oconee. These activities, with focused and highly engaged planning specific to water resources across the Upper Oconee watershed, including Lakes Oconee and Sinclair, will foster more comprehensive decision perspectives and better ultimate outcomes for current and future residents. The aim of scenario development would be to provide high quality ecosystem services from the Upper Oconee for two future generations of watershed residents (ca. 2080).

1.3.4 Assessing water quality from highway runoff at selected sites in North Carolina with the Stochastic Empirical Loading and Dilution Model (SELDM)

J. Curtis Weaver [1], Gregory E. Granato [2], Sharon A. Fitzgerald [1], [1] USGS South Atlantic Water Science Center, [2] USGS New England Water Science Center

In 2013, the USGS (USGS) and the US Federal Highway Administration (FHWA) published the national Stochastic Empirical Loading Dilution Model (SELDM). SELDM uses information about a highway site, the associated receiving-water basin, precipitation events, stormflow, water quality, and the performance of best management practices (BMP) to produce a stochastic population of runoff-quality variables (USGS, Granato, 2013). Output from SELDM allows the user to assess the statistical probability of water-quality standard exceedances downstream of a stormwater discharge. In 2015, the North Carolina Dept of Transportation (NCDOT) partnered with the USGS to enhance the national SELDM with additional NC-specific data to improve the model's predictive performance across the State. SELDM streamflow statistics were computed for 266 selected continuous-record streamgages, which were added to the USGS StreamStats application. Also, instantaneous streamflow at 30 selected continuous-record streamgages across North Carolina with drainage areas ranging from 4.12 to 63.3 square miles were used to develop recession ratio statistics. Lastly, water-quality transport curves were developed for 27 streamgages for suspended sediment concentration, total nitrogen, total phosphorus, turbidity, copper, lead, and zinc. The NCDOT identified NC highway-runoff water-quality and quantity data available from non-USGS sources. These data were reviewed for upload into the FHWA Highway-Runoff Database, the data warehouse and preprocessor for SELDM. Using techniques documented in a national BMP study (USGS, Granato, 2014) and available water-quality sample data from selected highway-runoff and BMP site pairs, performance data from the NC highway-runoff research reports were analyzed and incorporated into the NC SELDM model for three BMP types.

1.3.5 A web-based information management system for environmental data

Martin Kistenmacher and Aris P. Georgakakos

Georgia Water Resources Institute, Georgia Tech

The Georgia Water Resources Institute (GWRI) has been developing and transferring to practice information management (IM) and decision support (DS) tools for water resources and environmental planning and management for over three decades. Such tools have been developed for the ACF and other southeast river basins, the northern California river system (including Trinity, Sacramento, Feather, American, and San Joaquin Rivers and the Bay delta), Nile River, Yangtze River, and many other river basins. As the information technology platforms evolved, so did the GWRI IM&DS tools, with the initial tools focusing on single-user PC-based applications and the subsequent versions evolving to multi-user client-server applications and, more recently, to web-based applications. In addition to IT platform changes, the GWRI IM and DS tools also evolved in applicability, with the initial versions being highly customized and system specific and the later versions being more generally applicable. The purpose of this article is to describe the structure, functionalities, and application range of the most recent GWRI information management system (IMS), especially focusing on its distinguishing, state-of-technology features and applicability to a wide range of water resources and environmental management applications. *Value of IM tools in water and environmental resources management.* IM tools are becoming increasingly useful, if not necessary, as a means to keep up and manage the rapid socio-economic, environmental, and climatic changes impacting water and environmental resources. What makes these changes challenging is that their impacts are interlinked, requiring *integrated* assessments that combine multiple data types and sources across many socio-economic and environmental sectors. A case in point is provided by a recently initiated GWRI project (Septic System Impact Study, SSIS) aiming to assess the effect of septic systems on the water quality of Lake Lanier. This project is implemented in cooperation with the Gwinnett County Dept of Water Resources, UGA, Cornell University, and USGS and is described in separate articles of the conference. As part of the SSIS project, GWRI is compiling and collecting a host of geospatial and time series data for Lake Lanier and surrounding areas related to land use, hydrology, hydrodynamics, meteorology, water quality, and ecology. Such data include in-situ measurements with sensors and measurement devices, gridded climatic data, grab samples to be analyzed in laboratories, sediment cores, visual media such as photographs and videos, GIS information in the form of shapefiles and rasters, and written documents such as permits and reports. In order to utilize this information effectively, GWRI is developing an Information Management System (IMS) to help organize and analyze this data in a systematic fashion. *IMS features.* The IMS is a web-based application that includes modules such as (1) a mapping component to represent the geospatial nature of the data (e.g., water samples and field measurements taken at different locations and depths), (2) several different data formats for representing data types such as timeseries and depth profiles, (3) an account management system that allows multiple users to view, edit, upload, and share information, (4) functionalities to keep track of project equipment and field campaigns, and (5) tools for visualizing and analyzing project data. While this application is focused on the SSIS project, it is designed to be generally applicable. The application's user-driven nature allow organizations and individual users to create, share and manage content dynamically without having the rely on site administrators. This presentation provides a general overview of the system and discusses our future plans to link it with various modeling applications related to water permitting and river basin planning and management.

1.5 Water Management II

1.5.1 Comprehensive watershed management decision support system development with Hydro-Geospatial Models Integration - Lake Lanier Watershed, the case study

Sudhanshu Panda, Conrad Moore, and Yesenia Lucas, *University of North Georgia*

It is essential for watershed managers and stakeholders to know the spatial location and the sources of pollution to take preventive measures for the lake water quality enhancement. Scouting every acre of the large watershed is a cumbersome and time-consuming task. Advent of geospatial technology (GIS, Remote Sensing, GNSS, and information Technology) and ultra-high resolution data, it is becoming easier to ascertain the spatial characteristics of watersheds to know the locations and source of impairment with ease. Hydrologic model development has become easier with the model-building platform and capability available with ArcGIS software. Lake lanier watershed is the drinking water supply source for over 5 million Atlanta residents and is severely under environmental stress recently due to exponential urban growth in the watershed along with changing agricultural practices (poultry and cattle concentrated animal feedlot operations) that is environmentally regressive.Watershed analysis models developed with geospatial technology used in the comprehensive decision support system development are: Stream Health Assessment Model; Non-point Source Pollution Spatial Determination Model; Weight-based Subwatershed Pollution Vulnerability Analysis Model; Virginia Tech Bacteria Source Load Calculation model; Soil and Water Assessment Tool (SWAT) Model; Land-use Change Analysis Model; and RUSLE Model. For these model development high-resolution and easily available data were procured and processed in ArcGIS Pro software. Other than the SWAT model, all these models were developed as automated Geospatial Models in ArcGIS Pro ModelBuilder platform. All these model results were integrated together with a 12-digit HUC scale based spatial resolution to determine the integrity of each. The study result would help Lake Lanier watershed managers to pinpoint the environmentally regressed locations in the watershed and take initiative for its restoration so that Lake Lanier, a direct economic lifeline for over half a million people, would survive longer.

1.5.2 Can Georgia Power mitigate the ACF conflict?

Fred Gordon, *Columbus State University*

We hear too often that the Army Corps of Engineers is the pivotal stakeholder in the ACF conflict. However a policy impasse remains. Who is Georgia Power and what role have they played and will play in future ACF negotiation round? This paper draws upon federalism, home rule and, national mandate theory and terminology.

1.5.3 2019 update to the statewide nonpoint source management plan

Anna Truszczynski and Veronica Craw, *Nonpoint Source Program, Georgia EPD*

The Georgia EPD is updating the 2014 Statewide Nonpoint Source Management Plan, a part of the Georgia Nonpoint Source Management Program, as required under Section 319(b) of the Clean Water Act. The Statewide Nonpoint Source Management Plan outlines the goals, priorities, and implementation strategy for controlling nonpoint source discharges, such as runoff from urban areas and agriculture, to waters of the State and improving the quality of those waters. The initial development of the Plan and all subsequent updates include a robust stakeholder and public involvement process. The Plan underwent significant revisions in 2014, including the development of a watershed prioritization tool; however, the State has seen a number of changes to nonpoint source management and an update is timely. Since the 2014 Plan revision, the Georgia Coastal Nonpoint Program was approved by NOAA and EPA. Upon approval, the Georgia Coastal Nonpoint Program becomes part of the Statewide Nonpoint Source Management Plan. Additionally, several concurrent initiatives, including electronic reporting, have increased the amount and accessibility of tracking data. As a result, this update builds on the work started until the 2014 version and focuses on the following objectives: 1) enhancing the Coastal section to include critical components of the Coastal Nonpoint Source Program; 2) strengthening the connection between the Plan and existing TMDLs; and 3) developing a new assessment section that outlines Georgia EPD's strategy for tracking the implementation and impact of the Nonpoint Source Management Plan.

1.5.4 Considerations for emergency action plans for high hazard dams in Georgia

Kristin J. Ray and Ann Nunnelley, *Hazen and Sawyer*

In 2016, the Rules of Georgia Dept of Natural Resources were amended to include Rule 391-3-8-.11 titled Emergency Action Plans. This new state rule required owners of high hazard dams to develop and submit an Emergency Action Plan (EAP). Subsequently, the Georgia Safe Dams Program developed a template to assist dam owners with EAP preparation. The *Federal Guidelines for Emergency Action Planning for Dams* says an EAP "is a formal document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize loss of life and property damage." EAPs consist of actions and communications taken when an abnormal situation arises at a dam as well as downstream inundation mapping used for evacuation in the event of a dam failure or imminent failure. The EAP should define responsibilities of the dam owner and those of local emergency management agencies (EMAs). Currently, there are no requirements for owner-developed EAPs to be coordinated with EMAs, leading to inconsistencies in the breakdown of responsibilities between owners and emergency responders across EAPs, even for dams in the same community. Also, verbiage used in typical owner-prepared EAPs sometimes conflicts with verbiage used by the local emergency responders, leading to confusion during an emergency. Lastly, typical EAPs contain paper copies of inundation maps with evacuation routes and tables listing contact information for downstream properties at risk, where many EMAs use modern technology to notify people and initiate evacuations. This paper will describe the current standard of practice for developing and maintaining EAPs in Georgia, as well as discuss ideas for the dam industry to raise the standard to develop more meaningful EAPs. EAP workshops and tabletop exercises will also be discussed as a way to collaborate between the dam owner and EMAs to develop and practice the emergency processes before an actual emergency develops.

1.5.5 Rainwater harvesting: A self-funded stormwater utility

Steve Williams, *Steven Williams LLC*

This proposal will explain how using rainwater harvesting as a Best Management Practice (BMP) to reduce flows during rain events and use the water for non-potable needs. Water captured from storm events can be sold to customers needing non-potable water through the leasing of tanks and access to water from larger tanks via hydrants. If rainwater harvesting systems (RHS) were placed through out a city to supply clean non-potable water, much of our water could be supplied directly from the rain. The problem of implementing RHS on a large scale in the private sector is large upfront costs and lack of short-term payback. Many irrigation RHS will take will have a payback of 10 years or more due to seasonal use and the erratic climate patterns; however, once installed, cost and maintenance are minimal. A RHS have a life cycle of 20-30 years or more giving a positive return on 10 years or more to payback. If the utilities had a revenue source from rain harvesting they should embrace the practice. Through my investigation in this project, the lower energy requirements discovered and stormwater management benefits in RHS are the key to making them economical. This led me to realize that this concept could be used as a self funded stormwater utility that provides a product (water) for a fee to pay for the utility cost. By managing rainwater and stormwater efficiently would insure plenty of water for generations. Expanding the reservoir system with the cost of land, new infrastructure, energy use, environmental issues and the loss due to evaporation seems futile. A decentralized system can be implemented within several years instead of the decades it takes to complete a reservoir. With drought conditions forecast for Georgia in the near future, now is the time to consider implementing this plan.

1.6 Water Management III

1.6.1 Groundwater litigation: Recent lawsuits, new theories

Douglas A. Henderson and J. Houston Shaner, *Troutman Sanders LLP*

In the last few years, a wide range of federal and state lawsuits have been filed involving claims related to groundwater quality. Some of these lawsuits involve claims under the Clean Water Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act. Other lawsuits have been filed as more traditional trespass, nuisance, strict liability and nuisance actions. Still other groundwater lawsuits have been filed as class actions or mass tort actions, in some cases seeking the costs of "medical monitoring." And a few lawsuits have been filed as "natural resource damage" actions involving groundwater impacts. This presentation reviews the wide range of legal theories for filing and defending cases involving claims of groundwater quality. Using a few actual cases, the presentation will review and analyze the legal requirements for bringing lawsuits over groundwater quality and quantity, discuss available defenses, and summarized the recurring issues that arise in groundwater litigation.

1.6.2 Including groundwater users into future irrigation buy-out auctions in the FRB

Jeffrey Mullen and David Flynn, *UGA Dept of Agricultural and Environmental Economics*

Georgia's Flint River Basin has water management challenges from extensive groundwater pumping for agriculture and in-stream flow requirements. The state has experimented with buying out irrigation permits through auctions. Past auctions were relegated to surface water permits. Recently, the state has allowed groundwater permit holders to participate in future auctions. Techniques are needed to reconcile the disparate impacts of groundwater and surface water withdrawals on in-stream flows when comparing offers in a buy-out auction. In this presentation, we demonstrate one possibility which we call the Flow-Impact Offer (FIO). The FIO is based on the flux-to-withdrawal ratio associated with an irrigation withdrawal. We illustrate the potential efficiency gains of the FIO through a simulated auction in the Flint River Basin.

1.6.3 Pilot study on alternative instream flow considerations

Wei Zeng, *Georgia EPD, Watershed Protection Branch*

During the first round of Regional Water Planning and the subsequent Review and Revision, the State's Interim Instream Flow Protection Policy has been used as instream constraints in Surface Water Availability Resource Assessment. Given that the Interim Policy mostly deals with low flows and that it was developed for permitting rather than planning purposes, there clearly is room for consideration of alternatives. As requested by the Middle Ocmulgee Regional Water Planning Council, EPD commissioned a pilot study looking into alternative instream constraints that specifically correspond to resource values and usage. This submission summarizes the effort and preliminary results of the pilot study.

1.6.4 Protecting and restoring flows in our Southeastern Rivers: State policies and partnerships for water security and sustainability

April Ingle and Katherine Bear, *River Network*

This presentation provides an overview of the findings from the "Protecting and Restoring Flows in Our Southeastern Rivers: A Synthesis of State Policies for Water Security and Sustainability" report. The report synthesizes and compares the status of 15 flow-related policies in Alabama, Georgia, North Carolina, South Carolina, and Tennessee: *Water budgets*– Policies relating to gathering and utilizing information on how much water is being used and returned to river basins. *Managing supply* – Policies relating to management of water supply and river flows, including water withdrawal permitting and tracking, interbasin transfer evaluation and water planning. *Flow protection* – Policies relating to both science-based environmental flow criteria as well as mechanisms or policies to apply the criteria, including water allocation and withdrawal permitting policy and water quality standards. *Reducing Demand* – Policies relating to water conservation and efficiency, including managing water loss and integrating conservation and efficiency into withdrawal requirements. *Built Environment* – Policies relating to reducing the demand for water and creating more natural systems in the "built environment" that contribute to and replenish our streams and rivers, including requiring more water efficient fixtures and appliances and encouraging or requiring, through stormwater permitting, developments to retain more water on-site. The report is currently being updated and policy changes between 2016 and 2019 will be highlighted. The session will also feature an overview of the Business for Water Stewardship Project Bank. The Business for Water Stewardship Project Bank was developed in response to growing business interest in projects that restore river flows and recharge ground water and offers an opportunity for organizations to share their restoration projects with potential corporate partners. The Bonneville Environmental Foundation uses the Project Bank to share and learn about organizations and restoration projects and to represent specific projects to businesses seeking opportunities to support environmental water stewardship.

1.6.5 Demonstrating progress toward improving water supply efficiency

Tim Cash, Bill Frechette, Johanna Smith, Wei Zeng

Georgia EPD

The presentation will highlight current water efficiency requirements for water systems who serve populations greater than 3,300 and how these requirements are now being incorporated into EPD's water withdrawal permitting processes. EPD will present the next steps for further implementation of the Georgia Rules for Public Water Systems to Improve Water Supply Efficiency and Water Stewardship Act. With seven years of water audit data available, EPD is evaluating trends in the submitted water audit data for the basic measures captured in the Rules as part of the application evaluation process. This analysis is taking a closer look at the implementation of the Rule and examining ways to make this process straightforward for systems.

1.7 Water Management IV

1.7.1 Lake management strategies for source water quality improvement

Elizabeth Crafton, Erik Rosenfeldt, Doug Baughman, *Hazen and Sawyer*

There is an overall increasing trend in algal blooms, most notably cyanobacteria-dominated algal blooms. Many water supply systems are plagued by such blooms, which places an added burden on the water treatment plant and increases operational costs. In addition to addressing the biomass from elevated algal/cyanobacterial growth, secondary metabolites, such as, taste and odor compounds must also be accounted for and sufficiently removed in the treatment plant. Furthermore, a group of toxic secondary metabolites produced by cyanobacteria, cyanotoxins have elevated concerns due to required tracking of potential toxins. Addressing these issues requires a holistic multi-barrier approach that encompasses treatment process improvements, short-term management and long-term restoration of the source water system, and watershed management. The focus of this paper will be on the source water component; it will outline both short-term management techniques that can minimize the impact on the water treatment plant and reduce the risk of cyanotoxin presence, and long-term restoration techniques to prevent excessive growth and blooms. A key point of the source water component is the need for more effective monitoring and data review as it will drive both short-term management decisions and long-term restoration options. Maintaining source water quality is imperative and requires active, data-driven management. Source water monitoring and data review are the first steps to mitigating excessive algal/cyanobacterial growth and blooms. Recommended strategies for source water management and the implications for water utilities will be presented.

1.7.2 Conservation easements are effective in maintaining ecosystem services in the Upper Chattahoochee Watershed in the Southern United States

Fabio Jose Benez-Secanho and Puneet Dwivedi, *UGA Warnell School*

There are several private and public tools that can be used in conserving natural lands to maintain Ecosystem Services (ESs). A conservation easement (CE) legally places a permanent restriction on the development of a private land parcel and in turn provides tax benefits to the landowner. We used the modular toolset InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) for quantify provision of six ESs (carbon storage, nitrogen, phosphorus, and sediment retention, water production, and wildlife habitat quality) provided by CEs and other land typologies (buffer area, watershed average, federal, state and local protected areas) within the Upper Chattahoochee watershed (UCW), which provides 72% of drinking water to about six million residents of the Atlanta Metropolitan Area (AMA). There were 44 CEs present in the UCW in 2011. We found that CEs provided higher levels of ESs relative to surrounding areas located in the vicinity of CEs. However, the ESs from CEs were lower relative to federal and state protected areas. Additionally, higher levels of ESs were concentrated in the northern part of the UCW because of the presence of federal and state protected areas. Overall, our results suggest that CEs are an effective tool for ensuring continuance of ESs.

1.7.3 Managing forested wetlands in Georgia as a public good

John Paul Schmidt, *UGA Odum School of Ecology*

Forested wetlands in the southeastern US provide a suite of critical ecosystem services (habitat/biodiversity, water quality, protection from extreme events), yet, relative to a pre-settlement baseline is been poorly understood at present. We present an analysis of the current management of forested wetlands in Georgia and how that management has shifted over the last 2 decades. We also estimate the value of the ecosystem services provided by forested wetlands under a set of future scenarios that differ in degree the level of conservation investment. Finally, we consider the potential for incentives to private landowners in terms of both landowner opportunity costs and public welfare.

1.7.4 Oconee Confluence Clean Water Alliance (OCCWA): Forested watershed protection to improve drinking water source quality and quantity in the Upper Oconee River Basin

Cassidy Lord, *UGA Warnell School*

Across the Unites States, 180 million people rely on the forest-water connection to supply 26 thousand communities with high quality water for municipal use (USDAFS, 2000). Nearly two-thirds of the State of Georgia’s 25 million acres are forested, 90% of which are privately owned (USDAFS, 2012). In the Upper Oconee river basin of Northeast Georgia, forested lands constitute 55% of the landscape. Twenty percent of these forests disappeared in the last 20 years. Communities in the basin have a 94% reliance on surface water sources for drinking water and a 30 year projected population increase of 52%. State, regional and local agencies have documented extensive levels of fecal coliform contamination and pervasive signs of urban stream syndrome in local waterways (GAEPD, 2018; NEGRC, 2017, ACCGOV, 2018; Walsh et al, 2005). The Oconee Confluence Clean Water Alliance (OCCWA) is being developed to address both decreasing forest cover and deteriorating water quality related to changing land use and urban development in the Upper Oconee watershed. OCCWA is tasked with employing non-traditional watershed management strategies, such as payment for ecosystem services, to develop forest watershed conservation initiatives that protect future drinking water supplies. The goal of this project is to facilitate stewardship, management, protection, and conservation of the greater Oconee watershed and forests through improved and enhanced multi-stakeholder collaboration, local funding mechanisms, and development and implementation of targeted watershed projects. Watershed assessments allow OCCWA’s efforts to be focused on priority areas and guide future development away from sensitive environmental resources. Other states, regions and watershed groups can easily replicate this work, facilitating expansion of forest watershed protections. Relationships between stakeholders will be strengthened, improving communication between government, agencies and organizations. These outcomes, when paired with leveraged funding and corporate interest, will enable the project to be sustained into the future.

1.7.5 Economic Drivers Make the Case for Reuse

Marilyn Hall, *Athens-Clarke County Public Utilities Dept*

1.8 Green Infrastructure

1.8.1 Cumulative effects of green infrastructure (GI) on watershed hydrology: A case study and future directions

Nahal Hoghooghi [1], Brian P. Bledsoe [1], and Heather E. Golden [2], [1] *UGA College of Engineering,* [2] *US Environmental Protection Agency*

Urbanization alters natural hydrological systems by changing stream channel networks, creating microclimates, and generating rapid runoff from precipitation and snowmelt events. Green Infrastructure (GI) has been introduced as an alternative to stormwater management practices in many urban and suburban areas to reduce the adverse water quantity (e.g., flooding) and water quality effects from urbanizing systems. Numerous studies (field study or modeling) have shown the effectiveness of local scale (i.e., plot or parcel) GI practices. However, the extent to which GI practices mediate downstream water quantity and quality needs to be evaluated. We assess how GI implementation affects watershed hydrologic responses in a 0.092 Km^2 watershed with mixed suburban, agricultural, and forest land cover. Specifically, we ask: How does the type and extent of GI practices affect water balance components. We used a spatially explicit ecohydrological model called Visualizing Ecosystems for Land Management Assessments (VELMA) to simulate ten scenarios across multiple spatial configurations of GI. We compared changes in watershed hydrological responses (peak flow, surface runoff, evapotranspiration, shallow subsurface runoff and infiltration) before and after implementation of three GI practices—rain gardens, permeable pavements, and riparian buffers. Our findings suggest the importance of the spatial configurations and extent of GI practices, as well as the model selection and degree of watershed heterogeneity in assessing the hydrological responses of watershed-scale GI implementation. Furthermore, we highlight current research gaps and challenges in GI research at the watershed scale.

1.8.2 Green infrastructure, stormwater planter bulb-outs and modular rainwater storage as part of a triple-bottom-line solution for an urban environment

Cara Scharer and Alex Logan, *Jacobs Engineering Group*

English Avenue is an urban, residential neighborhood in West Atlanta within the Proctor Creek watershed that experiences frequent flash-flooding events during downpours. To address this issue, the City of Atlanta Atlanta's Dept of Watershed Management is funding the English Avenue Neighborhood Green Streets Project and has designed twenty-eight stormwater planter bulb-outs along five neighborhood streets to reduce stormwater runoff volume and increase groundwater recharge through infiltration, while improving water quality and street aesthetics. The bulb-outs are an innovative modified form of bioretention, consisting of layers of engineered media and vegetation, that are designed to be robust, maintainable, and well-integrated into the urban landscape. Additionally, the City is funding the English Avenue Project, in addition to other green infrastructure projects in the Proctor Creek watershed, through an Environmental Impact Bond (EIB). EIBs target environmentally conscious impact investors, whom are repaid based on environmental performance. In the case of English Avenue, the metric for environmental performance is stormwater volume captured. The English Avenue Project also embodies a Triple Bottom Line project approach: environmentally, it is capturing and treating stormwater where it falls and reducing runoff into the combined sewer system or Proctor Creek, an impaired tributary to the Chattahoochee River; economically, it provides an opportunity for green jobs and local infrastructure investments; and socially, it provides an employment opportunity for residents of a historically underserved community to develop a skillset maintaining green infrastructure practices. This presentation will provide insight into the planning and design criteria for stormwater bulb-outs and modular rainwater storage systems in an urban setting, including the site selection process and ways to address maintenance concerns. Lessons learned in design, an overview of the Environmental Impact Bond, and opportunities for future refinement will also be highlighted.

1.8.3 Atlanta's green infrastructure: Initiatives and impediments to just sustainability

Lacey Jon Davis, *Georgia State University, Dept of Geosciences*

Increased population growth and urbanization of the City of Atlanta, Georgia has led to innovative policy solutions to stormwater management and limited water supply. Atlanta policymakers have recently prioritized sustainability initiatives and green infrastructure because of their potential to mitigate negative corollaries of urbanization on the city's hydrologic systems, as well as, ensure a more resilient city. A range of green infrastructure initiatives are currently being implemented through Resilient Atlanta and the Green Infrastructure Task Force. However, policymakers need to consider the potential hydrosocial ramifications of the implementation, maintenance, and viability of sustainability initiatives in relation to their effects on marginalized Atlanta communities. Reviewing centralized and decentralized green infrastructure initiatives illustrates the progress that Atlanta is making towards environmental resilience and illuminates the improvements in policy and legislation needed to garner a more holistic approach to sustainability. Utilizing a critical hydrosocial approach highlights policymakers' obligation to reduce consequences of unbalanced sustainability initiatives which result in green gentrification. Green growth policies and legislation that prioritize economic and environmental initiatives without centering social equity undermine the sustainability of green infrastructure. Sustainability initiatives that do not account for the social and economic differences in green infrastructure costs and benefits based on demographics of Atlanta residents and communities fundamentally impede the resilience of Atlanta's future. Authentic community involvement and education regarding water resource policy and decision-making processes remains imperative for actualized just sustainability initiatives.

1.8.4 Stormwater management through potable use of harvested runoff at the Georgia Tech Kendeda Building for innovative sustainable design

Nazia Nakir [1], April Kelly [1], and David Bell [2], [1] *Environmental Health & Safety Facilities Management, Georgia Institute of Technology,* [2] *Jacobs Engineering Group*

The Georgia Institute of Technology (Georgia Tech) is committed to developing its campus with an integrated, ecologically based landscape and open space system that helps them achieve their goal of environmental sustainability. Stormwater is recognized as having a significant role in improving the ecological process occurring in the campus' urban environment. To achieve the goal of environmental sustainability, Georgia Tech has developed Key Stormwater Goals including water capture and reuse, volume reduction, mimicking the natural process, a campus "regional" approach, and exceeding regulatory requirements. In coordination with these goals, Georgia Tech has partnered with The Kendeda Fund to build what is expected to become the most environmentally advanced educational and research facility in the Southeast. The Kendeda Building for Innovative Sustainable Design will pursue certification as a "Living Building," a rating system developed by the International Living Futures Institute called the "Living Building Challenge." To achieve this certification, rainwater harvested from the building roof will be treated onsite to supply all potable demands within the building. As there is currently no local ordinance to regulate rainwater harvest for potable uses from a commercial or institutional building, Georgia Tech is pursuing designation as a Public Water System (PWS) through the Georgia Dept of Natural Resources EPD (GAEPD). Jacobs Engineering is supporting Georgia Tech through coordination with the GAEPD's Public Water System permitting process which includes requirements to monitor quality of rainwater to determine potential impacts of the materials used for the facility on the roof runoff. This presentation will provide an overview of the The Kendeda Building, the Living Building certification requirements, the innovative technologies used to capture and treat stormwater for potable use, and the methods used to evaluate water quality as well as results.

1.8.5 Rules of thumb for considering rainwater harvesting on jobs large or small

Richard Hanson, *Georgia Water Tanks*

Learning Objectives: To classify client interest in rainwater harvesting in order to better match design to customer requirements. Several rules of thumb to quickly estimate available water, tank size, and usage.

TRACK 2

2.1 Computer Modeling

2.1.1 Evaluation of mixing capability for different nozzle configurations inside a circular water storage tank using Computational Fluid Dynamics

Tien Yee, Amy Gruss, Pete Williams, Charles Butterfield, *Kennesaw State University*

Water storage tanks are essential structures for any water distribution system. Normally, water is stored in these tanks for use during peak demand. Water quality within the storage tanks that are not cycled on a daily basis may deteriorate and causes concern to end users. It is essential for water storage tank to be treated with chlorine to minimize harmful pathogens residing within it. The Computational Fluid Dynamics (CFD) technique can be used as a tool to study mixing of colorless chemicals such as chlorine. In this study, a typical three dimensional circular water storage tank in Columbia County, Georgia was modeled to observe mixing capabilities of jet nozzles placed in different locations and orientations. Three nozzle configurations were observed. The CFD model chosen for this study employs the Reynolds Averaged Navier-Stokes (RANS) solver with renormalized k-ε closure model. In addition, a passive scalar transport equation was used to study tracer concentration in the storage tank. For each nozzle design configuration, potential dead zones were identified and the mixing capabilities of each configuration is quantified. The tracer study shows that for a common flowrate, the different nozzle placements produced vastly differing mixing capabilities. Summary of the results will be presented at the conference. This study may help the local water authorities, operators and engineers in assessment of geometrically similar water storage systems, or in cases of retrofitting nozzle systems to existing circular water storage tanks.

2.1.2 Revisiting the longest flow path algorithm

Huidae Cho, *Institute for Environmental and Spatial Analysis, University of North Georgia*

The longest flow path is one of important watershed parameters for hydrologic modeling and analysis. For example, many hydrologic models such as HEC-HMS, SWAT, and SWMM require the length of the longest flow path as input. However, an extensive literature review has revealed almost little to no efforts in improving its efficiency. To the author's knowledge and based on the literature review, the current grid-based longest flow path algorithm was introduced by Peter Smith in 1995 in his Hydrologic Data Development System for the Texas Dept of Transportation. This algorithm requires the calculation of two grids including the upstream and downstream flow-length grids. For a single watershed, this multi-grid approach works fine, but producing multiple longest flow paths for a large number of watersheds using this algorithm can be very inefficient because the downstream flow-length grid needs to be recalculated for each watershed. In this study, the author investigates the efficiency of this method and introduces a faster longest flow path algorithm that is implemented as a module in the Geographic Resources Analysis Support System (GRASS). He compares the performance of both approaches for random watersheds in Georgia and discusses his preliminary results.

2.1.3 Growing application of hydraulic modeling and increasing reliance on simulation

Rasheed Ahmad, *WSP USA*

In general, hydraulic modeling has undergone significant changes over the past 15 to 20 years. During this period, water modeling went through different phases. In the beginning, its utilization was limited to fire flow prediction and master planning. Now, it is used for water availability determination, outage and repair analysis, condition assessment system changes, boil-water advisory impact areas identification, water main renewal/replacement evaluation, and water loss audits. This role will continue to expand to include risk analysis, real-time monitoring, energy optimization, pressure management, and intelligent water solutions for the future. Regarding wastewater collection systems, limited hydraulic modeling of sewers didn't start until the early to mid-2000s when many large utilities had to go through consent-decree compliance for sewer overflows and spills with the threat of possible sewer moratorium. Modeling became one of the main tools for identifying system deficiencies and addressing capacity issues. Because of large data requirements and complexities of hydraulic modeling, utilities have been slow in performing in-house sewer modeling work. However, this trend is changing over the last several years due to modeling benefits of capacity optimization, smart network, and advanced alert systems. This paper presents more than a decade of in-house water and sewer hydraulic modeling experience by the author for the southeast's largest utility. It covers the evolution of modeling needs and roles, and explains why utilities are heavily relying on simulation tools. The work can greatly benefit water industry professionals and other stakeholders.

2.1.4 Climate change impact on crop yield and irrigation demand in the Apalachicola-Chattahoochee-Flint (ACF) River Basin

Husayn El Sharif and Aris P. Georgakakos

Georgia Water Resources Institute, Georgia Tech

Biophysical crop models coupled with modern meteorological and soil data can support better crop planting strategies, more efficient irrigation water use, and more resilient drought management responses to climate variability and change. In this study, soil, crop, and meteorological gridded data are combined with the Decision Support System for Agrotechnology Transfer - Cropping System Model (DSSAT-CSM) to assess the sensitivity of crop yield (peanuts, corn, soybeans, and cotton) and irrigation demand to historical and projected climate conditions in the Apalachicola-Chattahoochee-Flint (ACF) river basin. The data used in the study include University of Idaho GRIDMET daily meteorological data (GRIDMET), HarvestChoice Global high-resolution soil profile database for crop modeling applications (HC-GHRSPD), USDA-NASS CropScape Cropland Data Layer, and bias-corrected, downscaled Global Circulation Model (GCM) outputs. *Historical crop yield trends.* Preliminary simulation results with the historical climate suggest that throughout the ACF, the yields of most major crops show no significant trends, except for corn in the southern ACF where yield is declining due to rising temperatures and precipitation shortfalls. In this region, even when corn water demand is met fully (via supplementary irrigation), crop yield is decreasing due to temperature stresses. *Historical irrigation demand trends.* The assessments illustrate that the irrigation demand required to sustain current yields is increasing markedly, especially during drought years when the required irrigation amounts are several times the long term historical irrigation means. Our investigations also confirm that droughts are occurring with increasing frequency and severity, especially in the southern half of the ACF. *Projected (future) crop yield and irrigation trends.* Climate change assessments with bias-corrected and downscaled General Circulation Model (GCM) projections (of temperature and precipitation) to the end of the current century suggest that both rain-fed and irrigated agricultural activities are likely to experience reductions in yield and increases in irrigation demand. Such changes would impact other ACF water uses and call for the development of comprehensive climate adaptation plans.

2.3 Groundwater

2.3.1 A metric for assessing groundwater sustainability: Case study, Well Field 3, Augusta-Richmond County area, Eastern Georgia

Gerard J. Gonthier, USGS South Atlantic Water Science Center

The USGS (USGS), in cooperation with Augusta Utilities, has been assessing groundwater sustainability of the Cretaceous aquifer system in the Augusta-Richmond County area, Georgia. Augusta Utilities has been operating Well Field 3, located about 11 miles south of the Fall Line in central-southern Richmond County since 2007. The USGS has monitored water levels in wells with continuous recorders in Richmond and Burke Counties for Augusta Utilities and the Georgia EPD since 1995. Water-levels in three of the four long-term monitoring wells and all five wells at Well Field 3 have been declining. A metric was devised that uses both the rate of water-level decline and the height of the present-day water level above the top of the aquifer to determine sustainability of production wells at Well Field 3. The water-level trend is determined using least-squares regression on water-level measurements that are minimally affected by recent pumping. The trend line is then lowered by the amount that pumping is determined to lower the water level. The lowered trend line is then extended into the future to the time that the water level is projected to go below the top of the aquifer. The predicted time for the water level to go below the top of the aquifer is then used as a guide to assess groundwater sustainability for the production well. Using this technique, metric values for Well Field 3 wells range from approximately 50 to 550 years. The method assumes that the rate of water-level decline is constant through time. The actual rate may change, depending on pumping rates or possible attainment of aquifer hydraulic equilibrium, thereby changing conditions for when the water level would recede beneath the top of the aquifer. Continued water-level monitoring will be required to verify any change in decline rate.

2.3.2 Fiber optic distributed temperature sensing: An emerging groundwater monitoring technology

Kristen B. McSwain, USGS South Atlantic Water Science Center

The exchange of water through the groundwater/surface water interface of waterbodies has been the subject of much research over the past twenty years. Despite intense study, adequately describing the temporal dynamics and spatial patterns of groundwater/surface water interactions continues to be a challenge. Groundwater discharge areas are not often readily discernable and may require a tracer to differentiate between groundwater and surface water. Temperature has been shown to be an excellent passive environmental tracer to infer areas of groundwater movement as it interacts with surface water. The relatively recent addition of fiber optic distributed temperature sensing (FO-DTS) networks into the hydrologist's data collection tool box has increased the spatial and temporal scale of temperature observations to extensions of 5 kilometers or more with resolution of less than 1 meter and temperature precision of 0.1 degree Celsius. In an application of this technology, a 725 meter FO-DTS survey was conducted in an unnamed tributary to Hawe Creek at the Barite Hill/Nevada Goldfields Superfund Site near McCormick, South Carolina. The goal was to determine if groundwater discharge affected by acid mine drainage could be located in a tributary that bounds the abandoned mine. Four areas of groundwater discharge were identified on the basis of thermal differences. Synoptic measurements of pH and specific conductance in the surface water above and below the identified groundwater discharge sites suggest the groundwater has been adversely affected by acid mine drainage originating from the Main Pit Lake.

2.3.3 Simulation of groundwater flow in the Brunswick area, Georgia, for 2015 Base Case and selected groundwater-management scenario

Gregory S. Cherry, USGS South Atlantic Water Science Center

The Upper Floridan aquifer (UFA) is the principal water source for industrial and public supply in Glynn County, Georgia. Industrial pumping from production wells tapping the UFA near the city of Brunswick has created steep vertical hydraulic-head gradients in the Floridan aquifer system, causing high chloride (saline) groundwater from the Fernandina permeable zone of the Lower Floridan aquifer to migrate upward into freshwater zones. A regional USGS (USGS) groundwater-flow model (MODFLOW-2000) provided the basis to evaluate horizontal hydraulic-head gradients near an area of chloride contamination. The USGS particle-tracking code MODPATH was used to generate advective water-particle pathlines and calculate time-of-travel for a 2015 Base Case and a scenario simulation (Scenario C). Nine production wells near the chloride plume were eliminated from the Base Case to represent Scenario C. MODPATH computes groundwater-flow directions and time-of-travel for simulated particles in backtracking mode from discharge (three remaining production wells) toward upgradient areas. Results from the 2015 Base Case 20-year time-of-travel period indicate total particle movement ranging from 5,530 to 8,270 feet with a mean distance traveled ranging from 276 to 413 feet per year (ft/yr). Results from Scenario C 20-year time-of-travel period indicate particles moving from 2,510 to 3,647 feet with a mean distance traveled ranging from 126 to 182 ft/yr. Simulated groundwater-flow directions for Scenario C are predominantly from the west and southwest for two production wells located just north of the chloride plume and mostly from the southwest and south for the third production well located just east of the central portion of the chloride plume. Continued monitoring of groundwater quality and modeling of changing groundwater use are essential for adaptive management of critical groundwater resources in coastal Georgia.

2.3.4 Guidance for regulation of aquifer storage and recovery

Gail Cowie, Keith Carnley, Audra Dickson, Jim Kennedy, Abigail Knapp, Bijan Rahbar, *Watershed Protection Branch, Georgia EPD*

In 2016, the Georgia General Assembly passed HR1198, which directed the EPD to review regulations related to aquifer storage and recovery (ASR) systems and revise them as needed to protect aquifers and underground sources of drinking water. This review was finalized in 2017 and concluded that existing regulations, if implemented in a coordinated manner, are sufficient to protect aquifers and underground sources of drinking water. The review also identified four actions to facilitate more integrated and transparent implementation of these regulations. The presentation will describe guidance recently completed by EPD to address these four actions and detail current regulatory expectations for the permitting of ASR systems. The guidance is expected to be useful to EPD in implementing the agency's rules, to parties interested in undertaking an ASR project, and to others interested in the protection and preservation of the state's water resources.

2.5 Urban Infrastructure

2.5.1 Long-term responses of a Piedmont headwater stream to the rapid urbanization of Its watershed

Ted Mikalsen [1] and Robert L. Bourne [2], [1] *Georgia EPD (retired),* [2] *Cobb County Water System*

Among the few studies (Trimble, 1997; Leopold, et al., 2005; and Colosimo, et al., 2007) that have evaluated the long-term responses of streams to the onset of urbanization, Mikalsen and Bourne reported "An evaluation of the physical, biological, and chemical response of a tributary to Proctor Creek in Cobb County to ten years of rapid development" in the 2007 proceedings of this conference. This proposed presentation and manuscript would, utilizing 2009 and 2018 follow-up investigations, evaluate the long-term geomorphological and biological responses of this Piedmont headwater stream to sediment loading and changes in stormwater regimes over a twenty-two year period over the following three distinct phases of the development of its 1.4 mi^2 watershed: 1) 1996-2006, when the stream experienced heavy sediment and impervious coverage of the watershed increased rapidly from 21-36%; 2) 2006-09 when imperious coverage doubled to 41% and development crested at an estimated 95% of buildout; and 3) 2009-18 when little further development occurred. Historic trends, substantial changes, and interrelationships among the following physical and habitat/macroinvertebrate community responses to the sediment loading and changing stormwater regimes in the study reach and two physically different sections of the reach were evaluated: Estimated velocity, bankfull (equivilent of a 1.5 year return frequency stomflow) quantity, and shear stress; Planform and longitudinal responses such as sinuosity and slope; Bedform evolution, with reference to straight, meandering, and braiding thresholds derived from slope/quantity relationships; Changes in channel geometry, width/depth and entrenchment ratios, and Rosgen Stream Classification; Sediment particle caliber and distribution; and Habitat assessment and macroinvertebrate community composition. Among the questions addressed were: has a dynamic equilibrium been re-established; has sediment starvation occurred; how long has it taken for early heavy sediment loads to "sift" through the study reach; and has the aquatic habitat and macroinvertebrate community "improved" over time?

2.5.2 Water supply forecasting as a potential tool for regional planning and utility management

John Clayton [1], Reed Palmer [1], Steve Nebiker [2]

[1] *Hazen and Sawyer,* [2] *Hydrologics*

Surface water providers, regulators, and managers reliant on reservoir storage for supply are often vulnerable to drought-driven water shortage, during which receding lake levels threaten allocation limits, regulatory supply permits, water quality problems, or even physical supply accessibility. In many cases, these agencies develop action plans that suggest or codify physical criteria for declaring drought shortage conditions as well as response actions, such as water use restrictions and emergency supply measures, to resist or cope with further supply deterioration. Often the physical criteria for signifying drought in these plans are based on hydrologic and storage measurements, such as rainfall deficits and critical streamflow or storage levels. Reservoir storage forecasting is a powerful method for identifying water shortage conditions that is becoming increasingly accessible to local-scale water providers and managers. Instead of basing shortage conditions on fixed reservoir levels or action zones, these methods forecast the range of possible elevation trajectories over the upcoming months in a manner that resembles hurricane ensemble forecasts. Forecasts are produced by applying multiple potential scenarios of upcoming inflows to water balance models of reservoir storage and supply operations, producing corresponding storage trajectories emanating forward from the most recent levels. From this information the probability (percent of scenarios) that elevation reaches prescribed critical levels can be determined and updated as droughts continue. Shortage plans can use these probabilities as a basis for action criteria. Forecast-based trigger methods have significant advantages over static methods in that they provide an intuitive portrayal of true supply risk and that they are highly adaptable, automatically incorporating up-to-date knowledge on refill and drawdown seasonality and demand conditions. This paper will illustrate the application of reservoir supply forecasting for water supply systems in North Carolina and Georgia, and will discuss how these methods could be further applied throughout Georgia.

2.5.3 Effect of freshwater pollution on the integrity of bridge structures in the State of Georgia

Saman Hedjazi, Francisco Cubas and Daniel Castillo

Civil Engineering and Construction Department, Georgia Southern University

A preliminary assessment was done to investigate the effects of water pollutants on concrete and steel bridges located above surface waters in the state of Georgia. A research investigation was conducted to determine which contaminants, commonly found in the streams of Georgia, could deteriorate and accelerate structural damages in concrete and steel bridge structures, thereby decreasing their designed life span. Water data collected from the GA 305(b)/303(d) list of impaired waters revealed that bridge structures are continuously exposed to contaminants such as nitrate, sulfate, phosphorus, corrosive materials, and organic matter derived pollutants (e.g. humic substances and CO2) that have detrimental effects on the steel and concrete of all bridge structures. Additionally, eutrophic waters have the potential to corrode steel structures and damage concrete piers by increasing or decreasing the pH of surface waters. This study reveals that the most common negative effects on steel and concrete structures include: corrosion of reinforcing steel and other embedded metals, concrete deterioration, cracking, delamination, and spalling. Identifying initial signs of concrete and steel deterioration without compromising the structure is a difficult task. In most cases, a visual inspection was not sufficient to determine early stages of structural damage. Therefore, a more comprehensive analysis involving non-destructive tests was performed. Infrastructures in Georgia were selected and after analysis of the surrounding surface water and recognition of the water contaminant, Non Destructive Tests (NDT) were conducted to detect corrosion in concrete and steel material in the structures exposed to the polluted water. A comparison between the result of different NDT on the areas exposed to polluted streams and areas far from the pollution is presented to highlight the effects of fresh water contaminants on infrastructures.

2.5.4 Analysis of quality-control split-replicate discrete water-quality samples on an urban water-quality program in Gwinnett and DeKalb Counties, Georgia

Andrew E. Knaak, *USGS South Atlantic Water Science Center*

The USGS (USGS), South Atlantic Water Science Center (SAWSC), in cooperation with Gwinnett County Dept of Water Resources and DeKalb County Dept of Watershed Management, have established extensive surface water-quality programs to determine long-term trends and relate them to watershed characteristics. Discrete water-quality samples are collected seasonally and analyzed for a suite of constituents including nutrients, metals, and suspended sediment. The USGS implements policies to include routine collection of quality-control (QC) samples to estimate the magnitude of errors associated with variability in sample collection, sample processing, and laboratory analysis. Replicate QC samples are two or more water samples considered to be identical in composition and analysis. Replicate samples are processed and analyzed the same way to determine potential sources of variability. Different types of replicates are designed to isolate potential sources of variability in different processes. One type of replicate QC sample, split-replicate, helps determine potential sources of variability associated with sample splitting and filtering, the laboratory environment, and laboratory analysis, as the variability of sample collection are removed because a single sample is collected and then split. The USGS SAWSC has collected 121 split-replicate samples between 25 stations over a range of different flow conditions between March 2001 and March 2018. This study examines variability in 5 constituents including total nitrate plus nitrite, total phosphorus, total zinc, total suspended solids, and total dissolved solids by estimating the standard deviation as a function of concentration over a range of observed constituent concentrations.

2.6 Hurricanes & Flooding

2.6.1 Historic flooding in North and South Carolina following Hurricane Florence

Toby D. Feaster, J. Curtis Weaver, Anthony J. Gotvald, and Katharine R. Kolb, *USGS South Atlantic Water Center*

On September 14, 2018, Hurricane Florence made landfall as a Category 1 hurricane at Wrightsville Beach, North Carolina. Once over land, the forward motion of the hurricane slowed to about 2 to 3 miles per hour resulting in historic rainfall amounts across parts of North and South Carolina. New peak streamflows of record were recorded at 18 USGS (USGS) streamgages in North Carolina and 10 sites in South Carolina. Another 49 streamgages recorded peak flows in the top 5 for their record. For 11 of the 28 streamgages for which the September 2018 peak streamflow was the peak of record, the October 2016 peak following Hurricane Matthew was the second largest peak of record. For another six sites, the September 1999 peak following Hurricane Floyd was the second largest peak of record. This presentation will give an overview of the Hurricane Florence flooding as documented in USGS Open-File Report 2018-1172. It also will discuss the issue of whether having historic peak flows within such a short period of time at the same location is unprecedented.

2.6.2 Response of stressed marsh following Hurricane Irma

Jacque L. Kelly and Christine M. Hladik, *Georgia Southern University*

Salt marshes buffer developed coastal areas from storm surge produced by large storm events, like Hurricane Irma. Salt marshes have also been experiencing dieback events, leading to large mudflats, which erode, lose elevation, and impede marsh recovery. We have been monitoring vegetation, soil, groundwater, and dieback boundaries at a dieback site near St. Simons Island, GA since 2014. The dieback was recovering before Hurricane Irma, which impacted the area in September 2017. Following the hurricane, once healthy Spartina alterniflora on the platform and upland boarder vegetation became stressed, most-likely from elevated salinities and storm surge flooding. New dieback along the creek bank also appeared. Periodic monitoring of the site in the months following the hurricane has shown that the upland boarder vegetation and new dieback along the creek bank have largely recovered. The existing dieback on the platform has continued to recover, however; the stressed S. alterniflora has remained stressed. Overall, we find that the marsh is generally resilient, with most areas of the marsh returning to pre-hurricane conditions within one year following the hurricane.

2.6.3 Effects of storm surge on coastal storm water systems in Georgia

Zhongduo Zhang and Hermann M. Fritz, *School of Civil and Environmental Engineering, Georgia Institute of Technology*

The Georgia coastline has been constantly vulnerable to hurricane strikes due to extremely low-lying topography. During the 2016 and 2017 Atlantic Hurricane season, the Georgia coastline experienced two significant surge events caused by Hurricane Matthew and Irma significantly affecting the coastal storm water systems, especially in the Savannah area, despite not making nearby landfalls. Historically in 1893 and 1898, two major hurricanes made landfalls near Savannah, causing storm tides ranging from 16 to 18 feet and extensive damage. Given the growth in infrastructure, settlements and population along the coastline over the past century, it is important to study the effect of storm surge on modern coastal storm water systems to prepare for similar events in the future. The general objective of this study is to identify and model storm water systems along the Georgia Coast that are particularly susceptible to storm surge. Initially, storm water systems vulnerable to storm surge along the Georgia Coast are selected. Then, a storm water model is created for the selected system to analyze how it will be affected by storm surge and inland flooding. Furthermore, research into lower cost alternatives are investigated for the study area. HEC-RAS and HEC-MAS models are used to construct the model based on LIDAR bathymetry data, hurricane data from International Best Track Archive for Climate Stewardship (IBTrACS), and storm water system data from Savannah Area Geographic Information System (SAGIS). The results of this study will serve to educate coastal Georgia municipalities on the effects and hazards associated with storm surge and storm water system interaction. This will benefit the municipalities by increasing awareness of storm water insufficiencies and will provide a baseline technique for analyzing storm water system vulnerability to storm surge.

2.6.4 Informing floodplain management and hazard communication through probabilistic flood inundation maps

Brian Bledsoe and Tim Stephens, *UGA Institute for Resilient Infrastructure Systems*

Existing regulatory flood hazard maps in the United States depict the 100-year floodplain as a discrete boundary-indicating wet or dry, failing to account for the inherent uncertainty associated with model estimates and assuming a constant probability of flood occurrence through time. However, the uncertainty around flood hazard estimates is spatially and temporally variable and can be extensive. Further, changing land use, climate, and drainage networks can interact to compound the uncertainty associated with flood hazard estimates and impose unprecedented challenges on floodplain management. Thus, there is a need for an improved method to portray flood hazards that accounts for the inherent uncertainty associated with model estimates, clearly communicates flood hazard probability, and enables integrated floodplain management. This presentation will outline novel techniques for quantifying and portraying flood hazards through probabilistic floodplain maps and socially relevant flood hazard metrics. Probabilistic flood inundation maps that reflect uncertainty in model inputs and parameters are generated through Monte-Carlo simulations of regulatory hydraulic models. The likelihood of inundation and confidence bounds around flood extents resulting from Monte-Carlo simulations are compared with deterministic evaluations of flood hazard from current regulatory flood hazard maps in multiple climate regions of the US. Preliminary survey results that explore respondent's preference for various flood hazard depictions are presented. Additionally we describe how the confidence bounds around inundation extents can be utilized to identify areas of elevated or hidden risk and inform floodplain management. By facilitating alternative approaches of portraying flood hazards, the novel techniques described in this presentation can contribute to a shifting paradigm in flood management that acknowledges the inherent uncertainty in model estimates and the potential dynamic behavior of land use, climate, and drainage networks.

2.6.5 Obtaining event-based flood data through the USGS flood event viewer

Anthony J. Gotvald, *USGS South Atlantic Water Science Center*

The USGS (USGS) plays an important role in the collection and dissemination of flood data resulting from coastal and inland flooding events. In addition to the continuous monitoring of streamflow through its network of long-term streamgages, the USGS has established a network of short-term coastal sites for the measurement of storm surge elevation and wave height during hurricane events. The data collected by numerous self- recording water-level sensors that are deployed for the duration of an event, along with surveyed inland and coastal high-water mark elevations collected immediately after an event, are stored in the USGS Short-Term Network (STN) database for long-term archival. The collected flood data can be viewed by the public in the USGS Flood Event Viewer (FEV; https://stn.wim.usgs.gov/fev/). The FEV is a map-based data portal that allows users to explore and download sensor-based data and high-water mark records for any event in the STN database; including historic flood events dating back to 1888. The implementation of the STN has been instrumental in expanding the USGS response to flooding events such as Hurricane Matthew in October 2016, with the FEV providing an efficient method flood data dissemination.

2.7 Forecasting & Treatment

2.7.1 Stakeholders perceptions of a small-scale wastewater treatment facility in DeKalb County

Leesi Barinem, *Dept of Geosciences, Georgia State University*

Large amounts of sewer spills in DeKalb County coupled with aging wastewater collection infrastructure and increasing high-density has left the County with limited solutions. As a result, a federal judge issued a consent decree to DeKalb County to mitigate its sewage spill incidents, which mandated $700 million in sewer improvements to redress 836 raw sewage spills between 2006 and 2010. Although DeKalb County is currently attempting to fix and replace its wastewater pipelines, new, innovative, and sustainable solutions are needed. This research examines Emory University's WaterHub, a small-scale, on-site wastewater treatment facility. Through qualitative analysis that includes semi-structured interviews with three water management professionals and nine key WaterHub stakeholders, the WaterHub case study, and archival research seeks to understand the perception of small-scale wastewater treatment facilities. This research will discuss stakeholders' thoughts towards the benefits and drawbacks of the WaterHub infrastructure and stakeholder belief's regarding diversity and inclusion in the planning process of the WaterHub. Furthermore, this research will discuss if stakeholders believe that more small-scale wastewater treatment facilities like the WaterHub can reduce burdens on wastewater capacity problems in the larger DeKalb County area.

2.7.2 Uncertainty in demand forecasting: Tampa Bay Water case study and relevance to regional planning in Georgia

John Clayton, Jack Kiefer, Lisa Krentz, Dave Bracciano, *Hazen and Sawyer*

Developing long-term plans for managing water supply and use within a region often requires multi-year or -decadal forecasts of regional water demands, including agricultural, environmental, and M&I needs. M&I forecasts are inherently uncertain for several reasons. The future number of water users is never known with certainty, be it defined in terms of population, land use, dwelling units, employment, or other water use entity. The amount of water each user will demand, in turn, depends on other factors that are never known with certainty including 1) the relative amounts of users of different types, or sectors (such residential versus nonresidential or even more detailed sector profiles), 2) factors that influence use rates in each sector such as economic conditions, weather and climate, and end-use efficiency, and 3) inherent uncertainty in per-user demand estimates, even if all the above conditions are precisely known. Recognizing these uncertainties requires acknowledging and defining the range of influencing conditions that may occur, determining the corresponding range of demands, and using this range to develop plans that are flexible enough to satisfy multiple future outcomes, allow adaptation if projected demands are not realized, or both. Tampa Bay Water (the Agency), the largest wholesale water provider in Florida, provides a regional-scale case study for incorporating uncertainty in M&I demand forecasts as a planning tool. The Agency serves approximately 2.5 million people in three counties around the Tampa Bay region with a total demand of approximately 250 MGD. Since 2003, the Agency has been producing probabilistic demand forecasts that characterize demand ranges based on uncertainty in number of users and conditions affecting per-user demand. The most recent model updates, completed in 2018, incorporate all forms of uncertainty discussed above. This paper will discuss the approaches Tampa Bay Water currently takes to incorporate uncertainty, reveal several interesting outcomes including the relative importance of uncertainty from various factors and the importance of incorporating projections of future increased water use efficiency, and discuss how concepts developed herein could be selectively applied to planning in Georgia.

2.7.3 The role of location cost considerations of firms on water pollution

Temitope Arogundade, *Dept of Political Science, Clemson University*

Considerable number of studies have found that poor and minority households are disproportionately affected by pollution. Hypotheses that have been used to explain the correlation includes; the location cost considerations of firms, pure discrimination, and the migratory responses of people to pollution. This study examines the relationship between water pollution and the factors that firms consider in their location decisions. The hypothesis is that firms locate their pollution-generating facilities based on economic factors that maximize their profits, and because those factors are correlated with income and race, the poor and minorities are disproportionately affected. Examples of such factors include availability of a skilled workforce, local regulations on pollution, and the level of income, education, or political participation in a community. Understanding the relationship between such factors and the distribution of water pollution among groups will help to know whether water pollution should in fact be part of the environmental justice discourse or whether the disproportionate distribution of pollution is limited to other types of pollution. To test the relationship, the study collects data on education, employment, political participation, race, income, population, and the risks of water pollution. A multiple regression analysis is used to test the effect of each factor on water pollution. It is expected that the relationship between water pollution and factors that allow firms to locate in low-skilled and low-income communities will be negative. That is, the lower the skill-level or the poorer a community is, the higher will be the risk of water pollution. Whereas, factors that make firms locate in higher-skilled or higher-income communities will have a positive relationship with water pollution. If the expected findings hold, then it would be concluded that location cost considerations of firms do contribute to why the poor and minorities are exposed to polluted water than other groups.

2.7.4 Residential water efficiency in Georgia: Opportunities for further leadership, impact, and research

Andrew D. Morris, *Metropolitan North Georgia Water Planning District*

Georgia has established itself as a national leader in water efficiency. Recently, Georgia was graded the 4th most efficient state by the Alliance for Water Efficiency, which makes Georgia the most efficient state east of the Mississippi River. Efforts by utilities in the Metropolitan North Georgia Water Planning District ("District") have helped reduce metro Atlanta's per capita water withdrawals by over 30% since 2001. The District's efforts have been recognized by EPA's WaterSense awards programs for four consecutive years. But our work is not finished. Driven by WaterSense and plumbing fixture efficiency standards in other states, manufacturers are producing new, more efficient fixtures at prices comparable to older technology. For showerheads and faucets, the new technologies are already being used across the state and are ready today for widespread adoption. Opportunities exist to improve Georgia's plumbing code, and the District is also providing input at a national level on updated WaterSense specifications. Reducing lawn irrigation in instances when it is unneeded remains a priority, but our data show that a small percentage of residential customers account for most excessive lawn watering. The District is reworking its lawn irrigation efficiency and education efforts to focus on this small group. The data also show that most customers "underwater" their lawns based on current lawn watering recommendations. Further research is needed to understand how much water a lawn truly needs for maintenance during drought. We are exploring ways to reduce leaks on the customer's side of the meter, which account for a noteworthy percentage of indoor water use according to national data. Several utilities with AMI now have programs to alert their customers of leaks, and some customers are installing smart home technology that alerts them of leaks. The water savings potential appears promising, but further research is needed on programs and technologies.

2.7.5 Updating flood-frequency statistics and regional regression equations for rural basins in the Southeastern United States

Toby D. Feaster, J. Curtis Weaver, Jonathan W. Musser, and Anthony J. Gotvald, *USGS South Atlantic Water Science Center*

Reliable estimates of the magnitude and frequency of floods are part of the technically-based framework for hydraulic-structure design and flood-plain delineation in Georgia, South Carolina, North Carolina, and Georgia. Annual peak flows measured at USGS (USGS) streamflow gaging stations (stations) are used to compute flood frequency estimates for a location on a stream. However, such estimates also are needed at ungaged stream locations. A process known as regionalization is used to estimate the magnitude and frequency of floods for ungaged locations. Regionalization combines at-site flood-frequency estimates from a group of stations within a hydrologic region and selected basin characteristics to form the basis of estimates for ungaged stream locations within that region. In October 2017, the USGS began a cooperative investigation with the Georgia, South Carolina, and North Carolina Departments of Transportation to update the flood-frequency estimates at the USGS streamgages and to update the regional regression equations for rural basins. The most recent flood-frequency reports for the three states included data through October 2006. Consequently, many of the USGS streamgages included in that previous investigation now have 10 or more additional years of record. Updating the current regional flood-frequency equations will allow for the opportunity to reduce the uncertainty in the flood statistics and regional equations. Moreover, the peak-flow records for stations in the Midlands and Coastal Plain regions of South Carolina will include flood data from the historic October 2015 flood, which at some locations was shown to be the largest documented flood since at least 1893. In addition, record peaks also have recently been recorded at USGS stations in the Coastal Plain of South and North Carolina because of historic rainfall associated with Hurricane Matthew in October 2016 and Hurricane Florence in September 2018.

2.8 Climate & Drought

2.8.1 Simulated water availability in the Southeastern US for historical and potential future climate and land cover conditions

Jacob H. LaFontaine [1], Lauren E. Hay [2], Rheannon M. Hart [3], William H. Farmer [2], Andrew R. Bock [4], Roland J. Viger [2], Steven L. Markstrom [2], R. Steve Regan [2], and Jessica M. Driscoll [2], *[1] USGS South Atlantic Water Science Center, [2] USGS Water Mission Area, Integrated Modeling and Prediction Division, [3] USGS Lower Mississippi Gulf Water Science Center, [4] USGS Colorado Water Science Center*

A study was conducted by the USGS (USGS) to evaluate the hydrologic response of a daily time step hydrologic model to historical observations and projections of potential climate and land-cover change for the period 1952–2099. An application of the Precipitation-Runoff Modeling System (included as part of the USGS National Hydrologic Model) was used to develop the hydrologic simulations. The model simulations were used to compute the potential changes in hydrologic response and streamflow statistics across the Southeastern United States. Thirteen historical and 45 future downscaled general circulation model (GCM) simulations from the Coupled Model Intercomparison Project Phase 5 were used to represent a range of potential future changes in climate. Annual land cover maps developed by the USGS Earth Resources Observation and Science Center for the period 1938-2100 were used to represent changes in land cover in the simulations. The streamflow statistics were selected to describe streamflow conditions that may be most useful in defining the suitability for each river or stream to support sustaining populations of priority aquatic species across the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC) region in the Southeastern United States. The results of this study showed increases in air temperature, a mix of increases and decreases in precipitation and actual evapotranspiration, and general decreases in runoff throughout the Southeastern United States. Results from a statistical analysis (Kolmogorov-Smirnov test) showed that the downscaled GCMs generally have more skill in producing historical streamflow statistics in the duration and magnitude categories and less skill in producing historical streamflow statistics in the frequency, rate of change, and timing categories for this study area. The potential changes in hydrologic response are available through the GCPO LCC Conservation Planning Atlas (https://gcpolcc.databasin.org/), an online science-based mapping platform built specifically for land managers and planners.

2.8.2 Drought vulnerability model development of Georgia using updated geospatial data for management decision support

Sudhanshu Panda, Caleb Davis, and Timothy Davis, *University of North Georgia*

Droughts are events that occur where water is absent for a long period of time in an area where is it considered unusual compared to its usual conditions. Major factors that cause droughts are lack of precipitation, deforestation and global warming. With lack of precipitation in areas that usually have precipitation, the soil could get dried up. With deforestation, the ground will get more exposure to sun which could set off drying conditions. With global warming occurring, warmer temperatures increases evapotranspiration amount resulting in more dryness and bush fires. Droughts can cause a lot of different impacts that range from economic to environmental to social. For example, an economic impact would be farmers having to spend more money on getting water for their crops and livestock and another impact would be businesses that sell farming equipment are losing money since farmers are spending their money on getting water. An environmental impact would be water bodies drying out or having low quality soil, or animals having to migrate to a new habitat in search for water which would make them vulnerable to new threats that they could face. A social impact would be people having health problems or people having to move to another place that has water. Drought generally leads to wildfire which a general norm in Western United States. However, since 2010, north Georgia and even Okefenokee swamp are consistently encountering wildfire due to persistent drought. The goal of this study is to develop an automated geospatial model ArcGIS Pro ModelBuilder platform to develop drought vulnerability map of Georgia using high-resolution and timely geospatial data. Drought related geospatial data - Precipitation (USDA-NRCS Geospatial Data Gateway - datagateway.nrcs.usda.gov/); Soil Drainage, Porosity, Bulk Density, and Available Water Content (STATSGO vector data - websoilsurvey.sc.egov.usda.gov/ App/WebSoilSurvey.aspx); Temperature/Solar Radiation (Geospatial Data Gateway PRISM database); Evapotranspiration (Georgia Weather Network - www.georgiaweather. net/); Land Cover (National Land Cover Database (NLCD) 2011 raster data - (www.mrlc.gov/finddata.php); Slope (Digital Elevation Model (DEM) raster data - datagateway.nrcs. usda.gov/); Intensity Duration Frequency (IDF) raster data (NOAA site); Georgia Agriculture Land (NASS CropScape - nassgeodata.gmu.edu/CropScape/); were collected, processed, and analyzed on ArcGIS Pro to develop the automated drought vulnerability model for Georgia. Then a sustainable drought management decision support system was developed based on the results so that state authorities could be prepared for such eventualities. This automated model being very comprehensive with geospatial data use can be replicated by other researchers in different spatial areas.

2.8.3 Resilience of the Middle Oconee River to anthropomorphic watershed impacts and precipitation extremes

Emad A Ahmed [1], E. W. Tollner [1], Brian Bledsoe [1], Mu Lan [2]

[1] *UGA College of Engineering,* [2] *UGA Dept of Geography*

Increase in population and economic development combined with climate change modifies the river system both by changing the watershed characteristic (land use) and hydrologic regime which leads to altered flow pattern poor water quality and destruction of aquatic habitat if it is not managed properly. In order to effectively manage the precious resource it is vital to understand and consider the combined impact of climate and landuse changes to the flow. Therefore, it is important to assess the future change in flow and water quality based on predicted landuse change and climate so that policy and decision makers be informed timely. In this project we used ArcSWAT to model the flow in middle Oconee River. We calibrated and validated our model using SWAT-CUP SUFI2 algorithm for a period between 1992 to 2006 and 2007 to 2013 respectively. The model efficiency for the calibration is p-factor 0.76, r-factor 1.05, R2 0.80, which is in acceptable range. Climate projections from three different models from CMIP 5 project with extreme case greenhouse gas emission scenario RCP 8.5 is used. Land Transformation Model, which uses the Artificial Neural Network and ArcGIS, is used to project a possible land use change in the study area. The calibrated and validated SWAT model generated the projected flow for 2050 using the Climate and Landuse projections. These possible flow projections will help managers understand the combined effect of climate and landuse change and develop their plan accordingly. In addition the result will also help identify ways to how we fulfill the future needs without compromising the environmental flow.

2.8.4 Climate-related variability in streamwater solute concentrations and fluxes at Panola Mountain Research Watershed, Georgia

Brent T. Aulenbach, *USGS South Atlantic Water Science Center*

The effects of climatic variability on streamwater solute concentrations and fluxes were quantified from 31 years of input/output fluxes at the Panola Mountain Research Watershed, a 41-hectare relatively undisturbed, forested watershed near Atlanta, Georgia. Atmospheric inputs were determined from weekly wet deposition samples while stream solute outputs were estimated from weekly and event-based (high flow) sample concentrations using regression-based methods. All ten solutes analyzed had concentration relationships that varied with climatically controlled watershed attributes. The most pertinent climatic attributes varied by solute and included current or antecedent statuses or conditions of the shallow, deep, or overall watershed storage. The relationships varied more for reactive solutes such as sulfate and dissolved organic carbon (DOC) and less for weathering products (base cations and dissolved silica) and conservative chloride. Many solutes exhibited higher concentrations when storage levels were lower, which was likely the result of either the concentrating effects of evapotranspiration and/or the buildup and flushing of weathering products associated with longer watershed residence times. Sulfate concentrations and fluxes were substantially higher when hydrologic conditions wetted up in the fall, and particularly after long-term droughts. The effects of climatic-based changes in the concentration relationship on annual flux varied by solute and ranged from about 5% (magnesium) to 52% (nitrate and DOC) expressed as relative standard deviations. Wet deposition inputs were relatively constant over the study period except for the nearly 50% decline in acidic deposition (sulfate, nitrate, and hydrogen ion) that occurred predominantly over the last 10 years of the study. After removing the effects of climate on streamwater fluxes, no trends were observed; indicating that there was either insufficient time to detect, or an indirect response of, changes in streamwater concentrations to declines in acidic deposition. The climatic effects on streamwater concentrations may imply future effects of climatic change on streamwater fluxes.

2.8.5 Low flow trends at Southeast US streamflow gages

Tim Stephens and Brian Bledsoe, *UGA Institute for Resilient Infrastructure Systems*

The southeast US is widely perceived as a water rich region, yet recent droughts, highly variable streamflow, and growing demands for water have revealed vulnerabilities and the potential for widespread water scarcity. Additionally, water management and infrastructure design depend on quantifying thresholds in minimum flows. Recent studies indicate a decreasing trend in low flows at many stream gages in the region, but they fail provide a coherent and quantitative depiction of regional trends. Further, trends identified as statistically significant are often ignored, and thus exclude stream gage records that might nevertheless provide insight into future low flow conditions. We identify trends in the annual minimum 7-day mean streamflow for four distinct time periods over the last century and identify those trends that occur as an abrupt shift. Further, we quantify linear trend slopes regardless of statistical significance and conduct a type II error analysis to evaluate the probability of erroneously declaring a trend does not exist. A decreasing trend in low flow magnitude is identified in approximately 80% of the streamflow records over the last century. An abrupt shift in the mean low flow magnitude was identified in approximately 50% of the gage records, occurring predominantly around 1975 – 1985 and 1995 – 2005. Trend slopes indicate an accelerated rate of decline in low flow magnitude over recent decades compared to the last 50-75 years. Where statistically significant trends are not identified short record lengths (< 50 years) and high variability in hydrologic time series result in a high probability of a type II error. The results of this analysis have widespread implications for water resource management and infrastructure design.

TRACK 3

3.1 Water Research and Education

3.1.1 Private well water program to educate UGA extension agents and homeowners

Gary L. Hawkins [1], Beth Lunsford [2], Uttam Saha [3], C. Monte Stephens [4], Stephanie Butcher [5], Dana Lynch [6], Patricia West [7], Phillip Edwards [8], Amelia Hawkins [9], [1] *UGA Crop and Soil Sciences,* [2] *Emory University Rollins School of Public Health,* [3] *UGA Agricultural and Environmental Services Laboratory,* [4] *UGA Oconee County Extension,* [5] *UGA Coweta County Extension,* [6] *UGA Monroe County Extension,* [7] *UGA Bryan County Extension,* [8] *UGA Irwin County Extension,* [9] *North Oconee High School*

Private water wells are the source of water for over 65,000 homeowners in Georgia alone. This water is used for drinking, bathing, food preparation, and other uses. If the water source is contaminated with bacteria or other contaminates in the aquifer or soil above the aquifer, this could lead to health problems for the homeowner or animals that consumes the water. Therefore, the Well Water Team in the College of Agricultural and Environmental Sciences (CAES) at UGA has developed a private well water program that is being used to educate homeowners with private wells on the importance of protecting their well and how to test their water. The program has two parts. The first is designed to provide UGA Extension Agents information on aquifers, well construction, water testing, and geology. This six-hour part of the program is a powerpoint presentation, hands-on scenario analysis of private well water samples processed through the UGA Agricultural and Environmental Services Laboratory, and a demonstration of the downwell camera. The second part provides the agents with a copy of the same presentation they were trained with and they develop and host a workshop in their county(ies) to provide education on well water to homeowners with private wells. This part of the program is usually one-hour and includes a set of bottles provide by the agent to allow the homeowners to collect and sample their well water for contaminates including bacteria, minerals, and pH. The program has trained over 75 of our agents, and a few members of partner organizations. There has also been a few county-based programs developed and delivered. The Private Well Water program in CAES is designed to provide in-depth training and education for our UGA Extension agents so they are better prepared to answer questions for private well owners in their county(ies).

3.1.2 Water education and incentives for Murray 4-H'ers

Brenda L. Jackson, *UGA Murray County Extension*

To educate the youth of Murray County on the effects of stormwater runoff pollution, the Murray County ANR and 4-H Extension Agents collaborate through various experiential learning activities to educate youth on environmental awareness and water quality issues. The Agents also collaborate with Georgia Adopt-a-Stream, Army Corp of Engineers, and the UGA Warnell Schoolof Forestry Cohutta Fisheries Center, to conduct an annual 4-H2O summer camp. This camp provides educational tours and hands-on activities that focus on water conservation, aquatic ecology and sustainable aquaculture. Youth learn about the importance of reducing stormwater runoff, how to monitor water quality, and are given the GA Adopt-a-Stream exam. They are taught canoe safety and recovery while picking up trash along Carter's Lake Dam. The Cohutta Fisheries Center shares current research on channel catfish production and sturgeon aquaculture in addition to allowing them the experience of fishing in the stocked ponds (catch and release). Youth passing the Adopt-a-Stream exam are offered previously selected locations around the local watershed to adopt and monitor for one year. If they complete a specified number of monthly tests, they are offered a summer camp scholarship appropriate to their age group. In 2016, twenty 4-H members took the exam and passed, ten chose to adopt a location for one year, two 4-H'ers completed at least five monthly tests, and two completed a full year of tests. In 2017, seventeen 4-H'ers took the exam and passed and three are currently testing adopted sites. The data that these students collect is entered into the Adopt-A-Stream website, which they use to monitor the health of our local water systems. This presentation will show how the Murray County Extension agents and collaborators use the hands-on activities to better explain the importance of environmental awareness to youth through fun and hands-on activities.

3.1.3 Educational materials and demonstration site designed to better educate on the management of on-site wastewater

Beth Lunsford [1] and Gary L. Hawkins [2], [1] *Rollins School of Public Health, Emory University,* [2] *UGA Dept of Crop and Soil Science*

Wastewater is an issue that impacts everyone worldwide. As of 2015, UNICEF reported that in rural parts of the United States, roughly 70 percent of homes rely on septic tanks (UNICEF, 2017). Additionally, in 2013, Circle of Blue estimated that nearly 13-36% of all new homes being built will depend on septic systems (LaFond, 2015). Most of the time, once someone flushes a toilet or drains a sink, thoughts of how and where the water and waste go is a distant memory. Even though that is the case, wastewater and gray water management needs to be considered. Within the UGA Crop and Soil Science Department in partnership with the Emory Rollins School of Public Health and the Georgia Dept of Public Health, educational programs have begun to materialize. One specific continuing education program consists of a PowerPoint presentation for UGA County Extension Agents to utilize during educational modules. Course development consisted of basic information on the background of on-site wastewater treatment, management practices, and items that should or should not be flushed. In part with this program, site development has begun on UGA's Griffin Campus to house a training and demonstration facility. This site will be used to conduct field trainings for DPH personnel, UGA Extension Agents, and On-site septic industry members on various aspects of the wastewater process. These trainings for DPH personnel and on-site waste industry members will be used as a means to provide both certification trainings and renewals. The proposed presentation is to provide a short insight into what the educational module looks like as well as a preview to the design of the training facility in Griffin, GA.

3.1.4 Gwinnett's Water Innovation Center – A new approach to water resiliency

Melissa L. Meeker, *Gwinnett County DWR, Water Innovation Center*

Gwinnett County's approach to innovation is more than technological, it's transformational. Today's Utility of the Future is challenged with increasing demands on water, human and financial resources. Integrating these challenges to address community concerns, meet workforce needs and training requirements, and provide solutions to operational and water quality/quantity burdens – through research and innovation - is critical. Our response to these challenges is the Global Water Innovation Campus @Gwinnett (GWIC), set to open in 2021. The campus, anchored by the F. Wayne Hill Resources Recovery Facility in Buford, will include the Water Innovation Center, a 63,000 square foot LEED-certified building containing a three-story demonstration bay with direct connections to multiple water quality flows from the F. Wayne Hill WRC and adjacent source waters, wet and dry lab space, a microbiology lab, classrooms and boardroom space, an atrium with public exhibits, and a 250-seat auditorium. We are developing partnerships with many groups, including research and trade organizations, universities, equipment manufacturers and service providers to design the facility and programming needs. Our staff and distinguished partners will perform targeted research, develop and prove new technologies, train new workforces, and educate thousands through public outreach. And we will fully integrate these services so that they build upon and enhance one another. This presentation will describe the proposed governance, programming and current on-going projects of regional significance.

3.3 Agricultural Wetland Policy & Practice

Tina Jerome [1], Sharon Swagger [1], and Jenny Pahl [2]; *[1] USDA-NRCS, [2] Corblu Ecology Group*

In addition to the Federal Clean Water Act, agricultural producers are compelled to comply with the Food Security Act (1985) Swampbuster provisions regarding impacts to wetlands. This policy limits the extent to which agricultural producers, who benefit from federal programs, can negatively affect wetlands within their properties. Where agricultural wetlands have been impacted, there are several incentive programs for restoring wetland functions. This session will explore Food Security Act policies as they relate to wetlands in agricultural landscapes as well as the voluntary and compensatory wetland restoration programs that are available to producers under the Act. The Wetland Reserve Easement program is a voluntary mechanism that incentivizes restoration through payments from the Natural Resource Conservation Service. Presentations will highlight trends in the use of the WRE program throughout Georgia as well as recent projects. Compensatory wetland restoration/mitigation under the Food Security Act is addressed by the Georgia Agricultural Wetland Mitigation Bank, a new program to assist producers with mitigating impacts to isolated wetlands.

3.5 Ecosystems

3.5.1 Creation of macroinvertebrate performance standards for a South Georgia stream restoration project

Sean Miller, *Mitigation Management*

Stream restoration has become a valuable tool in the field of conservation. The majority of stream restoration that occurs in Georgia is done through the commercial mitigation banking process regulated by the US Army Corps of Engineers. This industry is based on the restoration of ecological function in streams and wetlands to offset permitted impacts to federally jurisdictional waters as defined in the Clean Water Act. Historically, the main focus of these stream restoration projects was the creation of a geomorphically stable stream channel. However, current guidelines have begun to place a much greater focus on restoration of the suite of functions: physical, chemical, and biological. Due to the limited datasets available in Georgia, appropriate documentation of biological lift, especially in regard to benthic macroinvertebrates, has been difficult. The goal of this project was to create a set of performance criteria for documenting macroinvertebrate community lift within restored streams channels. This study was conducted in the 65h ecoregion of Georgia. Reaches assessed included proposed restoration streams and references streams. Data was analyzed for physical characteristics of the channels and then statistical analysis was performed on the community dataset in order to determine similarity/dissimilarity between communities collected from proposed restoration streams and reference reaches. Based on this analysis, it appears that Insecta taxa richness, proportion of Ephemeroptera taxa, and proportion of burrower individuals were likely metrics to document possible lift in the proposed restoration channels following the completion of restoration activities.

3.5.2 Of Limpkins and Apple Snails: Invasive species, novel ecosystems, and an uncertain future

Chelsea Smith, Steve W. Golladay, Brian Clayton, *The Jones Center at Ichauway*

Novel ecosystems, combinations of species without historical analog, are now abundant across the landscape providing opportunities to study characteristics of communities that are composed of invasive or nuisance species. Reservoirs are common novel ecosystems created where dam construction has altered river flow to support human needs. Here, we examine Lake Seminole as a case study for such interactions. Lake Seminole is a run of the river reservoir in southwestern Georgia completed in 1957 for hydropower and navigation. It lies at the confluence of the Chattahoochee, an urbanized highly regulated river, and the Flint River, which is largely free-flowing and rural. Multiple invasive species exist in the lake, including *Hydrilla vertiillata* and *Corbicula fluminea* introduced in the 1960's, as well as *Pomacea maculata*, first noted in the early 2000's. Examination of *Hydrilla* coverage revealed variation with both seasonal and annual hydrologic conditions with coverage ranging from 35-50% of the lake. During the *Hydrilla* growing season, we have observed substantial reductions in nutrient levels as water moves through the lake. Nutrient uptake within beds and by *Hydrilla* tissue has also been documented. Water column mixing within the beds changes during development providing heterogeneous nutrient absorption potential through time. Corbicula populations were sufficiently abundant to affect water quality through filtration, with estimates ranging from 6-181 days to filter the lake volume, depending on temperature (55± 29 individuals/ m^2). Egg mass surveys revealed *P.maculata* populations to be rapidly expanding, which has resulted in more permanent Limpkin populations on the lake. While each of these species is generally viewed as a nuisance outside of their native range, at a whole-lake or ecosystem scale, they provide important services and functionality considered 'desirable' to the river basin. Considering these services and often limited management resources, should the focus be on extirpation or integration.

3.5.3 Wading through Georgia's oyster regulations – Shucking our way to a vibrant half-shell industry

Danielle Goshen, *UGA Law, Georgia Sea Grant*

In the early 20th century, Georgia led the nation in producing oysters with more than eight million pounds harvested annually. However, this industry collapsed and in the mid-1960s when Georgia's last oyster shucking house closed its doors. While over-harvesting and fisheries mismanagement were the primary causes of the oyster industry's decline in Georgia, market demand for canned oysters also changed. In Georgia, this required industry practices to change from harvesting wild oysters, to growing oysters using aquaculture techniques that would produce oysters on the "half-shell." While the oyster industry is now geared to half-shell consumption, regulations in Georgia still reflect an industry that is geared to harvesting wild oysters. Many argue that this is what is keeping Georgia behind, compared to other states in the area which have adapted their regulations to changing industry practices. To consider potential routes for unlocking the full potential of Georgia's oyster industry, this case study will focus on some of the challenges and opportunities facing stakeholders and policymakers and will conclude with possible ways to promote best practices and economic development of the oyster industry.

3.6 Stream Health

3.6.1 Stream health analysis using geospatial data to assist in further in-situ water quality analysis: Lake Lanier Watershed, a case study.

Michael Mirroli, Zach Reeves, Sudhanshu Panda, *North Georgia University*

Lake Lanier, a 150-km^2 surface area reservoir with 692 miles of shoreline receives water from a catchment area of 1040 sq. mi. Landuse practices in the catchment area has dramatically changed over the years with incessant urban sprawl and chicken production. With these changes, more and more point and non-point source pollution is happening in the watershed polluting the streams. It is essential to understand the stream health of the watershed that ultimately contribute to the Lake Lanier water quality. Due to paucity of funds, total maximum daily load (TMDL) analyses are conducted only on few randomly selected streams. Therefore, it is crucial to develop an easy, effective, economic, less-time consuming, and remote process to determine individual stream health in the watersheds, so that TMDL can be initiated on the low health streams along with restoration project development to safeguard the reservoir from being polluted. The goal of the study was to develop a geospatial model using different watershed physical parameters in line with the Watershed Habitat Evaluation and Biotic Integrity Protocol (WHEBIP) to determine the stream integrity (health) of the RF2 level streams in the watershed. WHEBIP is a score assessment approach that was developed to rate the quality of streams depending on certain parameters that surround it. There are 12 categories and each one uses different Subscores based on how it correlates with the stream. The parameters are: 1) land-use along the stream, 2) average width of riparian belt, 3) riparian canopy continuity, 4) presence of wetlands, 5) active agriculture, 6) forest or brush presence beyond the stream bank, 7) upstream riparian vegetation, 8) upstream forest and brush, 9) watershed land gradient, 10) point source pollution, 11) presence of roads, and 12) conservation activity in the watershed along the stream. These physical features were analyzed to determine the stream health using 2015 classified NAIP (1m) imagery, ESRI provided TIGER road and census data, 10 m DEM, National Wetland Inventory (NWI) supported wetlands data, data created with personal knowledge on construction and conservation activities, density of chicken houses data developed from the geospatial analysis of the NAIP data, and active agriculture data from NASS Cropscape portal. A geospatial model was developed in ArcGIS Pro ModelBuilder to automate the process so that each physical parameter scaling (a point value) could be determined through the geospatial analysis of the GIS layers. The model finally summed up the points for each parameter and provided a total score for each stream. Finally, each stream were ranked from Very Poor to Very Good – a five point stream integration scale using Jenk's Natural Break algorithm. The benefit of this study is that the entire process is an automated method to know the stream health of a watershed without direct visit to the field or any costly water quality analysis. At the same time, it would support watershed management planners to take measures for improvement where it is necessity.

3.6.2 Mowers versus growers: Riparian buffer management in the Southern Blue Ridge Mountains, USA

J. Sanders, M. Welch-Devine, C.R. Jackson, *UGA Warnell School*

Maintenance of undisturbed soils and vegetation near streams is fundamental to nonpoint source pollution Best Management Practices. Streamside vegetation is also important for wildlife habitat and regulation of stream processes, yet the presence or absence of vegetation along Southern Blue Ridge (SBR) streams is frequently determined by individual landowner decisions rather than protective statutes. In the upper Little Tennessee River (ULT) basin in Macon County, North Carolina, landowners feature a mix of long-term area residents as well as recently arrived amenity-seeking urbanites. Although most landowners in the ULT report an aesthetic preference for vegetated streambanks, over half routinely mow these areas. We examined riparian change over 16 years and conducted semi-structured interviews with residential landowners to document how and why stream riparian zones are being managed. Buffer width in 1999 and 2015 was remotely sensed and compared using USGS High Resolution 4-band Digital Orthoimagery. Streambanks without riparian vegetation decreased by 18%, while narrow (one tree width) and intermediate buffer categories increased by 13% each. Shrub buffer increased 73% over 1999 levels, but forested buffer remained essentially static, despite sustained education and restoration initiatives during this time. Interviews are now ongoing to document attitudes and motivations for riparian management behaviors, including both mowing and replanting of vegetation. Preliminary results suggest that a knowledge deficit about the importance of riparian buffers does not explain mowing behavior. The goal of this work is to inform education and management strategies, and to identify ways to reconcile landowner management preference with programs which aim to protect and restore stream ecological health.

3.6.3 Knickpoints, undercuts, and slumps: Stream habitat monitoring at Chattahoochee National Recreation Area

Jacob M. McDonald [1,2], Eric N. Starkey [2], Christopher S. Cooper [2,3], *[1] UGA Warnell School, [2] Southeast Coast Network, National Park Service, [3] UGA Dept of Geography*

The Southeast Coast Network (SECN) stream habitat monitoring protocol collects data to give park resource managers insight into the status of and trends in stream and near-channel habitat conditions. Wadeable stream assessments are currently implemented at the five SECN inland parks with wadeable streams. These parks include Horseshoe Bend National Military Park, Kennesaw Mountain National Battlefield, Ocmulgee National Monument, Chattahoochee River National Recreation Area, and Congaree National Park. Streams chosen for assessment were specifically targeted for management interest (e.g., trail erosion issues and upstream urban development) or to provide a context for similar-sized stream(s) within the park/network. During a two week period in June 2017, data were collected at Chattahoochee National Recreation Area (CHAT) to characterize the in-stream and riparian habitat of 14 stream reaches. The watersheds draining to the surveyed stream reaches at CHAT ranged from small mostly forested 1st order to mostly developed 3rd order watersheds. All of the survey reaches are recovering from a legacy of poor land use and responding to varying amounts of impervious surface cover in their watersheds. Six of the fourteen streams are impacted by the headward migration of a downstream knickpoint. Where resistant bed material are lacking, these knickpoints are causing the stream bed to incise; increasing bank heights and narrowing the channel. As a result of changes in bed elevation (from base level lowering or through the process of complex response), bank undercutting and slumping is a common process occurring at every stream that was surveyed. In the smaller streams and the lower energy portions of the larger streams, these slumps may become colonized by vegetation and become stable sediment sinks. In the large streams and in the higher energy portions of the smaller streams, these slumps will likely be eroded and will contribute additional sediment to areas downstream.

3.6.4 An assessment of water quality along the Appalachian Trail in Georgia

Caleb Sytsma, *UGA Warnell School*

The Appalachian Trail attracts over two million visitors annually, many of whom begin in Georgia to hike northbound. While the importance of following proper waste disposal methods are stressed to hikers, trail visitors have been shown to negatively impact vegetation and soil quality. This can negatively impact hikers in turn, as they are generally restricted to collecting water from sources along the trail during their hikes. Prior studies have found *Escherichia coli* levels exceeding government standards in streams within the Great Smoky Mountains National Park, but little to no data exists on surface water quality along Georgia's section of the Appalachian Trail (AT). Nutrient, trace metal, and *Escherichia coli* levels will be measured for 25 sites along the Georgia section of the AT, which will consist of official AT water sources, streams directly near the trail, and streams further away from hikers' potential influence. Gathered water quality data for all sites will be compared to historic precipitation chemistry and groundwater chemistry data, and then between the different types of assessed sites. Sites with low water quality and any discovered relationships between those sites will be discussed, and further relationships including proximity to trails, campsites, and privies will be explored. Initial data collections will occur between late February and the end of March to correspond with the greatest influx of hikers, and a second round of data will be collected in June and July.

3.7 Restoration

3.7.1 Improving fish habitat below impoundments using alternative discharge structures

James "Jay" L Shelton [1], Todd C Rasmussen [1], Gary R Hopkins [2], *[1] UGA Warnell School; [2] Storm Water Systems*

Impoundments commonly discharge water from lake (or pond) surfaces, which are usually warmer than deeper waters due to direct solar inputs. In Georgia, top-discharge impoundments release water that commonly exceed 30ºC during the summer, which is generally harmful to sport and non-sport fisheries that prefer temperatures below 20ºC. While benthic waters in most Georgia impoundments maintain acceptable temperatures (i.e., T < 20ºC), low dissolved oxygen concentrations found below the photic zone are deleterious to fish health and survival. Efforts to discharge benthic waters (bottom discharge) must account for both the need to increase oxygen concentrations as well as reduce dissolved metals (Fe, Mn, Hg) that result from anoxia and are also deleterious to fish. This study first summarizes the impacts of impoundment water quality on fish health, and then proposes a method to alter impoundment discharge structures that promote fish health and survival. A simple, easily installed addition to a conventional impoundment structure is shown to improve both water temperature and quality below the impoundment.

3.7.2 White Dam removal: Lessons learned

James "Jay" L Shelton, *UGA Warnell School*

The White Dam near Athens GA was built in the early 1900s and provided hydroelectric power for a local textile mill for several decades. The dam was removed during Summer 2018, and allowed water to flow unimpeded for the first time in over a century. This talk will summarize the technical, economic, and legal challenges faced in removing small dams. It is hoped that this exercise will serve as a model for future dam removal projects.

3.7.3 Uniting stormwater management and stream restoration strategies for greater water quality benefits

Roderick W. Lammers [1], Tyler Dell [2], and Brian P. Bledsoe [1]

[1] *UGA College of Engineering,* [2] *Civil and Environmental Engineering, Colorado State University*

Urbanization alters the delivery of water, sediment, and pollutants to receiving streams. In response, channels erode which increases loading of sediment and nutrients, degrades habitat, and damages or destroys sensitive biota. Stormwater control measures (SCMs) are constructed in an attempt to mitigate some of these effects. In addition, stream restoration practices such as bank stabilization are increasingly promoted as a means of improving water quality by reducing downstream sediment and pollutant loading. Each unique combination of SCMs and stream restoration practices results in a novel hydrologic regime and set of geomorphic characteristics that interact to determine stream condition, but in practice implementation is rarely coordinated. In this study, we examine linkages between basin scale implementation of SCMs and stream restoration in Big Dry Creek, a suburban watershed in the Front Range of northern Colorado. We combine continuous hydrologic model simulations of watershed scale response to SCM design scenarios with channel evolution modeling to examine interactions between stormwater management and stream restoration strategies for reducing loading of sediment and adsorbed phosphorus. Model results indicate that integrated design of SCMs and stream restoration interventions can result in synergistic reductions in sediment and adsorbed pollutant loading. Not only do piecemeal and disunited approaches to stormwater management and stream restoration lose out on these synergistic benefits, they make restoration projects more prone to failure, wasting valuable resources that could be better applied for pollutant mitigation.

3.7.4 Shore protection for a sure tomorrow

Julia M. Shelburne, *UGA Georgia Sea Grant*

This presentation examines shore protection laws in seven Southeastern states: Georgia, Alabama, Florida, North Carolina, South Carolina, Maryland, and Virginia. Effectively protecting shorelines is critical because shores serve as the primary defense against severe weather events, erosion, and sea level rise. In addition to protecting the shoreline, shore protection laws govern coastal development through establishing jurisdictional setback lines from the shoreline or an analogous ecological marker. This research emphasizes the application of science to inform law and policy decision-making as well as considers an adaptive management approach to best respond to shoreline changes. The coastal states in this study area broadly apply “fixed”, “floating”, “hybrid”, or “other” legal provisions to establish the jurisdictional setback lines. Fixed jurisdictional lines extend a specified distance from certain features (i.e. elevation contours, shore protection structures, mean high water marks) while floating jurisdictional lines vary by coastal erosion rates. Fixed jurisdictional lines are beneficial because they are easy to identify and enforce, but their effectiveness may be weakened by the inability to review the lines based on existing legal provisions. On the other hand, floating jurisdictional lines more readily apply available scientific data in response to shoreline changes but may be more difficult to identify. While acknowledging each state’s unique coastal ecosystems and varying legislative goals, this research identifies policy options and encourages establishing legal provisions with methods for regular review of the jurisdictional area rather than preferring fixed or floating jurisdictional lines.

3.7.5 The effects of beaver dams on bioavailable organic carbon in urban streams

Elizabeth Sudduth, Kelley Curry, *Georgia Gwinnett College*

Many urban streams, including those in the Atlanta area, suffer from high inputs of highly labile bioavailable dissolved organic carbon (BDOC) from human and animal waste. This carbon is easily used by microbes and can fuel ongoing problems with microbial growth in urban streams, including that of human pathogens. Beaver populations are rebounding throughout the US and seem well adapted to living in urban streams. Beaver-created ponds and wetlands provide ideal sites for microbial processes that could take up, transform, and remove this labile organic carbon from urban streams, reducing the risks of higher microbial loads and pathogens. We collected multiple replicates of filtered stream water upstream and downstream of beaver dams in three urban streams in Atlanta. The filtered samples were inoculated with unfiltered water and then either immediately acidified or first incubated in the dark for 30 days, then acidified, filtered, and analyzed for total organic carbon concentration. The change in concentration over the 30 days represents the BDOC concentration. We saw consistently high BDOC in the upstream samples, consistent with patterns seen in other urban streams, and a decrease of BDOC in the downstream samples, suggesting removal of labile organic carbon can occur in beaver ponds or wetlands. These patterns demonstrate the potential for beaver activity to help restore water quality in urban streams and suggest that urban watershed managers should consider allowing beavers to remain in these systems or even fostering their colonization of impacted streams.

3.8 Wetlands

3.8.1 Multiscale assessment of estuarine water and sediment quality in National Park Units within the Southeast Coast Network

Eric Starkey, Brian Gregory, Wendy Wright, *US National Park Service, Southeast Coast Network*

Due to the importance of water resources to park management from ecological, regulatory, and visitor experience perspectives, estuarine water and sediment quality in and around parks were selected to be monitored by the National Park Service (NPS) Inventory and Monitoring Division’s Southeast Coast Network (SECN). Since 2005, the SECN has employed a multiscale approach to assess estuarine resources in seven park units located in North Carolina, Georgia, and Florida. Data collected as part of this effort are intended help resource managers: 1) better understand ecological processes and impacts caused by development, 2) make informed management decisions, and 3) form/maintain strategic partnerships to improve water quality. In addition, given the diverse and dynamic nature of estuaries, this monitoring is intended to capture the spatial and temporal variability of these systems. Monitoring at permanent fixed stations using continuous data loggers and discrete samples allow for evaluation of temporal patterns in core water quality parameters (dissolved oxygen, pH, salinity, temperature, and turbidity) and nutrients (nitrogen, phosphorus, and chlorophyll a). While fixed station monitoring provides fine resolution data to determine diel, monthly, and seasonal fluctuations in water quality, it lacks spatial extent. In order to fill this gap, spatial variability of water and sediment quality is determined with park-wide assessments every 5 years. These assessments include discrete sampling of nutrients, water quality parameters, and evaluation of sediment contaminates following methods developed by the Environmental Protection Agency-National Coastal Assessment Program. This monitoring approach leads to an understanding of the spatiotemporal status and variability of estuarine water quality and will yield information useful to park management.

3.8.2 Using satellite data to develop wetland hydrologic models

Courtney Di Vittorio and Aris Georgakakos, *Georgia Water Resources Institute, Georgia Institute of Technology*

Given the increasing availability, quality, and frequency of satellite observations, new opportunities exist to develop process-based hydrologic models of wetlands that can be integrated into decision support tools for water resources management. However, data uncertainties and limited knowledge of the hydrologic processes being simulated should be considered when designing these models to avoid overparameterization. In this presentation we demonstrate how information from satellites can be used to estimate hydrologic variables, including inundation extents, precipitation, and potential evapotranspiration. Additionally, we show that limited flow observations can be supplemented with satellite-derived water level variations and statistical models. These satellite-derived estimates enable the formulation a lumped conceptual wetland hydrologic model that can be incrementally improved through an iterative modeling framework. This modeling approach takes advantage of available data while ensuring model integrity, parsimony, and relevancy for intended applications.

3.8.3 Comparative metabolism of wetland-dominated estuaries

CS Hopkinson [1], N Weston [2], I Forbrich [3] , *[1] UGA Marine Sciences, [2] Villanova University, [3] Marine Biological Laboratory*

Whole estuarine system C budgets for two estuaries in contrasting biogeographic provinces suggest remarkable similarity in terms of tidal marsh and aquatic metabolism. Levels of GPP and community respiration are similar in the Plum Island and Sapelo Island tidal wetlands with each being substantially autotrophic. Yet the fate of the excess ecosystem production (NEP) differs considerably. In the Acadian biogeographic province, Plum Island marshes, over half the net ecosystem production (NEP) is buried, while in the Virginian biogeographic province, Sapelo marshes, >90% of the NEP is exported as OC. The metabolism of the aquatic portions of the estuaries is also similar, but with considerably more respiration than GPP. Both aquatic systems depend heavily on OC exported from the adjacent tidal wetlands to sustain their high levels of heterotrophy. With global change we can expect effects to differ between autotrophic and heterotrophic components. This differential will likely impact the ability of wetlands to sequester atmospheric CO_2 and/or continue to support high rates of secondary production, which is crucial for coastal fisheries.

3.8.4 Determination of predominant water source(s) to a Georgia Piedmont wetland using hydrologic modeling

Bruce A. Pruitt [1], Morris C. Flexner [2], William B. Ainslie [3], Carson A. Pruitt [4], *[1] USACE Engineer Research and Development Center, [2] USEPA Region 4, Science and Ecosystem Support Division, [3] USEPA Region 4, Water Management Division [4] US Forest Service*

A hydrological study was conducted on a palustrine, forested depressional wetland located on the floodplain of Cornish Creek, near Covington, Georgia. Given the wetland's proximity to Cornish Creek and its depressional geomorphology, the objective of the study was to model the wetland water budget for surface and ground water inputs and outputs to determine the predominant water source responsible for maintaining wetland processes and functions. Cornish Creek is a fourth-order Piedmont stream in the Alcovy River watershed within the Altamaha River Drainage Basin. Based on aerial photography, verified using laser surveying technology, the wetland was approximately 1,538 square meters (0.378 acres) at normal pool. The local hillslope catchment area (left backslope) above the wetland was 0.0288 square kilometers (7.106 acres). Four shallow groundwater wells equipped with pressure transducers were installed along the hillslope catena on March 12, 2015. In addition, a stage recorder was installed in Cornish Creek, and an automated rain gage was installed on the backslope to determine surface and ground water responses to local rain events. During the period of record (POR), monthly total rainfall measured on site was not significantly different from historic monthly average rainfall during 2015 and 2017. However, rainfall recorded on site during 2016 was significantly less than historic monthly average rainfall. Above average, extreme rain events occurred in November 2015 (8.35 inches), January 2017 (7.64 inches), and April 2017 (6.22 inches). Channel full (CHF) stage in Cornish Creek was observed seven times during the POR. However, based on groundwater data collected in the well located on the stream levee, overflows into the wetland only occurred during two of the seven CHF events. In addition, as evidenced by the steepness of the rising and falling limbs of the storm hydrograph, Cornish Creek is extremely flashy, consequently, overflows recede back into the stream channel rapidly. Subsurface interflow was expressed in the well located at the footslope several times during the POR and coincided with groundwater rise in the backslope well indicating a hillslope hydrologic source. Saturated overland flow or concentrated flow in concave surfaces on the backslope was observed on one occasion but was not considered a predominant water source. Overall, during the POR, hillslope hydrology via subsurface interflow and return flow was the predominant water source to the wetland system. In conclusion, sustaining wetland hydrology and associated processes and functions in Piedmont wetlands is probably dependent on hillslope processes, more so than overbank flood events especially in deeply entrenched streams common in the Piedmont.

TRACK 4

4.1 Georgia Aquatic Connectivity Team Working Group (offsite)

Sara Gottlieb, *The Nature Conservancy*

4.3 Preventing Lead in School Drinking Water

Shannon Evanchec [1], Samantha Becker [1], Herb Johnson [2], Paul Schwartz [3]; [1] TruePani, [2] Atlanta Public Schools, [3] Campaign for Lead Free Water

A panel discussion on preventing lead in school drinking water based on new research and the revised EPA 3T's program: An overview to lead in drinking water including how contamination happens and common misconceptions that cause the public to distrust water quality; Reasons schools are more susceptible to high lead levels (dead ends in plumbing, longer contact time between water and plumbing infrastructure, longer sections of pipe); What states are mandating drinking water testing in schools; Results from schools that have tested (a report from the government accountability office found that nearly 40% of schools that tested found elevated lead levels); How to properly conduct drinking water testing (traditionally first draw but new research is advocating for flush samples); The remediation process (filters vs. fixing plumbing infrastructure); Federal, state, and local funding opportunities to help schools test their water (EPA WIIN grant); and New technology that can help monitor point of use water quality on an ongoing basis.

4.5 Surface Water Quality

4.5.1 Source water optimization: How CCWA is combatting taste and odor issues with aggressive in-lake and watershed improvements

Roger Scharf [1], Lauren Chamblin [1], and Kelly Taylor [2], [1] *Jacobs Engineering Group,* [2] *Clayton County Water Authority*

Clayton County Water Authority (CCWA) is aggressively studying and implementing solutions to prevent and treat as necessary taste and odor issues originating within its source water. In 2016, CCWA embarked on a comprehensive year-long sampling program in the four reservoirs (Shamrock, Blalock, Hooper, and Smith) that supply drinking water to its three Water Production Plants (WPP). The outcome of the sampling was the recommendation to implement a holistic approach to address both the cause and effect of taste and odor compounds by implementing management measures throughout the entirety of CCWA's complex water cycle. The recommendation included installing oxygenation systems in two reservoirs, installing aeration systems in one reservoir, installing back-up measures at the WPPs, and piloting a novel phosphorus scavenging approach in the upstream constructed treatment wetlands. They oxygenation systems and aerations systems are currently in construction, and the wetland pilot study demonstrated up to 50% total phosphorus removal in wetlands that currently have limited capability for phosphorus uptake. Continuous water quality monitoring stations were installed within the reservoirs to enable optimization of these new treatment system. These improvements will enable greater flexibility and lower operational costs to the new unit operations CCWA is considering within their treatment scheme.

4.5.2 Predicting harmful algal blooms in Middle Chattahoochee Reservoirs

Wesley L. Gerrin and Susan B. Wilde, *UGA Warnell School*

Harmful algal blooms (HABs) threaten aquatic ecosystems worldwide, adversely effecting wildlife, fisheries, water quality, and human health. Forecasting blooms using water quality monitoring is critical for drinking water utilities. They need to develop efficient sampling protocols that will enable early detection and response to increasing algal densities potentially causing hypoxia/anoxia, producing taste and odor compounds and harmful toxins in drinking water intakes. Moreover, they need to identify nutrient sources so that watershed management strategies can be implemented to reduce eutrophication. Because time and resources are limiting, efficient sampling procedures are needed. We used sensor data (Temperature, DO, Conductivity, pH, Chlorophyll-a, and Phycocyanin) and laboratory water analysis (Total Nitrogen, Total Phosphorus, and extracted Chlorophyll-a) to develop a predictive model of HAB dynamics in three reservoirs on the middle Chattahoochee River (Harding, Goat Rock, and Oliver). Data were collected seasonally (May, July, and September) during 2018 and supplemented with quarterly data provided by Georgia Power Co. (2000-2017). Using Principal components analysis of 2018 data, we identified critical sensor data parameters and laboratory analysis required to model and accurately a predict Chlorophyll-a concentrations in these reservoirs. These data will provide advance warning of water quality conditions conducive to HAB formation so utilities can intensify toxin monitoring in raw/finished water and implement additional activated carbon processing to ensure safe drinking water.

4.5.3 Microbial source tracking in the Chattahoochee River National Recreation Area

Anna M. McKee, *USGS South Atlantic Water Science Center*

Despite designation as a National Park, 84% of the Chattahoochee River within the the Chattahoochee River National Recreation Area (CRNRA) in the greater Atlanta area is listed as impaired due to fecal coliform levels. We used microbial source tracking (MST) with human, dog, and ruminant quantitative PCR markers to (1) assess seasonal and rainfall-associated variations in sources and levels of fecal contamination in the CRNRA; (2) correlate *E. coli* and MST marker levels to test for evidence of primary contributors of *E. coli*; and (3) investigate MST marker levels in tributaries throughout the CRNRA watershed to assess associations with subbasin land use. Results indicated that ruminants were not major contributors of fecal contamination in the CRNRA, and that contamination from humans and dogs was highest in the winter and after rainfall events. Dog MST marker concentrations were more strongly correlated with *E. coli* concentrations than human or ruminant MST marker concentrations. However, *E. coli* was detected in some samples for which the dog MST marker was not detected, suggesting other sources may also be determinants of *E. coli* levels. The human MST marker was positively associated with wastewater treatment plant density, whereas the dog and ruminant marker concentrations were not associated with any investigated land use classification. Understanding contamination sources and origins will help Park managers target outreach efforts within the CRNRA as well as begin discussions with local communities to improve land use practices adjacent to tributaries flowing into the Park

4.5.4 Tracking and managing nonpoint source pollution at Lake Herrick Watershed, Athens, Georgia

Ashwini Kannan [1], David Radcliffe [2], Thalika Saintil [2], Todd Rasmussen [3], *[1] UGA College of Engineering, [2] UGA Crop and Soil Sciences, [3] UGA Warnell School*

The Lake Allyn M. Herrick watershed is about 131 ha and covers portions of the UGA's East campus, the Oconee Forest, residential and commercial land use. Lake Herrick, a 6-ha water body established in 1982 at the UGA campus was closed in 2002 for recreation due to fecal contamination. Subsequent monitoring confirmed cyanobacterium blooms on the surface of the lake and elevated nutrient concentrations, especially phosphorus. Previous studies showed that phosphorus and fecal coliform were the main contaminants. Two inflow tributaries (Birdsong and Armadillo) and the outlet stream (Below Dam) were monitored for discharge, *E. coli*, forms of nitrogen and phosphorus and other water quality parameters during baseflow and storm conditions from February 2016 to October 2017. Our results showed that total phosphorus was significantly higher during stormflow compared to baseflow, but total nitrogen remained the same. *E. coli* results indicated that most of the bacteria entered the lake through the tributaries during stormflow. Microbial source tracking methods were used to detect the bacterial source in the samples specific to a dog, ruminant or human host. We found that dogs were a more likely source of this bacteria than humans or deer. The fact that human sources were uncommon in the Lake Herrick watershed indicated that there was reduced risk for human source contamination. Lake Herrick was reopened for limited recreation in October 2018.

4.5.5 Strategic grazing for resistance to extreme weather events

Subash Dahal [1], Dorcas H Franklin [1], Anish Subedi [1], Miguel L Cabrera [1], Dennis Hancock [1], Lawton Stewart [2], Kishan Mahmud [1], *[1] UGA Crop and Soil Sciences, [2] UGA Dept of Animal and Dairy Sciences*

A greater number of extreme weather events such as drought and hurricanes, are predicted in coming decades, due to changing global climate, and they have significant impacts on agricultural systems. A study was conducted in Southern Piedmont of Georgia to develop a grazing system that is more resistant to extreme weather events. Nitrogen in surface-runoff from conventionally managed pastures results in (i) loss of expensive Nitrogen from the field, and (ii) stream contamination accelerating eutrophication. The runoff loss of N can be exaggerated during hurricanes due to much intense precipitation. In August 2015, runoff collectors were established to collect surface runoff in eight "Conventionally" managed beef-pastures in Southern Piedmont, Georgia, USA. Runoff samples were collected immediately after runoff events and filtered (< 48 hours; 0.45 µm filter) and analyzed for nitrate (NO_3^-) and ammonium (NH_4^+). In May 2016, "Strategic-Grazing" was devised and implemented in four pastures and the remaining four pastures were conventionally managed with rolling out of hay. "Strategic-Grazing" includes excluding and over seeding vulnerable areas (concentrated flow paths), strategic placement of shade, hay, and water, and moderate rotational grazing. During a prolonged drought in 2016 (6 months), the Strategic pastures produced more forage as compared to Conventional pastures resulting in lower hay requirement. After treatment, during a wet period in 2017 (June-October), which included a Category-5 hurricane (Irma), the runoff-NO_3^- per unit soil nitrate in Strategic pastures was 1/3 times lower as compared to the Conventional pastures. This was mainly attributed to forage growth in the excluded areas, lower bulk density, and the cattle-rotation that allowed forage shoot and root regeneration. These results indicated that "Strategic-Grazing" could be a useful management tool in developing resistance to extreme weather events while increasing forage productivity in beef pastures.

4.6 Erosion & Nutrients

4.6.1 Geospatial model development to analyze the reservoir volume change with the soil erosion model perspective

Sidney McVay and Sudhanshu Panda, *University of North Georgia*

Revised Universal Soil Loss Equation (RUSLE2) developed by USDA-ARS is the proven empirical equations and processes to develop the R, K, L, C, and P factors for erosion prediction. However, it does not consider the latest climate, topographic conditions for estimating those factors. As mentioned in the USDA-ARS's RUSLE2 site, the rainfall erosivity factor (r) is created from the Isoerodent Map spatial data that is developed as a product of the storm's total energy, which is closely related to storm amount, and the storm's maximum 30-minute intensity. But there is no option in the software to use the latest spatial (pixel) based 30-minute storm intensity data to the model to calculate r-factor for each pixel. NOAA has developed and made available latest 30-minute storm intensity data in raster format that can be accurately used to estimate R-factor for each pixel. It also updates the storm event data based on recent climatic change scenario. Soil erodibility factor (K), slope length (L), and slope gradient (S) data are now available on 10 m pixel basis through USDA-NRCS Geospatial Data Gateway provided gSSURGO data. That would update the RUSLE model. Classified 30 m resolution National Land Cover Data (NLCD) is not a correct representation of the landuse of a small study area, Elachee Nature Center that is used as the case study. Therefore, ultra-high resolution classified ortho-imageries, such as 2015 NAIP (1m) imagery would help develop accurate and timely C-factor and P-factor rasters. The goal of the study is to develop an automated comprehensive geospatial model in ArcGIS Pro Model Builder to produce two dates (1974 and 2018) soil erosion maps of the watershed that feeds to the lake inside Elachee Nature Center near University of North Georgia campus. The Soil Erosion maps are developed with the automated geospatial model that include the geospatial data described above to develop R-, K-, L-, S-, C-, P-factor rasters and integrate to provide soil erosion amount for each 10 x 10 m (100 sq. m.) spatial location. Another objective of this study was to develop an automated geospatial model to conduct the volume change analysis of the reservoir over years of 1974, 1985, 1991, 2001, 2005, 2008, 2010, 2011, 2013, 2015 and 2018. Different spatial resolution classified maps (NLCD or self-classified) of these years (60m – 1974, 185; 30m - 1991, 2001, 2005, 2008, 2011; 1m – 2010, 2013, 2015, and 0.5m - 2018) were used to determine the siltation based volume change. The results were correlated with the erosion rate prior to 1974 and recently by 2018. This study will help watershed managers to learn the impact of land cover changes in reservoir catchments to safeguard the reservoirs from siltation to increase their longevity.

4.6.2 Identifying the impacts of prescribed fire on nutrient erosion into aquatic ecosystems utilizing lake sediment records from the SE USA

Matthew Waters [1], Alex Metz [1], Joseph Smoak [2], and Rachel Kuntz [1], *[1] Auburn University, [2] University of South Florida*

The relationship of land-use change with water quality typically is established through monitoring efforts and forecasting models. These effective tools are used to set management parameters and future environmental targets for aquatic resources. However, these decisions are constructed from data that represent a short timescale of a water body's history negating important periods of environmental change that could be useful to management practices. One way to reconstruct historic land use and water quality change is to use the sediment record as a long term data set of environmental change. Here, we report on the sediment record of Ditch Pond, Alabama, and Ocean Pond, FL where lake sediments have recorded decades of material inputs from prescribed fire in National Forests. Sediment cores spanning the last 5,000 years of environmental history were analyzed for organic matter, nutrients (C, N, P), heavy metals, algal production, cyanobacteria production, forest inputs, and fire. Results show that the modern environmental impacts to the lakes are driven by prescribed fire management causing changes in nutrient inputs into the lake system. For both systems, phosphorus inputs increased over 200% during the burn period with carbon and nitrogen inputs showing opposite trends. Primary producer responses were different for each system with only Ditch Pond developing an increase in trophic state from the material inputs. These data provide one of the longest records of environmental history in areas that are chronically burn and identify potential drivers of concern for future water quality and management decisions.

4.6.3 Strategic rotational grazing reduces sediment and sediment carbon in runoff

Anish Subedi, Dorcas H. Franklin, Subash Dahal, and Miguel L. Cabrera, *UGA Crop and Soil Sciences*

Pastures can sequester soil organic carbon or be a source of contamination to local streams depending on management. Rotational grazing, exclusion with over-seeding of areas vulnerable to erosion and runoff, and use of cattle lures may improve soil carbon abundance and retention in pastures. This strategic rotational grazing system (SRG) was compared to conventional grazing with rolling out of hay (C) on 8 pastures: four near Watkinsville and four near Eatonton. This portion of the study compares loss-on-ignition (LOI) carbon in soil samples and total suspended sediments (TSS), Carbon in sediments (CS) and dissolved organic carbon (DOC) in runoff water samples from baseline (2015) to post-treatment years (2016-2018) between C and SRG. Compared to baseline, SRG had significantly greater LOI at 0-5 and 10-20 cm depths in 2017 and 2018. Comparison of treatments (SRG and C) showed statistically similar TSS and CS during baseline whereas, SRG had significantly lower TSS and CS in post-treatment years. DOC in C pastures was statistically similar in baseline and post-treatment years whereas, DOC in SRG pastures was significantly greater in post-treatment years as compared to baseline. Increase in LOI in SRG was likely due to accumulation of organic matter from mixing in of feces and root growth at greater depths. Exclusion of low-lying and high-cattle-activity areas and strategic placement of hay-ring and waterer at higher elevation in the pastures could have decreased the TSS and CS in SRG. The difference in DOC maybe due to greater amount of organic carbon in SRG pastures as compared to C pastures and/or burning down of exclusions before planting.

4.6.4 Removal of nutrients from agricultural wastewater by modified biochar

Jared P. Conner, Lucas N. Favero, and Valentine A. Nzengung, *UGA Dept of Geology*

The pollution of freshwater by agricultural wastewater is a threat to humans and ecosystems worldwide. Nutrients such as nitrogen and phosphorus enter waterways in runoff from fields where animal wastes have been over-applied. This can be mitigated by treating agricultural wastewater before application to fields, as well as preventing the leaching of nutrients from soil. Biochar is a low-cost, charcoal-like product made from waste biomass that can remove nutrients from wastewater and retain nutrients in soils. However, most biochars are poor at removing phosphate ions. Recently, biochars modified with metals have been shown to be effective for removing phosphate ions from wastewater. Little is known about the relative effectiveness of different metal impregnated biochars for phosphate removal. Also, the simultaneous removal of phosphate and ammonium-nitrogen by metal modified biochars is not well understood. The goal of this study was to evaluate the relative effectiveness of metal modified biochars for removing ammonium and phosphate from agricultural wastewater. Solutions of Aluminum, Calcium, Iron, and Magnesium salts were used to modify peanut shell biochar. Batch sorption tests and sorption isotherms were used to compare the effectiveness of the modified biochars for removal of ammonium and total phosphorus from swine wastewater and pure solutions. All of the modified biochars except the calcium-biochar showed high rates of phosphorus removal. The magnesium-biochar was most effective, showing increased removal of phosphorus, but also enhanced removal of ammonium, compared to the unmodified biochar. After wastewater treatment, spent biochar could be applied to fields as a slow release nutrient source in soil, thus reducing the use of artificial fertilizer.

4.6.5 The mosaic reservoir process in sediment transport in large river systems

Benjamin Webster, *Auburn University*

Reservoirs provide multiple ecosystem services to their surrounding communities; because of these services, the construction of reservoirs exploded during the 1900s. Despite their prevalence in the United States, there has been little reservoir research in comparison to natural lakes. Reservoirs and dams are known to prevent natural sediment transport. Models have anticipated vast quantities of phosphorus bound to the sediment trapped behind their walls, however the efficiency of nutrient storage is still unknown. Before the Clean Water Act in 1972, there were no regulations on what pollutants Atlanta, GA waste water treatment plants (WWTPs) could load into the Chattahoochee river. These WWTPs loaded considerable amounts of phosphorus into the Chattahoochee, notably starting in the 1960s, and slowing from improved management practices of the fully enforced Clean Water Act in the mid-1990s. A study on a five-sequenced reservoir chain was conducted along the Chattahoochee river, downstream of the City of Atlanta, using paleolimnological techniques. Our findings depicted a known spike in phosphorus loading, a majority of which was sequestered within Lake Harding and West Point Lake. Strong reproducibility from such dynamic systems coupled with historic nutrient loading data allows us to better understand how urban inputs, specifically changes to wastewater management strategies, impact reservoir dynamics. We plan to use this information to help further justify and improve future WWTPs management and regulations.

4.7 Agricultural Modeling

4.7.1 Geospatial technology supported environmental impact assessment of historical gold mining in North GA

Jeffery Robertson, Sudhanshu S Panda, Martin Durand, and William Balco, *University of North Georgia*

North Georgia became the center of America's first gold rush, an event that significantly transformed the local and regional culture, economy, and landscape. Between the 1830s and 1850s, gold miners with the dream of extracting untold riches from the ground were attracted to its mountains. Of the various mining techniques employed in this effort, hydraulic mining was the most impactful, transforming the environment by channeling water across the landscape though a complex series of ditches, drains, pipes (denoted as tubes on historic maps), and trestles to wash away hillsides. These techniques had the unintentional side effect of clogging local streams and rivers with tailings and silt and impairing the local soil and waterbodies with unwanted contaminants, especially mercury. Mercury introduced to soil and bodies of water does not disappear quickly. Therefore, we hypothesize that the mercury and other heavy metals employed by the historic mines in and around Dahlonega likely remains *in situ*. The objective of this study is to develop a detailed site map showing the mining locations and collect and test water and soil samples from selective locations to confirm if traces of mercury still remain in the water and soil in the study area. With detailed field study using GNSS equipment and analysis of ultra-high resolution orthoimagery along with field interviews, a detailed gold mine site location map was developed in and around Dahlonega study area. A stratified random sampling algorithm was employed to select sampling locations (covering public and private lands) in the study area to collect soil and water samples. Water and soil quality tests for about 20 locations were completed at the Analytical Environmental Services, Inc., Laboratory using mercury amalgamation technique suggesting if mercury was present in the water samples. The samples were collected following the United States Geological Survey (USGS) sample collection processes. Fortunately, the sampled water did not contain any trace of mercury. The Soil testing is still under progress and its result will be available during presentation. Above all, we also created watersheds for each sampling points to determine the run-off amount coming to sampling locations and determining the soil erosion amount. This study provided a great relief to local population as our hypothesis of having mercury still in water in the study area proved wrong and the relief will be permanent once the soil test results comes out negative for mercury.

4.7.2 Projecting future agricultural water use under varying climate scenarios

Jeffrey Mullen, *UGA Dept of Agricultural and Environmental Economics*

Future climatic conditions are anticipated to have profound effects on agricultural productivity and the demand for irrigation water that vary by location depending on resource endowments and economic conditions. Crop growth simulation models such as DSSAT can offer powerful insight into the effects of weather and management practices on agricultural production. One of the fundamental questions that must be addressed during a simulation exercise, however, is "What is the producer's objective function?" A researcher's choice of objective function can significantly affect the predictions derived from a modeling exercise as well as the prescriptive policy recommendations based on those predictions. The economic literature has identified numerous possible objective functions for agricultural producers, the two most prominent of which are yield maximization and profit maximization. We model nine crops– alfalfa, barley, corn, cotton, peanut, rice, sorghum, soybean, and wheat – in the Unites States. For each crop, we simulate yield and irrigation water use across 25 US counties and 7 irrigation management strategies under 4 future climate scenarios through the year 2100. For each year, 100 county-level weather files are developed using MarkSim for 4 representative concentration pathways (RCPs) – RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5 – to simulate crop production. Coupling the production simulations with projected water prices and crop prices allows us to generate county-level distributions of yields, net returns, and water use for each RCP and irrigation management strategy. With our county-level distributional results for each of the nine crops, we are able to estimate the following for each of the 4 RCPs, over both time and space: 1) the economic (crop price and water price) conditions under which yield maximization and profit maximization lead to the same "optimal" irrigation management strategy; 2) thresholds for the economic parameters above which the optimal strategies for the two objective functions diverge; 3) the water price threshold above which profits under rainfed production exceed those of irrigated production; 4) expected yield impacts of climate change under optimal irrigation management; 5) expected irrigated water demand as a function of water price; and 6) the relative profitability of crops.

4.7.3 On-farm evaluation of dynamic variable rate irrigation

V. Liakos, G. Vellidis, W. Porter, Liang Xi, C. Perry, M. Tucker, and A. McLendon, *UGA Crop and Soil Sciences*

The adoption rates of variable rate irrigation (VRI) technology are getting higher in American farms especially at the southeast USA. However, irrigation systems equipped with variable rate technology are not standalone but they require more information in order to be beneficiary. The UGA developed a dynamic VRI system to increase the irrigation water use efficiency. The system consists of the EZZone management zone software, the UGA Smart Sensor Array (UGA SSA) and an irrigation scheduling decision support tool (DST). This paper will present the applications of the dynamic VRI in cotton and peanuts which were carried out on commercial farms over the last three years in Georgia. Every field was divided into parallel strips. Every other strip was designed to receive variable rates based on the UGA SSA DST. The rest of them were to use uniform irrigation based on farmers' recommendations. Continuously, irrigation management zones were delineated using satellite images and soil properties. In every experiment, all the data were combined in the EZZone software to delineate management zones. Furthermore, UGA SSA soil moisture probes were installed in the strips after planting. The UGA SSA system reported soil moisture data hourly and they were visualized on the UGA SSA web portal. The DST converted soil moisture data to actionable irrigation recommendations based on the latest soil moisture readings. This paper will present the results of the yield of both crops and irrigation water use efficiency comparison between the two irrigation treatments. The analysis of the three years of experiments showed that the irrigation water use efficiency was 30% higher in the VRI strips than the strips irrigated conventionally.

4.7.4 ET-based smartphone applications for irrigation scheduling in corn, cotton, and soybean

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The goal of this work was to develop easy-to-use and engaging irrigation scheduling tools for corn, cotton, and soybean which operate on a smartphone platform. The model which drives the SmartIrrigation Apps (Apps) is an interactive ET-based soil water balance model. The Apps use meteorological data from national digital weather data sets, weather station networks, soil parameters, crop phenology, crop coefficients, and irrigation applications to estimate root zone soil water deficits (RZSWD) in terms of percent as well as of inches of water. The Apps send notifications to the user when the RZSWD exceeds 40%, when phenological changes occur, and when rain is recorded. They operate on both iOS and Android operating systems. The Cotton App has been publicly released, the Soybean App was beta-tested by growers during 2018, and the Corn App is currently under development. The Cotton App was evaluated in field trials for five years and performed well when compared to other irrigation scheduling tools. This paper will present the ET-based models driving the Apps and performance data from all three.

4.7.5 Comparative study of estimation methods for determining soil carbon and nitrogen content in right-of-way areas in the State of Georgia

David Penn II, Francisco Cubas, and Celine Manoosingh, *CEC Department, Georgia Southern University*

Soil quality indicators from five sites within a right-of-way (ROW) area in the state of Georgia were analyzed and compared to parameters estimated from existing databases using a series of widely used estimation methods. The Soil Survey Geographic Database (SSURGO), ordinary kriging (OK), and lognormal kriging (LK) estimation methods were examined to determine which method produced an accurate assessment of ROW land quality. Soil organic carbon (SOC) and soil nitrogen (SN) were selected as the examined soil quality indicators due to their importance for plant growth and to test the potential of using ROWs for biocrop production. Rigorous statistical analyses were conducted to determine relationships and performance levels among the estimation methods examined. Results indicated that LK serves as a stronger predictor for SOC content when compared to OK and SSURGO. SN results from LK analyses did not outperform OK and SSURGO results regarding the ability to model SN from averaged field measurements. Results also demonstrated that SSURGO tends to overestimate SOC for the majority of site-specific soil map units (SMUs), while SN was severely underestimated in comparison. For SOC contents among all sites, a strong positive correlation existed between averaged field measurements and OK ($r = 0.9884$; $p = 0.0015$), however statistically significant correlations ($r = 0.998$; $p = 0.0001$) were obtained between mean field measurements and backtransformed LK values. Field measurements strongly correlated with SSURGO and OK results more closely than SN obtained from LK estimations. Results showed that differences between estimation methods and field data were due to changes in soil type as a result of earth movement performed during the construction of highways. These local changes are commonly not registered in bigger databases such as SSURGO. It is expected that this study will help better predict soil quality parameters in ROW areas from existing data using common estimation methods.

4.8 Vegetation & Hydrology

4.8.1 Applying isotopes, mass balance, and xylem deuterium correction to water use and sourcing of two biomass tree species

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Some soil water sourcing studies using stable isotope signatures have been hampered by an unexplained apparent depletion of tree stem ^2H relative to soil water source signatures and the evaporation line. We observed the same type of depletion when attempting to identify water sources for two woody biomass species, loblolly pine and sweetgum, over the course of a full growing year. The magnitude of ^2H separation decreased as the water content of xylem samples increased, reaching zero between 50-60% sample water content. We used the relationship between xylem ^2H offset and sample water content to correct xylem ^2H signatures. We used the corrected ^2H along with ^{18}O in a Bayesian mixing model and compared the predictions to soil water and transpiration fluxes. Mixing model predictions based on corrected xylem ^2H values had less overall uncertainty and aligned more closely with soil water fluxes than mixing model predictions based on uncorrected xylem ^2H values. Corrected mixing model predictions indicate a greater proportion of xylem water was sourced from deep soil. A more complete and accurate description of stem water sources was achieved by using soil water and transpiration fluxes to validate isotopic predictions. The combination of mass fluxes and sampling isotopes at a higher temporal resolution could help shed light on the mechanism(s) responsible for xylem water ^2H fractionation.

4.8.2 Influence of forest and vegetation type on annual evapotranspiration estimated by water budgets across 46 rural basins in the Southeastern US

Seth E. Younger, C. Rhett Jackson, and Todd C. Rasmussen, *UGA Warnell School*

Evapotranspiration (ET) typically accounts for 60-70% of precipitation in the southeastern United States. Most studies show that evergreen forests have higher ET than deciduous forests and pastures. Streamflows have been decreasing in the region which is partially attributed to droughts, precipitation changes, afforestation and consumptive uses. This study addresses the effects of forest cover and type on long term average annual streamflow and low flows. Long term annual ET rates were calculated as $ET = P - Q$ for 46 USGS gaged basins with, data for the 1982 - 2014 water years, 40% forest cover, low conductivity aquifers, no significant basin exports, and no large reservoirs. Land cover was regressed against ET and low flow, to describe effects by forest type. Budyko analysis was employed to compare the watersheds. Regression analysis indicates evergreen land cover had a positive relationship with ET while deciduous and total forest had a negative relationship with ET, although the relationships were noisy. Low flows increased as total forest cover and deciduous cover increased, and decreased as evergreen cover increased, these relationships were also noisy. Comparison to the empirical Budyko curve and related functions indicated variation in ET that is not explained by the curves. This work suggests considering forest cover type improves understanding of watershed scale ET at annual and seasonal levels which is consistent with global reviews of paired watershed experiments.

4.8.3 Simulated longleaf pine (*Pinus palustris* Mill.) restoration increased streamflow -- A case study in the Lower Flint River

Ji (Jill) Qi, Steven Brantley, and Stephen Golladay, *The Jones Center at Ichauway*

Water scarcity in the southeastern United States has increased in recent decades due to rapid population growth, land use intensification, and climate variability. While precipitation in the region is relatively high (~1300 mm/year), declines in river discharge suggest a growing need to evaluate land management options focused on reducing evapotranspiration and maintaining watershed yield. Restoration of longleaf pine [*Pinus palustris* Mill. (Pineaceae)] forests, which once dominated the southeastern United States Coastal Plain, represents one possible land management option to restore hydrologic function and help mitigate water scarcity in the region. Ichawaynochaway Creek is a major tributary of the lower Flint Basin, which largely overlaps with the historic range of longleaf pine and has seen recent conflicts over water appropriations. We used the Soil and Water Assessment Tool (SWAT) to evaluate the potential effect of large-scale longleaf pine restoration to affect streamflow in the Ichawaynochaway Creek Basin. Specifically, we simulated the conversion of ~24,000 ha of degraded mixed-species forest to longleaf pine savanna. Model results confirmed that longleaf pine savanna has the lowest demand for water as evapotranspiration compared to other major vegetated land cover types in the Ichawaynochaway Creek Basin. Conversion to longleaf pine increased annual streamflow by 18 mm, or 53 million m^3. The impact was most prominent during low flow and low precipitation periods. Results indicated that longleaf pine restoration is an effective way to increase streamflow, with the majority of reduction in evapotranspiration being converted into the streamflow. Although the change in annual yield was relatively small, it may prove vitally important in maintaining quality in-stream habitat for imperiled aquatic organisms during seasonal droughts and critically dry periods. Large-scale restoration of longleaf pine savanna could help mitigate water scarcity in the Ichawaynochaway Creek Basin, especially during drought.

4.8.4 Spatial and temporal dynamics of groundwater uptake by riparian vegetation at the Panola Mountain Research Watershed

Jeffrey W. Riley [1,2] and Luke A. Pangle [1]; *[1] Georgia State University, [2] USGS South Atlantic Water Research Center*

Riparian zones in humid regions are often dominated by vegetation that can directly access the saturated zone (groundwater). When forests are the dominant vegetation, large quantities of water may be removed from the saturated zone during periods of no rainfall. While it has been shown that transpiration is the single largest efflux of water in many temperate and humid regions, it would be useful to know how much of that may be sourced from groundwater and where in the landscape this connection is prevalent. During drought periods this could have implications for water supply, water quality, and forest health. This study examines the spatial variability of evapotranspiration derived from groundwater (ET_G) across the riparian zone of a small headwater catchment at the Panola Mountain Research Watershed located near Atlanta, GA. ET_G fluxes were estimated for the 2018 growing season from analysis of diurnal oscillations in the groundwater level hydrographs. Spatial variation was evaluated from nine wells located in different landscape positions in three transects across the riparian zone. We found that shallower water-table depths were generally associated with greater ET_G flux. Additionally, we found that basal area of wood stemmed vegetation > 5cm in a 100 m^2 plot centered on the well was poorly correlated with the ET_G flux. The average daily magnitude of ET_G over the growing season generally followed the pattern of length of day and solar radiation (i.e. potential evapotranspiration). However, there were notable exceptions where ET_G flux was higher later in the season, likely due to a greater reliance on saturated zone moisture as a prolonged rain-free period led to low plant available water in the vadose zone. While preliminary, this study provides insight into spatial and temporal relations between riparian vegetation and groundwater uptake in a humid catchment.

TRACK 5

5.3 Lake Lanier and Septic Systems

5.3.1 An assessment of septic system nutrient contributions to Lake Lanier

Brigette N. Haram and Denise Funk, *Gwinnett County Dept of Water Resources*

Gwinnett County Department of Water Resources is conducting a study to better understand septic system effects on Lake Lanier water quality. Lake Lanier supplies all of Gwinnett County's drinking water facilities, and receives advanced treated reclaimed water from our F. Wayne Hill Water Resources Center. Georgia EPD recently finalized a Total Maximum Daily Load (TMDL) for chlorophyll-a, associated with nitrogen and phosphorous in Lake Lanier. The TMDL model incorporates point and non-point sources of nutrients in the lake's watershed, including contributions from both functioning and failing septic systems. This study's main objectives are to: measure the concentration and movement of septic effluent constituents in the groundwater and soils at lakeside septic sites; monitor lake water quality in areas adjacent to those septic sites; and assess whether replacing septic systems with sewer would significantly improve lake water quality. Gwinnett County is working with researchers from the Georgia Water Resources Institute, Georgia Institute of Technology, UGA, Cornell University, and USGS to collect and analyze samples from groundwater, surface runoff, lake water, soil, and lake sediment. Data will be used in the development of models to assess various remediation scenarios and elucidate the most cost effective strategies for reducing nutrient loads into the lake.

5.3.2 Assessment of septic system impacts on Lake Lanier

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Recent decades have seen intense residential development along lake shorelines, including the shoreline of Lake Lanier and many other Georgia lakes. Fast residential development generates increasing volumes of domestic sewage and is not sustainable without effective and safe treatment and disposal technologies. At present, the dominant such technologies are onsite sewage treatment and disposal (septic) systems. Conventional septic systems comprise a septic tank (where household wastewater first flows to retain and reduce solids through bacterial digestion) and a drainfield infiltration system (where the liquid effluent is distributed into the soil to remove nitrogen, phosphorus, chlorides, sodium, microbial pathogens, and other metal and organic compounds). Properly designed, maintained, and functioning septic systems are generally reliable, effective, and adequate. However, in high density areas, some systems are likely to experience failures, leading to incomplete sewage treatment and unsustainable releases of nutrients and pathogens to receiving surface water and groundwater bodies. This article describes the technical framework and activities of a comprehensive assessment project initiated recently to assess the impacts of septic systems on the water quality of Lake Lanier. The project is sponsored by the Gwinnett county Dept of Water Resources and is implemented through the Georgia Water Resources Institute in collaboration with Georgia Tech, the UGA, Cornell University, and USGS.

5.3.3 Preliminary assessment of shoreline septic system impact on Lake Lanier water quality

Samuele Ceolin and David E. Radcliffe, *UGA Crop and Soil Sciences*

Lake Lanier is a 150-km^2 reservoir in North Georgia that is the drinking water source for Gwinnett County, one of the largest counties in Metro Atlanta with a population of 0.9 million. Lake Lanier has a TMDL for chlorophyll-*a* that calls for a reduction in nitrogen (10-13%) and phosphorus (18%) inputs to the lake (GA EPD, 2017). Our objective is to develop an estimate of the contribution of nutrients and bacteria from homes along the shoreline with onsite wastewater treatment systems (OWTS) through monitoring and modeling. We will install approximately 25 groundwater monitoring wells at each of 9 homesites that are representative of the homes along the Gwinnett County shoreline. Approximately, twenty of the wells will be installed in a dense grid close to and running parallel to the shoreline to intercept any OWTS plume that may be present. Chloride concentrations and specific conductivity detected at the shoreline wells will be used as indicators of plume presence. The other wells will be installed in an upslope transect perpendicular to the shoreline in an attempt to track the plume. These wells will be sampled monthly and analyzed for forms of nitrogen, phosphorus, and *E. coli*. HYDRUS 2-D software will be used to model 3 homesites: the models will be calibrated with data collected in the field and they will be used to predict the average load of nutrients and coliforms to the lake over 10 years. Well installation has been completed at two sites. Preliminary results of shoreline well samples from Site 1 and Site 2 showed high and localized concentrations of chloride up to 21.05 mg/L at Site 1 in January and up to 77.41 mg/L at Site 2 in February. These results, paired with elevated specific conductivity values up to 215.5 μS/m at Site 1 in August and up to 289.1 μS/m at Site 2 in October, appear to be a good indication of plume presence.

5.3.4 Advances in modeling the influence of onsite wastewater treatment systems on water quantity and quality

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Onsite wastewater treatment systems (OWTSs) are widely used in the Piedmont and Coastal Plain of the Southeast US for domestic wastewater treatment. In Georgia, approximately 30% of homes are on OWTSs, which is higher than the national average of 24%. Failing or high-density OWTSs can degrade water quality in both surface water and groundwater. Estimates of the percentage of OWTSs that fail vary widely, ranging from 1 to 20%. Furthermore, OWTSs are susceptible to the impacts of climate change. For instance, in coastal areas higher sea levels will decrease the distance from land surface to the groundwater table leading to decreased OWTSs functionality in some locations. However, data on the functionality and effectiveness OWTSs are sparse and mainly available at the scale of individual parcels. Thus, there is a need to quantify how OWTSs affect water quantity (i.e., runoff and discharge) and quality at nested watershed scales. In addition, significant research gaps exist in assessing OWTSs vulnerability in coastal GA and how to create models and tools that empower local OWTSs planners to examine future scenarios and improve infrastructure resilience. We present model simulations of the influence of high density and failing of OWTSs on water quantity and quality in urban watersheds of GA Piedmont. Further, we discuss a methodology for assessing the effects of sea level rise on GA coastal communities' OWTSs and integrating this information into local wastewater and land use planning activities.

5.3.5 Septic system impact to surface water quality study

Daniel E. Johnson [1], Jared Ervin [2], Cristin Corless Krachon [2], and Brandon Steets [2]; *[1] Metropolitan North Georgia Water Planning District, [2] Geosyntec*

The Metropolitan North Georgia Water Planning District (the District) was created by the Georgia General Assembly in 2001 as the designated agency for water resource planning in the fifteen-county metropolitan Atlanta area including 95 cities and over 50 water and wastewater providers. In its 15 years of existence, the District has produced three rounds of water resource planning documents with the first release of the Water Supply and Water Conservation Management Plan, the Wastewater Management Plan, and the Watershed Management Plan in 2003 and the most recent update in 2017. The Water Resource Management Plan addresses many aspects of septic management including land use planning, coordination among multiple jurisdictional departments and the local boards of health, management of septic systems in critical areas, as well as proper planning for septage disposal. Moving forward, the District Governing Board has considered implementing additional required actions to improve surface water quality across the region. To assess what, if any, measures would provide benefits to water quality, the District Governing Board first directed the District staff to conduct a septic system impact to water quality study. The overall sampling and analysis approach chosen for this study is to collect samples from fecal coliform impaired streams across a range of watershed septic densities and use advanced analysis of human DNA markers paired with conventional indicators of bacteria and nutrients to quantify the impacts of septic systems on bacterial and nutrient loading. Results will be used to identify factors controlling septic influences and identify possible management actions to protect surface water quality.

5.5 AWRA Student Career Panel

Ridwan Bhuiyan [1], Amber Ignatius [2], Cody Hale [3], and Jacob LaFontaine [4]; [1] *Jacobs,* [2] *University of North Georgia,* [3] *Nutter & Associates,* [4] *USGS South Atlanta Water Science Center*

5.6 Clean Water Act Regulation of Hydrologically Connected Groundwater: Supreme Court and EPA Actions

Houston Shaner [1] (moderator), Frank Holleman [2], Alison Lathrop [3], Cody Hale [4], and Holly Hill [1]; [1] Troutman Sanders, [2] Southern Environmental Law Center, [3] Georgia Pacific, [4] Nutter and Associates

Over the past year, various United States Courts of Appeal have split on whether the Clean Water Act governs discharges to surface waters that first travel through groundwater. Which court is correct presents a thorny question and one that might soon be addressed by the Supreme Court. This panel would also explore how the U.S. Environmental Protection Agency might take the initiative to resolve the issue on its own through rule-making, guidance, or other means. Questions to be addressed include: What should we expect the Supreme Court to do? What room have the courts left EPA to maneuver (and what room might the Supreme Court leave)? What's the best legal option for EPA: Defining "discharge?" Defining "point source" or "non-point source?" Something else? What technical criteria would inform the rule, and how should the agency define these? Traceability? Geology? Proximity? How could EPA fashion permits for these discharges? Is it better to use a formal rule or informal guidance? How would a groundwater rule interact with the soon-to-be published revision to the definition of "waters of the United States?" Note that, by the time of the conference, both the Supreme Court and the EPA might take regulatory action on this issue.

5.7 Nutrient Trading

Laurie Fowler (moderator)[1], Mary Walker (invited)[2], Anna Truszczynski [3], Mike Giles [4], and Brook Anderson [5];

[1] *UGA River Basin Center,* [2] *EPA,* [3] *EPD,* [4] *Georgia Poultry Federation* [5] *Etowah Water and Sewer Authority*

This session addresses the experiences of nutrient trading in the U.S. and the potential for trading in the State of Georgia and specifically invites input from the audience. It includes panelists from the federal and state regulatory agencies as well as representatives from point and non-point sources of nutrients who have been investigating nutrient trading in the Coosa River Basin.

5.8 Conasauga River

Session: Research and Conservation in the Conasauga River

The Conasauga River Basin of Georgia and Tennessee hosts a uniquely diverse fauna. Long-term monitoring data indicate significant declines in several species of conservation concern, including the Frecklebelly Madtom, Coosa Chub, and Tricolor Shiner. Multiple parties have been involved with research and conservation initiatives in the basin, and this session will highlight these efforts and partnerships. Projects include long-term fish and water quality monitoring, surveys for the Trispot Darter (recently listed as federally Threatened), a Rapid Watershed Assessment of a major Conasauga tributary, and efforts to include landowners in conservation programs. A discussion of major threats, conservation strategies, and priority actions will follow the formal presentations.

5.8.1 Range-wide declines and spatial synchrony in Amber Darter (*Percina antesella*) populations identified with multivariate analysis

Edward Stowe [1,2], Seth Wenger [1,2], Bud Freeman [1,3], and Mary Freeman [4]; [1] *UGA Odum School of Ecology,* [2] *UGA River Basin Center,* [3] *UGA Georgia Museum of Natural History* [4] *USGS Patuxent Wildlife Research Center*

Spatial synchrony—the presence of correlated abundance fluctuations among geographically-disjunct populations—has been documented in numerous aquatic taxa, and primarily arises from dispersal of individuals between populations and shared regional climate. Animals experiencing high levels of spatial synchrony are thought to face greater extinction risk, and yet evaluations of species vulnerability, including those mandated by the Endangered Species Act, rarely consider spatial synchrony. To gage extinction risk, these assessments instead focus on the spatial extent and number of populations, and the long-term abundance trend of each population. Examining spatial synchrony in these assessments alongside the traditionally considered species attributes may provide a more robust understanding of extinction risk, while also generating insight into the relative importance of intrinsic and extrinsic drivers of population dynamics. Here we demonstrate a method for estimating long-term abundance trends in the populations of an Endangered fish, while simultaneously quantifying the magnitude of spatial synchrony among populations. Using sampling data from 16 shoal sites in north Georgia from 1996-2017, we performed multivariate autoregressive state-space (MARSS) analysis to assess the status of the Amber Darter (*Percina antesella*) within its known populations in the Conasauga and Etowah rivers. MARSS models can provide estimates of long-term growth rates while also indicating whether fluctuations of separate populations are correlated. Our analysis suggests that Amber Darters have declined substantially over the last two decades but at differential rates between the rivers: approximately 12% annually in the Conasauga and 9% in the Etowah. However, population fluctuations between the rivers covaried, suggesting that the two populations experience correlated environmental variation. Ultimately this analysis indicates that both populations of Amber Darters are imperiled, and that the overall vulnerability of the species may be compounded by non-independent population fluctuations. This analysis also demonstrates the utility of MARSS modeling for assessing extinction risk.

5.8.2 Establishing a fish and mussel monitoring program in the Holly Creek Watershed

Phillip M Bumpers [1], Anakela Popp [2], Mary C. Freeman [3] and Seth J Wenger [1]; [1] *UGA River Basin Center, Odum School of Ecology,* [2] *Georgia Dept of Natural Resources Wildlife Resources Division,* [3] *USGS Patuxent Wildlife Research Center*

The Conasauga River is a major tributary to the Coosa River that serves as an upstream refuge for many species that have been extirpated from downstream reaches. The Conasauga system is biodiverse, harboring thirteen federally protected species and six state protected species. Long-term studies suggest that the Conasauga fauna is increasingly imperiled. Holly Creek is a major tributary of the Conasauga River that drains the southern Cohutta Mountains. The upper portion of this tributary is one of the few remaining strongholds of several mussel species, as well as several fish species that are declining in the mainstem Conasauga. However, the lower reaches of Holly Creek appear to be impaired as a result of agricultural and urban land uses. In collaboration with the National Fish and Wildlife Foundation we have established a fish and mussel monitoring program in the upper Holly Creek watershed. The goal of this project is to establish baseline conditions of the fish and mussel community to inform restoration activities, as well as to track the response of biota to management actions. In fall 2018 we conducted initial fish and water quality surveys at 10 sites (National Forest boundary to Highway 411) and will conduct mussel surveys during spring 2019. Dissolved phosphorus concentrations were relatively low at all sites. Dissolved nitrogen was variable and generally higher at downstream sites. We encountered two federally-listed and one state- protected fish species during our surveys. Initial sampling suggests that species presence did not differ (PERMANOVA >0.05) among survey sites. However, species composition, accounting for abundances, was different at sites upstream of Chatsworth compared to sites at or downstream of Chatsworth (PERMANOVA < 0.05). Our initial surveys provide baseline information to inform future management decisions and may identify areas in the watershed to target future restoration and best management practices.

5.8.3 Evidence of spatial and temporal changes in benthic habitat conditions in the Conasauga River mainstem

Mary C. Freeman [1] and Byron J. Freeman [2]; [1] *USGS Patuxent Wildlife Research Center,* [2] *UGA Georgia Museum of Natural History*

The Conasauga River in northwest Georgia and southeast Tennessee has for decades been of interest to ecologists as a haven for species-rich assemblages of fishes and mussels. Monitoring data, however, have shown compelling evidence of species declines in the Conasauga River mainstem over the past two to three decades. We generally do not know the causes of species losses, and multiple factors may be responsible. To assess the potential contribution of habitat shifts to faunal change, we have compiled observations of benthic habitat conditions as measured in a variety of studies conducted over the last three decades. In the 1980's, a study of habitat use by the federally-listed amber darter (*Percina antesella*) at mainstem locations between the GA-TN state line and Beaverdale, GA, found the darter foraging over cobble and gravel substrates that were free of silt or accumulated biofilm, in shoals where the submerged macrophyte *Podostomum ceratophyllum* commonly occurred. Lush stands of *Podostemum* also occurred on shoals downstream from Beaverdale, including at the Mitchell Bridge crossing. In the late 1990's and early 2000's, notes made during autumn fish sampling at and downstream of the Beaverdale site documented for the first time extensive benthic algal mats in some years and declining *Podostemum* occurrence. Longitudinal studies by Jane Argentina in 2005 and Christina Baker in 2010 subsequently quantified a decrease in *Podostemum* cover and biomass from upstream to downstream along the Conasauga mainstem. Baker's data also showed corresponding downstream declines in multiple taxa of benthic macroinvertebrates. Together with observations during ongoing annual fish sampling, these studies document a decline in *Podostemum* and an increase in occurrence of algal and diatom mats, both from upstream to downstream along the mainstem and at particular shoals over time, offering clues to factors affecting overall ecological condition of the river.

5.8.4 Genetics and the conservation status of the Trispot Darter, *Etheostoma trisella*, a recently federally listed species endemic to the Coosa River drainage

Bernie Kuhajda [1], Brook L. Fluker [2], and Matthew S. Piteo [3]; [1] *Tennessee Aquarium Conservation Institute* [2] *Dept of Biological Sciences, Arkansas State University;* [3] *Abernathy Fish Technology Center, US Fish and Wildlife Service*

The Trispot Darter, *Etheostoma trisella*, is endemic to the Coosa River drainage in Alabama, Georgia, and Tennessee. This species resides in backwaters and along the edge of pools in large creeks and small rivers in the summer. In the fall, *E. trisella* migrates into tributaries, moving into ephemeral and headwater streams and groundwater seeps in late winter and early spring to spawn. Because *E. trisella* requires this highly specialized spawning environment, it is susceptible to habitat destruction and alteration. Even though the species was rediscovered in the middle Coosa River drainage in Alabama in 2008 after a 50 year collection hiatus, it was federally listed as Threatened in 2019. Phylogenetic analysis of complete mitochondrial ND2 gene sequence data from Alabama (Little Canoe Creek, Ballplay Creek), Georgia (Coahulla Creek), and Tennessee (Mill Creek) populations revealed only slight haplotype variation (< 1% sequence divergence) and some shared haplotypes, suggesting a lack of historical isolation among creek systems. Yet pairwise F_{st} estimates revealed moderate and significant levels of genetic differentiation among creek systems, and we identified significant genetic structure between the Little Canoe, Ballplay, and Coahulla/Mill creek systems using microsatellite DNA, perhaps due to isolation as recent as the impoundment of the Coosa River. *Etheostoma trisella* must locate ephemeral streams to spawn annually, therefore they may possess homing abilities to locate natal seep areas. Microsatellite DNA data were compared between four breeding sites within the Little Canoe Creek system, including three spawning areas with only 200-800 meters separating the mouths of these tributaries. The four breeding sites were not a homogenous group. Genetically based assignment tests showed that individuals were more often assigned to their home site compared to other potential breeding sites, and each breeding site contained a high percentage of non-migrants. Collectively, these results suggested the possibility of breeding site fidelity.

Poster Session

P01 A comparison of benthic invertebrates in the Etowah River, 1958 & 2018

Jeremy Miller [1], Gabriel Pierce [1], Rachel Tempia [1], Rachel Pesaresi [1], William Tietjen [2], Margi Flood [1], [1] *University of North Georgia – Gainesville,* [2] *Georgia Southwestern State University, Emeritus*

The Etowah River originates in Lumpkin County northwest of Daholnega. It flows south then west across North Georgia joining the Oostanala to form the Coosa River. It is famous for its biodiversity and is home to many threatened and endangered aquatic species. Landscape use in North Georgia has changed in the past 100 years, shifting from agriculture to secondary regrowth of forests to increasingly large pockets of urbanization. This project examines benthic invertebrate composition change over sixty years in a small section of the Etowah. Monthly benthic samples were taken at three locations in the section of the Etowah that abuts Dawson Forest from August 1958 to August 1959. Organisms were identified to the lowest possible level. These were the 'Before' samples for a project to assess radiation impact on the river from an unshielded reactor. The project and the reactor were shut down and the data were stored. We replicated equipment and collection sites from September 2017 to September 2018. Organisms were identified to lowest possible taxa and organic matter was identified and weighed. September, October and November 2017 have been analyzed. There does not seem to be a huge difference in composition which may be due to the fact that the watershed was recovering from heavy agricultural use in the 1950s and has been relatively protected since then. This is changing rapidly with urbanization. Antidotal evidence suggests large quantities of sand have reduced heterogeneity and depth in some areas. The discussion of species loss and baseline shifting is in the news now. Our present day understanding of what is here is very different from what was here. We suggest that the boxes in closets containing field notebooks and old vials be checked to find interesting and important archived data.

P02 Gene flow among fish populations spanning the continental divide in Gwinnett County.

Jacobo J. Rivera, Erin Menezes, Peter C. Sakaris, and James E. Russell, *School of Science and Technology, Georgia Gwinnett College*

Gwinnett County is bisected by the southeastern continental divide that separates water flowing to the Gulf of Mexico and water flowing to the Atlantic Ocean. We are currently working with the Gwinnett County Parks and Recreation department to sample fish species in and around county parks on either side of the continental divide to address the central question, does the continental divide act as a physical barrier to gene flow? Headwater steams on either side of the divide were sampled for fish species in 2018 and tissue samples were used for molecular analyses. Four species, *Semoptilus atromaculatus*, *Nocomis leptocephalus*, *Campostoma anomalum*, and *Luxilus zonistius* were identified using molecular barcoding, and two of the four species, *S. atromaculatus* and *N. leptocephalus*, were collected on either side of the continental divide. Preliminary results suggest species found on either side of the divide have distinct and separate genotypes only found in one of the two watersheds, suggesting the divide acts as a physical barrier to gene flow. Furthermore, based on genetic divergence for the mitochondrial gene region used for molecular barcoding, there appears to be a unique subspecies distribution pattern for *N. leptocephalus*. Future research will seek support for the sub-species designations using morphological and behavioral analyses. These results will be used to further develop and test hypotheses related to evolutionary patterns among species spanning the eastern continental divide in Georgia.

P03 Gene migration of sunfish (*Lepomis* spp.) populations across the southeastern continental divide

Amanda G. Haney, James E. Russell, and Michael A. Erwin, *School of Science and Technology, Georgia Gwinnett College*

Gwinnett County is bisected by the southeastern continental divide that separates water flowing to the Gulf of Mexico and water flowing to the Atlantic Ocean. We are currently working with the Gwinnett County Parks and Recreation department to sample fish species in and around county parks on either side of the continental divide to address the central question, does the continental divide act as a physical barrier to gene flow? Headwater steams on either side of the divide were sampled for fish species in 2018 and tissue samples were used for molecular analyses. Preliminary results suggest species found on either side of the divide have distinct and separate genotypes only found in one of the two watersheds, suggesting the divide acts as a physical barrier to gene flow. In 2019 additional species, sunfish in the *Lepomis* genus, were sampled on either side of the divide to test the generality of gene flow hypothesis for fish species. These results will be used to further develop and test hypotheses related to evolutionary patterns among species spanning the eastern continental divide in Georgia.

P04 Investigating coliform bacteria ratios relative to rainfall and stream stage in the Upper Chattahoochee river

Kristina J. Ashe, Olivia T. Husted, James B. Deemy, *Dept of Natural Sciences, College of Coastal Georgia*

Coliforms and other potentially pathogenic bacteria can be transported to streams during storm runoff events or through baseflow exposed to historic septic fields as well as leaking sewage lines. Coliforms are typically associated with turbidity spikes after rainfall events. Accordingly, relationships between turbidity and both total coliforms and *E. coli* are used to monitor these components of biological water quality. The ratio of *E. coli* to total coliforms can provide insight to the magnitude of human and domestic animal coliform sources relative to antecedent coliforms. Our objectives are to 1) quantify patterns in ratios of *E. coli* to total coliforms based on stage and prior precipitation; and 2) model coliform ratio changes associated with discharge and precipitation; and 3) determine if stream stage can be used as a monitoring parameter for potential pathogen exposure where turbidity data is lacking. Stream stage data and coliform monitoring data was downloaded from the USGS Water Watch program and the BacteriAlert program for the Chattahoochee river gauging stations near Norcross (02335000), Powers Ferry Road (02335880), and at Paces Ferry Road (02336000). Coliform ratios were calculated for all sites and dates prior to correlating with stage. Sampling events were also compared based on prior rainfall (-/+). Our preliminary analysis indicated the ratio of *E. coli* to total coliforms increased after rain events compared ($p<0.001$). These results potentially indicate that anthropogenic influences on streams proportionally increase post rainfall events. Future analyses will continue to investigate the relationship between stream stage and coliform ratios.

P05 Assessing coliform ratios in depressional wetlands as potential indicators of hydrologic connectivity.

Catherine Wang [1], Kimberly K. Takagi [1], James B. Deemy [2], Todd C. Rasmussen [3], *[1] Cedar Shoals High School, [2] Dept of Natural Sciences, College of Coastal Georgia, [3] UGA Warnell School*

Depressional wetlands occur in dense clusters on the Dougherty Plain, a physiographic province of Georgia dominated by agricultural land use. Hydrologically, these systems are primarily driven by precipitation and evapotranspiration but a substantial subset are connected to episodic storm flows. Water quality of wetlands connected to episodic flows (recurrence interval <2 years) differ from those that are more isolated from flows (recurrence interval >2 years) and it may be possible to determine wetland connectivity and/or source waters through water quality methods. Our objectives were to 1) analyze longitudinal patterns in coliform ratios from an episodic flow; 2) analyze coliform ratios in a subset of depressional wetlands based on episodic flow connectivity; and 3) determine water quality variables that are potential monitoring parameters for coliform ratios. Water quality data was collected from seven sites along an episodic flow path during a flow event (February-March 2014) and through monthly monitoring of 31 depressional wetlands (March 2014 - March 2015). A common suite of biological (coliforms), chemical (nutrients, dissolved carbon), and physical (conductivity, turbidity, dissolved solids) water quality parameters were measured during each sampling regime. Coliform ratios decrease longitudinally along the episodic flow paths which may indicate that wetlands reduce *E. coli* at greater rates than total coliforms ($p<0.0001$). Wetlands connected to episodic flows did not differ in coliform ratios from depressional wetlands isolated from flows. Preliminary results indicate that specific conductivity and turbidity could be potential monitoring parameters for coliform ratios in isolated wetlands as well as episodic flows. These results build on prior biological water quality data for wetlands on the Dougherty Plain and applicable to understanding coliform water quality function in this physiographic province.

P06 Field methods and photogrammetric techniques for generating maps of invasive aquatic vegetation using unmanned aerial systems imagery

Philip Ashford [1], Steve Golladay [2], Marguerite Madden [1]

[1] UGA Geography Department, [2] Jones Center at Ichauway

New technology and methods to acquire and interpret aerial imagery, including unmanned aerial systems (UAS), structure from motion photogrammetry (SfM), and geographic object-based image analysis (GEOBIA), are democratizing access to high-resolution aerial imagery products for research and commercial applications. While high costs have historically limited access to aerial imagery for most small businesses, nonprofit organizations, and individuals, UAS is enabling broader integration of imagery and geospatial data products to document, visualize, and study a given area. It is more affordable than ever before to acquire all the necessary UAS equipment and computer software and hardware to create 3D models, digital elevation models (DEMs), and ultra-high (<10cm) resolution orthomosaic imagery. This study describes a UAS-based field survey methodology and image processing workflow used to map invasive aquatic vegetation and discusses the relative merits and practical limitations of UAS for ecological monitoring purposes. The results of this study demonstrate the capacity of consumer-grade UAS to survey, map, and detect features of interest over a large geographic expanse and support the viability of UAS as alternative to other remote sensing platforms.

P07 Predicting future potential resistance and resilience of river ecosystem function to altered hydrology

Caitlin Conn [1], Seth Wenger [1,2], Amy Rosemond [1], Phillip Bumpers [1,2], Mary Freeman [2,3], and Kyle McKay [4]

[1] UGA Odum School of Ecology, [2] UGA River Basin Center, [3] USGS Patuxent Wildlife Research Center, [4] US Army Corps of Engineers

Projected changes in climate and land use will affect river hydrologic regimes and ecosystem processes such as nutrient uptake and rates of production of plants and animals. We need to be able to predict *how* these continuing global changes will affect these processes because they key to healthy and stable freshwater systems, which we rely upon for a multitude of services. How resistant and resilient the processes are to different current hydrologic disturbances may help us predict future responses to global change and therefore the consequences of different water resource management strategies. To explore the resistance and resilience

of ecosystem functions to variations in hydrology, we are determining how different flow conditions affect ecosystem processes via changes in primary producer groups in the Middle Oconee River in Athens, GA. Prior studies indicate that differences in plant and algal growth form can determine the susceptibility of these producers to different flow disturbances, such as floods and droughts. Research also indicates that these growth forms exhibit differences in physiology that can translate into distinct functional responses such as carbon fixation rates or uptake rates. These functional responses cumulatively result in the ecosystem processes that determine the health of the streams and rivers. Therefore, how susceptible these producers are to different flow conditions and how quickly they rebound from disturbances can help us understand how overall ecosystem processes may change in response to future scenarios, and thus how resistant and resilient the ecosystem will be to continuing global change.

P08 Impacts of understory rhododendron removal on Southern Appalachian Mountain stream temperatures

Scott Raulerson [1], C. Rhett Jackson [1], Nathan D. Melear [1], Seth E. Younger [1], Maura Dudley [2], Katherine J. Elliott [3]

[1] UGA Warnell School, [2] UGA Odum School of Ecology, [3] USDA Forest Service, Center for Forest Watershed Research, Coweeta Hydrologic Laboratory

Rhododendron maximum L. has expanded in many parts of the Southern Appalachian Mountains following the decline of chestnuts associated with the chestnut blight, and more recently eastern hemlocks from the hemlock wooly adelgid invasion. This expansion has led to dense understory thickets of rhododendron covering streams and their adjacent riparian areas, creating localized, low-light microclimates. In an effort to understand the impacts of this rhododendron encroachment, we investigated the thermal regime of streams in the region prior to, and after the removal of rhododendron thickets. We selected four Southern Appalachian Mountain headwater streams with a significant portion of dead eastern hemlock in the overstory and removed 300-m sections of these rhododendron thickets from two streams. Summer stream temperature was continuously monitored within, upstream, and downstream of the treatment reach for one summer prior to rhododendron removal (2014), and for two summers after the treatment (2015-2016). This occurred in the two treatment watersheds where 300m sections of thickets were removed, as well as in the two undisturbed reference watersheds. Temperature metrics were significantly different across all streams, as well as within streams during the pretreatment year. Additionally, the temperatures in the reference streams were significantly different year to year. Regression relationships were developed for daily minimum, mean, and maximum temperature between the reference and treatment watersheds during the pre-treatment year (2014). Application of these models to the post-treatment years, and analysis of the modelled residuals served as the baseline in assessing the impacts of rhododendron removal.

P09 Comparing rate of soil moisture loss for conventional and conservation tillage systems

Rachel Collier [1], Gary L. Hawkins [2], E.W. Tollner [1], *[1] UGA College of Engineering, [2] UGA Crop and Soil Sciences*

Soil moisture is an important factor for crop production and water conservation. Field studies were conducted to compare the rate of soil moisture retention under conservational tillage verses conventional tillage in cotton (*Gossypium hirsutum*) production. Conservational tillage methods are used to prevent erosion by protecting the soil surface from high intensity rainfall events, reducing runoff, increasing infiltration and increasing soil organic matter. These reduced tillage systems are known to increase infiltration, however there is a knowledge gap on how these systems influence the soil moisture retention rate. Research was conducted on fields managed under conservational strip tillage systems (ST) and conventional tillage systems (CT) to determine if there is a difference in the water loss rate. Experiments were conducted at three locations throughout Georgia in the counties of Oconee, Bulloch and Pulaski (two fields per county). At each of the six fields in the study, soil moisture sensors (Decagon 10HS and TEROS12) were installed at 10, 20 and 30 cm depths. Data was analyzed to determine the rate of soil moisture loss during wet and dry periods. This poster will present the results of the research.

P10 Comparing LiDAR to standard field survey methods for wetland mapping in three geographically isolated wetland types

Brian A. Clayton, Jean C. Brock, Stephen W. Golladay, *The Jones Center at Ichauway*

Typical characterization of wetland topography and hydrology requires expensive and labor extensive ground surveys, as a result most wetland mapping is limited to small areas. The use of remote sensing for wetland studies is increasing and may be better suited for large areas. Light Detection and Ranging (LiDAR) data is becoming an accepted tool to gather information on topography and forest structure. Limitations to LiDAR have been noted and include its inability to penetrate water and high density canopy cover. Our study compared LiDAR Digital Elevation Model (DTM) to a standard field survey method for mapping wetlands. We used three wetland types: marsh (no tree canopy), cypress savannah (intermittent tree canopy), and swamp (full tree canopy). We found that, LiDAR was sufficient for topographic mapping of marsh and cypress savannah wetlands, but did not perform as accurately in the swamp wetland, which had a denser tree canopy. Our results suggest that as LiDAR imagery becomes more readily available, it could be useful for providing information about wetlands at a landscape scale. However, some field measures will be essential for groundtruthing and providing detail in heavily forested areas.

P11 Water quality monitoring in an urban nature preserve undergoing stream restoration

Michael Kshatri [1], Elizabeth Sudduth [2], Sarah Ledford [1], Lisa Casanova [1], *[1] Georgia State University, [2] Georgia Gwinnett College*

The urban creek that is the focus of this study is located in an urban nature preserve that is undergoing a restoration process after being damaged by unauthorized residential development. Although the creek is surrounded by protected land and home to different mammals and aquatic organisms, it is subject to runoff from the streets and residential areas surrounding the preserve. A major part of the restoration efforts involves the installation of beaver dam analogues (BDOs) to encourage beavers to take up residence and conduct natural activity in the stream. Over approximately half a mile, 15 sites have been selected for installation of BDOs to be done in stages. To better understand how BDOs influence water quality, 15 sites were sampled for *Escherichia coli*, weekly before, during, and after BDO installation. Samples were taken weekly at 15 sites along the creek. Samples were analyzed by membrane filtration using BioRad Rapid *E. coli* 2 agar. During warmer periods of the year, E. Coli levels were higher in comparison to the late fall and winter months. Generally, *E. Coli* values ranged from 320 CFU/100 mL to as high as 2800 CFU/mL (2.50 to 3.45 $\log_{10}$). In the winter months values were lower, ranging from 7 CFU/mL to 200 CFU/mL (0.82 to 2.35 $\log_{10}$). During weeks with rainfall, *E. Coli* levels were higher in comparison to weeks without; for example, dry winter months had *E. Coli* levels <200 CFU/mL but during weeks of precipitation values reached ~700 CFU/mL. It appears that rainfall leads to higher *E. Coli* in the stream, potentially caused by urban runoff. Further long-term monitoring can provide further insight into how long-term stream restoration using BDOs affects water quality in the creek. This data could then be used to improve urban development and understand how to manage urban stream restoration while avoiding potential contamination to local preserves and creeks.

P12 Prioritization of subwatersheds in the Upper Coosa for freshwater habitat protection

Jon Skaggs and Seth Wenger, *UGA River Basin Center, Odum School of Ecology*

The Upper Coosa River Basin, composed of the Etowah, Conasauga, and Coosawattee watersheds in north Georgia and southwest Tennessee, is a highly diverse and imperiled river system. Recent studies have described declines in site occupancy and abundance of fish species in the region while potential threats, such as land use change and degradation of water quality, are projected to increase in extent and intensity. Although state agencies, federal agencies, and NGOs are interested in expanding protected areas, resources available for habitat protection are limited. Therefore, priority areas for habitat protection must be identified. Spatial conservation prioritization systematically identifies geographic areas that maximize conservation objectives and minimize costs, but no systematic prioritization of the Upper Coosa has been developed. We used Zonation, a conservation prioritization framework and software, to identify highest priority subwatersheds in the Upper Coosa based on species distributions, connectivity, and cost. Species distributions were based on known and estimated occurrences of state and federally listed freshwater species using maximum entropy modelling. Connectivity was included as an upstream-downstream linkage to account for hydrologic relationships between subwatersheds. Cost efficiency was incorporated using an index of land acquisition cost. Outcomes of this work could guide conservation planning in the region.

P13 Assessment of the fate of anthropogenic nitrogen and phosphorus compounds in the Ogeechee River eight years after the fish kill event

Sumaia Islam and Francisco Cubas, *Georgia Southern University, CEC Department*

In May 2011, the King America Finishing Company inadvertently triggered one of the largest fish kills in the history of the state of Georgia. Investigation of the event, performed by the GA Environment Protection Division, revealed that during the fish kill event, segments of the Ogeechee River contained elevated amounts of ammonia, phosphate, formaldehyde, pyrazole (ammonia containing compound), and Tetrakis (hydroxymethyl) phosphonium chloride (THPC). In this study, long-term impacts on the Ogeechee River downstream the King America Finishing discharge site were assessed from collected river water and sediment samples tested under different environment conditions in a laboratory setup. Samples from two sites downstream the discharge point (Highway 301 and Oliver boat ramp) and one site upstream (Rocky Ford) were tested on a controlled anaerobic environment to measure the release of nitrogen and phosphorus species from the microbial mineralization of pyrazole and THPC, which were discharged prior to the fish kill event. The objective was to evaluate nitrogen and phosphorus release from these two chemicals. Results revealed that although no increased concentrations of nitrogen or phosphorus were observed in the experiments, the chemicals discharged have made the environment too toxic for the bacteria to thrive. Therefore, the microbial community was not as active at Highway 301 and Oliver sampling sites as it was upstream at Rocky Ford. Results further suggested that microorganisms were not able to mineralize the discharged chemical under anaerobic conditions suggesting that these chemicals are recalcitrant and may stay sorbed to the sediments for a long period of time. Eight years after the fish kill event, indirect measurements for pyrazole and THPC mineralization rates have shown that they are not an immediate source for additional nitrogen and phosphorus in the Ogeechee River. However, these chemicals might still represent a toxic hazard to aquatic biota in the river.

P14 Georgia Adopt-A-Stream: Citizen science and water quality monitoring

Harold L. Harbert [1], Seirisse Baker [2] and Bailey Crapps [2]; [1] *Watershed Outreach Manager,* [2] *State Coordinator, Georgia Adopt-A-Stream, Georgia EPD*

Georgia Adopt-A-Stream (AAS) is the largest citizen science water quality monitoring program in the southeast and one of the largest in the nation. With over 200 groups actively monitoring upwards of 700 sites, the AAS online database has registered over 54,000 monitoring events accumulating 262,637 data points. All AAS water quality data is publicly accessible by site, group, watershed, region or state. These data have been used in a number of research papers, resulting in published scientific papers. This poster will highlight the success of the AAS program, sharing uses of data and how the public and private sector can participate.

P15 Implementation guide to West Atlanta Watershed Alliance Community Science Program

Tori Mister, *Emory University, West Atlanta Watershed Alliance*

I will create a standardized training manual for the West Atlanta Watershed Alliance to use for implementing their community science program. This manual will guide staff members and volunteers how to teach West Atlanta residents to identify illicit spills in their watershed. Components of the manual include background information, resident recruitment, stakeholder engagement, fieldwork assessment, and a frequently asked questions page. Proctor Creek is one of the watersheds that flow into the Chattahoochee River. It was "designated a priority area for investment through the Urban Waters Federal Partnership", thus deserving immediate attention. It is home to more than 90,000 residents who are mostly African Americans. Characterized by illegal dumping, standing water, and faulty storm water infrastructure, illicit spills are characterized as unauthorized discharges from storm drains including pollutants and pathogens. They can come from vehicle operations, outdoor materials, waste management, and landscaping (WAWA). Proctor Creek has become a health hazard for West Atlanta residents (Jelks et. al, 2018). The City of Atlanta proactively visits this site as a regulatory standard every 5 years. Municipalities are interested in implementing low cost methods for identification of illicit spills (Irvine, 2011) and a community science program can meet those requirements. The creation of a training protocol will allow staff members to provide residents with political leverage, education, and community accountability through the Community Science Program.

P16 Twenty years of community stream monitoring in Athens, GA: Analysis and policy recommendations

Luke Marneault [1,2], Todd Rasmussen [1,3], Phillip Bumpers [1,4]; [1] *Upper Oconee Watershed Network;* [2] *Oconee County High School,* [3] *UGA Warnell School;* [4] *UGA River Basin Center, UGA Odum School of Ecology.*

For twenty years, community volunteers have collected stream habitat and water quality data in local rivers and streams near Athens, GA. What started as the Community Watershed Project (CWP) evolved into the Upper Oconee Watershed Network (UOWN). Over time, the annual River Rendezvous expanded to include quarterly monitoring at priority sites. Monitoring includes visual, chemical water quality, and benthic macroinvertebrate assessments. Additional partners have contributed analytical services for microbial testing using UOWN volunteers to collect water samples. This paper summarizes both spatial and temporal trends using these data.

P17 Ecological restoration: Student projects

Jon Calabria, *UGA College of Environment & Design*

Graduate students from the Ecological Restoration course assisted several landowners with ecological restoration projects during the Spring 2019 semester. Projects included stream restoration in urban settings in the Piedmont of Georgia. Students were involved with watershed characterization and assessment, then created design and interventional responses. Projects aspired to collectively improve environmental, social and economic components to maximize landscape performance. Projects included coordinating with stakeholders in the Proctor Creek watershed to enhance designs proposed by various agencies, including the Corps of Engineers. Other sites included Lilly and Tanyard Branch at the UGA main campus and private lands. Each site presented challenges when trying to address the "Urban Stream Syndrome." Challenges include addressing connectivity, improving floodplain access and riparian vegetation management in a variety of land uses accessed by many users. Challenges of each site and commonalities will be reviewed, then design interventions will be presented to illustrate the design response. Student learning and reflections will also be shared.

P18 Native salt-tolerant landscaping for Georgia's coastal hazards

Rachel S. Smith [1] and Keren Giovengo [2], [1] *UGA Odum School of Ecology,* [2] *UGA Marine Extension and Georgia Sea Grant*

Georgia's lower coastal plain and its associated plant communities are vulnerable to various coastal hazards, including storm surge, flooding, sea level rise, and drought. Because native plants are adapted to the distinct environments of Georgia's lower coastal plain, native plants can be used in coastal landscaping to provide natural resiliency to these coastal hazards. Specifically, native plants in maritime dune, maritime forest, and tidal wetland ecosystems are adapted to salt spray, tidal inundation, strong winds, high temperatures, and sandy, saline soils. Planting salt-tolerant native plants in a landscaping setting can enhance important ecosystem services, such as flood control, water purification, and coastal protection in natural, residential and commercial areas. Additionally, because native plants are adapted to local conditions, they also require less pesticide, fertilizer, water, and maintenance. We have identified a list of salt-tolerant plants that are native to coastal Georgia that can be used for resiliency planning, mitigation, restoration, and landscaping by homeowners and professionals. Furthermore, we provide best practices for site planning, plant selection, sourcing, installation, care and maintenance.

P19 A spatial model to identify and prioritize potential oyster reef restoration sites along the Georgia coast

Cameron C. Atkinson and James B. Deemy, *Dept of Natural Sciences, College of Coastal Georgia*

Steep declines in oyster populations were observed during the 1900s and many populations are now less than 10% of historic levels. Oyster restoration has been gaining popularity in efforts to recover oyster fisheries. Reef restoration success is dependent on locating sites based on a balance of physical, chemical and biological factors. A challenge in restoring oyster reefs is that sessile adult oysters cannot escape adverse water quality conditions. Physicochemical water quality factors such as salinity (14-28 ppt), water temperature (20-30°C), dissolved oxygen (>20%), and turbidity (0.6-2.0 NTU) contribute to successful recruitment and survival of spat and adult oysters on restored reefs. Spatial assessment of these four physicochemical drivers, along with proximity to pre-existing oyster reefs (spat sources) could be used to prioritize potential restoration sites. Our objectives are to 1) build a framework to identify spatial patterns in physicochemical drivers of oyster reef success; 2) create a spatial index of oyster restoration suitability for Georgia coastal estuaries; and 3) prioritize identified restoration targets according to restoration suitability. Spatial data were downloaded from the Georgia Dept of Natural Resources G-WRAP program and were used to build an oyster reef restoration suitability index for the Georgia coast. The index identified potential restoration priorities based on our four focal physicochemical drivers as well as proximity to extant oyster reefs. The index rated estuary habitat by combined parameter suitability. A final ArcGIS map was produced by integrating the four physiochemical drivers as well as proximity to pre-existing oyster reefs. This final map also factored in the influence of several anthropogenic stressors to oyster reef success. This research provides a baseline map for targeting future restoration locations along the Georgia coast while also providing a framework that can be applied or adapted to other geographic regions.

P20 Coastal geomorphology change and spatial characterization using airborne LiDAR along the southeast Florida coastline

David F. Richards, IV[1], Adam M. Milewski [1], Brian Gregory [2]

[1] UGA Dept of Geology, [2] National Park Service, Southeast Coast Inventory & Monitoring Network

The use of digital elevation models (DEM) derived from light detection and ranging (LiDAR) provides an opportunity to examine coastal alterations occurring along the southeast Florida coastline. Cape Canaveral National Seashore, of the Southeast Coastal Network (SECN) of the National Park Service (NPS), is a highly vulnerable site where sea level rise threatens the sustainability of this coastal zone. Geomorphologic and anthropogenic changes (i.e., channel migration, dune migration, inundation, shoreline retreatment, saltwater intrusion, runoff and waste discharge) were evaluated to understand their role in the coastal dynamic response to sea level rise. LiDAR collected from NOAA, USGS, and NEON were processed using ENVI and ArcGIS. LiDAR derived DEMs at 1m scale resolution acquired from the National Oceanic and Atmospheric Administration Digital Coast (NOAA) has demonstrated that LiDAR is more accurate than ASTER DEMs from earth's orbiting database acquired from the USGS (USGS). Data processing involved understanding the spatial volumetric change in dunes, statistical analysis to characterize topographic features and the correlation of how geomorphologic/anthropogenic changes affect the coastal geomorphology. This study serves as a proof of concept to better understand how the impact of sea level rise on coastal environments effect the surface/subsurface water interactions. The high-resolution data informs us of how the variance in the elevation values and dune systems affect the hydrological and hydrogeological response of this coastal zone. The advantages of LiDAR and other remote sensing technologies will provide insight on how to improve coastal water resources and the understanding of the coastal geomorphological dynamic.

P21 Modeling small order watershed freshwater contributions to estuaries along the Georgia coast

Isabelle D. McCurdy and James B. Deemy, *Dept of Natural Sciences, College of Coastal Georgia*

Small order watersheds are an understudied component of coastal hydrology relative to the area the systems occupy along coastlines. These small order watersheds could represent substantial hydrologic and water quality contributions to the estuaries and sounds in which they terminate. Our objectives were to 1) map small order watersheds (1st and 2nd order) that terminate directly into estuaries and sounds along the Georgia coast; 2) estimate monthly precipitation / evapotranspiration balances for each watershed; and 3) compare the collective contribution of these small order watersheds to larger nearby watersheds terminating within the same estuary. Our focal areas of analysis are the coastlines along Glynn and McIntosh counties. Elevation data (10m) was downloaded from the USGS Earth Explorer data portal. Flow direction and flow accumulation maps were generated from the elevation rasters which were then used to model watersheds. Larger order stream watersheds were eliminated from analysis extent to ensure that only small order coastal watersheds were mapped. Monthly rainfall data was interpolated from rainfall time series data collected at USGS (Water Watch program) gauging stations along the coast. Evapotranspiration data was calculated using Thornthwaite's equation and surface temperature data downloaded from USGS Earth Explorer. Precipitation and evapotranspiration were combined to generate a monthly water budget estimate for each watershed. Water budgets were used in combination with land use / land cover based runoff estimates to model freshwater contributions to streams terminating in the estuaries and sounds. Our preliminary analysis indicates several dozen small order watersheds in each county. These watersheds span a range of magnitudes and dominated by a variety of land uses and land covers. We believe that the modeling framework we have developed could also be applied in other regions with frequent small order watersheds along the coastline.

P22 Modeling potential storm surge flooding in the Lower Satilla River

Sabrina R. Hodges and James B. Deemy, *Dept of Natural Sciences, College of Coastal Georgia*

Storm surge results from combined effects of wind and pressure drops during hurricanes. As sea water is pushed inland through river channels by the approaching storms river stages increase accordingly and flood stages may be reached. Tidal stage can also combine with storm surge and antecedent river discharge to increase the magnitude of river flooding. Our objectives are to 1) statistically asses stage distribution in the Satilla river at the most downstream gauge; 2) model a range of storm surge and tidal magnitude combinations in conjunction with three sea level rise scenarios; 3) apply modeled flood stages in a spatial assessment of flooding in the lower Satilla river. Stage data was downloaded from the water watch program at the Waycross (022265000), Atkinson (02228000), and Woodbine (02228070) gauging stations. We selected three arbitrary storm surge scenarios 1m, 1.5m, and 2m. Stage data was statistically analyzed for discharge quantiles as well as frequency distribution using empirical cumulative density function. We combined statistical descriptions with 0.1m, 0.25m, and 0.5m sea level rise scenarios. Our focal scenarios are to combine conservative, moderate, and high range sea level rise scenarios with both spring and neap tides, for each discharge quantile during a 1m, 1.5m, and 2m storm surge. In ArcGIS a spatial flood risk model was generated from modeled flood stage elevations and 1/3 arc second elevation data. Our models will be evaluated by comparing predicted water levels to stages recorded during Hurricanes Matthew and Irma. The spatial model will be compared to projected storm flooding maps provided by NOAA and USGS. Model results could be used to refine flood mapping predictions as well as identify development vulnerable to future storm surge flooding.

P23 Using tidal stage to model hurricane storm surge inundation risk to development along the Georgia Coast, USA

Clayton M. Davis, Summer G. Wright, James B. Deemy, *Dept of Natural Sciences, College of Coastal Georgia*

Recent hurricanes have generated interest in improved storm surge risk maps along the Georgia coast. Storm surge is defined as flooding due to increased sea level resulting from low atmospheric pressure in the storm center. Risk from storm surge is a function of hurricane's extent, intensity, tidal stage at landfall, and magnitude of anthropogenic development at low elevations. Tidal stage during hurricane landfall is one of the most critical factors in determining the extent of storm surge risk. Our objective was to map risk to anthropogenic development along the Georgia coast from a 2 m storm surge at a range of tidal stages. A two-meter storm surge was selected based on observed storm surges during Hurricane Matthew (2.1 - 2.3 m, 2016) and Hurricane Irma (1.1 - 1.4 m, 2017). Mean higher high water (MHHW) and Mean lower low water (MLLW) were based on local NOAA tidal gauges to establish tidal amplitude. Anthropogenic development was mapped using 30 m land use / land cover available through the 2011 National Landcover Dataset. Risk maps were generated by modeling potentially inundated elevations and then overlaying developed LULC data. Initial analysis of the Georgia coastal counties included a study area of approximately 9,400 km^2 of which 742 km^2 is considered developed. Inundation of high-development areas at the low tide interval was 1.52 km^2 and inundation at high tide was 10.43 km^2. There was a nearly 600% increase in high-developed land at risk during high tide versus low tide. Categories were based on development level from LULC data; open areas, Low, medium, and high intensity development. Future research explores additional tidal stages (extremes and intermediate stages) and potential impacts on roadways and intensity of inundation, such as level above ground. Additionally, localized sea level rise predictions will be incorporated into future inundation models.

P24 Water quality of a small, semi-isolated freshwater wetland on the Georgia Coast, USA

Summer G. Wright and James B. Deemy, *Dept of Natural Sciences, College of Coastal Georgia*

Wetland water quality is a function of concomitant physicochemical conditions and biological processes. Precipitation, runoff, atmospheric conditions, flora, and fauna all contribute to wetland water quality. Relative to larger waters, aquatic vegetation and algal communities can disproportionately drive biogeochemical cycles in small depressional features. Seasonal patterns in aquatic vegetation and algal community growth drive cycles in photosynthetic activity, which drives dissolved oxygen, carbon dioxide, and pH through time. Fall leaf senescence and spring leaf out may drive water quality changes due to an increase of decaying organic matter (leaves, dead plants, etc.) during the fall and decreased light penetration after spring leaf out. In comparison to nearby charismatic salt marshes, small coastal freshwater wetlands are highly understudied. Accordingly, our objectives are to 1) establish a baseline water quality dataset for a small semi-isolated wetland on St. Simons Island, GA; 2) quantify changes in water quality related to fall senescence and leaf-out; and 3) determine monitoring potential water quality parameters. Weekly water quality measurements were collected between 10/19/2018 through 1/25/2019 with data collection continuing through April 2019. Dissolved oxygen, pH, specific conductivity, and temperature were measured with a Hydrolab MS5 multiparameter probe and turbidity was measured with a Hach 2100Q turbidimeter. Dissolved oxygen initially increased during plant die off potentially due to decreased water temperatures. Subsequently, dissolved oxygen fluctuated through January in response to precipitation. The decreased DO may be due to increased organic matter decomposition post senescence. Specific conductivity increased, which may be caused by increased runoff and hydraulic soil water inputs during early winter. Turbidity decreased which may be a response to decreased water column algal growth. No observable changes in pH occurred through the sampling period. Measurements will continue through the winter and spring of 2019.

P25 Comparison of radon-derived groundwater discharge fluxes from Georgia tidal creeks

Katherine L. Curran and Jacque L. Kelly, *Dept of Geology, Georgia Southern University*

Groundwater discharge fluxes are known to be spatially and temporally variable. They are also known to impact the biology of the receiving areas. We have been studying these variations, in addition to water chemistry to assess potential correlations between groundwater discharge and eastern oyster (*Crassostrea virginica*) beds. We collected groundwater and estuary samples from four recreational oyster harvesting creeks along the Georgia coast. Oyster Creek near Tybee Island, Jointer Creek near Jekyll Island, Medway River between Ossabaw and St. Catherines Islands, and Teakettle Creek near Sapelo Island were surveyed between July and October 2018. We collected groundwater samples using peristaltic pumps connected to push-point piezometers driven to ~50 cm depth at locations above the low-tide line from each creek bank. Groundwater discharge was surveyed using a commercially available radon detector (RAD-7), which monitors for radon-222, a well-established tracer of groundwater discharge. In the lab, we diluted, filtered, and analyzed the samples using ion chromatography. We found that the amount of groundwater discharge varies within each creek. Water quality and nutrient concentrations will be compared to oyster data that was collected simultaneously with the groundwater data to evaluate the relationship between oyster health and groundwater discharge sites in Georgia's recreational harvest areas.

P26 Groundwater conditions in Georgia, An interactive website

Debbie Warner Gordon and Richard Scott Young, *USGS South Atlantic Water Science Center*

Groundwater-level data are essential for water-resources assessment and management. Water-level measurements from observation wells are the principal source of information about the hydrologic stresses on aquifers and how these stresses affect groundwater recharge, storage, and discharge. The USGS (USGS) website, Groundwater Conditions of Georgia, located at www2.usgs.gov/water/southatlantic/ga/infodata/gwconditions/index.php, presents hydrographs of select wells that represent all of the major aquifers in Georgia. The USGS has been publishing a Groundwater Conditions Report in Georgia about every two years since 1978. During 2017, the publication series was converted into an interactive website that pulls data directly from the USGS National Water Information System database to summarize water-level data on maps and graphs for each aquifer. The website initially presents hydrographs for the entire period of record but allows the user to zoom in to any date range of interest. For example, to see period of record hydrographs of three surficial-aquifer wells, go to www2.usgs.gov/water/southatlantic/ga/infodata/gwconditions/surficial.php. Period of record and recent 10-year trends in the mean monthly groundwater levels also are presented in tabular form and in the interactive graphs for each monitoring well. Groundwater monitoring in Georgia is conducted through ongoing partnerships with numerous local organizations, private companies, and State and Federal agencies. These organizations and agencies include the following: City of Albany Utility Operations; Augusta Utilities Department, City of Augusta; Georgia Dept of Natural Resources, EPD; Brunswick-Glynn County Joint Water and Sewer Commission; and Miller Coors LLC. All these organizations participate in the USGS Cooperative Water Program, an ongoing partnership between the USGS and State and local agencies. The program enables joint planning and funding for groundwater monitoring and systematic studies of water quantity, quality, and use. Data obtained from these studies are used to guide water-resources management and planning activities and provide indications of emerging water problems.

P27 Investigating subsurface flow in a karstic system considering the potentiometric surface

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Aquifer recharge and surface water - groundwater connectivity are poorly understood in the Dougherty Plain, a karstic region heavily utilized for agriculture in the ACF River Basin (Apalachicola River, Chattahoochee River, Flint River). Groundwater and surface water models for this region have been created by the USGS but lack appropriate detail to accurately explain smaller areas inside the Dougherty Plain. A linear finite element model is being created with existing information and new site-specific information to generate finer-scale results at the 29,000-acre Joseph W. Jones Ecological Research Center in Baker County, Georgia. The successful completion of this project will provide the Joseph W. Jones Ecological Research Center with a tool to predict the potentiometric surface and flow direction of the Upper Floridan Aquifer on site. Additionally, a sensitivity analysis will be completed to identify regions more susceptible to water level fluctuations when subject to groundwater extraction. Knowledge of aquifer recharge, flow direction, and areas of high sensitivity could aid future research projects and land conservation decisions on site. Improved insight into karstic hydrology benefits future best management practices in karstic regions regarding aquifer recharge and the effects of groundwater extraction on surface water entities such as wetlands, creeks, and rivers.

P28 Impact of land cover on groundwater quality in the Upper Floridan Aquifer in Florida, USA

Ranjit Bawa and Puneet Dwivedi, *UGA Warnell School*

Although agricultural lands are generally assumed to correlate negatively with groundwater quality, the extremely intricate relationship between general land cover and level of contaminants present in an aquifer may vary substantially; contingent upon the land type, interaction terms, and scale considered. The Upper Floridan Aquifer (UFA) is a primary source of potable water supply for the state of Florida. The Suwannee River Water Management District (SRWMD), located in northcentral Florida, relies exclusively on the UFA for water supplies. Over much of the SRWMD in the UFA is unconfined, rendering it vulnerable to contamination from surface sources. Groundwater concentrations of Nitrate-Nitrogen (NO_3-N) and Potassium (K) from shallow wells across the SRWMD were analyzed to assess the effects of different land cover on groundwater quality over time. Annual potentiometric surface maps were used to delineate semicircular recharge zones of 500m, 1000m, and 2000m radii upstream of sampled well stations. Proportions of agriculture, forest, and urban land were identified for each buffer zone using USDA Cropland Data Layer. Multivariate regression models were developed to infer relationships between land cover and NO_3-N & K concentrations. Results show significant associations among land cover type, water table height, and groundwater quality parameters. Specifically, we find a large proportion of agricultural cover consistently associated with larger increases in groundwater pollutant loads relative to urban or forest cover across all models, after controlling for depth-to-water table. Our conclusions suggest an immediate need for widespread adoption of cost-effective agricultural best management practices (BMPs) that can help to mitigate environmental pollution of the region's water supply.

P29 Investigating the relationship between water flow path and contaminant risk from Georgia Coal Ash Ponds in the Piedmont

Claire Mathis, *Georgia State University*

Coal ash, otherwise called Coal Combustion Residuals (CCRs), accounts for one of the highest waste streams in the United States, half of which is stored in surface ponds called coal ash ponds. CCRs are known to contain a variety of toxic contaminants, which differentially leach in these ponds and contaminate nearby ground and surface water resources. Georgia in particular is a major coal consumer, ranking 18th in the US in 2017 for consumption of coal for electricity generation. When considering power plants with capacities of at least 200 MW, Georgia has a total of 8 coal power plants, both active and retired. Furthermore, all of the coal ash ponds in Georgia are completely unlined and left without any leachate removal system to prevent groundwater contamination. For my research I will analyze publicly available water quality data from Coal Ash Pond Groundwater Monitoring Reports. I plan on focusing on the coal ash ponds within Plant Scherer, Plant Wansley, and Plant Yates, which are all within the Piedmont Geographic Province. I will look for patterns in the contaminant concentrations, such as Boron, Calcium, Chloride, Fluoride, Sulfate, TSS, and various metals, and their flow paths. From analyses of preliminary data, I suspect that some of the higher levels of constituents are coming from surface infiltration of dry coal ash surrounding the pond, as opposed to the pond itself. This finding raises questions regarding developing practical solutions and best practices that needs to be put in place to prevent groundwater contamination in unlined coal ash ponds.

P30 Flood-inundation maps for the Yellow River from River Drive to Centerville Highway, Gwinnett County, GA

Jonathan W. Musser, *USGS South Atlantic Water Science Center*

Digital flood-inundation maps for a 16.4-mile reach of the Yellow River in Gwinnett County, Georgia, from 0.5 mile upstream from River Drive to Centerville Highway (Georgia State Route 124) were developed to depict estimates of the areal extent and depth of flooding corresponding to selected water levels (stages) at two USGS (USGS) streamgages in the mapped area. The maps for the 9.0-mile reach from 0.5 mile upstream from River Drive to Stone Mountain Highway (US Route 78) are referenced to the streamgage Yellow River near Snellville, Ga. (station 02206500), and the maps for the 7.4-mile reach from Stone Mountain Highway to Centerville Highway are referenced to the streamgage Yellow River at Ga. 124, near Lithonia, Ga. (02207120). At the Yellow River near Snellville streamgage, the profiles ranged from a stage of 18.0 ft to a stage of 33.0 ft. At the Yellow River near Lithonia streamgage, the profiles ranged from the National Weather Service action stage of 13.0 ft to a stage of 29.0 ft. A one-dimensional step-backwater model was developed using the US Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC–RAS) software to simulate water-surface profiles of the mapped reach for the selected stages. The simulated water-surface profiles were then combined with a geographic information system digital elevation model—derived from light detection and ranging (lidar) data having a 5.0-ft horizontal resolution—to delineate the area flooded at the selected stages. Real-time stage information from these streamgages can be used with these maps to estimate near real-time areas of inundation. National Weather Service forecasted peak-stage information for these two USGS streamgages can also be used to show predicted areas of flood inundation in the mapped area.

P31 A hybrid approach of analyzing urban flood risk: A case study in the City of Atlanta, GA

Nirajan Dhakal, and Kayla Oriyomi, *Environmental and Health Sciences Program, Spelman College*

The Atlanta metropolitan area has been one of the most rapidly urbanizing population centers in the United States since the mid-20th century. The City of Atlanta is susceptible to flooding from the Chattahoochee River as well as several creeks that flow through the city. In recent years, Atlanta has experienced severe flooding that has caused substantial damage along Peachtree Creek. The magnitude of damages and loss of life caused by these events have motivated serious re-assessment of current flood infrastructure and flood policies for emergency preparedness and response. Therefore, it is important to provide easy to read graphical information related to flood hazard to the public, city planners and emergency managers. The aim of this study is to support emergency response in Peachtree Creek watershed in Atlanta by producing comprehensive inundation maps for flood events of different return periods (10-, 25-, 50-, 100-, and 500-year floods). We will use a hybrid approach in identifying flood risk zones and assessing the extent of impact of the hazard by integrating HEC-RAS, GIS and HAZUS technologies. The specific objectives of this study are: (1) simulation of flood flows of different return periods using a hydraulic model (HEC-RAS), (2) production of estimated flood-inundation maps at various stream stages using the HEC–GeoRAS computer program and a geographic information system (GIS); (3) modeling the social, physical and economic effects of estimated floods on critical infrastructure and surrounding communities using HAZUS computer program; and (4) combining the results of HEC-RAS, HEC–GeoRAS and HAZUS into a single map. The results of this study can assist the decision-making authorities to stay informed about the possible higher magnitude flood risk areas in the three watersheds and integrate this information while developing flood policies for emergency preparedness and recovery planning as well as mitigation plans.

P32 Relationships between discharge and land use / land cover in the Altamaha watershed

Kimberly K. Takagi [1], Victoria Mattiello [1], James B. Deemy [2]

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Watershed land use / land cover (LULC) changes alter the timing, duration, and magnitude as well as the water quality of stream discharge. However, changes in LULC do not affect streams equally. When changes occur in close proximity to streams, discharge is more directly impacted. Changes further from the stream however are associated with delayed or indirect impacts. The objectives of this study were to 1) determine how LULC changes in the Altamaha watershed are associated with changes in discharge metrics; 2) determine which LULC changes are most closely related to discharge; and 3) determine spatial scales at which LULC changes are associated with any alterations in discharge metrics. Preliminary analyses indicate positive discharge relationships between minimum recorded discharge and both agricultural land use and forest land cover within a 50 m stream buffer. As expected, developed land use cover within 50 m of streams was negatively correlated with both minimum recorded discharge and first quartile discharge. Interestingly, wetland land cover was negatively correlated with minimum discharge within this buffer scale. Within the 500 m stream buffer, positive relationships between minimum recorded discharge and both agricultural land use and forest land cover were observed. Wetland and developed land use were negatively correlated with minimum recorded discharge within the 500 m stream buffer. These assessments imply associations between LULC and discharge metrics in the immediate vicinity of the stream (50 m) and within (500 m) of the stream. Decreases in minimum and first quantile flows associated with increased developed LULC could be driven by decreased base flow due increased surface run off. Higher minimum recorded discharges associated with increased forest cover and agricultural LULC may be driven by increased infiltration.

P33 Land use and land cover change in the Caloosahatchee River Basin in Southern Florida

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Alterations in land use and land cover (LULC), such as increases in developed and agricultural areas, can decrease water quality by increasing runoff, erosion, sediment and nutrient loads, and reducing natural filtration of water. The US Fish and Wildlife Service (USFWS) Water Resource Inventory and Assessment (WRIA) project is an initial step in understanding water resources on National Wildlife Refuges (NWR). Currently, WRIAs are being created for the J.N. Ding Darling Complex in Lee and Sarasota Counties, Florida. Using datasets from various state and federal agencies that encompass nearly all aspects of the water resources (geospatial information, quality and quantity, management and infrastructure, and potential threats and needs) along the Caloosahatchee River and within the Pine Island Sound, the WRIAs provide refuge management with relevant, summarized water resource datasets, an assessment of challenges facing the refuge, and recommendations moving forward. Various datasets identified in the WRIAs, as well as additional LULC data for a defined Region of Hydrologic Influence (RHI) were collected for this study to address possible water resource concerns and potential links between water quality and LULC change. Landsat images and data from the National Land Cover Database (NLCD) were processed and classified, and results showed increases in developed land, and decreases in agricultural, wetland, and other LULC types. Water quantity and quality, as well as additional data (salinity, phosphate, and nitrate) from the USGS Water Quality Portal, were used to identify potential correlations between quality and LULC change. Salinity, phosphate, and nitrate showed seasonal trends as well as correlations with river discharge. The LULC changes within the RHI pose a threat to the water quality of the Caloosahatchee River and Pine Island Sound.

P34 Discharge distributions in the Satilla river: relationships between discharge metrics and land use / land cover

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Watershed land use / land cover (LULC) changes can alter hydrologic stage distribution as well as the water quality of streams. Land use / land cover changes that occur in close proximity to streams are more likely to alter discharge and while changes occurring further from the stream less likely to alter discharge. Our objectives were to 1) determine if LULC changes in the Satilla watershed are associated with changes in discharge metrics; 2) determine which LULC changes are most closely related to discharge distribution; and 3) determine spatial scales at which LULC changes are associated with any alterations in discharge metrics. Our preliminary analyses indicate positive discharge relationships between minimum recorded discharge and both agricultural land use within 50 m stream buffer. Developed land use cover near streams was negatively correlated with both minimum recorded discharge. Within the 500 m stream buffer, positive relationships between minimum recorded discharge and agricultural land use as well as forest land cover were observed. Developed land use was negatively correlated with minimum recorded discharge within the 500 m stream buffer as well. Preliminary assessments indicate associations

between LULC and discharge metrics in the immediate vicinity of the stream (50 m) and within (500 m) of the stream are stronger than those within the intermediate distance (100 m). Decreases in minimum quantile flows associated with increased developed LULC could result from decreased base flow potentially due to increased surface run off associated with the impervious nature of developed land use. Higher minimum recorded discharges associated with increased forest cover and agricultural LULC could result from increased infiltration.

P35 Multi-decadal forest streamflow behavior in Falling Creek, Georgia

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We present long-term streamflow datasets (1964 - 2018) for four Georgia Piedmont watersheds. While most watersheds contain a mix of developed, agricultural, and forest uses, over 95% of the Falling Creek watershed contains forests managed by the US Fish and Wildlife Service and the US Forest Service. Peak discharges (normalized by watershed area) are consistent between watersheds, but Falling Creek is skewed toward lower flows than the other watersheds, possibly due to increased evapotranspiration, low-permeability subsoils, numerous gullies and deeply incised channels from legacy cotton farming, or the absence of ponds. Identifying the cause of the poor hydrologic behavior of this forested watershed is needed to guide restoration efforts.

P36 Comparative analysis of water-storage dynamics and storage-discharge relations among variably-urbanized catchments within the South River Watershed, Dekalb County, GA.

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Continued population growth in the southeastern US, especially in the Atlanta Metropolitan area, is driving the persistent expansion of the urbanized landscape. Urbanization dramatically impacts the hydrologic cycle by enhancing surface runoff and reducing infiltration and groundwater recharge. It is often shown that increases in impervious surfaces in urbanized landscapes correspond to reductions in baseflow in streams during rainless periods, although there are many exceptions. For example, we observe the greatest baseflow magnitude in the least urbanized of seven sub-catchments of the South River Watershed (SRW) in Dekalb County, GA. These contrasting findings highlight our lack of understanding about how urbanization impacts the dynamics of water storage within landscapes—given that storage is a first-order control on baseflow. We are conducting a comparative analysis of seven nested watersheds within the SRW of Dekalb County, GA. The research questions are: (1) what is the estimated amount of water stored in a watershed and how does change in dynamic storage vary across different watershed scales, (2) what inference can be made about the nature of subsurface flow processes based on analysis of storage-discharge relations across the nested watersheds, (3) how does discharge sensitivity to water-storage change vary across an urban-suburban gradient? Utilizing streamflow data from USGS gauging locations, we employ the dynamical system approach proposed by Kirchner (2009) to quantify the catchment sensitivity function and storage-discharge relationship. The approach is different from others as it does not require an arbitrary base flow separation, or *a priori* assumption of any particular functional relation between storage and discharge. The results from this study will reveal how urbanization impacts the magnitude and temporal variability of water storage within the landscape. We view water storage, particularly the temporally dynamic fraction of storage, as the fundamental factor determining the resiliency of urban-stream flow to environmental stresses.

P37 Assessing geophysical methods to detect nutrient movement from septic systems to Lake Lanier

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Eutrophication is a major problem when considering the water quality of Lake Sidney Lanier. The Total Maximum Daily Load for nutrients developed for the lake specifies that failing septic systems need to be reduced by 50% in order to meet the prescribed Chlorophyll a standards. Detecting failing septic systems, however, is a challenging task due to the number of septic systems present and the sudden nature of their failure. Hence it is important to 1) investigate environmental conditions most susceptible to failing septic systems and 2) determine ideal monitoring locations to detect septic system contribution to water bodies. Towards this effort, we are attempting to quantify nutrient contributions by individual septic systems installed in heterogeneous (topography, soils and vegetation) environments around the lake. We are exploring the use of geophysical methods, specifically, Electrical Resistance Tomography (ERT) and Electro-Magnetic Induction (EM31) to delineate the wastewater plume from individual systems to the lake by mapping sub-surface conductivity. For this purpose, we are mapping the cross-sections of 9 households, plus a control site with no housing. Data is being collected once a month with the EM31 and twice a season (dry and wet conditions) with the ERT at selected sites. Preliminary results of February and March samplings are showing that even though there is some correspondence between the values measured with the EM31 instrument and the conductivity of the water registered in pre-installed monitoring wells, its utilization at two new sites has not yet shown relevant data to advise new monitoring well installation. The noticeable amount of rain of the past months is probably interfering with the ability of EM31 to show a remarkable difference in conductivity in the area of the plume. Preliminary data shows that ERT is more informative than EM31 in explaining subsurface conductivity.

List of Authors