Proceedings of the 2025 TENNESSEE WATER RESOURCES SYMPOSIUM

April 9-11, 2025

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Proceedings from the

34th Tennessee Water Resources Symposium

Montgomery Bell State Park
Burns, Tennessee

April 9-11, 2025

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Keynote Speakers

Wednesday, April 9th

Amanda Rosenberger
Professor, Tennessee Tech University

"Mussel Power: How Freshwater Mussels Shape Our Water Resources and Future in Tennessee"

Thursday, April 10th

Andy Carroll
Co-Founder and Chief Technology Office, Skytec

"Development of the Tennessee Wetland Screening Tool"

PRE-SYMPOSIUM SESSION

PRESENTATIONS

POSTERS

PRE-SYMPOSIUM SESSION

Wednesday, April 9th at 9:00am - 11:30am

Measuring Outcomes of Stream Restoration
Cidney Jones, Ecosystem Planning & Restoration

Best Practices for Assessment and Natural Channel Design under Stream Quantification Tool (SQT) Methodology
Anthony Brais, Stantec

Tennessee Stream Quantification Tool V.2 for Compensatory Mitigation
John Schwartz, University of Tennessee Knoxville

MEASURING OUTCOMES OF STREAM RESTORATION

Cidney Jones

Monitoring across multiple disciplines is critical to ecological restoration. Stream Quantification Tools (SQT) have been developed for multiple states, incorporating quantitative assessment methods to score stream functions in five functional categories: hydrology, hydraulics, geomorphology, physicochemical, and biology. The TN SQT compares measured physical, chemical, and biological conditions to reference standard for biotic integrity. Monitoring is most effective when measurements tracking progress and evaluating project outcomes are clearly linked to a project's goals and objectives. To set meaningful goals and objectives, practitioners need to consider the site-specific restoration potential in goal setting and then determine specific, measurable, achievable, relevant, and time-bound objectives. SQTs provide accountability by integrating goals, objectives, and success criteria into a monitoring framework. The tools support multiple program and environmental management objectives including "no net loss," ensuring authorized stream impacts are adequately mitigated in the Clean Water Act Section 404 (CWA §404) regulatory program. This presentation will cover the stream functions pyramid framework and how the TN SQT, or an SQT approach, can provide a structured approach to monitor stream restoration project effectiveness over time.

BEST PRACTICES FOR ASSESSMENT AND NATURAL CHANNEL DESIGN UNDER STREAM QUANTIFICATION TOOL (SQT) METHODOLOGY

Anthony Brais

The Tennessee Stream Quantification Tool (SQT) provides a quantitative framework for stream assessment and design to measure functional loss or lift for stream restoration projects. Practitioners evaluate existing and proposed stream reaches against the stream functional pyramid (hydrology, hydraulics, geomorphology, physicochemical and biology) through measurements of multiple field and desktop parameters. These values are compared against an ecoregion specific reference index to determine the functional status of each stream. Functional loss or lift is directly influenced by the application of SQT methods to the existing conditions assessment or proposed natural channel design (NCD). Desktop SQT parameters are limited by the accuracy of the input datasets. Stream centerlines delineated from high resolution LiDAR digital elevation models are often longer than those delineated with portable GPS units. The desktop approach selected can impact credit generation but also influences proposed sinuosity targets of the NCD. Careful evaluation of existing conditions flow regime is required to minimize the potential for conversion of perennial/intermittent streams to ephemeral systems post restoration. This applies often on small, degraded headwater reaches were maintaining surface hydrology difficult without design of specific structures or construction techniques. Lastly, field assessments and NCD need to be stream type specific. Stream succession and legacy degradation create challenges to characterize existing conditions metrics (low bank, bankfull, etc.) appropriately to determine bank height and entrenchment ratios. Failure to identify the appropriate existing and proposed stream type can create an unstable restored system even if NCD methodologies are applied. Best practices are needed to appropriately assess and design stream channels to accurately characterize functional loss and lift under SQT methodologies.

TENNESSEE STREAM QUANTIFICATION TOOL V.2 FOR COMPENSATORY MITIGATION

John Schwartz

The Tennessee Stream Quantification Tool (TN SQT) was developed to provide an objective, consistent, and transparent method for quantifying the functional lift (or loss) associated with stream mitigation and restoration projects by scoring sites before and after the implementation of restoration activities. Its development assists the Tennessee Department of Environment and Conservation (TDEC) with quantifying aquatic resources losses as debits for the Tennessee's Aquatic Resources Alteration Permit (ARAP), and both the US Army Corps of Engineers and TDEC to estimate required compensatory mitigation credits per Section 404 of the Clean Water Act and Tennessee Water Resources rules. The TN SQT provides for the assessment of various stream attributes for functional lift quantifying existing and proposed stream conditions to obtain credits in linear length of restoration. Existing condition scores and proposed impacts to streams from development, highway construction, or other are used to calculate functional loss in the TN Debit Tool. The TN SQT was finalized in 2019 and it has been implemented for over two years. During the first year if use, practitioners, academics, and some state agencies found multiple issues with the first version of the TN SQT. Because of these issues/concerns, TDEC leadership formed a TN SQT Review Working Group. This Review Working Group consisted of the TDEC, USACE, and consultants, and they met for about one-year starting in August 2020 to compile the issues and propose ideas for a revision. Following outcomes of these meetings, proposed updates to TN SQT parameters were evaluated from a comparative study of the existing versus the proposed changes during fall 2021. A final revision of the TN SQT was completed in fall 2024 and placed on public review in winter 2025. This presentation summarizes the outcome of these efforts, and the update TN SQT version 2.0.

SESSION 1A

Wednesday, April 9th at 1:30pm - 3:00pm
WATER QUALITY
(Moderator: Richard Cochran, TDEC)

Microplastics in Tennessee's Wastewater Treatment Plants and Receiving Streams: A Method for Quantification and Identification
C. Hitchcock, G. De Almeida, T. Denney, A. Wilhelm, T. Datta, J. Murdock

Investigating the Cause of Excessive Bacterial Growth in a Small Rural Tributary to the Harpeth River
R. Jackwood

Per- and polyfluoroalkyl substances (PFAS) bioaccumulation in stream food webs and transport across the stream and terrestrial boundary
J. Murdock, P. Blum

Wednesday, April 9th at 3:00pm - 5:00pm
MODELING
(Moderator: Ingrid Luffman, ETSU)

Navigating the Waters: Using CE-QUAL-W2 to Assess the Murfreesboro Water Resources Recovery Facility Expansion
B. Crary

TN-SWAPyT: A Python Tool to Automate Tennessee's Source Water Assessment Program Reports
R. Ransom, A. Dempsey, K. Knierim, B. Ham, D. Ladd

Estimates of Flood Frequency and Magnitude for Urban and Rural Tennessee Streams
D. Ladd, D. Wagner, E. Heal, P. Ensminger

MICROPLASTICS IN TENNESSEE'S WASTEWATER TREATMENT PLANTS AND RECEIVING STREAMS: A METHOD FOR QUANTIFICATION AND IDENTIFICATION

Caroline Hitchcock[1], Gabriela De Almeida[1], Tori Denney[1], Annabella Wilhelm[1], Tania Datta[1], and Justin Murdock[2]

Wellhead Protection Plans (WHPP) for groundwater sources have existed since 1986, emphasizing the importance of preventing contamination rather than remediating it. In Tennessee, these plans categorize wellheads based on service connections and water extraction. However, a potential discrepancy arises when legal classifications diverge from the actual groundwater dynamics, especially if a public water system is deemed non-community despite significant groundwater withdrawal. This presentation explores synthetic examples illustrating diverse methods (mathematical, analytical, numerical) for delineating wellhead protection areas under various scenarios with increasing hydrocomplexity (multiple wells, hydraulic gradients, withdrawal regimes, hydraulic properties). The goal is to address the possibility that regulatory-defined zones might underestimate real groundwater capture zones. This is crucial, as oversight could compromise the regulation, protection, and supervision of areas vital for maintaining clean groundwater resources and ensuring the integrity of public supply systems. The findings underscore the limitations of relying on arbitrary radius zones, revealing the potential for significant underestimations, with zones five to ten times smaller than numerically modeled groundwater capture zones after 25 years' time of travel, while maintaining an overly simplified circular shape. The implications are substantial, emphasizing the need for a more sophisticated approach to regulate, protect, and supervise areas susceptible to contamination. The results prove valuable for public supply systems aiming to exceed regulatory standards, offering a better understanding of the anticipated groundwater capture zones. Embracing a "water steward" mindset aligns with the proactive principles that inspired WHPP decades ago, guaranteeing the ongoing success of groundwater resource preservation and the dependable operation of public supply systems.

[1] Department of Civil and Environmental Engineering, Box 5015, Tennessee Technological University, Cookeville, TN 38505.

[2] Center for the Management, Utilization and Protection of Water Resources, P.O. Box 5033, Tennessee Technological University, Cookeville, TN 38505.

INVESTIGATING THE CAUSE OF EXCESSIVE BACTERIAL GROWTH IN A SMALL RURAL TRIBUTARY TO THE HARPETH RIVER

Ryan Jackwood

Trace Creek, rural tributary of the Harpeth River, experienced an unusual bloom of white, hair-like organisms during the summer of 2022. The bloom was confined to a 400-meter section immediately downstream of a wastewater treatment plant (WWTP) outfall. The white hair-like bloom was absent in sections of Trace Creek that were above the WWTP outfall or further downstream below the bloom. Metagenomic analysis identified the blooms dominant organism as *Thiothrix lacustris*, a sulfur-oxidizing bacterium, comprising over 70% of the bloom composition. This suggested that excess sulfur in this section of the stream enabled *T. lacustris* to proliferate. The proximity of the WWTP outfall to the bloom and the likely presence of sulfur in the plant made it the prime candidate of the source of sulfur to Trace Creek.

Collaborations with the Tennessee Department of Environment and Conservation and WWTP operators identified calcium thiosulfate, used for dechlorinating treated wastewater, as the primary contributor. In June 2023, operators implemented two key changes: reducing calcium thiosulfate dosing by 40% and relocating the dosing point within the treatment plant to increase contact time before being discharged into Trace Creek.

These adjustments yielded observable improvements. Over the following year, the size of the bloom diminished steadily. By June 2024, the distinctive white hair-like structures of *T. lacustris* were no longer visible in the affected section of Trace Creek. This case study highlights the vulnerability of small rural streams to water quality imbalances and the resiliency of those streams to recover when the imbalance is corrected.

PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) BIOACCUMULATION IN STREAM FOOD WEBS AND TRANSPORT ACROSS THE STREAM AND TERRESTRIAL BOUNDARY

Justin Murdock[1] and Peter Blum

Airborne electromagnetic (AEM) surveys are a powerful geophysical technique to rapidly generate millions of models of the electrical properties of the subsurface that can be correlated with hydrologic and geologic groundtruth to produce rich datasets detailing entire landscapes. In 2019-22, the U.S. Geological Survey (USGS) acquired airborne electromagnetic geophysical survey data in western Tennessee as part of the Mississippi Alluvial Plain (MAP) groundwater study. Surveys were conducted along west-to-east trending flight lines with an even, three kilometer spacing. More targeted surveys were flown along the Mississippi River levee and in the New Madrid seismic zone in Western Tennessee. By synthesizing traditional hydrologic and geologic information with geophysical measurements, collected on a regional scale, we aim to refine existing groundwater models and contribute valuable insights for groundwater resource availability, infrastructure assessment, and seismic hazard analysis.

The airborne geophysical data collected in this region was integrated into existing hydrogeologic frameworks and models to greatly enhance their ability to characterize and understand the subcropping geology, aquifer and confining units, and water availability. Subsurface lithological variations were delineated continuously and at high resolution to facilitate the identification of potential windows within confining units and aid in the development of targeted strategies to mitigate risks to those underlying units.

AEM survey lines flown adjacent to levees along the Mississippi River determined the hydrogeologic properties of the units underlying the levees. The data were then categorized into groups based on their modeled permeability using a machine learning model. These categories were then used to optimize the locations of geotechnical investigations. Additionally, targeted survey lines were collected in the New Madrid Seismic Zone to identify faults and provide crucial data for seismic hazard assessment.

The results obtained from the airborne geophysical surveys have also contributed to the construction of high-resolution hydrogeologic frameworks and groundwater models, which support informed decision-making processes for sustainable water resource management. This study highlights the multifaceted applications of airborne geophysics in addressing groundwater dynamics and infrastructure risk in Western Tennessee.

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

NAVIGATING THE WATERS: USING CE-QUAL-W2 TO ASSESS THE MURFREESBORO WATER RESOURCES RECOVERY FACILITY EXPANSION

Ben Crary, PE (MN), Hazen and Sawyer

The Murfreesboro Water Resources Recovery Facility (MWRRF) is currently rated to treat 24 MGD of primary wastewater; however, MWRRF would need to expand its treatment capacity to accommodate the rapid growth that is occurring within its service area. The MWRRF is currently permitted to discharge into the West Fork Stones River (WFSR) 11 miles upstream of J. Percy Priest reservoir. The reach that receives the discharge is currently designated as not fulfilling its designated uses because of exceedances of the DO criteria. Therefore, it is incumbent on MWRRF to demonstrate through modeling that expanded discharge will not result in a measurable decrease of the DO concentration in the WFSR.

Hazen and Sawyer, on behalf of the Murfreesboro Water Resources Department (MWRD), developed a CE-QUAL-W2 model of the WFSR to evaluate the impact of expanded discharge into the river. CE-QUAL-W2 is a two-dimensional, laterally averaged, hydrodynamic and water quality model, and it was selected over other water quality models because of its ability to model the hydrodynamics and water quality in long and narrow river systems. CE-QUAL-W2 was originally developed by the US Army Corps of Engineers and is actively maintained by Dr. Scott Wells of Portland State University. The model has been used widely for riverine modeling and is an accepted quality model by the US Army Corps of Engineers, US Geological Survey, Tennessee Valley Authority, and more.

Continuous monitoring, physical and biological survey data, and water quality sampling data were collected throughout the summer of 2023 to develop a calibration dataset to support the development of the model. Temperature, DO, and water depth were continuously measured at six points along the river, flow measurements and cross sections were collected to characterize the river channel, surveys of macrophyte and periphyton abundance were conducted, and water quality grab samples measuring nutrients, chlorophyll, and CBOD were collected under low flow conditions. Collectively, these data supported the development of a well-calibrated model that simulates the DO dynamics of a 5 mile stretch of the WFSR downstream of MWRRF. The calibrated model predicted temperature with less than 1 degree C RMSE and predicted daily minimum and maximum DO concentrations with less than 0.3 mg/L RMSE.
Results of this effort demonstrated that DO within this stretch of the WFSR is dominated by benthic photosynthesis and respiration. Measured periphyton biomass was as high as 25 grams per square meter, and daily swings of DO concentration were as high as 6.5 mg/L during low flow conditions (<13 cfs). Alternately, CBOD5 concentrations were less than 2 mg/L and had 5-day decay rate constants of k<0.12 per day. A modeling scenario at critical low flow and temperature conditions with the MWRRF discharge expanded from 16 MGD to 32 MGD demonstrated that the increased flow rate from the MWRRF resulted in smaller diurnal swings in DO, and that the minimum DO concentrations were elevated throughout the entire model. The results from this model will be used to support a permit application for expansion of the MWRRF.

TN-SWAPYT: A PYTHON TOOL TO AUTOMATE TENNESSEE'S SOURCE WATER ASSESSMENT PROGRAM REPORTS

Rebecca K. Ransom[2], Annabelle Dempsey[1], Katherine J. Knierim[2], Brian Ham[1], and David E. Ladd.[2]

The Tennessee Department of Environment and Conservation (TDEC) and the United States Geological Survey (USGS) have collaboratively developed an automated data analysis and reporting tool to support TDEC's Source Water Assessment Program (SWAP). The tool, referred to as TN-SWAPyT, is a geospatial toolbox that leverages Python, the ArcPy package, and LaTeX Document Preparation System to automate GIS analysis and SWAP reporting. The tool is executed from an ArcGIS Pro session to: delineate protection zones by using public supply source locations and National Hydrography Dataset Plus (NHDPlus) water body data; collate and map the potential contaminant sources in protection zones and utilize digital environmental datasets to rate susceptibility of public supply sources to potential contaminants; and generate a standardized report that summarizes the findings. The susceptibility of public water sources to contamination is assessed using TDEC-managed potential contaminant datasets and publicly available environmental GIS datasets including land use data, slope data, soil characteristic data and StreamStats, which enables public water systems to be better informed of potential vulnerabilities through consistent, accessible, and up-to-date SWAP reports across the state of Tennessee.

[1] Tennessee Department of Environment and Conservation
[2] U.S. Geological Survey Lower Mississippi-Gulf Water Science Center

ESTIMATES OF FLOOD FREQUENCY AND MAGNITUDE FOR URBAN AND RURAL TENNESSEE STREAMS

David E. Ladd, Daniel M. Wagner, Elizabeth N. Heal, and Paul A. Ensminger

Transportation engineers require reliable estimates of the magnitude and frequency of peak streamflows to design bridges, culverts, and other structures near streams and rivers. Methods used to estimate the magnitude and frequency of peak streamflows at ungaged locations are updated periodically to include recent data from nearby streamgages, incorporate statistical improvements in frequency analysis, and reflect technological improvements that increase the accuracy of basin and climatic characteristics that affect hydrologic response in streams. The U.S. Geological Survey (USGS), in cooperation with the Tennessee Department of Transportation, recently updated the methods used to predict peak streamflows on streams in Tennessee in both urban and rural settings. One set of urban equations was developed for Tennessee and parts of Alabama, Georgia, Mississippi, North Carolina, and South Carolina using streamflow data through the 2022 water year. Four sets of equations for rural streams were developed for four physiography-based regions across Tennessee and adjacent parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia using streamflow data through the 2013 water year. Equations for predicting streamflows for 50-, 20-, 10-, 4-, 2-, 1-, 0.5- and 0.2-percent annual exceedance probabilities (the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods, respectively) were updated and incorporated into the USGS StreamStats application (https://streamstats.usgs.gov/ss/) for automated retrieval of basin characteristics and peak streamflow statistics.

SESSION 1B

Wednesday, April 9th at 1:30pm - 3:00pm
MITIGATION
(Moderator: John Schwartz, UTK)

Navigating CLOMR Complexity: Moving a Project with Over a Mile of Natural Stream Design & 9 New Structures Through FEMA's CLOMR Process
D. Spinks

Compensatory Mitigation for Stream Restoration: A Process-Based Approach to Quantifying Ecological Uplift
C. Parks Oliver

Stream Mitigation at Dry Creek Water Reclamation Facility
M. Clabaugh

Wednesday, April 9th at 3:00pm - 5:00pm
GIS
(Moderator: Andrea Ludwig, UTK)

The Future of Wetland Mapping in Tennessee: A Comparison Between the National Wetlands Inventory and a New Predictive Model
S. Terpstra

Delineating Riparian Boundaries for Stream Networks in Tennessee and Assessing Policy Implications
M. Johnson

Assessing Stream Health in West Tennessee: Advancing Scalable GIS and Remote Sensing Techniques for Stream System Analysis
S. Sengupta, M. Yaeger, G. Williford, Y. Kwon

NAVIGATING CLOMR COMPLEXITY: MOVING A PROJECT WITH OVER A MILE OF NATURAL STREAM DESIGN & 9 NEW STRUCTURES THROUGH FEMA'S CLOMR PROCESS

David Spinks

In 2018 the Tennessee Department of Transportation (TDOT) Hydraulics group began planning the drainage for a large roadway project that would relocate approximately 4 miles of SR-115 (Alcoa Highway) including a new interchange with SR-162 (Pellissippi Parkway) near the McGhee Tyson Airport in Blount County, TN. This area also contains Russell Branch and its Zone AE Special Flood Hazard Area.

It became clear in the project's early stages that regardless of the design choices made, the roadway fill and nine new structures impacting Russell Branch's FEMA Floodway were going to necessitate a Conditional Letter of Map Revision (CLOMR), so the decision was made to relocate over one mile of stream channel using Natural Stream Design (NSD) in order to generate stream mitigation credits. As the greater project was being designed, the group was also tasked with incorporating a "temporary" crossing for an Amazon distribution center access road that would eventually have to fit into the final design. During the lengthy design and review process TDOT developed and refined a 2D Hydraulic Model using Aquaveo's SMS SRH-2D to help check the 1D CLOMR submittal accuracy (this is being updated with the new SMS 3D structures functionality introduced in v13.3.9).

Attendees will hear TDOT Hydraulics Team Lead David Spinks discuss this project, the choices and challenges that were encountered while developing the Russell Branch hydraulic models, as well as the lessons learned during our 28 month CLOMR application process.

COMPENSATORY MITIGATION FOR STREAM RESTORATION: A PROCESS-BASED APPROACH TO QUANTIFYING ECOLOGICAL UPLIFT

Ceara Parks Oliver

The Clean Water Act (CWA) is evolving, as evidenced in recent years, but its mission remains the same: to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The Compensatory Mitigation Rule for Losses of Aquatic Resources (2008 Rule) expanded compensatory mitigation procedures under the CWA, solidifying a market-based approach to stream restoration. Central to the 2008 Rule is the Watershed Approach, designed to promote holistic strategies for restoration practices, but its potential remains underexplored. Despite a burgeoning stream restoration industry, recovery of biological integrity in urbanized landscapes remains inconsistent and, at times, unattainable. Recent trends, such as the Whole Watershed Act in Chesapeake Bay, highlight current efforts to explore catchment-scale restoration to tackle such challenges. This presentation evaluates a compensatory mitigation framework integrating catchment-scale stormwater management and reach-scale stream restoration practices in urbanizing watersheds with an emphasis on biological integrity. A key component of this framework is its connection to Section 303(d) of the CWA, potentially linking ecological performance standards to compensatory mitigation. The framework integrates hydrologic stormwater practices with ecohydraulic modeling using SWMM and River2D. It incorporates weighted usable area (WUA) based on fish and macroinvertebrates guilds, aligning with 303(d) impairment specifications. Functional categories for measuring restoration success include sediment, riparian corridor, and habitat - key drivers of ecological conditions in streams. A case study of Turkey Creek, listed on the 303(d) list of impaired waters due to sedimentation, will be presented to explore the application of this framework to an urbanizing watershed.

STREAM MITIGATION AT DRY CREEK WATER RECLAMATION FACILITY

Aaron Thomas and Matt Clabaugh

Metro Water Services (MWS) Dry Creek Water Reclamation Facility (WRF) experienced significant damage during the May 2010 Flood. MWS developed a plan to mitigate future risks to the WRF, including construction of a perimeter wide floodwall system for all structures and equipment within the WRF. The proposed flood mitigation plan included the relocation of 1,200 feet of portions of Dry Creek and Grizzard Creek, perennial tributaries to the Cumberland River, within the MWS WRF site in Nashville, Tennessee. The channel will be relocated and designed using natural channel techniques including stable dimension, pattern, and profile and a functional floodplain bench, as well as a native riparian buffer. As a result of the restoration, numerous geomorphology and hydraulic functions as well as in-stream habitat will improve. The proposed stream relocations will result in a stream loss of approximately 320 linear feet; however, the relocated streams' ecological functions will be an improvement compared to the existing streams. This presentation will summarize the stream mitigation plan to offset the loss of stream linear footage as a result of the proposed flood mitigation project.

THE FUTURE OF WETLAND MAPPING IN TENNESSEE: A COMPARISON BETWEEN THE NATIONAL WETLANDS INVENTORY AND A NEW PREDICTIVE MODEL

Sarah Terpstra[1]

The National Wetlands Inventory (NWI) Wetland Mapper has historically been the go-to mapping tool for estimating the presence and types of wetlands throughout the United States. Though once a valuable tool, the NWI geospatial dataset is based on data and imagery that is frequently 40-50 years old and is often incorrect. In an effort to improve wetland mapping capabilities in Tennessee, Skytec LLC, a company specializing in GIS technology, developed a predictive wetland model using the Wetland Identification Model (WIM), created by Dr. Gina O'Neil, which utilized LiDAR elevation data and machine learning. To develop the model, Skytec created a training dataset consisting of 2,558 confirmed wetland features, split into six distinct ecoregions of Tennessee. The purpose of this study is to evaluate the differences in the quantity and distribution of wetlands between the historic NWI and the new Skytec Model based on both county and HUC 10 watershed boundaries. Using ArcGIS Pro, I downloaded the NWI data and imported the Skytec Model for Tennessee and used the "summarize within" geoprocessing tool to summarize the wetland acreage and symbolize by percentage of total acreage according to the two selected boundaries. I also evaluated the presence and location of predicted "geographically isolated" wetlands in order to estimate the potential impacts from recently proposed legislation to remove state protections for such wetlands. My research revealed that nearly twice as many wetlands were predicted in Tennessee by the Skytec Model (> 1.5 million acres) than have historically been identified by the NWI (~860,000 acres), and that the majority of wetlands in the State are in West Tennessee in the Mississippi Delta region. Equally important, the Skytec Model predicts the likely presence of "geographically isolated" wetlands in two significant and vulnerable areas of Tennessee: above the Memphis Aquifer recharge zone, and in the Upper Duck River Watershed. This research highlights the great diversity of Tennessee's hydrologic landscape by both county and watershed and identifies the areas which are most vulnerable to proposed legislation.

[1] Tennessee Department of Environment and Conservation, Division of Water Resources

DELINEATING RIPARIAN BOUNDARIES FOR STREAM NETWORKS IN TENNESSEE AND ASSESSING POLICY IMPLICATIONS

Madison Johnson

Riparian zones are transitional areas between land and bodies of freshwater, and are an essential component of a functional riverine system. They are defined topologically, usually bounded by locations of frequent flooding that mark drastic changes in both the vegetative communities and land formations. It is well known that a riparian zone consisting extensively of native vegetation is key for the health of water resources, and this is reflected in current MS4 guidelines for riparian buffer widths. An average buffer width of 30 feet for streams impacted by siltation, and average width of 60 feet for Exceptional Tennessee Waters. These guidelines are similar to many states' policies for establishing and maintaining riparian buffers within new development areas, applying individual buffer widths based on certain criteria to streams across a jurisdiction. However, the actual extent of the riparian zone likely exceeds these minimum buffer requirements in some locations, and in some locations buffer requirements may exceed the actual extent of the riparian zone. In addition, there are numerous streams that remain unaccounted for and unprotected by these water quality laws, such as headwater streams with locations that are difficult to define. Gaining a better understanding of riparian boundaries for forest and water resource conservation planning is extremely important considering Tennessee's rapid development, and anticipated changes in water quality protections. Using the Riparian Buffer Delineation Model (RBDM), which was created by the US Forest Service in partnership with USGS, a riparian boundary map for the state of Tennessee will be created for all "in-network" streams. This map will be used to assess where policies for riparian buffer widths may be inadequate, to locate areas of high conservation and restoration priority, and to gain insight into factors impacting riparian health across the state.

ASSESSING STREAM HEALTH IN WEST TENNESSEE: ADVANCING SCALABLE GIS AND REMOTE SENSING TECHNIQUES FOR STREAM SYSTEM ANALYSIS

Sanghamitra Sengupta[1], Mary Yaeger[1], George Williford[1], Youngsang Kwon[1]

Recent assessments by the Tennessee Department of Environmental Conservation (TDEC) reveal that many streams in West Tennessee's agricultural regions are impaired, failing to support riparian and aquatic ecosystems. This impairment raises concerns regarding further degradation due to climate change and land-use modifications. In response, this project develops scalable geographic information systems (GIS) and remote sensing technologies to refine stream health assessments. The primary objectives are to establish remote sensing-based indices to assess stream health and quantify anthropogenic pressures on the stream riparian corridor, validate them using machine learning techniques, and apply these tools to classify unassessed stream health across the region. A multi-tiered methodology leverages Sentinel-2 satellite imagery, National Agriculture Imagery Program (NAIP) aerial data, and unmanned aerial vehicles (UAVs) equipped with hyperspectral and LiDAR sensors. These technologies provide precise, high-resolution data critical for assessing riparian vegetation health and water quality. A key innovation is an automated GIS platform integrated with Python-based tools within QGIS, enabling streamlined computation of indices like the Modified Soil Adjusted Vegetation Index (MSAVI) and Human Footprint Index (HFI). Machine learning algorithms, including Random Forest, validate and refine the indices, classifying stream segments as “healthy” or “impaired” based on the indices and field assessments. On completion, this project will deliver accurate, cost-effective, and scalable tools for stream health evaluation. By addressing critical gaps in current practices, this project will lay the groundwork to support sustainable water resource management and provide conservation agencies with actionable insights to safeguard Tennessee's aquatic ecosystems.

[1] University of Memphis

SESSION 2A

Thursday, April 10th at 8:30 am - 10:00 am
ALGAE
(Moderator: Jessica Rader, TDEC)

Development of an Index using Diatoms to Determine the Trophic State of Infralittoral Sites in Tennessee Reservoirs
J. Lebkuecher, D. Redwine

The Influence of Nutrient Availability on Algal Growth, Community Composition, and Microcystin Production in Large Rivers
J. Li, J. Murdock

Microcystins in Middle Tennessee Waterways
A. Jaegge, K. Hill, D. Moore, T. Byl

Thursday, April 10th at 10:30 am - 12:00 pm
AQUIFERS
(Moderator: Shannon Williams, USGS)

Data Collection Efforts in Shelby County Tennessee
S. Smith

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

Development of a dynamic modeling framework for water availability assessments: Mississippi Alluvial Plain
L. Duncan

Thursday, April 10th at 1:30 pm - 3:00 pm
GROUNDWATER
(Moderator: Rodrigo Villalpando-Vizcaino, CAESER)

Investigation of the influence of geological structures on groundwater flow in the Memphis aquifer: An AEM-based study
K. Karki, D. Larsen

From Soil Water Retention to Aquifer Recharge: Conceptualizing Multi-Scale Hydrological Processes in Tennessee's Agricultural Loess Hills
M. Yaeger, J. Pickering, D. Larsen, R. Villalpando-Vizcaino, B. Waldron, B. Leib

Bridging the Gap: Development of a Next-Generation Hydrogeologic Model for Future Water Resource Management in the Mississippi Embayment
W. Kress

Thursday, April 10th at 3:30 pm - 5:00 pm
GROUNDWATER (PART II)
(Moderator: Wade Kress, USGS)

Managing an Aquifer: What does groundwater protection look like in Tennessee?
S. Houston

Groundwater quality of the major supply aquifers of West Tennessee
K. Hill, L. Ruhl-Whittle, A. Hourigan, S. Smith

DEVELOPMENT OF AN INDEX USING DIATOMS TO DETERMINE THE TROPHIC STATE OF INFRALITTORAL SITES IN TENNESSEE RESERVOIRS

Jefferson Lebkuecher[1] and Daniel Redwine

Assemblages of infralittoral periphytic diatoms are understudied due partially to the historical emphasis on phytoplankton and other water-column characteristics to evaluate the integrity of lentic systems. We tested the null hypothesis that characteristics of diatom assemblages at infralittoral sites in reservoirs of Middle and East Tennessee do not infer trophic state. One infralittoral site in five mesotrophic and five eutrophic reservoirs in Middle and East Tennessee was sampled to determine the relative abundance of epilithic soft algae, concentrations of epilithic chlorophyll (chl) a, and water concentrations of chl a, total phosphorus (TP), and total nitrogen (TN). The concentration of epilithic chl a correlates significantly to the concentration of TP but not to TN. The water concentration of chl a does not correlate significantly to concentrations of TP, TN, or epilithic chl a. Trophic-state indicator values for 162 diatom taxa are calculated as the abundance-weighted average of the concentration of epilithic chl a normalized between 0 and 100. The trophic-state indicator values indicate the relationship of the abundance of diatom taxa to trophic state and contribute to our limited knowledge of the effects of eutrophication on infralittoral diatom assemblages. Trophic-state indices are calculated as the mean abundance-weighted average of trophic-state indicator values for diatom taxa of an assemblage. The index values infer the trophic state of the sites and are the first to use epilithic concentrations of chl a as opposed to water-column characteristics to indicate trophic-state optima for periphytic algae of lentic systems. The indices are easy to calculate and provide novel tools to help evaluate and monitor the trophic state of infralittoral sites in reservoirs of Middle and East Tennessee.

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THE INFLUENCE OF NUTRIENT AVAILABILITY ON ALGAL GROWTH, COMMUNITY COMPOSITION, AND MICROCYSTIN PRODUCTION IN LARGE RIVERS

Jingjing Li[1], Justin Murdock[1]

Harmful algal blooms (HABs) in rivers are increasing in frequency worldwide, with this trend driven in large part by increasing nutrient loading into the watershed. Nitrogen (N) and phosphorus (P) dynamics are key factors regulating algal growth and composition in lakes, but it is not clear if these relationships transfer to flowing waters, and especially large rivers with complex and constantly changing hydrology, light, and nutrient regimes. This study investigated the effects of nutrient concentrations and stoichiometry on algal community development in the Ohio River, near Huntington, WV. We conducted 40-day laboratory incubations of river water in the spring and summer of 2024 under varying N and P gradients and ratios to identify optimal nutrient conditions that trigger cyanobacteria growth and toxin production. Ohio River algal growth is co-limited by N and P, with N uptake tightly tied to P availability. Low N:P ratios promoted the growth of N-fixing cyanobacteria, which significantly increased N input via N fixation. Additionally, N availability was a key driver of microcystin synthesis, so increases in P relative to N may indirectly promote toxin production. These findings emphasize the critical role of N and P in shaping algal communities, toxin production, and HAB dynamics in river systems. This research provides essential insights into nutrient-driven algal dynamics, offering valuable data to refine predictive models and inform effective river management strategies to mitigate harmful algal blooms in flowing waters.

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MICROCYSTINS IN MIDDLE TENNESSEE WATERWAYS

Andrea C. Jaegge[1], Kristi L. Hill[2,3], Devin M. Moore[2,3], Thomas D. Byl[2,3]

Cyanobacterial toxins (cyanotoxins) are a growing threat to water bodies worldwide. Microcystins, one of the most commonly detected cyanotoxins, are potent hepatotoxins and can negatively impact humans, livestock, pets, and the environment. Because middle Tennessee has abundant surface water and connected groundwater resources important for recreation and drinking water, identification of temporal and spatial patterns of microcystin events is needed. From September 2022 through November 2024, cyanotoxin grab samples were collected biweekly along with a suite of environmental parameters in collaboration with the Tennessee Department of Environment and Conservation (TDEC). Solid Phase Adsorption Toxin Tracking (SPATT) samplers were also deployed and subsequently retrieved on a biweekly basis. SPATT samplers passively adsorb cyanotoxins during a deployment period, making them a useful tool when ambient concentrations are persistent but low. Sampling sites included areas used for recreation, agriculture, and utilities as well as wetlands, small lakes and streams, rivers, and reservoirs. Detectable concentrations of microcystins in whole water grab samples ranged from 0.10 to 1.25 µg L^{-1}. The highest concentration was detected at Tennessee State University near agricultural pastures in early fall 2024. Microcystin concentrations obtained from SPATT samplers ranged from 0.10 to 70.1 µg L^{-1} g $resin^{-1}$ day^{-1} and peaked near the J Percy Priest Reservoir dam. Across the 18 total sites sampled, all locations had at least one instance of detectable microcystin concentrations, suggesting that cyanotoxins are widely present across middle Tennessee waterways.

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DATA COLLECTION EFFORTS IN SHELBY COUNTY TENNESSEE

Spencer Smith

The U.S. Geological Survey has been dedicated to the comprehensive study of groundwater resources in the Memphis area for nearly a century. Our ongoing efforts include the systematic collection and publication of monthly groundwater level data, alongside annual water quality sampling from Memphis Light, Gas and Water (MLGW) production well fields. These initiatives provide essential insights into the fluctuations and trends within the aquifer system, ensuring the integrity and safety of groundwater resources. Additionally, geophysical logging of test holes is employed to guide strategic water extraction practices, with all datasets made publicly available through USGS platforms.

In late 2020, data collected were utilized to create a potentiometric map visualizing groundwater dynamics in the region. Historical water withdrawals from the aquifer, dating back to 1886, have resulted in a significant cone of depression in the potentiometric surface, which features several smaller cones associated with municipal well fields in Memphis. Notably, average daily water withdrawals in Shelby County decreased from 142 million gallons per day in 2015 to 132 million gallons per day in 2020, a trend reflected in comparative water level analyses from these years.

Our study incorporates innovative methodologies, such as the deployment of a towed transient electromagnetic tool for geophysical data collection in urban environments. This technique has proven effective in enhancing our understanding of the geological formations comprising the aquifer system. Specifically, geophysical investigations conducted in Shelby Farms Park and along the Wolf River aim to delineate areas where the Upper Claiborne Confining Unit is either thin or absent. Collectively, these initiatives are vital for improving groundwater resource management and promoting sustainable practices in the Memphis area.

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

Ryan Adams and Wade Kress

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

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.

DEVELOPMENT OF A DYNAMIC MODELING FRAMEWORK FOR WATER AVAILABILITY ASSESSMENTS: MISSISSIPPI ALLUVIAL PLAIN

Leslie Duncan

Scientists with the USGS Lower Mississippi-Gulf Water Science Center carrying out the Mississippi alluvial Plain (MAP) Integrated Water Availability Assessment have worked toward the development of a dynamic modeling framework to allow groundwater models to be more quickly constructed or updated iteratively as new data or conceptualizations of the system are made available using automated, repeatable workflows. The MAP dynamic modeling framework has been designed to integrate data from a variety of active mapping and monitoring activities into a series of supporting models used to construct and/or update both regional and inset groundwater flow models developed in the USGS's MODFLOW6 groundwater modeling software. Supporting models were designed to supply updated information on groundwater levels, water use, surface water flows, water budgets, and three-dimensional hydrogeology on an annual basis. The groundwater flow models were also used to provide feedback to the supporting modeling teams, indicating areas for improvement within their models.

For the MAP Integrated Water Availability Assessment, the MAP groundwater modeling team used the development of a scripted workflow consisting of an open-source software library for robust, repeatable, automated model construction of a number of MODFLOW6 groundwater flow models to address localized stakeholder interest in the region. This workflow was used to create a regional groundwater flow model and four high-resolution inset models. The regional groundwater flow model was developed for the Mississippi Embayment aquifer system to provide boundary fluxes and heads for the inset models to support stakeholder resource decisions. The inset models were developed to provide improved estimates of groundwater availability and aid water resource managers in evaluating potential engineering and conservation practices to sustain water availability for agricultural practices and ecosystem services in the region. This presentation will detail the efforts, accomplishments, and challenges encountered in the development of a dynamic modeling framework to provide actionable information to resource managers.

INVESTIGATION OF THE INFLUENCE OF GEOLOGICAL STRUCTURES ON GROUNDWATER FLOW IN THE MEMPHIS AQUIFER: AN AEM-BASED STUDY

Kapil Karki and Daniel Larsen

The Memphis aquifer, the major source of public water supply in western Tennessee, lies within the Mississippi Embayment and New Madrid Seismic Zone (NMSZ). Recently acquired airborne electromagnetic survey (AEM) data suggest that the continuity of groundwater flow in the Memphis aquifer is influenced by fault structures within the NMSZ. High-spatial-density AEM surveys were flown to delineate subsurface features and characterize aquifer geometry in northern Shelby County, Tennessee. Within the semi-consolidated sediments of the Memphis aquifer and overlying upper Claiborne confining unit, faults offset both permeable and impermeable layers, potentially compartmentalizing aquifers. When clay-rich confining layers are faulted, clay gouge along the fault creates low resistivity zones that are likely to impede groundwater flow. However, cataclasis and fracture networks create high-resistivity zones along fault zones that may create conduits for fluid flow and breach of confinement for underlying aquifers. Deformation and folding of sedimentary layers are evident along some structures, which likely disrupt the continuity of aquifers and modify conditions of groundwater storage and recharge. This study demonstrates the utility of AEM data in mapping of fault architecture within the subsurface, especially where resistivity contrast exists between aquifer and aquitard layers. When combined with traditional geological and hydrogeological techniques, AEM data enable a more thorough understanding of the distribution of structural features and thus allow for the development of accurate conceptual models. These models are fundamental to understand the hydrogeologic influence of fault networks within aquifer systems and assess vulnerability of the aquifer to contamination as well as limitations of resource availability. his work emphasizes the need for further investigation into the influence of geologic structures on aquifers and highlights the role of advanced geophysical techniques in sustainable Memphis aquifer management.

FROM SOIL WATER RETENTION TO AQUIFER RECHARGE: CONCEPTUALIZING MULTI-SCALE HYDROLOGICAL PROCESSES IN TENNESSEE'S AGRICULTURAL LOESS HILLS

Mary Yaeger, Jenn Pickering, Dan Larsen, Rodrigo Villalpando-Vizcaino, Brian Waldon, and Brian Leib

Western Tennessee’s Mississippi Valley Loess Plains are characterized by hills covered in deep, water-retentive, highly-erodible, silt-loam soils derived from loess deposits and alluvial sediments. This predominantly rural, agricultural region is dissected by five branched rivers which flow orthogonally into the Mississippi River. This network of low-gradient streams with sand beds and weak, erodible silt banks represents a dynamic geomorphic system. The complexity of this landscape is mirrored in the complex subsurface heterogeneity described in recent regional studies and corroborated by the current work: confining layers may not be as contiguous as previously thought, subsurface paleochannels may serve as preferential lateral groundwater flow pathways, and discontinuous clay lenses are present in the recharge zone, perching infiltrating surface water. The region’s thick silt-loam soils retain water against gravity, only draining under near-to-fully-saturated conditions or steep topographic slopes. Seasonal vegetative demand dries the root zone, creating a matric potential gradient that draws water upward from wetter deep-soil layers. In winter and early spring, when all layers approach saturation, the gradient reverses downward, moving water past the extinction depth and potentially into deeper sediment layers. This seasonal pattern is reflected in all monitored groundwater elevations, where declines during the growing season are followed by partial-to-full recovery or slower rates of decline in winter/spring. Both short- and long-term groundwater monitoring in west Tennessee show stable groundwater levels except at one upland well with no nearby pumping influence, which has exhibited a decrease of one ft/yr (30.5cm/yr) since installation, and only one 0.5-ft (15-cm) winter recovery in 2022. Uplands typically drain along topographic gradients, with groundwater elevation recovery signals occurring only in/after very wet years and with lags of up to 10 years for deep (>20ft, 6m) groundwater. This drainage accumulates in bottomlands, slowly discharging laterally to nearby streams, while some portion may move deeper into the subsurface, contributing to deep aquifer recharge where confining units are absent. Perched infiltration creates shallow water tables, affecting drainage in lowland areas, but also serving locally as groundwater resources. Incised streambeds may also serve as additional recharge sources during high-flow periods. These processes combined may explain the stability of aquifer levels in west Tennessee over the last ten years.

BRIDGING THE GAP: DEVELOPMENT OF A NEXT-GENERATION HYDROGEOLOGIC MODEL FOR FUTURE WATER RESOURCE MANAGEMENT IN THE MISSISSIPPI EMBAYMENT

Wade Kress

The USGS has a longstanding tradition of developing hydrogeologic models in the Mississippi Embayment (ME) to support groundwater flow models in the evaluation of current and future water availability. However, a lack of centralized databases and reproducible scripted workflows hampers the development and adaptability of hydrogeologic models the agency uses to assess and forecast the availability of groundwater resources. Since 2015, the Lower Mississippi-Gulf Water Science Center has undertaken an ambitious initiative to create a next generation hydrogeologic modeling workflow incorporating techniques like those used by the petroleum industry to develop reservoir models. The next-generation hydrogeologic model of the ME incorporates a wide range of data, including geophysical (borehole, terrestrial, water-borne, and airborne), geologic, lithologic, hydraulic, and geochemical information. To support this model, we are developing SQL databases and scripted workflows to produce robust and adaptable 3D models of the hydrogeology. This approach aims to enhance the model's utility for both regional and local groundwater availability assessments by being more adaptable to new data as it becomes available, ultimately contributing to more effective water resource management. This presentation will detail our efforts, accomplishments, and challenges encountered in the development of this next generation hydrogeologic model. This initiative is supported by both appropriated and reimbursable programs, combining efforts from the water mission area, various science centers, multiple federal and state cooperators, as well as academic partners.

MANAGING AN AQUIFER: WHAT DOES GROUNDWATER PROTECTION LOOK LIKE IN TENNESSEE?

S. Houston

Flowing crystal clear from the earth, the Memphis Sand Aquifer has been said to contain 2,000 year old water with a limitless supply. That legend began to unravel in the 1980s when city drinking water wells in South Memphis and Collierville were shut down due to contamination. New research continues to reveal how vulnerable our drinking water supply is to contamination. The reality is, our groundwater is unmanaged, and no aquifers in Tennessee are properly protected. Protect Our Aquifer has analyzed state law and a series of ordinances and contracts between 1987-1991 that established the Groundwater Board and expanded the Water Quality Branch of the Shelby County Health Department (SCHD). Numerous programs were outlined within the governing documents, including well permitting, wellhead protection, observation wells, and spill prevention that have never been enacted. We have compared these possible programs with others across the country and in the context of new data and development pressures. In this presentation, we propose a phased work plan to bring aquifer management to fruition in Shelby County that could be replicated in other areas of the state. In conjunction with sustainable, equitable funding sources, we can begin to manage our groundwater for the benefit of current and future generations.

GROUNDWATER QUALITY OF THE MAJOR SUPPLY AQUIFERS OF WEST TENNESSEE

Kristi L. Hill[1], Laura S. Ruhl-Whittle[1], Amy M. Hourigan[1], Spencer R. Smith[1]

Groundwater is the primary source of water for public and private supply for drinking and domestic use in Tennessee. Major supply aquifers, such as the Memphis aquifer, require minimal treatment before distribution due to of the composition of the water and a relatively low susceptibility to contamination. As anthropogenic influence and water demand continue to increase, characterizing the ambient water quality of major aquifers will provide a better understanding of the contribution of human activity and other surface influence on the groundwater. The purpose of this study is to characterize the major supply aquifers of West Tennessee (i.e. the Holocene Alluvium, Cockfield-Jackson Formations, Fort Pillow Sand, Memphis sand, Coffee Sand, Eutaw Formation, and McNairy Formation Aquifers) using data collected in cooperation with the Tennessee Department of Environment and Conservation as part of a groundwater quality monitoring network being developed for the state and historical data collected as part of regional aquifer studies for the USGS National Water Quality Networks. Groundwater samples collected from the early 1990's-2024 were analyzed for major ions, trace elements, nutrients, dissolved organic carbon, pesticides, volatile organic compounds, tritium, and field parameters. This dataset includes 21 recently sampled wells (from 2023-2024) with historical samples, as well as about 200 additional previously sampled wells from various regional aquifer studies to provide an opportunity to identify if and where water quality changes are occurring in these aquifers. Characterization of these aquifers 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 West Tennessee.

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SESSION 2-B

Thursday, April 10th at 8:30 am - 10:00 am
SEDIMENT
(Moderator: Forbes Walker, UTK)

Alluvial Fans at Reelfoot Lake in Northwestern Tennessee
E. Heal, T. Diehl, C. Lahiri

Updates to the Tennessee Erosion Prevention and Sediment Control Handbook
I. Simpson

Performance Evaluation of Sediment Basin Designs for Construction Sites in Tennessee
J. Schwartz, C. Emmett

Thursday, April 10th at 10:30 am - 12:00 pm
STORMWATER
(Moderator: Paul Davis)

A Review of Funding Mechanisms for Improved Stormwater Management
J. Camp

Prioritizing Green Stormwater Infrastructure Layout Using Hydrologic Disconnection Metrics to Evaluate Land-Cover Change Scenarios
F. Dell'Aira, C. Meier

Recycling Urban Stormwater Runoff Using Nature-based and Engineering Solutions
Y. Chen, E. Kuehler, J. Hathaway

Thursday, April 10th at 1:30 pm - 3:00 pm
FLOODING
(Moderator: Sharon Gordon, TLE)

Monitoring Stormwater Control Measures for Flooding and Water Quality Concerns
J. Thompson

Emerging Flood Monitoring Technology - the use of Electrical Conductivity (EC) Profiling
N. Chuang, D. Huang, J. Fan

Evaluating Methods for Trend Detection in Short-Duration Extreme Precipitation: A Case Study in the Southeastern US
N. Kafle, C. Meier

Thursday, April 10th at 3:30 pm - 5:00 pm
DAMS/GEOLOGY
(Moderator: Adrian Ward, Barge Design Solutions)

A Dam Conundrum: Updating the Bays Mountain Dam Emergency Action Plan
J. Melton

TN Safe Dams Program Overview
T. Hendren

Geospatial geologic structural datasets, Chattanooga Shale, Wells Creek Dolomite, and Knox Group, Tennessee
A. Hourigan

ALLUVIAL FANS AT REELFOOT LAKE IN NORTHWESTERN TENNESSEE

Elizabeth Heal, Timothy H. Diehl, Chayan Lahiri

In cooperation with the Tennessee Wildlife Resources Agency, the USGS investigated alluvial fan deposition on the east side of Reelfoot Lake in northwestern Tennessee, as part of an ongoing hydrologic study of the lake and its tributary streams. Alluvial fans are important, ongoing sinks for sand and silt, thereby reducing the rate at which the lake is filling up with sediment. Clay is carried across the fans to form large plumes in the lake. The fans in the study area are fine-grained (sand to clay) with networks of channels that are subject to blockage by woody debris accumulations and resulting avulsions.

Analysis of four topographic maps and two digital elevation models, spanning nearly a century, shows that these alluvial fans resulted primarily from modern agriculture and channelization. The largest, the Reelfoot Creek fan, grew most rapidly during the period in which the Reelfoot Creek main stem underwent channelization. Vertical differences between the 2011 and 2019 digital elevation models reveal the areas in which fan deposition was rapid and the areas not currently undergoing deposition.

The sections of greatest deposition are gently sloping and surrounded by an anastomosing network of small channels. The depth of deposition exceeded two feet between 2011 and 2019 in some areas of the northern half of the Reelfoot Creek alluvial fan, and in a narrow strip fed by an unnamed tributary. Continued deposition of these areas threatens to increase backwater effects in the adjacent farmland. Meanwhile, the Indian Creek alluvial fan is entirely dormant in response to its sediment source having been cut off by a dam.

UPDATES TO THE TENNESSEE EROSION PREVENTION AND SEDIMENT CONTROL HANDBOOK

Ian Simpson

This Erosion Prevention and Sediment Control (EPSC) Handbook has been developed to provide comprehensive and standardized EPSC measures for use on construction sites to limit the export of sediment to surface waters in Tennessee. The current handbook is under extensive revision to expand the list of applicable EPSC measures, update various technical specifications for EPSC measures, streamlet text and logical flow, and highlight some of the updated requirements per the updated construction general permit. More critical amendments to the handbook will be highlighted. Furthermore, a new tool, the Sed-Emmitt Basin Model, will be demonstrated. This tool provides quick and effective designs of sediment basins for designers to implement on construction sites. This novel design tool accounts for various amendable input parameters, abides by the most updated Tennessee state requirements, and accounts for local soil properties/particle size distributions, the first of its kind.

PERFORMANCE EVALUATION OF SEDIMENT BASIN DESIGNS FOR CONSTRUCTION SITES IN TENNESSEE

Cole Emmett[1,2] and John S. Schwartz[2]

Performance of three sediment designs were tested for the 1) TDEC standard with a forebay, 2) TDOT design with check dam at the inlet, and 3) TDOT standard that does not include an inlet check dam. A scaled sediment basin was constructed next to an outdoor flume in which known water volumes and sediment mass where mixed in the flume before entry into the basin. The measurement for performance was simply the percent sediment mass retained in the basin from the total input per experimental run (% removal). Three experimental replicates per design were completed. Sediment was analyzed by concentrations, loads, and particle size distributions (PSDs). All designs were greater than 80% removal, and the TDOT design with an inlet check dam performed as well as the TDEC standard with a forebay. PSD data from the experiments provided key information for developing a sediment-basin design model. In addition, these experimental results were compared with sediment data collected at active highway construction sites with a sediment basin.

[1] McGill Associates, Ashville, North Carolina

[2] University of Tennessee - Knoxville, Department pf Civil & Environmental Engineering

A REVIEW OF FUNDING MECHANISMS FOR IMPROVED STORMWATER MANAGEMENT

Janey Camp

The State Revolving Fund (SRF) is established as a low-interest loan program by the EPA to fund projects related to both drinking water and the Clean Water Act. Potential exists to utilize such funds and other funding mechanisms for stormwater projects to improve water quality across the state. To better understand the potential opportunities and challenges of such an approach, a study of existing funding pathways and interviews of multiple peer states was conducted. The study involved preliminary data collection from publicly available data and a deeper-dive through mixed methods to learn more about the programs. A summary of the findings will be presented.

PRIORITIZING GREEN STORMWATER INFRASTRUCTURE LAYOUT USING HYDROLOGIC DISCONNECTION METRICS TO EVALUATE LAND-COVER CHANGE SCENARIOS

Francesco Dell'Aira[1] and Claudio I. Meier[1]

Recent advancements in urban watershed characterization show significant correlations between response-to-extreme-event variables (e.g., peak flows) and metrics of basin-wide hydrologic connectivity across distinct catchments in a homogeneous region. Hydrologically more connected basins tend to display more severe responses than less connected ones, even for watersheds of similar size and fraction of impervious areas.

Unlike traditional descriptors of a catchment's land use/land cover (LULC) configuration, typically expressed as percentages of the total basin area, connectivity metrics explicitly account for the extent and spatial arrangement of various LULC patches within a watershed, both natural and urbanized, with different vegetation densities and land-development intensities.

These findings suggest that the effects of different LULC change scenarios on a basin's response can be quantitatively compared in terms of variations in hydrologic connectivity, as measured by suitably defined connectivity metrics. We explore new uses for these indices, such as aiding the effective placement of green stormwater infrastructure (GSI) solutions or evaluating alternative urban expansion scenarios with minimal impact on storm response.

Our novel, connectivity-based framework for basin characterization represents a powerful alternative to traditional hydrologic modeling. It can be used for validating results from simulations or in regions suffering from data scarcity, where calibrating hydrologic models might be challenging.

[1] The University of Memphis, Department of Civil Engineering

RECYCLING URBAN STORMWATER RUNOFF USING NATURE-BASED AND ENGINEERING SOLUTIONS

Yujuan Chen[1], Eric Kuehler[2], and Jon Hathaway[3]

Urban land development usually results in increased impervious surfaces and consequently leads to stormwater runoff issues. Coupled with climate change, urban stormwater runoff becomes an emerging issue nationwide. As a nature-based solution, urban forests can mitigate stormwater runoff. However, few studies have explored urban stormwater management using a combination of nature-based and engineering solutions. This talk will share a novel and multi-beneficial urban stormwater management approach using a gravel bed+trees system that recycles stormwater on-site while providing parking space, tree canopy cover, and shade and cooling. Specifically, it will present the results of the first demonstration site at University of Tennessee and the preliminary results from a recent demonstration site at Tennessee State University. The overall objective of these two studies is to determine the effect of the gravel bed+tree system on stormwater runoff as well as tree growth. To do that, we are monitoring rainfall, estimating stormwater runoff via standard modeling techniques, and using HOBO water level loggers to determine outflow. A water balance will allow us to estimate losses from the system, and thus, its hydrologic benefits. Additionally, we will measure tree growth both within the gravel tree bed and at a nearly control tree. This includes diameter at breast height, height, and canopy area. These attributes will be compared between the two locations to assess the health of the gravel bed trees. The findings will be beneficial for diverse stakeholders including urban planners, urban foresters, engineers, policy-makers, researchers, and community members.

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[2] Metro Water Services, City of Nashville
[3] Department of Civil and Environmental Engineering, University of Tennessee

MONITORING STORMWATER CONTROL MEASURES (SCM) FOR FLOODING AND WATER QUALITY CONCERNS

Jeremy Thompson

As water managers and engineers, it's important to understand our watersheds, urban landscapes, and the response of SCM's during rain events like heavy precipitation, snow melt, etc. There are many benefits to monitoring a SCM and its discharge elements. These are not limited to, but include the following: knowing when flooding could occur, enabling proactive action, assessing water quality, protecting lives, and minimizing damage to private property and public infrastructure.

In this presentation, we will discuss the value of data collection for flood monitoring, warning, and protection as well as the impacts on water quality. We'll examine what an ideal monitoring system might look like and how data can help demonstrate the value of the SCM.

EMERGING FLOOD MONITORING TECHNOLOGY – THE USE OF ELECTRICAL CONDUCTIVITY (EC) PROFILING

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

Leveraging Internet-of-Things (IoT) technologies, Artificial intelligence (AI) edge gateway and machine learning mechanisms become powerful tools for efficient and accurate monitoring and analysis of hydrological data including water levels, sediment levels, and meteorological information.

After heavy rainfall, rivers often carry large amounts of sediment and dissolved substances, causing significant changes in electrical conductivity (EC) in the receiving water body. These fluctuations in EC, along with shifts in water levels, serve as crucial indicators of river conditions—particularly during the early stages of landslides or floods. As such, these variations can act as early warning signals for impending flood events or landslides.

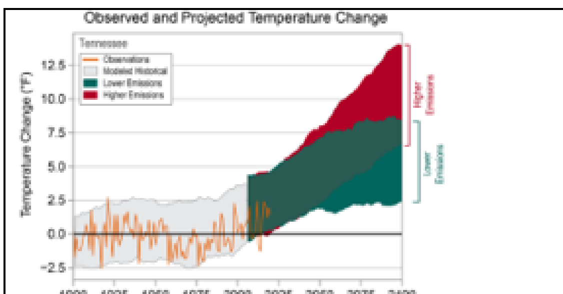
The use of a smart staff gauge, a multi-layer electrical conductivity (EC) profiler, enables timely EC profile data collection and transmission at multiple depths in specific locations within a water body. This profiling helps tracking water levels, sediment levels, erosion patterns, water health trends, 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 transmission technologies, such as Wi-Fi 802.11 ah, 4G Narrowband IoT (NB-IoT), and LoRa protocols, ensure efficient data transmission to mobile devices and network servers. The system is powered by rechargeable batteries backed by solar panels and optional wind-power, ensuring a reliable power supply for uninterrupted data collection and transmission. Additionally, the AI-integrated smart staff gauge features self-calibration to correct height deviations, improving data accuracy. The system also incorporates gravity and atmospheric sensors to monitor potential landslides or ground subsidence.

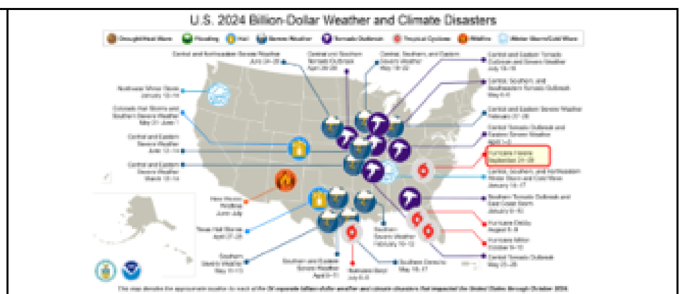
CHALLENGES

RISING TEMPERATURE AND ITS CONSEQUENCES

The global temperature rising since 1900 has being proved and it is projected to be much more in the future unless greenhouse gas emissions are effectively controlled. As reported in NOAA State Climate Summaries 2022, Tennessee temperature rising by 2100 is predicted to be in a range of 2.4 - 8.4 ^{o}F with a low emissions pathway and 6.5 - 14.0 ^{o}F with a high emissions pathway.



NOAA Climate Summaries 2022



https://www.ncei.noaa.gov/monitoring-content/billions/images/2024-billion-dollar-disaster-map.png

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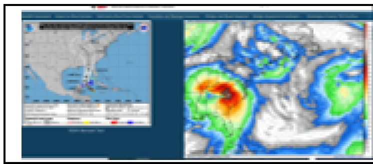
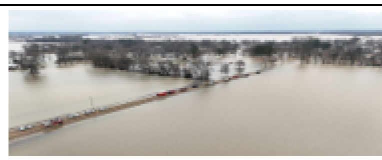
[3] Director, Product Management josephfan@nexcom.com.tw

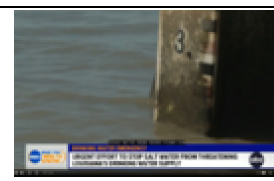
The consequences of global temperature rising including abnormal and extreme weather conditions such as increased droughts, tornedoes, abnormal intensive precipitations such as snow and rains resulting severer damages to properties and lives by flash flooding.

As documented on Britannica, in 2024, flooding caused by Hurricane Helene caused 230 killed and about 200 billion infrastructure damages. Substantial and historical rainfall produced by Hurricane Helene caused record-breaking river flooding that caused over 100,000 reported power outages, 4 wastewater treatment plants and 10 drinking water facilities impacted, 5 counties issued oil water advisories and 17 weather-related casualties as of October 21st, 2024.

		
https://storymaps.arcgis.com/stories/57af2ac1866f42d58bedb2f3c2154f8b	Emergency vehicles line up on a flooded road in Rives, Tenn. on Sunday, Feb. 16, 2025. (Photo: Jacob Fulbright)	Residential roads and homes sit inundated with floodwater in Rives, Tenn. on Sunday, Feb. 16, 2025. (Photo: Jacob Fulbright)

River systems began to rise significantly due to intensive rainfalls especially stalled frontal boundary of the mass. Timely water-level monitoring become an important tool for sending early warning to communities and government agencies for advanced preparation and prompt responses.

As shown below, abnormal weather conditions also causing water level dropping in river systems. Record-low water levels recorded along the Mississippi River during prime season for grain shipping in the dry year. Barge fill capacities are tremendously reduced to avoid high risk of hitting the river bottom.

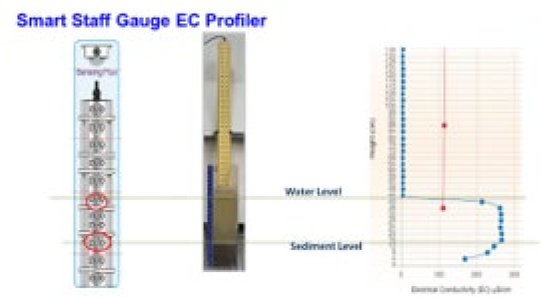
		
https://abcnews.go.com/US/record-low-water-levels-recorded-mississippi-river-prime/story?id=104012186 Oct.17, 2023		

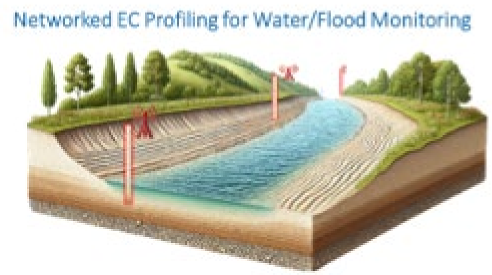
SOLUTIONS

Development of Internet-of-thing [IoT] technologies in water monitoring realizing the demand of timely, accurate water level monitoring data collection for resilient water management including water level monitoring for flood management, water health trending, erosion monitoring as well as sediment monitoring for water/wastewater treatment process. With the use of machine learning, edge/cloud computation, data analysis/modeling, GIS visual dashboard, general public and government agencies will be able to observe and predict trending of important factors for optimizing water resources management especially for flood early warning.

Smart Staff gauge EC profiling is an emerging technology of using a series of multi-layer EC electrodes at a certain interval for simultaneously measuring Electrical Conductivity (EC) in a defined range of a waterbody. Inversion points of the EC profile are used to identify the interface of two media such as air/water, water/sediment (mud/sludge) thus water level/sediment level can be identified.

The use of a multi-layer smart staff gauge at a fixed location of a water body, EC values at a certain interval of the water body can be collected and transmitted in a timely bases which provide more accurate data in comparison with the use of conventional practices.



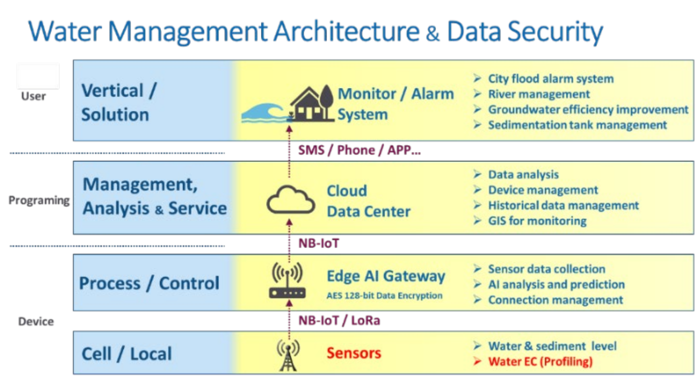


The trending of water level rising at monitoring stations along a water channel can be used for monitoring the direction, travelling time of impending flood and allowing the community and government agencies such as police, emergency rescue team, local administration for prompt responses to the incoming flood.

WATER MANAGEMENT ARCHITECTURE AND DATA SECURITY

At local level, after a network of smart staff gauge EC profilers timely collected EC data from each station will be transmitted simultaneously to a designated cloud data center or a command center for data analysis via NB-IoT and/or LoRa technology. Data security will be assured by using Edge AI Gateway with AES 128-bit Data Encryption. First tier data processed will then transferred to a Cloud Data Center for further data processing, analysis and service. In combination of GIS display, information such as station number, date/time, water level, sediment level and temperature will be presented on a dashboard either on a mobile device or a computer.

The management authorities such as the emergency response center, local administration can set an alarm level of water depth at each monitoring station, an email alarm message can be sent automatically to stakeholders on the mailing list for flood alert when the water level reached the alarm level.



For a network of EC Profilers, each RN-20 can individually send data directly to a designated Cloud Data Center via NB-IoT. Or, use LoRa technology for sending data from a RN-20 to a RN30 (an Edge AI Computing device) should the NB-IoT data channel not functioning well, then the RN 30 will transmit data collectively to the designated Cloud Data Center via NB-IoT or a Wifi network.

GIS technology and 3D visual tools can be utilized for geographical presentation for easy comprehending relevant information and subsequent management decision aids. Station ID, Date/Time, water level, sediment level and temperature of a chosen station are displayed after you click on the station icon on the Google Map.

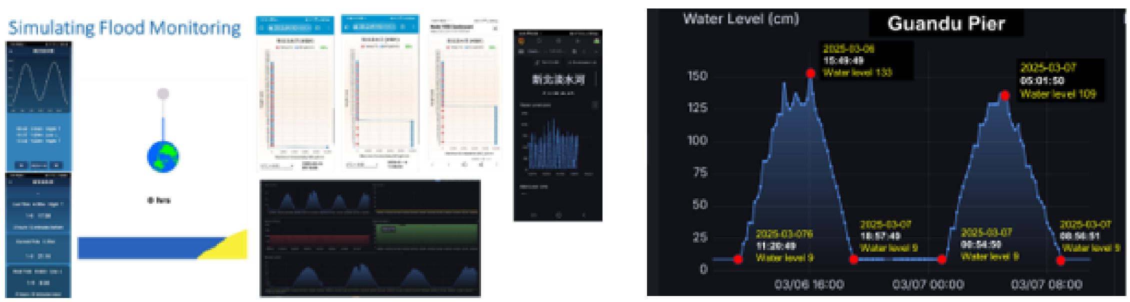
DATA INTEGRATION AND ANALYSIS ON CLOUD DATABASE
Monitoring data can be integrated and analyzed on the cloud database for further data analysis such as correlating EC with key water quality parameters such as TDS, DO, Total Hardness, pH etc. and other analysis such as flow pattern in a watershed, flood prediction and early warning by using artificial intelligence and machine techniques.

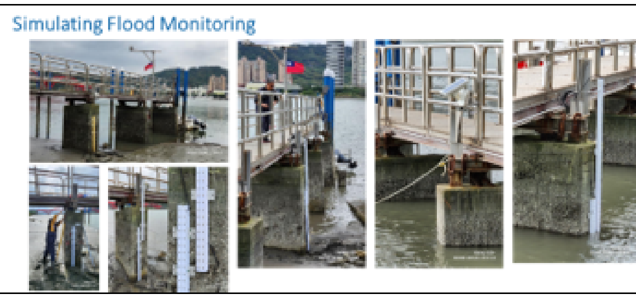
As shown in the graph below, while using a mobile device with internet access, the user can view the water level/EC/temperature profile from any location around the world at any time. A dashboard display can also be displayed by scrolling up and down of the screen to view graphs of water level, mud level, battery percentage and combined graph of water and mud level. However, the "CSV" file is download on a computer but not supported for downloading on the mobile device. Each "CSV" file contains one month of monitoring data.

A network of water level monitoring system can be established for a watershed or an urban area for flood early warning system. The speed of flood can be estimated by comparing the rate of water level rising at monitoring stations along a water channel and the distance between each monitoring station. A warning message via email to all stakeholders can be triggered by setting up warning water level at each monitoring station. Alarm can then be sent out via user's warning system. The trending of EC profiling can be used to monitoring the potential of pollution carried by the flooding.

CASE EXAMPLES
1. Water level monitoring and EC profiling – Irrigation channel – Taichung Taiwan
The system installed on January 10th , 2024 and is still operating...

2. Water level monitoring to simulate flood monitoring

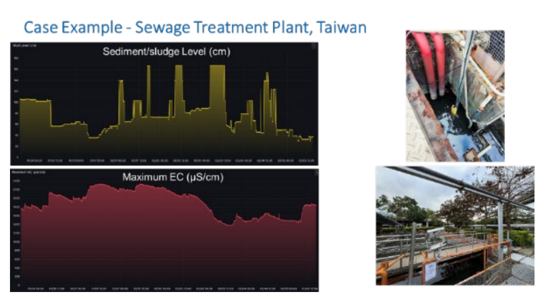




Each tidal cycle is used to simulate a flooding cycle. An alarm water level can be set in advance. When the flood water level reaches the alarm water level, an alert email will be sent automatically to stakeholders.

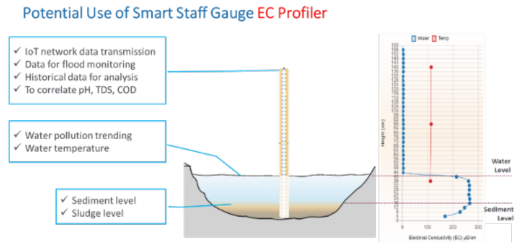
3. Settling tank sludge level monitoring

Inside the settling tank, the water level is normally consistent from inlet to outlet but the sludge level varies along the tank especially prior, after scrapping process as well as sludge discharging. Monitoring sludge level distribution between the inlet and outlet and the sump provides data for optimizing sludge scrapping and discharge rate. Energy and operating costs can be saved resulting from the improved sludge removal efficiency. As shown below, the sludge level data can be used for optimizing the sludge removal process. The Maximum EC profile at a settling tank provides information for optimizing dosing process. Should an EC profiler installed at the discharge outlet, the EC profiles can be used to track the trend of discharge water quality.

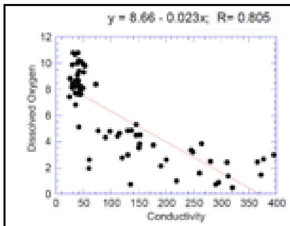
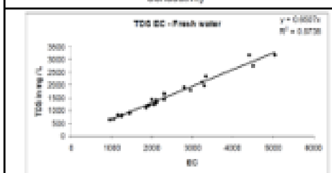
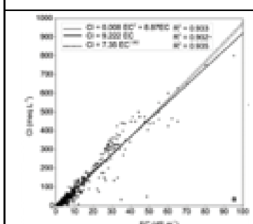


POTENTIAL USE OF SMART STAFF GAUGE EC PROFILER IN ADDITION TO FLOOD MONITORING

In addition to flood monitoring, the Smart Staff Gauge EC Profiler can also be used in monitoring water health by monitoring EC trending, water temperature, sediment/sludge level at a waterbody for scouring monitoring or a water/wastewater treatment plant for optimization of sludge removal.



Accordingly, some water quality parameters are significantly correlated with EC such as pH, Turbidity, Temperature, Chloride (Cl-), Dissolved oxygen (DO) Total Dissolved solids (TDS) and Chemical oxygen demand (COD).

	It is much easier and faster to measure EC than all anions and cations in a water body. As it has significant negatively correlated with DO, a study of overall relationship between electrical conductivity (µS/cm) and dissolved oxygen (mg/L) from the upstream to the downstream of the Langat River, Malaysia was conducted to exam the potential of using EC as a single indicator for water quality deterioration.
 TDS – EC relation for Fresh Water	Relation between TDS and EC of fresh water, sea water and tender coconut had been studied by S. Thirumalini and Kurian Joseph. It was concluded that in fresh water, a linear relation between TDS and EC exists but in sea water there is a non-linear in the relationship. However, it is worth to use mega historical data for further study the relation between TDS and EC in different type of water to exam the potential of using EC as a single indicator of water health.
 Water EC vs Chloride concentration Fits for 1358 samples collected from 1980 to 2008	As Cl^- contents is important indicator of groundwater quality especially at arid or semi-arid area and sea water intrusion at coastal areas. Héctor Peinado-Guevara et.al conducted studies for relationship between Cl^- and EC in groundwater using 1358 groundwater samples and concluded that the ECs in the groundwater has a linear relation with concentrations of Cl^-. The use of EC/Cl^-relation can be used as a rapid, reliable, and economical technique for successful drilling in searching of fresh groundwater.

Omar Anmar Almour et.al. conducted a study of correlation between EC and total hardness (TH), calcium (Ca^{+2}), chloride (Cl^-), sulfate $SO4^{-2}$, and total dissolved solids (TDS) for water samples from Tigris River's boundaries in Baghdad city. The author concluded that the liner regress equations developed for prediction of the concentrations of various parameters by using ECs can be used with reasonable accuracy. EC can be used to predict various physicochemical parameters in river waters.

To establish a water resilience, emerging technologies are introduced for collecting timely, accurate and reliable water monitoring data especially electrical conductivity and temperature data by using smart staff gauge with Edge AI Computing and secured data transmission to a designated cloud database using Edge AI Gateway, NB-IoT and LoRa technology. Advanced data analysis can be performed by using machine learning and AI mechanism.

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Emergency vehicles line up on a flooded road in Rives, Tenn. on Sunday, Feb. 16, 2025. (Photo: Jacob Fulbright), https://tennesseelookout.com/2025/02/18/flooding-devastates-small-west-tennessee-town-ahead-of-cold-snap/

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Omar Anmar Almoula; Dr. Khalid Adel Abdulrazzaq; Dr. Athraaa hashim Mohammed; Electrical Conductivity as a General Predictor of Multiple Parameters in Tigris River Based on Statistical Regression Model, Journal of Engineering Number Volume 27 February 2021.

EVALUATING METHODS FOR TREND DETECTION IN SHORT-DURATION EXTREME PRECIPITATION: A CASE STUDY IN THE SOUTHEASTERN US

N. Kafle and C.I. Meier

Trends in extreme precipitation have been reported globally because of climate change, leading to an increase in both the frequency & magnitude of urban pluvial flooding. In the Southeastern U.S., short-duration convective storms are primarily responsible for urban flooding. Because of this, evaluating trends in short-duration extreme precipitation should be a top concern, as it is essential to examine the adequacy of current urban drainage system design criteria.

A few studies in the US focus on trends in sub-hourly extreme precipitation, with most methodologies emphasizing frequency over magnitude. Frequency focused approaches have limited applicability in civil engineering because they typically consider daily or monthly precipitation data that does not adequately capture short-duration storm events critical to understanding urban pluvial flooding. On the other hand, magnitude-focused studies of short-duration precipitation are scarce and show inconsistent findings depending on the adopted statistics, methods, and assumptions. These inconsistencies highlight the need for evaluating methodologies in detecting trend in short-duration extreme precipitation.

In this study, we analyze rainfall data from 473 stations across the Southeastern US, with temporal resolutions of either 15 minutes (326 stations) or 1 minute (147 gauges), depending on station network. We will apply various trend tests to rainfall maxima over short durations, ranging from 15 minutes to 3 hours, to evaluate the robustness of different methodologies. Additionally, we will fit extreme value models for non-stationary sequences to maxima series, to detect non-stationarity. Our analyses aim to identify precipitation trends while exploring the strengths and limitations of different methods.

A DAM CONUNDRUM: UPDATING THE BAYS MOUNTAIN DAM EMERGENCY ACTION PLAN

Jeremy Melton[1]

INTRODUCTION

In 2024 the Tennessee Department of Environment and Conservation (TDEC) contracted Civil & Environmental Consultants, Inc. (CEC) to update the Emergency Action Plans (EAPs) for 12 dams, including five non-state-owned and seven state-owned facilities. Unprecedented storms in 2024 like Hurricane Helene severely impacted much of the Southeast, underscoring the critical nature of this work. Among the dams slated for EAP updates, the Bays Mountain Dam—owned by the City of Kingsport—presented one of the most challenging updates due to its complex, hybrid structure.

Built in 1915, the Bays Mountain Dam incorporates elements of an arch dam, a gravity dam, a masonry dam, and an earthen dam, requiring careful consideration for accurate breach analysis. The dam is primarily constructed of masonry, including the primary spillway which is approximately 26 feet wide and 4 feet deep. This spillway leads into a circular culvert with an approximate diameter of 3.2 feet that discharges into Dolan Branch on the downstream side of Bays Mountain Road. The dam has a 35-foot height, according to the National Inventory of Dams (NID). The dam crest measures about 530 feet long and 4 feet wide, with downstream embankments exhibiting slopes of 1 horizontal to 1 vertical (1H:1V). The normal water surface elevation of the reservoir is around 1833.00 feet, controlled by the outlet control structure.

Both the primary and emergency spillway discharge into Dolan Branch, which then flows into Little Horse Creek, which in turn flows into Horse Creek, ultimately discharging into the South Fork Holston River. The Kinsport Reservoir covers a surface area of approximately 36 acres and has a volume of about 550 acre-feet at crest elevation. The geometries and elevations of the dam crest, embankments, and appurtenances were sourced from the State of Tennessee LiDAR-derived terrain data. Finally, information was gathered during a site visit performed by CEC on October 10, 2024. All information gathered was used to produce the dam breach analysis discussed below and the creation of an EAP for Bays Mountain Dam.

METHODOLOGY

For the sunny-day breach scenario, CEC relied on data gathered during a site visit, TDEC-provided reports, and information from the NID. The mode of failure modeled was a piping breach at an elevation of 1800 feet, or the toe of the dam. Initially, the Froehlich equation—commonly used for earthen dams—was employed to calculate the breach parameters. However, upon further review, it became clear that this equation was not well-suited for the dam's unique composition.

After several iterations, CEC opted to base the breach parameters on guidelines outlined in the 1988 Federal Energy Regulatory Commission (FERC) report, *Notice of Revised Emergency Action Plan Guidelines,* and to approach the calculations with the dam modeled as a gravity dam. Out of the possible dam types that could be used as a basis for dam breach analysis, using the breach parameters for gravity dams as outlined by FERC would allow for analysis the quickest and most severe failure situation.

[1] Civil & Environmental Consultants, Inc. 2401 Cherokee Farm Way, Suite 100, Knoxville, TN 37920. (865) 210-3019. jmelton@cecinc.com

The parameters used to create the hydrologic analysis are shown in Table 1 below. The storage at normal pool elevation is 469 acre-feet at an elevation of 1833 feet. In HEC-HMS, CEC conducted both linear and sine wave breach progressions to produce outflow hydrographs. The hydrograph produced by the sine wave run was used as input for CEC's hydraulic analysis.

Variable	Sunny Day Values	Units
V_r, Volume of Reservoir at Normal Pool	469.00	ac-ft
Normal Pool Elevation	1833	ft-msl
Crest Elevation	1833	ft-msl
Dam Height	35	ft
Piping Elevation	1800	ft-msl
Breach Side Slopes	0.0	H:V
Piping Coefficient	0.6	-
Progression Method	Sine	-
Ko Coefficient	1.0	-
Failure Mode	Piping	-
Bottom Width	265	ft
Formation Time	0.1	hr

TABLE 1: BREACH PARAMETERS USED

CEC's hydraulic analysis consisted of two-dimensional unsteady flow modeling from the downstream end of the dam's crest to a location at which the water surface elevations did not rise above the base flood elevations (100-Year), as defined by the Federal Emergency Management Agency (FEMA). Generally, the mesh cell spacing modeled was 60 feet. To increase meshing detail, breaklines were added at roadway crossings and structures. The upstream boundary condition was the hydrograph created via the hydrologic analysis and the downstream boundary condition was normal depth to simulate a downstream energy slope.

RESULTS

The sine wave breach progression performed in HEC-HMS produced the most severe peak at 97,080 cubic feet per second.

Failure of the Bays Mountain Dam would cause hazardous and potentially life-threatening flood inundation of approximately 200 acres. This includes inundation affecting approximately 82 structures and eight (8) downstream roadway crossings. The breach would last approximately six minutes and result in the loss of half the dam's length (~265 feet).

CONCLUSION

With catastrophic weather events increasing in frequency and intensity, we must maintain and update the emergency preparedness procedures for our dams. Analysis is not as clear-cut a process as we would prefer, yet it is in the public interest that we model the most conservative and severe conditions, as is reasonable. This analysis, which proved to be an invaluable learning experience for young engineers, highlights the importance of adaptability and resourcefulness while enhancing understanding of two-dimensional dam breach modeling.

TN SAFE DAMS PROGRAM OVERVIEW

Terrell Hendren, PE[1]

The Tennessee Safe Dams Program is task with regulating the operation and construction of dams across the State of Tennessee. Permitting requirements are established for the construction, alteration, and operation of regulated dams. In addition, a comprehensive inspection program has been established to ensure the public safety is protected. The presentation will focus on the following:

- Types of structures regulated under the program.
- Dam owner responsibilities.
- State's inspection and assessment program.
- Relationship with FEMA and Corp of Engineers.

The presentation will be a general overview of the program.

[1] Tennessee Department of Environment and Conservation, Division of Water Resources

GEOSPATIAL GEOLOGIC STRUCTURAL DATASETS, CHATTANOOGA SHALE, WELLS CREEK DOLOMITE, AND KNOX GROUP, TENNESSEE

Amy Hourigan[1]

Efforts to preserve data from historical analog reports and maps have led to the creation and publication of geospatial datasets for three key geological units in Tennessee. The U.S. Geological Survey (USGS) and the Tennessee Department of Environment and Conservation (TDEC) worked together to identify high-priority publications, some existing in as few as one physical copy, to preserve and digitize for this work. Structure maps of the Chattanooga Shale, Wells Creek Dolomite, and Knox Group were selected for this initiative. Funding for this project was provided by the USGS National Geological and Geophysical Data Preservation Program (NGGDPP).

The project consisted of scanning and georeferencing maps, vectorizing points and contours, and rasterizing those vector data. The resulting products include georeferenced map images (GRIs), contour lines and well points with attribute tables for each unit. The vector datasets were used to generate raster surfaces representing altitude, depth, and thickness of the Chattanooga Shale and the Wells Creek Dolomite, and altitude and depth rasters for the Knox Group. The datasets represent valuable information for stakeholders, researchers, and resource managers, particularly for modeling efforts related to water and mineral resources. These rasters will immediately be incorporated into a 3D hydrogeological framework of Tennessee's major aquifers being developed by USGS Lower Mississippi Gulf Water Science Center. The GRI, vector, raster data, and accompanying metadata are publicly available on USGS ScienceBase.gov.

[1] U.S. Geological Survey, 640 Grassmere Park, Ste. 100 Nashville TN 37211

SESSION 3-A

Friday, April 11th at 8:30 am - 10:00 am
TECHNOLOGY
(Moderator: Brian Ham, TDEC)

Leveraging AI, Machine Learning, and GIS for Watershed Analysis
P. Li

Advancing Groundwater Monitoring with MONET: A Unified Framework for Multi-Aquifer Data Collection
P. Reyes-Garcia

High Definition Stream Survey (HDSS): Addressing Water Quality Challenges in the Hurricane Creek Watershed
B. Connell

LEVERAGING AI, MACHINE LEARNING, AND GIS FOR WATERSHED ANALYSIS

Peter Li[1]

The advent of artificial intelligence (AI) has revolutionized data processing, offering unparalleled power, efficiency, and accessibility. Among AI's applications, machine learning (ML) stands out as a powerful tool for analyzing complex datasets and identifying patterns. When combined with Geographic Information Systems (GIS), a cornerstone of spatial analysis, the integration of these technologies has significantly enhanced the ability to analyze spatial data with precision and speed.

This study harnesses the synergistic potential of AI, ML, and GIS to perform watershed analysis in Tennessee, utilizing water quality and demographic data. By applying machine learning techniques, we classify watersheds based on key attributes, uncovering spatial clusters and meaningful patterns. These findings reveal distinct watershed characteristics and their relationships with environmental and social factors, providing insights that are valuable for a wide range of applications, including resource management, environmental justice, and policy development.

This approach demonstrates how the integration of AI, ML, and GIS can transform spatial data analysis, offering scalable and efficient solutions for complex watershed analysis. The findings of this study will provide valuable insights into the spatial distribution of watershed conditions in Tennessee, contributing to improved water resource management, environmental planning, and policy development.

[1] Earth Sciences, Environmental Sciences, Tennessee Tech University, Cookeville, Tennessee

ADVANCING GROUNDWATER MONITORING WITH MONET: A UNIFIED FRAMEWORK FOR MULTI-AQUIFER DATA COLLECTION

Paulina Reyes-Garcia[1]

Water level data plays a critical role in understanding water resources, including both surface water and groundwater. It is particularly essential for groundwater monitoring as it helps capture key dynamics such as seasonality, stresses, and patterns. These insights are crucial for effective management, computer modeling, continuous data ground truthing, and decision-making. However, water level data is often collected through individual efforts that may be sporadic, inconsistent, or cumbersome to compile. While this data is widely valued and regularly gathered, its temporal and spatial coverage often fall short of painting the full picture of groundwater systems. To address the need for data integration and streamline field data collection, the University of Memphis CAESER developed "MONET", an ESRI-based collaborative tool for groundwater monitoring with over 400 points across West Tennessee. MONET collects field data that complies with widely accepted standards and protocols, such as those from the USGS, and enables the sharing of multi-aquifer water level data across projects. This ultimately supports more efficient groundwater monitoring and analysis with flexibility and ease of access.

[1] University of Memphis-CAESAR

HIGH DEFINITION STREAM SURVEY (HDSS): ADDRESSING WATER QUALITY CHALLENGES IN THE HURRICANE CREEK WATERSHED

Brett Connell[1]

The High Definition Stream Survey (HDSS) is being used to address the complex water quality issues across the 250-mile Hurricane Creek watershed in central Alabama, an area historically impacted by pre-1977 coal mining operations. Funded through the Abandoned Mine Land Economic Reclamation (AMLER) Program, this project aims to prioritize streams most in need of reclamation by providing a continuous, high-resolution dataset that supports multiple water resource management objectives.

The HDSS methodology rapidly captures continuous, 1-meter resolution GIS data throughout the stream corridors in a single survey pass. By integrating GPS, video, depth, side-scan sonar, and water quality sensors, the approach creates a comprehensive baseline condition inventory. Each second of video is georeferenced to a specific GPS point, enabling precise identification, selection, and prioritization of stream segments.

This presentation will summarize the HDSS methodology and showcase fieldwork highlights from the Hurricane Creek project. The results illustrate how HDSS data can determine the most cost-effective mitigation locations, monitor post-restoration progress, map instream habitat, assess geomorphic conditions, and identify infrastructure impacts. Additionally, HDSS provides an interactive "virtual tour" of the watershed, enhancing stakeholder collaboration and decision-making. The Hurricane Creek HDSS serves as a scalable model for addressing water resource challenges in historically impacted watersheds.

[1] Trutta Environmental Solutions

SESSION 3-B

Thursday, April 4th at 8:30 am - 10:00 am
HELENE
(Moderator: Daniel Saint, TVA)

Hurricane Helene impact on east Tennessee rivers: peak stage recurrence intervals and preliminary water quality findings
I. Luffman, M. Rasheduzzaman

Analysis of Tropical Storm Helene Flooding in Western North Carolina and East Tennessee in Context of USGS Peak Discharge Records
E. Hart

A Look Inside the Tennessee Valley Authority's Management of Flooding from Hurricane Helene
T. Zimmerman

HURRICANE HELENE IMPACT ON EAST TENNESSEE RIVERS: PEAK STAGE RECURRENCE INTERVALS AND PRELIMINARY WATER QUALITY FINDINGS

Ingrid Luffman[1] and Md Rasheduzzaman[2]

INTRODUCTION

Hurricane Helene made landfall in Florida on 9/26/2024, as a category 4 hurricane. It quickly traveled north into North Carolina (NC) and Tennessee (TN), and as a tropical storm, produced high winds and torrential rains in western NC. Runoff caused flooding in western NC and east TN that scoured channels and floodplains, removed riparian forests, and destroyed homes and sanitary infrastructure. Recurrence intervals for 3-day rainfall ranged up to 1000-year (0.001 Annual Exceedance Probability) for areas in western NC from Hendersonville to Asheville and northward to Spruce Pine (NWC, 2024), with the heaviest rainfall in the headwaters of the Nolichucky and French Broad Rivers. High relief, storm rainfall coupled with orographic effects, and floodplain development contributed to the scale of the damage. TDEC issued a temporary water contact advisory on 10/2/24 (TDEC, 2025), citing damage to wastewater treatment plants, sewer line crossings, and septic systems which could cause elevated levels of pathogens in downstream waters, a cautionary measure as there were no specific water quality data to inform the decision. This study, therefore, quantifies the magnitude of the flooding using recurrence intervals and presents initial water quality findings for pathogens along impacted rivers.

METHODS

At USGS stream gauges on affected rivers (Nolichucky, French Broad, Pigeon, and Doe Rivers and Big Limestone Creek) record stage was observed (Figure 1) and flood recurrence intervals were calculated for gauges on the French Broad (Asheville), Doe (Elizabethton), Nolichucky (Embreeville), and Pigeon (Newport) Rivers using the ~100+-year record of annual peak stage available at these gauges.

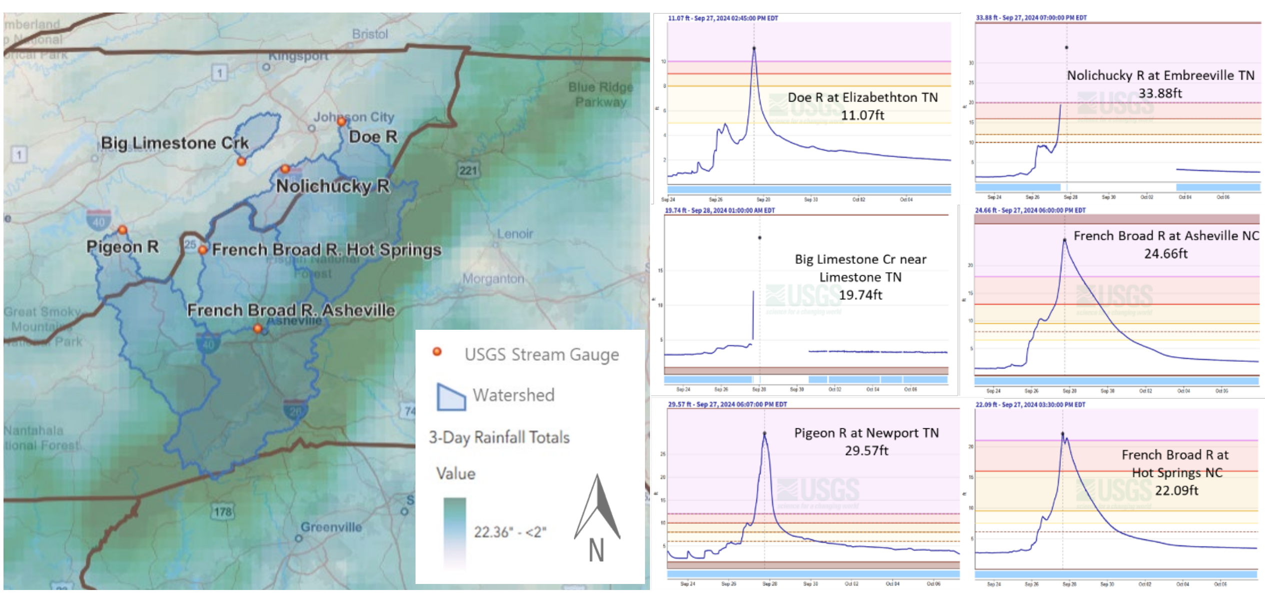

Figure 1. Hurricane Helen-associated 3-day rainfall totals and impacted watersheds.

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For each gauge, annual peak stage was ranked, and recurrence interval (*R*) was calculated for each record using *R = (years of record +1)/rank*. Next, stage vs. *log(R)* was graphed on a scatterplot, and logarithmic and power law models were fitted to the data. Using these equations, the recurrence interval for any stage can be modeled.

Because of extensive damage to sanitary infrastructure, we identified 15 sampling sites in the Nolichucky and Doe River watersheds and sampled them for *E. coli* and total coliforms, indicators of fecal contamination, using a 5-samples-in-30-days protocol during 10/27–11/20 2024. Sites were selected using the criteria of upstream damage, site accessibility, and existence of preexisting data, and included control sites with no or limited upstream storm impacts.

We collected equipment blanks and samples in 100mL sterile bottles using a dipper, which was sanitized with Liquinox between samples. Samples and blanks were tested for *E. coli* via IDEXX Colilert Defined Substrate and IDEXX Quanti-Tray/2000 (IDEXX, Westbrook, MN, USA) at ETSU (Standard Method 9223) (APHA/AWWA/WEF, 2018).

RESULTS
Recurrence intervals for Hurricane Helene runoff peak stage are shown in Figure 2, which displays the fitted models for the four rivers with a sufficiently long data record, and their associated recurrence intervals. The best-fitting model was determined by comparison of the coefficient of determination (R^2).

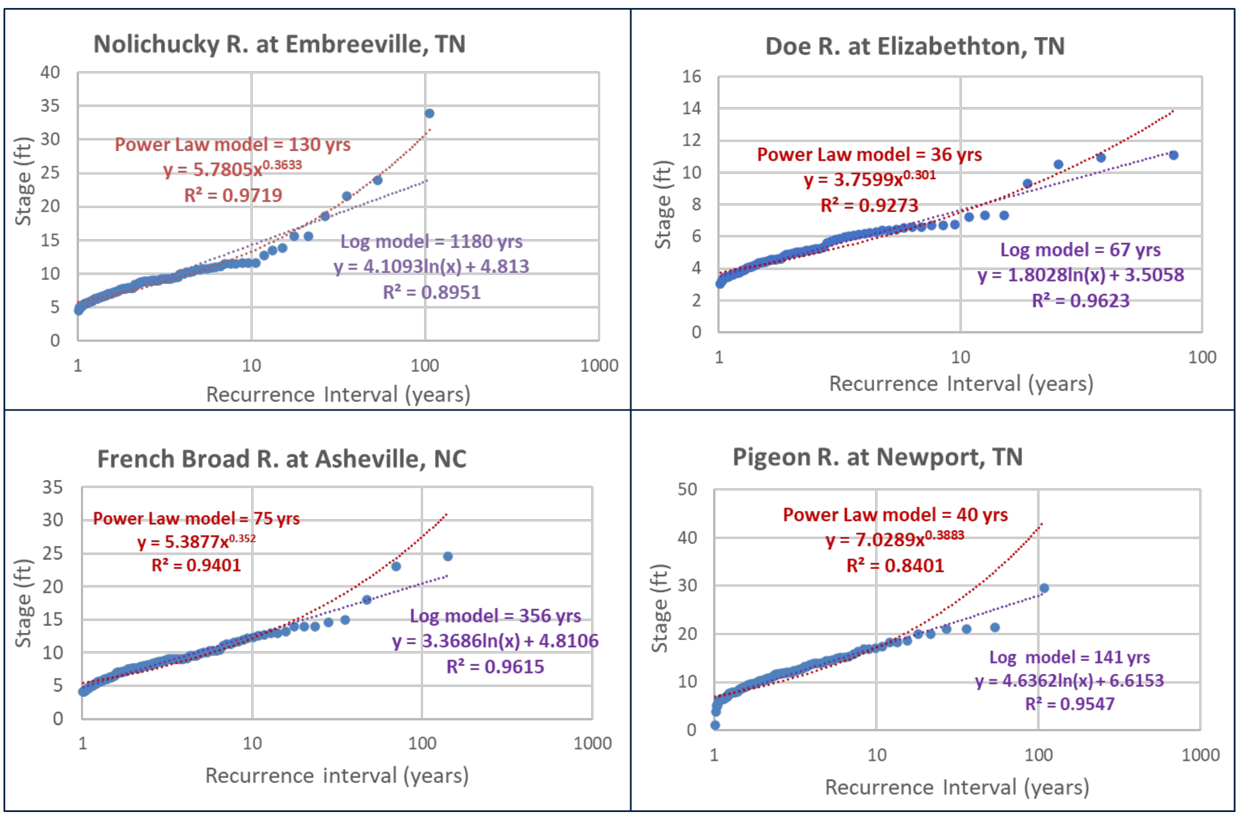

Figure 2. Recurrence intervals and models for Hurricane Helene-associated peak flows in east Tennessee and western North Carolina rivers.

Control sites and upper tributaries generally met or approached recreational water quality standards for *E. coli*, of 126 CFU/100mL as a geometric mean of the five samples. Downstream sites, especially those along the Nolichucky and its lower tributaries, did not meet standards. All but two sampling sites (Elizabethton Covered Bridge, Doe River and Garland Road, Little Limestone Creek) experienced notable increases in *E. coli* following precipitation (Figure 3).

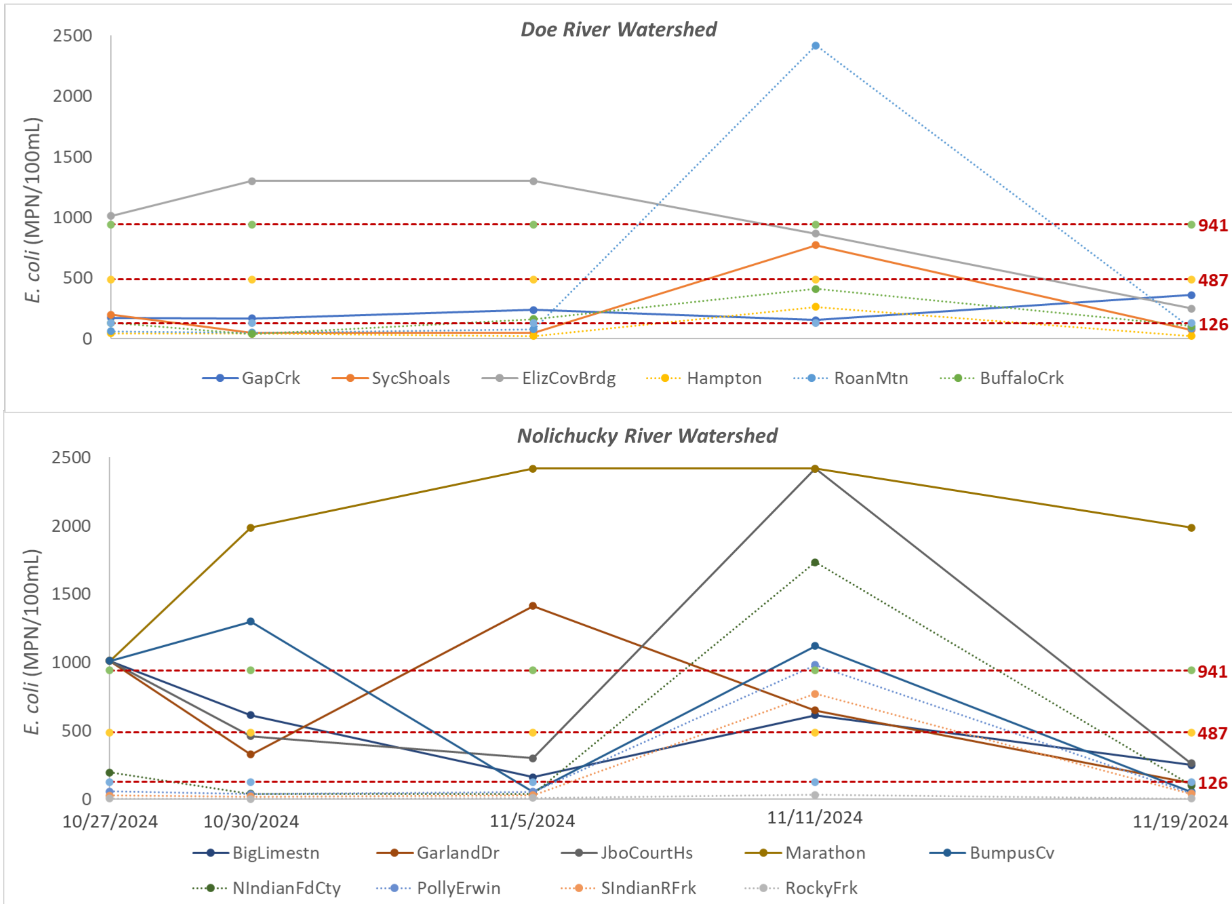

Figure 3 *E. coli* concentrations in water samples taken after Hurricane Helene in the Doe and Nolichucky River watersheds. Dotted series are located in headwaters. Red dashed lines indicate water quality standards for single samples (941 and 487 CFU/100mL) and the geometric mean of 5 samples in 30 days (126 CFU/100mL). Rain occurred prior to the 11/11/2024 sampling event.

DISCUSSION and CONCLUSION

Recurrence intervals for peak flows were sensitive to the choice of model, with variation in recurrence interval between models ranging from a factor of 2 (Doe River at 36 years (power law model) and 67 years (log model)) to a factor of nearly 10 (Nolichucky River at 130 years (power law model) and 1180 years (log model). We found that for most rivers, the traditional logarithmic model produced the best fit.

To validate our results, we compared them to National Water Center 3-day rainfall data for the event, who reported annual exceedance probabilities (AEPs) for rainfall on the order of 0.001 for headwaters of the Nolichucky and French Broad Rivers, the two rivers with the highest calculated recurrence intervals (Figure 2). Our peak flow recurrence intervals are generally lower than these values, though we feel that a conservative approach is most reasonable given the increasing trend toward more extreme rainfall, flooding, and flash flooding events in Tennessee counties (Afriyie, 2024). We elected to include historic and discontinuous peak flow data from historic floods along these rivers, which may have introduced bias in the dataset towards larger flood events, as years with lower peak flows (only minor flooding) were not recorded, historically. Inclusion of these records will result in smaller recurrence intervals, which may explain the discrepancy between the NOAA rainfall AEPs and our recurrence intervals.

This study provides valuable insights into the impacts of extreme weather events, such as Hurricane Helene, on water quality and emphasizes the critical importance of obtaining comprehensive baseline data to more accurately understand these impacts. For many sampling sites, the lack of preexisting water quality data limits our ability to conclusively determine whether observed water quality issues resulted directly from Hurricane Helene or reflect longstanding conditions. This underscores the critical need for establishing comprehensive baseline monitoring to accurately assess hurricane impacts on water quality.

Sampling was conducted along Limestone Creek near Jonesborough due to the availability of historical water quality data, despite the absence of significant flood damage at this site. Additionally, Rocky Fork was chosen as another reference location, anticipated to represent baseline conditions of water quality and minimal hurricane impact. Together, these sites provide crucial comparative data points to distinguish between Hurricane Helene's impacts and baseline water quality variability. It is important to note that our sampling strategy was constrained by restricted access to several locations, primarily because of extensive bank erosion or ongoing hurricane recovery activities. Although significant water contamination often occurs immediately after extreme weather events, sustained long-term monitoring is essential to fully understand the persistence of these impacts and the patterns of recovery in affected water bodies.

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ANALYSIS OF TROPICAL STORM HELENE FLOODING IN WESTERN NORTH CAROLINA AND EAST TENNESSEE IN CONTEXT OF USGS PEAK DISCHARGE RECORDS

Evan Hart[1]

Between September 25-28, 2024 a frontal boundary followed by Tropical Storm Helene delivered record-breaking rainfall to western North Carolina, resulting in catastrophic flooding across a 9000 mi^2 area. More than 100 fatalities and over $50 billion in damages occurred in North Carolina alone. The heaviest rainfall, enhanced by orographic uplift of southeasterly flow, was centered along the Eastern Continental Divide, in the headwaters of the Nolichucky, French Broad, Pigeon, Watauga, and New Rivers (Tennessee-Ohio drainage) and the Broad, Yadkin, and Saluda Rivers (Atlantic drainage). Eighty-three rain gauges recorded 4-day rainfall totals exceeding the theoretical 1000-year return interval. An additional 38 stations had 4-day rain totals surpassing the 100-year return interval. Twenty-four USGS stream gauges reached record stage heights on September 27, 2024, surpassing the devastating southern Appalachian floods of 1916, 1940, 1977, and 2004. Another 12 USGS stream gauges recorded their second-highest stage on record. At least 6 stream gauges reached flood heights outside operational limits, requiring USGS personnel to flag high water marks as peak stage indicators in the days following the floods. At some gauges, peak stage exceeded established discharge rating curves, requiring an indirect estimation of discharge. The return interval of Helene flooding is complicated by the short period of stream gauge records and the effect of dams. However, Helene flooding may have rivaled the 1867 (pre-dam) flood on the Tennessee system, but did not exceed Tennessee River paleo-floods of the mid-Holocene (~5000 years before present), which were three times larger than the 1867 flood.

[1] Tennessee Tech University

A LOOK INSIDE THE TENNESSEE VALLEY AUTHORITY'S MANAGEMENT OF FLOODING FROM HURRICANE HELENE

Tom Zimmerman[1]

This presentation will provide a look into the Tennessee Valley Authority River Forecast Center's (RFC) preparation, real-time response, and immediate aftermath of flooding from Hurricane Helene. Included highlights will include a brief overview of the River Forecast Center, rain forecasts and uncertainty, emergency response and activation of the Nolichucky Dam Emergency Action Plan, real-time flood damage management, emergency communications, flood debris management, and lessons learned.

[1] Tennessee Valley Authority

POSTERS

Simulation of Cascade Dam Breaches in Scott County, TN using HEC-RAS
P. Bajracharya, A. Kalyanapu, T. Hendren

Response of Corbicula fluminea Microbiomes to Cyanotoxin Exposure
C. Cunningham, R. Diner

Hurricane Floodwater Quality: The Whens, Wheres, and Whys
S. Fandino, E. Fidan

Machine Learning-Based Identification of Crop Types in West Tennessee Using Satellite Data
M. Farhadi Machekposhti, B. Leib, Q. Wu, D. Yoder, H. Herrero

Spatial and Temporal Water Quality of the Calfkiller River: Effects on Bluemask Darter Reintroduction
S. Haston, J. Murdock

Flood Impacts of Urban Growth: Evaluating Land Use and Land Cover (LULC) Changes Using Random Forest Model in the Tri-Cities, Tennessee
R.B. Ishan, I. Luffman

Analysis of Lag Time in Cummins Falls Flash Flooding
K. Kigar

Mapping Watershed Pollution Environmental Justice Scenarios Using 303d list
J. Medley

Evaluating Flood Hazard and Stormwater Management of an Underserved Community in Tennessee
J. Obeng, N. Wiegand, M. Arms, T. Datta, A. Kalyanapu

Optimizing the Minimum Operating Level in Large Storage Reservoirs: Case Study of Mugu Karnali Storage Hydroelectric Project in Nepal
K.R. Regmi, C. Meier

Hydraulic Performance of Bridge-end Deck Drainage
S. Sukupayo, K. Regmi, C. Meier

Development of Low-Cost Systems for Measuring the Selected Hydrologic Parameters
V. Swathi, H. Nukala, V. Keesara, A. Kalyanapu, T. Datta, J. Schwartz

Understanding Seasonal and Diel Carbon and Oxygen Dynamics in an Oligotrophic Freshwater Lake
M. Tajwar

Algal community shifts and cyanobacterial blooms in large rivers are more likely to occur at extreme light and temperature conditions
D. Tryba

Hurricane Helene Post-Disaster Analysis of Tennessee Flooding: Estimating Peak Discharge and Comparison with FEMA Flood Zones
M. Uehling, E. Hart

Electrochemical Decontamination in Petroleum Produced Water with High Hardness/Salinity
C. Wang, C. Swanson, Q. He

Delineation and validation of site-specific irrigation management zones using highly correlated variables in soybean cultivation
S. Xie

Refining the Firmicutes-to-Bacteroidetes Ratio as a Stability Indicator in Anaerobic Biological Wastewater Treatment Processes
X. Zhao, S. Chen, C. Swanson, Q. He

SIMULATION OF CASCADE DAM BREACHES IN SCOTT COUNTY, TN USING HEC-RAS

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

Failure of dams can pose a serious threat to human life and property. When dams are situated in cascade, the failure of an upstream dam can trigger the failure of downstream dams, amplifying the impacts of such catastrophic events. This study focuses on the cascading dam break analysis in the city of Oneida in Scott County, TN, encompassing two dams: Laxion Lake (upstream) and Pine Creek Number One Lake (downstream). The analysis employs the Hydrologic Engineering Center-River Analysis System (HEC-RAS), a hydraulic modeling tool, to simulate the dam breach scenarios and evaluate the downstream consequences.

The study aims to understand the progression of dam failures from upstream dam to downstream dam in a cascading fashion and quantify the potential impacts on downstream areas. By analyzing parameters such as time to breach formation, breach geometry and reservoir characteristics, this research seeks to provide insights into the behavior of cascading dam failures. This analysis will help understand how failure dynamics propagate through the cascade system under different scenarios and identify critical areas affected by the dam break.

This study will develop detailed inundation maps, which will serve as a tool for risk assessment and mitigation planning. These maps will highlight the spatial extent and depth of flooding, offering vital information for emergency response planning and infrastructure resilience improvement. Additionally, the findings will support engineers in prioritizing areas for safety enhancements and disaster preparedness measures. By addressing a range of possible breach scenarios, this research aims to enhance the reliability and applicability of dam safety protocols for cascade systems, ultimately safeguarding lives and livelihoods in downstream communities.

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

RESPONSE OF CORBICULA FLUMINEA MICROBIOMES TO CYANOTOXIN EXPOSURE

Champagne Cunningham[1] and R. Diner[1]

Corbicula fluminea (*C. Fluminea*) is a prolific species of freshwater clam that is highly invasive in North America. The natural history/behavior of *C. Fluminea* directly exposes them to harmful algal blooms (HABs) and their toxins. HABs are capable of negatively affecting water parameters and are considered environmental stressors. When present in freshwater environments, cyanotoxins such as microcystin or anatoxin can directly affect the physiology of *C. Fluminea*. *C. Fluminea* is frequently found in waters with high levels of pollution and/or algal toxins and has been used as a model organism for ecotoxicology studies. While the physiological responses of corbicula to toxicants are well-studied, little is known about the impacts on Corbicula microbiomes and host-microbe interactions. To address this knowledge gap, we have developed *C. Fluminea* as a model to study the impacts of harmful algal toxins in aquatic host-microbe systems. In initial baseline studies, we are determining tissue-specific microbiome variability in *C. Fluminea* and establishing an environmental time-series to determine exposure to HAB toxins and environmental impacts on the microbiome. Future laboratory studies will experimentally test the impacts of HABs on *C. Fluminea* microbiomes and physiology, examining both acute impacts and microbiome resilience.

[1] University of Memphis, Department of Biological Sciences, 3774 Walker Ave, Memphis, TN 38111

HURRICANE FLOODWATER QUALITY: THE WHENS, WHERES, AND WHYS

Sophia Fandino[1] and Emine Fidan[1]

Flooding is a significant issue across the world, but research on floodwater quality and its effects on surrounding waterbodies remains limited. The rapid onset and short duration of flooding hinders timely data collection and analysis before floodwaters recede. This study synthesizes and analyzes over 50 peer-reviewed floodwater quality studies published between 2002 and 2022, aiming to elucidate spatial, temporal, and socioeconomic patterns in water quality dynamics following hurricanes. Information on study location, parameters measured, and publication year was compiled. Spatiotemporal analyses were conducted using ArcGIS tools, incorporating socioeconomic data from the Census Bureau and flood hazard data from the Federal Emergency Management Agency (FEMA).

The results reveal a temporal correlation between hurricane frequency and the number of floodwater quality studies, with peaks in both data sets occurring in 2008 and 2020. Spatial analysis shows a strong relationship between states with high flood hazard zones, particularly along the Atlantic and Gulf coasts, and the number of studies published. Louisiana, Florida, and Texas were among the most studied states, reflecting their high flood risks due to frequent hurricane activity along the southeastern Atlantic coast. However, disparities in research coverage became apparent when accounting for socioeconomic factors and hurricane frequency. For instance, Louisiana, despite facing high flood risks and socioeconomic vulnerabilities, had fewer studies than expected based on its level of exposure. In contrast, states like Texas and Florida, which experience frequent hurricanes and have higher research capacities, exhibited more extensive research activity.

Regarding water quality parameters, the studies most commonly measured nutrient levels, temperature, salinity, dissolved oxygen, chlorophyll-*a*, and fecal indicator bacteria. These parameters provide insights into floodwater impacts on ecosystem health and biogeochemical processes. Despite these efforts, critical gaps remain in understanding the long-term impacts of flooding on waterbodies, particularly in underserved and socioeconomically vulnerable regions. Future research should prioritize these areas and explore comprehensive strategies to enhance floodwater quality monitoring, particularly in response to extreme weather events amplified by climate change.

[1] University of Tennessee at Knoxville

MACHINE LEARNING-BASED IDENTIFICATION OF CROP TYPES IN WEST TENNESSEE USING SATELLITE DATA

Mabood Farhadi Machekposhti, Brian G. Leib, Qiusheng Wu, Daniel Yoder, and Hannah V. Herrero

The agriculture sector is one of the largest water consumers in the United States, using more than 42% of the nation's total freshwater withdrawals. This sector utilizes 41% of the total land area in Tennessee. Since 2012, irrigated land in Tennessee has increased by 25%. Of the total agricultural land in West Tennessee, 10% is equipped with an irrigation system. Due to climate change and the financial benefits of irrigated agriculture, the expansion of irrigated farms is expected to increase further. Crop type is one of the major determinants of the amount of water used at the field level, making accurate identification of these crops crucial for estimating crop-specific water use. Knowing the spatial distribution of crop types enables water managers to develop more precise water resource management strategies. Therefore, identifying crop types is a fundamental step in developing a water management model. This study aims to identify summer crop types in the West Tennessee region. Major crops grown in the region include soybeans, corn, and cotton. In the region, more than 97% of the farms cultivate three primary crop types: soybean (43%), corn (41%), and cotton (13%). Therefore, this study focuses on identifying these three crops. The Normalized Difference Vegetation Index (NDVI), a metric that quantifies vegetation greenness by measuring the difference between near-infrared and red light, will be employed for this purpose. A total of more than 1,000 fields were surveyed across West Tennessee for two consecutive years (2023 and 2024) to train and validate the crop type identification model. Harmonized Landsat and Sentinel-2 (HLS) data for each location and all available dates were downloaded across each growing season using the Application for Extracting and Exploring Analysis Ready Samples (AppEEARS). Using red and near-infrared bands, the average NDVI value for each image was calculated to develop NDVI time series for each location. Cloud, shadow, and snow/ice masks were applied to exclude anomalous data from the time series. For each year, sites will be randomly assigned to training and testing datasets. Out of 1,000 fields, 800 sites will be used to train the model, while the remaining 200 will be used to test its performance. A machine learning approach will be employed to identify crop types based on NDVI time series. The Random Forest (RF) classifier will be utilized for crop classification in Python. The results of this study will provide the spatial distribution of crop types, enabling water managers to develop more precise water resource management strategies.

SPATIAL AND TEMPORAL WATER QUALITY OF THE CALFKILLER RIVER: EFFECTS ON BLUEMASK DARTER REINTRODUCTION

Seth Haston[1,2] and Justin Murdock[2]

The Bluemask Darter (*Etheostoma akatulo*) is a small benthic fish that was originally listed as endangered in 1993 by the United States Fish and Wildlife Service. These darters are endemic to the Upper Caney Fork System within the Cumberland River Drainage in Tennessee. Historically found in the Calfkiller River, Bluemask darters are now restricted to the Caney Fork River, Cane Creek, Rocky River, and Laurel Creek. Several reintroduction attempts have been made in the Calfkiller River, but these have not been successful, and the reasons for these failures is unknown. Previous work has identified suitable habitat is present, but also identified potential water quality issues due to a large quantity of spring water entering the stream at a single location (Twenty Springs) that may be originating from a municipal wastewater plant in the adjacent watershed. The objective of my research is to determine if the spring water is contributing to hypoxia, or other water quality issues that can effect reintroduction. Longitudinal water quality was collected seasonally by floating the upper Calfkiller to identify potential sources of groundwater inflow and its influence on stream water quality. Additionally, continuous measurements of dissolved oxygen are being recorded above and below Twenty Springs to estimate the effect of the spring on stream metabolism and oxygen use. This work will help to better understand how cross watershed water exchange may effect fish restorations in karst dominated areas, and contribute to a more wholistic understanding of successful fish reintroductions.

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

FLOOD IMPACTS OF URBAN GROWTH: EVALUATING LAND USE AND LAND COVER (LULC) CHANGES USING RANDOM FOREST MODEL IN THE TRI-CITIES, TENNESSEE

Rezaul Bari Ishan[1] and Ingrid Luffman[1]

Since 1990, the Tri-Cities, TN region (comprised of Bristol, Johnson City, and Kingsport) has experienced major changes in Land Use and Land Cover (LULC) due to urbanization. This study aimed to forecast LULC in 2041 for the region using a Random Forest (RF) classifier within the Google Earth Engine (GEE) platform. LULC data for 2001 and 2021 at a 30m resolution were downloaded from National Land Cover Database and combined with socio-environmental variables (population density, proximity to roads, distance to existing urban areas, distance to waterbodies, and slope) to forecast the LULC for 2041. Because of using high-quality LULC data, a diverse set of variables, and a sophisticated machine learning algorithm, the RF model achieved a high accuracy of 99.48% with a Kappa coefficient of 0.994. The results reveal that high-intensity developed land area is expected to increase by 2,843 acres by 2041, while low- and medium-intensity development may decline by 868 acres and 867 acres, respectively. These changes suggest a shift toward denser urban regions, particularly in city centers, commercial areas, and industrial zones, while indicating a decline in suburban sprawl. The study also forecasts a notable decrease in vegetated areas, with a loss of 396 acres between 2021 and 2041, contributing to a loss of green space and increased environmental impacts like flooding. This land use conversion signals urbanization in the Tri-Cities region, impacting soil imperviousness and potentially contributing to urban flooding. This study may be helpful to policymakers in incorporating flood mitigation measures into urban development plans, balancing growth with environmental sustainability, and ensuring a more resilient future for the Tri-Cities region.

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ANALYSIS OF LAG TIME IN CUMMINS FALLS FLASH FLOODING

Kyle Kigar[1]

Cummins Falls State Park in Jackson County, Tennessee is a popular spot for hiking and swimming. However, the section of the West Blackburn Fork beneath the falls is prone to flash flooding, posing a danger to park visitors, with some floods even occurring with no rain falling at the park. Evacuating the base of the falls during floods can take a significant amount of time, involving a half mile trek through the river and hiking up out of the gorge. To detect flood danger earlier, a series of stream and rain gauges were placed around the watershed starting in 2019. After obtaining the hourly rainfall totals and water level of the river just upstream of the falls, I selected rainfall events that led to the highest level and compiled them into tables, using this data to create hydrographs to evaluate lag time between peak rainfall and peak water height. I observed a trend of a two-hour lag time between peaks, but one-hour lag times between rain and dangerously high water levels. I then imported the tables into ArcGIS Pro, where I generated images interpolating rainfall totals across the watershed through Inverse-Distance Weighting, which showed the expected correlation of heavier rains near the falls leading to faster rising of the water height. Further research will involve collecting radar images of precipitation from these flash flooding events for analysis, as well as utilizing other interpolation methods in ArcGIS Pro.

[1] Tennessee Technological University

MAPPING WATERSHED POLLUTION ENVIRONMENTAL JUSTICE SCENARIOS USING 303 D LIST

Justin Medley

Per- and polyfluoroalkyl substances (PFAS) are a group of synthetic chemical compounds that have been in use since the 1940s, and are found in many man-made products. The purpose of this project is to use data from the state of TN's 303 d list along with GIS software to map the potential environmental justice scenarios that can result from these chemicals. Along with data on certain PFAS, a statistical analysis will be performed. The combination of statistical and GIS based analysis allows us to see what watersheds are affected by these chemicals, and to what extent.

EVALUATING FLOOD HAZARD AND STORMWATER MANAGEMENT OF AN UNDERSERVED COMMUNITY IN TENNESSEE

Jemima Obeng[1], Nicholas Wiegand[1], Maci Adams[1], Tania Datta[1], and Alfred J. Kalyanapu[1]

Flood and stormwater management are crucial for mitigating flood risks. Although populous urban areas may have the resources to address flood risks; underserved, rural communities may be lacking in resources. The Town of Gainesboro in Jackson County, Tennessee, is one such underserved community that has historically faced stormwater management challenges. A community-university partnership between Tennessee Tech University and the Town of Gainesboro was initiated in 2019 to address flooding and stormwater management within the Doe Creek watershed, where the Town is located.

Through this partnership, data on hydrology, socio-demographics, meteorology, land use, soil, and topography, water level, along with historical flood and sewer maps were collected and organized into a geodatabase. A hydraulic model using HEC-RAS is being developed to identify flood prone areas. The model will be calibrated and validated against observed flood events in Gainesboro. Hazard maps will then be generated for 24-hour design storms, highlighting flood-prone areas in need of infrastructure improvements to reduce flood risks. To enhance climate resilience, future flood scenarios will be simulated using outputs from Global Climate Models (GCMs), dynamically downscaled using RegCM and bias-corrected to Daymet under the SSP585 scenario. These simulations will provide insight into the potential impacts of future climate conditions on the watershed and inform long-term flood risks.

In addition, this research is employing Stormwater Management Model (SWMM) to simulate the existing stormwater infrastructure within the Town and evaluate its sufficiency to convey and manage runoffs.

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OPTIMIZING THE MINIMUM OPERATING LEVEL IN LARGE STORAGE RESERVOIRS: CASE STUDY OF MUGU KARNALI STORAGE HYDROELECTRIC PROJECT IN NEPAL

Khem Raj Regmi and Claudio I. Meier

Nepal relies mostly on hydropower for clean, renewable energy. But there is an issue: most rainfall, and hence runoff, occurs during the monsoon, while almost all powerplants are run-off-the-river type. Even though installed capacity has surpassed yearly peak demand, there are still deficits during the dry season. Significant storage is needed to handle demand-supply equilibrium in Nepal's Integrated Power System, so there are plans to build large reservoir to supply electricity during the winter, when run-off-the-river projects generate much less. The single-purpose Mugu Karnali Project is planned on the Karnali River, western Nepal. Ideally, all of a reservoir's storage would be used, but in practice only a fraction is available, the live or useful storage. Expected sediment yield and reservoir life are important when fixing the Minimum Operating Level (MOL), but for large reservoirs maximizing the annual energy generation becomes a key factor. We developed a program to simulate scenarios of energy generation for different combinations of MOL, dam height, and plant operation (base vs. peak load) for the project. Analyzing results for different combinations of dam height over a range of MOL values, average energy generation increases continuously for smaller dams, but a concave downward trend is reached for higher dams. The optimum MOL decreases if the plant is operated for base as compared to peak load plant. This highlights the importance of optimizing the MOL to maximize average energy generation, especially for large reservoirs, rather than simply setting it based on expected sediment yield and reservoir lifespan.

HYDRAULIC PERFORMANCE OF BRIDGE-END DECK DRAINAGE

Serox Sukupayo, Khem Raj Regmi, and Cladio I. Meier

The Tennessee Department of Transportation (TDOT) has established a new standard for bridge deck drainage, which features a side inlet positioned at the end of the bridge adjacent to the roadway. This inlet functions as a lateral weir or spillway, like a curb-opening inlet but open at the top, and it connects to a riprap-lined flume or chute that extends down the embankment. The hydraulic performance of this standard—encompassing capture efficiency, bypassed flow, water spreads and depths on the pavement, flow depths and velocities in the flume, and the potential for embankment erosion—must be evaluated across a variety of bridge conditions, including longitudinal and cross slopes, lane numbers, and widths, as well as varying rainfall intensities. Due to the complexities involved in understanding the interaction of sheet flow and gutter flow, a full-scale physical model is utilized to accurately replicate real-world conditions, supplemented by high-fidelity computational fluid dynamics (CFD) simulations suing OpenFOAM software. The findings from both the physical model and CFD simulations, validated against laboratory measurements, will contribute to the development of a design method and delivering engineering recommendations aimed at optimizing the drainage system, thereby minimizing water depths and spreads on the deck, reducing traffic disruptions, and lowering the risks of hydroplaning and visibility impairment due to splashing.

DETERMINING WATERSHED POLLUTION ENVIRONMENTAL JUSTICE SCENARIOS USING DATA FROM AMBIENT WATER AND FISH TISSUE

Voguri Swathi[1], Hema Nukala[1], Venkata Reddy Keesara[1], Alfred J. Kalyanapu[2], Tania Datta[2], and John S. Schwartz[3]

Accurate assessment of water level and waterbody bed profile is necessary in various fields such as flood monitoring, ecosystem health monitoring of water bodies, sedimentation and erosion analysis, and hydrological studies. Available conventional instruments may not provide the required information accurately and not fit to be used in remote places due to limited possibility of human intervention. Proprietary instruments even though providing accurate information, not feasible as they are uneconomical to install at every important location of waterbody. This leads to the Development of low-cost, open hardware enabled instruments for measuring selected hydrological parameters. This study presents development of low-cost sensor systems for measuring the water level and bed profile of different waterbodies in Telangana state of India under the funded project from SPARC (Scheme for Promotion of Academic and Research Collaboration) program, Government of India. The prototype development for the measurement of water level depends on the bed depth of the waterbody as it is taken as the datum. Side imaging sonar equipped with GPS is mounted on the boat hull to recreate the topographic profile of the water body, and the data is stored in the SD card. The data can be post processed to assess the topography of water body and also to observe the dynamic changes in the bed level of the waterbody. Ultrasonic sensor is used to measure the water level and the data transmission from the sensor to the cloud is achieved by the cellular network. This helps in installing the water level sensor (ultrasonic sensor) at remote places and also the sensor measures water level for every 15 minutes, creating a time series or tracking it over time dynamically .The bed profile obtained using side imaging sonar is taken as the reference for the water level prototype for accurate water level measurement. The assembling of all required components that are needed such as solar panel for battery recharging helps in working of bathymetry and water level prototype. Water level prototype involves the operation of microcontroller that is achieved with the help of micro python coding using Thonny IDE. Micro controller helps in activating the sensor for every 15 minutes and helps in sending the data to the cloud in order make the equipment cost- effective, easy to use and understandable. This developed low-cost prototypes are being tested in the lab to achieve the expected result. Further, the prototypes need to be installed in the field for monitoring of selected hydrologic parameters in real time.

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UNDERSTANDING SEASONAL AND DIEL CARBON AND OXYGEN DYNAMICS IN AN OLIGOTROPHIC FRESHWATER LAKE

Mahir Tajwar[1]

Freshwater lakes are critical components of global biogeochemical cycles, yet the diel (24-hour) and seasonal dynamics of carbon and oxygen in oligotrophic systems remain poorly understood. This study investigates the diel and seasonal dynamics of DO and $\delta^{13}C$ in Stephens Lake, an oligotrophic, shallow headwater pond, to address how photosynthesis and respiration respond to seasonal changes in light availability and temperature. The research focuses on the interactions between photosynthesis, respiration, and environmental factors such as light and temperature, which drive variations in dissolved oxygen (DO) and dissolved inorganic carbon (DIC). Using high-resolution temporal measurements and isotopic analyses ($\delta^{13}C$ and $\delta^{18}O$), this project aims to unravel the complex processes governing these cycles. During the fall 2024 sampling campaign, DO, temperature, and pH were continuously monitored using a YSI EXO Sonde, while $\delta^{13}C$ and $\delta^{18}O$ of DIC were analyzed to track carbon cycling processes. Diel patterns showed elevated DO during the day from photosynthetic activity, with higher $\delta^{13}C$ values indicating the preferential uptake of lighter carbon isotopes. At night, respiration dominated, reversing these trends. Seasonal variations are anticipated to reveal amplified diel fluctuations in spring and summer due to increased light and temperature. The study also evaluates trace element dynamics in relation to diel oxygen changes to understand their role in the biogeochemical cycles of the lake. By combining isotopic methods with geochemical analyses, this study provides a comprehensive understanding of how oligotrophic systems respond to environmental drivers. The findings contribute to advancing knowledge of carbon sequestration, oxygen dynamics, and the role of lakes in the broader carbon cycle, addressing critical gaps in freshwater ecology.

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ALGAL COMMUNITY SHIFTS AND CYANOBACTERIAL BLOOMS IN LARGE RIVERS ARE MORE LIKELY TO OCCUR AT EXTREME LIGHT AND TEMPERATURE CONDITIONS

Dalton Tryba

Harmful algal blooms (HABs) in large rivers are increasing, posing a risk to drinking water, recreation, and ecological stability. Our knowledge of how light and temperature alter community compositions and promote HABs in large rivers lags behind that of lakes, as flowing water can create a more complex environment with continuously changing resource availability. This study examined the effects of light intensity and temperature on algal community composition shifts and maximum cyanobacterial bloom potential in the Cumberland River near Gainesboro, TN and the Ohio River near Huntington, WV. The algae were incubated for 14 to 35 days across light gradients of 20 to 1,100 µmol m^{-2} s^{-1} and temperature gradients of 10 to 38 °C. In the Ohio River, the cyanobacterium *Microcystis* sp. dominated in light above 750 µmol quanta m^{-2} s^{-1} and temperatures above 27 °C. For both rivers, the cyanobacterium *Dolichospermum* sp. dominated below 150 µmol quanta m^{-2} s^{-1} and 18 °C. Communities were mostly diatom and green algae-dominated in between these values. The highest cyanobacteria growth in both rivers occurred above 750 µmol quanta m^{-2} s^{-1} and 28 °C or below 50 µmol quanta m^{-2} s^{-1} and 25 °C. These results suggest eukaryotic algae may be better competitors for resources and inhibit HABs when light and temperature are not at extreme values. Additionally, the similar community response to light and temperature between rivers provides some evidence that the observed trends may hold across large rivers, which is important to developing universal protocols for large river HAB management.

HURRICANE HELENE POST-DISASTER ANALYSIS OF TENNESSEE AND NORTH CAROLINA FLOODING: ESTIMATING PEAK DISCHARGE AND COMPARISON WITH FEMA FLOOD ZONES

Maggie Uehling[1] and Dr. Evan Hart[2]

On September 27-28, 2024, western North Carolina and east Tennessee experienced catastrophic flooding from Hurricane Helene, damaged stream gages, and recorded stage heights that exceeded USGS discharge rating curves. This study estimated the peak discharge of eight streams – four in each state – during Hurricane Helene (Fig 1) using peak stage measurements and LiDAR topographic control. We analyzed LiDAR-derived 2.5ft and 3ft DEM data in Esri's ArcGIS Pro software to generate elevation profiles. The Manning equation was applied to estimate peak discharge based on USGS peak stage heights. To digitize flood high water marks, we analyzed aerial imagery in ArcGIS Pro based on river debris and damage.

In Tennessee, estimated peak discharges range from: 150,000 ft^3/sec for the Nolichucky River at Embreeville, 67,000 ft^3/sec for the Pigeon River at Newport, 105,000 ft^3/sec for the French Broad River near Newport, and 28,000 ft^3/sec for the Doe River at Elizabethton. Our initial results indicate that the Nolichucky (104 years of record), the Pigeon (106 years), and the Doe River (73 years) experienced their largest floods on record, and the French Broad River (110 years) experienced its second-largest flood on record. In North Carolina, estimated peak discharges range from: 140,000 ft^3/sec for the French Broad River at Asheville, 50,000 ft^3/sec for the Swannanoa River at Biltmore, 14,500 ft^3/sec for the Mills River, and 17,000 ft^3/sec for Cove Creek near Lake Lure. Our results indicate that all four North Carolina locations experienced their largest floods on record.

Post-flood imagery on a 70-mile stretch of the Nolichucky River, an 8-mile stretch of the French Broad-Swannanoa River at Asheville, NC, and a 4-mile stretch of the Broad River, from Bat Cave, NC to Lake Lure, were evaluated to digitize high water marks for comparison with FEMA-predicted 500-year flood zones. Our findings indicate that 40% of the Nolichucky River (Fig 2), 7% of the French Broad-Swannanoa River, and 25% of the Broad River digitized flooded area exceeded the predicted 500-year flood elevation.

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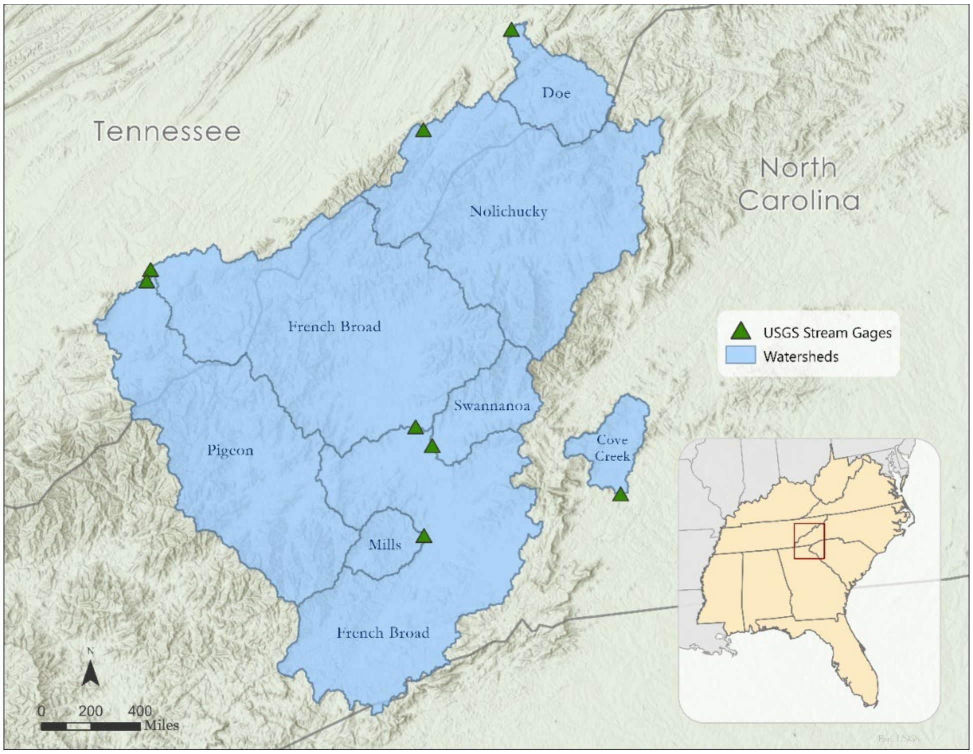

Figure 1. Study Area and included watersheds

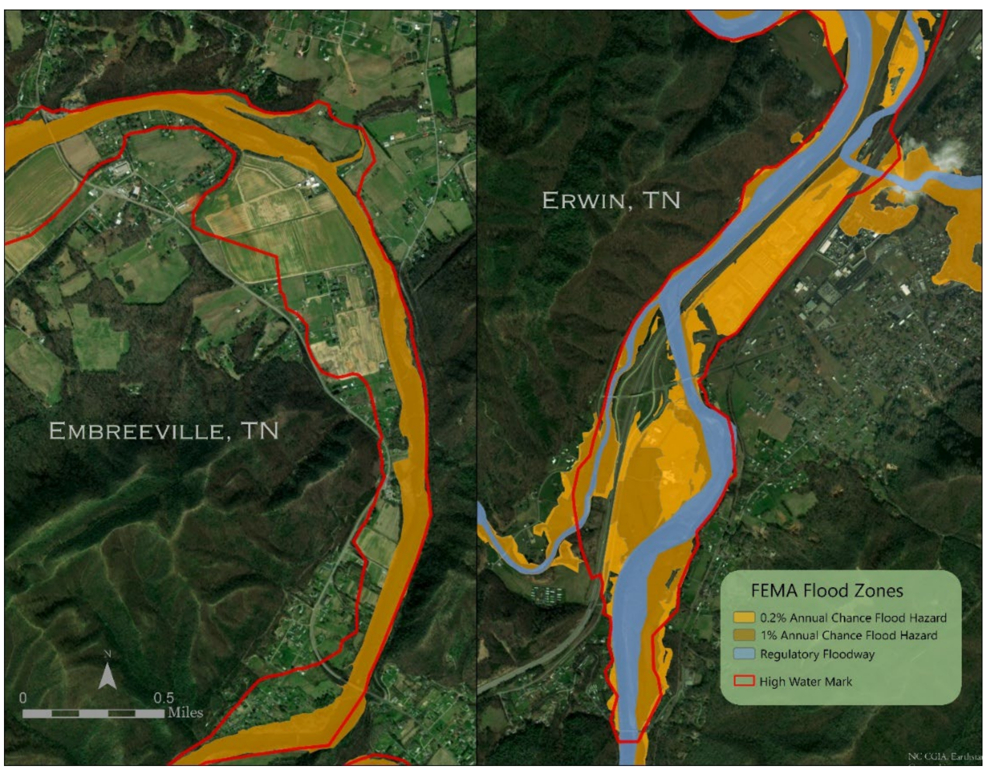

Figure 2. The Nolichucky River FEMA Flood Zones and digitized flood high water marks

ELECTROCHEMICAL DECONTAMINATION IN PETROLEUM PRODUCED WATER WITH HIGH HARDNESS/SALINITY

Chenyang Wang[1], Clifford S. Swanson[1], and Qiang He[1]

The production of oil and gas involves significant water usage and generates substantial volumes of wastewater containing high levels of total dissolved solids (e.g. sodium, calcium, and magnesium), hydrocarbons, and other contaminants. Advanced oxidation processes (AOP) offer an effective technical option for the degradation of recalcitrant pollutants in petroleum produced water. Electrochemical oxidation as an emerging AOP generates redox-active species from electrochemical reactions without chemical addition, a major advantage for field application. The objective of this study was to characterize process conditions for optimal electrochemical degradation performance.

An electrochemical reactor system was developed with simulated produced water typically found in oil/gas industry. *n*-Docosane was tested as a model pollutant in this bench-scale system with the monitoring of water quality parameters, such as pH, major cations and anions, and potential oxidants to determine the optimal voltage and electrode material. To test the impact of voltage on electrochemical degradation, boron-doped diamond (BDD) was initially chosen as the anode and graphite as the cathode. Significant degradation of n-docosane was observed at voltages of 4.0 V or higher, likely due to the production of reactive oxidative species derived from Cl^- and SO_4^{2-} above 4V. To evaluate the impact of electrode material, three sets of electrodes (cathode vs anode): BDD & BDD, BDD & graphite, graphite & graphite were tested. The graphite & graphite set demonstrated the highest performance for electrochemical degradation. Further testing revealed the adsorption of *n*-docosane to graphite electrode was responsible for enhanced electrochemical degradation, likely due to the high porosity of graphite, allowing for *n*-docosane adsorption followed by rapid electrochemical degradation. Kinetics analysis showed that the first order decay rate constant was 0.71 hr^{-1} for the graphite & graphite set, which was considerably greater that of the BDD & BDD set at 0.069 hr^{-1}.

However, it was found that prolonged operation of the electrochemical process would result in gradual deterioration in performance, with the first order decay rate constant decreased by 51% after 12 hrs of operation. Careful examination of the reactor system suggested that scale formation on the electrodes might hinder mass transfer and impede adsorption of n-docosane to the graphite electrode for subsequent electrochemical degradation.

To address this challenge, a novel strategy of alternating polarity was developed and tested to alleviate scale formation and subsequently improve electrochemical degradation efficiency. It was hypothesized that the frequency of polarity alternation would be important in electrochemical degradation. Tests were conducted at the voltage of 4.0 V and a 2-hr alternation frequency by using the graphite & graphite electrode sets. Results showed alternating polarity exhibited significantly enhanced efficiency in the degradation of *n*-docosane as compared with constant polarity. Specifically, alternating polarity achieved 85.7% removal of *n*-docosane as compared with the 71.4% removal accomplished with Constant polarity, consistent with a 85% reduction in scale formation due to polarity alternation. Overall, findings from this study show that electrochemical degradation combined with alternating polarity could be a promising option for the effective abatement of aquatic contaminants in situ.

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DELINEATION AND VALIDATION OF SITE-SPECIFIC IRRIGATION MANAGEMENT ZONES USING HIGHLY CORRELATED VARIABLES IN SOYBEAN CULTIVATION

Shuhua Xie[1]

Uniform irrigation practices often result in either waterlogging or insufficient water distribution, which can subsequently reduce crop yield. To address this, the concept of Management Zones (MZs) has been employed, which involves segmenting a field into sub-areas with similar soil or yield properties and applying tailored irrigation treatments. This study was conducted on a soybean field in Jackson, TN, characterized by sandy topsoil and silt loam subsoil with variable topsoil depths. Key variables measured included Electrical Conductivity (EC), Ground Penetrating Radar (GPR), and soybean yield under rainfed conditions to assess spatial variability. Following the initial delineation, a two-year soybean irrigation experiment was executed to determine the optimal irrigation strategy for each MZ. The findings revealed a high correlation among the three variables (EC, GPR, and yield) with a coefficient (r) of 0.8. To tackle issues of multicollinearity without biasing the results towards any single variable, three unsupervised clustering methods were utilized: K-means, Gaussian Mixture Models (GMM), and Sparse K-means. The Sparse K-means method particularly excelled in enhancing intra-cluster similarity and inter-cluster separation. Application of distinct irrigation treatments based on the delineation improved yields by 10 to 20%. This approach effectively managed the correlation between soil properties and soybean yield, optimizing field water usage, reducing costs, and enhancing crop productivity. This methodology demonstrates a robust framework for managing field spatial variability through tailored irrigation strategies.

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REFINING THE FIRMICUTES-TO-BACTEROIDETES RATIO AS A STABILITY INDICATOR IN ANAEROBIC BIOLOGICAL WASTEWATER TREATMENT PROCESSES

Richard Zhao, Si Chen, Clifford Swanson, Qiang He

BACKGROUND

The Firmicutes-to-Bacteroidetes (FB) ratio has been used as an indicator for process stability in anaerobic wastewater treatment. However, the application of this indicator has been limited to the phylum level, overlooking microbial populations at finer taxonomic resolutions specifically responsible for the dynamics of the FB ratio. Our study zooms in on the dominant family within the Bacteroidota phylum, Rikenellaceae, and further investigates OTU-level contributions to FB ratio fluctuations under diverse process conditions.

OBJECTIVE

To evaluate the FB ratio as a robust indicator of process stability in anaerobic wastewater treatment by analyzing family- and OTU-level microbial population dynamics, with particular focus on Rikenellaceae and its dominant OTU 5589.

METHODS

Using high-resolution microbial community compositions from anaerobic wastewater treatment processes, we examined temporal trends in the FB ratio, dominant microbial families, and OTUs. A stability index, integrating pH, methane, and biogas data, was developed to assess process performance comprehensively. The role of OTU 5589 within Rikenellaceae was analyzed to determine its contribution to changes in the FB ratio.

RESULTS

The FB ratio is strongly correlated with Rikenellaceae, the dominant family within the Bacteroidota phylum ($R^2 = 0.624$, $p < 0.001$). Process instability significantly reduced the FB ratio, with lower values observed during unstable process conditions compared to stable conditions ($p = 0.0019$). Within Rikenellaceae, OTU 5589 was identified as the primary driver of changes in the FB, showing significant fluctuations across stable and unstable conditions. The stability index exhibited a polynomial relationship with the FB ratio ($R^2 = 0.35$ in control, $R^2 = 0.31$ in experimental systems), validating its robustness. Analysis across process conditions confirmed the generalizability of the FB ratio, Rikenellaceae, and OTU 5589 as reliable indicators of process stability.

CONCLUSION

This study highlights the critical role of Rikenellaceae, particularly OTU 5589, in the stability of anaerobic biological wastewater treatment processes. By integrating family- and OTU-level insights with a stability index, we establish the FB ratio as a robust indicator of process stability. These findings provide actionable insights for modeling and optimizing anaerobic biological treatment processes