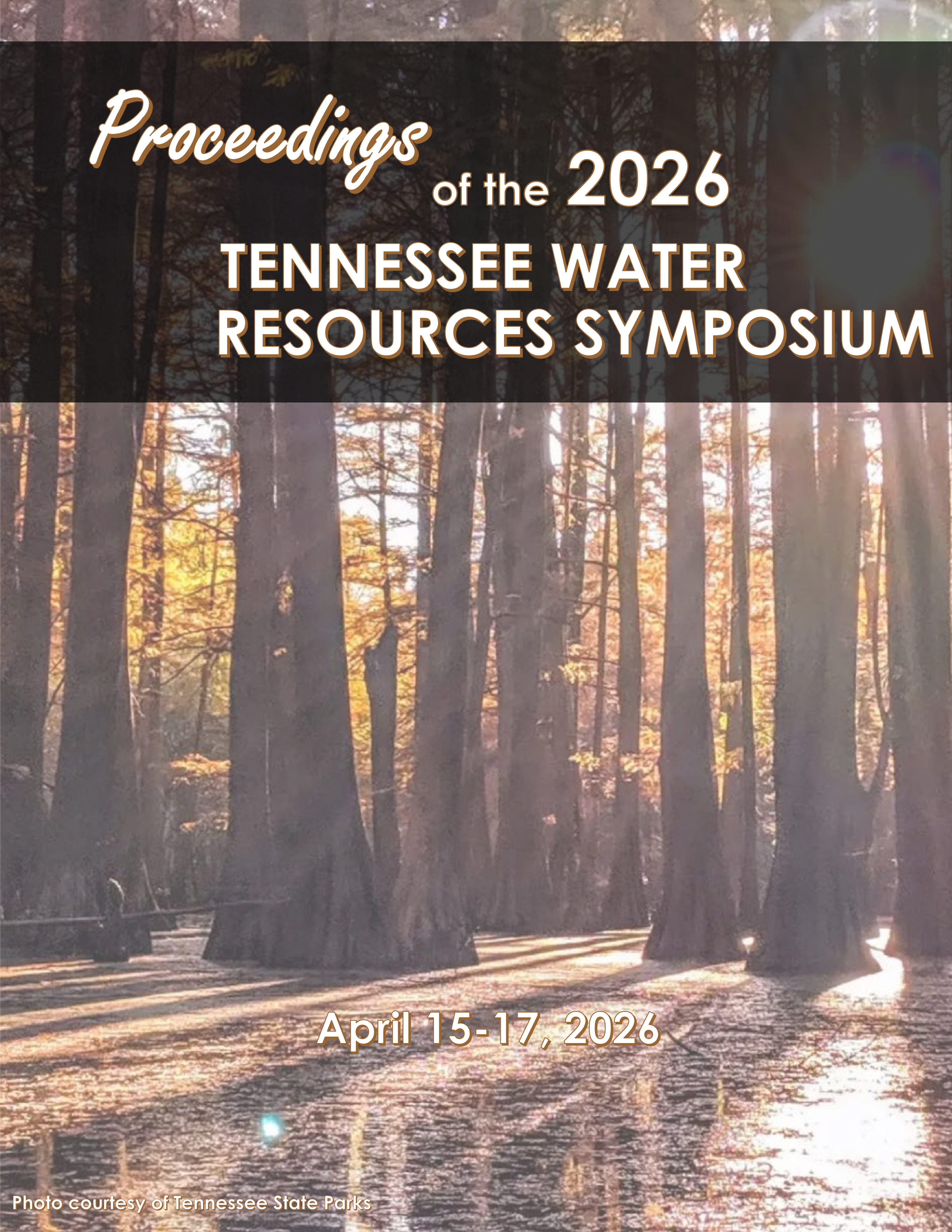
Proceedings of the 2026 TENNESSEE WATER RESOURCES SYMPOSIUM

April 15-17, 2026



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Proceedings from the

35^{th} Tennessee Water Resources Symposium

Montgomery Bell State Park
Burns, Tennessee

April 15-17, 2026

Sponsored by

Tennessee Section of the
American Water Resources Association

In cooperation with the Planning Committee

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PREFACE

On behalf of the planning committee, it is my honor as Symposium Chair to welcome everyone to the 2026 Tennessee Water Resources Symposium. The theme of the Symposium is "Navigating Changing Times," and we are excited to have Robert Stewart, Oak Ridge National Laboratory's Geospatial Science and Human Security Division Section Head, as the keynote speaker during lunch on Wednesday, and Tom Barnett, the Vice President for River Operations at the Tennessee Valley Authority, as the luncheon speaker on Thursday.

For over thirty years, this symposium has brought together water professionals from across the state and beyond to share knowledge, experience, expertise, insights, and passion, creating a unique opportunity for us all to play a critical role in the health and vitality of Tennessee's water resources. This year, we once again have an outstanding slate of presenters, moderators, and panel members that will continue the legacy as we navigate these changing times in our quest for continued protection and celebration of Tennessee's waters.

I would like to thank the entire planning committee for making this Symposium possible. Without paid staff, our organization relies on the voluntary actions of our members to keep this thing going. I have had the honor of serving on the planning committee for a few years now, and each year, I am blown away by the dedication of our officers and planning committee members that work diligently to ensure an impactful and enjoyable event for all.

We would also like to acknowledge our sponsors and exhibitors who make the symposium possible through their support. Please make sure to stop by the Exhibit Room to learn more about these organizations, partners, and businesses.

Sincerely,

Andrea Ludwig, PhD
President, Tennessee Section AWRA
2026 Conference Chair

LIST OF ATTENDEES

Attendee Name	Company, College, or Institute Name
Ryan Adams	U.S. Geological Survey
Kwesi Ahene	Tennessee Technological University
Brian Alford	Tennessee Wildlife Federation
Tamara Alimurka	University of Tennessee, Knoxville
Jaimie Armitage	Barge Design Solutions
Priyanka Bajracharya	Tennessee Technological University
Ashby Barnes	TDEC Division of Water Resources
Ken Barry	Civil & Environmental Consultants, Inc.
Hannah Bates	Davey Resource Group
Thomas Becktold	ARCADIS
Matt Beeler	Tennessee Department of Transportation
Brian Bendis	Xylem/YSI
Meagan Bertoli	Lord & Winter, LLC
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Charles Bohac	CEB and Associates
Claire Bohman	University of Tennessee, Knoxville
Dorie Bolze	Harpeth Conservancy
Emma Bradford	Neel-Schaffer, Inc.
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Jeremy Branch	Neel-Schaffer, Inc
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Andy Brown	Appalachian Resource Conservation & Development (ARC&D) Council
Beverly Brown	TDEC Division of Water Resources
Keven Brown	Tennessee Department of Transportation
Laurence Brown	Metropolitan Government of Nashville and Davidson County - Metro Water Services
Madalyn Brown	Tennessee Department of Transportation
Robert Brown	Oak Ridge National Lab
Bradan Bruce	University of Tennessee, Knoxville
Mary Bruce	Metropolitan Government of Nashville and Davidson County - Metro Water Services
Natalie Burger	Resource Environmental Solutions
Gerald Burnette	Civil & Environmental Consultants, Inc.
Karina Bynum	TDEC Division of Water Resources
Steve Byrson	Vertex Industrial Communications
Janey Camp	University of Memphis
Jordan Campbell	Tennessee Department of Transportation
William Cantrell	Tennessee Valley Authority
Macy Carman	University of Tennessee, Martin
Andy Carroll	Skytec
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Natalie Crisci	TDEC Division of Water Resources
Quinn Cypher	Knox County Engineering & Public Works - Stormwater

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Andrew Dickerson	East Tennessee State University
Fuhar Dixit	University of Tennessee, Knoxville
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Jillian Gorrell	Appalachian Resource Conservation & Development (ARC&D) Council
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Darrell Guinn	Tennessee Valley Authority
Brian Ham	TDEC Division of Water Resources
Tyler Hand	Ducks Unlimited
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Michael Harrison	Tennessee Technological University
Evan Hart	Tennessee Technological University
Jon Hathaway	University of Tennessee, Knoxville
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Ben Heath	Tennessee Valley Authority
Bradley Heilwagen	WSP

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Ian Hopkins	University of Tennessee, Martin
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Andrea Jaegge	TDEC Division of Water Resources
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Laura Jones	Pape-Dawson
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Joseph Lane	CAESER - University of Memphis
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Gage Lineberry	Tennessee Technological University
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Andrea Ludwig	University of Tennessee, Knoxville
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Grant Lynch	Resource Environmental Solutions
Carter Lynes	FLW Southeast, Inc
Curtis Maffei	Tennessee Valley Authority
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Colby Mann	Tennessee Department of Transportation

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Regan McGahen	TDEC Division of Water Resources
Taina McLeod	Tennessee State University
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Justin Medley	Tennessee Technological University
Scott Medlin	Tennessee Department of Transportation
Claudio Meier	University of Memphis
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Mark Miller	Komline AquaShield
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Gregory Nail	University of Tennessee, Martin
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Jim Parham	Trutta Environmental Solutions
Wesley Peck	Tennessee Department of Transportation
Mike Perkins	Barge Design Solutions
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Josh Rowe	Civil & Environmental Consultants, Inc.

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Rodrigo Ruiz	CAESER - University of Memphis
Daniel Saint	Tennessee Valley Authority
Jimmy Scales	Tennessee Department of Transportation
Janelle Schlamp	Barge Design Solutions
Marshall Schmitt	Oak Ridge National Lab
Scott Schoefernacker	Protect Our Aquifer
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Taylor Simpson	Tennessee Department of Transportation
Josh Sitz	KCI Technologies
Katey Slack	Tennessee Wildlife Federation
Kelly Smith	Stantec
Liz Smith	EPA Region 4
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Adam Spiller	KCI Technologies
David Spinks	Tennessee Department of Transportation
Will Stanley	Stantec
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Robert Stewart	Oak Ridge National Lab
Chester Sutherland	Tennessee Department of Transportation
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Brian Waldron	CAESER - University of Memphis
Forbes Walker	University of Tennessee, Knoxville
Madeline Walker	SEBA
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Michael Wellbaum	Pape-Dawson
Drew Westerman	U.S. Geological Survey
Grace White	Tennessee Technological University

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Mike Williams	Civil & Environmental Consultants, Inc.
Shannon Williams	U.S. Geological Survey
Scott Wilson	Palmer Engineering
Lindsay Wilson-Kokes	Civil & Environmental Consultants, Inc.
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DJ Wiseman	Tennessee Department of Transportation
JoTing Wong	Tennessee Technological University
Jesse Wooden	Tennessee Department of Transportation
Mary Yaeger	CAESER - University of Memphis
Gina Yao	Tennessee Department of Transportation
Nick Zemlachenko	TDEC Division of Water Resources
Xi Zhang	University of Tennessee, Knoxville
Xinghan Zhao	University of Tennessee, Knoxville
Jon Zirkle	Benesch
Ben Zoeller	WSP

Keynote Speakers

Wednesday, April 15th

Robert Stewart

Geospatial Science and Human Security Division Section Head, Oak Ridge National Laboratory

"Water Under Pressure: National Security Challenges When Water Becomes Too Little, Too Much, and Too Contested"

Thursday, April 16th

Tom Barnett

Vice President River Operations, Tennessee Valley Authority

"Hurricane Helene Response and Recovery"

Pre-Symposium Workshop

"Implementing an Urban Waters Report Card in Tennessee"

The University of Tennessee has partnered with municipal governments and state agencies to develop an Urban Waters Report Card (UWRC) for Tennessee. The goal is to provide municipal governments with a way to track incremental improvements in their streams – from stormwater management to stream rehabilitation efforts. This is not a regulatory program, but instead, an initiative to help better equip communities to identify challenges and opportunities related to hydrology, water quality, wildlife habitat, and community value of local streams. The UWRC has been piloted by municipalities across the state over the past year. Workshop attendees will learn about the initiative and how to implement the rating process in their streams.

PRESENTATIONS

SESSION 1A

SESSION 1B

POSTERS

SESSION 1A

Wednesday, April 15th at 1:30pm - 3:00pm
STORMWATER MANAGEMENT
(Moderator: Paul Davis)

Status of ASTM Committee E64 Standards Relating to Protocols, Practices and Specifications for Stormwater Control Measures
M. Miller

Critical Coarse Substrate Supply in Urban Streams: An Overview
K. Barry

Real-Time Control for Enhanced Urban Stream Function
J. Hathaway

Wednesday, April 15th at 3:00pm - 5:00pm
MODELING
(Moderator: DJ Wiseman, TDOT)

Streamlining PLET Modeling for Watershed Planning in Tennessee
E.G. White, T. Datta

A Hydrologic Simulation-free Approach for Assessing the Performance of Candidate Implementation Scenarios for Stormwater Control Measures
C. Meier, F. Dell'Aira, N. Kafle, J. Hathway

Full-scale Physical Modeling and CFD Simulations for Assessing the Performance of TDOT's New End-of-Bridge Drainage Standard
A. Shrestha, K.R. Regmi, S. Sukupayo, C. Meier

STATUS OF ASTM COMMITTEE E64 STANDARDS RELATING TO PROTOCOLS, PRACTICES AND SPECIFICATIONS FOR STORMWATER CONTROL MEASURES

Mark Miller

ASTM Committee E64 on Stormwater Control Measures (SCMs) has published a series of standards relating to protocols and practices for manufactured water quality treatment devices (MTDs). Consensus-based standards have been developed to objectively measure the performance of MTD technologies to provide improved assurance on the efficacy of tested and verified technologies. This presentation will discuss the ASTM standards process and how it produces consistent quality procedures and products for the benefit of all stakeholders. An overview of these standards will be provided to gain insight into their rationale and essential elements. This presentation will also explore the potential benefits of using these standards as part of an SCM regulatory program; and what implementation of these standards within an authority having jurisdiction (AHJ) could look like. The prospect of a national verification process for ASTM standards via the Stormwater Testing and Evaluation of Products and Practices (STEPP) initiative will also be discussed. The overall intent of the ASTM standards process is to provide a high level of confidence to AHJs that the MTDs will provide long term and consistent treatment to meet water quality goals.

Four E64 subcommittees are actively developing SCM standards for laboratory evaluations (E64.01), field evaluations (E64.02) component evaluations (E64.03) and terminology (E64.09). Laboratory-based standards to date apply to hydrodynamic separation and settling devices, filtration technologies, as well as a unique standard for trash & debris capture (≥ 5 mm in two directions). A field-based standard focuses on the practice of collecting paired influent and effluent flow-weighted composite samples using automated samplers. General specifications address standard terminology for SCMs, hydraulic characteristics and silica-based test sediment.

Eleven new standards are in progress. A practice for determining annual rainfall weighting factors for use in sizing SCMs is nearing completion. Microplastics is a growing concern and is a topic of standard development as well. A standard test method for laboratory testing of wrapped chambers for stormwater treatment is underway. Street sweeping currently lacks an ASTM standard and is under consideration. Another working item addresses a specification for organic and hydrocarbon test constituents for the evaluation of MTDs. The expanding use of continuous monitoring and adaptive controls (CMACs, “smart ponds”) as a component of SCMs may warrant a standard. Field data transferability will address a practice to apply field test data from a given location to another location where rainfall patterns differ from the test location.

CRITICAL COARSE SUBSTRATE SUPPLY IN URBAN STREAMS: AN OVERVIEW

Ken Barry, PE, BC. WRE, F. ASCE[1] and Patrick L. McMahon, PhD, PE, CFM[2]

Much of urban stormwater management has focused on preventing the introduction of nutrients and pathogens from the landscape and sanitary overflows/cross-connections as well as fine sediment from construction sites and roads and ameliorating the potential for hydromodification from increased storm flow durations, volumes, and peaks. The role of coarse substrate supply in urban stream health is recognized but has not been a primary focus. This presentation overviews the role of sediment in streams, hydromodifications effect on coarse sediment and substrate, assessment approaches, and potential prevention and mitigation approaches.

[1] Principal, CEC, Inc., 2704 Cherokee Farm Way, Suite 101, Knoxville TN 37920 kbarry@cecinc.com
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REAL-TIME CONTROL FOR ENHANCED URBAN STREAM FUNCTION

Jon Hathaway

Retrofitting static stormwater infrastructure with controllable valves has been investigated as a means to mitigate the effects of overburdened infrastructure. However, few case studies exist which quantify the impact of water release from actively controlled stormwater assets on receiving waters. To address this, a system of four dry extended detention basins were retrofitted with controllable valves in Knoxville, TN. Water quality and flow were monitored in the receiving stream to assess the impacts of this intervention. Coupled with this physical system was a computational model designed to allow testing of possible in-stream outcomes based on various control rules. This presentation discusses project results, lessons learned, and the path forward for technology in stormwater systems.

STREAMLINING PLET MODELING FOR WATERSHED PLANNING IN TENNESSEE

E. Grace White, Tania Datta

Watershed plans are essential for managing and restoring Tennessee's waterways. These plans document current environmental conditions, estimate potential pollutant loads, recommend best management practices (BMP) to address impairments, and fosters partnerships among water resources decision-makers to sustain improvements within a watershed. Modeling plays a critical role in watershed plans by estimating pollutant loads from existing land use, evaluating effectiveness of existing BMPs, and predicting nutrient load reduction from proposed BMPs. Many models with varying complexities are available for watershed modeling; however, the EPA's Pollutant Load Estimation Tool (PLET) is one that is widely adopted across watershed planning groups in Tennessee. Although relatively simple, PLET's accuracy depends on data inputs and assumptions, which can significantly impact its outcomes. This study aims to develop a framework for using PLET in watershed modeling, and to provide guidance for consistent, accurate modeling practices to address critical impairments Tennessee's waterways. Establishing a uniform modeling methodology will enable statewide consistency in considering data sources and assumptions and facilitate comparison across watershed plans developed by different users. This framework was developed through the combined efforts of statewide PLET users. These users come from various backgrounds, and all have a vested interest in improving Tennessee's water quality. This user group held frequent meetings to examine PLET inputs, sources, and modeling methodology for BMPs. This collaboration resulted in stronger methodology for building watershed plans for the health of Tennessee's waterways.

A HYDROLOGIC-SIMULATION-FREE APPROACH FOR ASSESSING THE PERFORMANCE OF CANDIDATE IMPLEMENTATION SCENARIOS FOR STORMWATER CONTROL MEASURES

Francesco Dell'Aira[1] Ph.D., Nischal Kafle[1], Jon Hathaway[2] Ph.D., and Claudio I. Meier[1] Ph.D.

Amid the climate driven intensification of extreme flooding, decentralized stormwater control measures (SCMs) have gained increasing popularity as supplements to traditional drainage infrastructure in urban watersheds. Retaining runoff near its source enhances flood mitigation, strengthens resilience, and reduces ecological impacts such as the "urban stream syndrome." A central challenge, however, is determining where to place SCMs within urban basins to maximize hydrologic benefits while balancing hydrologic, ecological, social, and economic considerations. This is traditionally addressed by calibrating a hydrologic model for the area of interest and simulating the performance of multiple candidate SCM implementation scenarios. Yet this process can be operationally intensive due to the difficulty of obtaining the necessary data and the need to perform model calibration.

To overcome this barrier, we introduce a new GIS based framework for comparing SCM configurations based on basin wide hydrologic connectivity. By characterizing how land use and land cover patches—from highly developed to densely vegetated, including SCMs—interact across topographic gradients, our framework helps identify optimal locations for SCM installation by targeting major runoff pathways. The method provides relative measures of hydrologic disconnection across alternative SCM layouts. This conceptual yet comprehensive metric can replace physically based simulations, substantially reducing data needs, computational time and calibration requirements. The resulting optimal SCM layouts are consistent with those derived from traditional modeling approaches, as shown for a few case-study watersheds.

[1] The University of Memphis, Department of Civil, Construction, and Environmental Engineering
[2] University of Tennessee - Knoxville, Department of Civil and Environmental Engineering

FULL-SCALE PHYSICAL MODELING AND CFD SIMULATIONS FOR ASSESSING THE PERFORMANCE OF TDOT'S NEW END-OF-BRIDGE DRAINAGE STANDARD

Ashish Shrestha, Khem Raj Regmi, Serox Sukupayo, and Claudio I. Meier

Effective management of stormwater runoff on bridge decks is critical for commuter safety and structural integrity. This study evaluates the hydraulic performance of the new Tennessee Department of Transportation's (TDOT) standard for bridge deck drainage, which utilizes a side inlet functioning as a lateral weir and diverts water into an embankment flume. To quantify the interaction between bridge deck geometry and inlet efficiency, the methodology employed a CFD-physical modeling coupled approach. This involved a full-scale physical model (12 ft x 48 ft) used in tandem with high-fidelity Computational Fluid Dynamics (CFD) simulations. The numerical study utilized the OpenFOAM environment with the k-omega SST turbulence model and the Volume of Fluid (VoF) method to accurately capture the free-surface flow dynamics. A parametric study was conducted across twelve scenarios, combining two cross slopes (2% and 4%), three longitudinal slopes (0.5%, 2%, and 6%), and two discharge rates (1.0 cfs and 1.5 cfs). Results indicate that capture efficiency is sensitive to bridge geometry, ranging from a minimum of 29% (at 6% longitudinal and 2% cross slopes) to a maximum of 93% (at 0.5% longitudinal and 4% cross slopes). The efficiency decreased with steeper longitudinal slopes and higher discharge rates, while increasing with steeper cross slopes. These findings suggest that the current TDoT standard requires design modifications to improve capture performance under high-velocity conditions. Based on our results, we recommend optimizing the inlet geometry by testing different depression geometries, to minimize water depths and spreads over the bridge deck.

SESSION 1B

Wednesday, April 15th at 1:30pm - 3:00pm
WASTEWATER
(Moderator: Jessica Rader, TDEC)

AI-Driven Sewer Monitoring: Predictive Detection of Blockages and Infiltration for Modern Wastewater Networks
D. Mendoza

Path-Dependent Responses of Anaerobic Digestion Systems to Repeated Temperature Disturbances
X. Zhao

Nutrient Removal in a Stream Receiving Treated Wastewater and Industrial Effluent
R. Brown, E. Johnson, S. Brooks, N. Griffiths

Wednesday, April 15th at 3:00pm - 5:00pm
BIOMONITORING
(Moderator: Rich Cochran, TDEC)

Streamside Salamanders in Tennessee: Surveys and Urban Impacts
A. Humphrey

A Statewide Survey of Algal Bloom and Cyanotoxin Distribution in Tennessee Surface Waters
J. Murdock, J. Li, A. Rosson

Biomass and Structure of Infralittoral Algal Assemblages Revealed by Computation of Taxon Importance Values in an Eutrophic Reservoir
K. Davis, L. Brown, C. Fecteau, M. Freeman, M. Halstead, M. Kubr, M. Litchfield, M. Meyer,, B. Peeler, A. Porter, P. Stafford, J. Zydel, Z. Melendrez, J. Lebkuecher

AI-DRIVEN SEWER MONITORING: PREDICTIVE DETECTION OF BLOCKAGES AND INFILTRATION FOR MODERN WASTEWATER NETWORKS

Daniel Mendoza

Wastewater utilities face mounting challenges as aging infrastructure, climate-driven rainfall variability, and increasing regulatory expectations place unprecedented pressure on sewer networks. Traditional sewer monitoring methods often rely on manual inspections or reactive alerts, resulting in emergency callouts, service disruptions, and environmental compliance risks. As communities demand more reliable and sustainable wastewater services, utilities must adopt technologies that enable earlier issue identification and more efficient asset management.

This presentation explores a next-generation artificial intelligence platform engineered to predict sewer blockages and infiltration events before they impact operations. The system analyzes real-time level data from manholes, CSO structures, and rainfall inputs to detect irregular trends that signal developing obstructions, infiltration, or inflow-related anomalies. Unlike traditional hydraulic modeling approaches, the solution requires no historical level data, no network schema, and no calibrated hydraulic model—making deployment fast, scalable, and practical for both large and small utilities.

Using advanced machine-learning algorithms, the system continuously evaluates sensor behavior, compares patterns across the network, and generates predictive alerts up to two weeks before potential failures. These early insights enable utilities to prioritize maintenance, optimize field resources, reduce emergency responses, and prevent environmentally harmful overflows. Case studies from active deployments demonstrate significant improvements in operational reliability, regulatory compliance, and cost efficiency.

Attendees will gain an understanding of the platform's AI engine, dashboard interface, deployment workflow, and integration approach. The session will also highlight best practices for introducing predictive analytics into wastewater operations, including lessons learned, data-quality considerations, and strategies for scaling the technology across diverse sewer environments.
This presentation is designed for utility managers, engineers, regulators, and technology professionals seeking practical, proven methods to modernize wastewater network management through AI-driven intelligence.

PATH-DEPENDENT RESPONSES OF ANAEROBIC DIGESTION SYSTEMS TO REPEATED TEMPERATURE DISTURBANCES

Xinghan Zhao

Anaerobic digestion (AD) systems used in wastewater treatment are increasingly exposed to temperature fluctuations due to climate variability, operational constraints, and energy optimization strategies. However, the extent to which prior thermal exposure alters subsequent system performance remains poorly understood. This study investigated the long-term, path-dependent effects of repeated temperature disturbances on reactor performance using a controlled, multi-phase experimental design.
Twelve lab-scale anaerobic reactors were initially stabilized at 35 °C and then subjected to different temperature histories, including moderate (38–41 °C) and high (44 °C) thermal disturbances, followed by recovery periods at 35 °C. A second, uniform high-temperature disturbance was subsequently applied to all treatment reactors. Reactor performance was monitored daily for over one year, including pH, total biogas production, and methane production. Linear mixed-effects models were used to quantify the effects of treatment history, experimental phase, and their interaction while accounting for repeated measurements over time.

Results demonstrated that temperature disturbances induced persistent, treatment-specific performance trajectories that could not be explained by operating temperature alone. Reactors with prior exposure to higher thermal stress exhibited disproportionately greater declines in methane production and gas yield during the second disturbance, along with delayed and incomplete recovery following temperature normalization. Notably, performance differences persisted even when all reactors were operated under identical conditions, indicating strong legacy effects of prior thermal exposure.

These findings highlight that anaerobic digestion systems exhibit path-dependent behavior under repeated thermal stress, with disturbance history exerting a lasting influence on functional resilience. From an engineering perspective, the results suggest that operational decisions involving temperature elevation may have cumulative impacts on system stability and recovery potential. Incorporating disturbance history into reactor management and resilience assessment frameworks may improve the robustness of AD systems facing increasingly variable operational environments.

NUTRIENT REMOVAL IN A STREAM RECEIVING TREATED WASTEWATER AND INDUSTRIAL EFFLUENT

Ethan Johnson[1], Robert Brown[2], Scott Brooks[2], Natalie Griffiths[2]

Nutrient removal within developed watersheds is a critical ecosystem function that mitigates downstream eutrophication. Routine monitoring of stream nutrients (i.e. nitrate) and a conservative tracer (i.e. chloride) below wastewater treatment and/or industrial outflows facilitates calculation of nutrient uptake patterns that inform stakeholders of nutrient export potential from a watershed. We investigated nitrate uptake patterns in a stream receiving consistent nitrate enrichment from industrial effluent in its headwaters (upstream reach) and treated wastewater (downstream reach). On seven sampling dates for each reach (October 2023 – December 2024), we calculated nitrate uptake length (S_w), which quantifies the average distance a molecule travels in the water column before uptake, uptake velocity (V_f), which accounts for stream width and flow, and areal uptake (U), which normalizes uptake rates per unit area of streambed. In the upstream reach, S_w ranged from 15.3 to 71.1 km, V_f ranged from 0.002 to 0.007 mm/min, and U ranged from 2.1 to 23.0 g/m^2/min, with 1,341 to 3,493 µg NO_3-N/L at the top of the reach. In the downstream reach, S_w ranged from 20.2 to 70.1 km, V_f ranged from 0.009 to 0.015 mm/min, and U ranged from 31.7 to 195.7 g/m2/min, with 1,501 to 14,081 ug NO_3-N/L at the top of the reach. Long S_w suggests substantial nitrate export from both reaches, while higher V_f and U suggest more net nitrate uptake in the downstream reach. Ongoing analysis of nitrate, ammonium, and phosphate for additional sampling dates will further refine our understanding of nutrient processing patterns.

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STREAMSIDE SALAMANDERS IN TENNESSEE: SURVEYS AND URBAN IMPACTS

Anna Humphrey

The disjunct populations of Streamside Salamander (Ambystoma barbouri) in Tennessee's Central Basin represent a unique portion of the species. These populations are highly associated with limestone cedar glades—a declining grassland—and have the highest genetic diversity across the species' range. However, these important populations are located in and around the rapidly expanding Nashville metropolitan area. The growth of this urban center has resulted in extensive habitat loss for Streamside Salamander populations. Where streams do remain, many have either been directly modified (e.g., armored, channelized, or put in culverts) or indirectly modified. Indirect modifications include the major "symptoms" of the Urban Stream Syndrome, such as increased temperature, increased scour, and decreased channel complexity. To understand how these changes are impacting Tennessee's Streamside Salamander populations, we have undertaken surveys to assess how urbanization impacts streams and salamander abundance. Streamside Salamander reproduction also relies on a strict hydroperiod which is threatened by increasing climate change impacts, which combine with the impacts of urbanization through the urban heat island effect and Urban Stream Syndrome. In this presentation I will discuss the two methodologies for surveying these species, preliminary results of my research, and the threats impacting the Streamside Salamander in Tennessee.

A STATEWIDE SURVEY OF ALGAL BLOOM AND CYANOTOXIN DISTRIBUTION IN TENNESSEE SURFACE WATERS

Justin Murdock, Jingjing Li, and Andrew Rosson

Harmful algal blooms (HABs) are increasing in all surface water types worldwide due in large part to continued watershed eutrophication and a changing climate. This trend appears similar in Tennessee. HABs, particularly cyanobacteria, can produce potent toxins that cause ecological harm by killing or sickening wildlife and domesticated animals, and effect humans by impacting drinking water quality and recreational use of surface waters. We partnered with USACE, TVA, and TDEC to survey major reservoirs, rivers, and other waters across the state from May through November 2025 to assess seasonal algal distribution and toxin concentration patterns, and related these algal patterns to water quality. We also used these samples to develop and validate a Tennessee specific genetic-based monitoring protocol to quicky and inexpensively detect toxin gene abundance of four common freshwater cyanobacteria toxins as an addition to, or potentially replacement of, standard HAB monitoring and risk assessment. Preliminary data assessment shows the highest risk of HABs in Tennessee are in smaller impoundments, and blooms and toxin production can occur from spring through fall. This study can help shape state HAB monitoring programs to more efficiently detect HAB occurrence, and better predict potential hotspots for future blooms.

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BIOMASS AND STRUCTURE OF INFRALITTORAL ALGAL ASSEMBLAGES REVEALED BY COMPUTATION OF TAXON IMPORTANCE VALUES IN A EUTROPHIC RESERVOIR IN THE SOUTHEASTERN UNITED STATES

Katie Davis, Logan Brown, Cynthia Fecteau, Melanie Freeman, Maranda Halstead, Micah Kubr, Maegan Litchfield, McKenzie Meyer, Belicia Peeler, Andrea Porter, Paul Stafford, Jacob Zydel, Zoey Melendrez, and Jeff Lebkuecher[1]

ABSTRACT

Assessments of periphytic infralittoral algal assemblages may be more useful to evaluate the impact of anthropogenic activities given they are more influenced by watershed pollutants relative to pelagic phytoplankton. The objectives of the research were to: (1) document the trophic state of the infralittoral zone of Cheatham Lake in Middle Tennessee, (2) evaluate the algal biomass associated with cobbles, submerged wood, sediments, and the dominant macrophyte at the site, Justicia americana (L.) Vahl, and (3) evaluate the structures of both soft-algal and diatom assemblages associated with cobbles and J. americana by computing the importance value for each taxon as the sum of the relative abundance, relative frequency, and percent cover. Concentrations of total phosphorous, total nitrogen, chlorophyll a in the water column, and concentration of chlorophyll a on cobbles are all greater than the threshold values used to designate aquatic habitats as eutrophic. The high concentrations of chlorophyll a on submerged wood and J. americana stems indicate the importance of these substrates for algal growth at the site. Most algal taxa were identified in only one of the replicate samples for both cobbles and J. Americana, thus have low relative frequency values. This result suggests that the assemblages exhibit a high degree of spatial heterogeneity which is not revealed by the relatively high values for evenness. This study is the first to incorporate relative abundance, relative frequency, relative percent cover, and importance values of assemblage taxa to describe algal assemblages which provide a greater understanding of assemblage structure such as distribution patterns of assemblage taxa.

INTRODUCTION

Periphytic algae are a major component of the trophic base of most infralittoral zones and assemblage composition may reflect habitat quality. Evaluations of water quality that use benthic biomass are almost exclusively based on samples scraped from artificial or natural lithic substrates such as cobble. Submerged wood and macrophytes may also be important substrates for algal growth at infralittoral sites, especially in areas where shifting sand or sediments dominate the benthos. This study evaluated the algal biomass on all of the major substrates and the structures of algal assemblages on cobble and macrophytes at an infralittoral site suspected to be impacted by nutrient enrichment to better understand the impacts of eutrophication on the integrity of infralittoral habitat quality.

Most reservoirs in the southeastern United States are eutrophic due mostly to agricultural runoff, removal of riparian habitats for shoreline development, and expansion of urban communities (TDEC 2022). Eutrophication results in habitat degradation in many ways. Eutrophication increases algal biomass, which in turn, can result in dramatic fluctuations in diurnal oxygen and carbon dioxide levels. Eutrophication also changes the composition of algal assembles which can decrease the richness and the ecological integrity of aquatic ecosystems. Laboratory studies of enhanced nutrient-induced increases of epiphytes can

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decrease the growth rates of macrophytes and may contribute to a reduction of macrophyte biomass in littoral habitats (Asaeda et al. 2004).

The degree of spatial heterogeneity of most littoral periphytic microalgal taxa is unknown due partially to the time needed to obtain relative frequency data from replicate samples. This lack of distribution data limits the ability to describe algal assemblage structure. Another problem that limits assessments of algal-assemblage structure is the difficulty of the determination of biomass for microscopic algal taxa which have a great diversity of morphologies. Biovolumes can be estimated based on geometric equations of the most common algal morphologies however, the calculations typically require a minimum of three measurements of each individual (Sun and Liu 2003). Estimates of biovolume using computer programs based microscopic images or models can be used to estimate unicellular phytoplankton biovolumes but are not accurate for highly branched and colonial forms common in periphyton (Sacca 2016, Borics et al. 2021).

Determinations of relative frequencies and relative percent cover enable the calculation of Importance Values (IV) for taxa of an algal assemblage. The IV is a metric widely used for decades in plant ecological studies to illustrate plant assemblage structure by incorporating the relative abundance, spatial heterogeneity, and dominance of different species (Curtis and McIntosh 1951). The relative dominance of a plant is typically expressed as the relative stem basal area or percent cover. The IV metric has never been employed for the assessment of microalgal assemblages due partially to the difficulties of obtaining values for relative frequency and relative dominance. This research overcame these limitations by: (1) identifying taxa present in replicate samples to obtain relative frequency values and (2) using an ocular grid reticle to estimate percent cover of identified taxa. These sampling methods allowed us to test of the null hypotheses that: (1) infralittoral periphytic algal taxa do not exhibit spatial heterogeneity as indicated by high relative frequency values among taxa, and (2) importance values for algal taxa of an assemblage do not provide insights into community structure as they do for plant communities.

METHODS

Study area.

Cheatham Lake is an impoundment of the Cumberland River in the lower part of the Lower Cumberland River Watershed. The watershed encompasses approximately 605,540 ha of Middle Tennessee in the Western Pennyroyal Karst (71e) and Western Highland Rim (71f) Level IV Ecoregions. The geologic base of the watershed is Mississippian-age limestone and includes some chert, shale, siltstone, sandstone, and dolomite. The soils are a thin loess mantle, highly erodible, and very fertile (Baskin et al. 1997). Forests are Western Mesophytic and consist largely of *Quercus* and *Carya* species (Baskin et al. 1997).

Cheatham Lake is approximately 40 km downstream of the Cumberland River reach that flows through the Outer and Inner Nashville Basin Level IV Ecoregions. These ecoregions have naturally high concentrations of phosphorus (P) due to the high P concentrations of the carbonate (TDEC 2005). The naturally high concentrations of phosphates and the cumulative effects of agricultural runoff, livestock access to streams, poorly functioning sewage systems, and erosion contribute to the poor-quality water of the lake. Cheatham Lake is listed as impaired by nutrient enrichment by the Tennessee Department of Environment and Conservation and the United States Environmental Protection Agency (TDEC 2022).

Sampling site and dates.

The sampling site is located at Pardue Boat Launch and Picnic Area at the end of Dozier Boat Dock Road in Cheatham County, Tennessee in the Southeastern United States. The area is managed by the United States Army Corps of Engineers and includes an infralittoral zone with benthic sections dominated by artificial cobbles that stabilize the bank, patches of the macrophyte *Justicia americana* (American water willow), and areas dominated by sediments that include sand, silt and decaying organic matter. The site was sampled on September 5 and 6, 2025.

Determination of water-column characteristics.

Concentrations of total phosphorus (TP) and total nitrogen (TN) of water were determined from samples collected 0.1 m below the surface in polyethylene sample bottles. Samples were stored frozen and concentrations evaluated at Hancock Biological Station of Murry State University in Murray, Kentucky using a Lachat QuickChem 8500 Flow Injection Analyzer. Concentrations of TP were determined using the persulfate-digestion and the ascorbic-acid method. Concentrations of TN were determined by the persulfate-digestion and cadmium-reduction method (Baird et al. 2017).

One replicate determination of specific conductance, concentration of dissolved solids, and pH was determined using a Multiparameter meter (Hana Instruments Incorporated, model HI 98194). Turbidity and concentration of chlorophyll (chl) *a* of water at 0.25-m depths were determined from three replicate measurements using a nephelometer and portable fluorometer (AlgaeChek Ultra, model RS232, Modern Water Incorporated).

The effect of organic matter in the water column on oxygen consumption by microorganisms was estimated by the biochemical oxygen demand assay (Baird et al. 2017). Water samples were retrieved from a depth of 0.25 m using a Van Dorn sampler. Samples were transferred to three borosilicate-glass bottles with ground-glass stoppers. Initial dissolved oxygen (DO) concentration was determined using a portable DO meter (model MW600, Milwaukee Instruments Incorporated). The bottles were incubated for 5 days in darkness at 25 ^{O}C and the concentration of DO consumed recorded as BOD_5 (mg DO $\cdot$ $L^{-1} \cdot$ 5 d^{-1}).

Determinations of the concentrations of chlorophyll a from algae removed from cobbles, wood, J. americana, and sediments.

Four replicate algal samples were collected from cobbles, submerged wood, sediments, and stems of *Justicia americana* L. Vahl along a transect parallel to the shore at 0.1 m to 0.25-m depths. Cobbles $\geq$ 10 cm^2 in diameter with most of the surface area for periphyton growth parallel to the surface were collected and transported to the lab in resealable plastic bags placed at 4^{O} C. Periphyton were scraped from 25-cm^2 sections of cobble surfaces using a scrub brush and a metal spatula into 100 mL of 90 % acetone.

Periphyton were scraped from wood sections (25-cm^2) using a toothbrush into 40 mL of 90 % acetone. Stem sections of *J. americana* approximately 10 cm to 17 cm below the surface (7-cm long sections) were collected using scissors. The stem sections were placed in polyethylene sample bottles and transported to the lab at 4^{O} C in darkness. Algae were removed from stem sections into 100 mL of 90 % acetone using a toothbrush. Algae associated with benthic sediments were sampled from 49-cm^2 areas designated by a core sampler using a plastic pipet with the tip cut off to increase pore size. The algae were placed in polyethylene sample bottles and transported to the lab at 4^{O} C in darkness. Algae were allowed to settle in darkness for 24 hours and transferred to 15 mL of 90 % acetone.

Ten-milliliter aliquots of the algae and acetone suspensions from cobbles, wood, *J. americana*, and sediments were placed in a mortar, ground with a pinch of sand using a pestle for 2 min, and filtered through Whatman no. 1 filter-paper circles. Optical density of the supernatant was determined at 664 nm to determine the concentration of chlorophyll (chl) a, then at 665 nm following acidification with 0.1 N HCl to correct for pheophytin *a*. Concentrations of chl *a* were calculated as described by Baird et al. (2017) and divided by the surface areas sampled to obtain concentrations per m^2. The surface area of stem sections was calculated following measurements of the stem diameters and calculations of the surface area sampled using the equation to determine the surface area of the sides of a cylinder:

Area $= 2\pi rl$, where r is the radius and l is the length.

Determinations of ash-free dry mass of organic materials on cobbles.

Ash-free dry mass of organic materials (AFDM) scraped from cobbles followed the methods described by Lebkuecher et al. (2015). The organic material that was scraped and suspended in acetone as the first step for the determinations of the concentrations of chl a was dried by allowing the acetone to evaporate at 25 ^{o}C, transferred to preweighed crucibles and weighed. The organic material was ashed at 550 ^{O}C for 2 h, and reweighed. The AFDM was calculated as the weight before ashing minus the weight after ashing. The Autotrophic Index (AI) was calculated using the equation of Crossy and LaPoint (1988):

AI = [periphyton AFDM ($mg \cdot m^{-2}$)]/ chlorophyll *a* ($mg \cdot m^{-2}$)]

Collection of samples for evaluations of algal composition.

Ten replicate algal samples were collected from cobbles and stems of *J. americana* along a transect parallel to the shore at 0.1 m to 0.25-m depths. Cobbles $\geq$ 10 cm^2 in diameter with most of the surface area for periphyton growth parallel to the surface were collected. Algae was scraped from 25-cm^2 areas using a scrub brush and metal spatula. Algae associated with *J. americana* stem sections were collected along 7-cm long stem sections located 10 cm below the surface. Algae were pipetted off stem sections using a plastic disposable pipet with the tip cut off to increase pore size. The stem sections were removed using scissors. Algae removed from cobble and sections of *J. americana* stems were placed into 250 mL polystyrene containers with 2 % glutaraldehyde preservative buffered to pH 7 with 50 mM Na Phosphate buffer. The samples were transported to the laboratory and stored in darkness. Algae from cobbles was concentrated by settling.

Identification of algal taxa and determination of percent cover.

Soft algae and diatoms were identified and enumerated until 10 individuals were identified from each of 10 replicate samples from cobble and *J. americana* stems. Primary taxonomic references used to identify soft algal taxa included Prescott (1982), Whitford and Schumacher (1984), Anagnostidis and Komárek (1988), and John et al. (2011). Percent cover of each individual was determined using a microscope ocular grid reticle (100 squares within 10 mm X 10 mm; BoliOptics, Rancho Cucamonga, California).

Diatom frustules were cleaned following the methods described in Carr et al. (1986) to remove cytoplasm and debris so markings on the valves could be observed. Valves were permanently mounted on glass slides and identified following the methods described by Lebkuecher et al. (2011). Primary taxonomic references to identify diatom taxa included Patrick and Reimer (1966, 1975), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), and Ponader and Potapova (2007).

Calculation of algal indices.
Shannon Diversity Index (H') and evenness (J) of soft-algae and diatom assemblages were calculated by the equations of Shannon and Weaver (1949):

$$H' = -\Sigma(P_i \ln P_i)$$

$$J = H'/\ln S$$

where P_i = abundance of species i and S = richness (number of taxa). Percent similarities of diatom and soft-algae assemblages were calculated as the sum of the lower of the two percent-composition values for each taxon common to two sites (Whittaker and Fairbanks 1958).

The values for Trophic-State Indices (TSI) developed to illustrate the impact of eutrophication on littoral algal assemblages were calculated following the methods of Lebkuecher et al. (2023). A trophic-state index value for an algal assemblage is high if the assemblage has a high abundance of taxa that are common in eutrophic habitats. The trophic state index using diatoms ($TSI_{diatoms}$) and the Trophic State Index using soft algae ($TSI_{soft\ algae}$) were calculated as: Index value = $[\Sigma_{j=1}^{sp.}\ n_j\ t_j]/N$ where: n_j = number of individuals of taxon j, t_j = trophic-indicator value for taxon j published in Lebkuecher et al. (2023), and N = total number of individuals tallied to calculate the index.

The importance value (Curtis and McIntosh 1951) for each taxon identified associated with cobbles and stems of *J. americana* was calculated as the sum of: (1) percent composition (relative abundance $\cdot$ 100), (2) relative frequency (percent of samples where the taxon occurs); and (3) relative percent cover (percent of the area the individuals of the taxon occupy relative to all individuals of all taxa).

Statistical methods
Statistical methods used to determine if there were significant differences of chl *a* concentrations between different substrates followed the recommendations of Sokal and Rohlf (2011) and Whitlock and Schluter (2020). Data for the concentrations of chl *a* on the different substrates were heteroscedastic as determined by the P values of a Brown-Forythe test (P= 0.04) and a Levene test (P= 0.04). The data were log transformed to eliminate heteroscedasticity and means compared using a Tukey-Kramer Honestly Significant Difference Test (Sokal and Rohlf 2011).

RESULTS AND DISCUSSION

Physical characteristics of water.
The physical characteristics of the water at the infralittoral site sampled in Cheatham Lake (Table 1) indicate poor water quality. The concentration of total phosphorus [TP] of water is well above the level suggested to designate lakes as eutrophic (> 25 µg TP $\cdot$ L^{-1}) by Carlson and Simpson (1996). The concentration of total nitrogen [TN] is also above the level suggested to designate lakes as eutrophic (> 1000 µg TN $\cdot$ L^{-1}) by the United States Environmental Protection Agency (1996).

Table 1. Physical characteristics at the infralittoral site sampled in Cheatham Lake. Values represent one replicate determination.

Total phosphorus ($\mu g \cdot L^{-1}$)	119
Total nitrogen ($\mu g \cdot L^{-1}$)	1103
Specific conductance (microsiemen $\cdot$ cm^{-1})	333
Total dissolved solids ($mg \cdot L^{-1}$)	167
pH at a depth of 0.25 m at 2:00 PM	9.5
Turbidity (nephelometric turbidity units)	45

The specific conductance, concentration of total dissolved solids, and pH of water sampled at Cheatham Lake indicate hard water due largely to the geologic base of mostly limestone (Table 1). Water in areas with a limestone geologic base have high specific conductance because of the presence of materials that ionize when washed into water. Mid-range specific conductance (200 to 1000 microsiemen $\cdot$ cm^{-1}) is normal for most major rivers with hard water. For example, four reservoirs in Middle Tennessee had values for specific conductance that range from 295 to 654 microsiemen $\cdot$ cm^{-1} and concentrations of dissolved solids that range from 148 to 327 $mg \cdot L^{-1}$ (Lebkuecher et al. 2022, Lebkuecher et al. 2023). The high value for the nephelometric turbidity units (NTU; Table 1) indicate a high concentration of suspended particles in the water. For example, NTU values above 25 indicate the water column contains an unhealthy concentration of suspended particles (USEPA 1986).

Biological characteristics of the water.
The high concentration of chl *a* of the water at the infralittoral site sampled (Table 2) is expected due to the eutrophic concentrations of TP and TN. The concentration of chl *a* is well above the value considered to indicate eutrophic conditions by Carlson and Simpson (1996; (> 7.3 $\mu g \cdot L^{-1}$) and Dodds (2006; > 8 $\mu g \cdot L^{-1}$). The high concentration of dissolved oxygen of the water in the afternoon (Table 2) is also typical of eutrophic environments as a result of photosynthetic activity.

Table 2. Biological characteristics of water at the infralittoral site sampled in Cheatham Lake. Concentrations of chlorophyll *a* of the water and values for the biochemical oxygen demand represent 3 replicate determinations.

Chlorophyll *a* of water ($\mu g \cdot L^{-1}$)	52.5 ± 6.2
Dissolved oxygen ($mg \cdot L^{-1}$) at 0.25 m depth at 1:30 PM	9.8
Biochemical oxygen demand assay ($mg\ 0_2 \cdot L^{-1} \cdot 5\ days^{-1}$)	14.6 ± 1.4

The value for the biochemical oxygen demand 5-day assay (BOD_5 assay; Table 2) is typical for samples with moderate concentrations of organics. BOD_5 values of water without excessive concentrations of organics range from near 0 to 8 mg O_2 consumed $\cdot L^{-1} \cdot 5\ d^{-1}$. Values of wastewater from wastewater treatment plants are often above 19 mg O_2 consumed $\cdot L^{-1} \cdot 5\ d^{-1}$ (Delzer and McKenzie 2003, Yun and An 2016).

Periphyton biomass and ash-free dry mass of benthic organic matter.
The concentrations of chl *a* on cobble, submerged wood, and stem sections of *J. americana* (Table 3) demonstrate the eutrophic condition of the site. Concentrations of chl *a* on cobble were much > 8 $mg \cdot m^{-2}$, a value suggested to designate infralittoral lentic sites in Tennessee as eutrophic (Lebkuecher et al. 2023). The high concentration of chl *a* on *J. americana* stems demonstrates that this macrophyte provides an important substrate for algal growth. The importance of *J. americana* for providing protection from wave

action in lakes and reducing flow in streams is well documented. Excessive growth of epiphytic algae has shown to decrease macrophyte biomass in the laboratory by coating leaves and decreasing growth (Asaeda et al. 2004). The biomass of epiphytic algae on the stems of *J. americana* is approximately the same as Asaeda et al. (2004) demonstrated to decrease macrophyte growth in the lab.

Table 3. Concentrations of chlorophyll *a* on cobble, submerged wood, stem sections of *Justicia americana*, and sediments at the infralittoral site sampled in Cheatham Lake. Means ± standard error represent four replicate measurements and are significantly different if represented by a different letter at the experiment-wise error rate of alpha = 0.05.

Substrate	chlorophyll *a* ($mg \cdot m^{-2}$)	Percent of total
Cobble	72.3 ± 11.2 A	57.3
Justicia americana stem sections	32.6 ± 8.9 B	25.8
Submerged wood	17.5 ± 1.9 B	13.9
Sediment	3.8 ± 0.5 C	3.0

The concentration of chl *a* on submerged wood is similar to the concentration of chl *a* on stems of *J. americana* (Table 3). The importance of submerged wood as a substrate for periphyton growth in benthic environments dominated by sediments has long been understood. Removal of submerged wood is very common from banks of waterways to enhance anthropogenic activities but can decrease habitat heterogeneity and primary production.

The concentration of ash-free dry mass of benthic organic matter (AFDM) on cobble (Table 4) is greater than the threshold value that indicates eutrophic environments in streams ($10\ g \cdot m^{-2}$) by O'Brien and Wehr (2010). The Autotrophic Index (AI) value, the ratio of AFDM to the concentration of chl *a*, at the Cheatham Lake site indicates dominance by heterotrophic periphyton. AI values generally range from 30 to 300 in streams (Torres-Ruiz et al. 2007). Heterotrophic dominance is correlated with high concentrations of dissolved organics which serve as a trophic base for microscopic heterotrophs. AFDM and AI values are affected by organic inputs that differ by season, bank characteristics, and allochthonous inputs (Lebkuecher et al. 2015). For example, AI values may be higher in regions such as Middle Tennessee with: (1) highly erodible soils, (2) in lentic environments with less constant water velocity to remove sediments from cobble surfaces relative to lotic environments, and (3) during the late summer and fall as a result of greater detritus input relative to winter and spring.

Table 4. Concentrations of ash-free dry mass of organics on cobble and the autotrophic index (ratio of ash-free dry mass of organic matter on cobble to concentration of chlorophyll *a* on cobble) at the infralittoral site sampled in Cheatham Lake.

Ash-free dry mass of organic matter on cobble ($g \cdot m^{-2}$)	17.6 ± 6.0
Autotrophic Index	225 ± 50

Metrics and Structure of algal assemblages.
The diversity of the algal assemblages at the infralittoral site sampled at Cheatham Lake is demonstrated by the richness of diatoms associated with cobble (Appendix 1), diatoms associated with stems of *J. americana* (Appendix 2), soft-algal taxa associated with cobble (Appendix 3), and soft-algal taxa associated with stems of *J. americana* (Appendix 4). The most abundant diatom taxon associated with cobble is

Cyclotella meneghiniana Kütz. followed by *Cymbella tumida* (Bréb.) Van Heurck. (Appendix 1). Both of these taxa are more common on cobble in eutrophic reservoirs relative to cobble in mesotrophic reservoirs in Tennessee (Lebkuecher et al. 2023). The most abundant diatom taxon associated with stems of *J. americana* is *Melosira varians* Ag. followed by *Cyclotella meneghiniana* Kütz. (Appendix 2). Both of these taxa are common phytoplankton in nutrient-rich water and settle in water with low velocity.

The richness, values for the Shannon Diversity Index, and evenness of the soft-algal assemblages (Table 5) are similar to those of other infralittoral sites in eutrophic reservoirs in Middle Tennessee. For example, the range of soft-algal taxa richness at four eutrophic reservoirs in Middle Tennessee ranged from 43 to 61 (Lebkuecher et al. 2023).

Table 5. Metrics for soft-algal assemblages associated with cobbles and *J. americana* stems at the infralittoral site sampled in Cheatham Lake.

Metric	Substrate	
	Cobble	*J. americana*
Taxon richness	49	38
Shannon Diversity Index	3.58	3.33
Evenness	0.92	0.74
Trophic-State Index using soft-algae taxa from cobble	62	

The Shannon Diversity Index (H’) ranges from 0 to approximately 4.6, with higher values indicating greater diversity. A value near 4.6 indicates a taxa-rich sample in which the individuals are evenly distributed. Typically, a low H' indicates poor environmental conditions. Evenness (J) is a useful indicator of the components that affect the Shannon Diversity Index value. Evenness ranges from 0 to 1. A sample of equal numbers of all taxa have a J value of 1. Low J values indicate dominance by a few taxa and often infer poor environmental conditions. Diversity values may not reflect habitat health because species richness and evenness can vary independently. Habitats with very poor water quality may have few taxa with the individuals evenly distributed resulting in a relatively high H' value (Pontasch *et* al. 1989). The value for $TSI_{soft\ algae}$ (Table 5) supports the conclusions from evaluations of the concentrations of TP, TN, and chl *a* that the site is eutrophic.

Cyanobacteria were the most important group of soft algae associated with cobble (57 % of the assemblage taxa; Appendix 3) and stem sections of *J. americana* (83 %; Appendix 4). Dominance by cyanobacteria is common at sites with assemblages impacted by eutrophication (Graham et al. 2023). The similarity value for soft algae taxa associated with cobble and stems of *J. americana* was only 36 %. The most abundant taxa sampled from cobble was the filamentous chlorophyte *Oedogonium* sp. (Appendix 1). The high relative abundance value for *Oedogonium* sp. most likely results from tallying different *Oedogonium* taxa that could not be identified to species without observing reproductive organs. The filamentous ochrophyte, *Vaucheria* sp. has the greatest Importance Value (IV) of the soft algae sampled from cobble (59.65; Appendix 3) due to the high values for relative abundance, high relative frequency, and relatively large size of the filaments. The most abundant soft-algal taxa associated with the stems of *J. americana* were the filamentous cyanophytes, *Phormidium incrustatum* Gomont and *Heteroleibleinia fontana* (Hansgirg) Anag. and Komárek (Appendix 4). Both of these taxa occurs in tufts of numerous filaments on cobble and as epiphytes and are common in water with high concentrations of $CaCO_3$.

The benefits of determining IV are demonstrated by examining the components of the IV for *H. fontana* associated with the stems of *J. americana*. *H. fontana* filaments are most often only 2 to 2.5 µm wide. The importance of *H. fontana* would be underestimated by reporting the relative abundance or biovolume alone. *Heteroleibleinia fontana* has the greatest IV despite its very small size, and thus percent cover value of only 1.12 (Appendix 3). The high IV is due to the fact that it is widespread as indicated by the high relative frequency value.

The majority of algal taxa identified were found in only one of the ten replicate samples for each substrate and thus have low relative frequency values. These data indicate that infralittoral periphytic algal taxa exhibit a high degree of spatial heterogeneity. This study is the first to characterize the infralittoral periphytic algal structures using IV for taxa. The substantial differences in the IV for soft-algal taxa due to differences in relative frequency and percent cover provide insight to the structure of the algal assemblages.

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Appendix 1. Relative abundance, relative frequency, relative percent cover, and Importance Value (IV) for diatom taxa removed from cobbles listed in alphabetical order.

Diatom taxon name removed from cobble	Relative Abundance	Relative Frequency	Relative percent cover	IV
Achnanthidium exiguum (Grun.) Czarnecki	1	10	0.30	1.30
Achnanthidium gracillimum (Meister) Lange-Bert.	1	10	0.46	11.46
Aulacoseira pusilla (Meister) Tuji and Houk	8	40	2.36	50.36
Cyclotella meneghiniana Kütz.	15	80	6.36	101.36
Cyclotella sp.	2	10	2.47	14.47
Cymbella affinis Kütz.	7	40	8.24	55.24
Cymbella sp.	3	30	4.22	37.22
Cymbella subturgidula Krammer	1	10	1.14	12.14
Cymbella tumida (Bréb.) Van Heurck	9	60	12.31	81.31
Cymbella turgidula Grun.	5	40	8.24	53.24
Fragilaria capucina Desm._	4	30	9.72	42.72
Fragilaria sp. (< 50 um length)	1	10	0.76	11.76
Gomphonema minutum (Ag.) Ag.	1	10	1.18	12.18
Gomphonema parvulum complex Kütz	6	30	4.44	40.44
Gomphonema sp.	3	30	4.06	37.06
Gomphosphenia lingulatifomis (Lange-Bertalot and E. Reichardt)	1	10	0.38	11.38
Grunowia tabellaria (Grun.) Rabenh.	1	10	0.23	11.23
Karayevia clevei (Grun.)	1	10	0.19	11.19
Lindavia ocellata (Pant.) Nakov, Guillory, M. L.Julius, E. C.Ther. and A. J. Alverson	3	10	0.85	13.85
Melosira varians Ag.	2	20	3.53	25.53
Navicula antonii Lange-Bert.	2	20	1.60	23.60
Navicula cari Ehrenb.	2	10	1.71	13.71
Navicula cryptotenella Lange-Bert.	6	40	4.67	50.67
Navicula sp. (< 12 µm length)	2	10	1.52	13.52
Navicula microcari Lange-Bert.	1	10	0.68	11.68
Nitzschia amphibia Grun	2	20	1.37	23.37
Nitzschia inconspicua Grun.	3	10	0.99	13.99
Psammothidium microscopicum (Cholnoky) S. Blanco	3	30	0.51	33.51
Pseudostaurosira sp.	2	20	1.67	23.67
Stephanodiscus minutulus (Kütz.) Round	1	10	0.30	11.30
Tabellaria fenestrata (Lyngb.) Kütz.	1	10	1.33	12.33
Thalassiosira weissflogii (Grunow) G. Fryxell and Hasle	1	10	0.87	11.87
Ulnaria delicatissima (W. Smith) Aboal and Silva	1	10	7.45	18.45
Ulnaria ulna (Nitzsch) Compère	1	10	3.87	14.87

Appendix 2. Relative abundance, relative frequency, relative percent cover, and Importance Value (IV) for diatom taxa removed from stems of *Justicia americana* listed in alphabetical order.

Diatom taxon name removed from the macrophytes	Relative Abundance	Relative Frequency	Relative Percent Cover	IV
Achnanthidium sp.	1	10	0.11	11.11
Aulacoseira ambigua (Grun.) Simonsen	4	40	2.95	46.95
Aulacoseira pusilla (Meister) Tuji and Houk	1	10	0.57	11.57
Cocconeis placentula Ehrenb	5	30	1.43	36.43
Cyclotella meneghiniana Kütz.	7	50	1.10	58.10
Cymbella affinis Kütz.	5	30	5.34	40.34
Cymbella turgidula Grun.	6	40	4.93	44.93
Discostella stelligera (Cleve and Grunow) Houk and Klee	3	30	1.48	34.48
Encyonema hamsherae Winter and L.L. Bahls	1	10	0.45	11.45
Fragilaria capucina Desm.	1	10	2.27	13.27
Fragilaria capucina complex	1	10	2.11	13.11
Fragilaria sp. (< 50 um length)	1	10	0.45	11.45
Fragilaria sp. (> 50 um length)	2	20	5.39	27.39
Gomphonema parvulum complex Kütz	6	40	1.92	47.92
Gomphonema lingulatiformis (Lange-Bertalot and E. Reichardt)	2	20	1.07	23.07
Grunowia tabellaria (Grun.) Rabenh.	1	10	0.18	11.18
Halamphora veneta (Kütz.) Levkov	1	10	0.30	11.30
Melosira varians Ag.	22	90	32.80	144.8
Navicula antonii Lange-Bert.	3	30	1.48	34.48
Navicula cryptotenella Lange-Bert.	3	20	1.59	24.59
Navicula subrotundata Hust.	1	10	0.25	11.25
Nitzchia amphibia	1	10	0.27	11.27
Nitzschia fonticola Grun.	1	10	0.16	11.16
Nitzschia semirobusta Lange-Bert.	2	20	0.45	22.45
Nitzschia small sp. complex	2	20	0.18	22.18
Nupela sp.	1	10	0.06	11.06
Nupela impexiformis (Lange-Bert.) Lange-Bert.	1	10	0.23	11.23
Pseudostaurosira brevistrata (Grunow) D.M.	1	10	0.57	11.57
Pseudostaurosira sp. 1	9	70	5.65	84.65
Pseudostaurosira sp. (unnamed)	1	10	0.80	11.80
Spicaticribra kingstonii	1	10	2.05	13.05
Thalassiosira weissflogii (Grun.) G. Fryxell and Hasle	3	30	0.84	33.84
*Ulnaria contracta (Ø*strup) E.Morales and M.L.Vis	1	10	2.16	13.16

Ulnaria sp.	1	10	2.50	13.50
Ulnaria ulna (Nitzsch) Compère	2	10	15.91	27.91

Appendix 3. Relative abundance, relative frequency, relative percent cover, and Importance Values (IV) for soft-algal taxa listed in alphabetical order by phylum removed from cobbles.

Taxon name removed from cobble	Relative Abundance	Relative Frequency	Relative percent cover	IV
Chlorophyta				
Characium pringsheimi A. Br.	1	10	0.20	11.20
Cladophora glomerata (L.) Kütz.	1	10	2.72	13.72
Desmodesmus communis (E. Hegewald) E. Hegewald)	1	10	0.09	11.09
Gloeocystis vesiculosa Nägeli	2	10	0.48	13.48
Oedogonium sp.	9	20	14.26	43.26
Oocystis lacustris Chodat.	1	10	0.26	11.26
Oocystis sp.	1	10	0.51	11.51
Pediastrum sp.	3	30	1.87	34.87
Rhizoclonium hieroglyphicum (C. Agardh) Kütz.	5	20	4.91	29.91
Rhizoclonium sp.	2	20	6.81	28.81
Scenedesmus sp.	5	30	1.02	36.02
Spirogyra sp.	2	20	4.97	26.97
Trochiscia sp.	1	10	0.05	11.05
Ulothrix cylindricum Prescott	1	10	3.40	14.40
Cyanobacteria				
Chamaesiphon amethystinus (Rostaf.) Lemmerm	3	10	0.10	13.10
Chroococcus minor (Kütz.) Nägeli	5	40	0.76	45.76
Chroococcus vacuolatus	1	10	0.03	11.03
Gloeocapsa kuetzingiana Nägeli	1	10	0.35	11.35
Gloeocapsa sp.	1	10	0.03	11.03
Gloeocapsopsis pleurocapsoides (Novácek) Komárek and Anagn	1	10	0.18	11.18
Gloeocapsopsis cyanea (Krieg) Komárek and Anagn.	1	10	0.08	11.08
Gloeocapsopsis sp.	1	10	0.12	11.12
Heteroleibleinia fontana (Hansgirg) Anag. and Komárek	8	40	1.12	50.12
Heteroleibleinia kuetzingii (Schmidle) Comp.	2	10	0.05	12.05
Heteroleibleinia sp.	2	10	0.03	12.03
Leptolyngbya foveolarum (Mont.) Anagn. and Komárek	1	10	1.00	13.0
Komvophoron hindakii	1	10	0.48	11.48
Komvophoron minitum (Skuja) Anagn. et				

Komárek	2	20	0.17	22.17
Leptolyngba nostocorum (Bomont.) Anagn. and Komárek	1	10	0.01	11.01
Leptolyngba sp.	1	10	0.14	11.14
Leptolyngbya truncata (Lemmerm.) Anagn. and Komárek	1	10	0.21	11.21
Lyngbya hieronymusii Lemmermann	2	10	0.63	12.63
Lyngbya martensiana Menegh.	1	10	0.32	11.32
Lyngba stagnina	1	10	0.68	11.68
Merismopedia glauca (Ehrenb.) Kütz.	3	20	18.38	41.38
Microcystis aeruginosa (Kütz.) Kütz.	1	10	3.50	14.50
Oscillatoria limosa (Dylwin) C. Agardh	4	40	3.68	47.68
Oscillatoria sp.	1	10	0.42	11.42
Phormidium diguetii (Gomont) Anagn. and Komárek	1	10	0.61	11.61
Phormidium fragile Gomont	4	20	0.40	24.40
Phormidium sp.	1	10	0.36	11.36
Phormidium tergestinum (Rabenh.) Anagn. and Komárek	1	10	0.56	11.56
Planktothrix agardhii (Gomont) Anagn. and Komárek	1	10	0.09	11.09
Pseudanabaena mucicola Naumann and Hub-Pest	1	10	0.23	11.23
Pseudanabaena limnetica (Lemmermann) Komarek	2	20	0.14	22.14
Pseudanabaena sp.	2	20	0.08	12.08
Euglenophyta				
Euglena sp.	1	10	0.20	11.20
Ochrophyta				
Vaucheria sp.	5	40	14.65	59.65

Appendix 4. Relative abundance, relative frequency, relative percent cover, and Importance Value (IV) for soft-algal taxa listed in alphabetical order by phylum removed from the macrophyte *Justicia americana*.

Taxon name removed from the macrophyte *Justicia americana*	Relative Abundance	Relative Frequency	Relative percent cover	IV
Chlorophyta				
Characium sp.	1	10	0.42	11.42
Mougeotia sp.	4	30	10.93	44.93
Oedogonium sp.	1	10	3.12	14.12
Pediastrum sp.	1	10	2.50	14.50
Rhizoclonium hieroglyphicum (C. Agardh) Kütz.	5	20	16.55	41.55
Rhizoclonium sp.	1	10	3.12	15.12
Scenedesmus sp.	5	40	1.28	46.28
Cyanobacteria				

Borzia sp.	1	10	0.31	11.31
Borzia trilocularis Cohn.	2	20	0.19	22.19
Chamaesiphon confervicola A. Braun	1	10	0.62	11.62
Chamaesiphon incrustans Grunrow	5	10	1.56	16.56
Chroococcus minutus Kütz.	1	10	0.05	11.05
Coelosphaerium nagelianum Unger.	1	10	0.47	11.47
Gloeocapsa kuetzingiana Nägeli	5	30	2.39	37.39
Gloeocapsopsis pleurocapsoides (Novácek) Komárek and Anagn	8	30	10.60	48.60
Heteroleibleinia fontana (Hansgirg) Anag. and Komárek	10	70	3.33	83.33
Jaaginema pseudogeminatum (G. Schmid) Anagn. And Komarek	1	10	0.55	11.55
Komvophoron constrictum (Szafer) Anagn. et Komarek	1	10	0.16	11.16
Komvophoron minitum (Skuja) Anagn. et Komárek	3	30	1.30	34.30
Leibleinia epiphytica (Hieronymus) Anagn. and Komarek	6	20	1.25	27.25
Leptolyngba nostocorum (Bomont.) Anagn. and Komárek	2	10	0.11	12.11
Leptolyngba sp.	3	20	0.30	23.30
Leptolyngba tenuis (Gomont Anagn. & Komarek	1	10	1.41	12.41
Leptolyngbya truncata (Lemmerm.) Anagn. and Komárek	2	10	0.67	12.67
Oscillatoria agardhii Gomont	1	10	1.09	12.09
Oscillatoria anguina Bory	1	10	1.09	12.09
Oscillatoria limosa (Dylwin) C. Agardh	1	10	3.50	15.50
Oscillatoria subtilissima Kütz. and DeToni	2	10	0.09	12.09
Phormidium diguetii (Gomont) Anagn. and Komárek	2	10	0.16	12.16
Phormidium fragile Gomont	1	10	0.39	11.39
Phormidium incrustaum Gomont	10	10	16.77	36.77
Phormidium sp.	1	10	0.31	11.31
Phormidium tergestinum (Rabenh.) Anagn. and Komárek	2	20	2.19	24.19
Pseudanabaena limnetica (Lemmermann) Komarek	2	20	1.09	23.09
Synechococcus aeruginosus Nägeli	3	10	0.41	13.41
Synechocystis sp.	1	10	0.01	11.01
Ochrophyta				
Vaucheria sp.	1	10	9.73	20.73

SESSION 2A

Thursday, April 16th at 8:30 am - 10:00 am
HYDROLOGY
(Moderator: Andrea Ludwig, UTK)

Updating Discharge Ratings for Cumberland River Basin Dams
C. Neel

When Sinkholes Stop Working: 2D Modeling a Karst Flood in Montgomery County, Tennessee
A. Ward, J. Bryant

Advancing Methods for Stream Natural Channel Design
J. Schwartz

Thursday, April 16th at 10:30 am - 12:00 pm
FLOOD MANAGEMENT
(Moderator: Adrian Ward, Barge)

Flooding Krav Maga: Teaching Citizens to Defend Themselves During a Flood
B. Heilwagen

Prioritizing Management Decisions from Hurricane Helene on the New River with High Definition Stream Survey (HDSS)
B. Connell

Expansion of the FIMAN Surface Water Gauge Network for NCDOT and NC Emergency Management
C. Moore

Thursday, April 16th at 1:30 pm - 3:00 pm
HURRICANE HELENE IMPACTS
(Moderator: Daniel Saint, TVA)

Nolichucky Dam - Response and Recovery
J. Bryant

From Soil Water Retention to Aquifer Recharge: Farming After the Flood: Efforts to Revegetate Pasture Fields Flooded Post-Helene in East Tennessee
F. Walker

Restoring Riparian Resiliency in Helene-Impacted Watersheds
A. Ludwig

Thursday, April 16th at 3:30 pm - 5:00 pm
REGULATED RIVERS
(Moderator: John Schwartz, UTK)

Trends in Sub-Hourly Extreme Precipitation: Extracting Signal from Spatial Noise with a Neighborhood-Based Approach
N. Kafle, N. Peleg, C. Meier

Hitting the Curve - Ripshin Lake Dam Repairs
J. Reeves

Effect of PMP Centering on PMF Elevations at Critical Sites on the Tennessee River
J. Schlamp

UPDATING DISCHARGE RATINGS FOR CUMBERLAND RIVER BASIN DAMS

Clint Neel[1]

Accurate flow ratings are a necessary part of reservoir operations for flood mitigation, hydropower scheduling, navigation support, recreational activities, ecological benefits, and water quality releases. Imprecisions in reported dam releases impede the ability of water managers to facilitate flood operations, follow power generation schedules, regulate barge traffic, support recreational users, and maintain water quality standards. Since 2017, the Nashville District U.S. Army Corps of Engineers has coordinated with USGS regional offices to collect flow measurements below Cumberland River Basin dams. These measurements were used to update and extend the original turbine and spillway discharge ratings developed as many as 75 years ago. Fundamental hydraulic equations were used to predict gate releases with tailwater submergence while family of curves tailwater ratings determined spillway bay releases when gates were lifted out of the water. Measurements taken when releases from only one outlet type were in operation proved especially valuable in estimating hydraulic coefficients. Lessons learned were used to develop flow ratings for a recently constructed dam on the Ohio River. Multivariate flow ratings have also been developed at critical stream gage locations impacted by backwater and seasonal land use changes.

[1]Nashville District, U.S. Army Corps of Engineers, 110 9th Ave. South, Nashville, TN

WHEN SINKHOLES STOP WORKING: 2D MODELING A KARST FLOOD IN MONTGOMERY COUNTY, TENNESSEE

Jeff Bryant, PE[1] and Adrian Ward, PE[2], CPESC, CFM

In early 2025, Montgomery County experienced repeat flooding within the Farmington Basin, a watershed where regional sinkholes provide stormwater storage. Following a February rainfall event, runoff no longer drained effectively; subsequent storms filled the sinkhole network while prior storage remained occupied, resulting in flooding of single-family homes, apartments, and roadways.

To diagnose system behavior and support mitigation decisions, a two-dimensional (2D) unsteady HEC-RAS model was developed. The model used publicly available LiDAR refined with development plans, computational breaklines, and a Rain-on-Grid approach to simulate distributed rainfall, infiltration, overland flow, and ponding. Runoff losses were represented using a curve-number grid and National Oceanic and Atmospheric Administration (NOAA) precipitation frequencies.

Model outputs delineated inundation extents and event-driven ponding volumes for four primary areas, enabling a focused alternatives analysis. Mitigation concepts prioritized restoring reliable dewatering of sinkhole storage without dependence on unpredictable sinkhole throats, including gravity conveyance, mechanically assisted conveyance, and supplemental injection wells. Montgomery County selected a gravity-based conveyance alternative designed to recover sinkhole storage within a 7-day period for a 100-year event, with optional engineered injection wells in two sinkhole areas.

This presentation shares lessons learned from moving rapidly from flood response to design, including how 2D modeling improved understanding of complex flow paths and storage interactions, and provides guidance on when 2D methods are warranted versus traditional 1D approaches.

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[1] Montgomery County Highway Supervisor
[2] Barge Design Solutions

ADVANCING METHODS FOR STREAM NATURAL CHANNEL DESIGN

John S. Schwartz[1]

Natural Channel Design (NCD) traditionally applies stream morphological dimensions normalized by channel bankfull width and depth dimensions from a reference stream as design criteria. In many cases, this implementation of this method results in a successful restoration project. However, in landscapes with land cover/use changes, and the potential hydrological changes due to climate change, using bankfull indicators for design may lead to project failure. Hydromodification leads to geomorphic processes no longer in dynamic equilibrium with water and sediment transport, the basis of the bankfull indicator concept. In stream conditions with non-stationary hydrology, hydrologic and hydraulic (H&H) models can be used for stable channel design. H&H model output is applied to channel bed and bank erosion, and sediment transport equations. Use of these equations with H&H model output is consistent with NCD principles, only the methods are modified to account for future geohydrological conditions to create sustainable, self-maintaining channel dimensions. The design flow chart for NCD in the USDA National Engineering Handbook Part 654, 210-VI-NEH, 2007) on Stream Restoration Design is used to demonstrate where in the NCD process that bankfull dimensions are replaced with hydraulic model outputs. In addition, hydraulic model output can be used to assess habitat quality, and enhance habitat quality in the design. Habitat enhancement is based on aquatic community composition. H&H modeling examples are presented on several streams in East Tennessee, and long-term monitoring results from the Beaver Creek restoration project.

[1] University of Tennessee Knoxville

FLOODING KRAV MAGA: TEACHING CITIZENS TO DEFEND THEMSELVES DURING A FLOOD

Brad Heilwagen

We're seeing a troubling pattern: intense storms that dump inches of rain in minutes, and floods that hit neighborhoods far outside of the Federal Emergency Management Agency (FEMA) mapped hazard zones. In the span of just a few weeks in 2025, flash floods swept across Texas, New Mexico, New Jersey, and New York – turning streets into rivers, disrupting transit, and overwhelming emergency systems.

Tennessee is not immune. After east Tennessee was ravaged by flooding from Hurricane Helene in 2024, the citizens of Tennessee witnessed flooding from Memphis to Johnson City and all points in between throughout 2025. In February, the small town of Rives in Obion County faced a full evacuation due to flooding. March and April saw widespread flash flooding reports across Middle Tennessee, from Dickson in the west to Mt. Juliet in the east, and from Lawrenceburg in the south to Portland in the north, including cloudburst flooding of neighborhoods in Metro Nashville. In early April, Clarksville set a five-day rainfall record and saw flood waters engulf roads and destroy homes. In July, Kingsport received well over half of their average monthly rainfall in three hours with multiple locations impacted by flooding.

Then on August 12, 2025, heavy rain caused a deadly flash flood in the Chattanooga area, resulting in four fatalities, widespread road closures, and the declaration of a state of emergency in Hamilton County. Chattanooga experienced its second-wettest single day on record, with over six inches of rain falling in just over four hours, nearly a 500-year storm event for that duration. Social media outlets were also flooded, no pun intended, with photos and videos of Interstate 24 covered in water as drivers fled their vehicles for higher ground.

A point of public discussion following the event was that the worst of the flooding occurred without an NWS flood watch in effect. Rainfall forecasts on the morning of the event were on the order of 0.5" – 2", and discharge forecasts on for South Chickamauga Creek, the primary source of flooding for Interstate 24, predicted no substantial increase in flow. So, what is a community to do to defend their citizens in the absence of appropriate warning from federal agencies? Teach those citizens some self-defense, flood style.

While self-defense techniques like Krav Maga do not teach techniques specific to surviving a flood, the core principles of situational awareness, stress management, and practical survival training can enhance anyone's chances of survival in high-stress, real-life emergencies such as floods. Using lessons learned from the August 12 event in Chattanooga, this presentation will discuss how the principles of self-defense can be used by community officials to help educate citizens on how to recognize an impending flood on their own and respond accordingly without the need for direction from federal or local government agencies.

PRIORITIZING MANAGEMENT DECISIONS FROM HURRICANE HELENE ON THE NEW RIVER WITH HIGH DEFINITION STREAM SURVEY (HDSS)

Brett Connell

Following Hurricane Helene, the New River High Definition Stream Survey (HDSS) provided a comprehensive post-storm assessment of the Virginia section of the river. Completed in partnership with Friends of Southwest Virginia and funded by the Appalachian Regional Commission, the survey created a detailed foundation for recovery planning and long-term watershed resilience.

Using HDSS technology, the project gathered continuous, meter resolution GIS data in a single pass by integrating GPS, video, depth sensors, and side scan sonar. The survey mapped and classified storm debris, documented flood-prone areas, evaluated recreational and infrastructure conditions, assessed floodplain connectivity, and identified priority areas for future restoration. Every observation was geotagged within the video archive and GIS dataset to support precise, data-driven decisions.

HDSS has been applied on more than 2,000 stream miles across the United States to document baseline conditions, evaluate restoration outcomes, understand invasive species impacts, support flood recovery assessments, and guide watershed restoration prioritization. Across these efforts, HDSS has helped managers see entire river corridors in a consistent, continuous format that supports transparent decision-making and efficient planning. The New River results now provide the region with a clear, defensible basis for infrastructure repair, debris removal, and long-term restoration planning.

EXPANSION OF THE FIMAN SURFACE WATER GAUGE NETWORK FOR NCDOT AND NC EMERGENCY

Crystal Moore

In North Carolina, more than 500 river, stream, and coastal gauges provide real-time data to support flood warning and water resource management. Over the past 30 years, the state has experienced multiple major storm events that caused extensive flooding, loss of life, and significant property damage. Following Hurricane Floyd, North Carolina Emergency Management developed FIMAN (Flood Inundation and Mapping Alert Network). Years later, NCDOT implemented Bridge Watch. Together, these programs improve situational awareness during storm events by delivering timely alerts so appropriate actions can be taken before flooding impacts critical infrastructure.

In 2024, North Carolina faced another major disaster with Hurricane Helene, which resulted in approximately 1,400 road closures; more than 1,530 bridges damaged; and roughly 150 bridges destroyed. One of the state's strongest defenses for warning residents and decision-makers during storm events is its network of gauges. These gauges typically report water levels every 15 minutes, increasing to every 5 minutes when conditions become critical—defined as water approaching within 0.5 feet of a bridge low chord or reaching the top slab of a culvert.

KCI was contracted by NCDOT and North Carolina Emergency Management to assess and install 55 gauges at high-priority locations across eastern and western North Carolina. KCI developed a standardized assessment checklist to evaluate site suitability, including access, safety, visibility, and long-term maintenance needs (e.g., minimizing vegetation control requirements and preventing obstructions to the roadway or channel). After assessing more than 80 candidate sites, KCI narrowed the list to 55 locations, completed surveys, and installed all 55 gauges.

To support project tracking and decision-making, KCI developed a dashboard to monitor each gauge through assessment, survey, and installation. This tool can also help identify potential future gauge locations prior to full integration into FIMAN. In addition, gauge data provide a valuable basis for calibrating flood hazard and hydraulic modeling outputs.

This presentation will walk through the full gauge deployment process—site assessments, surveying, installation, and coordination with key stakeholders (including NCDOT Divisions, Forestry, Emergency Management, Dam Safety, and others). It will also cover the steps following installation, including connecting gauges to Contrail and integrating data into Bridge Watch and FIMAN.

NOLICHUCKY DAM – RESPONSE AND RECOVERY

Jim Bryant

The Nolichucky Dam, located in northeastern Tennessee, experienced severe flooding during Hurricane Helene in late September 2024. Originally built in 1913 and later modified, the dam faced unprecedented rainfall and inflows from the Appalachian region, resulting in overtopping of the non-overflow section by over five feet and flows exceeding 180,000 CFS—double the previous flood record. Emergency protocols escalated from gray to red conditions as water levels rose, prompting evacuations and continuous monitoring despite loss of upstream gauges. Drone footage and infrared imaging were critical for assessing real-time conditions and later documenting extensive erosion, structural damage to the powerhouse, and compromised access roads.

Post-event recovery involved major engineering and construction efforts to stabilize and restore the site. Key actions included demolishing the damaged powerhouse, grouting penstocks, installing a large rock buttress on the right abutment, repairing spillway crest damage, and constructing a reinforced concrete slab over the former powerhouse footprint. Additional improvements included new fencing, handrails, electrical systems, staff gauges, and public access features such as parking areas and ramps. The project emphasized resilience, stakeholder coordination, and innovative use of drone technology for monitoring and planning. By late 2025, the site was fully restored, with enhanced safety measures and improved infrastructure for future flood events.

[1] Tennessee Valley Authority, Senior Program Manager – Dam Safety

FARMING AFTER THE FLOOD: EFFORTS TO REVEGETATE PASTURES FIELDS FLOODED POST-HELENE IN EAST TENNESSEE

Forbes Walker[1]

On September 26, 2024, Hurricane Helene made landfall in Florida, as a Category 4 hurricane. Hurricane Helene. By the time Helene hit Tennessee on September 27, it was a tropical storm. Much of the damage in Tennessee was the result of record rainfall in the mountains of western North Carolina that resulted in flooding in some areas that had not been seen in hundreds of years. Many farms lost topsoil on their most productive fields, others had large deposits of sand or silt-dominated sediments burying what was once productive hay and pasture fields, row crop fields or vegetable fields. Damage to farms across an eight-county area in East Tennessee is estimated to be $1.3 billion.

Since October 2024, a team of scientists from the University of Tennessee Institute of Agriculture has been working to assist farmers across the flood impacted areas. Sediments were collected from across the impacted areas. Sand and silt-dominated sediments were tested for plant nutrients, as well as contaminants. Germination tests and greenhouse studies were conducted to determine how to re-establish annual forages and other crops on the flood impacted fields. In the summer of 2025 research plots and demonstrations were established to evaluate strategies for restoring fields and protecting the streambanks. In October 2025 a series of on-farm experiments were established using different soil amendments, and reseeding techniques to reestablish cool-season pastures to reduce erosion and nutrient losses from Helene impacted sites and revegetate the impacted fields.

[1] Professor, Biosystems Engineering and Soil Science, University of Tennessee, Knoxville TN

RESTORING RIPARIAN RESILIENCY IN HELENE-IMPACTED WATERSHEDS

Andrea Ludwig[1]

The remnants of Hurricane Helene created a generational flow event in rivers draining Western North Carolina and East Tennessee in September 2024. Over a year later, communities and landowners have persevered to restore many aspects of life and vitality in the region; however, there remains an immense need for resources and effort towards restoring stability and resilience in riverbanks and riparian ecosystems. The effects of the extreme flow are seen in a wide variety of impacts, from scour down to historical cobble beds to deposits of multiple feet of sand to denuded floodplains. Much of the riparian forest that survived the storm was either removed during the debris “clean up” effort or has been impacted such that its health is declining. While natural succession is being observed throughout the watersheds, bioengineering approaches have been implemented to achieve stability of loose sediment deposits and promoting natural resilience. A 1000-ft long field-scale demonstration site has been established on a beef and forage farm in Limestone, TN, on the banks of the Nolichucky River, where bank and gully stabilization practices utilize the wood chips produced as a byproduct of debris “clean up.” A multi-agency collaborative has also been formed to address the ongoing needs of landowners and land managers related to riparian restoration. One of the significant products of this collaborative is the creation of the “Tennessee Stream Team,” a trained and skilled workforce ready to implement restoration strategies. This presentation will provide an overview of the efforts to date and share results of estimated sediment and nutrient reduction attributed to restoration activities.

[1] Professor & Extension Specialist, Institute of Agriculture, University of Tennessee

TRENDS IN SUB-HOURLY EXTREME PRECIPITATION: EXTRACTING SIGNAL FROM SPATIAL NOISE WITH A NEIGHBORHOOD-BASED APPROACH

Nischal Kafle[1], Nadav Peleg[2], Claudio I. Meier[3]

Understanding trends in short-duration (sub-daily) extreme rainfall is essential for climate resilience and infrastructure design. These extremes are typically produced by highly localized convective storms and are characterized by high spatial variability and temporal intermittency. However, most existing studies rely on point-based trend analyses, which suffer from two major limitations. First, sparse rain gauge networks, such as those common in the United States, often fail to adequately capture localized extremes. Second, station-level trend signals often exhibit low signal-to-noise ratios, leading to weak, inconsistent, or even contradictory trend patterns relative to expectations under warming climate. As a result, underlying regional signals may remain obscured, limiting our ability to design reliable infrastructure for the future. To address these limitations, we develop a neighborhood-based framework that explicitly incorporates spatial coherence into trend detection. Similar to regional frequency analysis, the proposed method combines annual maxima from a target station and its nearest neighboring stations to construct a neighborhood-level annual maxima series. By leveraging information from nearby stations, the framework enhances the signal-to-noise ratio of detected trends. The methodology is evaluated using (i) 1-minute rainfall records from 863 stations in Germany, and (ii) synthetic rainfall fields generated over a 100 × 100 km domain with and without imposed trends. Results demonstrate substantial improvements in the spatial consistency and statistical power of detected trends, revealing coherent regional signals that are often masked in conventional point-based analyses. These findings suggest that neighborhood-based approach provides a more reliable framework for detecting trends in short-duration extreme rainfall and can support developing design standards that better reflect the hydrological realities under changing climate.

[1] PhD Candidate, Dept. of Civil, Const., & Env. Eng., The University of Memphis, Memphis, TN
[2] Eccellenza Assistant Professor, University of Lausanne, Switzerland
[3] Professor, Dept. of Civil, Const., & Env. Eng., The University of Memphis, Memphis, TN

HITTING THE CURVE – RIPSHIN LAKE DAM REPAIRS

Jason Reeves, P.E.[1]

Motivation/Problem Statement

Ripshin Dam is an earthen dam located in Roan Mountain, Tennessee that impounds a 56-acre private lake. The dam was originally constructed in two phases from 1927-1928 and 1945-1946, and repairs were completed in 1995 that included raising the dam to a height of 42 feet and constructing a new concrete chute spillway. In 2021, S&ME began consulting for a siphon drain replacement of the dam. Additional challenges ("curve balls") were discovered during dam evaluation, design, and construction that significantly affected the dam repairs construction schedule and costs.

Methods/Procedures/Approach

An evaluation of the original approximately 75-year-old 20-inch steel siphon determined that the conduit was severely corroded and did not function properly. To meet TN Safe Dams lake drawdown requirements, two new 20-inch HDPE siphons were designed with butterfly valves and access vaults.

During the 1995 dam repairs, the downstream slope was steepened. A geotechnical exploration of the dam was performed as part of a stability evaluation. The exploration and historical research revealed that semi-hydraulic fill material had been placed within the dam during the 1940's construction to construct and impermeable core. The semi-hydraulic fill had low strength, and stability analysis concluded that a soil buttress with an internal chimney drain and blanket/toe drain system was required to meet regulatory stability requirements.

An original approximately 95-year old 30-inch CMP was present near the lower center of the dam from the original dam construction. Records were inconclusive on how the CMP was abandoned. During lake drawdown, a depression was observed at the toe of the upstream slope near the approximate alignment of the 30-inch CMP. It was recommended that the embankment be breached and the 30-inch CMP be removed. This would also allow the Construction observations indicated that the original CMP was grouted and conditions were more favorable than thought. The upstream end of the CMP was excavated and evaluated and backfilled with grout. The Owner elected to leave a portion of the grouted CMP pipe in place. The majority of the semi-hydraulic fill material was removed during embankment excavation and pipe removal.

Challenges were encountered during embankment excavation including temporary dewatering issues, working in a tight construction area, steep side slopes, and inclement weather in the Roan Mountain. Lake dewatering was performed using temporary siphons and a series of up to 7 8-inch to 12-inch pumps. Construction delays extended construction and lead to additional dewatering costs.

In September 2025, a significant amount of new embankment fill had been placed and the drainage system had been installed. The dam crest had reached a height of 10 feet below the concrete primary spillway when Hurricane Helene hit the region, and the site experienced approximately 15 inches of rainfall. Storm flows were passed using 4 remaining pumps and the two 20-inch siphons (which had

[1] Technical Principal/Vice President S&ME, Inc.

never been tested). Doe to rising water levels in the lake, an approximate 8 feet deep by 12 feet wide temporary spillway was excavated near the right abutment to pass additional storm flows. Stormwater was routed without overtopping the crest. The dam repairs were substantially completed in December 2024.

Learning Objectives

1. Learn about dam geotechnical evaluations with semi-hydraulic fill and mitigation methods.
2. Learn how the Terzaghi "Observational Method" was used on several occasions when previously unknown subsurface conditions and decisions were required.
3. Learn about changed construction conditions and communication between the Engineer, Owner, and Contractor for a dam repair project.
4. Learn about temporary dewatering measures and handling extreme storm water events during construction.

EFFECT OF PMP CENTERING ON PMF ELEVATIONS AT CRITICAL SITES ON THE TENNESSEE RIVER

Janelle Schlamp

Over 300 HEC-RAS model simulations were performed of the approximately 27,000 square miles of the Tennessee River watershed to evaluate probable maximum flood (PMF) elevations at critical downstream locations. The simulations incorporated variations in seasonal probable maximum precipitation (PMP) events as well as the spatial placement of the primary PMP event. A systematic, downstream-progressive approach was applied, beginning with PMP events centered over upstream storage reservoirs and advancing downstream, with simulation results guiding model decision-making. The modeling framework accounted for dam operations and potential impacts of dam overtopping. This process enabled selection of PMP scenarios that define the cumulative bounding PMF at critical downstream locations.

This presentation demonstrates how more than 300 PMP events, centered over different locations within the Tennessee River watershed, influence flood elevations at key downstream sites.

SESSION 2B

Thursday, April 16th at 8:30 am - 10:00 am
GROUNDWATER
(Moderator: Shannon Williams, USGS)

Making the Invisible Visible: A Visual Journey to Communicate Aquifer Heterogeneity
R. Villalpando-Vizcaino, L. Scrivener

The Speed of Trust: Evolution of the West TN H2O Delegation to Secure a Clean Water Future
S. Schoefernacker, S. Houston

Integrating River Geomorphic Processes into Groundwater Management: Insights from Numerical Modeling
M. Frempong, A. Paldor

Thursday, April 16th at 10:30 am - 12:00 pm
GROUNDWATER (PART II)
(Moderator: Scott Schoefernacker, Protect Our Aquifer)

Applications of Airborne Electromagnetic Surveys for Hydrogeologic Framework Development in Western Tennessee
R. Adams, W. Kress

Drivers of Irrigation Dependence: Untangling the Complex Relationships Between Groundwater Availability, Hydroclimate, Soils, Landscape, Economics, and Technology
M. Yaeger

High-Resolution Geophysical Mapping of Aquifer Structure: Assessing Geologic Complexity and Water Availability in Northern Shelby County, Tennessee
R. Adams, W. Kress

Thursday, April 16th at 1:30 pm - 3:00 pm
AQUIFERS
(Moderator: Rodrigo Villilpando-Vizcaino, CAESER)

Characterization of the Ambient Water Quality of the Central Basin Aquifer System in Tennessee
K. Hill, L. Ruhl-Whittle, A. Hourigan, S. Smith, B. Ham

Characterization of the Ambient Water Quality of the Highland Rim Aquifer System in Tennessee
A. Hourigan, K. Hill, L. Ruhl-Whittle, S. Smith, B. Ham

Variability of Nutrient Concentrations in the Principal Aquifers of Tennessee
L. Ruhl-Whittle, K. Hill, A. Hourigan, S. Smith, B. Ham

Thursday, April 16th at 3:30 pm - 5:00 pm
AI IN WATER RESOURCES
(Moderator: Ingrid Luffman, ETSU)

Artificial Intelligence: Boon or Bane?
G. Burnette

An AI-Enabled, Modular Research Platform for Water Resources Science
B. Ledesma, R. Villalpando-Vizcaino, B. Waldron

AI-Assisted Web Tools for Identifying Headwater Watersheds Using USGS APIs and Interactive Geospatial Analysis
P. Li, J. Wang, J. Frisbee, K. Bynum, B. Ham

MAKING THE INVISIBLE VISIBLE: A VISUAL JOURNEY TO COMMUNICATE AQUIFER HETEROGENEITY

Rodrigo Villalpando-Vizcaino[1, 2,*] and Lucinda Scrivener[1]

Aquifers are inherently invisible, often leading to oversimplified public perceptions, such as underground lakes and rivers, uniform “bucket of sand”, or a generic blue rectangle in a textbook diagram. In reality, groundwater systems such as the Mississippi embayment consist of multilayered, heterogeneous sequences of sands, silts, clays, and organic-rich intervals. This variability can influence groundwater flow, contaminant transport, vulnerability, and management, yet many people, including scientists outside hydrogeology, never see these sediments directly. Continuous sonic cores collected from more than a dozen sites across west Tennessee provide minimally disturbed samples that offer a rare visual window into this complexity. High-resolution subsurface photographs from the University of Memphis - Mississippi Embayment Research Center (MERC) core repository, highlight the colors, textures, oxidation patterns, and grain-size variations that occur even within a single hydrogeologic unit such as the Memphis aquifer. These differences reflect changes in depositional environment, geochemical conditions, and sediment sources through time. When paired with gamma logs, these visuals illustrate how intervals interpreted broadly as “sand” on geophysical logs, consist of numerous distinct layers with their own characteristics. These images also help contextualize how different units used in groundwater models encompass a wide range of physical and hydraulic properties. Feedback from education and outreach activities involving several hundred participants suggests that these visual comparisons significantly improve conceptual understanding relative to traditional explanations of unconsolidated aquifers. Audiences quickly grasp heterogeneity when they can see it, allowing them to move beyond the bucket-of-sand metaphor toward a more realistic layered conceptual model. By making the subsurface visible, intuitive, and engaging, this approach provides a practical bridge between scientific interpretations and public understanding of groundwater resources. Visualizing heterogeneity not only enhances education and outreach but also supports informed conversations and ultimately contributes to clearer and more sustainable groundwater management.

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THE SPEED OF TRUST: EVOLUTION OF THE WEST TN H2O DELEGATION TO SECURE A CLEAN WATER FUTURE.

Sarah Houston[1] and Scott Schoefernacker[2]

The West TN H2O Delegation is a collaborative effort of water authorities, agriculture, industry, utilities, academia, and nonprofit organizations working together since 2022 to advance the goals of Tennessee's first-ever statewide water plan, the 2018 TN H2O Plan. The delegation initially came together after the announcement of the $5.6 billion Ford Motor Company vehicle plant and SK On battery facility at the Megasite in Stanton, Tennessee. Each member recognized that increased development would impact water resources and our work at each respective organization. With West Tennessee sitting atop one of the largest aquifer systems in the country, the group discusses regional water management to sustain municipal, industrial, and agricultural needs. We have met quarterly for three years to reduce silos and increase alignment between differing water stakeholders, identifying ways to protect the aquifer and related surface waters as a public health, environmental, and economic priority. To date we have strengthened relationships among our diverse groups of stakeholders; identified data gaps and research needs to inform future investments; advancing local adoption of wellhead protection and regional solutions for groundwater, wastewater, and stormwater management; and facilitating data collection and sharing across agencies, municipalities, and industries. This unique partnership can serve as a model that can be replicated in other parts of the state and the Mid South region.

[1] Executive Director, Protect Our Aquifer, sarah@protectouraquifer.org
[2] Science Director, Protect Our Aquifer, scott@protectouraquifer.org

INTEGRATING RIVER GEOMORPHIC PROCESSES INTO GROUNDWATER MANAGEMENT: INSIGHTS FROM NUMERICAL MODELING

Marcia Achiaa Frempong[1] and Anner Paldor[1]

Natural geomorphic processes can significantly alter surface water–groundwater interactions, yet their influence on groundwater availability is not fully understood. As water managers increasingly seek strategies that integrate physical processes into sustainable policy decisions, understanding these interactions becomes essential. Using a fully coupled, surface water-groundwater model, we evaluate how a chute cutoff, which is one a common geomorphic process in rivers, affects aquifer dynamics (particularly drawdown patterns, groundwater levels, and surface water–groundwater exchange) under varying saturation conditions and pumping scenarios. Results show that although the cutoff initially reduces flow into the bypassed meander, the meander remains hydraulically connected, exhibiting alternating gaining (i.e., groundwater discharges into the river) and losing (i.e., surface water infiltrates the underlying aquifer) behavior. Simulations with a cutoff consistently experience smaller drawdowns, with the largest reduction occurring in partially saturated conditions. The cutoff enhances hydraulic connectivity between the surficial and subsurface drainage system across the watershed, allowing the stream to feed more water into the aquifer and raise groundwater levels well beyond the immediate river corridor. These findings suggest that river cutoffs can alter aquifer resilience by redistributing recharge, which could imply different pumping impact in different locations relative to the cutoff. Incorporating cutoff dynamics into water-management planning can support more adaptive policies, highlighting the importance of geomorphic–hydrologic linkages in sustainable groundwater and surface-water management.

[1] Department of Earth, Environmental and Planetary Science, University of Tennessee, Knoxville

APPLICATIONS OF AIRBORNE ELECTROMAGNETIC SURVEYS FOR HYDROGEOLOGIC FRAMEWORK DEVELOPMENT IN WESTERN TENNESSEE

Ryan F. Adams[1] and Wade Kress[1]

Airborne electromagnetic (AEM) surveys conducted by the U.S. Geological Survey in 2019–2021 have provided detailed imaging of the geology of western Tennessee. These surveys deliver high-resolution subsurface resistivity data that delineate key stratigraphic units, including the Sparta/Memphis Sand aquifer and the underlying Midway confining unit. The Sparta/Memphis Sand is the primary groundwater source for the region, exhibiting significant variability in thickness due to faulting and localized channel deposits, particularly near Jackson, Tennessee. AEM data enable accurate mapping of the aquifer's recharge zone east of Shelby County and reveal structural features associated with the New Madrid Seismic Zone and Reelfoot Rift.

Beyond structural characterization, AEM surveys serve as a foundation for developing robust hydrogeologic frameworks. These frameworks improve understanding of aquifer geometry, connectivity, and groundwater–surface water interactions, supporting sustainable water resource management. High-definition mapping of major rivers further enhances the ability to evaluate recharge across the region.

Building on these successes, additional AEM surveys are planned for summer 2026 to expand coverage along major rivers and fully capture the Sparta/Memphis Sand recharge zone. This expanded dataset will support future groundwater models and inform long-term planning for municipal supply, agricultural use, and habitat restoration.

The integration of AEM technology into water resource investigations represents a transformative approach for western Tennessee. By providing a detailed subsurface view at a regional scale, these surveys equip decision-makers with the information needed to protect critical aquifers and ensure sustainable water availability for future generations.

[1] U.S. Geological Survey Lower Mississippi-Gulf Water Science Center, Nashville, TN, USA

DRIVERS OF IRRIGATION DEPENDENCE: UNTANGLING THE COMPLEX RELATIONSHIPS BETWEEN GROUNDWATER AVAILABILITY, HYDROCLIMATE, SOILS, LANDSCAPE, ECONOMICS, AND TECHNOLOGY

Mary Yaeger

The Tennessee H2O plan was developed to aid the state in navigating changes in population, land use, and climate, and building resilience to both water surplus and scarcity. In west Tennessee, a mainly rural and agricultural region with two urban centers, groundwater is the primary source of water for all uses. Although surrounded to the west and south by densely-irrigated agricultural areas experiencing groundwater depletion, west Tennessee remains less than 20% irrigated, like its northern agricultural neighbors. The severe drought of 2012 prompted a doubling of irrigation well installations by 2013, raising questions about how an increase in intra- and multi-year droughts might influence future irrigation installations. This comparative analysis attempts answers by examining agricultural regions of varying irrigation densities across Arkansas, Illinois, Nebraska, and Tennessee for a better understanding of the natural and human system drivers behind past and potential future irrigation dependence.

Agriculture in Arkansas and Tennessee is concentrated in a small area compared to Illinois and Nebraska, yet it is in Arkansas and Nebraska that nearly 50% or more of statewide harvested cropland is irrigated. Nebraska's climate is moisture-limited, which explains most of its irrigation dependence, while Illinois is source-limited, explaining its relative lack of irrigation dependence. The drivers of irrigation dependence in east Arkansas and west Tennessee are more complex and interrelated. While these regions share hydroclimate and groundwater availability, they differ in soils and landscape topography. These differences, combined with economic and technologic drivers, have influenced the type and success of both crops and irrigation, resulting in two very different irrigation dependence trajectories.

HIGH-RESOLUTION GEOPHYSICAL MAPPING OF AQUIFER STRUCTURE: ASSESSING GEOLOGIC COMPLEXITY AND WATER AVAILABILITY IN NORTHERN SHELBY COUNTY, TENNESSEE

Ryan Adams[1] and Wade Kress[1]

In September of 2021, the U.S. Geological Survey and the University of Memphis contracted 1,200 km of airborne geophysical surveys in the northern portion of Shelby County, Tennessee. Electromagnetic sensors were used to map shallow aquifer and confining units and assess the degree of connectivity between the principal drinking water aquifer for Memphis, Tennessee and the surficial aquifer system that overlies it. The thickness and continuity of the layers overlying the principal drinking water aquifer change considerably due to tectonic and erosional features. This irregularity in the area's geologic structure creates difficulty in managing and modeling the usage of the aquifer for the local water utility.

The focus of this study is the Middle Claiborne confining unit—locally known as the Cook Mountain Formation. This Tertiary-age clay formation is the primary confining unit in the aquifer system. Analysis of borehole geophysical logs indicated potential windows within the Cook Mountain Formation where this unit was eroded or changed composition. These windows may facilitate vertical hydrologic communication between the surficial and deeper drinking water aquifers.

Due to the proximity of the New Madrid Fault Zone, numerous faults intersect the study area, and several bisect or offset the Cook Mountain Formation from its conventional stratigraphic position. These faults could also provide pathways for water to move through the confining unit and into the drinking water aquifer.

The airborne geophysical surveys greatly expanded the resolution of these geologic features—increasing the number of locations sampled from 250 boreholes to over 21,000 electromagnetic soundings. This increase in resolution refined the extent of the fault structures and clarified which faults cut the Cook Mountain Formation. The isolated windows in the Cook Mountain Formation identified by borehole logs and groundwater modeling coalesced into channel features carved by glacial outburst flooding. By mapping these layers at high resolution using efficient, non-contact data collection, a robust framework for modeling water quality and water availability can be established even inside a busy urban landscape.

[1] U.S. Geological Survey Lower Mississippi-Gulf Water Science Center, Nashville, TN, USA

CHARACTERIZATION OF THE AMBIENT WATER QUALITY OF THE CENTRAL BASIN AQUIFER SYSTEM IN TENNESSEE

Kristi L. Hill[1], Laura S. Ruhl-Whittle[3], Amy M. Hourigan[1], Spencer R. Smith[2], Brian Ham[4]

The U.S. Geological Survey, in collaboration with the Tennessee Department of Environment and Conservation (TDEC), is developing a groundwater quality monitoring network across the principal aquifers of Tennessee. The purpose of this study is to characterize the Central Basin aquifer system using water-quality data collected as part of this monitoring effort and historical data collected as part of regional aquifer studies for the USGS National Water Quality Networks. Middle Tennessee is comprised of two aquifer systems; the Central Basin – composed of Devonian and Ordovician aged, primarily carbonate, rocks and the Highland Rim – the surrounding, younger Mississippian aged rocks. Water-use data from 2015 identified that groundwater is the primary drinking water source for about 18% of Middle Tennessee residents, public-supply and domestic self-supplied combined; underscoring the importance of these freshwater resources (Dieter and others, 2018). Groundwater samples collected from the early 1990's-2025 were analyzed for major ions, trace elements, nutrients, dissolved organic carbon, pesticides, volatile organic compounds, tritium, and field parameters. This dataset includes 12 recently sampled wells (from 2024-2025) with historical samples, as well as about 142 additional, previously sampled, wells from various regional aquifer studies. These data provide an opportunity to identify if and where water quality changes are occurring in this aquifer system. Characterization of the water quality of the Central Basin aquifer system will provide a better understanding of the age, movement, and quality of the groundwater for this region to allow better planning and potential protection for the groundwater of Middle Tennessee.

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[4] TDEC, Division of Water Resources, Nashville, TN

CHARACTERIZATION OF THE AMBIENT WATER QUALITY OF THE HIGHLAND RIM AQUIFER SYSTEM IN TENNESSEE

Amy M. Hourigan[1], Laura S. Ruhl-Whittle[3], Kristi L. Hill[1], Spencer R. Smith [2], Brian Ham [4]

The U.S. Geological Survey, in collaboration with the Tennessee Department of Environment and Conservation (TDEC), is developing a groundwater quality monitoring network across the principal aquifers of Tennessee. The purpose of this study is to characterize the Highland Rim aquifer system using water-quality data collected from the major supply aquifers as part of this monitoring effort and historical data collected as part of regional aquifer studies for the USGS National Water Quality Networks. Middle Tennessee is comprised of two aquifer systems; the Highland Rim – composed of Mississippian aged, primarily carbonate, rocks which surround the Central Basin – the eroded basin of older, Devonian and Ordovician rocks. Water-use data from 2015 identified that groundwater is the primary drinking water source for 18% of Middle Tennessee residents, public-supply and domestic self-supplied combined; underscoring the importance of these freshwater resources (Dieter and others, 2018). Groundwater samples collected from the early 1990's-2025 were analyzed for major ions, trace elements, nutrients, dissolved organic carbon, pesticides, volatile organic compounds, tritium, and field parameters. This dataset includes 22 recently sampled wells (from 2024-2025) with historical samples, as well as about 292 additional, previously sampled wells from various regional aquifer studies. These data provide an opportunity to identify if and where water quality changes are occurring in this aquifer system. Characterization of the water quality of the Highland Rim aquifer system will provide a better understanding of the age, movement, and quality of the groundwater for this region to allow better planning and potential protection for the groundwater of Middle Tennessee.

[1] U.S. Geological Survey, 640 Grassmere Park, Ste. 100 Nashville TN 37211
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VARIABILITY OF NUTRIENT CONCENTRATIONS IN THE PRINCIPAL AQUIFERS OF TENNESSEE

Laura S. Ruhl-Whittle[3], Kristi L. Hill[1], Amy M. Hourigan[1], , Spencer R. Smith [2], Brian Ham [4]

The U.S. Geological Survey, in collaboration with the Tennessee Department of Environment and Conservation (TDEC), is developing a groundwater quality monitoring network across the principal aquifers of Tennessee. This network will be used to characterize the quality of groundwater in aquifers used for water supply and assess their suitability for domestic supply among other potential uses. To date, 67 groundwater sites in this network in west and middle Tennessee have been sampled for major and trace inorganics, nutrients, and volatile organic compounds; as well as pesticides, radionuclides, and fecal indicator bacteria at a subset of these sites. This presentation focuses on results for nutrient samples collected from 2023 through 2025 and supplements these data with 305 previously sampled wells (1989-2022). Nutrient concentrations varied across Tennessee, with 7 sites exceeding the MCL for nitrate (10 mg/L), and results were evaluated with respect to land use, well depth, geology, and dissolved oxygen concentrations (redox conditions). These data enhance the understanding of groundwater quality and how water quality changes along regional flowpaths in Tennessee, supporting water resource managers in planning and protecting the state's groundwater resources.

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ARTIFICIAL INTELLIGENCE: BOON OR BANE?

Gerald Burnette

Artificial Intelligence (AI) is becoming pervasive. Its promoters promise that a panacea of positive outcomes is immediately available by applying AI to every task we can imagine. Its detractors envision all sorts of dangers ranging from overreliance on technology to the total destruction of mankind. As with most technology, the truth probably falls somewhere in between. This presentation will offer a high-altitude assessment of how AI may affect humans in a number of important areas including societal, environmental, and economic. We will also assess the opposing pathway: how the rush to develop and deploy AI is affecting the technology.

AN AI-ENABLED, MODULAR RESEARCH PLATFORM FOR WATER RESOURCES SCIENCE

Benjamin Ledesma[1,2,*], Rodrigo Villalpando-Vizcaino[1,2], and Brian Waldron[1,2]

Advances in cloud computing and artificial intelligence (AI) have dramatically lowered the barriers to building custom scientific workflows, enabling research groups to automate computation while maintaining rigorous scientific judgment and validation. These shifts demand research platforms that prioritize transparency and interpretability alongside automation. At the University of Memphis - CAESER, we developed an interactive, cloud-based platform for water resources science, that integrates AI and cloud services into professional, in-house workflows, without requiring dedicated software developers. The platform is modular, with components implementing defined processes and pipelines to support end-to-end research activities, including collaborative data ingestion, sharing, analysis, reporting, and learning. Field-to-database workflows feature automated barometric compensation for pressure transducers, interactive data exploration, and water-level visualization, efficiently transforming raw observations into interpretable datasets. Other modules enhance data expansion and quality control through AI-assisted extraction of historical and unstructured records with iterative validation. The platform also integrates internal data, with real-time external databases (e.g., USGS monitoring), task management tools for collaborative workflows, and document readers and audio-based learning modules for training and education. Additionally, higher-level analytical and decision-support modules, such as recharge calculators and task-specific AI agents, build directly on this shared infrastructure. Users can generate, iterate, and expand codes, adding new modules as research questions and deliverables evolve. All components are immediately usable by professionals, researchers, and students, emphasizing reproducibility, uncertainty awareness, and critical evaluation. The platform applies not only computational techniques, but also encourages how to question results and evaluate outputs critically. This work demonstrates how small research groups can deploy, adapt, and share AI-enabled workflows that enhance scientific judgment while advancing open, collaborative water-resources research.

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AI-ASSISTED WEB TOOLS FOR IDENTIFYING HEADWATER WATERSHEDS USING USGS APIS AND INTERACTIVE GEOSPATIAL ANALYSIS

Peter Li, JoTing Wang, John Frisbee, Karina Bynum, and Brian Ham

Emerging AI technologies are rapidly transforming how water-resource professionals acquire, process, and interpret geospatial information. This presentation introduces TTUWatershed.com, an AI-assisted web platform designed to streamline the identification and analysis of headwater watersheds using HUC10 and HUC12 boundary data. Built with Python and guided heavily by large-language-model support, the system integrates three flexible modes of data ingestion: (1) automated retrieval of watershed boundaries via the USGS Watershed API, (2) selection from preset regional shapefiles, and (3) user-uploaded shapefiles for customized analysis.

Once processed, the platform automatically extracts headwater watersheds through AI-supported geospatial algorithms and displays them in an interactive, web-based map interface. Each headwater polygon is clickable, providing users with on-demand metadata and watershed characteristics. To support professional workflows, the platform also includes a built-in download mechanism allowing users to export their results Shapefiles or File Geodatabases (.gdb) for direct use in GIS software.

This project demonstrates how AI—when paired with traditional geospatial libraries—can accelerate watershed delineation, reduce manual preprocessing, and make hydrologic boundary data more accessible to scientists, engineers, educators, and decision-makers. The talk will highlight the underlying Python workflow, the role of generative AI in both algorithm design and interface development, and future directions for integrating more advanced hydrologic analytics into web-based decision-support tools.

SESSION 3A

Friday, April 17th at 8:30 am - 10:00 am
STREAM MITIGATION
(Moderator: Ken Barry, CEC)

24 Choice Lanes SQT Project
J. Armitage

Compensatory Mitigation for Stream Restoration: An Ecohydraulic Approach to Develop a Reference Curve
C. Parks Oliver

Overview of the Tennessee Mitigation Assessment Tool
J. Schwartz

I-24 CHOICE LANES SQT PROJECT

Jaimie Armitage[1]

The I-24 Choice Lanes SQT Project evaluated streams along the I-24 corridor between Murfreesboro and Nashville, Tennessee, in support of proposed Tennessee Department of Transportation (TDOT) capacity improvements. This effort involved comprehensive application of the Tennessee Stream Quantification Tool (TN SQT) through both field and desktop assessments across 119 stream reaches within the environmental technical study area.

The TN SQT was developed to quantify stream function through five primary functional categories: hydrology, hydraulics, geomorphology, physicochemical, and biology. Each category is evaluated using a suite of field-based and analytical parameters, producing individual functional scores that are averaged to generate an overall Existing Conditions Score (ECS) ranging from 0.0 to 1.0. These scores, in combination with proposed impact scenarios, are used to calculate changes in functional feet and determine compensatory mitigation requirements.

Results from this large-scale assessment were used to characterize baseline stream conditions and quantify the environmental and economic implications of potential impacts associated with the project. This presentation highlights the TN SQT methodology, field and desktop assessment workflow, and key findings from one of the largest transportation-related SQT applications in Tennessee. Additionally, the evolution of stream assessment methodologies, from the current TN SQT to the upcoming Tennessee Mitigation Assessment Tool (TMAT), is discussed in the context of large infrastructure projects.

[1] Barge Design Solutions

COMPENSATORY MITIGATION FOR STREAM RESTORATION: AN ECOHYDRAULIC APPROACH TO DEVELOP A REFERENCE CURVE

Ceara Parks Oliver

The mission of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Compensatory mitigation attempts to advance this mission by restoring sites to offset unavoidable impacts elsewhere. State-regulated tools, including the Stream Quantification Tool, are designed to evaluate functional changes in streams resulting from impacts and mitigation projects. Despite the national goal of "no net loss", studies have documented declines in biological integrity at restoration sites, highlighting the need to improve mitigation methods. Current mitigation practices include microhabitat structure, such as large woody debris, while overlooking mesohabitat features like pools and riffles. This study introduces a mesohabitat reference curve, translating ecohydraulics to biological conditions for compensatory mitigation. Seven stream reaches were surveyed across Tennessee's Ridge and Valley ecoregion, representing ecoregion reference, urban impaired, and urban restored conditions. Sites were selected based on Tennessee Macroinvertebrate Index (TMI) scores, where values above 32 indicate relatively good biological conditions while lower values indicate impairment. Two-dimensional hydrodynamic models (River2D) were built to quantify weighted usable area (WUA) - the estimated availability of suitable habitat - based on velocity, depth, and substrate. WUA, a key metric for evaluating mesohabitat structure, provides the basis for calculating field values. These values are then plotted against their corresponding TMI scores to generate the reference curve, with the resulting compensatory mitigation index score on the y-axis. This presentation will outline the construction of the mesohabitat reference curve, the statistical analysis behind it, and its potential to improve compensatory mitigation practices.

OVERVIEW OF THE TENNESSEE MITIGATION ASSESSMENT TOOL

John S. Schwartz[1]

The Tennessee Stream Quantification Tool (TN SQT) for compensatory mitigation debiting and crediting has been revised over the past several years from a working group of TDEC, USACOE, and practitioners. Because of the changes to the mitigation assessment framework, the TN SQT was changed as the Tennessee Mitigation Assessment Tool (TMAT). An overview of the TMAT is presented with an emphasis on the new assessment framework, and new metrics. Overall, the TMAT reduced the number of metrics assessed from the TN SQT, simplified the field data collection of the previously more time-consuming metrics, and provides non-bankfull metrics when bankfull indicators are not adequate.

[1] University of Tennessee, Knoxville

SESSION 3B

Friday, April 17th at 8:30 am - 10:00 am
EMERGING TECHNOLOGIES
(Moderator: Ryan Jackwood, Harpeth Conservancy)

Automated Technology Complements Community Science Stream Stage Monitoring Project
I. Luffman, D. Connors, D. Huang, J. Fan

Unlocking the Landscape: Land Cover Classification using AI
K. Lee Lum

Innovative AIoT Based Smart Monitoring and Early Warning for Flood Preparedness
R. Chuang, D. Huang, J. Fan

AUTOMATED TECHNOLOGY COMPLEMENTS COMMUNITY SCIENCE STREAM STAGE MONITORING PROJECT

Ingrid Luffman[1], Dan Connors[2], Dannis Huang[3], and Joseph Fan[3]

INTRODUCTION

Community science research engages community volunteers in the collection of scientific data while providing information and education about important public issues. Examples include the National Weather Service Community Collaborative Rain Hail and Snow (NWS CoCoRaHS) network of weather stations and the National Audubon Society Christmas bird count. In hydrology, such projects may include assessing flood risk perceptions or water quality, and monitoring stream stage. These projects encourage community members to collect observations, get involved in scientific research, and become engaged in an important public issue.

Since 2017, we have managed a community science project in partnership with Johnson City, TN to collect water level (stage) data on Brush Creek (HUC 060101060505) in the absence of any recent gauging data. The watershed is approximately 20 miles long and 1-2 miles wide, and flows through the city's historic downtown. Repeated flooding over the last century led to development of a stormwater utility in 2007, which funded construction of two new city parks that mitigate downtown flooding for moderate (~10-year return period) rainfall events.

Our project to monitor stage on Brush Creek, based on community input, provides useful data, but large data gaps exist overnight and during inclement weather. In particular, only 39 of 2243 (1.7%) community science data reports since 2017 were received between 11PM and 7AM and only 135 (6%) of observations were made when rain was recorded in the previous 15 minutes, and 194 (8.6%) with rain in the previous 30 minutes. Rainfall was recorded at the East Tennessee State University (ETSU) Geosciences weather station 1.2 miles upstream and within the watershed. Missing stage data during overnight and inclement weather leads to gaps in our understanding of rainfall-runoff-discharge relationships on this flood-prone creek.

METHODS

In April 2025, we partnered with NEXCOM to install an automated staff gauge on Brush Creek at Founders Park, adjacent to the manual staff gauge used by community scientists. This partnership provided an opportunity for NEXCOM to field test equipment under varying environmental conditions, and for us to solve our data gap problem. We have analyzed data from April through December 2025, during which stage was recorded at 10-15-minute intervals by the automated NEXCOM system (n = 19,740 measurements), and irregularly reported by community scientists (n = 68 reports).

To compare the two datasets, observations were aggregated into 15-minute intervals (at 00, 15, 30, and 45 minutes past the hour), and the Spearman correlation coefficient was used to account for the nonparametric distribution of the data.

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[2] Bradley Department of Electrical and Computer Engineering, Virginia Tech
[3] NEXCOM

The lime lag between rainfall and peak stage was estimated by performing a cross-correlation analysis with a 15-minute temporal resolution. We then interpreted the time of concentration as the lag associated with the highest cross-correlation. To evaluate the impact of antecedent rainfall on stage, we calculated the Spearman correlation between automated stage and antecedent rainfall at intervals of 30 mins, hourly to 12 hours, at 18, 24, and 36, and 48 hours, and daily from 3-7 days.

RESULTS AND DISCUSSION

Two large rainfall events on July 9 and July 30 were well documented by the community, though three smaller events around July 17 and one on July 27 were not (Figure 1). The mid-month events occurred overnight, illustrating the gap in data reporting that can be filled by the automated system. The July 27 event occurred at lunch time on a Sunday. Interestingly, during one of the high-water events mid-month, there was no rainfall recorded at the ETSU weather station, suggesting a localized cloudburst within the watershed that did not produce rain on campus. Further investigation revealed 0.97 inches of rain recorded at a weather station farther up the watershed (Weather Underground station Claude Gray Rd - KTNJOHNS217).

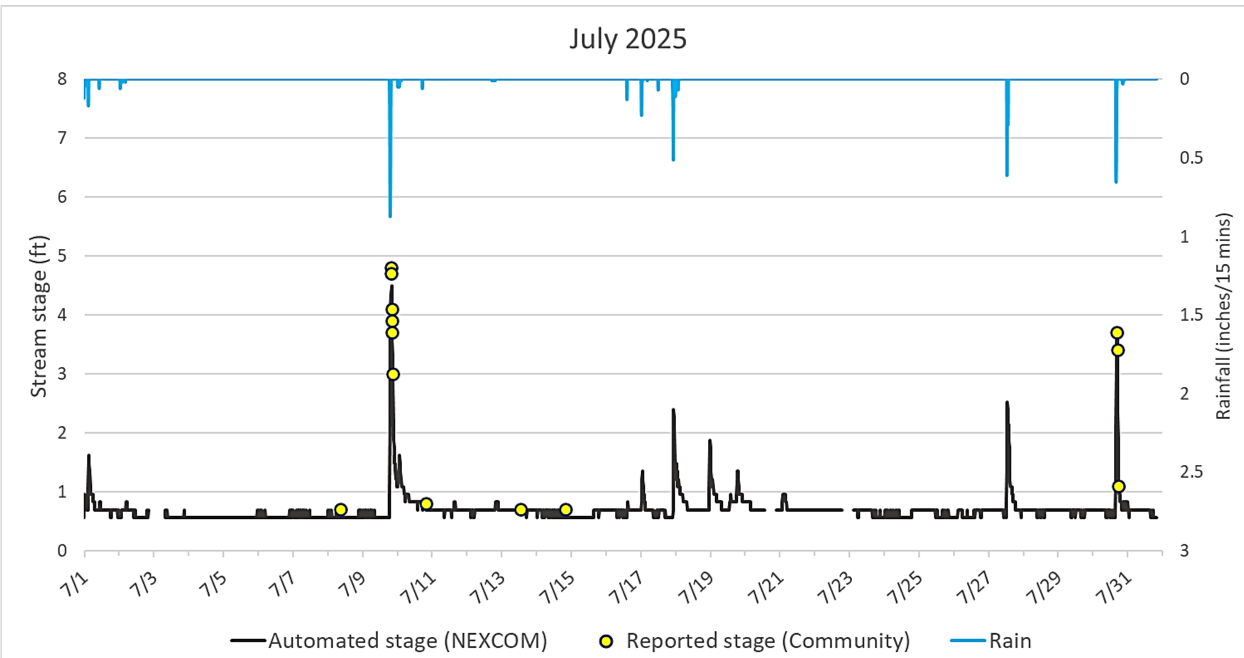


Figure 1. Good agreement is displayed between the automated and community reported stage.

We found good agreement between the automated stage data (NEXCOM system) and the reported stage from our community scientist volunteers (Spearman correlation $r = 0.757$, $p<0.001$). When automated and reported stage values did not agree, in 98% of the instances, the community science reported stage was higher by a median of 0.12 ft (range of 0.01 - 0.63 ft). The largest differences occurred when stage was the highest and the water surface was turbulent. One explanation is that the community scientists may report the stage associated with the wave crest rather than the midpoint or trough in turbulent water, producing a higher stage measurement. Another explanation is that the automated system may miss the peak stage if stream discharge crests during a gap between measurements.

Cross correlation analysis indicates a peak correlation of 0.532 between rainfall and stage at a lag of 45 minutes, confirming flashy behavior consistent with observations, and providing a coarse estimate for the time of concentration (45 mins).

In addition to the total rain received during an event, soil saturation conditions influence runoff. Thus, we calculated antecedent rainfall and found that it was an important factor related to stage; 4-day antecedent rainfall was most highly correlated with the automated stage (r = 0.449) and the 8-hour antecedent rainfall was most highly correlated with the community reported stage (r = 0.832), a discrepancy we attribute to bias associated with increased community reporting following heavy rainfall events and the small number of reported stage measurements (n = 68) (Figure 2). These results illustrate the positive correlation between moist/wet soil and higher stage, though rainfall in the immediate past (i.e., previous 30-45 mins) has the greatest influence on stage.

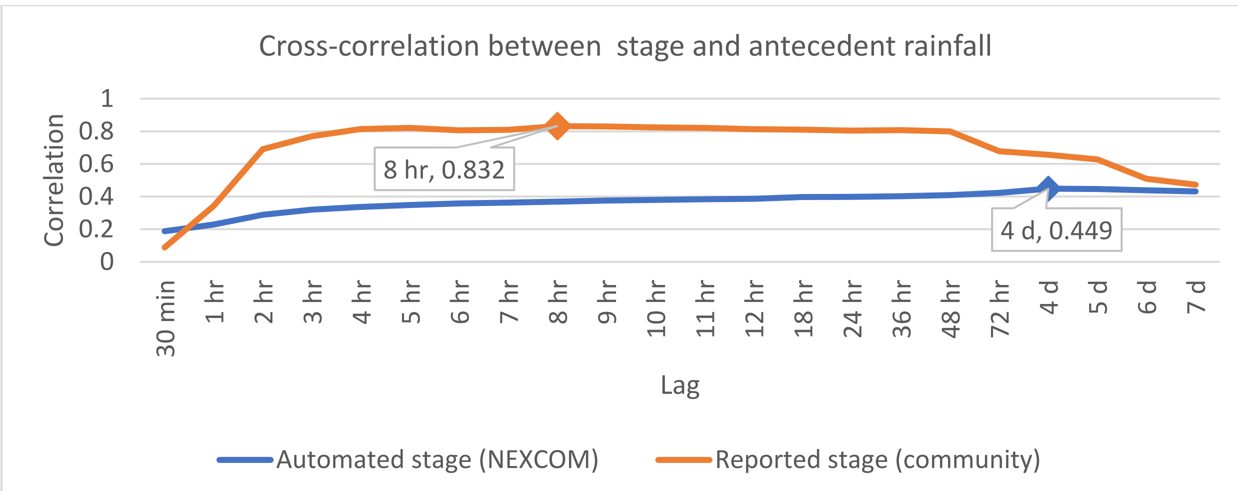


Figure 2. Cross correlation analysis of rainfall with automated and reported stage.

CONCLUSION

The automated staff gauge technology is an important complement to community science contributed data; the NEXCOM system fills important data gaps, capturing high flows associated with nighttime rainfall events not reported by community scientists. In turn, the community science data provide validated data for the automated system.

UNLOCKING THE LANDSCAPE: LAND COVER CLASSIFICATION USING AI

Kevan Lee Lum

Accurate land cover classification is essential for effective water resource management, urban planning, and environmental monitoring. Although traditional remote sensing methods have contributed significantly to the field, they often struggle to capture the complexity of spatial patterns and the diversity of spectral properties present in real-world environments. Recent advancements in deep learning and artificial intelligence offer promising solutions to enhance both the accuracy and efficiency of land cover classification.

Within the world of hydrologic and hydraulic modeling, the National Land Cover Dataset (NLCD)—developed by the Multi-Resolution Land Characteristics consortium—has long served as the industry standard due to its accessibility, comprehensive classifications, and annual updates. However, the evolution of modeling techniques and analytical software underscores the need for more detailed land cover datasets to improve modeling outcomes.

This presentation explores the application of the ESRI High Resolution Land Cover Classification Deep Learning model, demonstrating how satellite imagery can be rapidly and effectively transformed into highly detailed land cover datasets. The session will highlight the advantages of deep learning approaches, compare their outputs to those of traditional classification techniques and established datasets, and discuss the implications for water, GIS, and hydrologic modeling professionals.

INNOVATIVE AIOT BASED SMART MONITORING AND EARLY WARNING FOR FLOOD PREPAREDNESS

Roy Chuang[1], Dannis Huang[2], Joseph Fan[3]

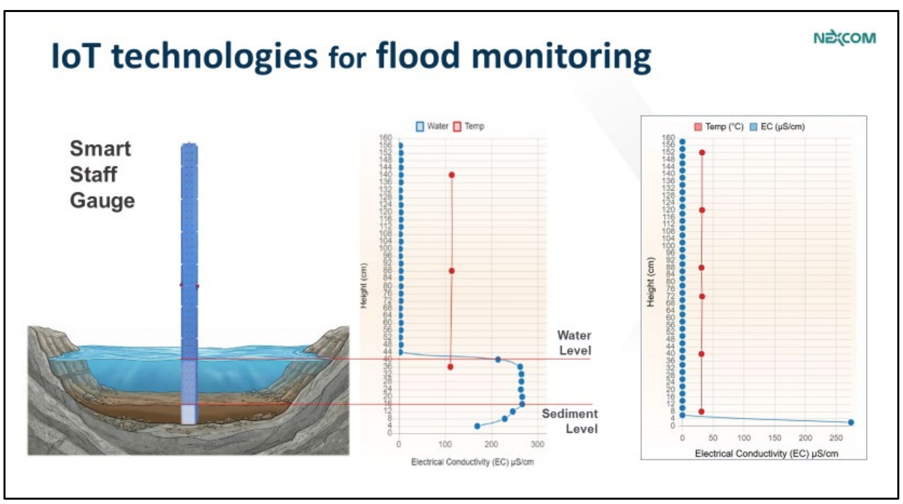
INTRODUCTION

As climate change accelerates, traditional water monitoring methods struggle to provide the real-time responsiveness required for modern disaster mitigation. Emerging technologies are available for All-in-One AI Smart Solution for flood monitoring and water resilience. By integrating Edge AI computing with Industrial IoT (IIoT), the smart flood monitoring system aims to deliver a high-integration, real-time system capable of spotting outliers and providing reliable early warnings in diverse hydrological environments.

Edge AI Computing and machine learning now enable efficient, accurate, and fully on-site monitoring and analysis of hydrological data --- including water level, sediment level, flood prediction, and local meteorological information --- without relying on cloud resources. By preforming deep-learning inference at the edge, the system transforms traditional static sensors into adaptive, intelligent instruments. This shift moves beyond conventional threshold rules toward data-driven predictive intelligence, establishing a new benchmark for smart city and climate-resilience infrastructure.

After heavy rainfall, rivers often transport large loads of sediment and dissolved substances, causing significant changes in electrical conductivity (EC). These EC fluctuations, together with concurrent water level shifts, are crucial indicators of river conditions — especially during the early stages of landslides or floods. These variations can provide early warning signals for impending flood events or landslides.

As depicted below, layered EC electrodes on the smart staff gauge provide EC profile of water body and/or air and/or sediment which can be used for water/sediment level monitoring. Combined with IoT technologies, real-time or near-real-time water level can be obtained promptly. Collected historical data can then be used for long-term hydrological and erosion studies.



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[3] Director, Product Management josephfan@nexcom.com.tw

CORE TECHNICAL FRAMEWORK

The system provides data integrity and accuracy:

- Data Acquisition (Big Data): Reliable data acquisition devices, such as the Smart Staff Gauge, gather near real-time information on water levels, temperature, and electrical conductivity (EC).
- Edge Deployment: Instead of relying solely on cloud processing, the system deploys Edge AI computing systems (e.g., RN-30/RN-50 gateways). This "Edge Intelligence" allows for localized data analysis, reducing latency for critical flood notifications.
- The use of a multi-layer electrical conductivity (EC) profiling smart staff gauge enables near-real-time EC profile data collection and transmission at multiple depths at specific locations within a water body. This profiling helps track water levels, sediment levels, erosion patterns, water quality trends, and provides early warnings of flash floods. A network of the multi-layer smart staff gauge EC profiler can offer timely data on water level fluctuations to trigger prompt warnings.
- Low-power data links (NB-IoT & LoRa) deliver data efficiently to mobile devices and servers. Solar panel provides resilient power for uninterrupted operation. Integrated AI enables self-calibration to correct height drift, improving data accuracy. The system also incorporates gravity and atmospheric sensors to monitor potential landslides or ground subsidence.

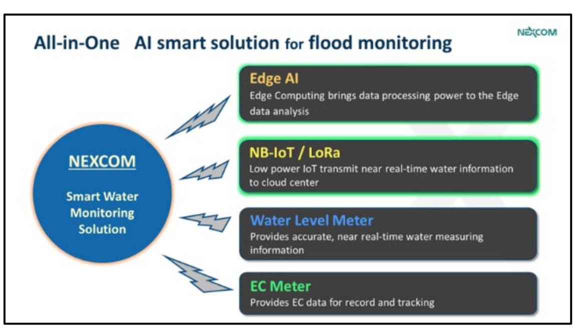
Popularized since 2010’s, application of machine learning requires more training data you can give it to obtain more confident predictions. Outliers must be carefully spotted and screened out from the data set to minimize the adverse impact on prediction results.

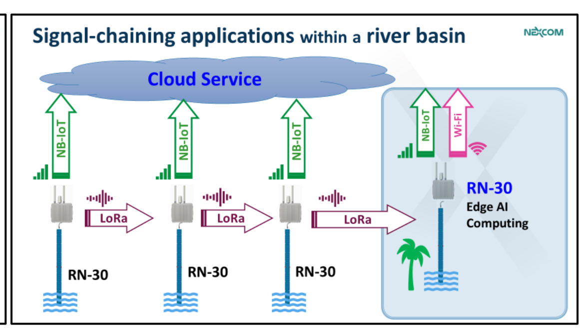
IOT COMMUNICATION AND INTEGRATION

The solution leverages a "One Device Service" model that integrates multiple communication protocols to maintain connectivity in remote settings:

Transmission Technologies: Near real-time information is transmitted to cloud centers via NB-IoT, LoRa, or Wi-Fi.

As depicted below, Edge AI, NB-IoT/LoRa, Water Lever Meter and EC Meter are major parts of the Smart Water Monitoring Solution.

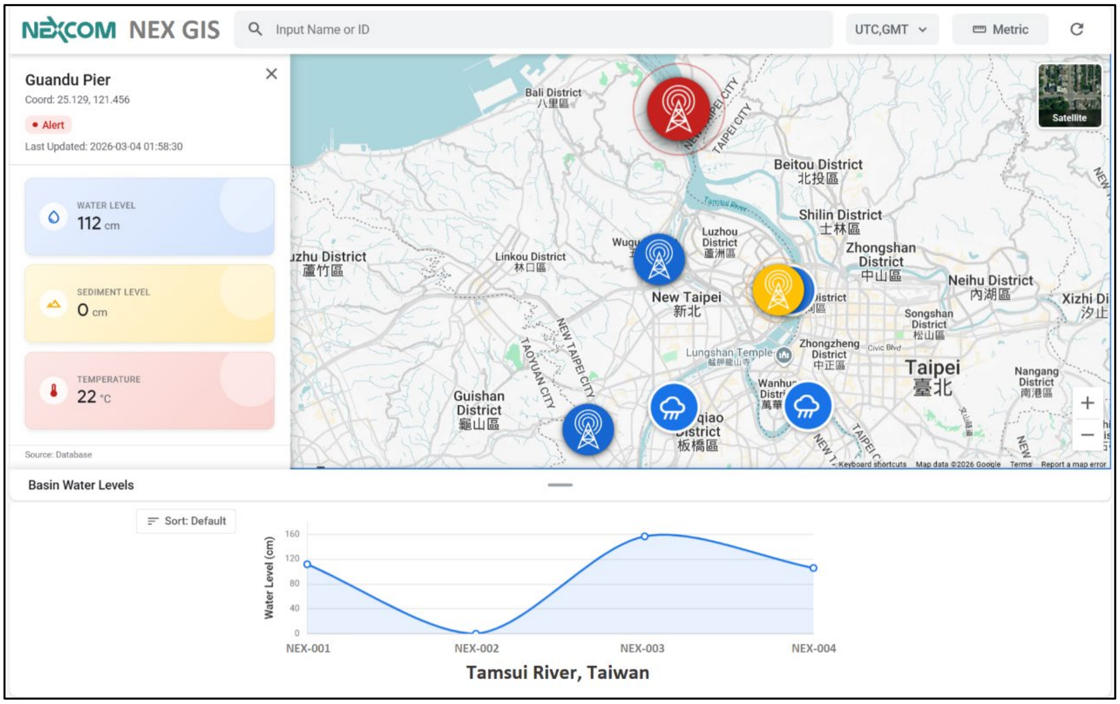




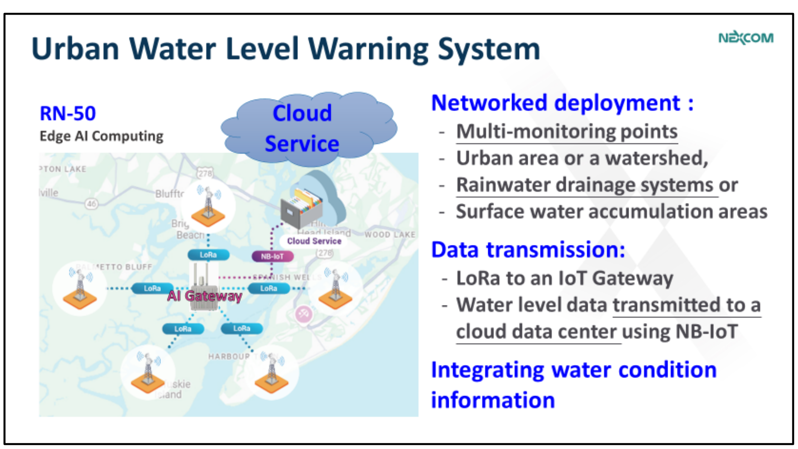
As depicted above, redundant data transmission pathways are important for uninterrupted data transmission so continuous real-time, near-real-time data can be obtained to support prompt decision making through flood monitoring period.

GIS-Based Management: A graphical dashboard utilizing GIS technology provides a "Global View" of monitoring stations, displaying station IDs, water levels, sediment levels, and temperature.

As depicted below, in addition to dashboard for individual monitoring station, the use of GIS technology with visual dashboard provide better situation comprehension and responding decision making.

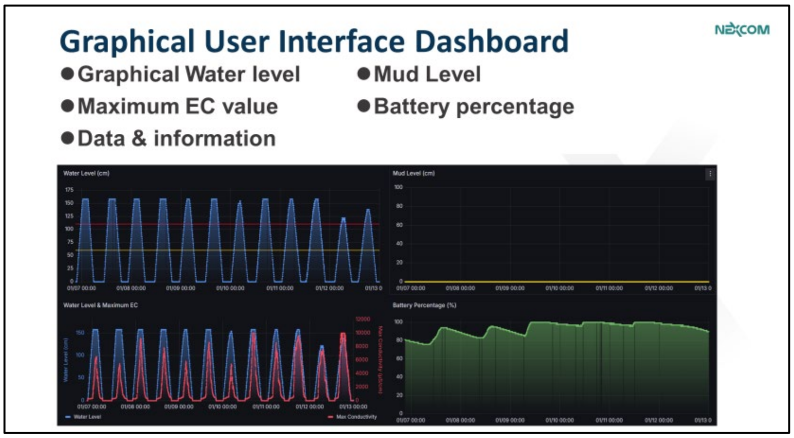


Alerting Mechanisms: The system features a customizable multi-level warning system. Alerts, categorized into levels such as "Yellow Alert" and "Red Alarm," are sent instantly via social media platforms or email with potential of connecting with automatic controlling system for prompt responses such as starting of drainage pumps, flood gate shutting off etc.



As depicted above, a network of AIoT based water level monitors provides multi-points monitoring for potential flooding zone at urban area or a watershed. Prompt data transmission is secured by LoRa technology and IoT Gateway to ensure water level data transmitted to a designated cloud data center properly via NB-IoT technologies.

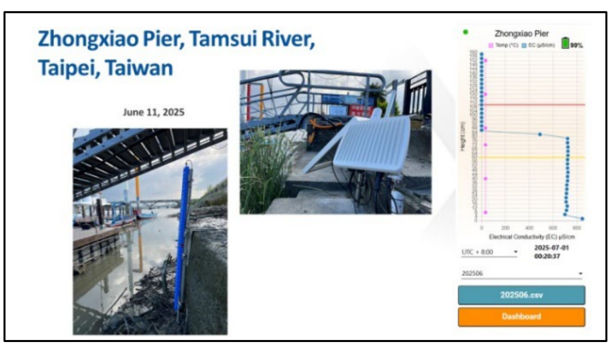
The graphical user interfaced dashboard provides current and historical data with graphical water level for flood monitoring, sediments levels for potential of scouring, maximum ECs for the trending of water health with potential pollutions. Also, the battery capacity can also be monitored to ensure data collection and transmission can be executed properly.

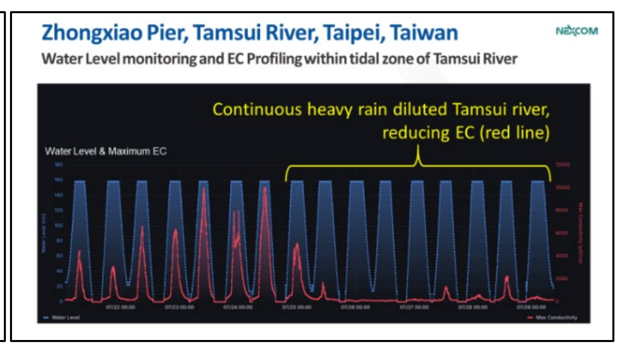


CASE EXAMPLES AND EMPIRICAL VALIDATION

The effectiveness of the system has been validated through multiple global and local installations:

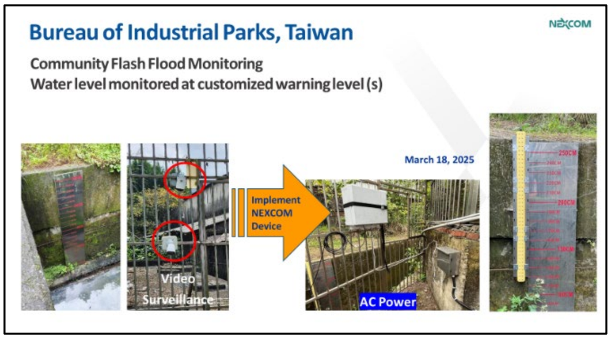
- Tidal Zone Monitoring (Taiwan): Stations at Zhongxiao Pier and Guandu Pier monitor the tidal cycles of the Tamsui River. These sites have successfully recorded how continuous heavy rain dilutes the river, resulting in measurable decreases in EC values.

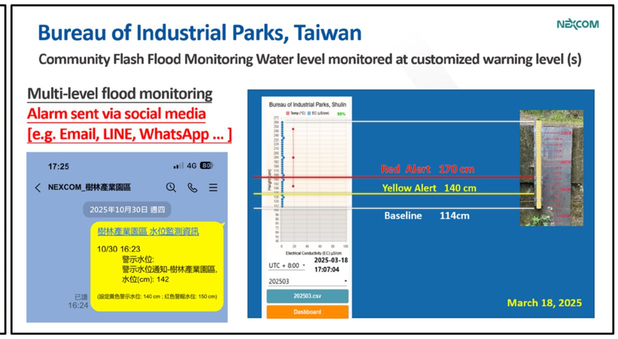


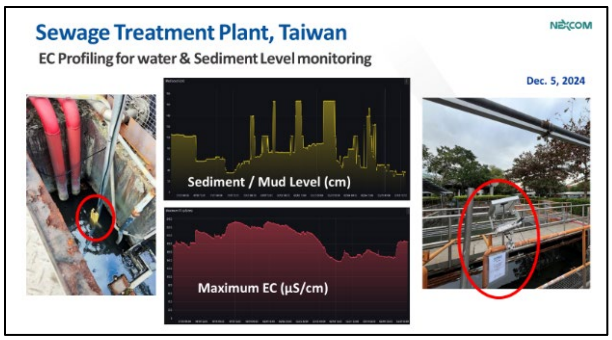


As depicted above reduced EC readings in the tidal zone of Tamshui River been observed after days of rainfall at the upstream area. Potential pollutions from point or non-point sources during regular days or after long rainy days could be observed for water health monitoring.

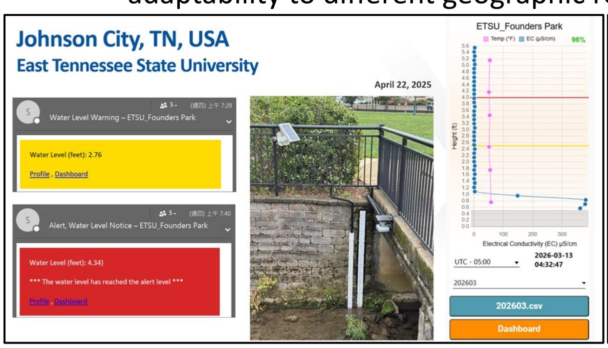
- Industrial and Urban Infrastructure: Systems are deployed at the Bureau of Industrial Parks (Shulin and Wugu) to monitor community flash floods and sewage treatment plant sediment levels.

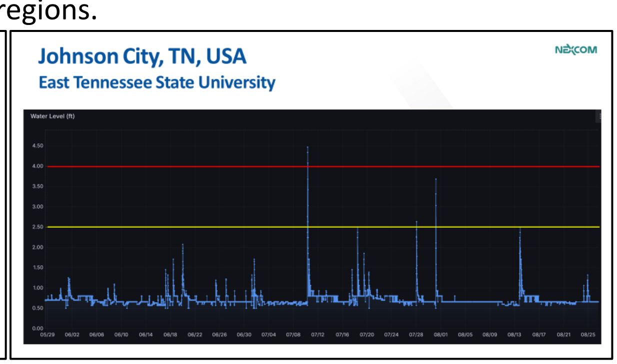






- International Collaboration: A station located at Johnson City, TN, USA, operating by East Tennessee State University since April 2025, has demonstrated the system's adaptability to different geographic regions.





FUTURE WORKS AND OUTLOOK

The future outlook for this technology focuses on providing even more precise water level and water health measurement equipment, serving as a powerful asset for big data collection. By integrating more comprehensive water condition information, the goal is to move beyond localized alerts toward a sophisticated, large-scale urban water level early warning network. With a scalable architecture and AI-optimized processing, this IoT solution bridges field data and near real-time decision-making for water management authorities.

As the Mayor of La Veta, Colorado, once noted regarding disaster response: "Just a few more minutes could save many lives." A network of IoT based water level monitoring stations collect valuable real-time water level data in conjunction with the use of AI data analysis and modeling will provide valuable information such lag time of peak flow, attenuation and delay of peak flow for all stake holders for integrated flood risk management such as land-use planning and early warning system.

POSTERS

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Addressing River Bank Re-stabilization Post-Climactic Disasters
T. Alimurka

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Coupled Carbonate Equilibrium and Metabolic Fractionation Drive δ^{13}C-DIC Variability in Freshwater Ecosystems
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Integrating modeling and Stakeholder Engagement to Develop a Watershed Plan for the Falling Water River Watershed
E.G. White, I. Hollingsworth, R. Kaiser, A. Kalyanapu, T. Datta

Water Quality Analysis of Horse Creek in Sullivan County, Tennessee
T. Winkler and I. Luffman

A PROOF-OF-CONCEPT LOW-COST TURBIDITY SENSOR

Kwesi Ahene[1], Alfred Kalyanapu[1], Tania Datta[1], and Ethan Adams[2]

Healthy water is essential for protecting public health and aquatic ecosystem, yet monitoring water quality, especially continuous monitoring, can be challenging due to the high cost of conventional water quality sensors. Turbidity, an important indicator of water quality, reflects the presence of suspended particles that can harbor pathogens and contaminants. Affordable turbidity measurements are critical for monitoring and maintaining aquatic ecosystems, including rivers and lakes, but current devices can range from $2,000 to $8,000 making them expensive for rural or resource-limited watersheds. This research presents a proof-of-concept for a low-cost turbidity sensor aimed at providing an affordable, reliable, and scalable solution for continuous turbidity monitoring, particularly in rural and developing regions. The proposed design employs readily available components, including a sensor (LED as the light source and a photodiode for detection), and a microcontroller for signal acquisition and processing. Calibration of the sensor was performed using standard formazin-based turbidity solutions. Experimental validation demonstrates that the sensor achieves an average error of 25% compared to measurements from commercial turbidimeter, while maintaining a total cost lower. The design emphasizes simplicity, low power consumption, and adaptability for real-time monitoring applications. By reducing cost barriers and enabling continuous turbidity monitoring, this work contributes to sustainable water management and supports global efforts toward improving water quality. Future work will focus on enhancing sensor robustness, integrating wireless data transmission, and exploring solar-powered operation for remote deployments.

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ADDRESSING RIVER BANK RE-STABILIZATION POST-CLIMACTIC DISASTERS

Tamara Alimurka

In 2024, Hurricane Helene, one of the most catastrophic mainland weather events since Hurricane Katrina in 2005, ripped across the southeastern United States leaving unprecedented levels of destruction in its wake. Hurricane Helene unleashed extreme flood conditions upon the watersheds of western North Carolina and east Tennessee. River banks stripped of their riparian buffers, vegetated strips along a water body, were left vulnerable to the dominance of invasive plant species, erosion of sediment, disruption of river channels, and the degradation of viable habitat for aquatic species vital to the welfare of the watershed. The watershed surrounding the Nolichucky River was among those severely impacted by severe flooding. To grasp the scope of the restoration potential for watersheds affected by Hurricane Helene, a field-scale sample plot was tested with bioengineering stabilization techniques to evaluate its capacity to reduce bank erosion and restore riparian zone stability. In the summer of 2025, a site along the Nolichucky overloaded with alluvial sand deposits was leveled, planted with native grasses, covered with layers of mulch and hay, and secured under coir matting to regenerate soil and diminish sediment erosion. Subsequently, the demonstration site has expanded and native bushes were live staked along the bank to reinforce the effectiveness of the anti-erosion treatments. A collaborative stream bank restoration taskforce was established in Cocke County, site evaluation tools, volunteer workshops were developed to to collect citizen science data assessing the efficacy of the restoration treatments while leveraging new opportunities for applied research across all demonstration sites. Expected outcomes include thoroughly documented successes in native plant re-establishment, vegetative cover restoration, riverbank sediment stabilization, and increased community education and involvement in future projects. Progress made during the initial stages of the restoration project demonstrates significant potential for the long-term collection of robust scientific data validating the viability and reproducibility of the bioengineering stabilization techniques implemented along the Nolichucky River to date.

IMPACT OF BATHYMETRIC DATA ON FLOOD INUNDATION AND HAZARD MAPPING FOR CASCADING DAM BREACH USING HEC-RAS

Priyanka Bajracharya[1], Alfred Kalyanapu[1], Terrell Hendren[2]

Dams are storage structures that provide essential services such as flood control and water supply for the users. However, their failure poses serious threats to human life, infrastructure, and ecosystems. When dams are situated in a cascade, the failure of an upstream dam can initiate the failure of downstream dams, amplifying the impacts of such catastrophic events. This study presents a cascade dam break analysis for two dams in series – Laxton Dam and Pine Creek Number One Dam, in the town of Oneida in Scott County, TN. The objective of this research is to evaluate the progression of dam failures in a cascade system, using topographic and bathymetric data and generate flood inundation and hazard maps based on both datasets for downstream areas to understand the impact of bathymetric data. Firstly, we conducted hydraulic modeling to simulate cascade dam breach using Hydrologic Engineering Center–River Analysis System (HEC-RAS) by incorporating breach parameters such as breach bottom elevation, pool elevation at failure, and breach formation time. We then integrated the bathymetric data for Pine Creek Number One Lake collected using an autonomous boat equipped with a sonar sensor into the HEC-RAS model to improve its accuracy. Model outputs from both simulations were post-processed using Python to generate flood inundation and flood hazard maps. The results demonstrate differences in flood inundation extent and hazard intensity between models with and without bathymetric data, showing the importance of accurate reservoir geometry in cascading dam breach analysis. The findings provide insights for dam safety evaluation, emergency response planning, and flood hazard management and can be applied to similar cascade dam systems to support informed decision-making and community resilience.

[1] Tennessee Technological University
[2] Tennessee Department of Environment and Conservation

PRELIMINARY ANALYSIS WATER QUALITY IN GRAVEL TREE STORMWATER SYSTEMS

Bradan Bruce

Trees in urban spaces are shown to have numerous benefits, including runoff reduction and temperature regulation. Gravel tree planters as bioretention systems have been shown to reduce urban runoff. Urban runoff is a major source of non-point source pollution, such as metals and microplastics, to the watershed downstream. Little work has been done to see whether gravel tree planters are effective at mitigating these pollutants. This study will investigate water quality in stormwater from an urban parking lot before and after passing through a gravel tree stormwater system. The data will analyze the difference in water quality between stormwater entering and exiting the system during storm events large enough that runoff is not completely captured by the system.

HYDROGEOLOGIC INVESTIGATIONS IN A SMALL WATERSHED ON THE HIGHLAND RIM ESCARPMENT

Gary Claywell

The Highland Rim escarpment is an extremely dissected region separating the Highland Rim from the Central Basin. Here hundreds of tributary hollows have been cut into the edge of the Highland Rim, and these drain to the master streams of the Central Basin, including the Caney Fork and the Cumberland River. The Highland Rim escarpment is underlain by soluble carbonate rocks that produce numerous sinking streams, dry stream reaches, and springs. Despite the importance of Highland Rim hollows in controlling runoff to the master streams of the Central Basin, the hydrogeology of these watersheds has not been investigated thoroughly.

We are conducting a study of the streamflow properties, geomorphology, and karst groundwater movement of Ferguson Hollow in southeastern Smith County, Tennessee. The main focus of this project involves dye tracing to better understand the movement of groundwater through Ferguson Hollow. In addition to dye tracing, we measured spring water conductivity, temperature, and spring discharge, as well as rainfall. Finally, ground penetrating radar (GPR) was used to characterize the subsurface near locations where streams sink in Ferguson Hollow.

The water temperature varied from between 16.0 to 19.0 °C in Claywell Creek, over a period of one month. Specific conductance was 413 µS/cm in Claywell Creek, and 225 µS/cm at Ferguson Cave Spring. This higher conductance in the surface water stream may be due to septic field lines and small agricultural operations very close to the stream in Ferguson Hollow. GPR results were useful in detecting the soil-bedrock contact; however, voids in the bedrock were not discernible. A dye trace was conducted in order to delineate the watershed of Ferguson Cave Spring. A total of four tributaries sink in the upper reaches of Ferguson Hollow, about 1.2 miles upstream from Ferguson Cave Spring. We gathered background samples from Ferguson Branch and Ferguson Cave Spring for two consecutive weeks using activated charcoal samplers. We also used charcoal samplers at three other catch-all locations further downstream and in adjacent watersheds. The Ferguson Cave Spring discharge at the time of the dye injection was estimated at 2.2 ft3/sec, using a Marsh-McBirney electronic flow meter. The dye was injected into Claywell Creek, one of the small tributaries of Ferguson Branch. We used 30 grams of Fluorescein dye in a 250 mL solution and collected the charcoal packets on days 1, 2, 3, and 7 after dye injection. Charcoal packets were eluted using a 15-ml alcohol/potassium hydroxide solution for one hour. Elutant samples were analyzed using an Agilent Cary spectrofluorometer. Dye was first detected on day 1, with the peak dye concentration occurring on day 2 after injection. Smaller amounts of dye remained in the Ferguson Cave Spring on days 3 and 7. Results from this study indicate that Ferguson Cave Spring is fed directly from upstream sinking tributaries, with a travel time of less than 24 hours. A higher specific conductance was measured for Ferguson Branch, a surface stream, compared to the cave spring, suggesting that surface streams may carry heavier nutrient loads, possibly related to septic field lines located very close to streams in the narrow valleys of hollows.

GEOCHEMICAL AND SPATIAL ANALYSIS OF ACID MINE DRAINAGE AT THE RAVENSCROFT MINE IN WHITE CO., TENNESSEE

Abby Daniel

Acid mine drainage (AMD) is a biogeochemical process that is associated with metallic ore and coal deposits. The oxidation of sulfide minerals (commonly pyrite, $FeS2$) in these deposits generates sulfuric acid which lowers the pH of the surrounding soil, surface water and groundwater. Along with sulfuric acid, these reactions also release metals into the environment, such as Cd, Fe, Mn, Zn, As and Hg (Jacobs et al., 2014). In the U.S., AMD impacts over 20,000 km of streams causing a degradation of water quality and biodiversity in affected soil and water (Skousen et al., 2019; Acharya and Kharel, 2020).

The Ravenscroft mine near Sparta, TN began operation in 1902. It was one of several area coal mines that operated until 1936 (Carmichael and Carmichael, 2025). The mine consisted of a vertical shaft 178 ft deep, a tipple to load coal into hopper cars and a powerplant. Part of the mining operation was the removal of subsurface rock to access the coal. Waste rock was brought up to the surface forming large tailings piles. Oxidation of these tailings produces acidic leachate that enters the soil, groundwater and flows away from the site as runoff. Today, the Ravenscroft mine is a historic site with a walking trail.

This research expands on a pilot study by Mofield (2024) on evaluating the potential for AMD at the Ravenscroft mine. Mofield (2024) determined that the tailings produce acidic leachate with conductivities of 54-281 µS/cm, indicating the presence of dissolved ions. However, Mofield (2024) did not identify these ions. In this study, we tested the AMD for over 20 metals and 8 anions as well as other water properties such as hardness, conductivity and dissolved organic content (DOC).

Preliminary results show that spring and stream water sampled in May-October 2025 had a pH that ranged from 3.4-6.9 and that the AMD contained elevated concentrations of aluminum (up to 14.3 mg/L), iron (13.2 mg/L) and sulfate (157 mg/L). Iron precipitate staining is ubiquitous in streams on and off the mining site including Buck Creek, a tributary of the Calfkiller River to the northwest. Streams and ponds on the site contain few if any fish, insects or macroinvertebrates. Site investigation indicates that the mine tailings extend far off the historic park site and have the potential to generate AMD over a large area. Future work will map the extent of the tailings and generation of AMD.

MICROPLASTIC QUANTIFICATION AND REMOVAL EFFICIENCIES IN WASTEWATER TREATMENT PLANTS ACROSS MIDDLE TENNESSEE

Gabriela de Almeida[1], Justin Murdock[2], Tania Datta[1]

Microplastics (MPs), defined as plastic particles smaller than 5 mm, have emerged as a global concern for ecosystems and human health. These particles, commonly present as plastic fragments, microbeads, and/or fibers, are pervasive across air, soil, freshwater, and marine environments. Wastewater Treatment Plants (WWTPs) are recognized as both sources and sinks for MPs as they receive, remove, and transform these emerging pollutants from diverse human activities. Understanding MP flux through WWTPs is therefore critical. Although numerous research studies have been conducted to understand the fate and transport of MPs in WWTPs, inconsistencies in sample collection, processing, and analysis persist due to the lack of standardized methods. In 2020, American Society of Testing Materials (ASTM) introduced two methods D8332-20 and D8333-20 aimed at standardizing MP sample collection and quantification in waters of medium to high suspended solid concentrations. However, these methods have seen limited implementation, hindering robust comparison across studies. This study applies modified ASTM methods to conduct a preliminary evaluation of MP reduction efficiencies in three middle Tennessee WWTPs of varying design capacities, service areas, unit processes, and modes of operation. Wastewater influent and effluent samples were collected and processed using wet peroxide oxidation along with Fenton's reagent and enzyme digestion. A Fourier Transform Infrared (FTIR) spectrometer equipped with a Focal Plane Array (FPA) was used to detect and characterize MPs in processed samples. Data will be analyzed through Purency Microplastics Finder software to determine MP type, count, size, and removal efficiencies.

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[2] Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University Cookeville, TN

A GIS-BASED FRAMEWORK TO ESTIMATE NUTRIENT REDUCTION POTENTIAL OF URBAN STORMWATER CONTROL MEASURES IN TENNESSEE

Tori Denney, Bruce Cunningham, Tania Datta

Stormwater runoff poses significant challenges to water quality and quantity, particularly in urban environments where it transports nutrients such as nitrogen (N) and phosphorus (P) into receiving waters. These nutrients drive eutrophication and degrade aquatic ecosystems, making effective stormwater management essential in Tennessee and beyond. Stormwater Control Measures (SCMs) are widely implemented to mitigate these impacts; however, evaluating their nutrient reduction potential can be complex. Despite progress through Municipal Separate Storm Sewer System (MS4) permits and SCM adoption, the absence of a centralized repository of SCMs and easy-to-use nutrient reduction estimation tools limit statewide assessment of effectiveness. This research addresses that gap by developing a GIS-based framework to compile MS4 urban SCM data and estimate their nutrient reduction potential.

In collaboration with the Tennessee Department of Environment and Conservation (TDEC), SCM data from 38 MS4s were compiled and organized into a geodatabase for visualization and analysis. The data primarily includes types and locations of SCMs. Simultaneously, to inform nutrient reduction estimates, 20 technical manuals were reviewed to identify removal efficiencies across SCM types. In addition, the Tennessee Urban Stormwater Nutrient Reduction Tool was developed as a GIS-based application that automates nutrient reduction calculations using SCM characteristics, land use, soils, and contributing drainage areas. Python programming was used to streamline data processing, reduce user inputs, and improve the overall usability of the tool. The tool integrates compiled nutrient removal efficiencies with a statewide SCM geodatabase and produces nutrient reduction outputs. Developed specifically for Tennessee, this first-of-its-kind resource enables environmental agencies, planners, and policymakers to evaluate SCM implementation and nutrient reduction effectiveness at multiple spatial scales. By centralizing SCM data and automating calculations, the framework improves efficiency and supports informed decision-making for statewide stormwater management.

A. DeRegis

Soil nutrient status directly influences watershed health, since nutrient-rich soils contribute to concentrated nutrient runoff and leachate, affecting surface and groundwater quality in agricultural and urban landscapes. Urban soils remain a relatively new area of study, posing unique challenges. This study aims to describe those challenges through quantitative analysis of small-scale food-production soil samples across Tennessee. Nutrient data from The University of Tennessee Soil, Plant, and Pest Center was organized by ZIP code, concentration, ecoregion, and population density. The data was uploaded into ArcGIS Pro (version 3.5.2, Esri, 2024) and statistically analyzed in R (version 4.4.1) using Welch's two-sample t-tests to compare urban and non-urban soil chemistry within each EPA Level III ecoregion. The results indicate significant urban–nonurban differences across 6 of 8 evaluated ecoregions. The Mississippi Valley Loess Plains (Ecoregion 74), which had the most balanced representation (approximately 55% urban and 45% nonurban), exhibited the strongest and most consistent patterns: boron (B), calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), zinc (Zn), and pH were all significantly higher in urban soils, whereas iron (Fe) and manganese (Mn) were significantly lower. Together, these results show that urban soils across Tennessee are chemically influenced by human activity, emphasizing the need to consider urbanization as a major driver of regional variability. Because soil nutrients affect transport to streams, lakes, and groundwater, these spatial patterns also signal potential hotspots of phosphorus and cation export, highlighting areas with water-quality risks.

EVALUATING WATER RESOURCES AT THE ERWIN NATIONAL FISH HATCHERY

Andrew Dickerson[1] and Ingrid Luffman[1]

INTRODUCTION

The Erwin National Fish Hatchery (ENFH), located in Erwin Tennessee (36.16551, -82.38789), supplies approximately 20 million rainbow trout eggs to the United States annually. The location of the hatchery was selected in 1897 due to a spring and a railroad line in proximity. The spring has been used since the establishment of the hatchery to provide a constant flow of fresh water that feeds into the hatchery's operations. However, little is known for the ENFH springs.

In 2008, Robert Benfield studied water sources at two springs and recommended further study of spring flow and water quality plus an inventory of springs and wells (Benfield, 2008). In 2024, the ETSU Geosciences Hydrology class performed a short 2-week pilot study of water resources at ENFH springs and found that the water from the Main Spring and the Brownhouse Spring do not originate from the same source based on a finding of statistically significant differences in water quality parameters between the two springs. ETSU's 2024 study also found a 4.5-day lag between rainfall and increased water level though there is no correlation between rainfall and water level chemistry. (Luffman et al., 2024).

The study described here is a follow-up study to determine whether short term trends observed in the pilot study persist over a longer time. In particular, the aims of this study are to 1) quantify changes in water level and chemistry of two ENFH springs in response to rainfall events and 2) compare water quality parameters between two springs.

METHODS

This study recorded water chemistry and flow from July 1 – November 24, 2025, at two ENFH springs: the Main Spring which ENFH relies on for its operations, and a second spring which is not currently in use as a water source. This second spring is an old Spring Box located on an adjacent plot of land and is a potential water source for the hatchery (Figure 1). Discharge and water quality of the Spring Box are unknown.

HOBO water level, conductivity, and rain gauge data loggers were deployed on site for the duration, collecting data at 15-minute intervals. A Teledyne ISCO sampler collected 900 mL water samples every 12 hours at the Main Spring. These samples were retrieved weekly, and water parameters were measured with a YSI ProDss multiparameter water quality meter. During site visits to retrieve water samples, water parameters at the Spring Box were measured using separate dissolved oxygen (DO), conductivity (EC), and turbidity meters to avoid cross—contamination between springs. Logger data were downloaded monthly, and all other data were recorded in a field notebook. Field equipment and water quality parameters are shown in Table 1.

[1] East Tennessee State University

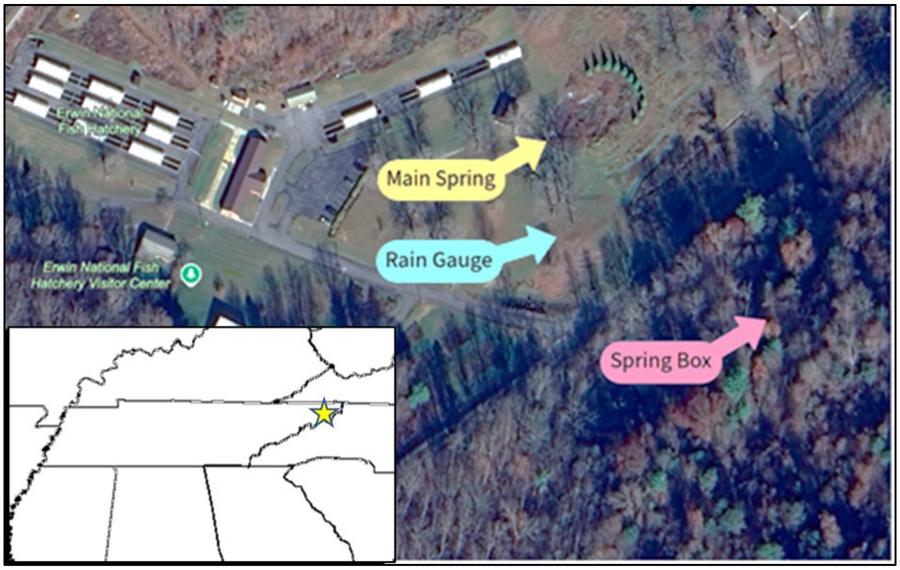

Figure. 1 Erwin National Fish Hatchery site map.

Table 1. List of equipment and water quality parameters.

Equipment	Location(s)	Parameters
Rain gauge (HOBO Onset RG2)		Rainfall
Water level data loggers (HOBO 30' U20L-01 and 100' U20-001-02)	Main Spring, Spring Box	Spring stage
Conductivity data logger (HOBO U-24-001)	Main Spring	Electrical Conductivity
YSI multiprobe (ProDSS-2 626870-2)	Main Spring samples	Dissolved Oxygen, Conductivity, Specific Conductivity, Total Dissolved Solids, Salinity, pH
Turbidity (LaMotte 2020we)	Main Spring, Spring Box	Turbidity
Teledyne ISCO 6712 automated water sampler	Main Spring	Collected 900 mL water samples every 12 hours

For proper QA/QC, all equipment to be placed in contact with spring water was soaked in an 1% Virkon solution and power washed with hot water. Further, the YSI was rinsed with a 1% solution of Liquinox and rinsed with deionized water between measurements.

To assess the relationship between lagged rainfall, water level, and water quality parameters, correlation and cross-correlation analyses were performed using IMB SPSS.

RESULTS AND DISCUSSION

Analyses reveal that water level in the two springs is correlated ($r = 0.228$, $p= 0.011$) and that they respond to rainfall events with increased discharge. However, the two springs have different lag times between rainfall and increased water levels. For the Main Spring this lag is approximately 4.5 days ($r = 0.050$) and for the Spring Box this lag is approximately 2 days ($r = 0.130$). Though these values are small, they are statistically significant. These results suggest that there are different recharge areas, known as springs sheds, for these two springs. This indicates that the Spring Box could be a valuable potential alternate water source for ENFH.

Further, water levels in both springs are positively correlated with EC at a lag of 0 days (Main Spring r = 0.558; Spring Box r = 0.642), indicating that as water level increases, so does conductivity. High conductivity suggests that the water supply for the springs has a longer residence time than the 4.5 days and 2 days suggested by the rainfall lags, which could indicate that runoff entering the groundwater system during a rainfall event pushes older water out at the spring, raising the water level and increasing conductivity.

We found that turbidity increased in the Main Spring for 1 to 3 days after rainfall, with the correlation between rainfall and turbidity peaking 2.5 days following rainfall (r = 0.391). When 48-hour antecedent precipitation was compared to turbidity, it peaked approximately 1 to 2 days later (r = 0.399). These findings contrast from the lags calculated for water level and EC, suggesting that increased turbidity may result from surface runoff carrying sediment into the spring.

DO was negatively correlated with rainfall at the Main Spring at a lag of 5-10 days (during this time, DO remained low before recovering). This finding indicates the complex nature of rainfall influences DO in karst systems. Usually, rainfall introduces DO into the system, but the inclusion of organic material into groundwater through sinkholes can have the opposite effect, reducing DO (Ge et al, 2025). DO was also negatively correlated with turbidity at a lag of 3-6 days. This means that after a 3–6-day lag, turbidity will increase, which means in turn DO will decrease.

The original study was intended to run from July through January to gauge seasonal changes in hydrology; however, freezing weather in November forced us to retrieve the ISCO sampler and data loggers and conclude the study early.

CONCLUSION

Prior to this study, little was known about the springs located at ENFH. This study built upon a short 2-week pilot study and an earlier study of only two water samples focusing on the Main Spring and evaluated a new potential water source at a Spring Box located on an adjacent plot. We measured different response times of water level increases following rainfall events between the Main Spring and the Spring Box of 4.5 and 2 days, respectively, which suggests that the springs have different water sources and spring sheds.

We also found a positive correlation between rain and turbidity at a lag of 1-3 days after rainfall, suggesting surface runoff inputs to the spring. Dissolved oxygen was negatively correlated with rain and turbidity at lags of 5-10 days, and 3-6 days, respectively, illustrating the complex nature of water chemistry in karst systems.

Overall, the findings indicate differing surface and groundwater inputs to the springs and indicate that the Spring Box may be a reasonable alternate water source for ENFH. These findings will be useful to the ENFH to understand spring responses to rainfall events and manage water resources in the future.

OCCURRENCE OF PFAS AND THEIR PRECURSORS IN WASTEWATER BIOSOLIDS ACROSS TENNESSEE

F. Dixit

The widespread use of wastewater biosolids as agricultural fertilizer across Tennessee and the broader North American region has created a significant environmental challenge regarding per- and polyfluoroalkyl substances (PFAS). These persistent synthetic chemicals are known to move through soil and water into the food chain, sparking intense concern among rural residents, downstream water users, and advocacy groups like the Tennessee Sierra Club. This public curiosity is further amplified by high-profile contamination incidents at dairies in other states, leading local producers to seek guidance from the University of Tennessee (UT) Extension regarding the long-term safety of both current and legacy application sites. A primary concern for these stakeholders is the potential for PFAS to migrate through the soil and accumulate in crops or groundwater over several decades.

A major technical hurdle in addressing these concerns is the presence of PFAS precursors, which are compounds that eventually degrade into highly toxic and strictly regulated substances such as PFOA, PFHxS, and PFOS. Because these precursors biotransform over time, biosolids that initially appear to have low levels of regulated chemicals can actually serve as long-term sources of contamination. Unfortunately, standard testing methods such as the EPA 533, 537 and 1633 are designed to target only a small fraction of known PFAS and frequently fail to detect the vast majority of these precursors. While non-targeted high-resolution mass spectrometry (HRMS) can identify these hidden compounds, the high costs and specialized expertise required make it an impractical choice for routine state monitoring and oversight.

To bridge this analytical gap, the Total Oxidizable Precursor (TOP) assay offers a more accessible and cost-effective solution for estimating total PFAS loads. By using thermally activated persulfate under high pH conditions, the TOP assay oxidizes unknown precursors into stable, measurable acids that can be detected using standard laboratory equipment. A significant advantage of this method is that it can be readily integrated into existing laboratories already performing EPA-based targeted methods. It does not require specialized equipment or uniquely trained operators beyond those already proficient in routine analysis, making it a highly practical alternative to more complex non-target or total fluorine combustion techniques.

This study provides a detailed exploration into the fundamental radical chemistry underpinning this process and demonstrates its applicability across relevant environmental matrices. By refining these analytical protocols, the research offers a comprehensive monitoring framework that is specifically helpful for Tennessee communities and utilities, particularly for wastewater, drinking water, and agricultural biosolids monitoring. Enhanced detection capabilities will allow for more comprehensive oversight and better-informed management of land-applied biosolids, ultimately safeguarding the water supplies and agricultural integrity of the state and the nation.

Sophia Fandino

Hurricane Helene hit Tennessee on September 27, 2024 causing extensive flooding across the Nolichucky watershed and depositing thick layers of sediment on agricultural fields. These newly formed deposits, primarily silt- and sand-dominated, raised concerns about changes in soil nutrient availability and contamination from heavy metals, as well as impacts on water quality. This analysis aims to characterize post-flood soil and water conditions to evaluate soil and water quality recovery in eastern Tennessee one year after the hurricane event. Soil cores (2 feet deep, 3 inch diameter) were collected from seven impacted farms along the Nolichucky River and sectioned into four depth intervals for laboratory analysis. Porewater extractions were analyzed for nutrient and metal concentrations, while soil samples were assessed for texture, plant-available nutrients using the Mehlich-1 extractant, total metal content using nitric acid digestion, and microbial DNA to characterize microbial community structure. Water sampling from wells and surface water was conducted to assess recovery of water quality. Field measurements include pH, conductivity, and dissolved oxygen, with laboratory analyses for major ions, E. coli, total coliforms, and microbial DNA via qPCR. By integrating soil chemistry, microbiological, and hydrological data, this research seeks to explain contaminant dynamics and ecosystem resilience following extreme inland flooding. The outcomes will provide insight for assessing agricultural soil and water vulnerability to major storm events in landlocked regions.

MONITORING THROUGH DEEP LEARNING: POULTRY ANIMAL FEEDING OPERATION DETECTION AND WATER DEMAND ESTIMATIONS IN TENNESSEE

Savannah B. Jobkar

Effective monitoring of Animal Feeding Operations (AFOs), particularly unpermitted poultry facilities, is critical for managing agricultural water demand, environmental risk, and infrastructure planning across the southeastern United States. This thesis presents a scalable, geospatial framework that leverages deep learning and remote sensing to detect poultry barns and estimate associated water use across Tennessee. A DeepLabV3 segmentation model trained on USDA NAIP imagery identified over 1,380 poultry barns in four counties; Bradley, Bedford, Weakley, and Henry, with strong accuracy metrics (87.8% IoU, 92.6% F1/Dice). Post-processing filters based on land use, transportation networks, and structural dimensions dramatically improved precision, especially when applied within agriculturally classified zones, increasing precision from 0.9–4.1% to as high as 69.6% in some counties.

Detected barns were then clustered using the DBSCAN algorithm to identify high-density production zones and support barn-level water use estimations. By integrating industry standard production assumptions with field validated water use data from Tennessee broiler operations, annual water demand was quantified for each barn and aggregated at the cluster and county level. Poultry water use reached 417 million gallons annually in Bradley County, and exceeded 1 billion gallons across all study areas. In Bedford County alone, poultry water use was estimated at 328 million gallons, equivalent to 20% of the county's municipal withdrawals and over 60% of the annual intake of the nearby GM Ultium Cells battery plant. These findings underscore the substantial but often underrepresented role of agriculture in regional water competition. By combining computer vision, spatial filtering, and environmental modeling, this framework addresses major data gaps in livestock infrastructure monitoring and provides a transferable tool for agricultural resource planning. The results support improved water allocation decisions, especially in unregulated regions, and offer a path toward more sustainable management of livestock-related water demand.

IMPROVING SUB-HOURLY RAINFALL DISAGGREGATION CONSIDERING RAINFALL TYPE

Nischal Kafle, Ashish Shrestha, and Claudio I. Meier

High-temporal-resolution rainfall data (e.g., 1 to 5 min) are essential for estimating short-duration depth-duration-frequency (DDF) values used in engineering design. However, such data are scarce in many regions, including much of the United States, where observations are more commonly available at 15-min or hourly resolution. This study investigates the capacity of machine-learning (ML) methods to disaggregate 15-min rainfall time series into 1-min records, as well as hourly rainfall into 5-min records, using information from nearby stations with available higher-resolution data. We propose a hierarchical ML model trained using observed high-resolution (i.e., 1-min or 5-min) rainfall records. For a given target day, the framework first learns the temporal structure of wet and dry intervals at the higher resolution using a 30-day window centered on the target day across multiple years. To account for the difference in temporal-distribution characteristics due to rainfall types (e.g., convective vs. frontal events), the framework is also conditioned on these, identifying them from suitable auxiliary datasets (e.g., atmospheric pressure, infrared brightness observations, and lightning detector datasets). This step predicts the rainfall occurrence pattern at the higher resolution. In the second step, a conditional model assigns rainfall intensities to each higher resolution wet interval, with zero rainfall imposed during dry intervals, such that the sum of the higher resolution values within each hour or 15-min exactly matches the corresponding lower-resolution total. The resulting disaggregated 1-min and 5-min rainfall series reproduce key temporal characteristics of observed records. Extreme-value statistics derived from the disaggregated series show good agreement with those computed from the original high-resolution observations, indicating that the proposed approach can reliably recreate short-duration rainfall behavior from lower-resolution data.

AN ASSESSMENT OF NITROGEN AND PHOSPHORUS DISCHARGE TRENDS FROM TENNESSEE'S WASTEWATER TREATMENT FACILITIES

Samantha Knott[1], Jackson Greenway[1], and Tania Datta[1]

Nutrient pollution degrades surface water quality, driving eutrophication and harmful algal blooms. According to the U.S. Geological Survey, Tennessee contributes approximately 5.5% of total nitrogen and 5.3% of total phosphorus flux to the Northern Gulf of Mexico, contributing to Gulf hypoxia. Many of Tennessee's streams are also impaired by excess nutrients. Municipal wastewater treatment plants (WWTPs) represent a source of nutrient inputs; however, their nitrogen and phosphorus loads, temporal trends, and variability by treatment type and facility capacity remain insufficiently studied in Tennessee. Understanding these patterns is critical for developing strategies to mitigate nutrient pollution.

This study analyzes seven years (2019–2025) of effluent data from Tennessee's municipal WWTPs, focusing on mechanical and lagoon-based treatment systems. Data were obtained from the Tennessee Department of Environment and Conservation (TDEC) and the EPA's Enforcement and Compliance History Online (ECHO) database. The dataset includes design capacities, average daily flow rates, unit processes, and effluent nutrient concentrations and loads. Trends in nutrient concentrations and loads were evaluated across treatment types and operational characteristics. By identifying patterns in nutrient discharge and treatment performance, this research aims to inform best practices for nutrient management within Tennessee's public wastewater infrastructure.

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P. Li

Arsenic contamination in drinking water remains a major public health concern, particularly for households relying on private wells. Point-of-use (POU) water filtration systems, such as activated carbon (AC) and reverse osmosis (RO), offer cost-effective and decentralized treatment options, yet the influence of biofilm formation on their long-term performance remains unclear. This study quantitatively evaluated how biofilm development affected arsenic removal under realistic operating conditions of residential POU systems. In the AC system, biofilm improved arsenic removal efficiency from 3.9% to 12.3%. In the RO system, arsenic removal initially increased from 90.3% to 99.7% and then declined to 96.9%. High flow rates reduced arsenic removal by shortening water–media contact time, and elevated pH shifted arsenic speciation toward forms that were more readily removed. Analysis of the biofilm and flow rate interaction indicated that biofilm moderated the influence of flow differently in the two systems. Biofilm alleviated the decline in removal efficiency at higher flow rates in the AC system, whereas biofilm development coincided with a greater decline in performance in the RO system. Temperature exerted a weaker influence and produced only minor variations in removal efficiency. Overall, the results demonstrate that the role of biofilm in POU filtration is dynamic and system-dependent, showing an initial enhancement followed by potential inhibition as biofilm continues to develop. Understanding this dual behavior can provide useful guidance for the operation and maintenance of POU systems for households to control arsenic in their drinking water.

AI APPLICATION IN ENVIRONMENTAL JUSTICE: THE RELATIONSHIP BETWEEN GEOGRAPHY AND DEMOGRAPHY IN HUC 10 WATERSHED

Gage Lineberry and Dr. Peter Li

The purpose of this study is to evaluate whether socioeconomic status and health outcomes are spatially associated across Tennessee's watersheds. Block group level data from the American Community Survey, county level data from the CDC Environmental Public Health Tracking Network and point locations of churches and health facilities in and around Tennessee were aggregated to HUC 10 watersheds using population and area weighted methods. Watershed aggregation matters because there are no data downloads that are on the HUC-10 basis and aggregating the data into watersheds requires determining what method will be the most accurate. Chat GPT by OpenAI was used in this study to help determine the most accurate methods, choose the best tables, keep records, help identify gaps, and help refine writing. The method for getting these data accurately on the watershed level involved using tabulate intersection and carefully considering what universes are compatible with this method. Various health factors were standardized and integrated into an overall health index for simple analysis. Results indicate spatial patterns in which lower socioeconomic indicators and poorer health outcomes are more frequently observed in and around urbanized regions and major waterways, while more favorable health outcomes are more common in less densely populated areas. These patterns suggest that socioeconomic conditions and health outcomes are not evenly distributed across space and highlight areas for future investigation.

A GEOAI FRAMEWORK FOR EXPLORING PERSISTENT TOXIC POLLUTANTS IN TENNESSEE WATERSHEDS

J. Medley

Persistent toxic pollutants (PBTs), including per- and polyfluoroalkyl substances (PFAS), are increasingly concerning for water resources due to their environmental persistence and uneven spatial distribution across hydrological systems. In Tennessee, understanding contaminant patterns at various scales is critical for informing monitoring strategies.

Unsupervised clustering of watershed-linked TRI records revealed distinct groups of Tennessee watersheds characterized by differing contaminant profiles. A small subset of clusters accounted for a disproportionately high concentration of PBT-associated facilities, suggesting spatial aggregation of persistent toxic pollutants within specific watersheds. This approach demonstrates the feasibility of unsupervised GeoAI methods for exploratory contaminant pattern discovery.

This poster presents a geospatial artificial intelligence (GeoAI) framework that integrates publicly available contaminant inventories with hydrological and geographic data to explore spatial patterns of PFAS and PBT occurrence. U.S. Environmental Protection Agency Toxic Release Inventory records are linked to watershed units, producing feature-rich datasets that incorporate hydrological context, and geographic attribution.

DEVELOPING A PYTHON-BASED TOOL FOR FLOOD HAZARD AND FLOOD RISK MAPPING FOR THE DOE CREEK WATERSHED, TENNESSEE

Jemima Obeng[1] and Alfred Kalyanapu[1]

Flooding poses a challenge for small, rural watersheds, where limited monitoring and technical resources constrain detailed flood risk evaluation. In the Doe Creek Watershed in Jackson County, Tennessee, recurring flood impacts highlight the need for tools that move beyond hydraulic model outputs to support practical flood hazard and flood risk assessment. While models such as HEC-RAS effectively simulate flood behavior, additional processing is required to translate these results into information that can support decision-making.

This study develops and applies a Python-based tool to assess flood hazard and flood risk in the Doe Creek Watershed by integrating HEC-RAS outputs with geospatial data. Flood hazard is quantified using depth and velocity metrics, while flood risk is evaluated by combining hazard with exposure and vulnerability components. Exposure represents land cover and building footprints located within flood-prone areas, and vulnerability accounts for the susceptibility of these elements to flood damage.

Application of the tool to the watershed produced flood hazard and flood risk maps, along with summary statistics describing the spatial distribution of flood impacts. Results show that most inundated areas fall within the low to high hazard classes, while very high and extreme hazard areas are limited and primarily confined to the creek channel and adjacent overbank regions. Moderate to high flood risk is mainly associated with developed low-intensity and open space land cover, whereas forested areas are largely classified as low risk. Building-level results indicate that most structures fall within low to medium risk classes, with no structures identified in the high or extreme risk categories.

A graphical user interface (GUI) was developed to guide users through the analysis, ensuring that flood hazard is computed prior to flood risk, reflecting the dependency of risk on hazard. Overall, this project demonstrates the usefulness of Python-based workflows for accessible, adaptable, and reproducible flood hazard and flood risk assessments.

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J. Power

The Nashville basin ecoregion is defined by its karst topography. This limestone dominated landscape provides the foundation for the intermittent streams relied upon by Ambystoma barbouri to reproduce and spend their larval stage. These streams, which typically flow from December to June, host a community of hardy benthic macroinvertebrates which must be able to aestivate for long periods of time, and must deal with the cold weather of their home stream's hydroperiod. Benthic macroinvertebrates are often noted for their role in breaking down organic matter, nutrient cycling, and as indicators of pollution. In a region that is experiencing urban and industrial growth, it is important to understand this macroinvertebrate community in the context of conservation of A. barbouri. It is also beneficial to explore this community as an indicator of the efficacy of current building regulations, and for its own unique contribution to the ecosystem. In the field, 20 sites were selected with historical presence of A. barbouri. I used two methods of invertebrate collection at each site, the Surber sampler and the Hester-Dendy (HD) multiplate sampler. The surber samples were collected at the time of the visit, whereas the HD samplers were collected after four weeks attached to the substrate to allow for colonization. Samples from developed sites will be compared with those from reference sites to assess the impact of development on the biotic community and possibly indicate changes in hydroperiod from anthropogenic effects. This research is ongoing and will be completed in the fall of 2025.

COUPLED CARBONATE EQUILIBRIUM AND METABOLIC FRACTIONATION DRIVE Δ13C-DIC VARIABILITY IN FRESHWATER ECOSYSTEMS

Mahir Tajwar[1] and John C. Ayers[2]

Freshwater carbon cycling in oligotrophic lakes is shaped by interacting metabolic and geochemical processes, yet the way these controls vary from diel to seasonal timescales remains poorly resolved. In this study, we integrate 48-hour high-frequency measurements across four seasons with δ^{13}C-DIC, water chemistry, and metabolism (GPP, ER) to evaluate the mechanisms regulating dissolved inorganic carbon (DIC) and its isotopic composition in Stephens Lake, a shallow headwater lake atop limestone in Franklin, Tennessee. Diel cycles in oxygen, pH, and temperature revealed clear metabolic patterns, with daytime photosynthetic CO_2 uptake and nighttime respiration generating characteristic shifts in DIC concentration. Corresponding δ^{13}C-DIC values displayed clear diel enrichment–depletion cycles, particularly during periods of high biological activity.

Seasonally, however, δ^{13}C-DIC values were anchored by broader changes in carbonate equilibrium, driven by variations in Ca, Mg, DIC, and carbonate saturation state as the lake transitioned from winter dormancy to summer autotrophy. Multivariate analyses showed that winter conditions were dominated by carbonate equilibrium processes with limited metabolic influence, whereas spring and summer exhibited strong metabolic control on δ^{13}C–DIC. Fall represented a transitional state in which moderate photosynthetic uptake and intermediate DIC concentrations jointly influenced δ^{13}C–DIC patterns.

Together, these patterns reveal two regulatory modes: (1) rapid diel metabolic forcing that drives short-term isotopic fluctuations, and (2) seasonal carbonate chemistry that sets the longer-term isotopic baseline. These findings offer a mechanistic framework for interpreting δ^{13}C–DIC dynamics in carbonate-influenced, oligotrophic freshwater systems and improve understanding of how metabolism and carbonate equilibrium jointly influence carbon cycling under varying watershed conditions.

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INTEGRATING HEADWATER WATERSHED CLASSIFICATION WITH NUTRIENT DATA FOR WATER QUALITY MANAGEMENT: AN INTERACTIVE WEB-BASED DASHBOARD FOR TENNESSEE

JoTing Wang, Karina Bynum, Brian Ham, and Peter Li

Headwater streams constitute a significant portion of stream networks and are critical areas for nutrient management due to their direct impact on downstream water quality. This study presents an interactive web-based dashboard developed using ArcGIS Experience Builder that integrates headwater watershed classification with nutrient priority areas identified by the Tennessee Department of Environment and Conservation (TDEC). TDEC utilized the USGS SPARROW modeling system to identify the top 10 watersheds for nitrogen, phosphorus, and combined nutrient concerns at the HUC 10 level. These priority areas were merged with HUC 12 headwater watershed classifications to enable comparative analysis between headwater and non-headwater systems.

The dashboard provides water resources specialists and watershed managers with tools to visualize and analyze nutrient distribution patterns across headwater versus non-headwater watersheds. Key features include interactive maps with filtering capabilities, statistical charts comparing nutrient loads between headwater and non-headwater areas, and data tables that allow users to query and identify specific watersheds with high nitrogen, high phosphorus, or both. This comparative approach reveals the proportion of TDEC's priority nutrient areas that occur in headwater versus downstream watersheds, enabling more targeted management strategies.

This tool supports data-driven decision-making by providing accessible visualization of complex spatial relationships, facilitating identification of priority headwater areas for best management practices implementation and helping allocate resources more effectively for nutrient pollution reduction efforts in Tennessee's headwater systems.

E. Weathers

The Tennessee Smart Yards Program (TSY) is an Extension-led initiative designed to promote water consciousness and ecological landscaping practices across Tennessee. Grounded in nine principles of stewardship, the program equips participants with practical strategies that improve soil health, conserve water, reduce runoff, and protect local waterways. This program educates using a combination of online modules and practical, hands-on workshops led by UT-TSU Extension and water resource professionals. Over the past five years, 900 yards have been certified through the TSY program - including the incorporation of 264 rain gardens, the establishment or maintenance of 339 healthy riparian buffers along waterways, the installation of rain barrels at 425 properties, and the installation of native plantings at 785 yards. This project seeks to raise awareness and expand impact within campus communities. Methods include 1) engaging residential student populations by drawing direct connections between sustainable practices being implemented on campus and those taught in the TSY program while 2) reaching off-campus students, faculty, and staff through targeted campus promotional activities, educational materials, and outreach events. These efforts position UTK's campus as a "living laboratory" for eco-friendly landscaping practices. Expected outcomes include the development of an interactive campus map highlighting TSY principles in practice, a student pledge to encourage life long stewardship, and a suite of materials targeting campus faculty and staff. Collectively, this initiative serves to foster an increase of land and water stewardship within Knoxville and to serve as a model for community engagement beyond.

INTEGRATING MODELING AND STAKEHOLDER ENGAGEMENT TO DEVELOP A WATERSHED PLAN FOR THE FALLING WATER RIVER WATERSHED

E. Grace White, Isaac Hollingsworth, Rachel Kaiser, Alfred Kalayanapu, Tania Datta

Watershed management plans are essential tools for protecting and restoring water quality. These comprehensive reports are tailored to the unique characteristics of individual watersheds, enabling the selection of appropriate best management practices (BMPs) to address specific impairments. This study presents a comprehensive watershed management plan for the Falling Water River Watershed (HUC 10), located in Middle Tennessee and encompassing parts of Putnam, White, and DeKalb Counties. The watershed, which includes the City of Cookeville and notable natural areas such as Burgess Falls State Park and Center Hill Lake, is characterized by unique karst geology and serves as critical habitat for the endangered gray bat. To identify and address water quality impairments, the plan utilized a combination of stream impairment analysis, hotspot mapping in GIS, and the EPA's Pollutant Load Estimation Tool (PLET) to estimate nutrient and sediment loads and evaluate the effectiveness of best management practices (BMPs). PLET modeling was also employed to estimate nutrient reductions across sub-watersheds, guiding the selection of BMPs for future implementation. An interactive HUB site was developed using GIS to facilitate stakeholder engagement and information sharing, ensuring transparency and collaboration throughout the planning process.

WATER QUALITY ANALYSIS OF HORSE CREEK IN SULLIVAN COUNTY, TENNESSEE

Tobias Winkler[1] and Ingrid Luffman[1]

INTRODUCTION

Recent plans for a limestone quarry and road construction on SR 93 threaten to pollute Horse Creek, a small tributary of the South Holston River in Sullivan County, Tennessee. Horse Creek flows through recreational and residential areas serving as a water source for small scale agricultural and livestock operations and is listed on Tennessee's 303(d) List of Impaired Waters due to excessive E. coli within the stream. Further, planned development of a limestone quarry in the watershed, and existing road widening upstream created a need to evaluate current stream water chemistry. Therefore, the aim of this study was to collect baseline data for the stream in anticipation of future permanent development within the watershed.

METHODS

Three sampling sites were selected to bracket the watershed disturbances. Site 1 was located upstream of all disturbances, Site 2 was located between the road widening project and the proposed quarry, and Site 3 was located downstream of both (Figure 1). Sampling was conducted working upstream, and at each site, sampling equipment was decontaminated with a 1% Liquinox solution and rinsed with de-ionized (DI) water before recording data.

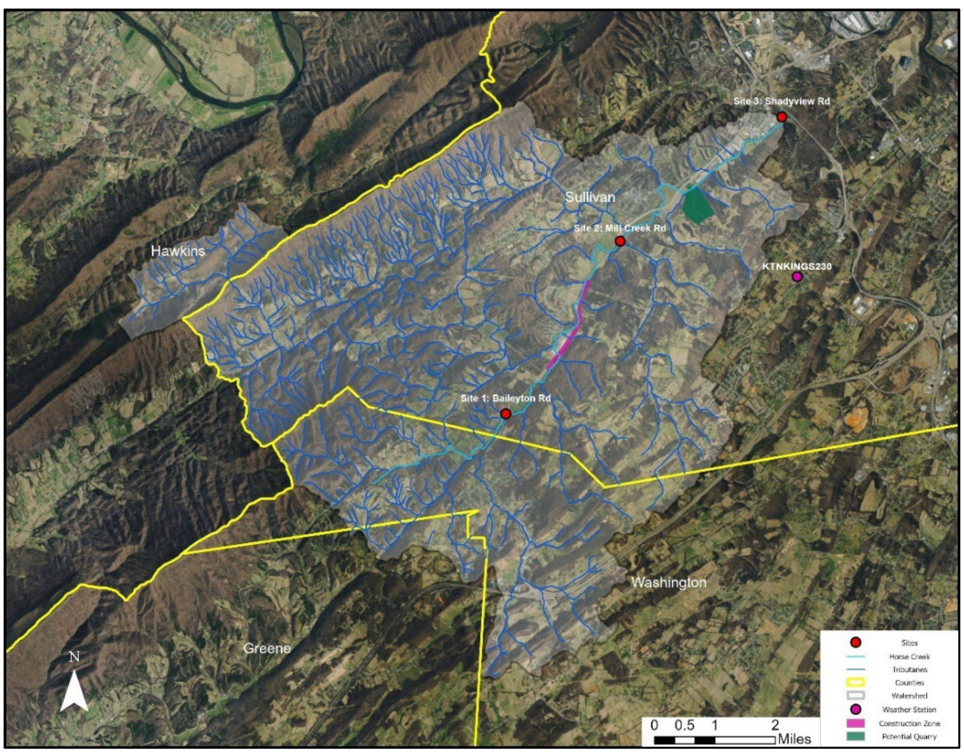

Figure 1: Study Area in Sullivan County, TN

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Water quality data were collected using a YSI ProDSS-2 626870-2 multiparameter water quality meter; temperature, pressure, dissolved oxygen (DO), specific conductivity (SPC), electrical conductivity (EC), electrical resistance (ER), salinity, turbidity, and pH were recorded on alternating days across three sites from July 2nd through September 2nd, 2025. Water samples were collected on consecutive days from July 2nd to July 6th at the furthest downstream site. Two 100 mL sterile bottles were used each day: one containing the water sample and one field blank. The field blank was filled with DI water from a spray bottle until full, while the sample bottle was placed into the stream until full. Both samples were stored on ice, transported to ETSU's Hydrology Lab, and processed within 2 hours using the Colilert Quantitray method to quantify *E. coli* within the stream.

Water quality data collected from the three sampling sites were analyzed using a Kruskal-Wallis Test (KW) using a=0.05 to detect significant differences in water quality parameters between sites. The geometric mean of the daily *E.* coli concentration was compared to TDEC's recreational *E. coli* water quality standard of 126 CFU/100mL to determine whether the stream was suitable for recreational activities.

RESULTS AND DISCUSSION

Descriptive statistics for water quality parameters at the three sites are presented in Table 1. Most parameters were consistent through time and across the three sites (see, for example, Temperature, DO, and Salinity). Other parameters varied across sampling days and between sampling sites (high SPC and EC were noted in Site 1 compared to the other sites, and turbidity had a high variance and large range for all sites, suggesting daily variability for this parameter).

The KW pairwise comparison tests (Table 2) show that Site 1 had different water quality parameter values than the other sites. Of the 8 parameters tested, only turbidity, temperature, and DO were not statistically different to one or more of the other two sites. These differences may be due to 1) differing land uses between Site 1 (proximal to the community of Fall Branch) and the other two sites which are largely agricultural land uses, or 2) the tributary Walker Fork which enters Horse Creek between Sites 1 and 2 and may have different water chemistry. Walker Fork is the largest tributary to Horse Creek within the study area, but no water samples were collected from this tributary. We recommend that future studies sample Walker Fork to help explain differences in water chemistry between Site 1 and the other two sites.

Sites 2 and 3 differed only for temperature, DO, and turbidity (Table 2). Site 2 showed statistically lower values for DO compared to Sites 1 and 3; low DO is often related to higher water temperature. However, Site 1 upstream had similar temperature statistics, but much higher DO than Site 2. High DO at Site 1 may have resulted from its proximity to the Fall Branch tributary, which travels over a waterfall before joining Horse Creek. Higher DO downstream at Site 3 is harder to explain via high DO tributaries, as there is an equal number of tributaries from higher relief zones between Sites 2 and 3 as between Sites 1 and 2. However, the largest tributary, Walker Fork, joins Horse Creek upstream of Site 2, and may be a source of lower DO water as this tributary is quite exposed in a wide agricultural valley in the three miles upstream of the confluence. We recommend that future studies measure DO in Walker Fork to test this hypothesis.

Table 1: Measured water quality parameter values across all three sites.

Site	Parameters	Temp. (C)	DO (mg/L)	SPC (µs/cm)	EC (µs/cm)	ER/K (KΩ*cm)	Salinity (ppt)	Turbidity (NTU)	pH
1	**Mean**	23.6	7.73	503.1	490.1	2.1	0.24	8.48	8.16
	Median	24.3	7.62	512.0	502.5	2.0	0.25	6.18	8.16
	Sample Variance	3.79	0.45	1073.38	1513.72	0.05	0.00	82.88	0.01
	Range	7	3.18	187.7	209.3	1.2	0.09	50.65	0.42
	Minimum	19.8	6.59	348.3	327.7	1.9	0.17	2.85	7.93
	Maximum	26.8	9.77	536	537	3.1	0.26	53.5	8.35
2	**Mean**	23.5	6.33	434.1	422.6	2.4	0.21	8.41	8.04
	Median	24.0	6.17	447.3	422.7	2.4	0.22	5.38	8.06
	Sample Variance	3.59	0.31	2820.27	3323.76	0.13	0.00	114.47	0.02
	Range	7.4	2	181	201.7	1.3	0.09	56.4	0.5
	Minimum	18.9	5.64	314.6	307.3	2	0.15	3.6	7.77
	Maximum	26.3	7.64	495.6	509	3.3	0.24	60	8.27
3	**Mean**	22.6	7.44	441.3	419.4	2.4	0.21	9.57	7.98
	Median	23.0	7.27	457.8	420.7	2.4	0.22	6.66	8.03
	Sample Variance	3.37	0.46	2542.62	2755.60	0.12	0.00	165.65	0.04
	Range	7.7	2.59	175.9	182.6	1.2	0.09	74.66	0.8
	Minimum	18	6.48	320.1	308.6	2	0.15	3.36	7.46
	Maximum	25.7	9.07	496	491.2	3.2	0.24	78.02	8.26

Table 2: P-values and adjusted p-values between pairs of sites across all parameters using Kruskal-Wallis test. Sites 2 and 3 show most similarity across all parameters.

Parameter	Sites 1-2		Sites 1-3		Sites 2-3	
	Sig.	**Adj. Sig.**	**Sig.**	**Adj. Sig.**	**Sig.**	**Adj. Sig.**
Temperature	0.934	1	0.018	0.055	0.023	0.068
Pressure	.030	0.091	<.001	0	0.077	0.231
DO	<.001	0	0.098	0.295	<.001	0
SPC	<.001	0	<.001	0	0.798	1
EC	<.001	0	<.001	0	0.642	1
Resistivity	<.001	0	<.001	0	0.775	1
Salinity	<.001	0	<.001	0	.676	1
Turbidity	0.253	0.76	0.179	0.537	0.013	0.039
pH	0.001	0.003	<.001	0	0.345	1

The geometric mean for *E. coli* measured over five samples in 30 days was 37.9 MPN/100ml, which meets the state recreational water standard of 126 CFU/100ml. *E. coli* contamination within the study area is attributed to grazing in riparian zones, according to the 2024 303(d) List. Horse Creek is not a source of drinking water as residents within the study area primarily get their water from Kingsport or Jonesborough’s public water supply whose source waters are the South Fork Holston River and the Nolichucky River, respectively. Also, Horse Creek is seldomly deep enough to partake in large scale recreation (boating/rafting) so most usages of stream come in the form of fishing and/or wading. With future land use change, changes in water quality are also to be expected. In particular, the amount of *E. coli* present in the stream may be reduced in future as agricultural land uses transition to developed land.

In 1998, the USGS collected information regarding specific dissolved ions present in Horse Creek. Silica, Chloride, Nitrate, Sulfate, are some of a few ions that were documented. Due to constraints during the study, we were unable to collect updated information of the concentration of dissolved ions. We recommend any future study on Horse Creek to collect updated information regarding specific dissolved ions in the stream.

The purpose of this study was to document water quality of Horse Creek during ongoing construction and in response to a potential quarry in the watershed. Though quarry plans have been shelved and are unlikely to come to fruition soon, we recommend continued regular water quality monitoring of baseline parameters and pathogens. Continued low *E. coli* concentrations could be justification for removal of Horse Creek from the 303(d) List of Impaired Waters.

CONCLUSION

In wake of ongoing construction and potential for quarrying within the watershed, water quality data were collected from Horse Creek in Sullivan County, TN across July, August, and early September 2025. Temperature, specific conductance, electrical conductivity, electrical resistance, salinity, turbidity, pH, fecal coliforms, and *E. coli* were collected across three sites to analyze current stream health and to understand expected values for water quality parameters within this stream.

Site 1 parameter values were statistically different across SPC, conductivity, resistivity, salinity, and pH with sites 2 and 3 being statistically similar across these six parameters. DO values are oddly lower at Site 2 when compared to Sites 1 and 3. This, along with differences between parameters at Site 1 when compared to Sites 2 and 3 may be tied to Walker Fork or due to changes in land use as the water makes its way downstream. *E. coli* levels within Horse Creek were found to be 37.9 MPN/100ml which is below TDEC's standard for recreational water, indicating that, during the study period, the stream met recreational water quality criteria for activities such as wading or fishing.

These findings add to the very limited existing pathogen data on record for this 303(d) listed stream and create a baseline dataset of water quality parameters that can be referenced for future work within Horse Creek.