2023 PROGRAM

GEORGIA WATER RESOURCES CONFERENCE

30 AND 31 MARCH, 2023

GEORGIA CENTER FOR CONTINUING EDUCATION, ATHENS, GA

UNIVERSITY OF GEORGIA
River Basin Center

Table of Contents

Special Events

Plenary, Doyle	3/30
Lunch Keynote, Manganiello	3/30
Lunch Keynote, Burnes	3/31
USGS Equipment Demo	3/30 + 31
Creature Comforts Social	3/30
Ecology Courtyard Social	3/31

History of the GWRC

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. This year's conference boasts 10 panels, well over 130 presentations and 47 posters.

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. Conference proceedings are 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 top-ics related to water policies, legislation, research, ongoing 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.

The Georgia Water Resources Conference is organized by the UGA River Basin Center, funded by the Georgia Water Resources Institute and 27 other sponsors, and fueled by the innovation of our participants.

UNIVERSITY OF GEORGIA River Basin Center

Schedule-at-a-Glance

Thursday, March 30

7:30-8:30	Registration and Coffee, Hill Atrium					
8:30-9	Welcome, Mahler Hall					
9-10	PLENARY SESSION: Martin Doyle, Mahler Hall					
10-10:30	MORNING BREAK, Hill Atrium					
	TRACK 1: Mahler Hall	TRACK 2: Room F/G	TRACK 3: Room Q	TRACK 4: Room R	TRACK 5: Room V/W	TRACK 6: Room Y/Z
10:30-12	1.1 Panel: Georgia River Access Law	2.1 Nutrients, Contaminants, WQ 1	3.1 N-EWN: Multiple Benefits of NI	4.1 Panel: Importance of Regional Water Planning	5.1 Visual Communication	6.1 Wastewater Surveillance
12-1:30	LUNCHEON AND KEYNOTE: Chris Manganiello, Magnolia Ballroom					
1:30-3:15	1.2 Screening, Q&A: Okefenokee Destiny	2.2 Nutrients, Contaminants, WQ 2	3.2 Flood Modeling	4.2 Forests for Water	5.2 Going Deep with Experiential Learning	6.2 Urban/ Stormwater
3:15 – 3:30	AFTERNOON BREAK (3:15 – 3:30) Hill Atrium USGS Demo (3:15-3:45) Lumpkin Plaza					
3:30-5:00	Poster Session, Pecan Galleria					
5:15-7	Nutter and Associates Creature Comforts Social					

Friday, March 31

7:30-8:30	Registration and Coffee, Hill Atrium					
	TRACK 1: Mahler Hall	TRACK 2: Room F/G	TRACK 3: Room Q	TRACK 4: Room R	TRACK 5: Room V/W	TRACK 6: Room Y/Z
8:30-10	1.3 Panel: Flint Basin	2.3 Dam Removals	3.3 Panel: Infrastructure Bill	4.3 Climate & Hydrology 1	5.3 Aquatic Biota 1	6.3 Urban Watersheds
10-10:30	MORNING BREAK (10-10:30) Hill Atrium USGS Demo (10-10:45) Lumpkin St. Plaza					
10:30-12	1.4 Flint Basin Talks	2.4 Panel: Aquatic Connectivity Case Studies	3.4 Panel: Military Community Resilience	4.4 Climate & Hydrology 2	5.4 Aquatic Biota 2	6.4 Innovative Stormwater
12-1:30	LUNCHEON AND KEYNOTE: Suzanne Burnes, Magnolia Ballroom					
1:30-3	1.5 ACF Water Quantity and Quality	2.5 Connectivity Team Meeting	3.5 Panel: Natural Infrastructure and Equity	4.5 Climate & Hydrology 3	5.5 Panel: Know Your River	6.5 Restoration & Management
3– 3:30	AFTERNOON BREAK, Hill Atrium					
3:30-5	1.6 Watershed & Regional Planning		3.6 Coastal Natural Infrastructure	4.6 Advances	5.6 Panel: Water Data and Databases	6.6 Road Xings Vulnerability
5:00-7	Ecology Courtyard Social					

CONFERENCE SPONSORS

Atlantic Sturgeon

Georgia Water Resources Institute

Georgia Power

Georgia State University | College of Arts & Sciences
Geosciences Department

Conasauga Logperch

Kleinschmidt

Marine Extension and Georgia Sea Grant, University of Georgia | Sea Grant

University of Georgia Institute for Resilient Infrastructure Systems
and the College of Engineering

The Jones Center at Ichauway

The Nature Conservancy

Coosa Madtom

Nutter+Associates Environmental Consultants

College of Coastal Georgia Environmental Science

Chemours

UNG University of North Georgia Lewis F. Rogers Institute for Environmental and Spatial Analysis

corblu Ecology Group

Carl Vinson Institute of Government, University of Georgia

YSI a xylem brand

Georgia Water Planning & Policy Center, Albany State University

American Rivers

Oconee Rivers Greenway Commission

Etowah Darter

Tetra Tech

Warnell School of Forestry & Natural Resources, University of Georgia

Chattahoochee Riverkeeper — Keeping watch over our waters since 1994

Jacobs — Challenging today. Reinventing tomorrow.

University of Georgia Franklin College of Arts and Sciences

CDM Smith

The Longleaf Alliance

Brown and Caldwell

University of Georgia Odum School of Ecology

Upper Oconee Watershed Network

Exhibitors

In-Situ
Nutter and Associates
Georgia Southern University
Storm Water Systems
YSI/Xylem
Odum School of Ecology
Corblu
College of Coastal Georgia
American Rivers
Oconee Rivers Greenway Commission
U.S. Geological Survey
Kleinschmidt
Georgia Water Planning and Policy Center

COMMITTEES AND VOLUNTEERS

Conference Coordinator

Cheryth Youngmann, River Basin Center and Odum School of Ecology

Technical Committee

Sarah Buckleitner, UGA Institute for Resilient Infrastructure Systems
James Deemy, College of Coastal Georgia
Duncan Elkins, UGA Warnell School of Forestry and Natural Resources
Todd Rasmussen, UGA Warnell School of Forestry and Natural Resources
Seth Wenger, River Basin Center, Odum School of Ecology

Steering Committee

Katherine Atteberry, ARC/Metro Water Planning District
Brian Bledsoe, Institute for Resilient Infrastructure Systems
Pam Burnett, Georgia Association of Water Professionals
Daniel Calhoun, US Geological Survey
Gail Cowie, Albany State University
Ben Emanuel, American Rivers
Jennifer Flowers, Georgia Association of Water Professionals
Aris Georgakakos, Georgia Institute of Technology
Steve Golladay, Jones Center at Ichauway
Cody Hale, Nutter and Associates
Erin Lincoln, TetraTech
Chris Manganiello, Chattahoochee Riverkeeper
Charles McMillan, Georgia Conservancy
Doug Oetter, Georgia College and State University
Jenny Pahl, Corblu Ecology Group
Luke Pangle, Georgia State University
Rena Peck, Georgia River Network
Will Pruitt, Kleinschmidt Associates
Jim Renner, Chemours
Mark Risse, GA SeaGrant
Eric Somerville, USEPA
Jill Stachura, Brown and Caldwell
Elizabeth Sudduth, Georgia Gwinnett College
Anna Truszczynski, Department of Natural Resources
Lori Visone, CDM Smith

Volunteers

Olivia Allen, University of Georgia
Henry Armstrong, Kennesaw University
Gin Bacon-Talati, University of Georgia
Shelby Bauer, University of Georgia
Akshat Biswal, University of North Georgia
Sarah Buckleitner, University of Georgia
Alexander Campbell, Kennesaw University
Carleisha Hanns, University of Georgia
Swaty Kajaria, University of Georgia
Vihaan Kesharwani, University of North Georgia
Jasmine Longmire ,University of Georgia
Fabiola Lopez-Avila, University of Georgia
Anna McQuarrie, University of Georgia
Jay Mrazek, University of Georgia
Cole Myers, Kennesaw University
Laura Naslund, University of Georgia
Alyssa Quan, University of Georgia
Laura Rack, University of Georgia
David Richards IV, University of Georgia
Sajal Sabat, University of North Georgia
Katie Schroeder, University of Georgia
Gabriel Stephenson, University of Georgia

About the River Basin Center

The River Basin Center connects freshwater science to management and policy. Although affiliated with the Odum School of Ecology, it is known for an interdisciplinary approach—its members are drawn from units across the University of Georgia.River Basin Center faculty, staff and students work on aquatic management issues around the globe, but the center maintains an emphasis on the southeastern U.S.

Our mission is to produce and disseminate the knowledge and tools for sustainable management of aquatic resources and ecosystems through applied scientific and policy research, and by training the next generation of managers and researchers. The RBC works in three broad areas: **(a)** Conservation ecology of aquatic ecosystems; **(b)** Applied research on aquatic system stressors and development of appropriate management tools; **(c)** Policy development and outreach.

UNIVERSITY OF GEORGIA
River Basin Center

MARTIN DOYLE

Director, Water Policy Program, Duke University

Martin Doyle is a professor at Duke University with research ranging from sediment transport to financial markets. Beyond his academic research, he has worked at the US Army Corps of Engineers' Institute for Water Resources, launched a new initiative at the Department of Interior, and advised corporations and investment funds on risks and opportunities in water sustainability. He is the author of two books: Streams of Revenue, a study of stream mitigation banking, and The Source: How Rivers Made America and America Remade its Rivers, which was selected by Amazon as a top 10 history book of 2018. He is currently completing his 3rd book, Water & Wall Street, a study of infrastructure, finance, and equity in United States cities. He is a Guggenheim Fellow, National Academy of Sciences Kavli Fellow, and has coached a series of above average little league baseball teams in Hillsborough, North Carolina.

CHRIS MANGANIELLO

Water Policy Director, Chattahoochee Riverkeeper

Dr. Christopher J. Manganiello is Chattahoochee Riverkeeper's Water Policy Director. He leads Chattahoochee Riverkeeper's water supply program, tracks regional water planning, and works on legislative initiatives to ensure there is enough clean water for communities, environments, and economies that face a changing climate. Since 2010, Chris has provided strategic policy analysis and direction for the Georgia Water Coalition.

Chris has written extensively on natural resource topics including energy, water, agriculture, and wildlife. He wrote a book, titled Southern Water, Southern Power: How the Politics of Cheap Energy and Water Scarcity Shaped a Region (University of North Carolina Press), and was co-editor, with Paul S. Sutter, of Environmental History and the American South: A Reader (University of Georgia Press). He has published in Environmental History, the Journal of the History of Biology, the Journal of Southern History, and Southern Cultures. Additionally, Chris has written and served as a subject matter expert for the Washington Post, the Atlanta Journal Constitution, public radio, and other media outlets.

Prior to joining Chattahoochee Riverkeeper, Chris was the Georgia River Network Policy Director. Before that he was a Smithsonian Institution Fellow, and a University of Georgia and Georgia Gwinnett College faculty member.

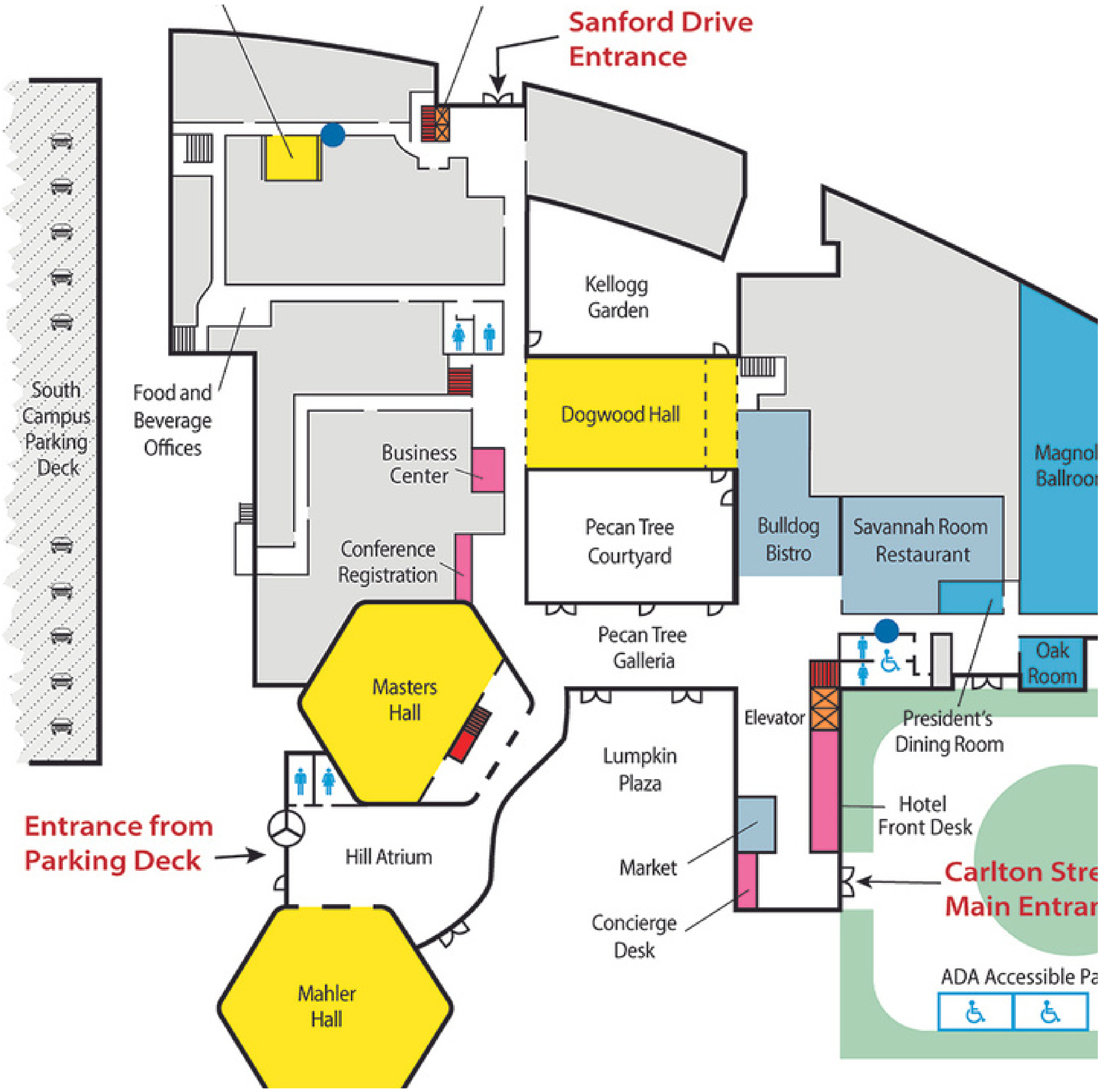
SUZANNE BURNES

Director of Just Growth, Partnership for Southern Equity

Suzanne Burnes is a long-time change agent in metro Atlanta, who brings more than 30 years of experience in sustainability, community development and environmental justice to her role as director of the Just Growth Portfolio for the Partnership for Southern Equity (PSE). She facilitated the Atlanta Water Equity Task Force from 2018-2020, with representatives from the City of Atlanta Watershed Management Department, partners ECO-Action, West Atlanta Watershed Alliance, American Rivers and The Conservation Fund, resulting in the Atlanta Water Equity Roadmap. Her leadership also resulted in the development, delivery and adoption of Georgia's first local government Equitable Growth and Inclusion Strategic Plan for the City of East Point in 2021. She currently leads a team of staff and consultants in the development and execution of new programming to advance the democratization of land use and development for greater community and ecological benefit, including the acquisition and adaptation of EcoDistricts, a national framework for neighborhood-scale equitable, climate-resilient community development.

Her career started in 1992 as a consultant to EPA around Superfund site clean up and Department of Defense environmental compliance and she later founded an Atlanta community development corporation in southeast Atlanta. Other chapters of her career have included: leading Georgia state government's efforts to create public-private sustainability partnerships; serving as executive director of local nonprofit Sustainable Atlanta; and founding Collective Wisdom Group, an Atlanta-based firm serving nonprofit, local government, higher education and philanthropic clients. Through her practice, she notably advised local governments across the Southeastern US on their sustainability efforts, particularly around partnership development and integration of equity into their climate resilience and green infrastructure projects. Suzanne's strengths are in building relationships among diverse voices for community and ecosystem benefit. She holds a BA in Environmental Studies from Warren Wilson College.

2023 PROGRAM



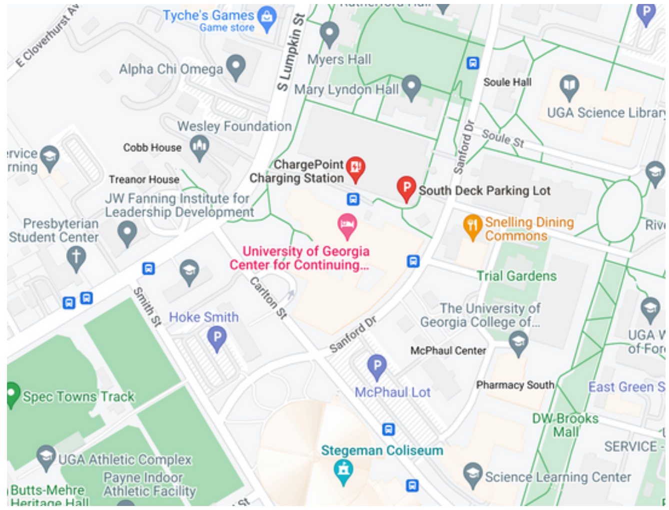
Georgia Center first floor. Lunch, breaks, the plenary talk, and Track 1 will take place on the first floor.

2023 PROGRAM

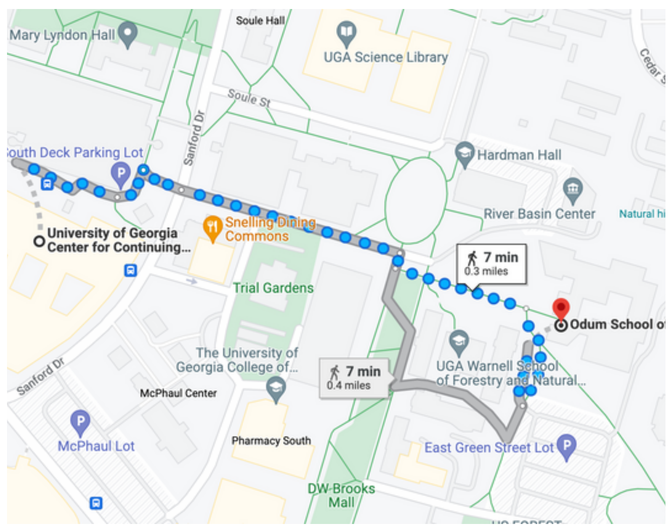
Georgia Center second floor. Tracks 2-6 will take place upstairs.

Parking Information

Parking for the conference is available in the South Deck Parking Lot, 100 W Green St., for $10 a day. The deck is immediately adjacent to the conference center—see map. For registrants lodging at the Georgia Center, parking is included with your stay.



The first-day social will be held at Creature Comforts Brewing, 271 W Hancock Ave, Athens, GA 30601. See map for directions from the conference center to the brewery



The second-day social will be held in the Odum School of Ecology Courtyard, 140 E Green St, Athens, GA 30602. See map for walking directions from the conference center to the school. Parking is also not enforced in lot S07 after 5 p.m.

Reminder—to participate in the Creature Comforts Social, head to the brewery and show Kristy Teems of Nutter and Associates your conference name tag to receive a drink ticket. Kristy will be wearing a conference name tag with a yellow volunteer sticker!

Shuttle

For guests staying at the Georgia Center, a shuttle service has been arranged for the Creature Comforts Social, with 5:15 and 5:30 p.m. departure from the hotel and then a 6:30 and 7 p.m. pick up at the offsite locations. The shuttle can only accommodate 10 people, so most guests should still plan on alternative transportation. Guests should go to the hotel lobby/front desk area and let them know they are there for shuttle.

You can also call directly for pick-up at: 706-206-2266. The shuttle service runs 5pm-10pm.

Food

In addition to lunch, refreshments will be provided at our morning and afternoon breaks. If anyone would like a full breakfast before registration and programming begins, Bulldog Bistro opens at 7 a.m.

The registration desk will be staffed at all times except lunch. If you lose your way or have questions, head back to Hill Atrium and find a student volunteer there. All volunteers are identifiable by a yellow sticker on their name tag!

UNIVERSITY OF GEORGIA
River Basin Center

TRACK ONE

Track 1, Session 1: Panel, The Legal Dispute Over Fishing and Boating Rights on Georgia's Rivers

Moderated by Joe Cook, *Georgia River Network*. Panelists: Dan MacIntyre, GA *Canoe Association*, Max Jarck, *UGA Law School*, Gordon Rogers, *Flint Riverkeeper*.

Track 1, Session 2: Okefenokee Destiny Screening and Q&A

Moderated by Rena Peck, Georgia River Network. Panelists: Michael Lusk, *Okefenokee National Wildlife Refuge*, Rhett Jackson, *UGA Warnell School of Forestry and Natural Resources*, Darlene Taylor Rep. *173rd District,* Emily Floore, *St. Marys Riverkeeper*.

Track 1, Session 3: Panel, Long-term Management of the Lower Flint River Basin

Moderated by Gail Cowie, *Georgia Water Planning and Policy Center at Albany State University*. Panelists: Mark Masters, *Georgia Water Planning and Policy Center at Albany State University*, Gordon Rogers, *Flint Riverkeeper*, Anna Truszczynski, *Georgia Environmental Protection Division*.

Track 1, Session 4: Flint Basin Talks

1.4.1. The Georgia Flow Incentive Trust (GA-FIT): An Overview by Kristin Rowles, *Albany State University: Georgia Water Planning and Policy Center*

1.4.2. Modeling Sustainable Yield and Potential Impacts of Additional Withdrawals on the Claiborne and Cretaceous Aquifers in the Lower Flint River Basin. by Christine Voudy, *Georgia Environmental Protection Division.*

1.4.3. Improving Our Understanding of the Claiborne and Cretaceous Aquifers by Edward Rooks, *Georgia Environmental Protection Division.*

1.4.4. GA-FIT: Resilient and Sustainable Water-Resources Development Using Deep Groundwater in the Lower Flint River Basin by Todd Rasmussen, *University of Georgia*

1.4.5. Geospatial Engineering and Technology Based Modeling Approach for Groundwater Depletion-related Environmental Vulnerability Study by Sudhanshu Panda, *Institute for Environmental Spatial Analysis, University of North Georgia*

1.4.6. Status of mussel populations in the lower Flint River and conservation planning efforts envisioned under GA-FIT by S.W. Golladay, *Jones Center at Ichauway*

Track 1, Session 5: ACF Water Quantity and Quality

1.5.1. Lake Lanier Septic Study by Brigette Haram, *Gwinnett County DWR*

1.5.2. Lake Lanier Water Quality and Ecological Model by Xiaofeng Liu, *Georgia Water Resources Institute, Georgia Tech.*

1.5.3. New Capabilities Provided by ArcGIS Pro in the Aquatic Vegetation Management Context: Point Cloud Analysis from Lake Seminole, Georgia, USA by Philip Ashford, *University of Georgia*

1.5.4. Cost Effectiveness of Source Switching v. Irrigation Buyout Auctions in the Lower Flint by Jeffrey D. Mullen, *University of Georgia*

1.5.5. Assessment of Agricultural Yield and Irrigation Demand for the ACF River Basin by Husayn El Sharif *Georgia Water Resources Institute, Georgia Tech.*

1.5.6. No talk slated.

Track 1, Session 6: Watershed & Regional Planning

1.6.1. Flow-Dependent Benefits and Uses of Water Resources in the Oconee River Basin by Gail Cowie*, Georgia Water Planning and Policy Center at Albany State University*

1.6.2. Ecological Indicators for Georgia Water Planning by Laura Rack, *Odum School of Ecology, University of Georgia, River Basin Center, University of Georgia*

1.6.3. Tying Research to Policy: A District Approach by Celine Benoit, *Metropolitan North Georgia Water Planning District*

1.6.4. How the Southeast Conservation Blueprint Can Support Your Work in Georgia by Alex Lamle, *SECAS*.

1.6.5. Utilizing Data from the US EPA's Preliminary Healthy Watershed Assessment (PHWA) Project to Compare the Health and Vulnerability of Watersheds in Georgia by Don Lane, *Elachee Nature Science Center*

1.6.6. No talk slated.

TRACK TWO

Track 2, Session 1: Nutrients, Contaminants, Water Quality I

2.1.1. Average Annual Hydrologic Residence Time Drives Nitrogen Deposition in Reservoirs by Benjamin Webster, *Auburn University*

2.1.2. Riparian Denitrification Preventing Nitrate-Contaminated Groundwater from Reaching Stream by Scott Raulerson, *University of Georgia, Warnell School of Forestry & Natural Resources*

2.1.3. Nitrogen Dynamics Along the Lower Ogeechee Riverine Floodplain: An Assessment Through Seasonality and Flood Pulse Magnitude by Gabriela Cardona-Rivera, *University of Georgia*

2.1.4. Spatiotemporal Dynamics of Groundwater-Surface Water Interactions and Riparian Nitrogen Cycling: Incised vs. Un-incised Streams by Daniel Buhr, *University of Georgia*

2.1.5. Understanding the Role of Recalcitrant Organic Phosphorus on Freshwater Harmful Algal Blooms – Proposed Workshop Series by Francisco Cubas, *Georgia Southern University*

2.1.6. Using Water Quality as a Metric for Success in Wild Pig Management by Caitlin L. Sweeney, *The Jones Center at Ichauway*

Track 2, Session 2: Nutrients, Contaminants, Water Quality II

2.2.1. Potential for PFAS Phytoextraction Via Accumulation by Woody and Herbaceous Plants: A Greenhouse Study Evaluating Six Compounds by David K. Huff*, Nutter and Associates*

2.2.2. USGS Providing Technical Support to the U.S EPA to Address a Legacy of Groundwater Contamination Facing an Underserved Community, Fort Valley, Georgia by Jim Landmeyer*, U.S. Geological Survey*

2.2.3. The Ecological Implications of Plastic Pollution in Freshwater Ecosystems: Microbial Community Succession on Macroplastic by Fabiola Lopez Avila, *UGA Odum School of Ecology & Savannah River Ecology Research Laboratory*.

2.2.4. Exploring Patterns in Microplastic Pollution in a Large Rural Watershed by Emily Martin, *University of Georgia*

2.2.5. Assessing the Impact of Water Quality on the Sustainability of Point-of-Use Water Disinfection by Elijah Carl Bright, *Department of Civil Engineering and Construction.*

2.2.6. Georgia Power's R&D Efforts for Responsible Water Utilization by Rebecca Osteen*, Southern Company*

Track 2, Session 3: Barrier Removals in Southeastern US: Lessons Learned and Future Directions

2.3.1. State of Dam Removal and Prioritization Efforts Nationally, in the Southeast, and in Georgia by Ben Emanuel, *American Rivers.*

2.3.2. Multi-Objective Decision-Making for Dam Removal, Retrofit, and Repair, by Daniel Buhr, *University of Georgia.*

2.3.3. A Decision-Support Framework for Dam Removal Planning, by Suman Jumani, *University of Georgia*

2.3.4. Dam Safety Considerations in Dam Removal Decision Making, by David Griffin, *Georgia EPD Safe Dams Program*

2.3.5. Incorporating Biogeochemical Cycling into Decisions About Dam Removal and Long-Term Management, by Laura Naslund, *University of Georgia.*

2.3.6. Reconnecting Shoal Bass Habitat on the Middle Chattahoochee River: Science, Studies, and Stakeholders.
Patrick O'Rouke, *Georgia Power.*

Track 2, Session 4: Panel, Aquatic Connectivity Case Studies.

Moderated by Sara Gottlieb, The Nature Conservancy. Panelists: Troy Keller, *Columbus State University,* Ben Emanuel, *American Rivers,* Twyla Cheatwood, *National Marine Fisheries Service*, Dawn York, *Moffat & Nichol* and Danielle Darkangelo, *Cape Fear RC&D*, Drew Martin, *GA Department of Transportation*.

Track 2, Session 5: Georgia Aquatic Connectivity Team Workshop

Moderated by Sara Gottlieb, *The Nature Conservancy*. Panelists: Jay Shelton, *UGA Warnell School of Forestry and Natural Resources*, Ben Emanuel, *American Rivers*, Will White, Shawna Fix, *Southeast Aquatic Resources Partnership (SARP).*

TRACK THREE

Track 3, Session 1: N-EWN: Multiple Benefits of Natural Infrastructure

3.1.1. Economic Valuation of Nature-based Infrastructure: Best Practices and Beyond by Susana Ferreira, *University of Georgia*

3.1.2. Rising Seas, What to Do? - Increasing Coastal Resilience through Nature-based Solutions by Rhett Jackson, *University of Georgia*

3.1.3. Comparing Multiple Benefits of NI in a Spatial Prioritization Framework: A Case Study of Levee Setback Sites on the Missouri River, Omaha District by Alec Nelson, *University of Georgia, Warnell School of Forestry and Natural Resources*

3.1.4. A Critical Appraisal of Nature-Based Solutions' Role in Halting Freshwater Biodiversity Loss by Charles van Rees, *Odum School of Ecology and River Basin Center, University of Georgia*

3.1.5. The Effect of Marsh Length Scales on Flood Protection by Matthew V Bilskie, *University of Georgia*

3.1.6. An Experimental Approach to Modernizing the Federal Civil Works Benefit-Cost Analysis Through Applied Collaborative Research by Matt Chambers, *University of Georgia*

Track 3, Session 2: Multi-Hazard Flood Modeling from Inland to Coast

3.2.1. Modeling the Service Potential of Nature-Based Solutions in Coastal Stormwater Management Systems Under Multi-Flood Hazard Events by Matt Chambers, *University of Georgia*

3.2.2. Compound Flood Mapping Across Scales: The Power of Physics-Informed Machine Learning Frameworks
by David F Muñoz, *Virginia Tech*

3.2.3. Compound Flood Analysis With GIS-Based Dynamic Flood Model and Identification of Flooding Drivers for Coastal Urban Areas by Minjae Kim *School of Civil and Environmental Engineering, Georgia Institute of Technology*

3.2.4. Flood Inundation Study for Chatham County -Savannah Metropolitan Planning Commission by Matthew V Bilskie, *University of Georgia*

3.2.5. An Integrated Coastal-Urban Flood Modeling Framework Combining a Numerical Model and Sensor Observations by Youngjun Son, *Georgia Institute of Technology*

3.2.6. Identifying Compounding Flood Drivers Along the Savannah River Using Data-Driven and Hybrid Modeling Approaches by Katy Serafin*, Department of Geography, University of Florida*

Track 3, Session 3: Panel, Infrastructure Bill

Moderated by Brian Bledsoe, *University of Georgia, IRIS*. Panelists: Jan MacKinnon, *Georgia Department of Natural Resources, Wildlife Resources Division,* Stephen Clark, *Georgia Emergency Management and Homeland Security Agency*, Laurie Loftin, *Public Utilities Department, Athens Clarke County*, Brian Watts, *Pew Charitable Trust*, Alan Robertson, *AWR Strategic Consulting,* Danny Johnson, *Metropolitan North Georgia Water Planning District.*

Track 3, Session 4: Panel, Advancing Coastal and Ecosystem Resilience for Military Communities through Partnerships

Moderated by Michelle Covi, *University of Georgia, Marine Extension and Georgia Sea Grant*. Panelists: Ben Carswell, *UGA Carl Vinson Institute of Government, Defense Community Resilience Professional*, David Bell*, Jacobs Engineering, Senior Scientist*, Ashby Worley, *The Nature Conservancy, Coastal Climate Adaptation Director,* Ken Bradley, *Georgia Sentinel Landscape Coordinator*.

Track 3, Session 5: Panel, Natural Infrastructure and Equity Panel

Moderated by Brian Bledsoe, *University of Georgia, IRIS*. Panelists: Gabriela Langhorn, Haley Selsor, Sechindra Vallury, Marshall Shepherd, *University of Georgia.*

Natural infrastructure has a role to play in helping to address historic inequities in Georgia communities. This panel will highlight the ways in which natural infrastructure can protect vulnerable populations and build resilience, as well as explore the complex ways that infrastructure and water resource decisions impact equity.

Track 3, Session 6: Coastal Natural Infrastructure

3.6.1. Coastal Sediment Budgeting to Match Sediment Supplies, Dredging volumes, and Natural Infrastructure Enhancement Needs for Sea-Level Rise Adaptation by Caleb Sytsma, *Army Corps of Engineers, Engineer Research and Development Center (USACE ERDC)*

3.6.2. Economic Value of Green Infrastructure Investments on the Georgia Coast
by Craig Landry, *University of Georgia*

3.6.3. Let 'Em Grow: Do Florida Coastal Property Owners Value Mangroves? by Swaty Kajaria, *University of Georgia*

3.6.4. Planning for Resiliency in a Coastal Community by Michael Schmidt, *CDM Smith*

3.6.5. No talk slated.

3.6.6. No talk slated.

TRACK FOUR

Track 4, Session 1: Panel, The Importance of State and Regional Water Planning and What Lies Ahead

Moderated by Danny Johnson, *Manager, Metropolitan North Georgia Water Planning District*. Panelists: Jennifer Welte, *Assistant Branch Chief, Georgia Environmental Protection Division,* Katherine Zitsch, *Director, Metropolitan North Georgia Water Planning District*, Mark Masters, *Director, Water Policy Center, Albany State University*.

Track 4, Session 2: Managing Forests to Increase Water Supplies

4.2.1. Managing forests to increase water supplies: a review of concepts and case studies by Steven Brantley, *Jones Center at Ichauway*

4.2.2. Understanding the Complex Effects of Forest Management on Water Budgets: A Case Study Quantifying Water Budget Components in Longleaf Pine Woodlands by Stribling O. Stuber, *The Jones Center at Ichauway*

4.2.3. Longleaf Pine Forest Restoration Increases Geographically Isolated Wetland (GIW) Hydroperiod in Southwestern Georgia by S. W. Golladay, B.A. Clayton, S.T. Brantley, *Jones Center at Ichauway*

4.2.4. Simulating Hydrologic Responses of Longleaf Pine (Pinus palustris) Restoration Across Southeastern U.S. River Basins by Seth Younger, *Jones Center at Ichauway*

4.2.5. Forest Management for Water Yield: Assessing the Barriers and Impacts of Privately-Owned Open Pine Woodlands in the Southeastern U.S. by Chambers English, *Warnell School of Forestry and Natural Resources*

4.2.6. Exploring the impact of Sustainable Forestry Initiative Fiber Sourcing Standard on water quality in Georgia, United States by Catherine Cooper, Parag Kadam, C. Rhett Jackson, Gary Hawkins, Puneet Dwivedi, *University of Georgia*

4.2.7. Designing Watersheds for Integrated Development (DWID): Combining Hydrological and Economic Modeling for Optimizing Land Use Change to Meet Water Quality Regulations by Puneet Dwived, *University of Georgia*

Track 4, Session 3: Climate & Hydrology I

4.3.1. Historical Climate Trends in Georgia by Shivani Chougule, *Georgia Tech, Georgia Water Resources Institute*

4.3.2. Future Climate Trends in Georgia by Aris Georgakakos, *Georgia Tech, Georgia Water Resources Institute*

4.3.3. Estimating Extreme Rainfall Intensification, Current Science and Practical Guidance by Mark Maimone, *CDM Smith*

4.3.4. Temporal Variability of Water Availability in Georgia Using the Budkyo Framework and the USGS National Hydrologic Model by Jacob LaFontaine, *U.S. Geological Survey*

4.3.5. Evaluation of Low Flow Patterns Across Georgia, in the Context of Water Balance, Land Use, and Geologic Factors by Katie Price, *Nutter & Associates*

4.3.6. Linking Streamflow Trends With Land Cover Change in a Southern US Water Tower by Alexander Miele, *Virginia Tech*

Track 4, Session 4: Climate & Hydrology II

4.4.1. No talk slated.

4.4.2. The Importance of Hillslope Landscapes on the Climatic Variability in Recharge and Streamflow Generation in a Forested Headwater Piedmont Catchment, Panola Mountain Research Watershed, Georgia by Brent Aulenbach, *USGS, South Atlantic Water Science Center*

4.4.3. Changes in Long-term Stream Discharge is Associated with Stream Size and Ecoregion in Georgia, South Carolina and North Carolina, USA by Kelsey Wilbanks, *University of Georgia*

4.4.4. Effects of Impoundments on Selected Flood-Frequency and Daily Mean Streamflow Characteristics in Georgia, South Carolina, and North Carolina by Toby Feaster, *U.S. Geological Survey*

4.4.5. Predicting Inundation Dynamics in Small Depressional Wetlands by Jeffery Riley, *U.S. Geological Survey, South Atlantic Water Science Center*

4.4.6. Neotectonic Joints in Southwestern Georgia and Their Potential Effect on Stream-Aquifer Flux by Robin John McDowell, *Georgia State University*

Track 4, Session 5: Climate & Hydrology III

4.5.1. Simulation of Groundwater Availability for Three Scenarios and Evaluation of Water Management Strategies for South Carolina River Basins by Gregory Cherry, *U.S. Geological Survey South Atlantic Water Science Center*

4.5.2. Saltwater Intrusion in the Floridan Aquifer System Near Downtown Brunswick, Georgia, 2021 by Gregory Cherry and Michael D. Hamrick, *U.S. Geological Survey South Atlantic Water Science Center*

4.5.3. Development of a Southeast Georgia Regional Groundwater Model by Lauryn Falkenstein, *University of Georgia*

4.5.4. Groundwater Levels Within the Cretaceous Aquifers in Response to Wetter-Than-Average Precipitation Years, 2018 Through 2021 by Gerard Gonthier , *U.S. Geological Survey*

4.5.5. Possible Connections Between Regional Tectonic History and Structural Controls on the Groundwater System on St. Catherines Island, Georgia by James S. Reichard, *Georgia State University*

4.5.6. Surficial Aquifer Analysis at the Mission Mine Site in Georgia by Adam M. Milewski, *Department of Geology, University of Georgia*

Track 4, Session 6: Advances in Water Resources Modeling, Technology, and Policy

4.6.1. Oconee Joint Regional Sewer Authority (OJRSA) CMOM Implementation by Rasheed Ahmad, *WK Dickson & Co., Inc.*

4.6.2. Advancing Water Technology Innovation Through Communication and Collaboration by Kristan VandenHeuvel, *The Water Tower*

4.6.3. Basin Environmental Assessment Model and Its Application in Regional Water Planning by Wei Zeng, *Georgia Environmental Protection Division*

4.6.4. Towards an illicit discharge and Surface Water Monitoring and Protecting system using cost efficient sensors by Tien Yee, *Kennesaw State University*

4.6.5. No talk slated.

4.6.6. No talk slated.

TRACK FIVE

Track 5, Session 1: Visual Communication to Aid Resiliency Efforts

5.2.1. Using Landscape Architecture Style Graphics to Communicate about Nature-based Infrastructure by Kelsey Brioch, *University of Georgia*

5.2.2. Visual Communication to Aid Resiliency Efforts I by Emily Dolatowski, *University of Georgia*

5.2.3. Visual Communication to Aid Resiliency Efforts II by Ellie Hair, *University of Georgia*

5.2.4. No talk slated.

5.2.5. No talk slated.

5.2.6. No talk slated.

Track 5, Session 2: Going Deep: Implementing Field-Based Experiential Learning to Advance Water Science and Policy

5.2.1. Learning the Ropes: Approaches to Providing Support to New Faculty Developing Undergraduate Field-Based Courses by Emily Tarsa, *College of Coastal Georgia*

5.2.2. Curating Geographic Information Systems Curriculum to Analyze Hydrologic and Anthropogenic Effects Within the Apalachicola-Chattahoochee-Flint River Basin by Chelsea Brown, *College of Coastal Georgia*

5.2.3. Semester@Skidaway: Bringing Field-Based Marine Science Education to University of Georgia Undergraduates by Clifton Buck, *Skidaway Institute of Oceanography*

5.2.4. An Unexpected Learning Opportunity About the Ethics of Scientific Research and Sampling by Austin Heil and Anne Lindsay, *University of Georgia Marine Extension and Georgia Sea Grant*

5.2.5. Inquiry-based Learning in the Field Designed for Large Non-Major Courses by Robin McLachlan, *College of Coastal Georgia*

5.2.6. Swimming in Data Collection and Analysis From the Field: Successes and Challenges of Course-Based Undergraduate Research by Kimberly K. Takagi, *College of Coastal Georgia*

Track 5, Session 3: Aquatic Biota I

5.3.1. Investigating Freshwater Mussel Distributions in the Altamaha River Basin in Support of a Candidate Conservation Agreement (CCA) by Matthew Rowe, *Georgia Department of Natural Resources*

5.3.2. High-Volume Filtration Method Improves Environmental DNA Detection of Freshwater Mussels by Anna McKee, *US Geological Survey South Atlantic Water Science Center*

5.3.3. CSI Warnell: Investigating the Source, Dispersal, and Recruitment of the Weather Loach Using Otolith Microchemistry by Wesley Gerrin, *University of Georgia Warnell School of Forestry and Natural Resources*

5.3.4. Approach of the Loach: Using Genetics to Better Understand a Newly Invasive Species, the Weather Loach (Misgurnus anguillicaudatus), in Georgia by Sarah McNair, *University of Georgia*

5.3.5. Gut Content and Stable Isotope Analyses Inform the Management of a Newly Discovered Exotic Species (Misgurnus anguillicaudatus) in Georgia by Adam Musolf, *University of Georgia*

5.3.6. No talk slated.

Track 5, Session 4: Aquatic Biota II

5.4.1. No talk slated.

5.4.2. No talk slated.

5.4.3. Sex-Specific Variability in Population Demographics of Sicklefin Redhorse (Moxostoma sp.) by Eric Walther, *River Basin Center, Odum School of Ecology, University of Georgia*

5.4.4. Effects of Temperature on Simulium Vittatum Development by Sophie Racey and Darold Batzer, *Department of Entomology, University of Georgia*

5.4.5. Declines in Smaller-Bodied Taxa Underlie Shifts in Shoal Fish Communities in the Conasauga River by Mary C. Freeman, *U.S. Geological Survey, Eastern Ecological Science Center*

5.4.6. What happened to the Conasauga? by Seth Wenger, *River Basin Center, Odum School of Ecology, University of Georgia*

Track 5, Session 5: Panel, Know Your River: Data Democratization Tool

Moderated by Tonya Bonitatibus, *Savannah Riverkeeper*. Panelists: Damon Mullis, *Ogeechee Riverkeeper*, Kris Howard, *Ogeechee Riverkeeper*, Lindsay Wallace, *Newfields,* Rosco Peters, *Newfields*.

Track 4, Session 6: Panel, Water Data & Databases: Quantity, Quality, and Accessibility

Moderated by Janet Genz, University of West Georgia. Harold Harbert, *GA Adopt a Stream*, Robbie O'Donnell, *Water Data Collaborative*.

TRACK SIX

Track 6, Session 1: Testing the Waters: A Collaborative Approach to Building Infrastructure for the Future of Wastewater Surveillance in Georgia

6.1.1. State and Local Public Health: Epidemiology's Perspective on Wastewater Surveillance in Georgia by Cristina Meza, *Georgia Department of Public Health*

6.1.2. Cobb County Water System – A Local Utility's Experience in Wastewater Surveillance by Daniel Cochran, *Cobb County Water System (CCWS)*

6.1.3. Wastewater Surveillance of Severe Acute Respiratory Syndrome (SARS-CoV-2) at Georgia Public Health Laboratory by Steven Woods, *Clinical Microbiology Services, Georgia Public Health Laboratory*

6.1.4. Multi-Level Wastewater Monitoring for SARS-CoV-2 in Metro Atlanta by Christine Moe, *Center for Global Safe Water, Sanitation and Hygiene, Rollins School of Public Health, Emory University*

6.1.5. Building, Sustaining, and Sharing Wastewater Based Testing for SARS-CoV-2 in Athens, GA by Erin Lipp, *University of Georgia*

6.1.6. WaterSCAN: Utilizing Wastewater to Monitor for SARS-CoV-2, RSV, Influenza, Norovirus, Human Metapneumovirus, and Mpox in Georgia by Marlene Wolfe, *Emory University*

Track 6, Session 2: Urban/Stormwater

6.2.1. Stormwater Forecasting – A New Indicator To Manage Basin-Scale Urban Runoff Volume by Katherine Atteberry, *Metropolitan North Georgia Water Planning District*

6.2.2. Spatial Prioritization for Equitable Urban Riverscapes in the Southeastern Piedmont Region by Holly Yaryan Hall, *University of Georgia*

6.2.3. Stormwater Master Planning: Lessons Learned by Aaron Rogge, *Tennessee Stormwater Association*

6.2.4. Investigating Potential Pathways of Urban Landscapes' Impact on Stream Biota and Instream Stressor Interactions in the Southeastern Piedmont by Lu Juncheng, *College of Environment and Design, University of Georgia*

6.2.5. Patterns and Trends in Sediment Loads in 13 Suburban to Urban Watersheds in Gwinnett County, Georgia by Brent T. Aulenbach, *U.S. Geological Survey South Atlantic Water Science Center*

6.2.6. Disturbances in Nutrient and Water Fluxes in Leach Field Soils Impact Urban Tree Health by Courtney Scott, *Warnell School of Forestry and Natural Resources, University of Georgia*

6.2.7. The Oconee Rivers Greenway: A Citizen's Initiative by Karen Porter, *Oconee Rivers Greenway Commission*

Track 6, Session 3: Ecosystem Function, Infrastructure, and Conservation in Urban Watersheds

6.3.1. Urbanization Alters the Quantity and Quality of Riverine Dissolved Organic Matter by Shuo Chen, *Department of Biological Sciences, Idaho State University*

6.3.2. Baseflow Spatial Stability of Major Ions in a Highly Urbanized Watershed Matches Homogenous Stormflow Responses by Sarah H. Ledford, *Georgia State University*

6.3.3. Neighborhood Water Watch: Solving Urban Water Quality Problems With Community Science by Jessica Sterling, *Chattahoochee Riverkeeper*

6.3.4. Remotely Mapping Streambank Erosion Hotspots in Urban Areas by Kristina Hopkins, *U.S. Geological Survey*

6.3.5. Incorporating Beaver Into the Urban Stream Network: A Comparison of Water Transmit Time Distributions Across Urban Beaver Ponds and Stormwater Ponds by Claire Wadler, *Georgia State University*

6.3.6. No talk slated.

Track 6, Session 4: Innovative Stormwater Solutions

6.4.3. Biochar Use to Improve Water Quality in the City of Brookhaven by Daniel Markewitz, *Warnell School of Forestry and Natural Resources, University of Georgia*

6.4.4. Green Infrastructure Installations at the Water Tower Institute: Opportunities for Applied Research, Knowledge Transfer, and Training by Christopher Impellitteri, *The Water Tower Institute*

6.4.5. Using Biochar to Improve Soil and Stormwater Quality in Urban Tree Plantings by Rebecca Abney, *University of Georgia*

6.4.6. Managing Stormwater from Interstate Highways in Atlanta, Georgia by Gary L. Hawkins, *University of Georgia*

Track 6, Session 5: Restoration & Management

6.5.1. Protecting Critical Infrastructure Along Eroding Streams Using Bioengineering Techniques and Stream Restoration Methodologies by William Rector, *Pond & Company*

6.5.2. Investigating Indigenous Relationships with Watershed and Rivercane Restoration Through Cooperation with a Cherokee Trib by Alyssa Quan, O*dum School of Ecology, University of Georgia*

6.5.3. Application of a New Stream Condition Index to Calculate Average Annual Habitat

Units by Bruce Pruitt, *U.S. Army Corps of Engineers, Engineer Research and Development Center*

6.5.4. -6.5.5. Forests as Filtration: Managing Forests to Protect Drinking Water Sources
Nick DiLuzio[1], Kathy Hawes[2] *[1]Georgia Forestry Foundation, [2]Southeastern Partnership for Forests and Water*

6.5.6. Recent Findings Related to Submarine Groundwater Discharge and Eastern Oysters in Georgia by Jacque Kelly, *Georgia Southern University Department of Geology and Geography*

Track 6, Session 6: Road Crossings Vulnerability

6.6.1. Assessment of Road/Stream Crossings Structure Failure Vulnerability Under Extreme Precipitation Intensities Scenario: Culvert Mouth Silting Probability
Akshat Biswal, *University of North Georgia*

6.6.2. Assessment of Road/Stream Crossings Structure Failure Vulnerability under Extreme Precipitation Intensities Scenario: Probable Culvert Location Determination.
Vihaan Kesharwani, *University of North Georgia*

6.6.3. Geospatial Engineering and Technology Based Modeling Approach for Groundwater Depletion-Related Environmental Vulnerability Study
Sudhanshu S. Panda, *Institute for Environmental Spatial Analysis, University of North Georgia*

6.6.4. Assessment of Road/Stream Crossings Structure Failure Vulnerability under Extreme Precipitation Intensities Scenario: Streambank Erosion Vulnerability Analysis
Sajal Sabat, *University of North Georgia*

6.6.4. No talk slated

POSTER SESSION

P01. Educational Demonstration and Lessons Learned from Coastal Stormwater Green Infrastructure by Jessica T. R. Brown, presented by Lisa Gentit, *University of Georgia*

P02. The Response of Artificial Channels to Large Storm Events on Sapelo Island, Ga by Raymond P. Kidder[1], *Georgia Southern University*

P03. Using Landscape Architecture Style Graphics to Communicate About Nature-Based Infrastructure by Kelsey Broich, *UGA Carl Vinson Institute of Government*

P04. Landscape Restoration in Southwest Georgiaby Anna McQuarrie, *UGA College of Environment + Design.*

P05. Water Stewardship Choices on Georgia Green Landscapes by Martin Wunderly, *[1]UGA Extension Northeast District*

P06. Implementation of Green Stormwater Infrastructures on Spelman's Campus to Improve The Water Quality Of Proctor Creek by Destinee Whitaker, *Spelman College*

P07. Septic System Drain Field Densities in Athens-Clarke County, Georgia by Sonrisa Reed, *University of North Georgia*

P08. Watershed-Level Effects of Septic System Density and Wet-Weather Events on Stream Water Quality and Human Fecal Markers in the Atlanta Metropolitan Area by Carter Coleman, *University of Georgia.*

P09. Habitat Suitability Assessment for Urban Beavers in Metro Atlanta by Alisha Guglielmi, *Georgia State University*

P10. Assessing Urban Impacts on Surface-Water Quality Across the Atlanta Region by Oluwatosin Orimolade, *Georgia State University*

P11. A Survey of Microplastic Concentrations in Selected Tributaries of The Chattahoochee River That Flow Through the City of Atlanta by Charles Lawal, *Georgia State University*

P12. Long Term Increases in No3-N Concentrations from Four Upper Floridan Aquifer Springs in the Lower Flint River Basin, Georgia by Natalie Horn*, The Jones Center at Ichauway*

P13. Wadeable Stream Habitat Resurveys at Chattahoochee River National Recreation Area by Rachael Bell, *University of North Georgia, [2]National Park Service*

P14. Innovative Research for Phosphorus Recovery in Freshwater Sediments, an Experimental Framework by John Collins, *Georgia Southern University*

P15. An Experimental Framework to Unravel Microplastic Fate in Aerobic and Anaerobic Freshwater Sediments by Corina Fluker, *Georgia Southern University, Civil Engineering and Construction Department*

P16. Prevalence of Well Water Contaminants in Georgia From 2010-2022 by Angelique Willis, *Georgia State University, [2]University of Georgia*

P17. Verification of Manning's Roughness Coefficients, N, for Selected South Carolina Streams by Jonathan Musser, *U.S. Geological Survey*

P18. Aquatic Nuisance Species in Georgia: Current Status of Weather Loach Research by UGA Warnell School of Forestry and Natural Resources by Rachael Byrne, *University of Georgia*

P19. Macroinvertebrate Biodiversity of Urban Beaver and Stormwater Ponds by Elizabeth Sudduth, *Georgia Gwinnett College*

P20. Investigating The Effects of Increased Salinity on the Function and Fitness of an Aquatic Invertebrate Decomposer (Caecidotea Sp.) by Zach B. Gordon, *Oglethorpe University*

P21. Can Aerial Lidar Detect Streambank Erosion in Urban Watersheds? Preliminary Findings by Charles Stillwell, *U.S. Geological Survey.*

P22. Quantifying Large-Scale Hydrologic Processes in Ungauged Basins: Remote Sensing Applications in Souss-Massa Basin, Morocco by Lea Davidson, *University of Georgia.*

P23. Remote Sensing of Okefenokee Swamp, USA by Emma Vail, *University of North Georgia*

P24. Repeatability of a Terrestrial Lidar Survey of a Stream Channel by Jacob M Bateman McDonald, *University of North Georgia*

P25. Summarizing Current Gaps In Knowledge Surrounding Stream Metabolism and Its Controlling Factors by Deandre Presswood, *Georgia State University*

P26. A Stable Isotopic Landscape of Southern Georgia Surficial Waters and Its Implications On Regional Groundwater Recharge Process by Riley Griffin, *Valdosta University*

P27.

P28. Wetland Monitoring Change Detection of The Southeastern United States by David F. Richards IV, *Department of Geology, University of Georgia*

P29. Determining the Influence of Wind Velocity on the Enhanced Tidal Flooding of Little Cumberland Island, Georgia by Conlan Bertram, *College of Coastal Georgia, Department of Natural Science*

P30. Effects of Dissolved Oxygen and Turbidity on Biodiversity in Freshwater Pond Ecosystems by Soraya Byrdsong and Kimberly Takagi, *College of Coastal Georgia, Department of Natural Science*

P31. Evaluation of Mapped Wetlands on the Dougherty Plain of Southwest, Georgia Using Heads Up Digitizing by Dannyell Hendrix, *College of Coastal Georgia Department of Natural Sciences*

P32. Experiential Learning on Hydrodynamics and Sediment Transport Based on Physical Properties: Little Cumberland Island, Ga by Jonathan Warehime, *Department of Natural Sciences, College of Coastal Georgia*

P33. Field-Based Learning in the Estuarine Fish Monitoring Collaboration
Harrison Faulk,*College of Coastal Georgia, [2]Sapelo island National Estuarine Research Reserve, [3]UGA Marine Extension and Georgia Sea Grant, [4]UGA Warnell School of Forestry and Natural Resources*

P34. Learning How to Grow Phytoplankton Cultures with Special Needs: What Soil Extracts from Coastal Georgia Does Levanderina Fissa Prefer?
Dillon Doomstorm,*University of Georgia,*

P35. Paleochannel Geometry and Fossil Prevalence in Clark Quarry, Ga Indicate a Reworked Back-Barrier Environment of the Late Pleistocene
Nikki Patton, *Department of Natural Sciences Environmental Science Program, College of Coastal Georgia*

P36. Rapid Fluvial Deposition Event of the Pleistocene Era on the Coast of Southern Georgia by Katie Richardso, *College of Coastal Georgia,*

P37. The Effect of Nitrate, Nitrite and Phosphorus Levels on Crassostrea Virginica Spat Recruitment in Southeast Georgia by Cheyenne Osborne, *Department of Natural Sciences, College of Coastal Georgia*

P38. The Effects of a Vegetation Buffer on Ammonia, Phosphate, Nitrate, and Nitrite Levels by Carlie Blackburn, *Department of Natural Sciences, College of Coastal Georgia*

P39. Hydrologic Restoration by Drainage Ditch Plugging of Southeastern Depressional Wetlands by Morgan Bettcher, *UGA Warnell School of Forestry and Natural Resources*

P40. Hydrogeologic Characterization of the Lower Flint River Basin Based on Time Series Analysis of Surface and Groundwater Levels by Zachary Normile, *University of Georgia*

P41. Restoring One of Georgia's Seven Natural Wonders: Radium Springs by Brian Clayton, *The Jones Center at Ichauway*

P42. USGS Resources for Georgia and Beyond by Debbie Gordon, *U.S. Geological Survey*
P43. USGS SAWSC Urban Hydrology Unit by Andrew Knaak, *U.S. Geological Survey*

P44. Biomonitoring of Zebra Mussels (Dreissena Polymorpha) in a Reservoir Lake Using Environmental DNA (EDNA) by Amy Rodriguez, *University of North Georgia, Gainesville*

P45. Efficacy of Removing Antibiotic Resistance Bacteria from Wastewater Effluent Using Algal Turf Scrubbers by Victoria Clower, *Georgia Southern University*

P46. Environmental Life Cycle Assessment (Lca) of Treating Pfass With Ion Exchange and Electrochemical Oxidation Technology by Gengyang Li, *University of Georgia*

P47. Leveraging Low-Cost Water Quality Sensors for Informed Microbial Analyses by Astana Woody, *Department of Civil Engineering and Construction Georgia Southern University Statesboro*

P48. Mainland vs. Coastal: Comparing Morphologies of the Aquatic Salamander Amphiuma Means
Alexandra Theisen, *Georgia Southern University*

2023 GWRC ABSTRACTS

Track 1, Session 1: Panel, The Legal Dispute Over Fishing and Boating Rights on Georgia's Rivers

Moderated by Joe Cook, *Georgia River Network*. Panelists: Dan MacIntyre, GA *Canoe Association*, Max Jarck, *UGA Law School*, Gordon Rogers, *Flint Riverkeeper*.

Panelists from UGA Law School, Georgia Canoeing Association, Georgia River Network and Georgia Riverkeepers are defending the right of passage for anglers and paddlers on Georgia's waterways. Your legal right of passage down a stream owned on both sides by a private landowner in Georgia is governed by both Georgia and federal law. The most recent interpretations of those two bodies of law apply inconsistent results. Since the 1997 Ichawaynochaway Creek case, there have been significant development in the real (as opposed to legal) world. We believe that Georgia's water becomes cleaner and better protected when citizens have a relationship with the state's streams, rivers, lakes, estuaries, swamps and beaches. People who swim, fish, boat and recreate on Georgia's waterways are always the first to take action to protect those waterways. Georgia River Network believes that all of Georgia's waterways should be accessible and safe for the public use.

Track 1, Session 2: Okefenokee Destiny Screening and Q&A

Moderated by Rena Peck, Georgia River Network. Panelists: Michael Lusk, *Okefenokee National Wildlife Refuge*, Rhett Jackson, *UGA Warnell School of Forestry and Natural Resources*, Darlene Taylor Rep. *173rd District,* Emily Floore, *St. Marys Riverkeeper*.

Georgia River Network is the only statewide river conservation organization working to make Georgia's waterways safe to swim and is the lead NGO increasing Okefenokee visibility. Okefenokee Swamp, "The Trembling Earth," is a place unlike any other in the world. It's the largest intact blackwater wetland in North America and largest aggregate carbon sink in the nation. It's also in the heart of an economically depressed region and under pressure from mining which is expected to lower the water level of the shallow swamp destroying wildlife habitat and swamp tourism. How can the Okefenokee be conserved for future generations – and what lessons can we learn to keep from repeating our past mistakes? OKEFENOKEE DESTINY, (a 13-minute film, Nature Now Environmental Film Festival selection, and PBS EcoSense for Living documentary), explores these questions and takes viewers on a journey through the swamp while introducing them to individuals and organizations working to protect this natural wonder. Georgia River Network is taking "Okefenokee Destiny" on a tour around Georgia to help amplify the movement to protect the Okefenokee National Wildlife Refuge from mining. This film screening would be followed by panel discussion for audience Q&A with swamp experts featured in the film.

Track 1, Session 3: Long-Term Management of the Lower Flint River Basin

Moderated by Gail Cowie, *Georgia Water Planning and Policy Center at Albany State University*. Panelists: Mark Masters, *Georgia Water Planning and Policy Center at Albany State University*, Gordon Rogers, *Flint Riverkeeper*, Anna Truszczynski, *Georgia Environmental Protection Division*.

Distinctive features of the Lower Flint River Basin include abundant water resources, a diverse aquatic fauna, karst hydrology with areas of strong interconnection between surface water and a groundwater, and a regional economy that is heavily reliant on irrigated agriculture. Due to these distinctive features, the Basin has been a management focus for the State of Georgia for several decades. Previous initiatives greatly enhanced our understanding of the use of the Basin's resources and changes in resource conditions over time. Advances in information have, in turn, supported refinements in management of basin resources and laid the groundwork for current initiatives focused on source water conversion, flow restoration, and habitat conservation.

Panelists will briefly review the groundwork laid by previous initiatives in the basin and then discuss the components and initial results of GA-FIT (Georgia Flow Incentive Trust), a cooperative project to improve drought response capabilities to sustain the region's economy and its natural systems. Financial support for GA-FIT provided by the Robert W. Woodruff Foundation and the Governor's Office of Planning and Budget via infrastructure allocations under the American Recovery Plan Act.

Track 1, Session 4: Flint Basin Talks

1.4.1. The Georgia Flow Incentive Trust (GA-FIT): An Overview

Kristin Rowles[1], Mark Masters[1], Gail Cowie[1], Steve Golladay[1], Meagan Szydzik[1]
[1]*Albany State University: Georgia Water Planning and Policy Center*, [2]*The Jones Center at Ichauway*

In Southwest Georgia, water is the foundation for unique natural systems and a robust agricultural economy. Irrigation has supported the region in becoming one of the most productive agricultural regions in the United States. Most farmers in the region have adopted high efficiency irrigation equipment. However, during extended precipitation deficits, periods of water scarcity occur and cause low stream flows and reduced aquifer storage. These impacts threaten the resilience of the region's farm economy and rare aquatic species. The Georgia Flow Incentive Trust (GA-FIT) is a new program focused on implementing multiple projects to restore flows for aquatic habitats while addressing water security for farmers in the Flint River Basin of Southwest Georgia. GA-FIT has multiple components including incentives for the installation of new deep aquifer water sources for irrigators who rely on surface waters (DroughtSWAP), field testing of new incentives for drought year irrigation suspension, research on groundwater conditions, and a stakeholder-driven effort to develop a habitat conservation plan (HCP) for federally listed endangered and threatened freshwater mussels. GA-FIT was initially established through the generous support of the Robert W. Woodruff Foundation. In 2022, the project was significantly expanded through a grant from the Governor's Office of Planning and Budget via allocations established from the American Recovery Plan Act for infrastructure development. Project partners include the Georgia Water Planning & Policy Center at Albany State University, the Georgia Environmental Protection Division, the Golden Triangle Resource Conservation and Development Councils, and The Nature Conservancy. This presentation will provide an overview of the goals and components of GA-FIT, describe stakeholder engagement in the project, and explain the project approach to habitat conservation planning.

1.4.2. Modeling Sustainable Yield and Potential Impacts of Additional Withdrawals on the Claiborne and Cretaceous Aquifers in the Lower Flint River Basin.

Christine Voudy, *Georgia Environmental Protection Division.*

Presentation on Georgia EPD's data and modeling of the Claiborne and Cretaceous Aquifer systems in the Lower Flint River Basin. As directed by the Georgia State Water Plan, dated January 8, 2008, groundwater resource assessment modeling was conducted to evaluate water availability and potential challenges for current and future water supply demands. The groundwater resource assessment, along with the surface water availability and surface water quality resource assessments were designed to help regional water planning councils identify areas where management actions may be needed to ensure a region's resources can meet long-term demands for water supply.

The availability of groundwater resources in select prioritized aquifers was evaluated and included the Claiborne, Clayton, and Cretaceous Aquifer systems. Model scenarios included simulated changes in water-level elevations from increased pumping in the prioritized aquifers that was then compared with sustainable yield criteria developed for the State Water Plan study. An aquifer-wide range of sustainable yield was developed for each prioritized aquifer.

In 2017, at the request of the Lower Flint Council, an evaluation of the Claiborne Aquifer was done to determine whether the sustainable yield of the aquifer is affected by specific location and timing of groundwater withdrawals. The Reginal Coastal Plain model was run in transient mode to evaluate how the Claiborne Aquifer may respond to time-varying withdrawals during and between crop growing seasons in localized areas and to investigate replacing agricultural surface water withdrawals in Ichawaynochaway and Spring Creek watersheds with groundwater withdrawals from either the Claiborne or Cretaceous aquifers, where the aquifers are confined and not in direct contact with surface water.

1.4.3. Improving Our Understanding of the Claiborne and Cretaceous Aquifers

Edward Rooks, Caitlyn Holmes, Irene Valli, *Georgia Environmental Protection Division.*

Why do we need more information about these aquifers? The suspension of new or modified withdrawals from the Floridan aquifer has caused these two aquifers to become more desirable for use for agricultural irrigation. The Hydrologic Atlases for these aquifers are about 40 years old. New agricultural wells continue to be installed. We need to understand these aquifers so they can be protected while being utilized.

1.4.4. GA-FIT: Resilient and Sustainable Water-Resources Development Using Deep Groundwater in the Lower Flint River Basin

Todd Rasmussen, Adam Milewski, Charlotte Garing, David Stookesbury, *University of Georgia*

GA-FIT is a five-year initiative that focuses on the augmentation of irrigation supplies in Southwest Georgia during droughts using deep groundwater that lies within the Claiborne and Cretaceous Aquifers below the Floridan. We focus on interpreting subsurface information from boreholes (water levels, geochemistry, borehole logs, drill cuttings) as well as from landscape data (regional geology, geography) to build a conceptual model of groundwater flow and transport that integrates flow within and between aquifers and surface water. Long-term USGS groundwater monitoring data will be augmented with additional real-time groundwater level and quality data from newly installed monitoring wells. Downhole geophysical data will be compared with borehole cuttings to identify litho- and hydro-stratigraphic units within the region. Surface features will be examined to determine their potential predictive value in subsurface properties.

1.4.5. Geospatial Engineering and Technology Based Modeling Approach for Groundwater Depletion-related Environmental Vulnerability Study

Sudhanshu Panda, Prahalad Jat, *Institute for Environmental Spatial Analysis, University of North Georgia*

Sinkholes are common and naturally occurring geologic feature in Florida, South Georgia and South Alabama and being intensified by improperly managed ground water withdrawal for agricultural, industrial, and domestic use. Similarly, ground/soil subsidence occurs by excessive exploitation of aquifers. Both are a major geohazard in United States and the world. Karst topographic terrain, a major reason of sinkholes formation, evolves through dissolution of the bedrock (limestone) and development of efficient underground drainage. Sinkhole openings have major environmental consequences, i.e., polluting groundwater when sinkholes open in superfund and landfill site locations. Soil subsidence causes severe human infrastructures damage triggering important economic losses. The main goal of this study is to develop an automated geospatial model to determine the potential vulnerable locations for sinkholes, spatial groundwater contamination vulnerability using DRASTIC modeling approach, and locations of soil subsidence in south Georgia and northern Florida. Five types of geospatial data – Geology, gSSURGO (soil), land cover (NLCD 2011), aquifer, and USGS groundwater well were collected, geoprocessed, and analyzed in ArcGIS ModelBuilder to obtain the final sinkholes spatial vulnerability map of the study area. Another model was created developing DEM from the latest LiDAR data of the region and overlaying with 10 and 30m DEMs of 2000 and 1980s, respectively. Geology layer was reclassified into classes of carbonite, loose sediments, and clastic sedimentary rocks of different sinkholes risks. The soil Permeability and Drainage features, surface interpolated aquifer top-depth and groundwater well depth layers, and land cover layer were reclassified according as sinkhole vulnerability layer. Each reclassified layers were assigned sinkholes risk potential weights, developed through thorough literature review and personal expertise. All the weighted layers were analyzed integratively using weighted sum function of ArcGIS to obtain final classified sinkholes risk probability raster. Historical Sinkholes spatial data were used to validate our results. Amazingly, 85% accuracy were obtained from the study. It was also observed that metric level soil subsidence has occurred in the study area. The study would provide decision support for environmental managers, land-use planners, and other stakeholders for watershed management.

1.4.6. Status of mussel populations in the lower Flint River and conservation planning efforts envisioned under GA-FIT

S.W. Golladay, L.C. Sweeney, *Jones Center at Ichauway*

The southeastern US is a global epicenter for freshwater mussel (Mollusca: Bivalvia: Unionidae) diversity. Freshwater mussels are key species in rivers and their activities provide important ecosystem services including assimilative capacity and foodweb support. The ACF Basin and lower Flint River have a long history of studies documenting mussel diversity and abundance. Mussel declines have been documented globally and until recently mussel populations in the lower Flint were considered stable. However, more than a decade (1999-2013) of below normal rainfall punctuated by 3 multiyear droughts caused extremely low growing season flows and catastrophic declines in mussel abundance in the lower Flint. Mid-reaches of major tributaries crossing the Dougherty Plain showed the greatest effects and included populations of federally listed species. Since 2013, rainfall has been closer to historical averages, reducing growing season water stress. In mussel surveys conducted in 2014, mussel abundance remained low compared to historical averages and species richness was also lower in 2014 (0-8 species) compared to historical (2-11 species). It appears that long-term declines in freshwater mussels continued in the tributaries of the lower Flint River at least for several years following extended drought. The mainstem of the lower Flint and extensive segments of the tributaries were designated as Critical Habitat for freshwater mussels in 2007. Recognizing the extended period of water scarcity, conservation programs were implemented that included more efficient irrigation technology, permit moratoria, and 5-yr regional planning councils to reduce demand and build resilience into the water management. GA-FIT, with incentives auction and drought swap, builds upon previous water conservation efforts. Developing sustainability tools is a goal of GA-FIT and includes a basin-wide synoptic of mussel populations leading to a habitat conservation plan contributing to the long-term survival of freshwater mussel populations.

Track 1, Session 5: ACF Water Quantity and Quality

1.5.1. Lake Lanier Septic Study

Brigette Haram[1], Aris Georgakakos, David Radcliffe
[1] Gwinnett County DWR, *[2]Georgia Water Resources Institute, Georgia Tech, [3] University of Georgia*

Gwinnett County Department of Water Resources partnered with the Georgia Water Resources Institute, Georgia Tech, University of Georgia, and Cornell University to study current and historical effects of septic systems and residential development on Lake Lanier Water Quality. The project used a multi-pronged approach involving extensive field measurements of lake and shoreline processes, remotely sensed data, and modeling assessments to identify potential sources and pathways of nutrient pollution along developed and undeveloped shoreline and identify strategies to reduce nutrient loading into the lake. We found current and historical evidence that developed coves receive more nutrients than undeveloped coves, through both groundwater and surface runoff. The study also produced technical tools to support continuing lake monitoring efforts, including: a web-based data management system, chlorophyll-a remote sensing tool, lake water quality model, and an approach to increase accuracy of in-situ chlorophyll-a monitoring. We will present significant results from the study, the tools that were developed, and some of the challenges we encountered over this multi-year project.

1.5.2. Lake Lanier Water Quality and Ecological Model.

Xiaofeng Liu and Aris P. Georgakakos, *Georgia Water Resources Institute, Georgia Tech.*

Lake Lanier was listed on Georgia's 305(b)/303(d) list for not meeting the Chlorophyll *a* standard in both 2020 and 2022, indicating a declining water quality trend and raising important sustainability concerns and questions: Which are the main nutrient sources to the lake and what are their individual and collective impacts on lake water quality? What management alternatives can be adopted to improve lake water quality conditions? Lake monitoring is essential in assessing local water quality conditions, but it cannot anticipate future lake responses nor answer management questions like those stated above. The objective of the water quality program at the Georgia Water Resources Institute at Georgia Tech is to develop a coupled hydrodynamic-biogeochemical model for Lake Lanier that is accurate enough to inform environmental management decisions. The GWRI Lake Lanier model has been built based on the Delft3D FM modeling system. The hydrodynamic model simulates the lake flow and thermal response to hydroclimatic factors, and the water quality/ecology model simulates the interactions between phytoplankton, nutrients, organic matter, and dissolved oxygen. The comparison between the simulated with the observed lake levels over the two-year study period and shows that the hydrodynamic model is accurate within 5-10 cm. The simulated temperature profiles agree well with in situ temperature measurements across all seasons. The error standard deviations at all sites range from 0.83 to 1.23°C, and the average error mean from -0.13 to 0.53°C. There is also good agreement between model-simulated and satellite-estimated photic zone Chl-a concentrations. These results show that the Lake Lanier water quality model simulates key hydrodynamic, chemical, and biological parameters with high accuracy, and it can be a useful tool for lake water quality management.

1.5.3. New Capabilities Provided by ArcGIS Pro in the Aquatic Vegetation Management Context: Point Cloud Analysis from Lake Seminole, Georgia, USA

Philip Ashford[1], Can Vatandaslar[2], Steve Golladay[3], Marguerite Madden[1]
[1]University of Georgia, [2]Artvin Coruh University, Artvin Turkey, [3]Jones Center at Ichauway

Aquatic resource managers need practical tools and techniques for mapping actual shorelines, detecting invasive plants, monitoring nuisance vegetation, and determining the effectiveness of management decisions. Spatially explicit data collected by consumer-grade drones can provide timely information to guide decision-makers in a cost-effective way. However, 2-D data (optical images) creation and analysis are challenged by limitations in photogrammetric processing and they fail to completely characterize complex aquatic systems. By contrast, 3-D data (point clouds) offer a more realistic representation of the environment but the file size and configuration means that they can hardly be analyzed with traditional GIS software. Therefore, the present study aims to differentiate between land and aquatic vegetation classes in Lake Seminole, GA, as well as delineate the lake's shoreline based on dense point clouds created by a DJI Phantom 3 drone. Unlike other image analysis studies, we conducted all data analysis steps in one workplace, ArcGIS Pro, which allowed us to segment, classify, edit, and visualize point clouds within a 3-D scene. As such, the high-resolution height data were employed as a discriminator between land and aquatic vegetation. For model validation, the outputs were compared against the ultra-high-resolution (≤ 10 cm) orthomosaic imager. Initial findings showed that Lake Seminole's shoreline could be successfully delineated based on slope data derived from elevation data alone. Thus, we conclude that aquatic resource managers might benefit more from drone-based solutions when coupled with the 3-D data analyzing capabilities of ArcGIS Pro. As this study progresses, a more thorough description of the workflow and maps that best contribute to our understanding of the complex aquatic systems will be provided during the presentation.

1.5.4. Cost Effectiveness of Source Switching v. Irrigation Buyout Auctions in the Lower Flint

Jeffrey D. Mullen and Yizhou Niu, *University of Georgia*

Managing low stream flows throughout the Flint River Basin (FRB) has been a concern for more than 30 years. One of the key relationships established from research in the area is the effect of irrigation withdrawals on stream flows. Reducing irrigation withdrawals during drought periods is one of the most effective ways to maintain stream flows. Irrigation water, however, is a critical input into agricultural production in the area and agricultural production is the driving force of the region's economy. As such, reductions in irrigation can have significant economic impacts both on and off the farm. In 2001 and 2002, a set of auctions were held in the basin to buyout irrigation permits during an extended drought. The state of Georgia spent $10 million during those auctions for farmers to forego irrigation on 75,000 acres of crop land with surface water irrigation permits. Since that time, the Flint River Drought Protection Act created a provision to allow groundwater permit holders to participate in future irrigation buyout auctions. Georgia is fortunate to have a series of stratified aquifers in the FRB – the Floridan aquifer lies at the top with the Claiborne, Clayton, and Cretaceous below. While the Floridan can have significant hydrologic connectivity to the streams of the FRB, that connectivity diminishes considerably with the deeper aquifers. Given the hydrology of the region, an alternative water management strategy to a buyout auction is to pay farmers to switch the source of their irrigation water, either from a direct surface water withdrawal to a groundwater withdrawal, or from a Floridan withdrawal to a deeper aquifer. In this paper we describe the economic considerations for comparing source switching to a buyout auction and identify the conditions under which source switching is the more cost-effective policy.

1.5.5. Assessment of Agricultural Yield and Irrigation Demand for the 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) [Tsuji et al., 1994; Hoogenboom et al., 2017] to assess the sensitivity of crop yield (peanuts, corn, soybeans, and cotton) and irrigation demand to historical climate conditions in the Apalachicola-Chattahoochee-Flint (ACF) River Basin. This assessment included normal, dry, and wet years.

Then, using bias corrected General Circulation Model (GCM) climate projections, we estimate how crop yield and irrigation demand may materialize in the future. For this study, the ACF is divided into 14 sub-basins. Crop acreages for rainfed and irrigated peanut, corn, soybean, and cotton were obtained from the USDA Cropland Data Layer [USDA NASS, 2015] and the USDA Farm Service Agency. Annual crop yields and irrigation amounts for the control period 1980 – 2016 were simulated using the DSSAT-CSM model calibrated to the ACF region. Simulation results were then coupled with reanalysis climate data from the Climate Research Unit (CRU) to estimate typical crop yields and irrigation demand during dry, normal, and wet growing seasons. Preliminary results based on the latest bias-corrected CMIP6 climate data indicate that over the next thirty years, the frequency of dry growing seasons will increase from 25 to over 100 percent throughout the ACF, and that after year 2050 dry growing seasons will be twice to over five times more frequent than the present-day. Crop model simulations assuming no change in irrigated acreages suggest that compensating for the increased frequency in dry seasons will require on average a four percent increase in irrigation volume over the next thirty years and 16 percent increase by the end of the century. ACF sub-basins with more intense irrigation demands (i.e., southernmost basins) may require up to 25 percent more irrigation volume by the end of the century. Acknowledgements: This study was sponsored by the Georgia Water Resources Institute at Georgia Tech.

1.5.6. No talk slated.

Track 1, Session 6: Watershed & Regional Planning

1.6.1. Flow-Dependent Benefits and Uses of Water Resources in the Oconee River Basin

Gail Cowie[1], Laura Rack[2], Carol Yang
[1] Georgia Water Planning and Policy Center at Albany State University, *[2]University of Georgia River Basin Center*

Georgia's regional water plans recognize many benefits and uses of water resources in each region. However, regional water planning has largely focused on demand for offstream uses, in part because basin-specific information on instream uses and benefits is not readily available. To address this information gap, our project produced an inventory of flow-related benefits and uses for water resources in the Oconee River Basin. Water users in the basin provided input on benefits and uses important to them, including details on locations and variation with flow or lake levels. An interactive map was used to collect input from stakeholders. Based on participant input, benefits and uses were grouped in seven categories and presented in a composite interactive map: water supply, water quality and wastewater assimilation, direct economic value, recreation on lakes and rivers, aquatic habitat and species, recreation and habitat on adjacent lands, and environmental and historical education. We combined stakeholder input with review of technical and scientific studies relevant to the basin. Literature review and input from selected stakeholders provided additional information on the flow-dependence of certain uses and benefits, and we used this information to develop metrics for analysis of surface water availability. We identified metrics for recreational boating and for ecosystem function at lake and mainstem river locations throughout the basin. Metrics can be applied to evaluate results of Georgia Environmental Protection Division's modeling of surface water availability and to inform review and revision of the Upper Oconee Regional Water Plan.

1.6.2. Ecological Indicators for Georgia Water Planning

Laura Rack[1,2], Mary Freeman[3], Gail Cowie[4], Ben Emanuel[5], Seth Wenger[1,2]
[1]Odum School of Ecology, University of Georgia, [2] River Basin Center, University of Georgia, [3] Patuxent Wildlife Research Center, US Geological Survey, [4]Georgia Water Policy and Planning Center, Albany State University, [5]American Rivers

There is a growing demand for managers to account for multiple values in water planning and decision making that are beyond municipal water supply, such as recreation, biodiversity, and ecological functioning. Water planning in Georgia assesses surface water availability to satisfy off-stream demands while also meeting instream flow requirements. Instream flow needs for aquatic species and habitats have most often fallen under Georgia's interim instream flow policy, which sets minimum flow levels but are not based on location-specific flows needed to maintain ecological function. We adapted the "functional flows" approach for rivers in Georgia and identified parts of the flow regime that support ecological functioning, encompassing biological, physical, and chemical processes. We applied this approach in the Oconee Basin across the full flow regime and in the Upper Flint Basin with a specific focus on low-flows and drought. We identified five functions for Piedmont and Coastal Plain rivers and where information was available identified preliminary flow thresholds to support those functions. We also develop ecological metrics to evaluate those thresholds that could be evaluated alongside other water planning information, such as water supply or recreation (e.g., kayaking or canoeing). The addition of these metrics offers opportunities to target locations for future research to expand the geographic area or refine metrics, and in general, better integrate the environment into decision making about water resources.

1.6.3. Tying Research to Policy: A District Approach

Celine Benoit, *Metropolitan North Georgia Water Planning District*

Metro Atlanta's water supply is influenced by its physical geography, an increase in drought frequency, and the need to balance the region's economic prosperity while meeting our future water demands. The Metropolitan North Georgia Water Planning District (the District), recognizing the capabilities of water efficiency, puts forth efforts that have distinguished the District as a national leader in water conservation and have contributed to a 30% decrease in per capita water use within the Metro Atlanta region, while the area's population has increased by 1.4 million individuals since 2000. To address these current factors and to proactively account for the region's future water demands, the District develops a Water Resource Management Plan every 5 years. The District is continuing to expand our knowledge of how best to preserve our water resources. As irrigation efficiency becomes increasingly more significant, the District has conducted research on the potential benefits of drought-tolerant turfgrasses as well as implemented a new Action Item related to outdoor water efficiency. District Staff sought to advance understanding on Bermudagrasses that exhibit drought-tolerant qualities through research on the possible impact and influence on residential water usage. This analysis helped the District to strengthen our educational and outreach efforts for outdoor efficiency, in addition to providing guidance to planning policies. The Action Item expands upon previous landscape requirements to include whole system efficiency. The requirements now include pressure regulation through leading technologies, which helps improve system performance, minimize water waste, and reduce leaks. This work contributes to work put forth by the District in the commitment to building on its national leadership on water conservation and to better preparing for drought.

1.6.4. How the Southeast Conservation Blueprint Can Support Your Work in Georgia

Alex Lamle and Rua Mordecai, *SECAS*.

The Southeast Blueprint is the primary product of the Southeast Conservation Adaptation Strategy (SECAS), a regional conservation initiative that spans the Southeastern United States and Caribbean. Started in 2011, SECAS brings together a broad suite of partners like NGOs, state and federal agencies, private businesses, tribes, partnerships, and universities. To date, SECAS has helped secure over $55 million in conservation funds, helping to protect and restore over 82,000 acres in the Southeast. By providing regional context for local decisions, the Blueprint helps organizations with different objectives find common ground—aligning their efforts to protect fish and wildlife habitat, improving environmental justice and quality of life for people, safeguarding life and property, and developing strong economies. As the Blueprint guides decisions and brings in new resources to benefit our communities, our livelihoods, and our natural and cultural heritage, it is shaping a more sustainable future for our region. The Southeast Blueprint is updated annually, incorporating the best available data to help inform conservation action across the Southeast and Caribbean and comes with a free user support service to increase accessibility of data. The Blueprint serves as the roadmap for achieving the SECAS goal and has included input from more than 1,700 people from 500 different organizations, making it a truly collaborative spatial tool.

1.6.5. Utilizing Data from the US EPA's Preliminary Healthy Watershed Assessment (PHWA) Project to Compare the Health and Vulnerability of Watersheds in Georgia

Don Lane, *Elachee Nature Science Center*

In 2009, the US Environmental Protection Agency (EPA) created the Healthy Watersheds Program. A major component of this program was to provide technical analysis, tools, and data to help identify healthy watersheds and vulnerable watersheds. One of the outcomes of this effort was the PHWA. The PHWA was developed in 2017 and updated in 2021. The PHWA is a set of forty-eight statewide and 85 ecoregional-scale assessments that score watershed health and vulnerability in the contiguous United States. The PHWA focuses on six key attributes of watershed health (Watershed Health Index). These attributes are Landscape Condition, Geomorphology, Habitat, Water Quality, and Biological Condition. The PHWA also includes a Watershed Vulnerability Index which is derived from Land Use Change, Water Use, and Wildfire subindex scores. The EPA has released several state-wide and ecoregional products that can be downloaded by the public. Since the PHWA utilizes a myriad of metrics or raw data, indicators, sub-indices, and indices, a working knowledge of the interrelations of each is helpful. The main goal of this presentation is to demonstrate how to use raw data from the PHWA to compare the health and vulnerability of watersheds in Georgia. A secondary goal of the presentation will be to illustrate how the various metrics, indicators, and sub-indices interrelate in order to develop the Watershed Health Index and the Watershed Vulnerability Index.

1.6.6. No talk slated

TRACK TWO

Track 2, Session 1: Nutrients, Contaminants, Water Quality I

2.1.1. Average Annual Hydrologic Residence Time Drives Nitrogen Deposition in Reservoirs

Benjamin Webster[1], Matthew Waters[1], Stephen Golladay[2]
[1]*Auburn University,* [2]*Jones Center at Ichauway*

Reservoirs are hotspots for nutrient deposition however, less is known about how these systems transport deposited nutrients throughout a watershed with linked reservoirs. The phosphorus dynamics, including deposition, have been widely considered but sediment N processes has received less attention. In this study, we compared the average annual hydrologic residence time along with other potentially exploratory variables to the sediment nitrogen concentrations for eight reservoirs in the ACF (Apalachicola-Chattahoochee-Flint) watershed. Residence time is a function of water storage in a reservoir and the rate of outflow, which can be considered as the rate the reservoir empties. Reservoir residence time is understood to be a dynamic value dictated by the amount of water within the reservoir and discharge regulations. Residence time is an important quality that drives many ecological mechanisms including nutrient depositional efficiency from the water column. The eight reservoirs varied regarding residence time, type (surface area, water volume, land use, catchment area, unimpeded upstream river distance, primary usage (hydropower and storage), and placement along regulated and unregulated rivers. Using long-term reservoir flow datasets, federal long-term drought indices, geographic information systems, and classical paleolimnological techniques (i.e. sediment core analysis), average annual residence time was the only parameter found to correlate with sediment nitrogen concentrations and additionally concentrations of cyanobacteria photosynthetic pigments.

2.1.2. Riparian Denitrification Preventing Nitrate-Contaminated Groundwater from Reaching Stream

Scott Raulerson[1], Johnson Jeffers[1], Natalie Griffiths[2], Benjamin Rau[3], Cody Matteson[1], C. Rhett Jackson[1]
[1]*University of Georgia, Warnell School of Forestry & Natural Resources,* [2] *Climate Change Science Institute and Environmental Sciences Division, Oak Ridge National Laboratory,* [3]*USDA Forest Service, Northern Research Station, Timber and Watershed Laboratory*

Leaching of excess fertilizer nitrogen (usually in the form of nitrate) can cause long-term eutrophication of aquatic systems. We investigated nitrogen fate and transport from a heavily-fertilized short-rotation woody crop plantation through the riparian zone of an intermittent low-gradient blackwater stream. Following two years of pretreatment monitoring, 50% of a managed forest watershed was clearcut using modern forestry BMPs and converted to short-rotation pine production. Groundwater nitrate concentrations jumped to 0.5 – 1.5 mg/L within six months after the first fertilization and persisted in most wells in the seven years since. While groundwater nitrate has remained elevated, corresponding increases in riparian and stream water total nitrogen and nitrate concentrations have not occurred. Groundwater travel time modeling shows that nitrogen from near-stream plantation areas should have already reached streams. Two years of measuring nitrogen in a series of landscape-based well networks (within the plantation, swale, riparian edge, forested hillslope, and valley), show rapid transformation and denitrification within the forested wetland valleys. Based on analysis of the first year of measurements, denitrification in shallow groundwater system within toe slopes and the riparian zone is removing >80% of nitrogen.

2.1.3. Nitrogen Dynamics Along the Lower Ogeechee Riverine Floodplain: An Assessment Through Seasonality and Flood Pulse Magnitude

Gabriela Cardona-Rivera and Darold Batzer,
University of Georgia

Riverine floodplains are known to act as sinks of pollutants such as those brought by upland runoff and riverine discharge. Among these pollutants, one of the most present nutrients are composed of nitrogen. Once pollutants reach the floodplain, these are retained and either taken in by present biota such as microorganisms and plants, or even deposited in the soil. The occurrence and rate of processes that aid nitrogen sinking or liberation to the atmosphere, will depend on the environmental conditions in the floodplain. In this project we observed pulses during different times in the flood season for three years and recorded their respective peak discharge as pulse size. To assess the possible origin and fate of nitrogen, we measured its concentration in the forms of nitrate/nitrate (NOx), ammonia (NH_3), and total nitrogen (TN) in both the river and the floodplain of the Lower Ogeechee River, during the upswing and downswing of each pulse. In early seasons, TN, and NOx concentrations were significantly higher in the downswings of large pulses while in late seasons TN and NOx concentrations were significantly lower in the downswings of large pulses. We hypothesize that factors altered by seasonality and pulse size such as organic material availability and mixing during small versus large pulses, as well as temperature, may be part of the drivers of floodplain river interactions in the Lower Ogeechee River. With expected changes in discharge patterns, and temperature due to climate change, these results can help predict the efficiency of floodplains to sequester and process pollutants in rivers as well as contribute to pollution mitigation strategies in riverine floodplains. This assessment is part of a larger project observing other water quality components as well as invertebrate communities along the Ogeechee River.

2.1.4. Spatiotemporal Dynamics of Groundwater-Surface Water Interactions and Riparian Nitrogen Cycling: Incised vs. Un-incised Streams

Daniel Buhr[1], Brian Bledsoe[1], Roderick Lammers[2],
[1]*University of Georgia*, [2]*Central Michigan University*

Channel erosion and incision have the potential to reduce nutrient removal benefits of riparian zones, resulting in increased downstream delivery of pollutants. The effects of stream channel incision on groundwater-surface water exchange have been understudied, particularly outside of the mid-Atlantic US. We continuously measured stream and groundwater elevations for two years at paired incised and un-incised transects at two sites in the southeastern US with different physiographic settings, soil types, and land uses. We measured various species of nitrogen in riparian groundwater and surface water to quantify transport and transformation in riparian zones adjacent to streams of varying incision. Groundwater at incised transects was deeper below the ground surface and more variable than at un-incised transects. Incised streams were primarily gaining and un-incised streams were losing, although we observed seasonal and event-based variability in the direction of groundwater-surface water exchange in response to evapotranspiration and precipitation. Water quality analyses are ongoing, but total nitrogen concentrations have been higher in incised groundwater than in un-incised, despite greater ammonia in un-incised groundwater. Nitrogen removal has been positively correlated with nitrogen concentration and, thus, indirectly controlled by incision. This research will inform future modeling to estimate excess nitrogen loading to incised streams and prioritize restoration locations for maximized water quality benefit.

2.1.5. Understanding the Role of Recalcitrant Organic Phosphorus on Freshwater Harmful Algal Blooms – Proposed Workshop Series

Francisco Cubas and Tasnuva Farnza, *Georgia Southern University*

In the last decades, significant effort and resources have been invested to decrease external phosphorus (P) loadings from both point and nonpoint sources. Up to now, there has been considerable success in controlling external loading of inorganic P forms resulting in lower eutrophication levels in some cases. However, the reduction of external P loading has not necessarily been concomitant with a decrease in harmful algal bloom (HABs) events in P polluted waters. Therefore, massive HABs are still a frequent event across the U.S. and worldwide. An NSF funded study to understand the role of non-conventional P forms released through internal loading from legacy recalcitrant P in fueling HABs is underway. The objective is to quantify the amount of orthophosphate produced from the microbial mineralization of inositol phosphate, as an example of a recalcitrant organic-P, that fuels and sustains HABs. Success for this project relies on incorporating results from this research into current monitoring and mitigation strategies aimed at decreasing HABs. Therefore, a workshop series has been designed to explain stakeholders the importance of controlling organic-P forms in external and internal loadings to prevent

HABs and develop solutions that can be applied to specific systems. The objective of this talk is to inform current surface water stakeholder on the interactive activities that will be done as part of the workshop series during the project's duration to disseminate results from this research. Results from this research will be integrated with P data collected by local agencies in GA to explore how the combined set of data may improve nutrient management practices for each particular case. It is expected that result from this research will help complement common P data that is typically collected through current monitoring programs with the final aim of improving management strategies to control P pollution in GA.

2.1.6. Using Water Quality as a Metric for Success in Wild Pig Management

Caitlin L. Sweeney[1], Stephen W. Golladay[1], Justine L. Smith[2], Faith E. Kruis[2], Michael T. Mengak[3], L. Michael Conner[1]

[1] The Jones Center at Ichauway, [2]The Jones Center at Ichauway and University of Georgia, [3]University of Georgia

Wild pigs (Sus scrofa) are an invasive species that degrade habitat, compete with native wildlife, and cost Georgia agricultural producers over $150 million in damages and removal efforts annually. Their presence raises concern for water quality as they frequent riparian areas where they defecate and disturb soil by rooting and wallowing. However, prior research has shown variable success at detecting water quality degradation from their activity. Coordinated pig removal efforts are occurring on ~12,150 ha of private lands in the Albany, Georgia area as part of the Feral Swine Eradication and Control Pilot Program. Demonstrating success in wild pig management is difficult, and we are collaborating by assessing selected water quality parameters as indicators of removal. Monthly grab samples from 12 sites have been collected since August 2020 and are analyzed for inorganic and organic nitrogen and phosphorus, dissolved organic and inorganic carbon, pH, alkalinity, suspended sediment, and eDNA. Continuous water quality sensors that collect temperature, conductivity, and turbidity measurements in 15-minute intervals were installed in January 2022 in three locations with varying pig removal efforts. The monthly water samples have shown significantly elevated concentrations of suspended solids, NH_4-N, and soluble reactive phosphorus in streams adjacent to large row crop agricultural fields with dense pig populations. The continuous data show daily cycles in temperature, conductivity, and turbidity that are disrupted by increases in discharge. Spikes in turbidity can be observed during periods of stable flow, and rapid changes in conductivity at some spikes appear useful in separating flow-induced changes in turbidity from those of presumed pig activity. Through high and low flow conditions, the site with the least hunting pressure has the greatest average and most variable turbidity. Water quality monitoring will continue and estimates of pig population densities will be used to assess water quality response to pig removal.

Track 2, Session 2: Nutrients, Contaminants, Water Quality II

2.2.1. Potential for PFAS Phytoextraction Via Accumulation by Woody and Herbaceous Plants: A Greenhouse Study Evaluating Six Compounds

David K. Huff[1], Lawrence A. Morris[2], Lori A. Sutter[3], Jed Costanza[4], Kurt D. Pennell[4] - School of Engineering, Brown University

[1]Nutter and Associates, [2]Warnell School of Forestry and Natural Resources, University of Georgia, [3]University of North Carolina Wilmington, [4]School of Engineering, Brown University

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) comprise a suite of compounds that are used for fire suppression and in manufacturing to enhance the resistance of a wide variety of products to stains, grease, and water. As a result of this widespread use, PFAS have been widely detected in the environment, and exposure to these compounds has been linked to adverse human health effects. Phytoextraction, a phytoremediation process wherein plants are used to extract harmful compounds, is a potential method for remediation of PFAS-impacted sites. However, there is limited information on uptake of PFAS from soil by herbaceous and woody plant species. This study evaluated the potential for eight herbaceous and seven woody plant species to accumulate PFAS compounds, in a greenhouse experimental setting. Six PFAS compounds (PFPeA, PFHxA, PFOA, PFBS, PFHxS, and PFOS) were added weekly to irrigation water. Following an initial establishment period, the PFAS-dosed plants were cultivated for up to 14 weeks, after which tissues were evaluated for PFAS using ultra-performance liquid chromatography. Statistically significant accumulation of each individual PFAS compound was observed in at least one plant species. The best-performing plant demonstrated a mass recovery in above-ground tissue ranging from 3.8% (for PFOS by Festuca rubra) to a high of 42% (for PFPeA by Schedonorus arundinaceus). Hyperaccumulation (tissue/soil concentrations exceeding a ratio of 10 to 1), was observed for each of the six PFAS compounds in at least one plant species. The results of this study demonstrate the potential use of phytoextraction as a tool for remediating PFAS-contaminated sites.

2.2.2. USGS Providing Technical Support to the U.S EPA to Address a Legacy of Groundwater Contamination Facing an Underserved Community, Fort Valley, Georgia

Jim Landmeyer[1], Peter Johnson, P.G.[2]
[1]U.S. Geological Survey, [2]United States Environmental Protection Agency, Region 4

The Woolfolk Chemical Works Superfund site is located in downtown Fort Valley, Georgia. The 31-acre site is characterized by soil and groundwater contamination related to manufacturing of organic and inorganic pesticides between 1910 and the early 1980s. Some contaminants have leached into local groundwater, and these contaminants have created a "plume" that extends more than 2 miles from potential sources in downtown Fort Valley. The U.S. Geological Survey (USGS), in cooperation with the U.S. Environmental Protection Agency (USEPA), Region 4, are investigating the potential sources of the groundwater contamination, which has affected four aquifers, from the shallow water table to the deeper confined aquifers. Field and laboratory results from planned water-quality sampling of the impacted aquifers will be presented and discussed. Moreover, to help shrink the extent of the plume, an innovative treatment technology, called phytoremediation, will be evaluated to address shallow and deeper contaminated groundwater. Because some of the groundwater farther downgradient from Ft. Valley is deeper than the tree roots, groundwater in these areas will be pumped to land surface using a solar-powered pump and used to irrigate existing trees. This project is conducted with cooperation from faculty and students at Fort Valley State University.

2.2.3. The Ecological Implications of Plastic Pollution in Freshwater Ecosystems: Microbial Community Succession on Macroplastic

Fabiola Lopez Avila, Krista Capps, Raven Bier, *Odum School of Ecology University of Georgia & Savannah River Ecology Research Laboratory.*

An estimated 350 megatons of plastic are produced annually, and 80% of plastic is turned into waste which can be found globally, including in freshwater ecosystems. Plastics can be present in the environment for an extended amount of time and provide a novel physical and chemical habitat that can serve as a niche for biofilm formation. Plastic research in freshwater systems is most often conducted in contaminated urban streams yet the effects of plastic in rural streams may have unique consequences for stream biofilms and ecosystems. Microbial communities in stream biofilms are important for biogeochemical cycles and are the basis of benthic food webs. Several studies have shown that the bacterial diversity of biofilms on microplastics is less diverse compared to the surrounding water and natural substrates, but we have little understanding of how the properties of the plastic surface can provide different habitat qualities. For example, rough and smooth plastic surfaces could create different conditions for adhering to the surface. Most natural substrates in streams (wood, leaves, and rocks) have rough surfaces. Three sites in low-impact streams on Savannah River Site (Aiken, SC, USA) were selected to incubate two plastic sheet types, rough and smooth high-density polyethylene (HDPE) and a non-plastic poplar wood (Liriodendron tulipifera) sheet in stream water. Biofilm samples were collected at three time points, and the samples' extracted DNA was sequenced for 16S rRNA gene amplicons. We will report preliminary findings from this study, including the chlorophyll-a concentrations and biomsass of biofilm on the surface. The future direction of this study will include the analysis of the microbial communities in biofilms found on smooth HDPE, rough HDPE, and wood.

2.2.4. Exploring Patterns in Microplastic Pollution in a Large Rural Watershed

Emily Martin[1], Krista Capps[1], Stephen Golladay[2], Rae McNeish[3]
[1]University of Georgia, [2]The Jones Center at Ichauway, [3]California State University Bakersfield

Microplastics are a ubiquitous contaminant of emerging concern and their movement through freshwater systems is an understudied part of the "plastic cycle." To assess spatial and temporal variation in the composition and concentration of microplastics in a river system, I collected monthly surface water samples from 16 sites in an agriculturally dominated watershed in southwestern Georgia. I used generalized linear models (GLMMs) to investigate relationships among plastics, land use variables, and physicochemical properties. The analyses suggested that microplastic concentrations are strongly related to soluble reactive phosphorous (SRP) in the water column. These findings enhance our understanding of plastic pollution dynamics in rural watersheds.

2.2.5. Assessing the Impact of Water Quality on the Sustainability of Point-of-Use Water Disinfection

Elijah Carl Bright and Stetson Rowles, *Department of Civil Engineering and Construction.*

According to the World Health Organization, 785 million people lack access to basic drinking water facilities, and 144 million people rely on surface water which is prone to microbial contamination. Point-of-use (POU) water disinfection technologies can be adopted to help address these issues by treating water at the household level; however, navigating various POU disinfection technologies for a given water source or location can be difficult. While numerous conventual POU technologies exist (e.g., chlorination), new emerging POU technologies (e.g., using novel materials or advanced processes) have been coined by developers to be sustainable. It is unclear if these claims are substantiated and how technologies stack up against each other in terms of cost and environmental impacts. In this research, we compare four POU technologies using quantitative sustainable design. The technologies evaluated include chlorination using sodium hypochlorite, silver nanoparticle enabled ceramic water filter, ultraviolet disinfection with mercury lamps, and ultraviolet with light emitting diodes. We leverage open-source Python packages to assess the relative sustainability using technoeconomic analysis and life cycle assessment. Uncertainty is included in all input parameters, and sensitivity analysis is conducted through (Spearman's rank correlation). The study assumes a population of 1000 people, household size of 6 people, and lifecycle of 5 years. Escherichia coli is used as an indicator microbe in characteristic surface and ground waters. We set raw water types to capture impact of water quality parameters e.g., turbidity, total organic carbon, and hardness. Per capita cost (USD·cap-1·yr-1) and Global Warming Potential (kg CO2eq·cap-1·yr-1) are tracked as sustainability indicators. Results can potentially inform decision makers, non-profit organizations, and future research on sustainable POU technologies.

2.2.6. Georgia Power's R&D Efforts for Responsible Water Utilization

Rebecca Osteen[1], Dominic Weatherill[2], Stephanie Whitacre[2]
[1]*Southern Company,* [2]*Georgia Power*

As communities and industries across Georgia continue to grow, competing demands for water are rising. Georgia Power is committed to prioritizing the delivery of clean, safe, reliable, and affordable energy to our customers, which includes our dedication to protect and conserve natural resources. As a part of this commitment, the Water Research and Conservation Center (WRCC) was developed as a state-of-the-art research facility located at Georgia Power's Plant McDonough-Atkinson. The WRCC was developed to expand our focus on water conservation toward testing and implementing innovative solutions to continue to reduce our dependence on freshwater resources. The WRCC provides infrastructure for evaluating technologies related to heat transfer, cooling water chemistry, and water recovery and reuse to better manage and conserve water across our thermoelectric power generation sites. The WRCC is a collaborative project with the Electric Power Research Institute (EPRI) and several utility companies across the U.S.

As Georgia Power works to meet the goal of Net Zero carbon emissions by 2050, we are committed to an equitable transition and continued environmental stewardship. The studies and evaluations conducted at the WRCC provide solutions to maintain our commitment to environmental stewardship.

- Heat transfer improvements improve the efficiency of our power plants resulting in reduced greenhouse gas emissions and water intensity
- Cooling water chemistry research allows for optimized chemical use in our cooling and water treatment systems and identification of alternative and chemical-free treatment technologies
- Water recovery and reuse technologies allow for reduced withdrawal and consumption from freshwater sources

As Georgia Power develops technologies to enable the energy transition, responsible use of water resources is a key factor in planning a sustainable energy future. As new technologies emerge, the WRCC plays a vital role in assessing their water intensity and providing thought leadership in how to best manage water as a shared resource.

Track 2, Session 3: Barrier Removals in Southeastern US: Lessons Learned and Future Directions

2.3.1. State of Dam Removal and Prioritization Efforts Nationally, in the Southeast, and in Georgia

Ben Emanual, *American Rivers*

In the past two decades, the rate of dam removal across the United States has increased dramatically, though it continues to vary widely by state. American Rivers' annual "Free Rivers" report and online database capture up-to-date information on the state of dam removal across the country. Numerous factors—technical, regulatory, policy-oriented, funding-related, and otherwise—contribute to a conducive environment for dam removal in any given state. Since 2016, the Georgia Aquatic Connectivity Team has improved the environment for collaboration for dam removal projects in Georgia in several ways; these include convening diverse partners, producing handbooks and other resources, and enhancing collaboration to identify and prioritize barrier removal projects. A GIS-based barrier inventory and prioritization tool developed by the Southeast Aquatic Resources Partnership (SARP) provides foundational datasets to enable collaboration by GA-ACT partners to identify candidate projects. Since 2010, SARP has been working with partners to incorporate local on-the-ground information into a large-scale inventory of aquatic barriers to create a community of practice of barrier remediation that leads to on-the-ground project implementation. Currently, SARP has identified over 50,000 manmade dams as well as several road-stream crossing barriers in the state of Georgia. These barriers are located on a platform (https://connectivity.sarpdata.com) to download the data as well prioritize these structures for removal/remediation.

2.3.2. Multi-Objective Decision-Making for Dam Removal, Retrofit, and Repair

Daniel Buhr[1], Laura Naslund[1], Matt Chambers[1], Seth Wenger[1], Suman Jumani[1], S. Kyle McKay[2], Brian Bledsoe[1].
[1]*University of Georgia* [2]*US Army Corps of Engineers*

Many dams in the United States are at or near the end of their design life, resulting in poor or unsatisfactory condition and, in some instances, high hazard potential to society. Proactive and transparent decision making about the long-term management of dams is critical for successfully managing this aging infrastructure and presents an opportunity to apply Engineering with Nature principles to the end of the infrastructure lifecycle. Decision support tools have the potential to greatly increase the efficiency and scope of dam removal, retrofit, and repair decisions if designed to accommodate user needs. We analyzed 41 existing dam removal decision support tools to identify common objectives. Focal taxa (80%) and implementation cost (71%) were the most prevalent objectives, while few tools focused on safety, recreation, and historic preservation. Based on literature and professional judgment, we identified metrics for quantifying each objective and developed methods for calculating metrics. We created a web application with these results to facilitate effective use of existing decision tools and to support structured decision making about dams.

2.3.3. A Decision-Support Framework for Dam Removal Planning

Suman Jumani[1], Lucy Andrews[2], Theodore E. Grantham[2], S. Kyle McKay[3], Jeffrey Duda[4], Jeanette Howard
[1]*University of Georgia,* [2]*University of California Berkeley,* [3]*US Army Corps of Engineers,* [4]*U.S. Geological Survey, Western Fisheries Research Center,* [5]*The Nature Conservancy*

Dam removals are occurring more frequently with the rising cost of maintaining aging infrastructure, public safety concerns, and growing interest in river restoration. So far, most dam removals have been uncoordinated and opportunistic in their approach. Given the several thousand dam removals expected over the coming decades, a systematic approach to plan future dam removals holds potential for aligning and delivering multiple benefits. We present a hierarchical, multi-disciplinary decision-support framework to prioritize dam removals based on opportunistic factors (Tier 1), hydro-ecological variables (Tier 2), and socio-cultural considerations (Tier 3). This framework integrates multiple decision criteria under data availability constraints, incorporates value-driven weights, and can be applied to a portfolio of dams at various scales. We also develop a model to predict the estimated cost of proposed dam removals. Together, the final output facilitates the identification of dam removal projects that align opportunistic, environmental, economic, and social benefits. We recommend the application of this framework as a critical first step to identifying high-priority candidates for removal, recognizing that removal decisions will ultimately require detailed feasibility studies and stakeholder engagement. We conclude with recommendations for filling critical knowledge gaps and advancing systematic dam removal planning in the U.S. and beyond.

2.3.4. Dam Safety Considerations in Dam Removal Decision Making

David Griffin, *Georgia EPD Safe Dams Program*

There are several issues regarding dam safety when a dam removal is being considered. This talk will address some of these issues and consider ways they can be addressed.

2.3.5. Incorporating Biogeochemical Cycling into Decisions About Dam Removal and Long-Term Management

Laura Naslund[1], Seth Wenger[1], Amy Rosemond[1], S. Kyle McKay, U.S. Army Engineer Research and Development Center (ERDC)
[1]*University of Georgia,* [2]*US Army Corps of Engineers*

A comprehensive framework for evaluating the benefits and costs of dams is urgently needed to support decisions about the long-term management of this aging infrastructure. Dams and their reservoirs contribute many services and disservices through their impacts on elemental cycles. Carbon, growth-limiting nutrients, and other elements can be transformed by biological and chemical processes as they enter reservoirs from flowing waters. These biogeochemical changes can cause algal blooms and subsequent low oxygen conditions, resulting in undesirable effects in the reservoir and downstream aquatic ecosystems. This talk will provide an overview of the biogeochemical impacts of dams, present primary research on greenhouse gas emissions from small reservoirs, and argue for including elemental cycles more explicitly in dam removal decisions.

2.3.6. Reconnecting Shoal Bass Habitat on the Middle Chattahoochee River: Science, Studies, and Stakeholders

Patrick O'Rouke, *Georgia Power.*

In December 2018, Georgia Power filed a notice of intent to surrender the Federal Energy Regulatory Commission (FERC) licenses to operate the Langdale and Riverview hydropower projects, located on the Chattahoochee River near Valley, Alabama. The proposed removal of the three dams associated with these projects would reconnect 11 miles of the mainstem Chattahoochee River between West Point Dam and Lake Harding, along with a major tributary, Flat Shoals Creek. This location is within the native range of the Shoal Bass Micropterus cataractae, a highly-mobile fish that is listed as imperiled by the State of Georgia. Biologists associated with this project expect the dam removals to be ecologically beneficial for the Shoal Bass based on previous research and the known life history of the species.

After Georgia Power filed its surrender notice, some local residents began to vocally oppose the proposed removal of these dams. Many were anglers who expressed concern that dam removal would negatively impact the local population of Shoal Bass. Subsequent, site-specific studies have provided additional evidence supporting the benefits to Shoal Bass from dam removal. However, the highly divergent perceptions between professional biologists and anglers of the potential impacts of dam removal provides a lesson for managers of future projects that may impact recreational fisheries. While regulatory review must often focus on peer-reviewed scientific literature, project managers should make efforts to understand and address the perspectives of local anglers and other resource users once stakeholders are engaged on a proposed dam removal.

Track 2, Session 4: Panel, Aquatic Connectivity Case Studies

The Georgia Aquatic Connectivity Team (GA-ACT) will sponsor a panel on barrier removal case studies at various stages of completion. As a "bridge" between the session on Barrier removals in South-Eastern US: Lessons Learned and Future Directions and the Georgia Aquatic Connectivity Team Workshop, these presentations and discussion will focus on the application of prioritization, regulation, restoration, construction, and monitoring techniques to enable aquatic organism passage and habitat improvement in Georgia. Case studies to be covered:

- **Ecological Indicators of Stream Recovery after Dam Removal and Channel Restoration**

Troy Keller[1], [2]Colin Light, [3]Sara Gottlieb, [1]Stacey Blersch
[1]*Columbus State University,* [2]*Georgia DNR, Sara,* [3] *The Nature Conservancy*

Dams alter rivers on a global scale; more than 50% of all major river systems are impounded by dams. In Georgia, rivers are dissected by more than 30,000 dams. These dams sever connectivity among rivers segments and fragment once contiguous ecosystems. Because dams in Georgia are concentrated in low-order streams, they fragment habitat, interrupt material cycling, and disrupt energy flows at a critical interface between land and water. Ecological studies are needed to determine how removal of dams and the restoration of stream channels can rehabilitate low-order, coastal plain streams. A collaborative partnership between The Nature Conservancy and

Columbus State University was developed to address this knowledge gap. A Before After Control Impact study was implemented to evaluate chemical and biological responses in two dam removal projects. While construction temporarily increased turbidity and ammonium, monthly sampling indicated that nitrate, phosphate, pH and specific conductance recovered quickly or remained unchanged after restoration. Data from Hester-Dendy samplers indicated that drifting macroinvertebrates colonized the restored stream channels within one year, however macroinvertebrate community composition became dominated by Diptera. Since stream channel restoration resulted in the removal of the riparian canopy, we hypothesize that full ecological restoration of the macroinvertebrate community may depend on the re-establishment of canopy trees.

- Ben Emanuel, *American Rivers* – Removal of Ela Dam, NC

Collaborative Approaches to Restoring Migratory Pathways and Riverine Habitat in the Altamaha Basin

Twyla Cheatwood, *National Marine Fisheries Service*

Juliette Dam (previously known as East Juliette Hydroelectric Project) sits just east of the town of Juliette, GA on the Ocmulgee River in the Altamaha River Basin. Built in 1921 and the first barrier on the Ocmulgee River, Juliette Dam is 20 feet high and 1230 feet long. The hydroelectric facility ceased operation in 2014. Juliette Dam blocks over 40 miles of spawning and rearing habitat in the Ocmulgee and Towaliga Rivers for American shad, American eel, Atlantic sturgeon, and robust redhorse. NOAA Fisheries along with other federal and state agencies, universities, and non-profit organizations are working together to learn more about the migratory species that call this river home and the best path to restoring declining populations and habitats in the Altamaha River.

- Dawn York, *Moffat & Nichol* and Danielle Darkangelo, *Cape Fear RC&D*, Black River Aquatic Connectivity Project

- Drew Martin, GA Department of Transportation – Removal of Garwood Dam

- Sara Gottlieb, *The Nature Conservancy* – Holly Creek culvert assessment and progress on priority replacements

Track 2, Session 5: Georgia Aquatic Connectivity Team Workshop

Moderated by Sara Gottlieb. Panelists: Jay Shelton, Ben Emanuel, Will White, Shawna Fix. The Georgia Aquatic Connectivity Team has organized a session in every GWRC for the past 6 years as an opportunity for current members to reconnect and work together on topics of interest, to invite new participants to learn about our work, and to get feedback and input from the science community members in attendance. Anyone is welcome to join this session, which will be very interactive. Topics we intend to cover include:

Overview of GA-ACT purpose, activities, presence at GWRC since 2013 (Sara Gottlieb)

Presentation/Q&A on Dam Removal project opportunities from around the state (Ben Emanuel/Shawna Fix)

Presentation/Q&A on funding opportunities for fish passage projects (Shawna Fix)

A Survey of Aquatic Connectivity Teams in the Southeast Region

Jay Shelton[1] Kat Hoenke[2]

[1]UGA Warnell School of Forestry and Natural Resources, [2] Southeast Aquatic Resources Partnership

While many barriers have been removed in some regions of the US, other areas are lagging despite the presence of numerous obsolete or poorly designed structures. Achieving desired benefits to native fishes through improved connectivity involves building stakeholder partnerships that can balance ecological, social and economic constraints, and manage a broad range of potential conflicts. Within the United States, partners have been working together to initiate Aquatic Connectivity Teams (ACTs). The purpose of these ACTs is to build a community of practice among stakeholders that can work together toward the common goal of making barrier removal and remediation more commonplace within each state. Aquatic connectivity teams are self-selecting and include a diverse assortment of partners including federal and state agencies, NGOs, academic institutions, and others. Currently, within the Southeast Region, there are 7 ACTS, including one in Georgia (GA-ACT). Members of the GA-ACT conducted a brief survey of members from Arkansas, Alabama, Florida, Georgia, North Carolina, Tennessee and Virginia. We will present results of this survey, including the ways in which the ACT benefited statewide efforts in aquatic connectivity, and the biggest challenges faced by aquatic connectivity teams.

Presentation/Q&A Education and Outreach efforts by the team, including a new social media presence (Will White)

Closing discussion of opportunities to participate, and leadership transitions (Sara Gottlieb)

TRACK THREE

Track 3, Session 1: N-EWN: Multiple Benefits of Natural Infrastructure

3.1.1. Economic Valuation of Nature-based Infrastructure: Best Practices and Beyond

Susana Ferreira[1], Ben Blachly [2], Yukiko Hashida[1], Grace Anne Ingham[3], Craig Landry [1], Anna Perry[4]
[1]*University of Georgia,* [2] *Industrial Economics, Inc,* [3] *University of Wisconsin,* [4] *US Inernational Trade Commission*

This presentation reviews best economic valuation practices for nature-based infrastructure projects. An ecosystem services approach to capturing the full suite of ecological and social benefits of nature-based infrastructure projects is advanced. Within the ecosystem services approach, benefit-relevant indicators are covered as a tool for quantifying benefits. A guide is presented to different monetization techniques that can be used on top of the ecosystem services approach and benefit-relevant indicators to assign dollar values to those project benefits that are not explicitly economic in nature. Finally, the integration of social equity and risk aversion into Benefit-Cost Analysis is discussed.

3.1.2. Rising Seas, What to Do? - Increasing Coastal Resilience through Nature-based Solutions

Rhett Jackson, Caleb Sytsma, Ellis Kalaidjian, Oscar Villegas, Margaret Kurth, Mark Risse, Candice Piercy, *University of Georgia*

The low barrier islands and shorelines of the South Atlantic and Gulf Coasts are particularly vulnerable to increased flooding from sea-level rise. As sea-level rises two or three feet in the next 80 years, storm surge, tidal, pluvial, and compound flooding will all increase substantially, as will shoreline erosion. The mean high tide will rise above the elevation of substantial fractions of our barrier islands. In the absence of human infrastructure, barrier islands and shorelines would "retreat" inland due to sea-level rise, but society's property laws are based on fixed property boundaries, so society will need to enhance natural infrastructure, modify traditional infrastructure, and adapt flood management policy to increase the resilience of coastal communities to sea-level rise. Nature-based solutions incorporate and enhance the functions of naturally-occurring landscape features (i.e. natural infrastructure) that provide valuable services to people and society, such as minimizing damages from floods and shoreline erosion. Beaches, dunes, marshes, living shorelines, living reefs, and barrier islands themselves are examples of coastal natural infrastructure which can be protected, enhanced, constructed, or reconstructed to increase the resilience of shore communities to sea-level rise and climate change. Beneficial use of dredged sediments can reduce the cost of enhancements to natural infrastructure in coastal areas. The USACE is working with UGA and local communities to match sediment needs with supplies of dredged sediments. Protecting coastal properties and infrastructure will require a long-term program of adaptation and management of both natural and traditional infrastructure.

3.1.3. Comparing Multiple Benefits of NI in a Spatial Prioritization Framework: A Case Study of Levee Setback Sites on the Missouri River, Omaha District

Alec Nelson and Nate Nibbelink, *University of Georgia, Warnell School of Forestry and Natural Resources*

Natural Infrastructure (NI) is rapidly gaining prominence as an approach to providing multiple beneficial services to river systems, including flood risk reduction, water resources management, biodiversity conservation, social equity, and climate change adaptation. Mainstreaming NI will require established decision-support techniques and tools to optimize implementation success and the distribution of co-benefits across multiple sectors. The most significant gaps in adopting multi-criteria decision tools are in accounting for the range of tangible and intangible services and co-benefits. There is a considerable need to develop benefit evaluation techniques that correspond to stakeholder goals and values, recognizing the tradeoffs and synergies among different decision-making criteria to accelerate the application of NI for riparian infrastructure. This case study, in collaboration with the United States Army Corps of Engineers through the Network for Engineering with Nature, focuses on identifying and evaluating proposed levee setback realignment sites within the Omaha District of the Missouri River. We are building a spatial prioritization framework for assessing, normalizing, and comparing hydrological, ecological, and social characteristics across spatial and temporal scales. We will present our approach to evaluating the multiple societal co-benefits of hydrology, ecology, and equity in implementing nature-based solutions through spatial prioritization to recommend optimal locations for NI projects at large spatial scales. By developing multi-criteria decision-making frameworks to implement NI site prioritization effectively, we may better describe the implications for the distribution of water benefits among stakeholders and guide investment in future water resources management projects.

3.1.4. A Critical Appraisal of Nature-Based Solutions' Role in Halting Freshwater Biodiversity Loss

Charles van Rees[1], Suman Jumani[2, 3], Liya Abera [2,3], Laura Rack [1,2], S. Kyle McKay [2,4], Seth J. Wenger [1,2], [1]*Odum School of Ecology and River Basin Center, University of Georgia,* [2]*Network for Engineering with Nature* [3]*ORISE Postdoctoral Fellow, U.S. Army Corps of Engineers Engineer Research and Development Center – Environmental Laboratory,* [4]*Engineer U.S. Army Corps of Engineers Engineer Research and Development Center*

Enthusiasm for and investments in nature-based solutions (NBS) as sustainable climate adaptation strategies is building among governments, the scientific community, and engineering practitioners, particularly for water security and water-related risks. In a freshwater context, the NBS may provide much-needed “win-wins” for society and the environment that could partially address the decline in freshwater biodiversity. Our interdisciplinary team critically assessed how water-related NBS can make substantive contributions to biodiversity conservation. In particular, we established links between common NBS implemented in freshwater and six priority actions for freshwater life from the biodiversity conservation community. In particular, we illustrate how NBS can play a direct role in restoring degraded aquatic and floodplain ecosystems, enhancing in-stream water quality, and enhancing hydrological connectivity among freshwater ecosystems. By contrast, NBS may make more indirect contributions toward managing the exploitation of riverine resources and mitigating the impact of aquatic invasive species.

3.1.5. The Effect of Marsh Length Scales on Flood Protection

Matthew V Bilskie, Aditya Gupta, Brock Woodson, Brian Bledsoe, *University of Georgia*

Coastal wetlands are an effective natural feature that dampens waves and reduces storm surges. While the attenuation offered by wetlands is recognized, the level varies based on local landscape conditions and storm characteristics. This presentation will focus on the spatial scales of coastal wetland landscape configurations, the temporal scale of storm conditions, and their effects on storm surge attenuation. Hundreds of hydrodynamic simulations were performed on an idealized and actual mash system under varying landscape and storm-forcing conditions. From these simulations, we identified scaling metrics that can be used to predict the attenuation of storm surge for a given marsh system. This multivariate scaling relationship can provide guidance to engineers and coastal managers on salt marsh's flood hazard reduction benefits when entering the restoration and design phase of coastal marsh projects.

3.1.6. An Experimental Approach to Modernizing the Federal Civil Works Benefit-Cost Analysis Through Applied Collaborative Research

Matt Chambers[1], Matt Shudtz[1],David Crane[2], Brian Bledsoe[1]
[1] *University of Georgia,* [2] *USACE Omaha*

The federal government’s approach to evaluating the benefits and costs of water resources civil works has evolved for decades and is currently defined in the Principles, Requirements, and Interagency Guidelines (PR&G). The PR&G encourages agencies, such as the US Army Corps of Engineers (USACE), to under-take a multi-objective approach in benefit-cost analysis (BCA) that considers six co-equal principles for water resources planning. These principles weigh economic development on equal footing with environmental and social considerations. However, the PR&G lacks clear methodological guidance for quantification of environmental and social benefits and assumes agencies will apply professional judgement. This ambiguity enables agencies to continue using precedent guidance that myopically focuses on economic benefits. In the Water Resources

Development Act of 2022 (WRDA 2022), congress greenlit USACE to develop agency-specific BCA procedures and methodologies for benefits quantification. Furthermore, Section 116 of WRDA 2020 promotes the consideration of natural and nature-based features (NNBF) and opens the door for nature-based alternatives in feasibility studies. Our talk will introduce a collaborative effort with the USACE Omaha District to advance a nature-based alternative at a levee system on the Lower Missouri River through civil works planning. We will discuss benefits quantification methodologies for principles in the PR&G such as those pertaining to public safety, the environment, and the equitable distribution of benefits. We will discuss how quantified benefits can be translated into experimental alternative BCAs and procedures for addressing discrepancies in discounting at different levels of review. We will conclude with a discussion of implications and how this research will help promote the adoption of nature-based solutions in federal water resources planning.

Track 3, Session 2: Multi-Hazard Flood Modeling from Inland to Coast

3.2.1. Modeling the Service Potential of Nature-Based Solutions in Coastal Stormwater Management Systems Under Multi-Flood Hazard Events

Matt Chambers, Haley Selsor, Bob Deng, Sara Mallon, Kate Winters, Brian Bledsoe, Felix Santiago-Collazo, *University of Georgia*

This work explores modeling approaches to representing and evaluating the service potential of nature-based stormwater infrastructure in urban coastal systems that are subjected to multi-flood hazard events. We have applied a two-dimensional hydrodynamic numerical model (Interconnected Channel and Pound Routing) capable of dynamically exchanging surface-subsurface flows to serve as a test bed for designing nature-based stormwater infrastructure. This model is capable of accounting for hydrologic processes (e.g., infiltration, rainfall-runoff, and evapotranspiration), as well as coastal processes (e.g., storm surge and astronomical tides), stormwater drainage systems, and groundwater flow. This research has created conceptual approaches to representing the physical behaviors of nature-based features, as well as advanced modeling concepts for representing storm sewer networks to better isolate the service of nature-based features in coupled green-grey infrastructure systems. We quantify service potential under multi-flood hazard conditions and climate change effects by assessing patterns of inundation on roadways, evacuation routes, and structures of interest. This work will ultimately support the development of a natural infrastructure master plan for the City of Tybee Island and is a collaboration between public, private, and academic partners.

3.2.2. Compound Flood Mapping Across Scales: The Power of Physics-Informed Machine Learning Frameworks

David F Muñoz[1], Hamed Moftakhari[2], Hamid Moradkhani[2], Paul Muñoz[3]
[1]Virginia Tech, [2]The University of Alabama, [3] University of Cuenca

Flood hazard and risk assessments are crucial for adequate planning and emergency management decisions, especially in low-lying areas where approximately 190 million people are vulnerable to coastal flooding. Yet, such assessments in coastal to inland transition zones are challenging due to non-linear interactions and statistical dependences that might arise among flood drivers. Spatiotemporal coincidence and/or close succession of multiple (non-) extreme drivers (e.g., stream flow, precipitation, and storm surge) in addition to anthropogenic activities can lead to larger impacts than those produced by isolated drivers, and is commonly referred to as compound flooding. Although physics-informed (e.g., hydraulic and hydrodynamic) models can resolve flood dynamics through numerical discretization of the momentum and mass balance equations, their applicability at large scale is often constrained by computational resource availability and/or high-performance computing capabilities. To overcome these constraints, remote sensing data and local hydrodynamic model outputs can be integrated using data fusion and deep learning techniques into a "hybrid" framework that allows for rapid flood mapping, hazard, and risk assessments across scales. Such a hybrid physics-informed machine learning framework was applied over the southeast coast of the U.S. to map compound coastal flooding triggered by Hurricane Matthew in October 2016. The resulting flood maps agree well with those of the Coastal Emergency Risk Assessment (80% agreement) that relies on the operational ADCIRC model. Also, the flood maps from the hybrid framework capture twice the number of USGS high-water marks than the operational model alone and within the same model extent. The hybrid framework offers a cost-effective alternative that enables efficient estimation of exposure to compound coastal flooding and is particularly useful in data scarce regions.

3.2.3. Compound Flood Analysis With GIS-Based Dynamic Flood Model and Identification of Flooding Drivers for Coastal Urban Areas

Minjae Kim and Jian Luo, *School of Civil and Environmental Engineering, Georgia Institute of Technology*

Urban Flooding in coastal areas is a combination of complex components such as (1) coastal floods and nuisance driven by high tides, storm surge and sea-level rise; (2) flash floods caused by intense precipitation and surface water runoff; and (3) riverine floods caused by the rise in case of river delta area. Flooding drivers are intensive precipitation, old and aging storm water infrastructure, storm surge (temporal) also influenced by global warming. Due to these drivers and components, comprehensive research is required to analyze urban flooding in coastal areas. However, many flood studies and local projects focused more on flooding driven by fluvial flooding or high storm surges rather than integrated approaches to compound flooding. To achieve and construct a comprehensive analysis of compound flooding, this study developed a multi-scale numerical dynamic model that combined inland urban hydrology, hydraulics in storm water management systems (drainage, pipes, canals, and rivers), tides and sea level rise, as high-resolution GIS digital data sets. This study applied the analysis to a flood prone area of the City of Savannah and its vicinities in Chatham County, GA. The integrated model was constructed on flood modeling software including HEC-RAS for riverine flooding model, SWMM/PCSWMM for urban flooding model. The multi-scale mode aimed to maximize the potential of GIS data to minimize the computational model cost without sacrificing model performance, and generated high-resolution flood risk analysis with flooding driver identification. The study introduced a new flood risk analysis that combines flood depth with flood exposed time. It can be used to locate dynamic "hot spots" (e.g., pipelines, roads, and areas) which are vulnerable to specific types of flooding drivers. Scenario simulations include Hurricane Matthew (2016) and Irma (2017) due to its severity to the study area in terms of precipitation (Matthew) and high storm surge (Irma).

3.2.4. Flood Inundation Study for Chatham County -Savannah Metropolitan Planning Commission

Matthew V Bilskie[1], Felix Santiago-Collazo[1], Scott Pippin[1], Shana Jones[1], Ed DiTommaso[2], Jason Evans[3], Clark Alexander[1], Brian Bledsoe[1]
[1]University of Georgia, [2] GMC Network, [3] Stetson University

As a coastal county in southeastern Georgia, Chatham County includes more than 160 square miles of open water, large areas of coastal wetlands, and extensive riverine lowlands associated with the Savannah and Ogeechee rivers. With a population of more than 289,000, it is the most populous county in Georgia outside of the greater Atlanta metropolitan area – and the county is projected to grow. Rising sea levels, extreme weather events, and increased rainfall all threaten the transportation infrastructure, public health and safety, and quality of life in the MPC and CORE MPO planning areas. Chatham County's transportation system, of course, will be impacted by these flooding events. In this presentation, we will present an update on our coastal flood modeling approaches and their combination with an urban stormwater drainage network model of the greater Savannah region. Using the flood model results (flood inundation extent and depth), a roadway vulnerability index is being developed. Road vulnerability includes the likelihood of the transportation routes being impacted by flood events while also including connections to critical infrastructure. The final product is an interactive online GIS map developed for the Chatham County-Savannah MPC for use in future transportation planning studies.

3.2.5. An Integrated Coastal-Urban Flood Modeling Framework Combining a Numerical Model and Sensor Observations

Youngjun Son[1], Emanuele Di Lorenzo[1], Jian Luo[1], Kyungmin Park[3]
[1]Georgia Institute of Technology, [2] Earth, Environmental, and Planetary Sciences, Brown University, [3] Coastal Sciences Division, Pacific Northwest National Laboratory

As global climate change intensifies, extreme weather events along with sea level rise threaten coastal communities with an increased risk of floods. Particularly, stormwater drainage becomes less effective and even allows saltwater to flow back into uplands during high tides. In addition, the understandings of urban hydrologic heterogeneity are increasingly important in mitigation and adaptation planning for future flood risks. To address these challenges, we have developed an integrated approach for a better understanding of urban flood risks in coastal regions, combining a numerical flood model and a hyper-local sensor network, and applied it to the City of Tybee Island in Georgia. We use hyper-resolution modeling of a distributed hydrologic model (WRF-Hydro) with a stormwater drainage model (SWMM) to represent the hydrologic and hydraulic responses of coastal-urban systems to floods. Moreover, a web-based dashboard for operation flood predictions is built to provide a 3-day forecast of the flood information, which also integrates real-time feeds from traffic and beach cameras to enable rapid evaluations and improvements of the numerical flood model. Furthermore, as a flood model input, we use the observation datasets from an IoT-based hyper-local sensor network (Smart Sea Level Sensors) to consider the spatiotemporal variability of coastal water levels. We apply these flood modeling approaches for past flood events ranging from spring tides to Hurricanes Irma and Dorian. The simulation results with different settings demonstrate the importance of hydrologic and hydraulic modeling in representing compound floods due to high water levels and rainfalls. The integrated framework can be consistently monitored and enhanced through improvements by running the operational prediction system. Potentially, the framework that encompasses a numerical model and sensor observations can be transferred to other coastal communities that are similarly in need of identifying the emerging threat of floods and strengthening future flood resilience.

3.2.6. Identifying Compounding Flood Drivers Along the Savannah River Using Data-Driven and Hybrid Modeling Approaches

Katy Serafin[1], Samantha R. Timmers[1], Robert A. Jane[2], Md M. Rashid[2,3], Thomas Wahl[2], Brianna Tomko[1], Lauren Schmied[4], Christina Lindermer[4]
[1]Department of Geography, University of Florida, [2]Civil, Environmental and Construction Engineering & National Center for Integrated Coastal Research, University of Central Florida, [3]School of Ocean Science and Engineering, University of Southern Mississippi, [4]Federal Emergency Management Agency"

Flooding along rivers can arise through the interaction of multiple processes such as discharge, tides, and storm surge. A compound flood event occurs when flooding is generated by the combination of two or more of these processes. River gauges provide measurements for evaluating past flood events and in this study, we develop a method to identify locations along the Savannah River prone to compound flooding through observations alone. However, river gauges are often spatially limited, and records are short, restricting the observed combinations of coastal water level and river discharge. We overcome this challenge by using a hybrid modeling approach which merges statistical and numerical modeling by first deriving boundary conditions from a statistical model which captures the dependence between flood drivers. The synthetic sample of joint boundary conditions are inputted into the Hydrologic Engineering Center's River Analysis System (HEC-RAS) hydraulic model. This process is made computationally efficient by developing surrogate models, to limit the number of HEC-RAS runs. This approach allows for the evaluation of flood potential from thousands of plausible combinations of coastal water level and river discharge conditions, which may not have been captured in the shorter observational records. When applied to the Savannah River, we find that joint river discharge and coastal water level do not have to be significantly correlated for compound flooding to occur. While flood events at upriver gauges are predominantly river dominated, compound flooding has the potential to occur up to 60 km upriver, significantly farther than indicated by observations alone. We also find that on average the tide contributes approximately 85% of the coastal water level during compound flood events. Finally, while compounding processes do drive flooding, they do not drive the highest magnitude flood events. Overall, the hybrid modeling approach can expand our understanding of where combined river and coastal processes may impact flooding.

Track 3, Session 3: Panel, Infrastructure Bill

Moderated by Brian Bledsoe, *University of Georgia, IRIS*. Panelists: Jan MacKinnon, *Georgia Department of Natural Resources, Wildlife Resources Division,* Stephen Clark, *Georgia Emergency Management and Homeland Security Agency*, Laurie Loftin, *Public Utilities Department, Athens Clarke County*, Brian Watts, *Pew Charitable Trust*, Alan Robertson, *AWR Strategic Consulting,* Danny Johnson, *Metropolitan North Georgia Water Planning District.*

The Bipartisan Infrastructure bill is intended to, "rebuild America's roads, bridges and rails, expand access to clean drinking water, ensure every American has access to high-speed internet, tackle the climate crisis, advance environmental justice, and invest in communities that have too often been left behind" (Source: whitehouse.gov/bipartisan-infrastructure-law). This panel will bring together speakers who can shed light on how these funds will be distributed and put to use within Georgia communities.

Track 3, Session 4: Panel, Advancing Coastal and Ecosystem Resilience for Military Communities through Partnerships

Moderated by Michelle Covi, *University of Georgia, Marine Extension and Georgia Sea Grant*. Panelists: Ben Carswell, *UGA Carl Vinson Institute of Government, Defense Community Resilience Professional*, David Bell, *Jacobs Engineering, Senior Scientist*, Ashby Worley, *The Nature Conservancy, Coastal Climate Adaptation Director,* Ken Bradley, *Georgia Sentinel Landscape Coordinator*.

Climate change and extreme weather threaten military installations, their supporting communities and ecosystems. The Department of Defense (DoD) has responded by developing programs that partner with public and private sectors to support coastal resilience. The panel will discuss efforts University of Georgia, Jacobs Engineering, The Nature Conservancy and Georgia Sentinel Landscape have engaged with to further climate resilience and natural infrastructure that protects installations, communities, and ecosystems. Panelists will address Georgia and southeast initiatives that work across sectors to protect communities and ecosystems. For example, Georgia Sea Grant has established a liaison to advance engagement between DOD, NOAA, and other partners to further regional resilience efforts.

The UGA Defense Community Resilience Program, led by the Carl Vinson Institute of Government, is a partnership harnessing the resources and expertise of the University's Institute for Resilient Infrastructure Systems and the Network for Engineering with Nature to support planning, design, and implementation of resilient infrastructure projects and nature-based solutions in communities that support military installations. In Georgia's Camden County, The Nature Conservancy partnered with UGA, Goodwyn-Mills-Cawood, local governments, Naval Submarine Base Kings Bay, and others to produce a prioritized list of resilience projects for the Camden County Resilience Implementation Workplan. At Tyndall Air Force base in Florida, following devastation from Hurricane Michael, the DoD is rebuilding an "installation of the future" with Jacobs Engineering leading, bringing together a regional working group and coordinating coastal resilience projects with The Nature Conservancy, University of Florida and others. The Georgia Sentinel Landscape is a partnership between DoD, federal agencies, state and local governments and NGOs that work with private landowners to advance conservation practices and maintain working lands around military installations. In Georgia, this includes the entire coastal region. Community and ecosystem resilience is a growing concern that this expansive Sentinel Landscape is addressing with its partners.

Track 3, Session 5: Panel, Natural Infrastructure and Equity Panel

Moderated by Brian Bledsoe, *University of Georgia, IRIS*. Panelists: Gabriela Langhorn, Haley Selsor, Sechindra Vallury, Marshall Shepherd, *University of Georgia*.

Natural infrastructure has a role to play in helping to address historic inequities in Georgia communities. This panel will highlight the ways in which natural infrastructure can protect vulnerable populations and build resilience, as well as explore the complex ways that infrastructure and water resource decisions impact equity.

Track 3, Session 6: Coastal Natural Infrastructure

3.6.1. Coastal Sediment Budgeting to Match Sediment Supplies, Dredging volumes, and Natural Infrastructure Enhancement Needs for Sea-Level Rise Adaptation

Caleb Sytsma[1], Rhett Jackson[2], Mark Risse[2], Margaret Kurth[1], Clark Alexander[1], Matthew V. Bilskie[1], Oscar Villegas[1], Ellis Kaladjian[1]
[1]*Army Corps of Engineers, Engineer Research and Development Center (USACE ERDC),* [2] *University of Georgia*

Sediment has been called the currency of coastal resilience; material that is dredged to maintain the navigability of ports and waterways can be strategically placed to create natural infrastructure, such as a beaches, dunes, and marshes. However, efficient use of sediment at a regional scale requires data on the volume, grain size, and contamination status of sediment sources in addition to the volume and grain size needs of potential natural infrastructure projects. Using the Savannah District of the United States Army Corps of Engineers as a case study on how to match the supply and demand of sediment, we are developing a sediment budget that includes river loads, annual dredging quantities, sediment stored in containment facilities, offshore sand deposits, and net wave and current transport. Expected regional sediment volume needs for sea level rise adaptation, like those required for planned dune (re)construction, beach renourishment, sills, and thin layer placement projects, will also be compiled and included in the budget. We will review the uncertainties in the budget and evaluate the long-term sustainability of coastal natural infrastructure enhancement with respect to sediment needs and availability.

3.6.2. Economic Value of Green Infrastructure Investments on the Georgia Coast

Craig Landry, Nicholas Bradley, Jon Calabria,
University of Georgia

The City of Tybee Island was the first community in Georgia to create a municipal sea level rise plan (2016), assessing exposure to sea level rise and flooding over the next 50 years, examining vulnerability of existing infrastructure, and developing recommendations for immediate and long-term adaptation actions, primarily on the oceanfront. The Georgia coast was adversely affected by back-to-back 100-year storm events: Hurricanes Matthew (2016) and Irma (2017) and Hurricanes Michael and Florence in 2018. These hurricanes revealed additional vulnerabilities along the back side of the island, prompting the local government to seek inputs on climate risk management along the tidal marshes of the Back River. Using survey data from the Coastal Empire region of Georgia (Chatham, Bryan, and Liberty Counties), we assess respondents' perceptions of climate change, sea level rise, and flood & erosion risk; measure expectations of economic, social, and regulatory change; and estimate support and willingness to pay (WTP) for infrastructure approaches to manage climate risk, as well as the value of ecological services provided by infrastructure. A choice experiment is used to assess preferences for green, grey, and hybrid infrastructure investments along water ways in Coastal Empire. An existing policy tool, Special Purpose Local Options Sales Tax (SPLOST), is used as the payment/provision vehicle to enhance realism of the valuation exercise, and the choice experiment is designed to incorporate differential levels of service provision across infrastructure types (e.g., grey is better at flood protection, while green is better at habitat provision). Results indicate that green options are the most preferred, followed by hybrid, and grey designs. Economic value estimates indicate MWTP of $10.18 per household for a one percentage point decrease in severe flooding in low-lying areas (95% C.I.: $1.96 – $19.27) and WTP on the order of $700 per household for discrete improvements in wildlife habitat. Reduction in nuisance flood days is not statistically significant.

3.6.3. Let 'Em Grow: Do Florida Coastal Property Owners Value Mangroves?

Swaty Kajaria, Susana Ferreira, Yukiko Hashida,
University of Georgia

Scientists estimate that mangrove forests around the world reduce property damage by more than $65 billion and protect more than 15 million people per year from coastal flooding. However, because these ecosystem services are not traded in formal markets, they are often ignored in the development planning and decision-making process. Knowing the economic value of the services provided by mangroves and using these values in conservation planning, land management, and climate change adaptation is important to mitigate the risk of over-exploitation and degradation of these resources.

This paper investigates if Florida coastal property owners value the implicit ecological services provided by mangroves; it estimates households' willingness to pay for changes in mangrove forest area along the coast and examines how different attributes of mangrove are capitalized into property values. We use Google Earth Engine to extract Landsat imagery and use machine learning methods to predict the spatiotemporal extent of mangroves for each year for the last 27 years (1994-2020). Property characteristics and sales data for the six counties- Charlotte, Hillsborough, Lee, Manatee, Pinellas, and Sarasota were gathered from their respective county's tax assessor databases. The key variable in the analysis is the proximity of the property to mangroves other than the structural attributes of the property. In exploring this relationship, we also investigate the change stemming from the implementation of the Mangroves Trimming and Preservation Act 1996, to determine the causal effects of the presence of mangroves on housing prices. By improving our understanding of how people perceive and value coastal mangroves, our study will help local agencies implement evidence-based climate change adaptation strategies that account for the benefits of mangrove. It will allow them to develop better informed policies to incentivize the conservation and restoration of the mangroves.

3.6.4. Planning for Resiliency in a Coastal Community
Michael Schmidt, Lisa Sterling, *CDM Smith*

The St. Johns River, the largest river in Florida, flows through Jacksonville to the Atlantic Ocean. CDM Smith has assisted the City of Jacksonville since 1987 in development and updates to their master plan (MSMP) in coordination the St. Johns River Water Management District (SJRWMD) to provide an actionable plan to implement stormwater improvements that allow the city to grow and thrive while continuing to reduce the impacts of a changing climate to the residents and the economy. The City conducted updates to their MSMP in 2007 to 2011 including a Cooperative Technical Partner (CTP) FEMA Flood Insurance Rate Map (FIRM) update with SJRWMD. The MSMP and updates considered an 800 sq mi study area with dynamic USEPA SWMMs and evaluated combined rainfall and tidal flooding to accurately define flooding and solutions for existing and future land use, but not potential future climate conditions. Over the past 35 years, the City has used the MSMP to develop and implement more than $200 million of capital improvement projects through several bond initiatives, Brownfields flooding, public-private and public-public partnerships, and the stormwater utility. Recently, the City updated its models to evaluate the resiliency and future climate flood risk and updated the MSMP to protect public safety, critical assets and environmental resources for year 2040, 2070, and 2100 planning horizons. The models were also refined for increased tailwater elevations of 5.5 feet NAVD at the St Johns River, and 21.5 inches of rain in 24-hours . Floodplain mapping accompanied the modeling effort to derive asset-specific depths for the scenarios evaluated. The future flood risk scenarios are being used to guide the City's Resilience Strategy. Planning for the future allows the infrastructure we build today to be more capable of serving the residents of tomorrow.

3.6.5. No talk slated.

3.6.6. No talk slated.

TRACK FOUR

Track 4, Session 1: Panel, The Importance of State and Regional Water Planning and What Lies Ahead

Moderated by Danny Johnson, *Manager, Metropolitan North Georgia Water Planning District*. Panelists: Jennifer Welte, *Assistant Branch Chief, Georgia Environmental Protection Division,* Katherine Zitsch, *Director, Metropolitan North Georgia Water Planning District*, Mark Masters, *Director, Water Policy Center, Albany State University*.

This panel discussion will look back at the accomplishments in state and regional water planning over the last two decades. The panelists will provide an overview of significant accomplishments and how they have benefited the state and its regions to address the challenges of the past and prepare it for future growth and resiliency. From water conservation efforts in the Metropolitan North Georgia Water Planning District to groundwater policy in south and coastal Georgia, the audience will gain an understanding of how stakeholder and science based planning initiatives have benefited the state and prepared it for the future.

Track 4, Session 2: Managing Forests to Increase Water Supplies

4.2.1. Managing Forests to Increase Water Supplies: A Review of Concepts and Case Studies
Steven Brantley and Stephen W. Golladay, Jones Center at Ichauway

The provisioning of clean water is among the most critical ecosystem services. While forest cover generally benefits water quality and helps regulate flood risks, forest evapotranspiration (ET) can exceed desirable levels. High forest ET may reduce streamflow, deplete groundwater, and reduce wetland hydroperiod, with potential adverse effects for water supplies and for aquatic ecosystems. These effects are likely to worsen as climate warming increases ET. But forests can also be managed to use less water, increasing water yield—the difference between rainfall and evapotranspiration. Managing forests to maintain or increase water yield can protect human water supplies and support conservation of aquatic and semi-aquatic ecosystems including streams, rivers, and wetlands. Managing forests to increase water supplies is not a new idea with decades of research demonstrating the link between forest management and water yield. This presentation will summarize existing knowledge about links between forest management and water yield, and serve as an introduction to the special session on managing forests to improve water supplies. We will highlight key studies that demonstrate the effects of forest management on forest water budgets, with a specific emphasis on increasing streamflow, and discuss potential pitfalls in water-centric forest management.

4.2.2. Understanding the Complex Effects of Forest Management on Water Budgets: A Case Study Quantifying Water Budget Components in Longleaf Pine Woodlands

Stribling O. Stuber, Steven T. Brantley, Dakota L. Holder, R. Scott Taylor, *The Jones Center at Ichauway*

The question of managing forests for water yield is often presented simply: manage for lower basal area and water yield will go up; manage for higher basal area and water yield will go down. However, in forests with a dense herbaceous ground cover, this basal area-based generalization overlooks important forest structure variables. Throughout the southeast, frequent prescribed fire is a widely used and effective management tool for maintaining lower basal area, and it is critical to maintaining the open canopy and abundant, diverse ground cover of the longleaf pine ecosystem. We examined the effects of prescribed fire on the water budget of longleaf pine woodlands by comparing water budget components of stands of frequently burned longleaf to stands excluded from fire for ~20 years. Stands occurred across a gradient of soil moisture, thus water budgets were also evaluated within the context of site type. To estimate total stand water use, we separated the water budget into discrete components based on processes (evaporation or transpiration) and forest canopy level (overstory, midstory, understory, and ground cover) and measured or modeled water use for each. In both wet and dry sites, forest structure differed as expected: fire-excluded stands had sparser ground cover and greater understory and midstory basal and leaf area compared to frequently burned stands. At the dry site, these structural differences corresponded with lower water use in frequently burned stands. At the wet site, however, the frequently burned sites used more water than fire-excluded sites. This result was partly due to the substantial contribution of the dense ground cover layer to total stand water use through transpiration and physical interception of rainfall. These results emphasize the importance of considering site characteristics, all components of the water budget, and the density of all canopy layers when planning water-centric forest management.

4.2.3. Longleaf Pine Forest Restoration Increases Geographically Isolated Wetland (GIW) Hydroperiod in Southwestern Georgia

S. W. Golladay, B.A. Clayton, S.T. Brantley, *Jones Center at Ichauway*

Geographically isolated wetlands (GIWs) are well known as “hotspots” for biodiversity and other ecosystem services, making their value on landscapes disproportionate to the area they occupy. Regular cycles of inundation and drying makes hydrology a primary controlling variable for sustaining GIW functions. Many GIWs are degraded yet relatively little work has focused water-centric forest management as a way of sustaining, or restoring, GIW structure and function. We present a case study of longleaf pine forest restoration, by hardwood removal, on the characteristics of wetland hydroperiod over 10 years. Our study wetland is 0.89 ha with a catchment area of 31.2 ha (31.250 N, 84.495 W). Beginning in 2006, continuous water level and climate data were recorded in the wetland and adjacent well transects across the wetland catchment. In autumn 2009, hardwoods were removed or deadened resulting in a 37% reduction in basal area. Hydrologic responses were measured through 2016 by examining pre- and post-removal water levels, water yield-ecosystem (WYe), and standardized recession rates (RRstd). Generally, wetland hydroperiods began in December and ended in May but varied with rainfall pattern and amount. Hardwood removal increased WYe and decreased RRstd causing greater catchment water availability as reflected in water levels. Hardwood removal affected both the ascending and recessing limbs of wetland hydroperiods, substantially increasing the availability of ponded water in the wetland. Our results show that forest management activities can be used to reduce forest water demand and enhance conditions in associated GIWS. Our study was a management case study, limited in scope but conducted in a realistic operational setting. However, the results have implications at both the local scale, i.e., managing critical aquatic habitat for wildlife populations, and at a regional scale, i.e., providing support for landscape scale connectivity and water yields.

4.2.4. Simulating Hydrologic Responses of Longleaf Pine (Pinus palustris) Restoration Across Southeastern U.S. River Basins

Seth Younger[1], Steven T. Brantley[1], Jeffery B. Cannon[1], Steve W. Golladay[1], Chambers English[2]
[1]Jones Center at Ichauway, [2]University of Georgia Warnell School of Forestry & Natural Resources

Pine forests of the southeastern U.S. are economically and environmentally important. Plantation species including loblolly pine (Pinus taeda) and slash pine (Pinus elliottii) have replaced the historically dominant longleaf pine (Pinus palustris) woodlands due to their higher productivity. Along with increased productivity comes increased water use, which exacerbates water scarcity during growing season droughts. Longleaf pine restoration can help reduce growing season water use and provide habitat that supports high biodiversity and multiple endangered species. Restoration of longleaf pine ecosystems is increasingly considered in climate adaptive silviculture and could help manage water resources in warmer and drier future climates. Forests have the highest annual evapotranspiration among land uses yet also infiltrate and store more water to support streamflow. Longleaf ecosystems with lower leaf area, and stomatal behavior adapted for drought tolerance have lower mean annual evapotranspiration and can supply more streamflow per unit precipitation, especially during droughts. Previous hydrologic modeling of longleaf pine restoration in the Ichauwaynochaway Creek watershed with the Soil and Water Assessment Tool (SWAT) indicates the potential to increase mean monthly stream flow and low stream flows. We extend this work to larger watersheds across the southeast including the Ogeechee, Escambia, and Leaf Rivers. Our goal is to quantify the potential for longleaf restoration to increase mean monthly streamflow and low flows across the regional precipitation gradient. Initial SWAT model simulations restoring upland forests to longleaf pine indicate that restoration can increase mean monthly streamflow at the watershed outlet by up to 30% over baseline conditions. Potential for absolute increases in streamflow increase with annual precipitation, which can inform the amount of restoration required to meet specific streamflow increase objectives. Future work will combine hydrologic and management information to prioritize longleaf pine placement across the region.

4.2.5. Forest Management for Water Yield: Assessing the Barriers and Impacts of Privately-Owned Open Pine Woodlands in the Southeastern U.S.

Chambers English[1,2], Seth E. Younger[2], Jeffery B. Cannon [2], Steven T. Brantley[2], Daniel Markewitz [1], Puneet Dwivedi[1]
[1] Warnell School of Forestry and Natural Resources, University of Georgia, [2] The Jones Center at Ichauway

In the Southeastern United States, freshwater resources are being strained by increasing development, population growth, and the expansion of agricultural irrigation. Land restoration to low density, fire maintained longleaf pine savannas and woodlands may provide distinct ecosystem service advantages to mitigate flows for downstream ecosystems while reversing regional losses in biodiversity. We analyze economic and hydrologic impacts of longleaf pine restoration scenarios against other common land uses in the coastal plain of Georgia, identifying the financial barriers and water use impacts of alternate forest management regimes. Longleaf pine restoration shows the greatest increase in water yield per acre at 86% over baseline timber production scenarios but at a lower timber value return. Low density restoration of existing loblolly pine plantations may offer a more cost-efficient, immediate alternative that still improves water yields by 55%. Current government programs aimed at restoring native habitats on private lands increase economic returns but lack sufficient incentives needed to meet or exceed baseline forest income levels by \$47-\$150 ha-1 annually for longleaf savanna restoration. In the future, the emerging ecosystem service market in Georgia may steer difficult decisions about potentially competing values of carbon storage, water yield, and native habitat restoration.

4.2.6. Exploring the impact of Sustainable Forestry Initiative Fiber Sourcing Standard on water quality in Georgia, United States

Catherine Cooper, Parag Kadam, C. Rhett Jackson, Gary Hawkins, Puneet Dwivedi, *University of Georgia*

Forest certification programs are ensuring the sustainable management of existing forestlands to ensure the continuous flow of ecosystem services, including roundwood. The Sustainable Forestry Initiative's Fiber Sourcing Standard (SFI-FSS) allows certified wood processing mills to source from certified and non-certified stands based on specific requirements, an important program in Georgia, where forest certification is prohibitively expensive for the majority of forestland owners. Based on the need to protect drinking water quality and the focus of SFI-FSS on Forestry Best Management Practices (BMPs) on water quality protection, we studied the influence of increased cover of SFI-FFS certified mill wood baskets on water quality within a watershed. Suspended sediment concentration (SSC) and monthly and daily discharge data from 31 USGS monitoring stations in Georgia were utilized to explore this relationship across multiple watersheds. Crop and forest cover percent, rainfall-runoff erosivity (R Factor), reservoir presence in the AOI, and fixed-effect variables were also included as independent variables. A significant relationship between the independent variables and water quality was identified for both a single year of water quality data ($R2 = 0.46$) and three years of data ($R2 = 0.48$). An inverse relationship was identified between the SFI-FSS wood basket cover and water quality, indicating a reduction in SSC and discharge with an increase in SFI-FSS certified wood baskets, though it was only statistically significant for the single year of data. Overall, this relationship indicates watershed level water quality could be improved through the SFI-FSS certification program, providing a potential avenue to improve water quality in the face of increasing deforestation.

4.2.7. Designing Watersheds for Integrated Development (DWID): Combining Hydrological and Economic Modeling for Optimizing Land Use Change to Meet Water Quality Regulations

Puneet Dwivedi[1], Ranjit Bawa[1], Nahal Hoghooghi[1], Latif Kalin[2], Yu-Kai Huang[1]
[1]*University of Georgia,* [2] *College of Forestry, Wildlife and Environment, Auburn University*

By combining information on nutrient output from the Soil & Water Assessment Tool (SWAT) and secondary data on local profits from different crop types, we devise a profit maximization problem subject to dynamic water quality constraints, which become gradually more restrictive over time. The solution aims to detect the optimal allocation of land parcels by crop type that maximizes the total net present value of landowner profits throughout the watershed. Over a nine-year time span, our model construct is applied to the Little River Experimental Watershed (LREW) in South Georgia. Water quality constraints involve the landowner adhering to specific permittable limits on numeric nutrient criteria recorded at the watershed outlet under various scenarios, including i) NO3–N constraints, ii) total phosphorus (P) constraints, and iii) concurrent NO3–N and P constraints. In the most extreme case, a reduction in aggregate profits of $24.1 million and $8.1 million was observed for combined NO3–N and P constraints relative to commensurate solo constraints on NO3–N and P, respectively. The Designing Watersheds for Integrated Development (DWID) model could support policymaking for ascertaining trade-offs between economics and water quality channelized through direct and indirect land use change considering environmental regulations in Georgia and beyond.

Track 4, Session 3: Climate & Hydrology I

4.3.1. Historical Climate Trends in Georgia

Shivani Chougule, Husayn El Sharif, and Aris P. Georgakakos, *Georgia Tech, Georgia Water Resources Institute*

Climate variability and trends are important for Georgia's agriculture and the management of water resources. According to the EPA (US EPA, 2016), while Georgia has warmed less than most of the United States during the past century, over the next few decades the state is expected to become warmer and experience more severe floods and droughts. In this study, we assess the Georgia climate trends from 1980s to the present-day, using data from the Climatic Research Unit (CRU) gridded (~ 50x50 km) time series data (Harris et al., 2020). Assessments are performed for the monthly average minimum daily temperature (TMN), monthly average daily temperature (TMP), monthly average maximum daily temperature (TMX), monthly potential evapotranspiration (PET), monthly precipitation (PRE), and the difference between monthly precipitation and potential evapotranspiration (PRE - PET). This study focuses on state-wide climatic trends, and for this reason, all gridded variable data are first averaged over the entire state. Moreover, to identify trends at different time resolutions, the state-wide data are analyzed at monthly, annual, bi-annual, and four-year time scales. There has been a clear rising trend in state-wide average daily minimum, mean, and maximum temperatures over the last 10 to 15 years. Comparing the pre- and post-2010 historical periods, these temperature increases equal or exceed 1.5 oC (or 2.7 oF) for all three variables. Furthermore, the 1-, 2-, and 4-year rolling average sequences indicate that the interval (in years) during which each temperature variable exceeds a specific threshold has also been rising sharply. For example, prior to 2010, Georgia's 4-yr average maximum temperature only slightly exceeded 18 oC (64.6 oF) during 1990–1993 (3 yrs), 2001 (1 yr), and 2006–2007 (2 yrs). By contrast, post 2010, Georgia's 4-yr average maximum temperature has exceeded 18 oC continuously for more than 12 years. The rising temperature trends are expected to have important implications for agriculture, hydrology, water resources management, human health, and other socio-economic sectors.

A similar rising trend is observed for potential evapotranspiration (PET), which denotes the maximum water amount abstracted from the land by the atmosphere (Figure 4). All moving average sequences plotted in this figure show the increasing trend indicate an increase in the duration of higher potential evapotranspiration (Figure 4). In particular, the 4-yr moving average plot shows that pre-2010, the average PET was approximately 108 mm/month (~ 4.25 in/month) and attained a maximum of 113.5 mm/month (4.47 in/month). Post-2010, however, the average PET has reached 113.5 mm/month (4.47 in/month), has continuously exceeded the pre-2010 average (of 108 mm/month), and has attained a new maximum of 117 mm/month (4.6 in/month). Depending on precipitation changes (see below), these PET trends may have adverse impacts for Georgia's agriculture, hydrology (surface and subsurface), and water resources management, as under a no-change precipitation scenario, they imply a growing water supply deficit. Precipitation is more variable (over all time scales) than temperature and PET, and its trends are more difficult to ascertain. The plots indicate that heavy (maximum) precipitation appears to be increasing, but average precipitation appears to remain stable or increase slightly. Thus, a key question is whether the precipitation trends counteract those of the PET.

In the last decade, the difference (PRE-PET) exhibits a pattern similar to that of the 1987-1997 historical period. They also show that the period 1997-2013 was unprecedented in deficit (PRE-PET < 0) persistence and severity. Thus, the data presented here do not yet suggest a statistically conclusive answer to the above question. If, however, the Georgia climate in the next 10 years repeats the 1997-2013 pattern, this would suggest a clear climatic shift toward extended and deep deficits. We also note that part of the difficulty in reaching a conclusive answer to the previous question is that the quantity PRE-PET is not a suitable metric for assessing water cycle changes. Specifically, the previous analysis focuses on average values of PRE and PET and ignores their distinctly different variability over finer time scales. A conclusive answer may be obtained by explicitly incorporating the underlying hydrologic processes in the water cycle and assessing the shifts in soil moisture, streamflow, and surface and subsurface water storage. Such a hydrologic assessment is currently on-going for different hydrologic basins at the Georgia Water Resources Institute (GWRI).

Lastly, the assessment presented in this article pertains to climatic averages for the entire state. However, Georgia's climate exhibits noteworthy differences at least over three climatic regions, including the Blue Ridge Mountain region in the north, the Piedmont plateau in the middle, and the coastal region in the south. Another on-going effort at GWRI is to assess the observed climatic shifts in each of these regions, quantify the most likely climatic projections, and assess their water resources implications for the state's economy and environment. Acknowledgements: this study was sponsored by the Georgia Water Resources Institute at Georgia Tech.

4.3.2. Future Climate Trends in Georgia

Husayn El Sharif and Aris Georgakakos, *Georgia Tech, Georgia Water Resources Institute*

According to the US EPA (2016), Georgia's climate is expected to usher in warmer temperatures and more severe floods and droughts in the coming years. Such changes can have critical impacts for the State's environment and economy, but the extent and severity of these impacts are still debated. In a separate article of this conference, the Georgia Water Resources Institute (GWRI) provided evidence that significant climatic shifts are clearly detectable in the State's historical data of temperature, precipitation, and potential evapotranspiration (Chougule et al., 2023). In this study, we analyze the latest climate projections from 16 Global Circulation Models (GCMs) to assess whether the historical climate trends are likely to persist, intensify, or subside in the coming decades.

Our analysis of the future climate focuses on the monthly daily average temperature (TMP), monthly potential evapotranspiration (PET), monthly precipitation (PRE), and the difference between monthly precipitation and potential evapotranspiration (PRE - PET) projected to the end of the century under the Shared Socioeconomic Pathway 5 (SSP 5) fossil fuel emissions scenario (Nakicenovic et al., 2014). The study assesses the climatic trends over three climatic Georgia regions: the Blue Ridge Mountain region in the north, the

Piedmont plateau in the middle, and the coastal region in the south. Results are only presented for the Piedmont, but the identified trends are fairly similar for the Blue Ridge Mountain and the coastal regions. The GCM projections are analyzed at monthly, annual, bi-annual, and four-year time scales.

Systematic comparisons of the GCM-simulated climatic data for 1987–2014 versus the historical observations of the same period (Harris et al., 2020; Climatic Research Unit, CRU, gridded data upscaled to the GCM spatial resolution) indicate that all GCMs contain significant biases that must be removed before any analysis of future climate trends can be undertaken. Bias correction is carried out via a new bias correction approach named Joint Variable Bias Correction (JVBC; Georgakakos and El Sharif, 2023, El Sharif and Georgakakos, 2023), designed to remove the simultaneous biases of statistically correlated climatic fields.

All GCMs project rising temperature trends in the Piedmont region. Furthermore, the 1-, 2-, and 4-year rolling average sequences indicate that the interval (in years) during which temperatures exceed a specific threshold will rise sharply. For example, during the period from the 1980s to present, the 4-yr average temperature in the Piedmont region never exceeded 18 oC (64.6 oF). By contrast, all bias-corrected GCM projections indicate that beyond 2055, the region's 4-yr average temperatures will always exceed 18 oC. The rising temperature trends are expected to have important implications for agriculture, hydrology, water resources management, human health, and other socio-economic sectors.

Precipitation is more variable (over all time scales) than temperature and PET, and its trends are more difficult to ascertain. However, the plots clearly indicate that heavy (maximum) precipitation is projected to increase considerably, while average precipitation is expected to increase at a slower pace.

On the other hand, the Piedmont PET (Figure 5) is expected to rise sharply and outpace precipitation by 2040. After 2040, the long-term difference between precipitation and PET (PRE - PET) is expected to exhibit growing deficits, more severe than any deficits experienced in the 1987–2014 historical period. This ominous trend implies adverse impacts for Georgia's agriculture, hydrology (surface and subsurface), and water resources management. Bias-corrected climatic projections and similar assessments are currently been developed for all southeast river basins. GWRI plans to make this data publicly available through its website to facilitate detailed environmental and socio-economic impact studies. Acknowledgements: this study was sponsored by the Georgia Water Resources Institute at Georgia Tech.

4.3.3. Estimating Extreme Rainfall Intensification, Current Science and Practical Guidance

Mark Maimone, *CDM Smith*

Scientists estimate that mangrove forests around the world reduce property damage by more than $65 billion and protect more than 15 million people per year from coastal flooding. However, because these ecosystem services are not traded in formal markets, they are often ignored in the development planning and decision-making process. Knowing the economic value of the services provided by mangroves and using these values in conservation planning, land management, and climate change adaptation is important to mitigate the risk of over-exploitation and degradation of these resources.
This paper investigates if Florida coastal property owners value the implicit ecological services provided by mangroves; it estimates households' willingness to pay for changes in mangrove forest area along the coast and examines how different attributes of mangrove are capitalized into property values. We use Google Earth Engine to extract Landsat imagery and use machine learning methods to predict the spatiotemporal extent of mangroves for each year for the last 27 years (1994-2020). Property characteristics and sales data for the six counties- Charlotte, Hillsborough, Lee, Manatee, Pinellas, and Sarasota were gathered from their respective county's tax assessor databases. The key variable in the analysis is the proximity of the property to mangroves other than the structural attributes of the property. In exploring this relationship, we also investigate the change stemming from the implementation of the Mangroves Trimming and Preservation Act 1996, to determine the causal effects of the presence of mangroves on housing prices. By improving our understanding of how people perceive and value coastal mangroves, our study will help local agencies implement evidence-based climate change adaptation strategies that account for the benefits of mangrove. It will allow them to develop better informed policies to incentivize the conservation and restoration of the mangroves.

4.3.4. Temporal Variability of Water Availability in Georgia Using the Budkyo Framework and the USGS National Hydrologic Model

Jacob LaFontaine, *U.S. Geological Survey*

Quantifying the timing and volume of available water for human and ecological uses can assist resource management planning utilizing annual and seasonal classifications of water- and energy-limiting conditions and their effects on watershed hydrologic response, including climatic events such as droughts and exceptionally wet periods. The Budyko framework has historically been used to classify watersheds along the water-energy-limited continuum using long-term averages of annual precipitation, potential evapotranspiration, and actual evapotranspiration; actual evapotranspiration generally is computed as the difference between long-term average annual precipitation and streamflow. In this context, watersheds with more available precipitation than evaporative demand would be considered energy limited with more water available for recharge, storage, and runoff; while watersheds with more evaporative demand than available precipitation would be considered water limited with less water available for recharge, storage, and runoff. The availability of process-based hydrologic modeling tools such as the U.S. Geological Survey National Hydrologic Model (NHM) application of the Precipitation-Runoff Modeling System (PRMS) alleviate the need to assume negligible storage change (a typical assumption when using the Budyko framework) because these models compute a closed water budget. This approach can help to enhance the predictive capability of the Budyko framework to examine watershed behavior. Daily time step outputs of precipitation, potential evapotranspiration, actual evapotranspiration, and streamflow from hydrologic simulations using the NHM-PRMS for the period 1982 to 2021 are used to compute and analyze water- and energy-limiting conditions according to the Budyko framework for watersheds across Georgia at annual, seasonal, and climatic-event time scales. A quantification of the degree of variability in these classifications across varying time scales may improve the assessment of risk for water resource management decisions.

4.3.5. Evaluation of Low Flow Patterns Across Georgia, in the Context of Water Balance, Land Use, and Geologic Factors

Katie Price[1], Cody Hale[1], J.P. Gannon[2], David K. Huff[1], C. Rhett Jackson[3]
[1] Nutter & Associates, Inc., [2] Virginia Tech FREC, [3]UGA Warnell School of Forestry and Natural Resources

Streams and rivers in Georgia exhibit a wide range of flow patterns, from gradually changing, low-variability conditions to extremely wide ranging or flashy systems whose flows span many orders of magnitude. In addition to anthropogenic causes, this diversity results from hydroclimatological gradients interacting with geological, physiographic, and ecological factors that vary substantially across the state. This complexity presents challenges to researchers, practitioners, and regulators who seek cross-cutting strategies that apply to all parts of Georgia. The goal of this ongoing study is to use a combination of visualization and statistical approaches to facilitate understanding of flow variability across the state. This presentation emphasizes low flow metrics (e.g., baseflow index and 7Q10), as well as metrics targeting flow variability (e.g., flashiness and volatility). All active USGS gaging stations in Georgia were screened for >90% complete daily records over the past 15 years (for most metrics) or the past 30 years (for 7Q10-based metrics). Stations near reservoirs or in tidal zones were excluded. A total of 167 stations with 15-year records were identified meeting all criteria (68 stations with 30-year records). Adjacency of gaging sites to impervious areas, mining/industrial activity, or irrigation was considered during analyses. Flow metrics were evaluated with respect to watershed land cover, water balance metrics, geology, and existing multi-factor categories such as physiography and ecoregion. Preliminary results indicate that proportion of low flow to total flow is highest at stations located in aquifer recharge areas and in fault zones of crystalline rocks. As expected, the lowest extreme values are found in urban watersheds and where high evapotranspiration rates coincide with high irrigation rates. In general, these results show that no single factor explains state-wide patterns of flow variability, but anthropogenic factors, seasonal water balance, and connectivity between aquifers and surface waters collectively explain many observed patterns.

4.3.6. Linking Streamflow Trends With Land Cover Change in a Southern US Water Tower

Alexander Miele and Yang Shao, *Virginia Tech*

Characterizing streamflow trends is important for water resources management and understanding environmental change. Streamflow conditions, and trends thereof, are critical drivers of all aspects of stream geomorphology, sediment and nutrient transport, and ecology. Using the non-parametric Mann-Kendall test, we analyzed annual streamflow trends from 1996 to 2021 for the Southern

Appalachian region. The forested highlands receive high amounts of rain and act as a "water tower" for the surrounding lowland area, both of which have experienced higher than average population growth and urban development. For a total of 178 available streamflow gages, we also evaluated land change rates and patterns within the upstream contributing areas. Statistical methods (i.e. generalized linear models) are then used to assess any linkages between land cover change (LUCC) and streamflow trends. With this information, water managers would be aware of which areas are experiencing changes in streamflow amounts from LUCC, and could then apply this in planning and predictions. Our results so far show that 72 drainage areas are experiencing changes in their annual streamflow minimums, maximums, means or variability, with some experiencing changes in multiple characteristics.

Track 4, Session 4: Climate & Hydrology II

4.4.1. No talk slated.

4.4.2. The Importance of Hillslope Landscapes on the Climatic Variability in Recharge and Streamflow Generation in a Forested Headwater Piedmont Catchment, Panola Mountain Research Watershed, Georgia

Brent Aulenbach, Jeffrey W. Riley, *USGS, South Atlantic Water Science Center*

Understanding how climate affects streamflow generation is critical to ensuring sufficient water availability for humans and ecosystems, particularly in the southeastern U.S. which experiences recurring droughts. Long-term observations from the Panola Mountain Research Watershed (PMRW), Georgia, a 41-hectare forested catchment in the hilly Piedmont Province, was used to quantify groundwater recharge from the riparian and hillslope landscapes over a 15-year period. Streamflow at PMRW is sensitive to climate, with annual runoff ratios ranging from 0.13 to 0.50. Hillslope groundwater (GW) recharge, estimated from soil moisture profile dynamics, varied greatly, ranging from 6.6 to 58 cm annually (varying 8.7x between the minimum and maximum). This variability reflects a climate sensitivity of recharge from hillslopes with deep GW tables resulting from high growing-season evapotranspiration rates that dried soils and required sufficient rewetting to reinitiate drainage. The range in annual riparian GW recharge, meanwhile, varies by 1.8x, reflecting the annual variability in precipitation (2.0x) and storm runoff. A water budget calculated that hillslopes accounted for 55% of catchment GW recharge while representing 78% of the catchment area. Streamflow reflects the variability in hillslope recharge—annual and monthly hillslope recharge were strongly correlated with annual and monthly baseflow and (particularly) stormflow—however correlations for riparian recharge versus baseflow and stormflow were substantially weaker. Event stormflow runoff ratios were moderately correlated with maximum event hillslope soil moisture storage, demonstrating the importance of hillslope connectivity in enhancing stormflow generation. Monthly water budgets showed large climate-related variability in storage, which was consistent with changes in observed baseflow. While this variability in storage indicated a climate sensitivity, storage in the deep regolith on the hillslopes at PMRW supported a small but reliable amount of baseflow that provided some resilience to droughts. Accurately quantifying the large climatic variability in hillslope recharge and watershed storage likely will improve predictions of drought impacts.

4.4.3. Changes in Long-term Stream Discharge is Associated with Stream Size and Ecoregion in Georgia, South Carolina and North Carolina, USA

Kelsey Wilbanks and Darold Batzer, *University of Georgia*

Climate change will intensify the water cycle, which will ultimately modify the availability of our water-resources. Historic records can elucidate patterns already caused by climate change and be useful for evaluating overall trends of annual discharge fluctuations. We assessed long-term discharge trends for 200 streams from Georgia, South Carolina, and North Carolina. Discharge (sites with 50 + years) and site data were gathered from USGS. Mann-Kendall analyses were used to assess average annual discharge over time (1883–2020) for each site and statistical trends were grouped into significantly decreasing (negative tau, $p < 0.05$), decreasing trend (negative tau, $p > 0.05$), significantly increasing (positive tau, $p < 0.05$) and increasing trend (positive tau, $p > 0.05$). Trends were mapped using QGIS software to determine spatial patterns. A significant association was found between ecoregion and discharge trends (Pearson's Chi-squared test: X2 = 41.9; df= 15; $p < 0.01$), with the blue ridge containing a larger proportion of increasing trend sites (84 %), and the southern plains containing a larger proportion of decreasing trend sites (54 %) and significantly decreasing sites (14 %). Further, a significant association between stream size and discharge trends (ANOVA: $F_{3,197} = 9.2$, $p < 0.01$) were found with significantly decreasing and decreasing trending sites having larger volume streams and significantly increasing sites having smaller volume streams. Spearman's rank correlation analysis found Kendall for sites (n=200) to be significantly (S = 1773897, $p < 0.01$) different among drainage area (km2), with small streams (14 – 269 km2), averaging the largest, and subsequently decreasing with increasing drainage area. These observed patterns of discharge in the southeastern U.S. could be influenced by numerous factors including, climate, municipal growth, industrial development, agriculture or others, and requires further investigation.

4.4.4. Effects of Impoundments on Selected Flood-Frequency and Daily Mean Streamflow Characteristics in Georgia, South Carolina, and North Carolina

Toby Feaster and Jonanthan Musser, *U.S. Geological Survey*

The U.S. Geological Survey (USGS) has a long history of working cooperatively with the Georgia, South Carolina, and North Carolina Departments of Transportation developing methods for estimating the magnitude and frequency of floods for rural and urban basins that have minimal to no regulation or tidal influence. The USGS is currently working with the DOTs in GA, SC, and NC to update flood-frequency statistics for rural streams at gaged and ungaged locations. As part of that study, flood-frequency statistics were computed at 72 regulated streamgages across the three States. In a companion study with the SCDOT, the USGS is assessing the effects of impoundments on flood-frequency characteristics by comparing annual exceedance probability (AEP) streamflows from pre- and post-regulated (before and after impoundment) periods at 18 USGS long-term streamgages (30 or more years of record). For an assessment of how differences in such statistics can be influenced by period of record and hydrologic conditions captured in those records, which could be considered as natural variability, AEP streamflows at an additional18 long-term USGS streamgages that represent unregulated conditions in those three states were computed and compared for the first and last half of those records. A subset of the 72 regulated streamgages that are located predominately above the Fall Line, also have been used to develop regional regression equations that can be used to estimate flood-frequency statistics at ungaged regulated locations in GA, SC, and NC. This presentation will provide an overview of the results of this cooperative investigation.

4.4.5. Predicting Inundation Dynamics in Small Depressional Wetlands

Jeffery Riley and Charles C. Stillwell, *U.S. Geological Survey, South Atlantic Water Science Center*

Wetland hydroperiod (the duration of inundation) is a key characteristic that controls many wetland functions. Hydroperiod is especially critical for pond breeding amphibians where successful breeding requires wetland inundation to align with breeding phenology and span the period of larval development. In large wetlands, remote sensing products — such as the dynamic surface water extent (DSWE) derived from Landsat — may be useful for quantifying hydroperiods. However, in small wetlands (<0.5 hectares), especially those with forest cover, remote sensing approaches are rarely viable leaving researchers and land managers few options other than in-situ monitoring to obtain information on hydrologic dynamics. The goal of this study was to predict inundation dynamics in small, depressional wetlands using machine learning to extend inference from in-situ monitoring data. A dataset of surface water levels from 59 wetlands in Florida spanning 5-10 years was used to train and validate the machine learning models.

A random forest classifier was used to model wetland inundation dynamics. Water levels were first converted to presence/absence; levels greater than 2-cm were classified as inundated and levels below 2-cm non-inundated. Predictor variables describing wetland morphology and climatic water budgets (precipitation minus potential evapotranspiration) were then used to predict if wetlands were inundated or non-inundated at a daily timestep. We used two metrics — median hydroperiod and proportion of correctly classified days — to evaluate model performance. Median hydroperiod was predicted most accurately for wetlands that were infrequently inundated and least accurately for permanent wetlands. The proportion of inundated days, however, was predicted most accurately in frequently inundated wetlands (97%) followed by permanent (94%) and infrequently inundated (90%) wetlands. These results indicate this modeling approach performed well in this study area and suggests it may have additional applicability in other depressional wetlands systems.

4.4.6. Neotectonic Joints in Southwestern Georgia and Their Potential Effect on Stream-Aquifer Flux

Robin John McDowell, *Georgia State University*

Neotectonic joints in Upper Cretaceous and Cenozoic rocks in the Coastal Plain of southwest Georgia, southeastern Alabama, and northwest Florida indicate a regional change in maximum horizontal stress direction from generally NE-SW in the Georgia and Florida portions of the study area to NW-SE in adjacent Alabama. The change in dominant joint strike in the lower Flint River Basin of Georgia occurs over a distance of approximately 100 km, between NE-SW striking joints in Neogene sandstone of the Tifton Upland area of southwest Georgia to N-S striking joints in Eocene limestone in Ichawaynochaway Creek, to NW-SE striking joints in Eocene limestone exposed in Cohelee Creek near the Chattahoochee River. Regionally, the change in trend occurs almost directly north of the eastward pinch out of the Middle Jurassic Louann Salt offshore Apalachicola Bay, and joints west of Ichawaynochaway Creek trend sub-parallel to the axes of salt anticlines in the Apalachicola Embayment. This implies that extension caused by southwest-directed gravity sliding of post-Jurassic sedimentary rocks on the Louann Salt extends well into southwestern part of Georgia Coastal Plain. Changes in dominant fracture trends across the Lower Flint River Basin could affect the impact of individual or clustered irrigation wells on stream-aquifer flux, depending on which joint domain the wells are in.

Track 4, Session 5: Climate & Hydrology III

4.5.1. Simulation of Groundwater Availability for Three Scenarios and Evaluation of Water Management Strategies for South Carolina River Basins

Gregory Cherry, Matthew D. Petkewich, Andrea H. Hughes, Bruce G. Campbell, Emeritus, *U.S. Geological Survey South Atlantic Water Science Center*

A recently completed groundwater flow model was used to evaluate the effectiveness of implementing multiple water management strategies within the Edisto River Basin, South Carolina. The U.S. Geological Survey, in cooperation with the South Carolina Department of Natural Resources (SCDNR), updated historic water use and recharge rates to simulate groundwater conditions in the coastal plain of South Carolina from pre-development to 2020. The model scenarios simulated future water use to 2070 using (1) recent average pumping conditions (Current Scenario), (2) moderate population and economic growth projections (Moderate Growth Scenario), and (3) high population and economic growth projections (High Growth Scenario).

SCDNR will develop a water supply plan for all eight of South Carolina’s major river basins. The groundwater modeling methodology used for the Edisto River Basin can be applied to the remaining basins that have significant groundwater use, including the Lower Savannah-Salkehatchie River Basin with part of the basin located in Georgia. Recalibration of the existing groundwater model will be considered as an option to ensure current and future water demands in each river basin can be met over a 50-year planning horizon. Recalibration will focus on improving model fit within each river basin by refining the model grid within the individual river basins, confining the model calibration period to historic periods with the best available water-use and water-level data (2001-2021), and improving model run time and pre- and post-processing using FloPy, a package using the programming language Python to create, run, and postprocess MODFLOW-based models. FloPy provides functionality for creating new models as well as working with existing models. This modeling approach has the potential to vastly improve water management strategies in Georgia’s major river basins where groundwater is an important resource.

4.5.2. Saltwater Intrusion in the Floridan Aquifer System Near Downtown Brunswick, Georgia, 2021

Gregory Cherry and Michael D. Hamrick, *U.S. Geological Survey South Atlantic Water Science Center*

For more than 60 years, the U.S. Geological Survey (USGS) has led a cooperative water program with the City of Brunswick, Georgia to assess the effect of groundwater development on saltwater intrusion within the Floridan aquifer system (FAS). In 1959, elevated levels of chloride concentration were detected in wells completed in the Upper Floridan aquifer (UFA) near the southern part of the city. By the early-1960s, a plume of groundwater with chloride concentrations exceeding 250 milligrams per liter had migrated northward toward two major industrial pumping centers. In 1978, data obtained from a 2,720-foot-deep test well, south of Brunswick, indicate the source of saltwater was located below the UFA in the Fernandina permeable zone (FPZ) of the

Lower Floridan aquifer (LFA). During October 2021, water-levels were collected in 48 wells to map the potentiometric surface of the UFA in the Brunswick/Glynn County area. The constructed contours from the potentiometric-surface map of the UFA indicate primary groundwater-flow directions toward major pumping centers in well fields located in the downtown Brunswick area. Prior to development, groundwater-flow directions in the UFA were eastward toward the coast. During October 2021, chloride concentrations were also determined from 50 wells completed in the FAS. Both recent and long-term results from thirty of the wells sampled near the downtown Brunswick area indicate the shape of the chloride plume in the UFA has remained relatively stable over the past 20 years with maximum chloride concentrations exceeding 2,500 milligrams per liter. In addition, five real-time conductance monitoring wells located near the plume boundary serve to detect lateral movement of saltwater. During this period, pumping from the major well fields has controlled local vertical hydraulic-head gradients which allows upward migration of saltwater from the FPZ of the LFA into the upper and lower water-bearing zones of the UFA.

4.5.3. Development of a Southeast Georgia Regional Groundwater Model

Lauryn Falkenstein[1], Brian Landers[1], Todd Rasmussen[1], Adam Milewski [1], C. Brock Woodson[1] , James Renner[2]
[1]University of Georgia, [2]Chemours

Southeastern Georgia contains many valuable natural resources, including heavy minerals, inland and coastal fisheries, natural and commercial forests, agriculture, wildlife, and terrestrial and aquatic ecosystems. We are developing a regional groundwater model to study interactions between resource utilization and the region's hydrologic systems, especially the Satilla River, Okefenokee Swamp, and the coastal aquifers. This project leverages existing monitoring and characterization programs at well sites within the region to understand and predict groundwater flow at both local and regional scales. The project uses a state-of-the-art modeling platform (MODFLOW 8) to assimilate data from federal (USGS, USDA, USDI), state, and private surface and groundwater sources into a numerical framework. This regional groundwater model includes the surficial, Brunswick, and Upper Floridian aquifer systems as well as the upper and middle confining units. This model will be used to estimate impacts of mining on water levels and dispersion of solutes in both groundwater and surface waters with particular focus on solutes potentially entering the Upper Floridian aquifer or flowing towards the Okefenokee National Wildlife Refuge. The intent of model development is that private and public users will utilize it to better manage and protect the water resources of Southeast Georgia.

4.5.4. Groundwater Levels Within the Cretaceous Aquifers in Response to Wetter-Than-Average Precipitation Years, 2018 Through 2021

Gerard Gonthier , *U.S. Geological Survey*

The USGS has been monitoring groundwater levels in the Cretaceous aquifers in Richmond County, Georgia, for Augusta Utilities since 2007 and throughout central Georgia for the Georgia Department of Natural Resources (GA DNR) since at least 1995. Groundwater levels have been declining in most of 10 long-term continuous monitor wells that are open to the Cretaceous aquifers. From 2018 through 2021, precipitation rates in most of central Georgia have been above average, based on data from the National Oceanic and Atmospheric Administration (2023). Associated with these relatively wet conditions, groundwater-level rates of decline in the Cretaceous aquifers in central Georgia have been decreasing or reversing. After wet conditions from 2018 through 2021, rainfall rates during 2022 decreased to more normal values. In wells near the fall line in Richmond County, water levels have been decreasing during 2022 in response to decreased rainfall. Wells that are greater than 10 miles downdip (south-southeast) of the fall line also indicated a potential decline in groundwater levels during 2022. This change in groundwater-levels for wells greater than 10 miles from the fall line is too brief to determine whether it is part of a long-term trend. Apart from precipitation rates, pumping appears to be a primary factor affecting groundwater levels as is evidenced by groundwater-level fluctuations in the continuous monitor wells. National Oceanic and Atmospheric Administration, 2023, National Centers for Environmental Information. Accessed on January 18, 2023 at: https://www.ncdc.noaa.gov/IPS.

4.5.5. Possible Connections Between Regional Tectonic History and Structural Controls on the Groundwater System on St. Catherines Island, Georgia

James S. Reichard, R. Kelly Vance, Jacque L. Kelly, Brian K. Meyer, *Georgia State University*

Hydraulic head and chemistry data from a longitudinal investigation on St. Catherines Island strongly suggest that groundwater moves up from the Lower Floridan aquifer and into the Upper Floridan along vertical faults and or solution collapse features. In addition, head and chemistry data collected from a network of 30 monitoring wells in the surficial aquifer show that unusually large tides cause episodic saltwater intrusion events at discrete locations on the island. Geophysical data collected near the sites of saltwater intrusion reveal the presence of fractures, faults, and sag structures. We hypothesize that prior to modern pumping withdrawals from the Upper Floridan aquifer, artesian groundwater flowed to the surface along regional joint and fault trends in the carbonate system. Solution caverns and collapse features eventually developed along these trends, creating sag structures in the overlying clastic units. Today, large tidal events periodically cause saltwater to move laterally and vertically into the surficial aquifer along these preferred structural pathways. We also hypothesize that the pathways are ultimately related to the recurrent movement of deep-seated Mesozoic basement structures beneath the coastal plain sedimentary sequence. To test our hypotheses, we are installing shallow wells at a new site north of the original study area on St. Catherines Island. Based on topographic and preliminary geophysical data, this site appears to be associated with a solution collapse feature that falls along a suspected Mesozoic fault trend. To document potential saltwater intrusion, new wells will be instrumented with data loggers and sampled periodically for chemical analysis. Finally, well cores taken during drilling combined with ground-penetrating radar and electrical resistivity surveys will be used to examine the subsurface stratigraphy and structure at the new field site.

4.5.6. Surficial Aquifer Analysis at the Mission Mine Site in Georgia

Adam M. Milewski[1], David F. Richards, IV[1], Lea Davidson[1], James F. Renner[2], Steve White[2]
[1]Department of Geology, University of Georgia, [2]The Chemours Company

Responsible mining activities are necessary to help preserve the environment. This preservation requires sound, proactive research aimed at evaluating the impact of mining operations on the properties and behavior of the local hydrogeology, hydrology, and water quality. The goal of this research is to evaluate the impact of mineral sand mining operations on the local surficial aquifer. This is achieved through identifying data needs or gaps, performing a qualitative assessment of the existing groundwater data, development of a data framework system, and a detailed and comprehensive statistical analysis of the existing data to test for any significant trends from mining impacts. As a condition of its Surface Mining Permit, Chemours, Inc. has a hydrologic monitoring program at its Mission Mine site in Georgia. The program array includes monitoring wells installed 20 ft deep into the surficial aquifer in wetlands and uplands in and around the mine. Daily water levels and rainfall have been measured with pressure transducers since about 2013. Additionally, water quality samples are periodically collected from the wells and from surface streams draining from the mine site. Each year, Chemours has compiled hydrographs for each surficial aquifer well that demonstrate the influence of rainfall and nearby mining and reclamation. In particular, the hydrographs demonstrate a temporary drop in the water table of several feet when a nearby mine pit is being dewatered and a rebound of the water table when sand tails are replaced into the pit. A comprehensive groundwater trend analysis is underway using a suite of statistical analysis tests (e.g., ANCOVA, Bartlett, Mann-Kendall, Tukey, among others). This analysis provides insights on the impacts of active mining operations, aquifer recovery, and any geospatial relationships within the area. Preliminary analysis suggests no significant long-term impacts to the surficial aquifer exist; however further analysis is ongoing.

Track 4, Session 6: Advances in Water Resources Modeling, Technology, and Policy

4.6.1. Oconee Joint Regional Sewer Authority (OJRSA) CMOM Implementation

Rasheed Ahmad[1], Chris Eleazer[2], Kyle Lindsay[2]
[1] WK Dickson & Co., Inc. [2]Oconee Joint Regional Sewer Authority (OJRSA)

Due to wet weather capacity restraints resulting in several sanitary sewer overflows over the past few years, the OJRSA (Oconee Joint Regional Sewer Authority) enlisted WK Dickson in January 2021 to develop a Capacity, Management, Operation, and Maintenance (CMOM) program for their wastewater collection system. OJRSA owns and operates the Coneross Creek WWTP located in City of Seneca, SC. The WWTP has a permitted flow of 7.8 million gallons per day (MGD). The facility currently treats an average of 3.14 MGD of flow conveyed from approximately 19,000 residents and 19 permitted industrial users via 9,300 direct and indirect connections. The WWTP serves the municipalities of

Westminster, Walhalla and Seneca, and the Town of West Union, as well as other unincorporated areas of Oconee County. The facility discharges its effluent to Coneross Creek. Along with the treatment plant, OJRSA also owns, operates, and maintains a wastewater conveyance system (WWCS) that includes approximately 56 miles of gravity sewer, 16 pump stations and 14.6 miles of force mains. To best utilize OJRSA's resources, this study is completing the CMOM program through a series of phases over time. Now in the third phase of the project, it is performing a complete CMOM Audit consisting of a financial plan, personnel evaluations, lift station inspection and maintenance, sewer inspection and cleaning, easement/ROW maintenance, I/I evaluations, manhole inspections, and updates to the sewer use and grease ordinance. Before audit, a comprehensive review and assessment of the wastewater collection system was conducted and completed. The results were submitted to the State regulatory agency in a preliminary engineering report (PER). This paper will present the findings of the report.

4.6.2. Advancing Water Technology Innovation Through Communication and Collaboration

Kristan VandenHeuvel, *The Water Tower*

Water is a vital resource for every aspect of life. In Georgia, drivers such as population growth, aging infrastructure, and sustainability are illuminating the need for advancements in technology and policy regarding protecting and maintaining our precious water resources for generations to come. Often referred to as the "invisible industry," the water industry has been traditionally slow to adopt new processes and technology due to reasons such as extended lifespan of equipment, long project life cycles, and lack of resources or trust. These factors exacerbate challenges for novel solutions to be introduced and adopted in our communities. In order to increase uptake of innovative technologies, communication and collaboration across sectors of the water industry are crucial. Breaking down silos between vendors, manufacturers, universities, and end users and building strategic partnerships coupled with live technology demonstrations in real-world scenarios provides an opportunity for advancements in technology to gain momentum. This presentation will highlight several innovative technologies currently being demonstrated at The Water Tower, the new water innovation center in Buford, Georgia, as well as how to engage strategic partners and stakeholders to foster water innovation.

4.6.3. Basin Environmental Assessment Model and Its Application in Regional Water Planning

Wei Zeng[1], Feng Jiang[1], John Clayton[2], Megan Rivera[2],
[1]*Georgia Environmental Protection Division,* [2] *Hazen and Sawyer*

Georgia Environmental Protection Division (EPD), through Hazen and Sawyer, developed Basin Environmental Assessment Model (BEAM) for the purposes of supporting the State's Regional Water Planning effort and informing the regulatory review of surface water withdrawal applications. In the Regional Water Planning context, several examples of resource challenges on water supply side and on the quantitative side of wastewater assimilation challenges are presented and assessed. Potential solutions to these challenges are explored. Additional performance measures have been developed by EPD, its contractors, and Regional Water Planning Councils. A discussion on how these additional measures may affect the planning process is presented.

4.6.4. Towards an illicit discharge and Surface Water Monitoring and Protecting system using cost efficient sensors

Tien Yee[1], Henry Armstrong[1], Alex Campbell[1], Cole Myers[1], Erin Feichtner[2],Trimanda Williams[2], Katharine Horning
[1] *Kennesaw State University,* [2] *Cobb County Water System*

Streams and waterways in Georgia are important to sustain the needs of the growing population. These needs include important daily activities such as drinking, recreation, farming, etc., and hence it is important to protect and monitor them. In Georgia, water quality monitoring is typically conducted quarterly. This leaves the time in between sampling events unmonitored. While mechanisms such as citizen reporting are present, however not all illicit discharge events are reported in a timely manner to reduce the impact on surface water quality. Unreported illicit discharge events such as sewer spills may impact water quality and wildlife living within the water body, consequently rendering the stream impaired for its designated use. This study produced the hardware and interface for an in-situ illicit discharge monitoring system. The proposed system is capable of continuously monitoring water quality for a specified time interval of every ten minutes. Data collected indicated that fluctuations in typical water quality parameters are dependent on the time of the day as well as precipitation events and its pattern is sinusoidal and hence predictable. The same water parameters are less predictable during storm events. The system can potentially be used to monitor water quality to identify illicit discharge in streams of Georgia.

4.6.5. No talk slated.

4.6.6. No talk slated.

TRACK FIVE

Track 5, Session 1: Visual Communication to Aid Resiliency Efforts

5.2.1. Using Landscape Architecture Style Graphics to Communicate about Nature-based Infrastructure
Kelsey Brioch, Jon Calabria, Emily Dolatowski, Eleanor Hair, *University of Georgia*

A series of graphics were developed to demonstrate how conventional infrastructure can be modified to create biodiversity. A collaborative team of landscape architects, engineers and scientists met to identify design modifications. Using landscape architecture style graphics (cross sections, renderings and 3D modeling), these modifications were visualized into a series of graphics demonstrating the designs. Renderings were developed using scaled AutoCAD drawings, 3D modeling and photoshop. The graphics will be available to a variety of disciplines (landscape architects, engineers, and scientists) and used as examples for design. While these disciplines overlap, terminology can vary across professionals. Visuals can play a critical role in collaboration and the design, promotion and implementation of nature-based infrastructure. Future research could measure the impact of these graphics in community engagement or participatory design.

5.2.2. Visual Communication to Aid Resiliency Efforts I
Emily Dolatowski, Kelsey Brioch, Ellie Hair, Jon Calabria, *University of Georgia*

Beneficial use of dredge and Thin Layer Placement are nature-based solutions that are still being trialed and tested in the Southeast as we strive for resilient coastlines. Reusing the surplus of dredge material from the Savannah River would allow a long-term option that is more economical and beneficial for elevating areas and maintaining habitat. In an effort with the Georgia Department of Transportation, analyzing dredge placement suitability began as an alternative to protect Bird Long Island, which is in the mouth of the Savannah River. The process involves a Suitability Analysis to weigh several datasets to find the most feasible locations for dredge placement given the specified criteria. After the Suitability Analysis was created for Bird Long Island, Georgia DOT, the US Army Corps of Engineers Savannah District, and the University of Georgia have continued conversations and efforts to begin the process of beneficially placing dredge in the area. In this portion of the special session, the Suitability Analysis for dredge placement will be briefly outlined. It will also introduce the next steps of this analysis which involves refining the Suitability Analysis that ultimately drives the professional design decisions of where to place dredge material. The discussion will conclude with how this nature-based solution can be communicated to practitioners, the public, and others for increased understanding and the practice and propel the beneficial use of dredge material in the region.

5.2.3. Visual Communication to Aid Resiliency Efforts II
Ellie Hair, Kelsey Brioch, Jon Calabria, Emily Dolatowski, *University of Georgia*

Blueway and Greenway trails connect people to people, and people to nature, which encourages both economic growth and environmental education. Trail planning was used in southwest Georgia to plan connectivity of the neighboring towns in order to vitalize economy, promote human health activity, and increase awareness of natural ecology. ArcGIS was used to map out topographic features, streams and rivers, culturally significant places, historical sites, and recreation sites. The mapping of blueway and greenway trails was achieved through GIS planning, connecting significant sites while following topography and utilizing existing natural and infrastructural features. The result is a trail connectivity network, which connects the towns of southwest Georgia, passing through important natural, historical, and cultural sites. The implementation of this trail network will encourage people to use these trails and better familiarize themselves with exercise, their native environment, their neighboring towns, and cultural and historical stories. Next steps toward implementation will be community outreach to determine community preferences and needs. This trail network will continue to be accomplished through GIS mapping and planning.

5.2.4. No talk slated.

5.2.5. No talk slated.

5.2.6. No talk slated.

Track 5, Session 2: Going Deep: Implementing Field-Based Experiential Learning to Advance Water Science and Policy

5.2.1. Learning the Ropes: Approaches to Providing Support to New Faculty Developing Undergraduate Field-Based Courses

Emily Tarsa, Robin McLachlan, Kimberly Takagi, James Deemy, *College of Coastal Georgia*

Field-based experiential learning in an undergraduate setting has numerous benefits such as reinforcing course concepts, stimulating deeper understanding, and allowing students to apply content in a real-world setting. The benefits of field-based experiential learning can be particularly prominent in natural resources fields which, in practice, require individuals to adapt to unpredictable and complex situations. Despite the benefits of incorporating experiential learning in undergraduate education, new faculty training is often limited to supporting faculty success in a traditional college and classroom setting. Thus, many new faculty members are less prepared to develop, navigate, and implement field-based, experiential learning courses. In this presentation, we will introduce key pillars to incorporate into faculty training programs that offer additional support to new faculty interested in developing field-based courses or introducing a field and/or research component into current undergraduate courses. We will draw on immersive, field-based courses developed by new and senior faculty at the College of Coastal Georgia that span a diverse range of class sizes, natural resource topics, and experiential learning activities (e.g., research, reflection, service-learning). Finally, we conclude with suggestions for quantitatively assessing the ability of new faculty training programs to prepare educators for field-based learning, as well as ideas for overcoming potential barriers in traditional college settings to field-based, experiential learning opportunities for undergraduates.

5.2.2. Curating Geographic Information Systems Curriculum to Analyze Hydrologic and Anthropogenic Effects Within the Apalachicola-Chattahoochee-Flint River Basin

Chelsea Brown, Britney Hall, Lily Heidger, James Deemy, *College of Coastal Georgia*

Geographic Information Systems (GIS) is a mapping system that stores, processes, and analyzes data that can then be used to provide research experiences outside of the classroom. As undergraduate research expands, career-enhancing research experiences are being incorporated earlier and more consistently throughout early collegiate courses. GIS also greatly broadens the spatial scope of undergraduate research and is a key component of water resources education. Traditional field-based courses are an excellent way to prepare students for future careers in science, however, not all areas are feasible to study in person. We highlight how GIS methods were used to synthesize experiences from ENVS 3510: Geographic Information Systems and GEOL 4800: Hydrology and created an authentic research experience on the Apalachicola-Chattahoochee-Flint River Basin. This river system contains three of the fourteen river basins within Georgia and spans over 12 million acres, stretching from North Georgia to the Florida Gulf Coast. It would be highly impractical for undergraduate students to perform a traditional field study that includes the entirety of this river basin without a dedicated multi-week field course. However, using GIS methods and public data, two students were able to investigate and quantify the anthropogenic drivers within the watershed. The primary GIS teaching tool were PowerPoint protocols which provided a step by step guide on how to efficiently use ArcGIS to accomplish a variety of objectives. The curriculum also included traditional methods, such as reading and answering questions from a GIS textbook along with a variety for field exercises in Hydrology to provide concrete experiences. Throughout the concurrent courses, students were able to combine content and skills to produce a substantial authentic research product.

5.2.3. Semester@Skidaway: Bringing Field-Based Marine Science Education to University of Georgia Undergraduates

Clifton Buck, Jay Brandes, Natalie Cohen, Catherine Edwards, Skidaway Institute of Oceanography, Daniel Ohnemus, Rivero-Calle, Clark Alexander, *Skidaway Institute of Oceanography*

The Department of Marine Sciences at the University of Georgia established a domestic field study program at the Skidaway Institute of Oceanography during Fall 2022. Designed as a capstone experience for students in the Ocean Science major, this program provided an immersive learning experience for the participants. Students lived and worked at Skidaway and were provided with opportunities to earn research credits in the laboratories of Skidaway scientists alongside experts in the field and their research staff and graduate students. Thus, participants received a first-hand introduction to the scientific process. Blending classroom instruction on fundamental concepts in marine science with laboratory and field methods courses, the program allowed students to apply what they have learned to data originating from samples that they have collected themselves. Offered courses included Global Biogeochemical Cycles, Oceanography of the South Atlantic Bight, Quantitative Methods in Oceanography, and Field Study in Oceanography and Marine Methods. The highlight of the program is the opportunity to go to sea. As part of a three-credit course, students sailed on two research trips aboard the RV Savannah collecting water column and sediment samples. They analyzed these samples for a variety of biological and chemical parameters and presented their results to their peers and Skidaway faculty and staff. This presentation will provide an overview of the program. We will discuss strengths of the program and opportunities to learn from this initial offering.

5.2.4. An Unexpected Learning Opportunity About the Ethics of Scientific Research and Sampling

Austin Heil and Anne Lindsay, *University of Georgia Marine Extension and Georgia Sea Grant*

The UGA Marine Extension and Georgia Sea Grant promotes marine education using “hands on, feet in” experiential learning for all ages. One of our field-based experiential learning opportunities is an Estuary Trawl, where learners join UGA marine educators aboard the R/V Sea Dawg to sample the brackish rivers near Savannah. As educators, we talk to our learners about local ecosystems, water quality, and the trawling process, to name a few. Then, we talk about the biology and life history of the organisms caught in our trawl. Learners apply their content knowledge and observation skills to make inferences about the organisms caught. On my first trawl as an educator, a student asked me, “Why do you kill the organisms you catch in the trawl?” While we tell learners we have a special permit to collect organisms and many of them will be used to feed fish in our aquarium, the magnitude of what this means is not fully realized until the catch is pulled aboard. And on this day, the catch was large. My response reiterated to the learner about our permit and food for the aquarium. I explained that we keep diligent records of all organisms we catch for scientific purposes. This response was not sufficient. He pressed me, “So, you get to keep all of them just because you count them?” What ensued was an unexpected learning opportunity about the ethics of scientific sampling/research, born from this experiential learning opportunity. A small gathering surrounded me, waiting to hear my response to his question. I used this learning moment to explain to the students that, as scientists, it is important to collect samples to document changes, patterns, and responses in our ecosystems. In this talk, we explain how we approached this unexpected learning opportunity born from our experiential learning program.

5.2.5. Inquiry-based Learning in the Field Designed for Large Non-Major Courses

Robin McLachlan and James Deemy, *College of Coastal Georgia*

Engaging in hands-on experiential learning and reflection prepares students to apply their knowledge in the real world, which is more unpredictable and complex than a traditional classroom. Undergraduate students in natural-science programs commonly receive such opportunities in their upper-level courses where relatively small student-to-faculty ratios allow for a manageable learning experience. However, lower-level courses that are open to non-majors typically do not include a field component due to their large sizes which can become unwieldy in a field setting. In response to student interest in field-based experiential learning, faculty at the College of Coastal Georgia have incorporated field trips into GEOL 1121, an Area D course with a 96-student cap. To facilitate a structured learning experience, field trips occur during lab times when students are split into groups of 24 or less. These trips are inquiry based. For example, after a brief introduction to a local beach, students explore on their own and document what they notice and what they wonder. Observations often include evidence of erosion and human impacts. Students then come back together as a group and discuss what they have learned, answering each other’s questions and proposing new hypotheses. These discussions typically include lessons that were not planned by the instructor and fit a wide range of student interests and career trajectories, such as tourism, business, and finance. Finally, to facilitate reflection and continued application, students share what they learned via social media and/or instant messaging. As a result, students apply theory to real-world settings and incorporate their learning into their social groups and lives beyond the classroom and expertise of the instructor.

5.2.6. Swimming in Data Collection and Analysis From the Field: Successes and Challenges of Course-Based Undergraduate Research

Kimberly K. Takagi, *College of Coastal Georgia*

The Aquatic Ecology (BIOL 3060) and Marine Biology (BIOL 3250) students at the College of Coastal Georgia are tasked with course-based undergraduate research projects that: 1) Are rooted in water quality analyses collected and analyzed in the field, 2) Span the majority of the semester with weekly data collection, and 3) Involve environmental data that are collected by the students and deposited into a class-wide set that can be analyzed based on student-led research questions. The Aquatic Ecology course works with a community partner (Sea Palms West Association) to assess pond/ freshwater wetland ecosystem dynamics within a greenspace that was previously a golf course while the Marine Biology course has set out settling plates to assess larval dynamics as they relate to water quality dynamics in the tidal waterways of Brunswick, St. Simons, and Jekyll Island. In each scenario, students have the opportunity to apply knowledge acquired throughout their undergraduate program to an open-ended research project. This allows students to: 1) Address questions without a "correct," answer, 2) Challenge their understanding of statistical analyses, 3) Practice in-field data collection, and 4) Improve their science communication and writing skills in a final research paper. Previous students in these courses have indicated that improvement in each of these aspects have helped them apply to and obtain jobs, internships, and graduate school positions pre- and post-graduation. This presentation provides an overview of these course-based research experiences with a focus on program strengths, lessons learned, and opportunities to overcome challenges associated with applying course-based research in an undergraduate setting.

Track 5, Session 3: Aquatic Biota I

5.3.1. Investigating Freshwater Mussel Distributions in the Altamaha River Basin in Support of a Candidate Conservation Agreement (CCA)

Matthew Rowe, *Georgia Department of Natural Resources*

The Altamaha River System contains a diverse freshwater mollusk assemblage including five endemic mussels, one of which is federally Endangered, and other rare mollusk species. In 2018, the Georgia Department of Natural Resources entered a Candidate Conservation Agreement with Georgia Power and the US Fish and Wildlife Service to evaluate and monitor populations of rare mollusks in the Altamaha Basin with a focus on Georgia Power generating facilities. In the first four years of the project, four reservoirs and portions of the associated Ocmulgee and Altamaha River were sampled to establish distributions and relative abundances for target species. Timed surveys were conducted using a variety of sampling methods including snorkeling, surface supplied air, and SCUBA diving. To date, the project has observed over 15,000 individual mussels from 15 different species. Both natural and manmade features were found to dictate mussel distribution patterns. One of the rarest species, the Altamaha Spinymussel has not been detected despite surveys at sites where the species was historically present.

5.3.2. High-Volume Filtration Method Improves Environmental DNA Detection of Freshwater Mussels

Anna McKee[1], Katy E. Klymus[2], Yer Lor[3], Marissa Kaminski[3], Tariq Tajjioui[3], Nathan A. Johnson[4], Matt Carroll[5], Chris Goodson[5], Stephen F. Spear[3]
[1]US Geological Survey South Atlantic Water Science Center, [2]U.S. Geological Survey Columbia Environmental Research Center, Columbia, Missouri, [3]U.S. Geological Survey Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, [4]U.S. Geological Survey Wetland and Aquatic Research Center, Gainesville, Florida, [5]Georgia Department of Transportation, Atlanta, Georgia

Numerous studies have demonstrated that environmental DNA (DNA in environmental samples from organismal shedding, excrement, etc.; eDNA) can be used for detecting the presence of aquatic species. However, the ability to detect species that shed low levels of DNA may be limited if sufficient water volumes are not sampled. Freshwater mussels (Unionidae) are a taxon for which the application of eDNA-based surveys could have multiple advantages over traditional methods. However, studies that have tested detection of freshwater mussels with eDNA have had mixed results, potentially because of inadequate sample volumes. To test if increasing the volume of water filtered improves eDNA-based detection of freshwater mussels, we compared detection with eDNA captured from a high-volume filtration method often used to sample for pathogens in aquatic systems (dead-end hollow fiber ultrafiltration, D-HFUF; 50-liters/sample) to detection with eDNA captured from a standard eDNA filtration method (polyethylstyrene filters, PES; 1-liter/sample). eDNA samples were collected from two stream sites in Georgia and one stream site in Missouri with known mussel assemblages and screened with two Unionidae metabarcoding markers (COI and ND1). A total of 19 species were detected in D-HFUF samples, and 11 species were detected in PES samples across the three sites. For all three sites, more mussel species were detected in D-HFUF samples than PES samples both when markers were evaluated separately and when data were combined between markers. Three of the six species on the US Fish and Wildlife Service Threatened and Endangered (T&E) Species list known to occur in the study basins were detected with eDNA. Detection of these T&E species was more consistent between filter replicates and markers for D-HFUF samples than for PES samples. Our results demonstrate that high-volume filtration with D-HFUF may help improve eDNA detection of freshwater mussels when compared to standard eDNA filtration methods.

5.3.3. CSI Warnell: Investigating the Source, Dispersal, and Recruitment of the Weather Loach Using Otolith Microchemistry

Wesley Gerrin, Brendan Amman, Martin Hamel, James Shelton, Peter Hazelton, Brian Shamblin, *University of Georgia Warnell School of Forestry and Natural Resources*

Introductions of non-native fishes have increased in recent years, both in the number of species and their abundance. Invasive species can disrupt ecosystems through direct competition for food and space with native fishes, habitat alteration, and a reduction in biodiversity. Therefore, it may be important to determine the source of introduction and aspects of life history and population dynamics to understand and better manage invasive fishes. The Weather Loach (Misgurnus anguillicaudatus), a common aquarium fish native to eastern Asia, were discovered in Georgia between November 2020 and August 2021. Multiple populations were discovered in tributary streams to the Middle Oconee River and the Ocmulgee River. Therefore, we were interested in determining the source population, dispersal patterns among individuals, and the age structure from samples collected from various locations. We extracted sagittal otoliths from individuals from each sampling location for aging and microchemistry analyses. Microchemistry analysis indicated disjunct populations likely resulting from multiple introductions. The weather loach populations consisted of individuals of varying ages and the majority had natal origin signatures from Georgia river systems, indicating recent captures were produced in the system rather than introduced. These results imply that these introduced population have been present for a number of years and are successfully recruiting. Continued work to understand the impacts these fish will have on native ecosystems is imperative.

5.3.4. Approach of the Loach: Using Genetics to Better Understand a Newly Invasive Species, the Weather Loach (Misgurnus anguillicaudatus), in Georgia

Sarah McNair, Wesley Gerrin, James Shelton, Brian Shamblin, Marty Hamel, Pete Hazleton, *University of Georgia*

The Weather Loach (Misgurnus anguillicaudatus), native to east Asia, is an invasive species that was first documented in Georgia in November 2020 in a tributary of the Oconee River watershed. Sampling in 2022 detected this species in six Oconee tributaries and discovered a new population in the Yellow River watershed. As of December 2022, over 130 individuals have been collected across the Oconee River and Yellow River watersheds. We conducted genetic analyses using mitochondrial sequencing and nuclear microsatellite genotyping to compare with published data as well as to assess population structure among Georgia sites. Variable positions resolved five closely related control region (CR) haplotypes, three of which have been recorded in Japan. Haplotype CR4 represented a Chinese aquaculture strain of unknown origin. All Yellow River individuals shared haplotype CR1, which was absent among Oconee River individuals. Oconee haplotypes were shared among tributaries. Bayesian clustering using eight microsatellite loci identified strong divergence between watersheds. Individuals purchased from two aquarium stores in the Athens area formed a third genetic cluster, suggesting that they are not implicated as a source. No substructure was detected among Oconee tributaries, but groups of Indian Creek individuals formed additional genetic clusters. The genetic data support unrelated introductions of fish from similar lineages into each watershed, followed by dispersal from Indian Creek to downstream Middle

Oconee tributaries. The extent of colonization in each watershed is unclear. Future plans include resampling all sites where the Weather Loach has been detected as well as optimization of an environmental DNA protocol and assay to aid detection efforts for this species.

5.3.5. Gut Content and Stable Isotope Analyses Inform the Management of a Newly Discovered Exotic Species (Misgurnus anguillicaudatus) in Georgia

Adam Musolf, Pete Hazelton, Wes Gerrin, Jay Shelton, Marty Hamil, Brain Shamblin, *University of Georgia*

The Weather Loach (Misgurnus anguillicaudatus) was first discovered in Georgia in November of 2020 below Puritan Mill Dam on McNutt Creek, a tributary of the Middle Oconee River in Athens. The initial collection was 15 individuals. In August of 2021, another 10 Weather Loaches were found almost 40 river miles away in Indian Creek, another tributary of the Middle Oconee. During the summer of 2022, Weather Loaches were discovered in 5 additional tributaries of the Middle Oconee River, with each tributary having 1-3 individual Weather Loaches. Additionally, a new population was discovered in Sweetwater Creek, a tributary of the Ocmulgee River in Gwinnett County. To better understand how these fish interact with native fish communities, we are conducting stable isotope and gut content analysis studies using macroinvertebrate and trophic guild samples from 9 sites and intestine and muscle tissue samples from 133 loaches. Intestines taken from Weather Loaches were used for gut content analysis to understand how their feeding habits compare to those of native fishes. This analysis will help us determine if they are competing directly or indirectly with threatened or endemic species in the Upper Altamaha Drainage, such as the Altamaha Shiner (Cyprinella xaenura) and Ocmulgee Shiner (C. callisema).

5.3.6. No talk slated.

Track 5, Session 4: Aquatic Biota II

5.4.1. No talk slated.

5.4.2. No talk slated.

5.4.3. Sex-Specific Variability in Population Demographics of Sicklefin Redhorse (Moxostoma sp.)

Eric Walther, *River Basin Center, Odum School of Ecology, University of Georgia*

Understanding how demographic parameters vary between sexes is a fundamental aspect of a species' ecology and critical for effective conservation and monitoring. Variation in sex-specific population demographics among and within populations has been extensively documented for commercial or sport fishes; however, there has been less attention given to other native migratory fishes of conservation concern. Sickelfin Redhorse (Moxostoma sp.) is a rare, undescribed sucker species (family Catostomidae) endemic to the Hiwassee and Little Tennessee River systems and found in only a small portion of its historical distribution. Adult Sickelfin Redhorse occupy larger rivers and exhibit annual upstream migrations to access spawning tributaries making them particularly vulnerable to habitat fragmentation. The Sicklefin Redhorse Conservation Committee, a stakeholder led partnership, coordinates monitoring and conservation actions for the species. Annual monitoring of the Hiwassee basin population began in 2016 utilizing capture-mark-recapture techniques. In 2017, a passive integrated transponder (PIT) detection array was installed in Brasstown Creek, GA–a main spawning tributary–to detect tagged individuals (male: n = 189; female: n = 114). In this talk, I will present preliminary results from a Jolly-Seber capture-recapture model that estimated sex-specific population parameters for Sicklefin Redhorse in Brasstown Creek and discuss its conservation implications. The ability to describe sex-specific population demographics is critical for establishing successful conservation strategies for species of concern.

5.4.4. Effects of Temperature on Simulium Vittatum Development

Sophie Racey and Darold Batzer, *Department of Entomology, University of Georgia*

Empirical biological data on vector response to climate change is limited, with data on larval responses being especially scant (Vannote & Sweeney 1980). While modelling efforts are useful guidance, they rely on the validity of embedded assumptions and depend on the quality and quantity of available empirical data; relying solely on modelling efforts is risky (Bellard et al. 2012). For aquatic vector insects, such as black flies, ramifications of climate change will be mostly expressed through the larvae, even if blood-feeding adults actually transmit pathogens, because those active growth stages will be most affected by changing environmental conditions (Bernotienė & Bartkevičienė 2013). Larval responses to changing water temperatures may affect physical sizes, longevities, fecundities, and distributions of the adults (Nelson et al. 2020). The effect of water temperature on the development of Simuliidae larvae and pupae has previously been shown using larvae collected in the field (Becker 1973). The results of these studies are confounded by the effects of moving larvae from the field into laboratory conditions and therefore leave many unanswered questions. In this study, 24-hour old Simulium vittatum eggs, from the Black Fly Research & Resource Center at the University of Georgia, were exposed to different temperature regimes to assess changes in time to emergence and adult body size. Larvae were reared at 17, 19, 21, 23, 25, 27, and 29 °C. Black flies were reared in a temperature-controlled room, where three replicate artificial streams were maintained. We hypothesize high temperatures will induce high mortality, decreased emergence time, and smaller adult body size. We hypothesize medium temperatures will induce lower mortality, longer emergence time, and larger adult body size. We hypothesize low temperatures will induce higher mortality, longer emergence time, and failure to emerge from pupation.

5.4.5. Declines in Smaller-Bodied Taxa Underlie Shifts in Shoal Fish Communities in the Conasauga River

Andrew J. Nagy[1], Mary C. Freeman[2], Brian J. Irwin[3], and Seth J. Wenger[1]
[1]*River Basin Center, Odum School of Ecology, University of Georgia* [2]*U.S. Geological Survey, Eastern Ecological Science Center* [3]*U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit*

Freshwater biodiversity is one of Georgia's remarkable water resources, including at least 325 fish species. A portion of this diversity is concentrated in the upper Coosa River system, including the Conasauga River in Murray and Whitfield counties. Annual monitoring data, however, have shown evidence of declining populations of imperiled taxa (e.g, the amber darter, Percina antesella and Conasauga logperch, P. jenkinsi) in the Conasauga River since at least the 1990's, raising the concern that other taxa could be declining as well. We quantified temporal change in fish communities at six shoal sites sampled annually in most years from 1996 to 2019, and asked whether species traits hypothesized to underlie population vulnerability to environmental alteration in fact correlated with species-specific trends. Our analysis addressed 32 fish species that together accounted for >90% of captures in all samples. We estimated that total counts of fish in annual samples declined by ~ 2% per year, although declines were uneven among species and generally greater for less abundant taxa. Tests for species traits corresponding to temporal population trends provided evidence that crevice spawning minnows and smaller-bodied taxa had steeper declines compared with broadcast spawners and larger, longer-lived, more fecund taxa. Lower abundance, reliance on a particular habitat feature, and life-history traits that may limit population rebound from disturbance may all prove useful for identifying fishes at particular risk of future population decline in the Conasauga River and other Georgia rivers.

5.4.6. What happened to the Conasauga?

Seth Wenger[1], Phillip Bumpers[1], Mary Freeman[2], Byron Freeman[3]
[1]*River Basin Center, Odum School of Ecology, University of Georgia,* [2]*U.S. Geological Survey, Eastern Ecological Science Center,* [3]*Museum of Natural History, University of Georgia*

The Conasauga River in North Georgia and Southern Tennessee was once considered an aquatic biodiversity refuge. As the last major unimpounded tributary of the Upper Coosa, it supported an astonishing diversity of mussels and fish, including many that had declined or disappeared elsewhere. But something started to change in the Conasauga in the 1990s, and since then we've witnessed dramatic declines in many species across all major groups--mussels, fish, aquatic vegetation, and, we now suspect, even insects. The causes of these declines are unclear. In collaboration with multiple partners, we've embarked on a multi-pronged investigation to test hypotheses to explain the losses while simultaneously exploring the potential for nature-based restoration strategies. I'll provide an overview of the status of the river, the hypotheses for the species declines, and some of the monitoring and research programs that are currently underway.

Track 5, Session 5: Panel, Know Your River: Data Democratization Tool

Moderated by Tonya Bonitatibus, *Savannah Riverkeeper*. Panelists: Damon Mullis, *Ogeechee*

Riverkeeper, Kris Howard, *Ogeechee Riverkeeper*, Lindsay Wallace, *Newfields,* Rosco Peters, *Newfields*.

Hundreds of thousands of samples are collected on waterways throughout the United States every year by a wide variety of agencies and organizations. Each sample helps tell a story about the health of that waterway and its ability to handle stress from a variety of sources. Unfortunately, those data are often housed across various websites, in incompatible formats, and split between political boundaries. This is called ""silo-ing,"" and the result is an environment where data access is limited, and decision-making hindered. Access to actionable data helps our community members and leaders make more informed and holistic decisions. The Know Your River system was developed to overcome the silo-ing of data related to the health and quality of our waterways. Know Your River is built on ESRI's ArcGIS Online applications and Python—which collects, collates, and stores real-time and historical data from over forty federal, state, municipal and nonprofit sources and displays them together in one location. The system includes, but is not limited to, recreational, analytical, facilities and Environmental Justice data. Additionally, every dataset utilized is easily accessible for direct download or live linking via API.

System Components:

· Field Data Collection App- Mobile application utilized by Riverkeeper volunteers and citizen scientists to collect data
· Python- Backend coding utilized to automatically collect, collate, and pushes data to the Data Dashboard andOpen Data Portal for consumption
· Data Dashboard- Interactive visual display utilized to query and analyze data
· Open Data Portal- Repository for direct download and linkage to original and collated datasets

Currently, the system focuses on two river basins located in Georgia and South Carolina with planned expansions to include all rivers draining into the Atlantic seaboard of the US next year. Due to the versatile infrastructure on which the system was built, it can be adapted to anywhere, worldwide.

Track 5, Session 6: Panel, Water Data & Databases: Quantity, Quality, and Accessibility

Moderated by Janet Genz, University of West Georgia. Harold Harbert, *GA Adopt a Stream*, Robbie O'Donnell, *Water Data Collaborative*.

Many lines of research rely on publicly accessible water data. These data are collected from a broad array of sources that vary in techniques, frequency, and metrics reported. Additionally, there is substantial variation in what data are available in online databases, along with differences in filtering and other factors impacting the end-user. Consequently, the learning curve on effective utilization of many of the primary online data sources (e.g. USGS, GOMAS) is steep, and often dependent on awareness of available tools. The ability to identify, utilize, and contribute to online databases represents an important tool for researchers and other stakeholders in water quality and monitoring, but the accessibility of these growing online data repositories is not well-matched to the skills and resources available to those seeking specific data. How can researchers better identify which tools and databases are best oriented to their scientific inquiries, and how can data and databases be improved to support exceptional science? What limitations exist in collecting data and making it accessible to a broad range of end users, and what is needed to solve these identified issues? The goals of this panel are to provide a one-stop-shop for information regarding available data sources, tips on selecting and utilizing databases, and providing insights for researchers interested in engaging deeply with online data to improve its quality, perceived credibility, and ease-of-access. This panel will be a starting point for discussion among researchers, database contributors, and administrators to communicate their objectives for working with and improving online water data quantity, quality, and accessibility. Each panelist will present brief introductory comments highlighting a particular database or concept important to database management. After all presentations, time will be allocated to moderated questions, followed by questions from conference participants to expand the discussion.

TRACK SIX

Track 6, Session 1: Testing the Waters: A Collaborative Approach to Building Infrastructure for the Future of Wastewater Surveillance in Georgia

6.1.1. State and Local Public Health: Epidemiology's Perspective on Wastewater Surveillance in Georgia

Cristina Meza, *Georgia Department of Public Health*

In August 2021, the Georgia Department of Public health (DPH) received funding to conduct surveillance of SARS-CoV-2 (COVID-19) through wastewater as part of the Centers for Disease Control and Prevention's National Wastewater Surveillance System (NWSS). Since the GA NWSS program's initiation, DPH has developed close relationships with academic partners such as Emory University and University of Georgia Schools of Public Health, national organizations such as WastewaterSCAN, local public health, and wastewater treatment facility (WWTF) partners. Currently, eight of eighteen total public health districts in Georgia are represented in the GA NWSS program since wastewater sampling began in April 2022. Districts with a participating WWTF receive data from the state GA NWSS team on a weekly basis, and findings are then summarized and shared with district health leadership, directors in environmental health, epidemiology, clinical offices, and emergency preparedness. This information is also shared with community partners such as hospitals, schools, childcare facilities, and others.

Overall, these reports have been used to help supplement and validate other COVID-19 trackers such as case data and hospitalizations. Districts have also used these data to conduct outreach to their local WWTFs. Beyond direct outreach, district epidemiologists play a key role in establishing trust with local partners and sharing information related to the GA NWSS program. Through this partnership, state and local epidemiologists will be able to share their overall experience as collaborators in the GA NWSS program, and how wastewater data may inform public health surveillance of ongoing or emerging public health threats. Epidemiologists will also share challenges and/or successes they have encountered when sharing GA NWSS data. The underlying goal of the GA NWSS program is to build a sustainable infrastructure for wastewater surveillance utilization beyond COVID-19, and these relationships make that possible.

6.1.2. Cobb County Water System – A Local Utility's Experience in Wastewater Surveillance

Daniel Cochran[1], Alicia Giddens[1]Michael Reddick[1], Paul Hardie[1]

[1]*Cobb County Water System (CCWS)*

As a result of the COVID-19 pandemic, increased funding, research, and programming was dedicated to wastewater surveillance, resulting in the initiation of the Centers for Disease Control and Prevention's National Wastewater Surveillance System (NWSS). Since April 2022, ten wastewater treatment facilities (WWTF) across Metro-Atlanta have begun weekly raw wastewater sampling as participants in the GA NWSS program. One of these partners includes Cobb County Water System (CCWS). CCWS has participated in several projects involving the testing of wastewater to measure SARS-CoV-2 (COVID-19) levels. In one of CCWS' previous studies, they faced challenges sampling from all four facilities due to staffing shortages. Though hesitant at first due to this experience, CCWS worked with the Georgia Department of Public Health (DPH) to onboard one plant to the GA NWSS program. Raw wastewater was collected via 24-hour composite or grab sample from the influent of the facility twice weekly. CCWS was provided with sampling materials such as a 250 mL sampling bottle, absorbent material, ice packs, and a shipment cooler. CCWS trained staff to conduct sampling and communicated with DPH staff on a weekly basis and have since incorporated a second facility within the GA NWSS program. Overall, CCWS has enjoyed working with DPH on this program. DPH staff have communicated with CCWS, providing detailed instructions for program activities such as sampling and sample pick-up. DPH staff have also provided timely reporting of results and have worked to consistently incorporate partner feedback. During this presentation, CCWS will share their experience as partners in the GA NWSS program and any challenges or successes they have experienced. Additionally, CCWS will share a unique perspective on how this program may fit into long-term activities. Finally, CCWS will suggest improvements for local public health and researchers regarding outreach, participation, or other wastewater surveillance program details.

6.1.3. Wastewater Surveillance of Severe Acute Respiratory Syndrome (SARS-CoV-2) at Georgia Public Health Laboratory

Steven Woods[1], Ellen Daley[1], Carla Bartlett[1], Mary R Connelly[1], Stephen Hilton[2], Orlando Sablon III[2], Marlene Wolfe[2], Pengbo Liu[2], Christine L Moe[2], Cristina Meza[3], Amanda Feldpausch[3], Crawford Hannah-Leigh[3], Melissa Tobin-DAngelo[3], Tonia Parrott[1], Nandhakumar Balakrishnan[1]

[1]Clinical Microbiology Services, Georgia Public Health Laboratory, [2]Center for Global Safe WASH, Rollins School of Public Health, Emory University, [3]Acute Disease Epidemiology Section, Georgia Department of Public Health

Wastewater-based epidemiology is a promising approach to public health surveillance and is crucial to a timely response to infectious disease threats such as antimicrobial resistance and foodborne diseases. Wastewater monitoring can serve as an early warning of COVID-19 in communities. It also provides information that can help local communities intervene more quickly with mitigation strategies to slow disease spread. Using current molecular tools, monitoring the concentration of SARS-CoV-2 in wastewater can assist to determine the levels of virus circulation in the community. In collaboration with the Rollins School of Public Health at Emory University, the Georgia Department of Public Health Laboratory (GPHL) validated the extraction and amplification of SARS-CoV-2 from wastewater samples. Sample analyses included virus concentration (Ceres Nanotrap Particles), nucleic acid extraction (ThermoFisher MagMax Wastewater Isolation Kit), and Qiagen digital PCR amplification. Assay results and performance were compared between the GPHL lab and the Emory lab for 30 wastewater samples collected from five sites for three weeks. The concentrations of SARS-CoV-2 were compared between the two sites using Bland Altman analysis. Overall accuracy, 28 of 29 water samples fell within the 95% confidence interval of agreement for this analysis. Based on the sensitivity, the assay can detect less than 1 genome copy (GC) of SARS-CoV-2 in the wastewater sample. Based on the limit of detection, the assay can quantitate <1 GC/µL of SARS-CoV2 RNA (Range 0.054 -1141.5 GC). Ongoing GPHL efforts to sequence SARS-CoV-2 from wastewater and detect and track variants can provide valuable information on COVID-19 trends within the community.

6.1.4. Multi-Level Wastewater Monitoring for SARS-CoV-2 in Metro Atlanta

Christine Moe[1], Eugene J. Gangarosa[1], Pengbo Liu[1], Marlene Wolfe[1], Jamie VanTassell[1], Stephen P. Hilton[1], Lizheng Guo[1], Orlando Sablon[1], Lorenzo Freeman[2], Wayne Rose[2], Carl Holt[2], Mikita Browning[2], Lance Waller[3], Peter F. M. Teunis[1], Steven Bosinger[4], Stacey Lapp[4], Amanda Metz[4], Derrik Gratz[4], Steven Woods[5], Yuke Wang[1].

[1]Center for Global Safe Water, Sanitation and Hygiene, Rollins School of Public Health, Emory University, [2]City of Atlanta Department of Watershed Management, [3]Department of Biostatistics and Bioinformatics, Rollins School of Public Health, Emory University, [4]Emory Nonhuman Primate Genomics Core, Emory University, [5]Clinical Microbiology Services, Georgia Public Health Laboratory

Monitoring SARS-CoV-2 in wastewater is a valuable approach for tracking COVID-19 transmission in populations. Designing wastewater surveillance (WWS) with representative sampling sites and quantifiable virus results requires knowledge of the sewerage system and virus fate and transport. METHODS: We developed a multi-level WWS system to track COVID-19 in Atlanta using an adaptive nested sampling strategy; collected and analyzed wastewater samples from 80 sites in metro Atlanta for SARS-CoV-2; and sequenced a subset of positive samples for SARS-CoV-2 variant detection. RESULTS: From March 2021 to April 2022, 868 wastewater samples were collected weekly from 9 influent lines at 3 wastewater treatment facilities, 57 selected upstream community manholes, and 14 selected institutions (schools, correctional facilities, ATL airport). Sequence analyses of a subset of 487 wastewater samples positive for SARS-CoV-2 from October 2021-April 2022 identified three main groups of SARS-CoV-2 variants, including Delta, Omicron B.1.X, and Omicron BA.2.X. Temporal changes in SARS-CoV-2 concentrations in influent line samples preceded similar temporal changes in numbers of reported COVID-19 cases in the corresponding catchment areas. Community sites with high SARS-CoV-2 detection rates in wastewater covered high COVID-19 incidence areas, and adaptive sampling enabled identification and tracing of COVID-19 hotspots. SARS-CoV-2 variant results from wastewater closely matched available clinical data on the timing and prevalence of variants in the community. Testing at multiple levels within Atlanta yielded similar results for the timing of introduction

of new variants - from schools and correctional facilities to wastewater treatment facilities. This study demonstrates how a well-designed WWS provides actionable information including early warning of surges in cases and identification of disease hotspots and SARS-CoV-2 variants in the community.

6.1.5. Building, Sustaining, and Sharing Wastewater Based Testing for SARS-CoV-2 in Athens, GA

Erin Lipp[1], Megan E. J. Lott[1,2], William Norfolk[1], Leah Lariscy[1], Lily Metsker[1]

[1]*University of Georgia,* [2]*University of North Carolina Chapel Hill*

Those working in water quality have long known that raw sewage can act as an 'information highway;' what we flush can tell a lot about the population in a sewage catchment, from the medicines we take to the enteric diseases that may be circulating. Early in the pandemic there were reports that SARS CoV 2 was shed in feces, opening the possibility for tracking infection burden in an entire community by testing wastewater. Along with many others around the US, and globally, our laboratory at UGA ramped up a SARS CoV 2 wastewater surveillance program for the Athens Clarke County community. Sample collection and analysis began in June 2020 and continued twice weekly at three wastewater plants through the end of December 2022. 24-h composite samples were spiked with a bovine coronavirus process control and extracted directly with no pre-concentration and immediately analyzed by RT-qPCR for the SARS-CoV-2 N1 and N2 gene targets. Results, based on the N1 and N2 flow-normalized load, were posted weekly to our locally hosted dashboard with contextual information about the week's results. N1 and N2 assay positivity, viral concentration, and flow-adjusted daily viral load all correlated significantly with per-capita case reports of COVID-19 at the county-level. Wastewater assay positivity, during times of high clinical testing and reporting, could predict as a few 5 new cases per 100,000 people. As reported cases decline with use of at-home tests, the importance of wastewater based testing and public reporting of those data has become an increasingly valuable tool to understand community transmission levels.

6.1.6. WaterSCAN: Utilizing Wastewater to Monitor for SARS-CoV-2, RSV, Influenza, Norovirus, Human Metapneumovirus, and Mpox in Georgia

Marlene Wolfe, *Emory University*

Throughout the COVID-19 pandemic, wastewater monitoring has been widely adopted to ascertain the levels of the disease in a community. Concentrations of viral RNA measured in wastewater have been shown to correlate well with clinical data sources for disease at a community level. These measurements include those who may not seek or have access to healthcare or be included in traditional surveillance systems, and are not altered by changes in testing practices such as a shift to rapid testing. We show that this approach can be expanded beyond SARS-CoV-2 and data made rapidly and openly available to public health. We have shown that the concentrations of viral nucleic acids from a range of viruses (SARS-CoV-2, influenza A and B, RSV, metapneumovirus, and mpox) are associated with disease in the respective community. After verifying that the concentrations of these targets in wastewater are good indicators of community disease levels, we implemented wastewater testing in Georgia beginning in July 2022 as part of our national program, WastewaterSCAN. For this program, we receive samples of wastewater from municipal treatment plants at over 130 plants in 25 states, and provide measurements of SARS-CoV-2, influenza A and B, RSV, metapneumovirus, norovirus, and mpox. Data are available within 48 hours of receiving a sample at the laboratory and displayed at data.wastewaterscan.org. Within Georgia, 7 sites in the Atlanta metro area provide more granular information about differences in disease occurrence and pattern of outbreaks across the metro area. Wastewater provides an important opportunity to monitor diseases at a community level and promote health equity by including all, especially when clinical data sources are incomplete or non-existent.

Track 6, Session 2: Urban/Stormwater

6.2.1. Stormwater Forecasting – A New Indicator To Manage Basin-Scale Urban Runoff Volume

Katherine Atteberry[1], David Bell[2]

[1]*Metropolitan North Georgia Water Planning District,* [2]*Jacobs Engineering Group, Atlanta, GA*

Since 2001, the Metropolitan North Georgia Water Planning District (District) has coordinated strategies to protect watershed conditions and manage stormwater in conjunction with existing regulatory requirements. However, despite these efforts, urban stormwater runoff continues to remain a leading cause of nonpoint source pollution and flooding. Therefore, the District has developed a novel water quantity-based indicator, called the Stormwater Forecast (Forecast). The Forecast is a planning-level estimate of the total potential runoff management volume from development, calculated at the basin scale using site-scale post-construction stormwater performance standards. With this new approach, the Forecast represents a full accounting of the runoff volume from developed lands that have the potential to be managed by Stormwater Control Measures (SCM), if current post-construction stormwater management standards were fully in place. Future use of the Forecast is intended to complement and support the implementation of the District's existing water quality and flood reduction goals.

6.2.2. Spatial Prioritization for Equitable Urban Riverscapes in the Southeastern Piedmont Region

Holly Yaryan Hall[1], Brian Bledsoe[1]

[1]*University of Georgia*

The purpose of this project was to support decision-makers in prioritizing their conservation and capital investments along stream networks in addition to identifying and leveraging a suite of co-benefits. System-level approaches may offer natural infrastructure projects a framework that is flexible yet holistic enough to identify vulnerabilities (e.g., flooding, social inequity) as well as opportunities for functional improvements (e.g., habitat, water quality) in urban riverine corridors. To guide equitable and efficient reach and valley-scale interventions, we assessed social and ecological characteristics of the system and prioritized watersheds for potential stream improvements using a spatial multi-criteria decision analysis (MCDA). The spatial MCDA framework is well suited to landscape-scale stream management, restoration planning, and scenario comparisons, as it provides a logical and transparent way to incorporate multiple, competing goals and priorities from a variety of stakeholder groups. Objectives included a range of environmental, social, technical, economic, and policy considerations. We present a collaborative case study from the southeastern piedmont region, demonstrating a spatial MCDA approach for urban stream restoration that could be more broadly implemented in other social-ecological systems.

6.2.3. Stormwater Master Planning: Lessons Learned

Aaron Rogge, *Tennessee Stormwater Association*

Each community must make decisions that determine the future health of their waterways. Stormwater master planning is an important cornerstone of this decision-making process. Master plans are a detailed atlas of a community's flooding and water quality risks. They also provide a vision that balances growth and conservation within a defensible, science-based approach. Big data and new funding streams are ushering in a new golden era in planning. This presentation will provide several case studies of master plan development in communities of varying size throughout the Southeast. After the basic philosophical tenets of master planning are outlined, approaches for communities of varying sizes and political structures will be analyzed. Strategies for identifying useful capital improvement projects will be presented, including the prioritization and costing of those projects. All case studies include hydrologic modeling components, which will be summarized and contrasted. Topics covered in this talk also include: how to scope a master plan, what additional uses a master plan may have in an MS4's daily tasks, and how to approach a level of service determination. Common software platforms used for hydrologic modeling will be compared.

6.2.4. Investigating Potential Pathways of Urban Landscapes' Impact on Stream Biota and Instream Stressor Interactions in the Southeastern Piedmont

Lu Juncheng[1], Jon Calabria[1]

[1]*College of Environment and Design, University of Georgia*

Urbanization has greatly degraded stream health in the U.S. Southeast, which was reflected in well-documented physicochemical and biological responses to land use change. Recent studies (Waite et al. 2019, 2021) identified primary instream stressors affecting biological communities along urban gradient in the Southeast Piedmont. However, there is limited understanding of the complex mechanisms by which urban development affects stream health. Based on these studies, we investigated the potential mechanisms by which urbanization, as represented by landscape development intensity index (LDII), and several important environmental characteristics affected instream stressors and stream biological communities (fish, benthic macroinvertebrate and diatom) using pre-identified important instream stressors and the USGS Southeast Stream Quality Assessment (SESQA) dataset. We investigated the direct, indirect and total effects of LDII and environmental characteristics on instream stressors and biological communities as well as interactions among instream stressors using structural equation modeling with considering competing alternative models. We found that LDII had direct and/or indirect effects on all instream stressors and biological communities with complex impact mechanisms reflected by the number of paths, which demonstrated its importance in affecting stream health in the Southeast Piedmont. Moreover, the combination of instream stressors had greater cumulative total effects than the combination of landscape and riparian characteristics on biological communities, but LDII had the greatest individual total effect. Furthermore, we found potential interactions among instream stressors that were not widely discussed in previous studies. Compared with agricultural watersheds, urban watersheds had different mechanisms by which land use affected instream stressors and biological communities. Finally, we discussed the implications of our models for stream mitigation and watershed management practices and proposed that SEM could be developed as a useful tool for guiding stream mitigation and watershed management practices.

6.2.5. Patterns and Trends in Sediment Loads in 13 Suburban to Urban Watersheds in Gwinnett County, Georgia

Brent T. Aulenbach[1], Joshua C. Henley[1], Kristina G. Hopkins[1]

[1]*U.S. Geological Survey South Atlantic Water Science Center*

The Georgia Environmental Protection Division lists sediment as one of the most common sources of water-quality impairments in Georgia streams. The U.S. Geological Survey, in cooperation with Gwinnett County Department of Water Resources, established a long-term streamflow and water-quality monitoring program in 1996 for select suburban to urban watersheds in Gwinnett County, Georgia. Annual loads and yields were estimated using a turbidity-surrogate regression model approach for total suspended solids (TSS) and suspended-sediment concentration (SSC) at 13 watersheds for water years (WYs) 2002–2020. Sediment loads were typically higher for years with higher runoff, whereas the proportional range for annual loads of TSS and SSC were 4.8 and 3.5 times larger than for annual runoff, respectively. Higher-than-expected annual sediment loads occurred in years that also had some of the highest peak flows during the period, suggesting that large storms are responsible for much of the sediment transport. A few years with high sediment loads appear to be the result of large land development projects in proximity to streams. Year-to-year patterns in annual sediment loads indicated that eight watersheds exhibited a transport-limited behavior, one watershed exhibited a source-limited behavior, and four watersheds exhibited a mixed behavior. Higher sediment loads following droughts at six watersheds are indicative of the flushing of sediment that accumulated during droughts. Watershed sediment yields were not significantly correlated to watershed characteristics, such as imperviousness and the amounts of medium to high intensity developed land cover. For WYs 2002-2010, there were five significant decreasing trends in watershed loads for TSS and two for SSC. For WYs 2010-2020, there were three decreasing and one increasing trend for TSS and five decreasing and one increasing trend for TSS. The long-term dataset and the incorporation of continuous turbidity into the load estimation methodology provide insights into sediment transport within these watersheds.

6.2.6. Disturbances in Nutrient and Water Fluxes in Leach Field Soils Impact Urban Tree Health

Courtney Scott[1], Krista Capps[2], Nandita Gaur[3], Jason Gordon[1], Rebecca Abney[1]

[1]*Warnell School of Forestry and Natural Resources, University of Georgia,* [2]*Odum School of Ecology, University of Georgia,* [3]*Crop and Soil Science, University of Georgia,*

In the United States, on-site wastewater treatment (OWTS) or septic systems, are used in approximately 25% of residences. When functioning properly, OWTS utilize soil biogeochemical processes to filter carbon, nitrogen, and phosphorus from wastewater effluent. However, wastewater treatment can also result in the accumulation of nutrients, organic matter, contaminants, and water in leach field soils. This can create conditions that mimic hydric soils typically found in bottomland areas. Many city ordinances stipulate trees should not be planted within 50 feet of OWTS; however, many trees can be found inhabiting septic leach fields. Little is known about how the shifting soil biogeochemistry and hydrology in leach fields can impact soil functioning and tree condition and growth. The goals of this study were to (1) examine the impact of OWTS on soil chemical and physical properties related to biogeochemistry and soil hydrology (2) and understand how soils in leach fields influence tree condition and growth. I have conducted tree health assessments, identified tree species, and collected tree core and soil samples inside and outside of leach fields at private residences and institutional sites in Athens-Clarke County, Georgia. Soils were analyzed for nutrient content, soil organic matter quantity and quality, and other chemical and physical properties. Trees were assessed using dendrochronological analysis and, commonly used measures of growth and condition. Though results are preliminary, we expect that that bottomland hardwood tree species will have higher success inhabiting leach field soils, especially when compared to tree species that are not adapted to living in hydric soils. The results of this project will inform management practices that improve urban soil quality and tree condition.

6.2.7. The Oconee Rivers Greenway: A Citizen's Initiative

Karen Porter, *Oconee Rivers Greenway Commission*

Unlike most greenways the Oconee Rivers Greenway (ORG) in Athens-Clarke County (ACC) is an environmental area. Its purpose is the "protection of the natural resources of the North and Middle Oconee Rivers, their major tributaries and their floodplains…for the benefit and enjoyment of the citizens of Athens-Clarke County". It is also unique in that the citizens group the Oconee Rivers Greenway Commission (ORGC) was chartered by a County Ordinance in 1992 to plan the greenway and to advise the mayor and commission on matters that relate to environmental quality, management, planning, and development. In the 1970's, citizens including UGA faculty conceived of a riverside greenway. The ORGC, ACC, and the Oconee River Land Trust collaborated to develop a greenway plan that was approved in 1993. Funding included a federal Interstate Commerce and Transportation grant with ACC matching funds and citizens by-in through Special Purpose Local Option Sales Taxes (SPLOST). The original ORGC trail, dedicated in 2003, was 3.5 miles of hard surface and 4.5 miles of natural surface trails. Today, a total of 23.75 miles of multi-use trails and 28.4 miles of natural surface trails are open, funded, or under construction in ACC. The greenway is 15.75 miles of multi-use trails that connect to 8 miles of Firefly rail-to-trail. The ORGC collaborates with ACC Leisure Services to update the Greenway Network Plan (GNP) which includes connectivity beyond the river corridor. The goals are resource protection, environmental education, wellbeing, recreation, and alternative transportation. Challenges include funding for operating expenses and property acquisition. The burden of operations falls to ACC Leisure Services. To be sustainable the Oconee River Greenway will need sources of funding, in addition to ACC and SPLOSTs, in order to acquire new property, build, and maintain it if it is to be a model greenway system for Georgia and the region.

Track 6, Session 3: Ecosystem Function, Infrastructure, and Conservation in Urban Watersheds

6.3.1. Urbanization Alters the Quantity and Quality of Riverine Dissolved Organic Matter

Shuo Chen[1,2], Krista Capps[2], Kristina Hopkins[3], Denzell Cross[2], Crystal Pendergast[2], Christopher Rizzie[4], Liz Ortiz[4], Rebecca L. Hale[5], John Kominoski[4], Allison H. Roy[6,7], Jennifer Morse[8], Annika Quick[1,7]

[1]Department of Biological Sciences, Idaho State University [2]Odum School of Ecology, University of Georgia, [3]U.S. Geological Survey South Atlantic Water Science Center, [4]Institute of Environment & Department of Biological Sciences, Florida International University, [5]Smithsonian Environmental Research Center, [6]U.S. Geological Survey, [7]Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts Amherst, [8]Portland State University

Dissolved organic matter (DOM), plays an important role in mediating water quality and ecosystem functions. Urbanization changes the amount, sources, composition, and lability of aquatic DOM, however, little is known about how different urban characteristics influence the quality and quantity of fluvial DOM. We tested the effects of urbanization drivers (e.g., wastewater infrastructure, land cover) on riverine DOM dynamics in Atlanta, GA, using seasonal synoptic sampling campaigns ($n = 93$ streams sampled four times in 2021–2022). Preliminary results identified five DOM components, which were dominated by two terrestrial humic-like DOM (C1 and C3: 24.53 ± 5.58% and 19.74 ± 5.42%, respectively), a microbial humic-like DOM (C2: 36.13 ± 6.28%) and two proteinaceous DOM (C4 and C5: 15.22 ± 8.79% and 4.37 ± 8.68%, respectively). The quality and quantity of DOM in urban streams shifted seasonally from a high proportion of terrestrially-derived, aromatic DOM with high humification degree in early spring (March) to a larger quantity of dissolved organic carbon (DOC) and freshly-produced, microbially-derived humic DOM in summer (July and September). In winter (December), the DOM pool was enriched with small-molecular-weight, proteinaceous DOM. Increased human populations and housing densities were related to DOC concentrations with high aromaticity in late summer (September). In contrast, in the early spring, mid-summer, and winter, the human populations and housing densities were negatively correlated with terrestrial DOM but positively correlated with proteinaceous DOM. Additionally, we found that increased urban land use was associated with reductions in the aromaticity and the abundance of terrestrially-derived humic DOM, but facilitated the export of freshly-produced, microbially-derived DOM. This correlation was seasonal, and we did not see similar relationships in the quantity and quality of fluvial DOM in winter months. Altogether, our study highlighted the importance of incorporating various anthropogenic characteristics to better understand spatiotemporal carbon dynamics in urban streams.

6.3.2. Baseflow Spatial Stability of Major Ions in a Highly Urbanized Watershed Matches Homogenous Stormflow Responses

Sarah H. Ledford[1], Christopher Wheeler[2,3]

[1]*Georgia State University,* [2]*University of Kansas,* [3]*Kansas Geological Survey*

The variability in major ion chemistry of urbanized watersheds across space during baseflow represents a marker of groundwater discharge to such streams. While it is well established that stormflow in such systems is dominated by dilution from overland runoff, there is conflicting research on whether baseflow ion chemistry, representing groundwater chemistry, becomes more homogenous or heterogeneous with urbanization. With groundwater flowpaths as one of the least-studied aspects of urban hydrology, baseflow surface water snapshots help illuminate subsurface processes. In this study, we collected samples every five days from June-September 2020 from 18 sites in the Upper South River watershed in Fulton and DeKalb counties, GA. Samples were analyzed for major anion and cation concentrations. Sampling showed high spatial stability in ion chemistry, meaning that at baseflow sites did not vary across the watershed in their relative geochemistry through time. This was especially true for sulfate, calcium, potassium, and even nitrate. Sub-catchment leverage was calculated to estimate the downstream impact of individual headwater sites and showed headwater variability in concentration is eliminated by the time watersheds reach about 100 km2. Storm hysteresis responses (discharge-concentration) were also assessed for storms during this period at three of the sites. These results show ions almost always showed a dilution effect with a clockwise shape, pointing to a homogenous response with proximal sources during storms. Overall, despite high hydrologic variability driven by urban streamflow responses, sites showed strong spatial stability. Individual baseflow sites are highly heterogeneous in their absolute ion concentrations, but their pattern does not vary in time, while all sites become homogenous during storms. This points to consistent groundwater input patterns across the watershed that do not vary in response to storm events.

6.3.3. Neighborhood Water Watch: Solving Urban Water Quality Problems with Community Science

Jessica Sterling[1], Michael Meyer[1], Jason Ulseth[1]

[1]*Chattahoochee Riverkeeper*

Neighborhood Water Watch (NWW) is a community driven collaborative program between Chattahoochee Riverkeeper (CRK), neighborhood groups, schools and individual community members in the Chattahoochee River watershed. The program was started in 2011 to collect critical water quality data, detect pollution problems in urban streams and empower communities to protect their waterways. Each week, over 160 volunteers and partner groups bring water samples from 200 stream stations in the Chattahoochee River watershed to one of CRK's three laboratories. Water samples are analyzed for turbidity, conductivity, optical brighteners and E. coli bacteria. When high E.coli levels are detected, CRK staff and interns track it to the source, usually a leaking sewer line or overflowing manhole. CRK works directly with local governments to ensure the infrastructure is fixed and we continue to monitor until bacteria levels return to normal. Since the beginning of the NWW program, CRK has collected thousands of samples and detected and fixed over 120 sewer spills. In addition, NWW has become a model community-based water quality monitoring program and has been replicated in other watersheds in the US.

6.3.4. Remotely Mapping Streambank Erosion Hotspots in Urban Areas

Kristina Hopkins[1], Charles Stillwell[1], Laura Gurley[1], Ryan Rasmussen[1], Deanna Hardesty[1]

[1]*U.S. Geological Survey*

Streambank erosion is a natural process in fluvial systems. Excess sediment in streams can have negative impacts such as infilling of downstream reservoirs and give rise to poor water quality. Sediment derived from streambanks can be a dominant source of in-stream sediment, especially within the piedmont, but limited tools exist to understand the spatial extent of streambank instability. Current approaches, such as stream walks or citizen complaints, can be inefficient, inconsistent, and biased. The U.S. Geological Survey partnered with the City of Raleigh, North Carolina to develop an approach to identify stream reaches throughout Raleigh that may be most susceptible to streambank erosion. The approach paired rapid field geomorphic assessments with high-resolution lidar-derived metrics in order to develop a streambank erosion model to remotely map streambank erosion potential. Rapid field assessments were conducted at 124 sites to assess channel stability using the bank erosion hazard index and near bank stress ratings. Geomorphic characteristics of stream channels were characterized using lidar-derived 1-m digital elevation models (DEMs) and positive landscape openness datasets from years 2015 and 2022. Differences between the 2022 and 2015 DEMs were used to characterize changes in the elevation of stream channels over time. The capability of geospatial datasets, along with watershed characteristics, was tested to predict rapid field geomorphic assessment metrics. Predictions were aggregated and attributed to reaches within the stream network to provide an assessment of streambank erosion potential at a management relevant spatial scale. While this study focuses on urban streams in North Carolina the method has wide applicability to areas that have high resolution elevation datasets and allows for broad-scale mapping of potential channel-derived sediment sources across the city.

6.3.5. Incorporating Beaver Into the Urban Stream Network: A Comparison of Water Transmit Time Distributions Across Urban Beaver Ponds and Stormwater Ponds

Claire Wadler[1], Luke Pangle[1], Sarah H. Ledford[1], Sandra M. Clinton[2], Diego Riveros-Iregui[3]

[1]*Georgia State University,* [2]*University of North Carolina Charlotte,* [3]*University of North Carolina Chapel Hill*

Urbanization alters streamflow, causing increased stream flashiness and larger peak stormflow magnitudes. Best Management Practices (BMPs), including retention ponds, are implemented to mitigate these effects. While these structures may effectively modulate local surface runoff, empirical analyses suggest their cumulative effect on watershed-scale streamflow is marginal. Beaver impoundments represent an alternative, and perhaps complimentary, means of managing urban stormwater. In landscapes with marginal human impact, beaver dams slow the flow of water, altering the downstream hydrologic flow regime and nutrient dynamics. Previous studies suggest the removal of dissolved solutes (e.g., NO3-) from the water column may be strongly controlled by the residence time of water within the channel and hyporheic zone, an effect beaver ponds may accentuate by enhancing water and solute transit times through impounded channel sections. This study seeks to determine how the transit times of water traversing urban beaver ponds compare to those occurring within human-built stormwater ponds. A conservative tracer (Br-) was added near-instantaneously at points of inflow to three beaver dam sites and two stormwater retention ponds within the metropolitan areas of Atlanta, GA and Charlotte, NC. Possible relationships between characteristic transit times and metrics of pond geomorphology, flow path complexity, and hydraulics were explored. The BTCs spanned approximately 9 to 70 days in the fall, and 5 to 10 days in the spring. Similarity in the BTCs for the beaver ponds revealed little variance in flow path complexity between climatically wet and dry seasons, while the BTCs for the retention pond sites showed altered flow path configurations. This suggests that the constructed morphology of the retention ponds may allow for greater expansion and contraction of the wetted area of the ponds, which imparts greater variability in water flow pathways. The implications of these differences on solute retention are being explored in ongoing research.

Track 6, Session 4: Innovative Stormwater Management Solutions

6.4.1. No talk slated

6.4.2. No talk slated.

6.4.3. Biochar Use to Improve Water Quality in the City of Brookhaven

Daniel Markewitz[1], Rebecca Abney[1], Wesley Gerrin[1], James Shelton[1]

[1]*Warnell School of Forestry and Natural Resources, University of Georgia*

Biochar has received much recent attention for its potential as a soil amendment with some focus on reduction of soil nutrient leaching losses or direct benefits to water quality. A limited number of field studies have shown that biochar can both reduce NO3 losses but potentially increase P loses to waterways. In this research we are investigating the potential of biochar to improve water quality in the City of Brookhaven on Murphy-Chandler Lake and the North Fork of Nancy Creek. Here we report early results of laboratory absorption isotherm studies of biochar with NO3 and PO4. Future research hopes to scale up to field studies evaluating water quality benefits of biochar filters in situ.

6.4.4. Green Infrastructure Installations at the Water Tower Institute: Opportunities for Applied Research, Knowledge Transfer, and Training

Christopher Impellitteri[1], Kristan VandenHeuvel[1], Melissa Meeker[1], Chad Wilbanks[1]

[1]*The Water Tower Institute*

The Water Tower Institute (TWTI) is a 502c3 non-profit institute dedicated to applied research, development of innovative technologies, workforce education, and community outreach for water-related issues. The facility is in Gwinnett County, GA, and is adjacent to the F. Wayne Hill Water Resources Center, a world-renowned wastewater reclamation facility. Green infrastructure (GI) installations collect stormwater from TWTI's 56,000 ft2 (5200 m2) main building and associated parking areas. The 25-acre main campus also contains swales, basins, and channels for collecting stormwater. This presentation will provide details on the layout of the GI installations including the sub-surface drainage collection systems. Collaborative research opportunities will be discussed in addition to training and educational opportunities. Basic modeling results will be presented along with sampling data for nitrogen and phosphorous in the system.

6.4.5. Using Biochar to Improve Soil and Stormwater Quality in Urban Tree Plantings

Rebecca Abney[1], Holly Campbell[1], Alexis Martin[1]

[1]*University of Georgia*

Trees in urban spaces along roads, sidewalks, and walkways provide social, ecological, and economic benefits to communities. However, many of these trees are planted in vaults and other poor soils and thus experience a great deal of stress including drought, overwatering, heat stress, nutrient deficiency, compaction, and contamination. Biochar, which has high carbon content and sorptive capacity, has been shown to improve soil hydraulic conductivity, immobilize contaminants, and increase cation exchange capacity. Previous research supports the use of biochar to improve soil characteristics in many management settings, yet the use of biochar in urban tree vault plantings has not been fully investigated. The purpose of this study is to observe the effects of biochar on soil quality, outflow water quality (a proxy for stormwater quality), and tree growth in simulated tree vaults. We hypothesize that the addition of biochar will increase tree growth and improve water quality leaving the vaults. We are examining four different methods for applying biochar (1% and 5% biochar mixed homogenously, 1% biochar added at surface, 1% biochar added at the bottom of simulated tree vaults, and a control). Two common street trees, Willow Oak (Quercus phellos) and Red Maple (Acer rubrum), were planted in each of these treatments in containers in early spring of 2022. We found increased tree growth and survival in both species with biochar treatments, except for the bottom treatment when compared with the control. The biochar treatments increased the pH and electrical conductivity of the stormwater. Additionally, the trees in vaults with biochar also had higher water retention, which may lead to less water stress. We expect that urban stormwater managers and arborists could use these recommendations for practices to improve stormwater and soil quality, slow stormwater runoff, and improve tree health.

6.4.6. Managing Stormwater From Interstate Highways in Atlanta, Georgia

Gary L. Hawkins[1], Gleicy Cavalcante[2], Ernest "Bill" Tollner[3], Jon Calabria[4], Alfred Vick[4]

[1]*University of Georgia,* [2]*Atkins Global Engineering,* [3]*College of Engineering, University of Georgia,* [4]*College of Environment and Design, University of Georgia*

Stormwater management can treat runoff by reducing sediment and nutrients from entering receiving streams or waterbodies. Untreated impervious areas, such as Interstate Highways, generate runoff with constituents harmful to water quality. We researched the potential of using stormwater control measures to manage the first flush of runoff and monitor runoff from a section of the intersection of I-20 and I-75 in Atlanta. The discharge from this intersection drains into the CSO of Atlanta and enters Intrenchment Creek. The project monitored the water entering a stormwater basin and the resulting drainage from the basin. Results indicate a greater than 80% decrease in nutrient content and greater than 95% reduction in sediment. Along with the field experiment an in lab experiment used a 1:10th scale model of the basin was constructed to better understand the flow of water in the basin to determine the potential for short circuiting. The presentation will show results from the research and propose modification to inform future construction of stormwater control measures.

Track 6, Session 5: Restoration & Management

6.5.1. Protecting Critical Infrastructure Along Eroding Streams Using Bioengineering Techniques and Stream Restoration Methodologies

William Rector[1], Flynt Barksdale[1]

[1]*Pond & Company*

As land development continues and our waterways experience increased stormwater runoff, erosion within our streams and river systems has caused significant problems as it relates to existing critical utility infrastructure. Sanitary sewer, stormwater, natural gas, potable water, and electrical infrastructure all interact with these stressed stream corridors. Stream erosion within these utility rights-of-way has caused exposure of this critical infrastructure, which can be exposed to threats such as impacts from floating debris and hydraulic pressure during significant storm events. Potential failures or significant damage to the utility infrastructure can cause releases which have the potential to threaten human life and the environment, inhibit product delivery, create expensive repair and clean-up expenses, and result in extensive regulatory oversight and potential fines.

Typically, stream channels within maintained rights-of-way tend to be more severely impacted by erosion than forested/naturalized reaches usually found upstream and downstream of the right-of-way. Exposed pipelines along an eroded stream channel often reveal a lack of woody vegetation within the right-of-way with incised beds, widened channel banks, lateral migration, and sloughing.

The purpose of this presentation is to explore and provide alternatives for the maintenance and installation protocols currently used by government and private entities responsible for maintaining these rights-of-way that reside parallel and/or perpendicular to these ailing stream systems. This presentation will also look at providing alternative methodology for repairing these eroding stream channels around exposed and/or endangered critical infrastructure using bioengineered techniques and stream restoration methodology. An engineering evaluation of multiple utility line exposures in the Southeast will be used to demonstrate this comprehensive approach.

6.5.2. Investigating Indigenous Relationships with Watershed and Rivercane Restoration Through Cooperation with a Cherokee Tribe

Alyssa Quan[1], Caleb Hickman[2]

[1]*Odum School of Ecology, University of Georgia,*
[2]*Eastern Band of Cherokee Indians Natural Resources Department*

Traditional ecological knowledges (TEK) hold deep understanding of complex relationships within socio-ecological systems. Rivercane (Arundinaria gigantea), a native bamboo plant culturally important to Native American peoples, plays a major role in sustaining both cultural practices and habitat for various riparian species. The Eastern Band of Cherokee Indians (EBCI), an indigenous tribe residing on the Qualla Boundary in western North Carolina, have cultivated rivercane for centuries. In coproduction with the EBCI, my research explores the effects of EBCI cultural practices on present-day rivercane ecosystems with regard to the role of indigenous TEK. Understanding TEK alongside mainstream scientific approaches is key to fully grasping the mechanisms behind rivercane's impact on the watershed ecosystem. We are conducting an experiment in an unmanaged canebrake in western North Carolina to determine how traditional artisanal harvesting methods affect the long-term growth of rivercane culms. Experimental plots are set in the canebrake in which to implement artisanal harvesting treatments. In addition to this treatment, we will also have control plots as well as a clearing treatment in which all culms are removed. We hypothesize that the artisanal harvesting will lead to increased culm width and height. We also hypothesize the cleared plots will have overall decreased average growth rates, but an increase in density of new shoots. Animal activity in and around the canebrake will also be recorded to determine the species assemblage supported by rivercane. The results of this study will help inform riparian restoration efforts by strengthening riparian science with cultural knowledge in ways that benefit both the rivercane ecosystems and tribal communities.

6.5.3. Application of a New Stream Condition Index to Calculate Average Annual Habitat Units

Bruce Pruitt[1], W. Todd Slack[1], K. Jack Kilgore[1], Andrew Carpenter-Crowther[2]

[1]U.S. Army Corps of Engineers, Engineer Research and Development Center, [2]U.S. Army Corps of Engineers, Memphis District

The Army Corps of Engineers (USACE) planning guidelines require that there be a quantity component to habitat assessment for determining Future-Without (FWOP) and Future-With (FWP) project conditions. The study area was in North DeSoto County, Mississippi which includes the Memphis, Tennessee area. The primary problems identified in the study area were the risk of flood damages resulting in accelerated erosion of stream banks, severe channel head cutting, loss of aquatic habitat, and biological impairment. Average Annual Habitat Units (AAHU) have been used to estimate project cost/benefits and forecast FWOP and FWP using Habitat Suitability Indexes (HSI, Habitat Evaluation Procedure (HEP, USFWS)). A common risk in determining FWOP versus FWP from AAHUs generated from HSI of evaluation species is a suite of functions and processes are not accounted for including stream and valley components (e.g., riparian zone condition) and especially, engineering structural design. The Stream Condition Index (SCI) provides a promising model to bridge the gap between stream physical and biological conditions and HSI. The SCI, was formulated and verified for use at three scales (listed from the ground up): 1) Surface Assessments or project footprint scale; 2) Low-Altitude Photogrammetry; and 3) GIS Satellite Scale. The SCI models were formulated, verified and validated on fifteen variables across 65 unique field sites within the study area. Good correspondence was observed between the three vertical scales. SCI scores estimated at the GIS satellite scale provides: 1) prioritization of stream segments and watersheds for restoration, enhancement, preservation (conservation), and future risk of aquatic impacts; 2) a means of addressing impacts or improvements beyond the project footprint; and 3) assessment of conditions elsewhere including determining departure from attainable reference conditions. This research will make significant advances in project planning, assessment, implementation and monitoring including development of performance standards and success criteria.

6.5.4. -6.5.5. Forests as Filtration: Managing Forests to Protect Drinking Water Sources

Nick DiLuzio[1], Kathy Hawes[2]

[1]Georgia Forestry Foundation, [2]Southeastern Partnership for Forests and Water

Healthy forests improve water quality by regulating stormwater and filtering pollutants. Therefore, the management and conservation of forests adjacent to and upstream of drinking water intakes is a necessary component of any utility's source water protection plan. By managing and protecting woodlands in their watersheds, utilities are achieving bottom-line savings by reducing pretreatment costs and minimizing the need for expensive equipment upgrades.

The direct and positive impacts of healthy, managed forests on water quality and quantity – called the "forest-water connection" – have been studied at length and are widely accepted. Since state and private forest lands provide some portion of the drinking water for over 50 million people in the Southeast alone, the management and protection of those forests must be prioritized by utilities wishing to secure clean and abundant drinking water for the long term.

This work is most efficiently and effectively accomplished through collaboration. When partners from forestry, water, industry, and conservation come together, overlapping goals are easily identified. And by including multiple partners to achieve watershed-scale improvements to land and water, utilities can find new and increased funding sources for robust improvements to their source water protection programs.

Appreciating the forest-water connection is critical to a utility's future planning. The rapid development seen in many areas of the country results too often in massive forest conversion, and utilities are left struggling with expensive water quality problems. The presentations in this session will provide utilities with timely and innovative options for long-term source water protection.

6.5.6. Recent Findings Related to Submarine Groundwater Discharge and Eastern Oysters in Georgia

Jacque Kelly[1], John M. Carroll[1], Walker De La Torre[1]
[1]Georgia Southern University Department of Geology and Geography, [2]Georgia Southern University Department of Biology

Submarine groundwater discharge (SGD) is a natural process that transports groundwater and dissolved constituents to coastal zones worldwide. In many locations, SGD represents a major but inadequately constrained piece of coastal marine water and chemical budgets because it is spatially and temporally heterogeneous and because it can be difficult to identify. However, SGD has been proven to both positively and negatively impact various coastal ecosystems. Eastern oysters (Crassostrea virginica) are commercially important coastal species that provide many ecosystem services. Unfortunately, 85% of oyster reefs have been lost globally, prompting investments in restoration efforts to rebuild populations. Resource managers consider numerous environmental and water quality parameters when making restoration decisions. One understudied parameter that resource managers should consider is SGD. This presentation will provide an overview of recent research and findings that advances knowledge about the relationships between SGD, sedimentation, and eastern oysters. Although complex, in general, we find that SGD may result in localized areas of low dissolved oxygen and low pH that could inhibit oyster recruitment, growth, and survival. Thus, SGD appears to negatively impact eastern oysters in Georgia. With our current knowledge, we recommend that oyster resource managers who work in Georgia consider avoiding restoration efforts in areas with visible SGD as SGD appears to be a chronic stressor for eastern oysters.

Track 6, Session 6: Road Crossings Vulnerability

6.6.1.-6.6.3. Assessment of Road/Stream Crossings Structure Failure Vulnerability Under Extreme Precipitation Intensities Scenario: Culvert Mouth Silting Probability

Akshat Biswal[1], Sudhanshu S. Panda[1], Vihaan Kesharwani[1], Sajal Sabat[1]
[1]University of North Georgia

Forest road/stream crossings structures are more vulnerable to failure due to high gradient topography of major forestlands and recent extreme precipitation events. Failure of these culverts are getting enhanced due to increasing siltation at the culvert mouth. Therefore, goal of this study is to develop an automated geospatial model of Modified Revised Soil Loss Equation (M-RUSLE) to determine the siltation probability of each culvert due to the eroded soil coming to the culvert from their respective watersheds. This model result is combined with another culvert failure vulnerability assessment model - streambank erosion spatial vulnerability assessment (SBEVA) determines, the culvert structure failure vulnerability so that pro-active management decisions can be undertaken to safeguard the most vulnerable structures from failing miserably so that more fund would be warranted to replace or maintained it. M-RUSLE was developed to estimate pixel based erosion amount, which uses the proven empirical equations using R (Rainfall erosivity factor), K (Soil erodibility factor), L (Slope length factor), S (Slope gradient factor), C (Crop/vegetation management factor), and P (support practice factor) factors for erosion prediction. We used NOAA developed precipitation frequency estimated for100-year recurrence interval, 30-minute duration, partial duration series data to develop the Isoerodent map of the study area. The R-factor on pixel basis were determined from the Isoerodent map. The K, L, and S-factors were determined from gSSURGO data. Classified ultra-high resolution orthoimagery provided accurate and timely C-factor raster, which got developed using the Normalized Difference Vegetation Index raster. The P-factor raster was created with latest field information along with landuse-classified data. This study results of our area of interest, a HUC12 watershed that represent the uppermost part of Chattahoochee River in Georgia. The summed erosion amount of each individual culvert exit point contributing watersheds created in QSWAT. Thus a siltation-based culvert failure vulnerability map got developed.

6.6.2. Assessment of Road/Stream Crossings Structure Failure Vulnerability under Extreme Precipitation Intensities Scenario: Probable Culvert Location Determination.

Vihaan Kesharwani[1],Sudhanshu S. Panda[1], Akshat Biswal[1], Sajal Sabat[1]
[1]University of North Georgia

Forest road/stream crossings structures are more vulnerable to failure due to high gradient topography of major forestlands and recent extreme precipitation events. Even, detecting the spatial locations of these culverts are difficult as they are built long before and forgotten. Therefore, goal of this study is to develop an automated geospatial model to determine the possible locations of the forest (less accessed) road culverts and field verify them. Another objective of the study to create watersheds for the each verified culverts so that supporting culvert structure failure vulnerability assessment will be identified to take pro-active management decision to safeguard the most vulnerable structures t failed miserably so that more fund would be warranted to replace or maintained it. Finding each culverts in not-easily accessed roads are difficult through basic scouting. However, it is understood that when a road crosses a stream, a culvert/bridge is needed to be constructed. Using same principle, we have developed an automated geospatial model that uses an intense stream network obtained through the ArcHydro applications of DEM reconditioning, fill sink, flow direction mapping, flow accumulation raster development, stream link and stream network delineation along with catchment processing and a detailed road network (available trail networks) obtained from Open Street Map. Both were reclassified as rasters with a value of 1 and later combined to a single rasters to provide pixels with values of 2, where both the stream and road raster pixels overlapped. The obtained culvert locations were field-verified using GNSS equipment and subsequently, the Culvert location database got updated. The updated culvert location data layer was used in QSWAT to obtained watershed layer for each culverts as exit points. This study results are used in succeeding models to determine the culvert structure vulnerability to failure in climate change impacted extreme precipitation condition.

6.6.3. Geospatial Engineering and Technology Based Modeling Approach for Groundwater Depletion-Related Environmental Vulnerability Study

Sudhanshu S. Panda[1], Prahalad Jat[1]
[1]*Institute for Environmental Spatial Analysis, University of North Georgia*

Sinkholes are common and naturally occurring geologic feature in Florida, South Georgia and South Alabama and being intensified by improperly managed ground water withdrawal for agricultural, industrial, and domestic use. Similarly, ground/soil subsidence occurs by excessive exploitation of aquifers. Both are a major geohazard in United States and the world. Karst topographic terrain, a major reason of sinkholes formation, evolves through dissolution of the bedrock (limestone) and development of efficient underground drainage. Sinkhole openings have major environmental consequences, i.e., polluting groundwater when sinkholes opens in superfund and landfill site locations. Soil subsidence causes severe human infrastructures damage triggering important economic losses. The main goal of this study is to develop an automated geospatial model to determine the potential vulnerable locations for sinkholes, spatial groundwater contamination vulnerability using DRASTIC modeling approach, and locations of soil subsidence in south Georgia and northern Florida. Five types of geospatial data – Geology, gSSURGO (soil), land cover (NLCD 2011), aquifer, and USGS groundwater well were collected, geoprocessed, and analyzed in ArcGIS ModelBuilder to obtain the final sinkholes spatial vulnerability map of the study area. Another model was created developing DEM from latest LiDAR data of the region and overlaying with 10 and 30m DEMs of 2000 and 1980s, respectively. Geology layer was reclassified into classes of carbonite, loose sediments, and clastic sedimentary rocks of different sinkholes risks. The soil Permeability and Drainage features, surface interpolated aquifer top-depth and groundwater well depth layers, and land cover layer were and reclassified according as sinkhole vulnerability layer. Each reclassified layers were assigned sinkholes risk potential weights, developed through thorough literature review and personal expertise. All the weighted layers were analyzed integratively using weighted sum function of ArcGIS to obtain final classified sinkholes risk probability raster. Historical Sinkholes spatial data were used to validate our results. Amazingly, 85% accuracy were obtained from the study. It was also observed that metric level soil subsidence has occurred in the study area. The study would provide decision support for environmental managers, land-use planners, and other stakeholders for watershed management.

6.6.4. Assessment of Road/Stream Crossings Structure Failure Vulnerability under Extreme Precipitation Intensities Scenario: Streambank Erosion Vulnerability Analysis

Sajal Sabat[1] Sudhanshu S. Panda[1], Vihaan Kesharwani[1], Akshat Biswal[1]
[1]*University of North Georgia*

Forest road/stream crossings structures are more vulnerable to failure due to high gradient topography of major forestlands and recent extreme precipitation events. Failure of these culverts are getting enhanced due to increasing siltation at the culvert mouth and excessive streambank erosion probability is a major cause of the siltation. Therefore, goal of this study is to develop a streambank erosion spatial vulnerability assessment (SBEVA) model to determine the culvert structure failure vulnerability so that pro-active management decisions can be undertaken to safeguard the most vulnerable structures from failing miserably so that more fund would be warranted to replace or maintain it. The study was conducted for a HUC12 watershed that represents the uppermost part of Chattahoochee River in Georgia. We developed the SBEVA model in ArcGIS ModelBuilder using spatial data like 100 feet buffered along the stream networks (developed in ArcHydro) landuse, digital elevation models (DEM), soil characteristics, and design flood discharges calculated using 100-year recurrence interval 24-hour partial duration series storm data. Landuse data was created with orthoimagery segmentation using object based image analysis (OBIA) classification and groundtruth-based accuracy assessment. DEM (3m) was obtained from Geospatial Data Gateway. High-resolution (10 m) gridded SSURGO (gSSURGO) soil data was used to develop various characteristics raster for the model. The 100-yr storm discharge record was obtained from National Oceanic & Atmospheric Administration (NOAA). These spatial environmental variable rasters were reclassified with their vulnerability probability scale developed through Delphi weighted scale method. The combined parameters overlaid model provided the qualitative-scale vulnerability results of all the streams (created by watershed delineation methodology of ArcHydro) in the watershed including structure locations. 'Zonal Statistics' analysis was conducted for each culvert-watershed that was created in QSWAT to determine the culvert failure vulnerability on a High-moderate-low scale. The SBEVA based siltation-probability map explained the culvert condition.

6.6.5. No talk slated

6.6.4. No talk slated