Proceedings of the 2023 TENNESSEE WATER RESOURCES SYMPOSIUM

April 12-14, 2023

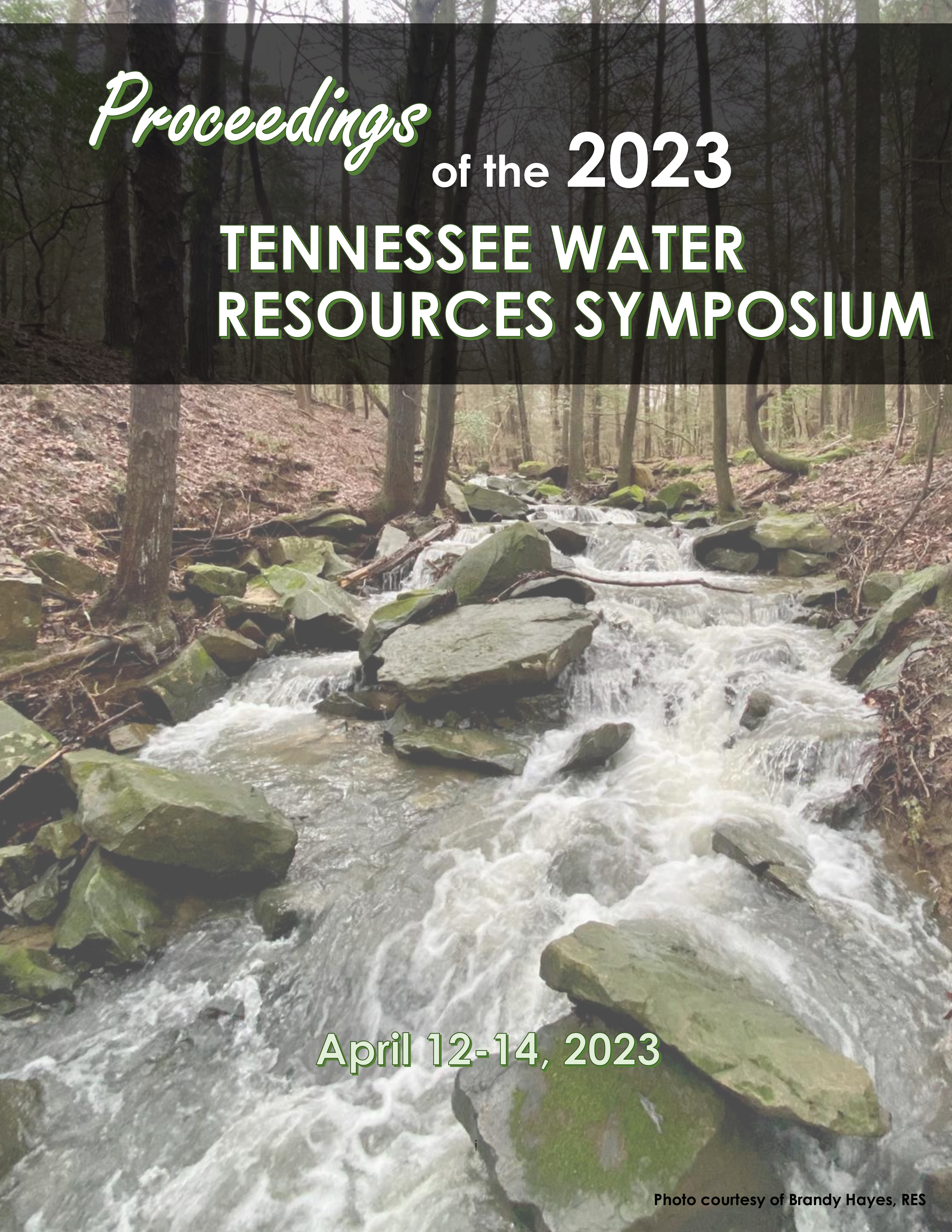

Photo courtesy of Brandy Hayes, RES

Proceedings from the

32nd Tennessee Water Resources Symposium

Montgomery Bell State Park
Burns, Tennessee

April 12-14, 2023

Sponsored by

Tennessee Section of the
American Water Resources Association

In cooperation with the Planning Committee

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Lori Weir, Retired

Mike Williams, Stantec

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American Water Resources Association
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April 12, 2023

On behalf of this year's planning committee, I'd like to welcome everyone back to our first in-person post-pandemic Tennessee American Water Resources Association Symposium at the beautiful grounds of and recently remodeled Montgomery Bell State Park. Although there might be a few more fist-bumps and hand wave greetings than in years past, I am looking forward to seeing our friends face-to-face instead of on a computer screen. From the pre-symposium workshop to final special presentation on the Stream Quantification Tool, I think you'll find the topics to be relevant, stimulating, and timely. The success of this meeting is due to the groundwork by past presidents who presided over the previous 32 meetings, the planning committees that have expanded in scope and depth over the years, and the presenters who have shared their work.

The meeting's success is also due in no small part to a small army of volunteers that have pulled together to fill the great shoes of Lori Weir. For those who haven't heard, TN AWRA would like to congratulate Lori on her retirement, and thank Lori for her dedication to TN AWRA and continued selfless participation with the planning committee. Among the current planning committee, I would like to recognize Regan McGahen and Mary Bruce who both have really stepped up to help ensure the success of this year's symposium. We are grateful for their help as well as the work completed by all members of the planning committee these last several months. A full list of planning committee member is available in the proceedings, please be sure to thank them for their efforts in ensuring the success of this year's symposium.

I would also like to acknowledge our exhibitors and sponsors who make our symposium possible through their attendance and financial support and who share valuable updates on emerging technologies and services. We are so pleased to have student attendees who enrich the symposium by being here. Make sure to attend and participate in our first ever evening poster session on Wednesday after dinner. Please be sure to take opportunities throughout the meeting to interact with these committed vendors and talented students and make them feel welcome.

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Finally, I'd like to invite you to actively participate in planning next year's annual symposium. The strength of the meeting is reflected in the diversity of the planning committee. Please consider volunteering your time by joining this dedicated group of people by offering your experiences, talents, and goodwill to make next year's symposium even better.

Thanks for coming and I hope you enjoy the meeting.

Daniel Saint

Daniel Saint, P.E.
President, Tennessee Section AWRA
2023 Conference Chair

Symposium Sponsored By

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https://www.tntech.edu/research/centersandfacilities/wrc

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Keynote Speakers

Wednesday, April 12th

Greater Nashville Regional Council

"Growth and Development Trends and the Implications of Regional Forecasts on Infrastructure and Environmental Quality"

The mission of the GNRC is to assist local communities and state agencies in the development of plans and programs that guide growth and development in the most desirable, efficient, and cost-effective manner, while ensuring the continued long-term livability of the region.

In carrying out this mission, GNRC convenes elected leadership and local practitioners to brainstorm strategies for improving quality of life; facilitates cooperative policymaking in order to prioritize state and federal investments into area social services and public infrastructure; and provides a public forum for Middle Tennesseans to shape regional decisions.

Thursday, April 13th

Brad Collett
Professor and Director, Tennessee RiverLine

"Tennessee RiverLine: Inspiring Resources Stewardship on North America's Next Great Regional Trail System"

Brad Collett has served as Director of the Tennessee RiverLine initiative since its inception 2016. Under his leadership, a diverse regional consortium of community and organizational partners collaborate with the UT Institute of Agriculture, UT Knoxville and TVA to realize the vision for North America's next great regional trail system and the economic development, public health, resource stewardship and equitable access benefits it promises future generations.

Brad is also a professor in the UT School of Landscape Architecture and UT Department of Plant Sciences. Prior to becoming director, his teaching, research, and creative interests include regional water resource stewardship through landscape planning and performance. His commitment to experiential learning and community engagement has led to the development of award-winning publications, HydroLIT: southeast Tennessee water quality playbook and Low Impact Development: Opportunities for the PlanET Region, as well as the genesis of the Tennessee RiverLine. A native of Cincinnati, OH, Brad is a licensed landscape architect in Tennessee, and was a Fulbright U.S. Scholar to Slovenia in 2016. He and his wife, Nicki, and two children, Ben and Lucie, live in Knoxville, TN. They love traveling, playing soccer and volleyball, spending time with family in Ohio and North Carolina, and, of course, paddling the Tennessee RiverLine!

PRESENTATIONS

SESSION 3A

STREAM RESTORATION

(Moderator: Ken Barry, S&ME)

POSTERS

SESSION 1-A

Wednesday, April 12th at 1:30 pm - 3:00 pm
WATER SUPPLY AND CONTAMINANT REMOVAL
(Moderator: Michael Hunt, Metro Water Services)

Water Use in the Tennessee Valley for 2020
J. Sharkey and G. Springston

Potential of Electrochemical Oxidation for the Removal of Water Contaminants
C. Smugor, C. Swanson, and Q. He

Dissecting the Microbial Food Web in Anaerobic Wastewater Treatment Processes
H. Newberry, S. Chen, and Q. He

Insurance Service Office recognition of Rural Lakes as Sources of Water for Firefighting
G. Nail

Wednesday, April 12th at 3:30 pm - 5:00 pm
GROUNDWATER AND DRINKING WATER
(Moderator: Scott Schoefernacker, U of M CAESER)

Quantifying Evaluating Disparities in Public Potable Water and Wastewater Systems using a Water Disparity Index
B. England and T. Datta

Update Regarding the Tennessee Department of Environment and Conservation's Division of Remediation's Groundwater Protection Efforts for West Tennessee
E. Spann and J. Woods

Investigating the effects of sand characteristics on contaminant adsorption patterns
D. Sharafoddinzadeh, B. Waldron, S. Schoefernacker, and D. Larsen

From Soil to Aquifer (Maybe): Understanding Water Movement, Storage, and Recharge Potential in West Tennessee Cropland
M. Yaeger

WATER USE IN THE TENNESSEE VALLEY FOR 2020 AND PROJECTED USE IN 2045

Jenny Sharkey and Gary Springston

The quality of life in the Tennessee Valley depends on ample water for homes, businesses, farms, meeting places, and recreational activities. Dependable water and low-cost electricity are fundamental to the economic growth of the region. It is anticipated that water supply and water quality issues coupled with emerging water use conflicts over the fixed supply will continue to increase across the southeast.

The Tennessee Valley Authority implemented their current reservoir operating policy in 2004. One of the objectives of the operating policy was to meet the off-stream water needs of the Valley until at least 2030. TVA inventories water use every five years to project water demand in the Valley and to examine trends in water use. These results are used to determine how well the assumptions behind the operating policy are holding up. Water use estimates focus on four categories of off-stream water use: thermoelectric power, industrial, public supply, and irrigation. Water use is summarized by source of water (surface water or groundwater) and location of withdrawal (reservoir catchment area).

This presentation describes the Tennessee River Basin's 2020 water use for industry, public supply, irrigation, and thermoelectric power generation. It also presents the projection for 2045 water demand. Trends in water use and their implications will be discussed.

POTENTIAL OF ELECTROCHEMICAL OXIDATION FOR THE REMOVAL OF WATER CONTAMINANTS

Caitlyn A. Smugor[1], Clifford S. Swanson[1], and Qiang He[1]

Removal of water contaminants is critical for the protection of water resources. Biological treatment processes are traditionally implemented for the degradation of contaminants, particularly those of organic origin. However, unfavorable environmental conditions may render biological treatment ineffective. One example is produced water from the oil and gas industry. In fact, produced water is the largest wastewater source by volume generated during oil and gas extraction. In 2012, an estimated 21.2 billion barrels of produced water from oil and gas were generated in the United States alone. High concentrations of chloride are frequently encountered in produced water as a naturally occurring constituent, representing a major challenge to the biological degradation of priority pollutants in produced water due to inhibition of biodegradation from elevated chloride. Electrochemical oxidation is explored in this study as an effective alternative for the removal of organic contaminants in produced water with the capability of converting elevated chloride into oxidative chemical species. Using acetate as a model contaminant, acetate degradation was tested with an elevated chloride concentration of 10 g/L in a continuously stirred batch mode reactor equipped with a boron-doped diamond anode and graphite cathode operated at various voltages controlled by a potentiostat. The application of voltage at 4V or 6V resulted in the degradation of 15 mM of acetate below detection after 24 hours of electrochemical treatment, demonstrating the effectiveness of electrochemical oxidation in produced water. Ongoing efforts are being made to test the feasibility of electrochemical oxidation for other organic contaminants relevant to produced water.

[1] Department of Civil and Environmental Engineering, University of Tennessee, Knoxville

DISSECTING THE MICROBIAL FOOD WEB IN ANAEROBIC WASTEWATER TREATMENT PROCESSES

Hope M. Newberry[1], Si Chen[1], and Qiang He[1]

Anaerobic wastewater treatment processes are superior to aerobic processes with reduced energy demand, lower excess sludge production, and methane generation as a renewable energy source. In anaerobic treatment, the microbial community converts organic constituents of wastewater into various metabolic intermediates, including volatile fatty acids and alcohols. These intermediates are further processed by specific populations into methane. However, under certain circumstances, the metabolism of some intermediates is not adequately efficient, resulting in accumulation to inhibitory levels and subsequent process instability. Therefore, it is important to identify microbial populations involved in metabolizing specific intermediates for the development of intervention strategies during process instability.

In this study, individual metabolic intermediates in anaerobic treatment were used as the sole substrate in anaerobic batch reactors to enrich microbial populations that could specifically utilize a particular intermediate. The acetoclastic methanogen Methanosaeta accounted for over 80% of all archaea for the metabolism of acetate, butyrate, or propionate, while hydrogenotrophic methanogens Methanobrevibacter and Methanobacterium dominated the archaeal populations involved in formate conversion. While ethanol enriched Methanosaeta as the dominant archaeal population, methanol was utilized primarily by the methylotrophic Methanolobus. Though some intermediates had dominant bacteria populations, namely Firmicutes accounting for over 60% of the bacterial populations enriched by butyrate or formate, the bacterial community compositions overall were much more diverse than the archaeal populations, and included Bacteroidetes, Synergistetes, and Proteobacteria.

These results shed light on the functions of specific microbial populations involved in anaerobic wastewater treatment, providing much needed insight for targeted intervention to improve process performance.

[1] Department of Civil and Environmental Engineering, University of Tennessee, Knoxville

INSURANCE SERVICE OFFICE RECOGNITION OF RURAL LAKES AS SOURCES OF WATER FOR FIREFIGHTING

Gregory H. Nail, PhD, PE[1]

In an emergency any rural lake is a potential source of water for firefighting. However, even if successful in extinguishing a fire, fire insurance rates are likely to be unaffected. The widely recognized Insurance Service Office (ISO), of Verisk, employs an analysis and rating of these water bodies. Rural lakes meeting ISO specifications as sources of firefighting water can potentially lead to local reductions in fire insurance rates. This potential reduction in fire insurance rates is motivation for carrying out the analyses required by ISO. This analysis involves the more unusual approach of estimating a minimum water surface elevation, and minimum storage. This presentation explores the drought study required by ISO for a rural lake as potential source for firefighting water.

[1] Associate Professor, Engineering Department, The University of Tennessee at Martin

EVALUATING DISPARITIES IN PUBLIC POTABLE WATER AND WASTEWATER SYSTEMS USING A WATER DISPARITY INDEX

Brady A. England[1] and Tania Datta[2]

Safe drinking water and wastewater treatment are some of the most important, and least thought of, technological advances in the modern world. Without it, much of society and industry would not be able to function. Yet, many people, in both wealthier and disadvantaged countries, still lack access to these essential services. Research on reliable potable water access and safe sanitation in wealthier countries, especially in the United States, is sparse; many areas are left with little or no research. Moreover, most studies on this topic focus on a singular variable, such as the number of people connected to a treatment system. Studies looking at multiple variables affecting reliability and quality of services is almost nonexistent. To alleviate this knowledge gap, the goal of this research study was to determine if disparities in potable water and wastewater treatment exist in rural and low-income counties in Tennessee, and, if disparities exist, how rural and low-income counties are affected. Counties were categorized by economic classification and three were randomly selected from each group. A water disparity index that considers numerous variables relating to access, treatment infrastructure, and affordability of treatment service was also developed. Preliminary results suggest that disparities in drinking water and wastewater treatment services exist between economically distressed counties and wealthier counties, while the distinction between rural and urban counties was less clear. Further work, including more counties, reliable data, and determining optimal weights for each variable, are necessary to determine the rankings.

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[2] Tania Datta, Associate Professor, Civil and Environmental Engineering, Tennessee Technological University, 1020 Stadium Drive, Box 5015, Cookeville, TN 38505, Phone: 931-372-3446, Email: tdatta@tntech.edu

UPDATE REGARDING THE TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION'S DIVISION OF REMEDIATION'S GROUNDWATER PROTECTION EFFORTS FOR WEST TENNESSEE

Evan Spann and Jamie Woods, P.G.[1]

Groundwater is a critical resource for West Tennessee and is the sole source of drinking water for large municipalities such as Memphis and Jackson. The Tennessee Department of Environment and Conservation's (TDEC) Division of Remediation (DoR) works with the Environmental Protection Agency (EPA) on National Priority List (NPL) sites to ensure the investigation and cleanup of groundwater contamination. This presentation will provide an overview of TDEC DoR's work to ensure groundwater protection in West Tennessee.

[1] Tennessee Department of Environment and Conservation, Division of Remediation Evan.W.Spann@tn.gov and Jamie.Woods@tn.gov

INVESTIGATING THE EFFECTS OF SAND CHARACTERISTICS ON CONTAMINANT ADSORPTION PATTERNS

Donya Sharafoddinzadeh[1,2,*], Brian Waldron[1,2], Scott Schoefernacker[1], and Daniel Larsen[1,3]

Groundwater serves as a major source of drinking water for many people across the world. Aquifer properties have been studied extensively, as well as contaminant transport within aquifers and remediation of contaminated aquifers. Yet many studies neglect to factor in the importance of aquifer matrix, in this instance sand. This study shows the importance of studying an aquifer matrix by highlighting the differences in the characteristics of sand and how those differences translate to differing adsorption behaviors when interacting with various contaminants. The study used six sand samples with varying grain sizes, clay content, and chemical properties. Several distinct adsorption patterns in terms of adsorption capacity and kinetics were observed. Studying the sediment in its natural form, is paramount for providing accurate background information to track interaction with contaminant plumes, as well as assess remediation strategies.

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FROM SOIL TO AQUIFER (MAYBE): UNDERSTANDING WATER MOVEMENT, STORAGE, AND RECHARGE POTENTIAL IN WEST TENNESSEE CROPLAND

Mary Yaeger

Growth in west Tennessee is increasing the demand for groundwater. Ensuring a sustainable future supply requires knowledge of present availability, use, and replenishment rate. Cropland in the region is distributed across a rolling landscape consisting of three main landforms: “upland”, hillslope, and bottomland. To better-understand crop water use, soil water movement, and recharge potential, sensor arrays (three in the root zone, and a fourth below it) were deployed in fields around the region. To connect this to groundwater use and characterize aquifer properties, wells were installed in both confined and unconfined areas to record water levels and irrigation effects. Preliminary results suggest that low-slope “upland” soils are more well-drained while flat bottomland soils tend to be poorly-draining. Hillslope soils tend to have a restrictive layer about 3 ft below the surface, inhibiting both infiltration and root depth. In a well-drained “upland”, soils 5 ft below ground surface (bgs) wet up in response to rainfall and then dry down, while on the hillslope it may take several small, or one large, rainfall event to show any wetting at this depth. Bottomland soils tended to be wetter (at or above field capacity) at 5 ft bgs, regardless of inputs, or lack thereof, from the surface. Groundwater levels decline during the growing season, but recover by mid-winter. Geophysical surveys of the new wells revealed low-permeability layers in the unconfined aquifer, explaining some of the heterogeneity in the drawdowns produced by nearby pivots, and suggesting that recharge may occur on a more regional scale.

SESSION 1-B

Wednesday, April 12th at 1:30 pm - 3:00 pm
MODELING AND DATA MANAGEMENT
(Moderator: Rodney Knight, USGS)

A Century of Migration of the Wolf River in Memphis
W. Peck

Flood Trigger – Determining flood impacts in an urban/rural watershed using HEC-RAS and GIS in Shelby County, TN, toward developing an automated notification system
B. Waldron and G. Holt

Integrating Databases for Improved 3-Dimensional Hydrostratigraphic Frameworks: A Case Study of the Mississippi Embayment
R. Reichenbacher, B. Sperl, T. Frank, W. Kress, K. Knierim, B. Waldron, and S. Ausbrooks

The Case for Teaching Data Management Principles to Environmental Students
G. Burnette

Wednesday, April 12th at 3:30 pm - 5:00 pm
WATER MANAGEMENT AND EMERGING TECHNOLOGY
(Moderator: Wade Kress, USGS)

AIoT EC Profiling and its Potential Application for Tennessee Water Resource Management
R. Chuang and D. Huang

Advancements in Flocculant Based Technologies to Achieve Optimal Effectiveness and Efficiency in the Field
S. Bray

Leveraging Remote Monitoring Technology Advancements to Dynamically Monitor Water Resources
A. Mindermann

Watershed-based Environmental Justice in Tennessee – A GIS Approach
P. Li

A CENTURY OF MIGRATION OF THE WOLF RIVER IN MEMPHIS

Wesley Peck, PE[1]

Urbanization and channel works have caused major changes to the Wolf River on the north side of Memphis. The path of the river has changed tremendously since the early 20th century. This presentation uses historical mapping and imagery to trace the changes of a reach of the Wolf River around the US-51 (Thomas Ave) bridge since the 1920's. Through georeferencing we will attempt to trace the river banks and overlay them for comparison to see how the river around US-51 has changed over the past century.

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FLOOD TRIGGER – DETERMINING FLOOD IMPACTS IN AN URBAN/RURAL WATERSHED USING HEC-RAS AND GIS IN SHELBY COUNTY, TN, TOWARD DEVELOPING AN AUTOMATED NOTIFICATION SYSTEM

Brian Waldron and Grayson Holt

Within the last two decades, the frequency and intensity of large storms (100-year +) have been experienced in Shelby County, causing flooding and damage to infrastructure. Attempts were made to estimate inundation and impact to property (parcels) by extrapolating water surface elevations derived at river gage locations over the terrain with good success; however, limitations in these methods resulted in overestimation of threat. An advanced solution is proposed where phase 1 (of two) is a discovery of inundation impacts to buildings based on modeling varying storm intensities and sizes using HEC-RAS and GIS; whereby, communities more frequently impacted by flooding are identified. This phase is funded through the USACE Silver Jackets program and financial support from local municipalities. Phase 2 involves acquisition of FEMA funding to install stage reading devices at key locations to monitor real-time stages on the rising limb and to notify first responders of an impending localized flood event. Here we focus on phase 1 where we model the Wolf River in Shelby County using HEC-RAS 5.0. LiDAR terrain at 1-meter resolution was modified using an automated ArcGIS Model Builder routine to burn hundreds of "natural" channels into the terrain at road crossings. Three basin sizes were constructed to represent the Wolf River watershed and numerous storm events fit to the basins including the multi-thousand-year storm that resulted in major flooding in Germantown (2019). Results indicate basins more prone to flooding and damage; thereby, providing guidance on phase 2.

INTEGRATING DATABASES FOR IMPROVED 3-DIMENSIONAL HYDROSTRATIGRAPHIC FRAMEWORKS: A CASE STUDY OF THE MISSISSIPPI EMBAYMENT

Renee M. Reichenbacher, Benjamin J. Sperl, Tsai Frank, Wade H. Kress, Katherine J. Knierim, Brian Waldron, and Scott M. Ausbrooks

INTRODUCTION

Hydrostratigraphic framework modeling is an integral part of water availability studies. Increased demand for regional frameworks highlights the need for an integrated system that manages extensive datasets collected over the past several decades in different mapping campaigns, from multiple companies, and with different geophysical methods and instrumentation. Development of a comprehensive database with 3-dimensional visualization capabilities is critical to improving existing models as new data becomes available. The U.S. Geological Survey; Arkansas Department of Energy and Environment—Geological Survey; Arkansas Department of Agriculture – Natural Resources Division; Memphis Light, Gas, and Water; Louisiana State University; and University of Memphis are partnering to enhance the development of water availability models for the Mississippi Embayment (ME). The ME comprises about 100,000 square miles in the Gulf Coastal Plain and is underlain by water-bearing geologic units that are the subject of many previous and ongoing water availability studies. Additionally, the aquifer systems within the ME are a critical water source for agriculture and municipalities throughout the region. While several national and regional hydrostratigraphic studies have been conducted in the region since the early 1900's, to date these have not been compiled in a centralized USGS database. Additionally, many previously published hydrostratigraphic frameworks in the ME from local, state, and academic institutions provide interpretations of geologic surfaces without making the input datasets readily available. This project aims to develop a data management system that both integrates existing data sets and makes the interpretive process for modeling hydrostratigraphic frameworks more transparent. Ultimately, the goal is to develop a platform that facilitates 2- and 3-dimensional visualization of the subsurface and allows government agencies and academic institutions to consolidate, cross-check, and publicly share important hydrostratigraphic datasets. This database platform will provide important information for modeling and understanding the groundwater resources within the Mississippi Embayment.

APPROACH

Traditional hydrostratigraphic framework and groundwater flow modeling can be considered a one-time process: the model input datasets are constructed for a specific, static time, the model is subjected to calibration (also known as history matching). The entire modeling process is documented in publications and then the analysis is deemed complete. This project will support an alternative, and more attractive approach to groundwater modeling, where model data sets are systematically updated at prescribed intervals so that the model is kept current with respect to aquifer conditions. The USGS aims for continuous use and improvement of models that can help with decision support and be updated as new data are available.

The current phase of this project includes data compilation, database construction, and application development to store and aid in the rapid assessment and construction of hydrostratigraphic frameworks. Development of a database schema that is flexible, links to USGS groundwater data in National Water Well Information system (NWIS) and supports multiple sources of hydrogeophysical data such as geophysical logs, lithological descriptions, aquifer tests, and terrestrial, water, and airborne geophysical data will support robust interpretation of groundwater system geometry.

RESULTS AND DISCUSSION

The datasets selected for integration include: a borehole geophysical log database used for structural models, an airborne geophysical database for geophysical models, a national water-well database (NWWDB) for facies models, an aquifer test database for petrophysical models, and data from NWIS for geochemical models.

Data compilation for the ME Borehole Geophysical Database is ongoing and includes paper geophysical logs from test holes, lithological descriptions, and hand-written tables containing picks of formation tops some of which had never been made digitally available. Currently, the database has over 2,000 points with hydrostratigraphic and geologic picks from logs or previously published frameworks. The structural model is being compared to airborne resistivity depth slices to improve the surficial and subcrop hydrostratigraphic maps of the Mississippi Alluvial Plain (MAP).

The Airborne Geophysical Database contains over 80,000 line-km of Airborne electromagnetic (AEM) data for the Mississippi Alluvial Plain (MAP). The AEM method has proven effective for mapping the thickness and extent of aquifers because of the distinctive resistivity signatures of various water-bearing geologic materials. The geophysical model provides input data for structural, facies, petrophysical, and geochemical models.

The NWWDB compiled by Ben Sperl is an aggregation drillers description of lithology from water-well records that have been standardized to a common format and translated to controlled vocabularies. The database has been used to map lithostratigraphy on both national and local scales.

The aquifer test database (Pugh, 2022) contains data from over 2,000 aquifer tests for our center. The database contains information on aquifer hydrostratigraphic and groundwater properties that has been used to establish a petrophysical relationship between mean resistivity from AEM and aquifer transmissivity in the Shellmound grid in the alluvial plain (Ikard et al, 2022).

The USGS National Water Information System (NWIS) database (U.S. Geological Survey, 2016 provides information on water quality, groundwater, water use, and surface water. Water-quality data from NWIS were used to train machine-learning models and map water quality predictions in the ME (Knierim, et al. 2020a; Knierim, et al. 2020b). As part of the water quality modeling, local aquifer codes from NWIS had to be correlated across state boundaries for the ME, which was a time consuming and error-prone effort. The integrated database schema will contain a cross-walk of aquifer codes and borehole to NWIS site numbers creating a link between water quality and framework datasets.

The integration of these datasets will produce a platform that facilitates building a hydrostratigraphic framework, subsurface modeling, and allows government agencies and academic institutions to consolidate, cross-check, and publicly share important hydrostratigraphic datasets. Ultimately, this database platform will provide important information for modeling, understanding the groundwater resources within the Mississippi Embayment, and be an integral part of water availability studies in this region.

REFERENCES

Ikard, S.J., Burke, M.J., James, R.R., Kress, W. H., In press, A model of transmissivity and hydraulic conductivity from AEM-derived electric resistivity of the Mississippi River Valley Alluvial Aquifer: U.S. Geological Survey

Knierim, K.J., Kingsbury, J.A., and Haugh, C.J., 2020a, Machine-learning model predictions and groundwater-quality rasters of specific conductance, total dissolved solids, and chloride in aquifers of the Mississippi Embayment: U.S. Geological Survey data release, https://doi.org/10.5066/P9WBFR1T.

Knierim, K.J., Kingsbury, J.A., and Haugh, C.J., 2020b, Machine-learning model predictions and rasters of dissolved oxygen probability, iron concentration, and redox conditions in groundwater in the Mississippi River Valley alluvial and Claiborne aquifers: U.S. Geological Survey data release, https://doi.org/10.5066/P9N108JM.

Pugh, A.L., 2022, Hydrogeologic Aquifer Test dataset, Lower Mississippi-Gulf Water Science Center, December 2020: U.S. Geological Survey data release, https://doi.org/10.5066/P9Q9SI92.

U.S. Geological Survey, 2016, National Water Information System data available on the World Wide Web (USGS Water Data for the Nation), at URL [http://waterdata.usgs.gov/nwis/].

THE CASE FOR TEACHING DATA MANAGEMENT PRINCIPLES TO ENVIRONMENTAL STUDENTS

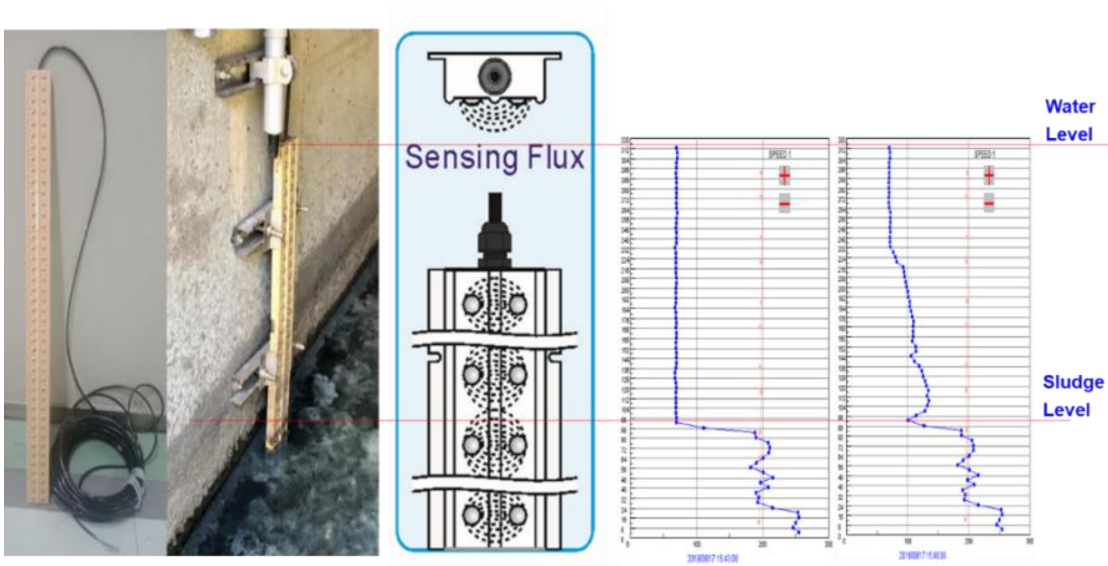
Gerald Burnette

The current generation of students in Environmental Science programs has grown up with computers and software as an integral part of their education. This situation provides them with some substantial advantages, but also introduces the potential for some significant pitfalls as well. The temptation to use familiar software tools can lead to issues with data quality. In this presentation we will discuss the primary objectives of effective environmental data management and identify problems encountered when attempting to manage environmental data with tools designed for other purposes. We will identify more appropriate tools and suggest how they can be properly taught and implemented in Environmental Science programs. We will also discuss common propositions used to argue against this approach.

AIOT EC PROFILING AND ITS POTENTIAL APPLICATION FOR TENNESSEE WATER RESOURCE MANAGEMENT

Roy Chuang and Dannis Huang

Timely and accurate measurement of water monitoring parameters is the key for successful water resource management. To date, these parameters are normally measured at a single depth at a time using a single or multi-sensor probe. An innovative smart staff comprises multi-layered electrical conductivity (EC) sensors providing real-time continuous profiling becomes a useful part of Artificial intelligence of things (AIoT) tools for water monitoring and resource management such as water/wastewater treatment facility, agriculture, aquaculture, disaster early warning, riverbed/bridge scouring monitoring, and saltwater intrusion monitoring.

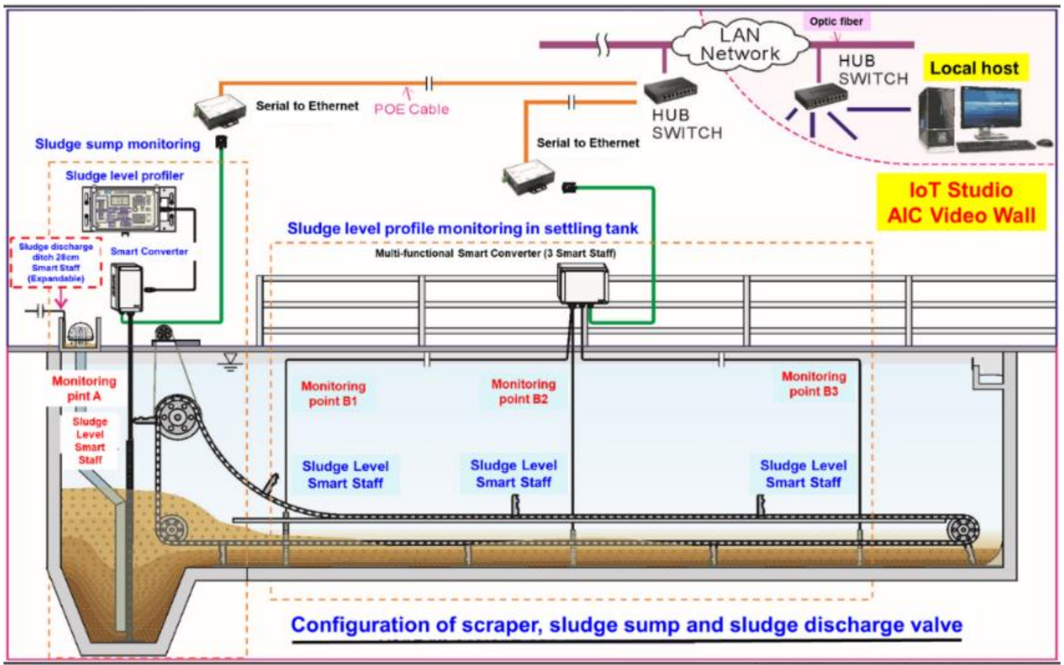


As depicted in the graph above, the sensing principle is that electrical conductivity (EC) varies depending on the characteristics of the media based on its ability to conduct electricity. Based on the proprietary simultaneous digital sensing technology, a built-in data acquisition board collects electrical signals from each paired-electrode and converts it into digital EC values in correspondence to chemical characteristics of the media at an interval of 2cm or 4cm. The capability of batch data transmission of EC values with time stamps provides real-time profiling and time-series profiles. As EC values in water and sediment (sludge/sand) are significantly different, the inversion point of the vertical EC profile represents the interface of water/sediment of the water body such as a sedimentation tank, riverbed etc. Therefore, comprised of multi-layer paired electrodes, the real-time, accurate, and maintenance-free water level/sediment/silt profiler becomes a key element of climate change resilient water infrastructure design and low impact development (LID).

By using the innovative design of multi-layer paired electrode and built-in smart converter, the Smart Staff provides real-time accurate EC measurements at an interval of 2cm or 4cm depending on application.EC data can be transmitted to a local host computer/SCADA system or to an IoT Cloud for data security, data sharing, cloud computation, and decision support system. With preset critical factors, warning or response actions may trigger optimizing operating processes or emergency responses.

Real-time, accurate, and continuous data at depths presents dynamic and time series profiles of a water body for important information such as water level, water/sediment interface, presence of pollutants etc. in the waterbody. The real-time EC-profiling helps to optimize unit operation at a water/wastewater facility; to provide early warning of urban flash flood for local community and emergency management; to provide early warning of scouring/erosion in riverbed/piers and other potential applications.

APPLICATION OF EC PROFILING FOR WATER/WASTEWATER TREATMENT



As depicted in the graph on the right, Smart Staff real-time water/sediment interface profilers installed in a settling tank provide plant engineers a clear picture of sludge accumulation conditions for sludge removal optimization such as sludge discharging arrangement, chemical addition and mixing adjustment, etc. The use of web-based IoT Studio and AIC Video Wall applications assure security and backup of local host control system.

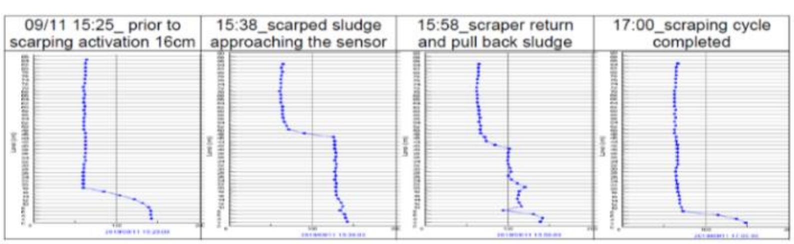


Figure 2-1(＃1) Less residual sludge after scraping resulting in normal sludge settlement.

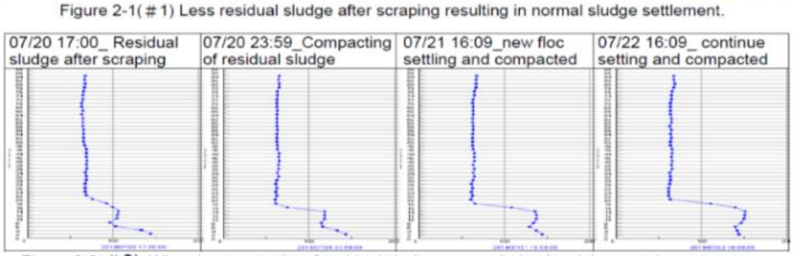
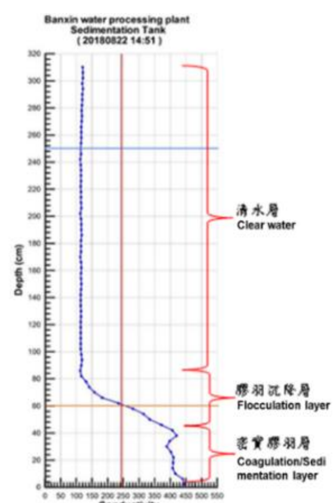
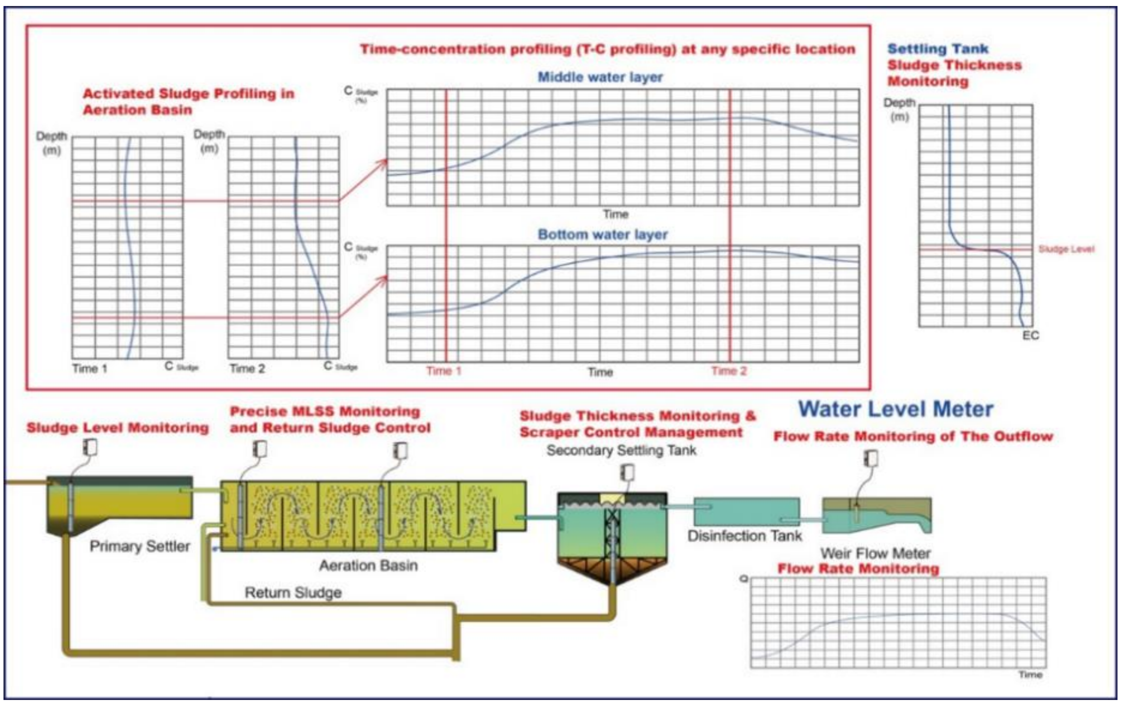


Figure 2-2(＃3), When large quantity of residual sludge occur, sludge level does not increase at beginning but sludge concentration continue to increase until the bottom layer become compacted.



The diagram below illustrates two series of real-time EC profiles collected at a sedimentation tank at Banxin Water Processing Plant in New Taipei City, Taiwan. The four EC profiles on the top row represent the scraping cycle from 15:25 to 17:00 on September 11, 2018. The inversion point of the EC profile rises along the time of sludge accumulation then drops down after the scraping cycle has completed. EC profiles at the bottom row from 17:00 on July 20 to 16:09 on July 22 indicate compacting of residual sludge after scraping with new floc settling and compacting again. The snapshot of the EC profile at the right represents three different concentration layers in the sedimentation tank. The clear water layer on the top with almost identical EC values from the surface at 310 cm down to the depth of 85cm is where the flocculation layer started. The flocculation layer with a thickness of about 40cm started from ~85cm down to 45cm. The bottommost layer is a condensed sludge layer with a thickness of 45cm starting from the inversion point of the EC profile with high EC values to the bottom of the settling tank.

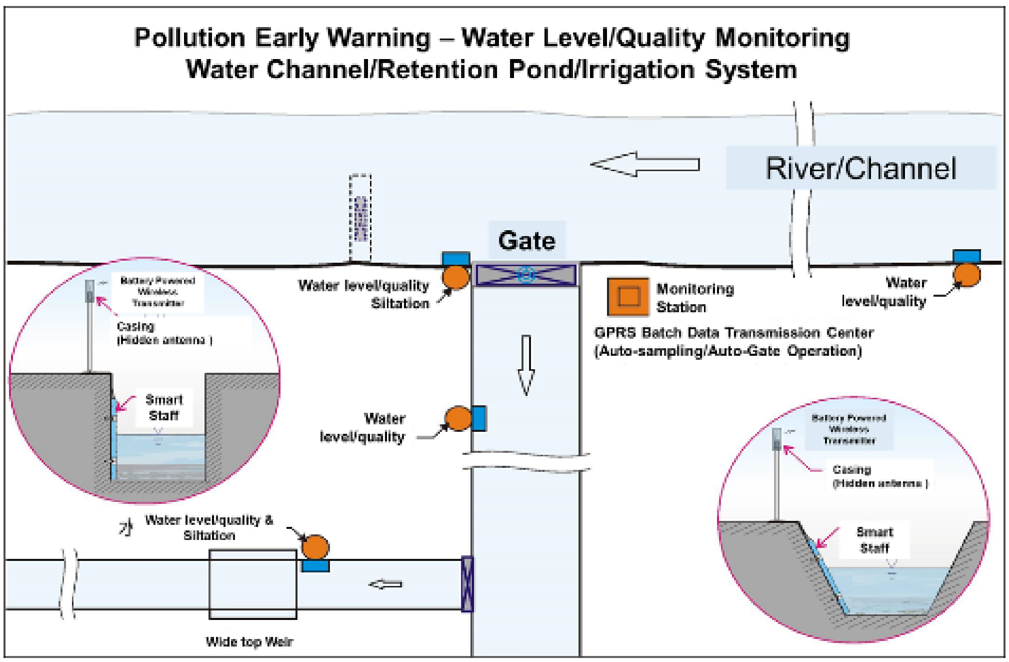


As depicted in the graph above, a Smart Staff water/sediment profiler can be applied at different stages of a water/wastewater treatment facility to form a comprehensive monitoring network. At the process stage, EC values indicate trends of contents in the water body. Engineers can interpret conditions of the operating unit by reviewing time series curves in this operation unit as an aid to operation optimization.

In summary, sludge concentration profiling (SCP) can be used in an activated sludge process (ASP) for online monitoring and control of MLSS, and it can return monitoring of settling velocity, sludge volume index (SVI), and sludge index (SDI). It provides early warning of abnormal performance of the activated sludge process. The real-time sludge level profiling provides sludge removal optimization in concentration tanks and sludge digesters.

APPLICATION OF EC PROFILING FOR WATER POLLUTION EARLY WARNING

Water pollutions could come from point or non-point sources with several parameters that are biological, chemical, or physical in nature. Conventional water sampling and laboratory analysis for water quality monitoring are time consuming, costly, and time lagging for prompt responses. No single parameter can define water quality completely but a critical parameter that is significantly correlated with others could be used as an indicator of water quality trends. For example, pH, turbidity, temperature, Chloride (Cl), sulphates, dissolved oxygen, total dissolved solid (TDS) and chemical oxygen demand (COD) are important water quality parameters that are significantly correlated with electrical conductivity (EC) (EPA 2001, Bhandari & Nayal 2008). Therefore, EC profiling of a water body can be used for indicative water pollution early warning.



As depicted in the graph above, an EC profiler installed at upstream of water intake provides real-time information of water level and indicative water quality profiling. Jointly, additional EC profilers can be installed at the water intake (Gate) and other locations according to monitoring requirements. Since EC profilers are easy to install, the deployment scheme can be adjusted easily.

APPLICATION OF EC PROFILING FOR WATER/WASTEWATER TREATMENT

Groundwater is an important resource for communities and ecosystems at coastal zones as the quality and quantity of available groundwater supply is vital for public supplies, agriculture, and industrial needs. Coastal ponds, wetlands, and other coastal ecosystems are sustained by sufficient groundwater presence.

Groundwater overdraft will cause land subsidence, saltwater intrusion, and consequently resulting in unusable land and freshwater supply. Therefore, monitoring of groundwater usage at coastal areas is critical to sustainable use. As EC readings of a water body are strongly correlated with salinity, they can be used to monitor the salinity conditions at a groundwater aquifer within coastal areas. Thus, a network of EC profilers will be able to provide real-time saltwater intrusion conditions for prompt action.

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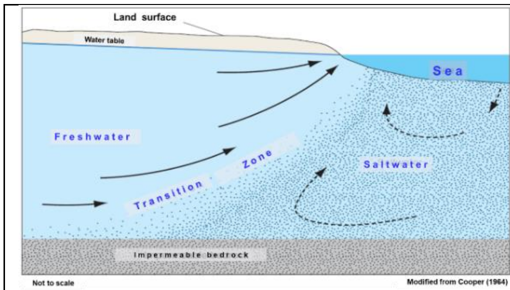
<td>
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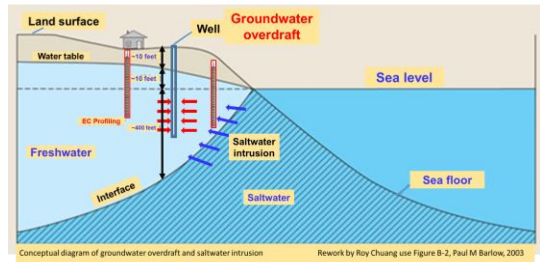
<td>
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<td>Groundwater flow patterns and freshwater-saltwater transition zone in an idealized coastal aquifer.
(Paul M Barlow, 2003)</td>
<td>Concept of saltwater intrusion resulting from groundwater overdraft and potential use of EC profiling for real-time saltwater intrusion monitoring. (Figure B-2, Paul M Barlow, 2003)</td>
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</table>

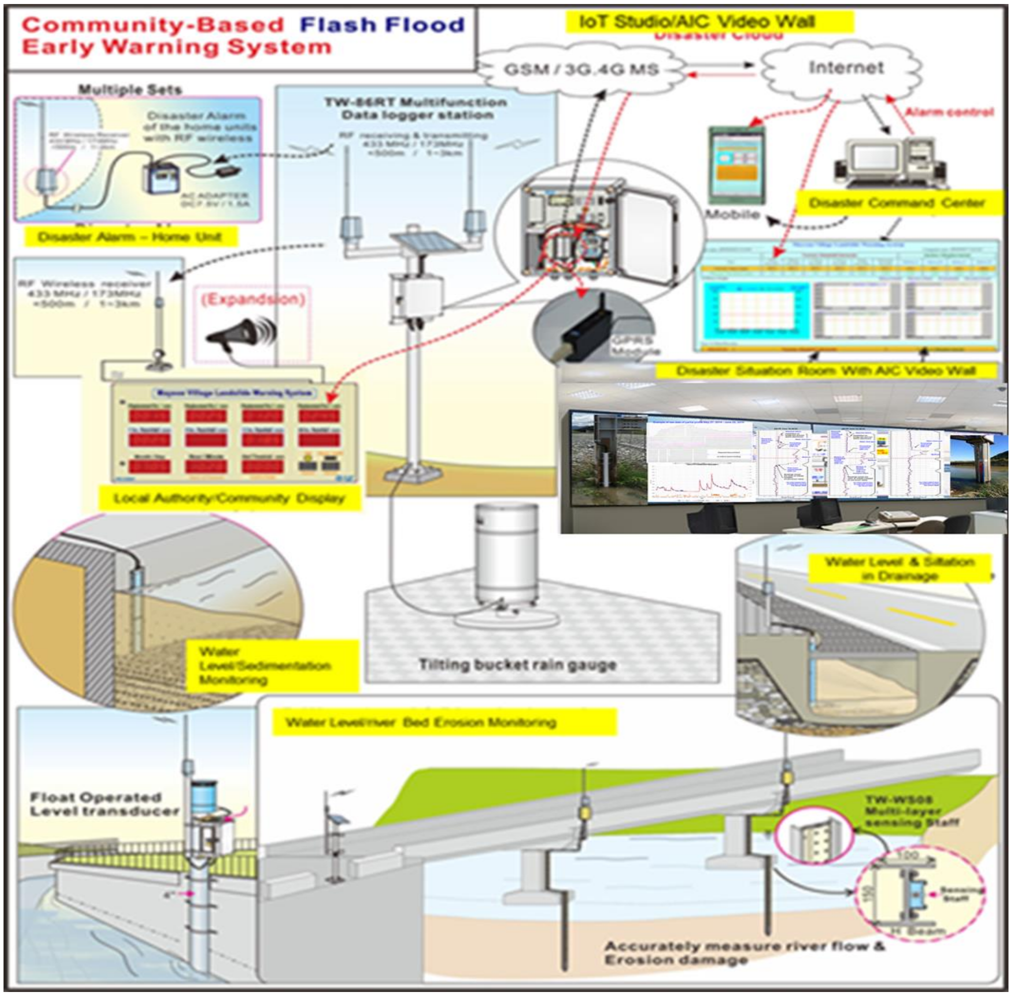
As depicted in the graphs above, EC profilers can be deployed at coastal areas for saltwater intrusion especially for the communities heavily rely on groundwater for potable water supply.

APPLICATION OF EC PROFILING FOR COMMUNITY BASED FLOOD EARLY WARNING

Global warming is a hot issue since significant Earth's climate changes have been observed in the last century. Extreme weather conditions such as frequency and strength of hurricanes, heatwaves, wildfires, droughts, floods, precipitation, cloud patterns, and vegetation cover changed significantly. Rapid economic growth as a result of industrial revolution hastened urbanization development. It is estimated that by 2050 more than two-thirds of the world's population will live in cities (Thangavel Palanivel, 2017). Although urbanization has the potential to improve the well-being of societies, it also created many environmental concerns such as vulnerability to natural disasters such as storms, cyclones, and floods - especially for coastal communities.

Extreme rainfalls and storms are more common as result of climate change, and they can cause disastrous flash floods and landslides. A flood is normally measured by monitoring stage height (water level at a certain location of the river) and flow rate (amount of water run through a specific location within a particular time).

Effective flood observation for early warning and response is heavily reliant on prompt and accurate forecast as well as measurement of precipitation and rainfall. The emerging technology of EC profiling provides real-time accurate water level and scouring data for community disaster early warning systems. Backed by IoT technologies and cloud services, a regional/watershed flood-monitoring scheme can be established to provide prompt flood warning to community disaster response centers, local police/fire departments, and household flood sirens.



As depicted in the graphs above, a community based flash flood early warning system can be established by using EC profilers in conjunction with IoT Studio and Video wall technologies.

APPLICATION OF EC PROFILING USING IOT STUDIO AND AIC VIDEO WALL

Effective water resource management is heavily dependent on a reliable monitoring program with quality monitoring data. The use of a prompt, accurate, and comprehensive database will generate a better model. Data from all monitoring devices collected via internet-of-things technology linked by either public internet or a dedicated private network to a cloud storage can provide this robust database.

OPC UA (Open Platform Communication Unified Architecture) is a set of industrial communication protocol standards that enable the exchange of digital data between machines (M2M). It is an independent platform that is not depending on any programming language or application platform. Devices conforming to the OPC standard send real-time data to the server through OPC; the user obtains real-time data through the client from the real-time monitoring equipment.

Based on machine-to-machine (M2M) communication processing, OPC UA is used to define data transmission between two or even multiple devices, which can be wired or wireless transmission. It belongs to Internet of Things transmission and not limited to smart devices and data exchange. It also includes digital signal transmission of sensors and actuators, which is transmitted from on-premises to the cloud after edge computing for complex factory data transmission and analysis operations. Under the trend of Industry 4.0, the so-called "Smart Factory" has the ability to optimize its process by itself without human intervention. It is able to track in real-time the entire process, life cycle, utilization rate, cumulative production values, and innovation benchmarks - all of these can be achieved via IoT for learning through OPC UA. The open standard unified architecture simplify M2M communication and can work on any operating system including Windows, Linux, MacOS, iOS, and Android.

Virtualization is the main technology used in cloud computing that enables a physical computing device to be separated into one or more "virtual" devices to manage different computing tasks.

Cloud storage and analysis of big data collected by the monitoring program provide effective data sharing for prompt reminders, early warning, and decision analysis for relevant parties. Cloud data management tools such as IoT Studio and AIC Video Wall provide beneficial applications for SCADA and process automation.

AIC IOT STUDIO ON-PREM NETWORK DEVELOPMENT SOFTWARE

AIC IoT Studio is an Internet of Things (IoT) development application based on IBM flow-based development tool, Node-RED. IoT Studio uses visual drag-and-drop and near codeless development method to expedite factory/facility equipment/machine management setup. A smart factory/facility is then developed according to the big data with a visual management environment.

The factory/facility just needs a server with internet for setting up a cluster flow diagram with each functional "Node" - information technology hardware and programming cost can be eliminated. Operation of each process functional "Node" will be executed in the sequence of the designed order using the building block "Node" created in the server. Each functional "Node" is composed by using a JavaScript program. With HMI (Human-machine interface), IoT Studio creates a visual operation of a factory/facility.

A community version of IoT Studio can be downloaded free of charge without expiration. Installation is simple because it is a Windows compatible software package for ease access to each functional "Node" such as Modbus, PLC (programmable logic controller) , HTTP (HyperText Transfer Protocol) , and OPC UA (OPC Unified Architecture - a cross-platform, open-source, IEC62541 standard for data exchange from sensors to cloud applications developed by the OPC Foundation.). Connected to various equipment/machine, the user is available to create their own smart factory/facility.

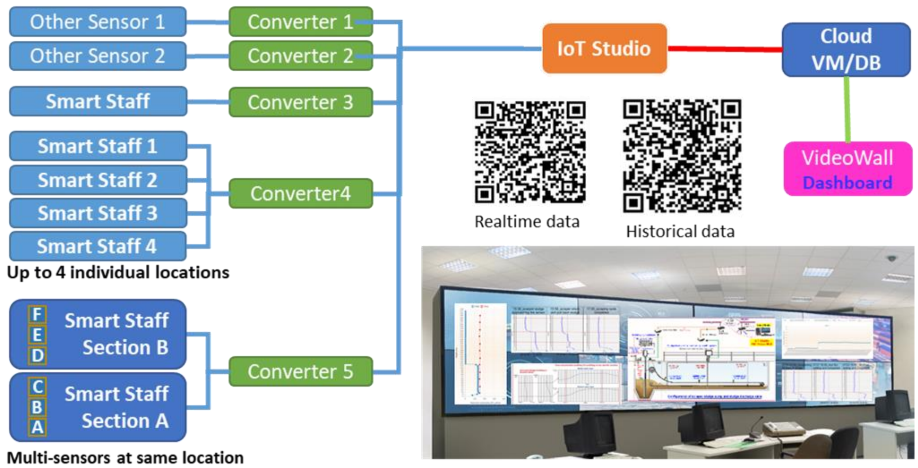
The logic of IoT studio application for a factory/facility can be applied to water resource management such as a water/wastewater treatment plant, community based disaster warning system, soil erosion monitoring, agricultural management, etc.

Data acquisition stage:

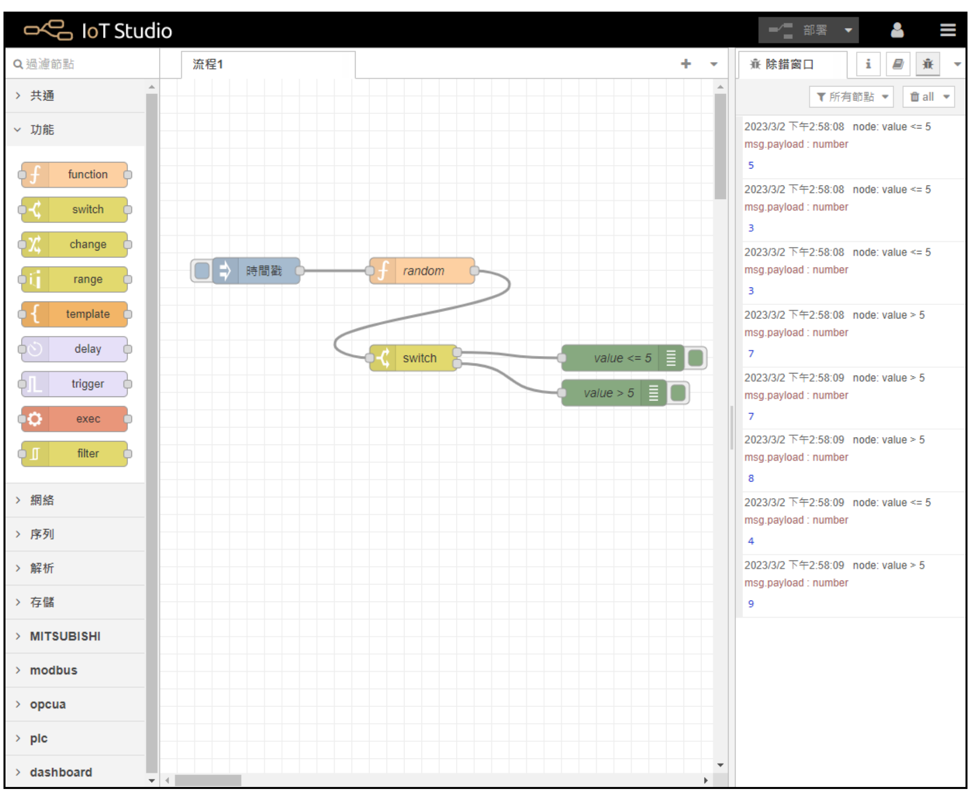
For water resource management, IoT Studio installed on a Windows based server can be used in the following scenario - monitoring data can be read from each sensor via "RS-232 Node", processed by the "Functional Node," and then transmitted to the cloud "DB Node." A "DB Node" is a storage node connected with databases and perform different operations such as update, insert, delete, and select statements. Each database requires its own type of configuration information.

Graphic display stage:

Monitoring data obtained via a DB Node can be displayed on a Dashboard Node via Node-Red installed on a cloud virtual machine (VM).



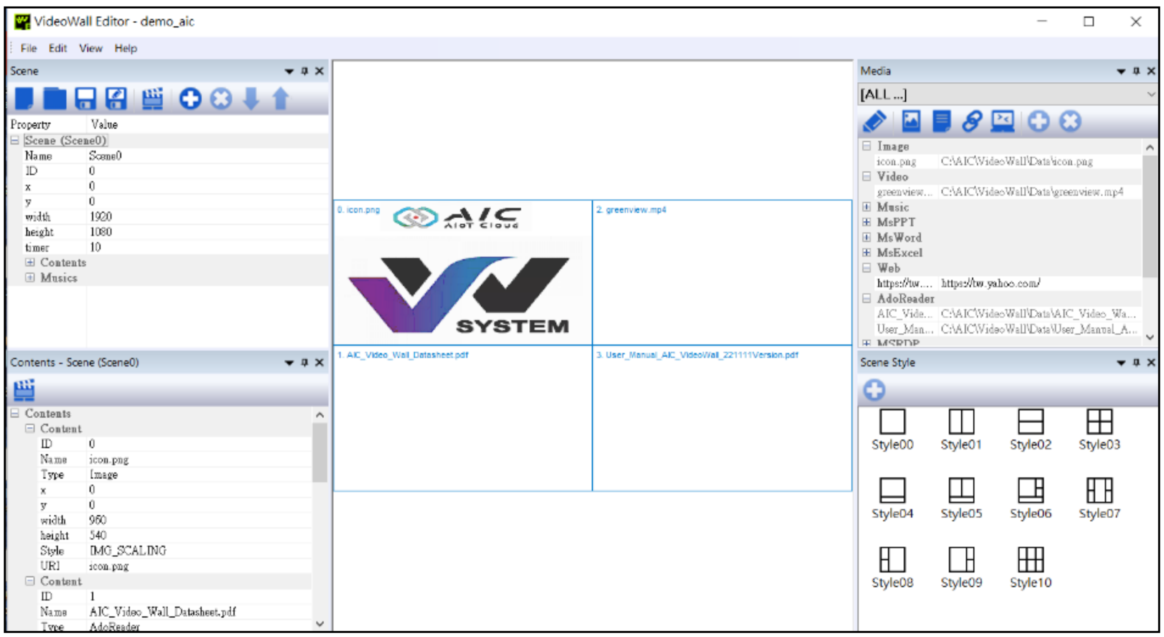
As depicted in the diagram below, raw monitoring data from each sensor were collected and processed by a converter, transmitted to a Windows based IoT Studio, then consequently sent to the dashboard of Video Wall via cloud DB. The graphic below depicts building blocks on the left of the screen that can be drag-and-dropped to build a visualized process flow diagram with functional Nodes as shown in the middle of the screen.



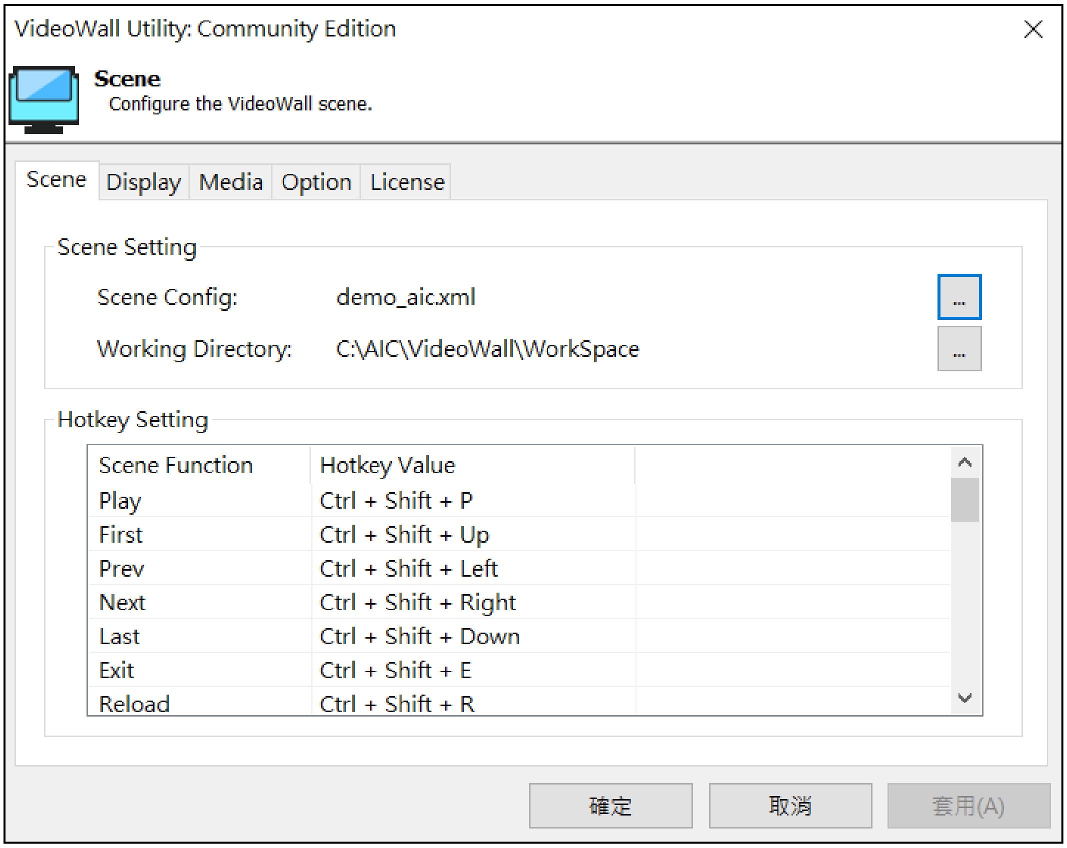
A Snapshot of IoT Studio application

1. AIC Video Wall Display Utility
   a. To display information of different functional applications on one monitor or several monitors, the display can be split to several sets of individual windows for each application such as 1x1, 1x2, 2x2, 3x2, 2x3, 3x3, 4x3, 3x4, 4x4, etc via software.
      [Community version of AIC IoT Studio provides 2x2=4 windows only]
b. Applications of display contents include Chrome browser, Microsoft Office (including PowerPoint, Word, Excel, etc.), 4K video media, as well as advertisement banner, video, animation, images, 3D model, and widget tools.
c. The users may display their own applications in any arrangement they wish.
d. Suitable for use in any industry that needs interactive display of their operations such as war/situation rooms for an enterprise and/or a smart factory, indoor/outdoor display, art gallery, business showcase, banquet room, game room, air/sea port, command center, fire station, military monitoring system, and other displays.

Graphs below are snapshots of video wall editor, a community version of utility video utility, and dashboard.



A snapshot of Video Wall Editor (for editing)

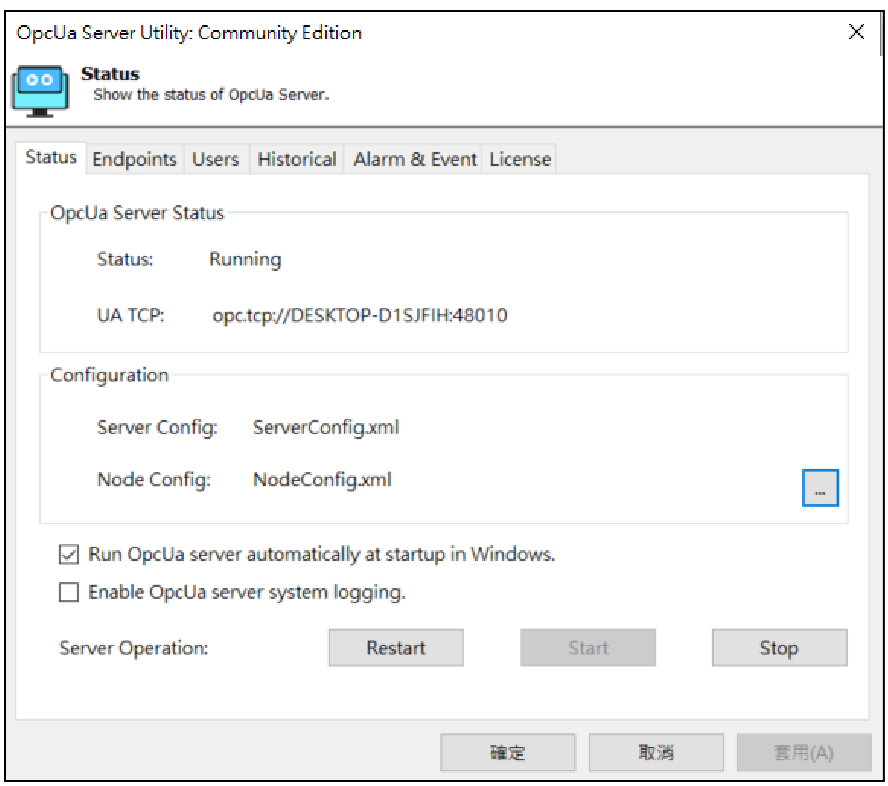


A snapshot of a Video Wall Utility (for displaying)

Dashboard

A snapshot of a two dashboards display example

- OPA UA (**O**pen **P**latform **C**ommunication **U**nified **A**rchitecture) is an industrial communication standard that allows for digital data exchange between machines (M2M).
- The user can perform real-time device monitoring by using data from a server where real-time monitoring data are collected by each OPC standard compliant device.
- The software is compatible with all types of operating system such as Windows, Linux, MacOS, iOS, and Android, and allows for all types of API connection. Different operating systems can be easily linked to prevent the constraints of specific operating system or programming language dependency.
- The AIC IoT network allows for wired or wireless digital data communication/exchange with smart devices, sensors, and actuators. After on-premises computing, real-time data will be submitted to the cloud database for advanced data processing and analysis.
- Integrated OPC UA standard
    a. OPC DA (Open Platform Communication Data Access), primarily for collecting real-time data from a device then transmitting to remote storage systems such as MES (Manufacturing Execution System), SCADA (Supervisory Control and Data Acquisition), etc. via DCOM (Distributed Component Object Model).
    b. OPC HDA (Open Platform Communication Historical Data Access): In contrast to OPC DA, it transmits archived data of a device to an analytical software such as a spreadsheet or a trending application for subsequent operation.
    c. OPC A&E (Open Platform Communication Alarm and Event): To set specifications for alarms and events exchange process to notify alarms, obtain sequence of events, perform alarm strategy audits, and optimize their operation.



A snapshot of the Community Edition OPA UA Server Utility

Smart Staff usage at sites such as a water purification plant for sludge level monitoring and a large creek for scouring monitoring in Taiwan demonstrated promising application of a new and innovative water resource monitoring technology.

As some water quality parameters such as pH, Turbidity, Chloride (Cl), Dissolved oxygen (DO), Total dissolved solids (TDS), Chemical oxygen demand (COD) were reported significantly correlated with electrical conductivity (EC) (EPA 2001; Bhandari & Nayal 2008; Verma & Singh 2012; Patel & Vaghani 2015), there are research potentials for correlating EC profile and time series data with these parameters using big data and cloud computing. Should a certain mathematical relation between any of these parameters against a certain parameter, more efficient water resource monitoring model could be established.

Pilot projects can be set up to show how this innovative technology can help improve water resource management in Tennessee.

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ADVANCEMENTS IN FLOCCULANT BASED TECHNOLOGIES TO ACHIEVE OPTIMAL EFFECTIVENESS AND EFFICIENCY IN THE FIELD

Seva Bray

Flocculant treatment systems have become common practice across the US and globally. Due to the versatility and effectiveness of anionic polyacrylamide (PAM) and PAM enhanced BMPs and technologies. PAM has been used in agriculture since the early 1950s, mining and water treatment since the 1970s, and in the 1990s was introduced to the erosion control and stormwater treatment industries. PAMs have proven highly effective in soil stabilization and water treatment applications, while being safe for the environment and aquatic organisms. Anionic PAMs have the ability to reduce and remove contaminants such as suspended solids, metals, and excess nutrient loading that contributes to poor water quality and makes it difficult to stay in compliance and meet discharge limits. Anionic PAM technologies have been used in many different forms (logs, liquids, powders), applications, and a variety of different introductory systems. PAMs have demonstrated consistent, effective results in erosion control and water clarification for over two decades. Although the PAM itself generally remains the same, there has been increased demand for varying applications and more robust treatment systems. This has led to anionic PAM and PAM based technologies that have evolved and adapted so that they are able to be used in a wider range of projects and applications. In many applications, flocculant treatment systems have been streamlined to fit space limitations, to treat varying amounts of water more efficiently, and to work together more effectively as the industry has developed new and innovative BMPs. In addition to modified and improved methods for applying safe and effective PAMs, interest and research in recent years has also focused on developing and implementing even "greener" polymers and how they may be incorporated into effective flocculant treatment systems. This presentation will discuss proven, safe, and effective flocculant treatment systems and show how they are correctly applied in the field. It will highlight how flocculant treatment systems have been streamlined in multiple different applications to allow for better and more effective treatment options. Decades of projects, data and research will be included that highlight applications that have successfully utilized flocculant treatment systems to remove 95%+ of turbidity. Recent research will also be included that discuss the most recent advancements of these flocculant-based technologies.

LEVERAGING REMOTE MONITORING TECHNOLOGY ADVANCEMENTS TO DYNAMICALLY MONITOR WATER RESOURCES

Andrew Mindermann

Traditional remote monitoring of water resources has often been costly, time consuming and limited by the need to choose either micro or macro-level analysis. However, recent advancements in remote sensing technologies enable organizations to dynamically monitor natural resources at both micro and macro-scales.

Skytec's Geospatial Operations Manager, Andrew Mindermann, will share how the Chattanooga-based team of geospatial and environmental professionals have leveraged the latest technological advancements to create dynamic remote monitoring solutions that enable organizations to proactively manage assets, steward resources, and meet commitments.

Attendees will learn how micro-level data products like LiDAR and imagery can be paired with macro-level satellite imagery to create efficiencies and increase the overall quality of water resource monitoring efforts.

Skytec will share potential uses cases for dynamic remote sensing and how these practices have been used in Southeast Tennessee for stream and wetland mitigation projects.

WATERSHED-BASED ENVIRONMENTAL JUSTICE IN TENNESSEE – A GIS APPROACH

Peter Li

In Southeast region of the United States, minority is identified to have 62% more likely than non-minorities to currently with highest traffic delays from high-tide flooding. Lower education attainment population are predicted to be 18% more likely than others with highest projected percentage of land lost to inundation. Except for counties surrounding three major urban areas: Nashville, Knoxville and Chattanooga, other counties' Ability to Pay Index are lower than the state average. In this study we focus on developing environmental justice risk index based on HUC-10 watershed in Tennessee. Data from EPA, TDEC, and US Census Bureau are used to spatially processed to create scale and then ordinal categories for selected watersheds. The results provide insights and guidelines for future watershed management and decision-making processes.

SESSION 2-A

Thursday, April 13th at 8:30 am - 10:00 am
CLIMATE CHANGE AND HYDROLOGY
(Moderator: Paul Davis, PE)

New perspectives on extreme floods on the French Broad River, Tennessee, derived from old floods
L. Davis, R. Lombardi, and M. Gage

Paleofloods provide insight into extreme flood risk on the Lower Tennessee River
R. Lombardi, L. Davis, M. Yaw, and C. Jawdy

Examining Shifts in Biochemical Processes from Long-term Monitoring of Water Quality in the Great Smoky Mountains National Park
J. Schwartz, M. Kulp, and J. Renfro

Changes in the Hydrologic Cycle from Pasture Conversion of Cool- to Warm-season Grasses in the United States Fescue Belt
J. Song, J. Schwartz, and S. Hawkins

Thursday, April 13th at 10:30 am - 12:00 pm
STORMWATER RUNOFF AND CONTROLS
(Moderator: Ingrid Luffman, ETSU)

Undergraduate Research Experience in Establishing Experimental Set-Up
J. Bathi, E. Pinson

The Behavior of Metallic Engineered Nanoparticles in Stormwater Runoff
L. Wright, E. Pinson, and J. Bathi

A New ASTM Standard for Determining Trash and Debris Capture Performance by SCMs
M. Miller

Residential Rain Gardens to Protect Water Quality: Applications and Tools
A. Ludwig and M. Ross

Thursday, April 13th at 1:30 pm - 3:00 pm
STORMWATER MANAGEMENT
(Moderator: Brandy Hayes, RES)

Investigating temporal trends in urban stormwater quality to improve modeling and management
I. Simpson, J. Schwartz, J. Hathaway, and R. Winston

MWS Stormwater Master Plan
A. Ward and M. Tays

Tracking and Quantifying the Benefits of Nashville's Stormwater Control Measures in a Watershed-based Framework
M. Hunt and D. Bambic

Smart Stormwater Technologies for Watershed Management
J. Hathaway

Thursday, April 13th at 3:30 pm - 5:00 pm
FLOOD MITIGATION AND MANAGEMENT
(Moderator: Ingrid Luffman, ETSU)

When Dry Creek Gets Wet - Flood Mitigation at Dry Creek WRF
C. Foster and A. Thomas

Proactive Management of Flooding with Innovative Technology for Every Budget
B. Register

Evaluating Flood Hazards in a Rural TN Watershed through a Community-University Partnership
M. Young, T. Datta, A. Kalyanapu, and K. Moore

A West Tennessee Perspective on the Waverly Flood of 2021
M. Bhuyian, D. Blackwood, and K. Gordon

NEW PERSPECTIVES ON EXTREME FLOODS ON THE FRENCH BROAD RIVER, TENNESSEE DERIVED FROM OLD FLOODS

M.A. Lisa Davis[1], Ray Lombardi[2], and Matthew Gage[3]

Extreme floods are severely underrepresented in streamflow records. Consequently, flood frequency analyses (FFA) of these large and rare floods contain much uncertainty. This is problematic for assessing the safety of river infrastructure. We reconstructed discharges of extreme floods extending back to 1730 CE using sedimentological evidence of past, old floods (paleofloods). We dated, measured, and analyzed sediment cores sampled from a floodplain of the French Broad River near Newport, Tennessee. We used particle size measurements of deposits that occurred during the period of instrumentation and a nearby USGS gauge's peak discharge record to develop a linear regression model that estimates discharges based on percent coarse sand volume (R Square = 0.70, $p < 0.01$). We used the linear regression equation to estimate the discharge of 17 floods that occurred prior to instrumentation. Flood discharges were largest in the late 1700s CE. The most extreme paleofloods occurred in 1791 CE and 1802 CE. These floods far exceeded the discharge of the historic flood of record in 1902 CE. We developed two Bayesian flood frequency (RMC-BestFit) models: one including the 1791 CE and 1802 CE paleoflood and one with gauged floods only. The flood frequency model with the two extreme paleofloods reduced the uncertainty curves produced with only gauge data by 42% for the 100-yr recurrence interval and 46% for the 10,000-yr recurrence intervals. Our findings demonstrate the potential to improve flood frequency estimates of extreme floods by incorporating paleoflood data, which can greatly improve confidence in flood hazard assessments.

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PALEOFLOODS PROVIDE INSIGHT INTO EXTREME FLOOD RISK ON THE LOWER TENNESSEE RIVER

Ray Lombardi[1], Lisa Davis[2], Miles Yaw[3], and Curt Jawdy[4]

INTRODUCTION

With rainfall becoming more intense across the U.S. (Easterling et al. 2017) and multiple, major river basins experiencing 1-in-500-year events in recent years, many water professionals are asking whether extreme floods are the 'new normal' (Bolstad 2016)? As a case in point, the Iowa State University Institute for Transportation estimated that the 100-year flood of the 20th Century will be the 25-year flood of the 21st Century in the Cedar River Basin of Iowa (Anderson et al. 2015). Prediction of future changes in flood magnitude and frequency is hamstrung by relatively short streamflow records, which not only limit the data available to conduct flood frequency analyses but also makes validating model simulations of future precipitation and flooding scenarios challenging. Increasingly, hydrologists are working with geoscientists to combine flood information obtained from sedimentary deposits (paleoflood hydrology), which can provide thousands of years of flood information, with conventional hydrologic methods to improve predictions of extreme flood risk. The centennial- and millennial-scale records paleoflood reconstructions contain more extreme events, which lowers statistical uncertainty in flood frequency estimations (England et al. 2019). Additionally, paleoflood records can yield new insights into flow regime changes. They span longer cycles of climate variability and pre-date human modification of the landscape, which can help with discerning hydrologic change caused by climatological versus land-use changes. Recently revised USGS flood frequency guidelines provide a methodology for including paleoflood data in flood frequency analyses and were used to complete this research (England et al. 2019).

APPROACH

We have constructed a 5,700-year record of extreme flooding in the Tennessee River Basin using natural records of floods obtained from sediments deposited in caves and floodplains. A combination of radiocarbon dating (14C), optically stimulated luminescence, and Bacon age modeling was used to determine flood ages. For the floodplain site (Big Oak), we measured particle size every 1 cm from a 3 m sediment core sample. Flood layers were identified based on peaks in medium to coarse sand identified using statistical analyses described in Toonen et al. (2015) and Leigh (2017). We estimated the size of extreme floods by determining the depth of flow required to transport the coarsest sand measured in a flood layer (the D90) and by reconstructing the pre-regulation hydraulic geometry of the river channel ascertained from soil and historical maps and bathymetry data supplied by Tennessee Valley Authority. The topographic position of the cave site (PBJ) was used to estimate minimum paleoflood peak stage. Flood discharges were calculated using a 1-D, HEC-RAS model for both the floodplain and cave sites.

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[3] Hydraulic Engineer, Tennessee Valley Authority
[4] Senior Manager of Operational Research and Support, Tennessee Valley Authority

RESULTS AND DISCUSSION

Across the two sites (cave and floodplain), we found evidence of eight extreme floods. The three largest floods occurred between 3,200-3,700 BCE and generated an estimated upper discharge of 575,000 cubic feet per second (cfs). Four extreme floods occurred between 590 CE and 1690 CE that roughly equaled the estimated discharge, ~400,000 cfs, for the flood of record on the middle section of the Tennessee River, the Great Freshet of 1867 CE.

Though smaller than the three largest floods contained in the paleoflood record, the Great Freshet of 1867 was an exceptional flood and likely among the largest to have occurred within the last 2000 years.

Although floods of a variety of magnitudes occurred during the entire 5,700-year record, no evidence of extreme flood events were found between 3200 BCE and 590 CE. Interestingly, this time frame overlaps with the widespread settlement of floodplains and lower terraces in the Tennessee River Valley by indigenous peoples.

The timing of all the documented extreme floods coincide with major climate transition intervals experienced during the Holocene. The three largest extreme floods (occurred between 3200-3700 BCE), as the Holocene Thermal Maximum was drawing to a close. The Holocene Thermal Maximum was a globally warmer climate episode created by orbital changes that increased solar radiation. It was followed by a globally cooler and wetter climate episode called the Neoglacial Period during which alpine glaciers worldwide grew, and it culminated in the Little Ice Age, which extended into the early 20th Century. The climate of the Neoglacial period resulted from the combined effects of orbital changes and increased volcanic activity. Our data show that flood frequency increased and at least five extreme floods, including the Great Freshet of 1867, occurred between 590 CE and 1867 CE, as the Little Ice Age ended, and the Current Warming Period began.

The timing of past extreme floods during climatic transition intervals suggest that times of climatic transitions, such as the one happening currently, are prone to the most extreme floods. These findings validate concerns that contemporary floods are more extreme than in the recent past times (much of the 20th Century). They also demonstrate the utility of longer flood records, which span many climate episodes and transitions, in understanding trajectories of change as applied to estimating future flood risk.

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EXAMINING SHIFTS IN BIOCHEMICAL PROCESSES FROM LONG-TERM MONITORING OF WATER QUALITY IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

John S. Schwartz, PhD, PE[1], Matt A. Kulp[2], and Jim Renfro[2]

Throughfall (TF) deposition of sulfate (S) and inorganic nitrogen (N as NO3- + NH4+) are key drivers to stream acidification in base-poor regions of eastern United States (US). Significant declines in S and N deposition in the past 20 years have been observed in this region, including the Great Smoky Mountain National Park (GRSM). GRSM has been intensively studied since 1991, however the last spatial TF survey was conducted in 2000. A substantial decline in S and N deposition occurred in 2008 and the decline quantified at the Noland Divide Watershed (NDW) high-elevation monitoring station. Park-wide data for TF deposition was collected in 2016-2017 and compared with 2000 data. Results from the 2016-2017 study found that S deposition ranged between 1.6 and 5.5 kg ha-1 yr-1 compared to 6.5 and 33.6 kg ha-1 yr-1 in 2000; and N deposition ranged between 2.6 and 11.6 kg ha-1 yr-1 compared to 4.8 to 25.0 kg ha-1 yr-1 in 2000. Annual TF S and N depositions significantly increased with increasing elevation, however TF deposition base cations (BC) did not. TF BC and N (mostly NH4+) were influenced by forest canopy exchanges. This finding may partially explain why stream pH and acid neutralizing capacity remains relatively unchanged from the 2000s to the present. Precipitation volumes were also strongly correlated with TF ion depositions. Shifts in biogeochemical processes were assessed through the review of long-term watershed ion input-output budgets at NDW, where prior to 2008, S was retained annually in the watershed and recent budgets shown annual mass S export. BC and N budgets have also shifted between pre- and post-2008 periods. The role or organic S in retention and export was also examined in 2018, where a dominant S sink was quantified as organic S in the A/O soil horizon. This research demonstrated the important role of carbon dynamics and possible soil BC depletion are dominate factors to continued stream acidification in GRSM. In 2020, because of the potential affect of organic acids on stream acidity, a survey of dissolved organic carbon was conducted in the GRSM and data are reported here within. Continued long-term research in the GRSM provides necessary data to support biogeochemical modeling efforts to predict the recovery period of stream water quality from acidification, and has implications to the possible environmental effects of climate change.

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CHANGES IN THE HYDROLOGIC CYCLE FROM PASTURE CONVERSION OF COOL- TO WARM-SEASON GRASSES IN THE UNITED STATES FESCUE BELT

Jian Song[1], John S. Schwartz, PhD, PE[2], and Shawn Hawkins[3]

Global adaptations to agricultural production will be required in the future as a result of climate change and the need to maintain food security. Grasslands, which cover 70% of the world's agricultural areas provide critical fodder, sequester soil carbon, and provide ecosystems services as an integral part of the hydrologic cycle. Grassland adaptation for climate change may consist of species diversification and selection of adaptive genetics. Future projections for the Southeast United States are for warmer spring and summer temperatures. On average, annual precipitation is projected to neither increase nor decrease, but the distribution will become more variable with greater intensity storm events. Such climate change patterns are expected to negatively impact biomass yields from tall fescue. The objectives of this study are to examine potential shifts in a catchment's hydrological cycle with conversion of some portion of pasture forages from tall fescue to NWSGs. Specific focus is given to hydrologic mass balance changes that during growing seasons with average as well as above and below average rainfall. The study design is based on a modeling exercise using the Soil and Water Assessment Tool (SWAT), wherein calibrated model output analyzed for a typical catchment with land use dominated by existing cow-calf farm pastures in Tennessee. Model output demonstrates how evapotranspiration controls the water balance. Slight shifts in runoff and infiltration occur form the pasture land conversion to ward season grasses. Farmers benefit from greater biomass (forage) yields on an annual basis, and are more resilient to droughts.

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UNDERGRADUATE RESEARCH EXPERIENCE IN ESTABLISHING EXPERIMENTAL SET-UP

Emily Pinson and Jejal Reddy Bathi

Stormwater runoff contains many pollutants, organic and inorganic materials, heavy metals, pathogens, etc. that can be harmful to human health and the longevity of the environment. Due to anthropogenic influences such as urbanization and increasing population, along with emergence of newly realized contaminants like engineered nanoparticles, the need for efficient pollutant removal is becoming increasingly necessary. A bioretention system is one conventional treatment method that aims to remove pollutants from urban runoff. And while this type of treatment has been successful at removing suspended particulates, metals, and even nanoparticles, there is still much to be discovered to optimize the design and implementation of these systems. My recent focus of research has been designing and building a bioretention column apparatus to be used in testing various system parameters that may influence its efficiency. Through this project it became apparent that obstacles will arise during a study and the importance of figuring out alternatives was certainly realized. For instance, one key challenge in designing the bioretention table was making sure that the nanoparticles did not react with the medium of the column in which the runoff would flow through. Ultimately this problem was solved by the choice of material for the column tubes and the column apparatus was successfully built and will be used to facilitate further studies of removal efficiency within similar systems. More specifically, this experimental apparatus will be used to construct bioretention columns with various designs (e.g. different soil media, varying physical and chemical parameter, etc.) to gain a better understanding of how these varying design properties may impact the efficiency of a bioretention to remove contaminants from stormwater runoff.

THE BEHAVIOR OF METALLIC ENGINEERED NANOPARTICLES IN STORMWATER RUNOFF

Laura Wright[1], Emily Pinson[1], and Jejal Reddy Bathi[1]

As the use of engineered nanoparticles (ENPs) grows, so does the concern for these emerging contaminants in our environment. Despite their tremendous benefits, the inevitable release of ENPs into the environment may be detrimental and hence cause for concern. Stormwater runoff is a key pathway for contaminants like ENPs into surface waters, and is where transformations begin to happen, such as aggregation and/or adsorption of natural organic matter, which likely effect the fate and toxicity of the ENPs. Existing research is heavily focused on ENPs' occurrence, fate and transport in wastewater systems, but not to the same extent in the case of stormwater runoff. Our going research is exploring potential fate and transport of metallic ENPs (MENPs) and quantifying how physical and chemical properties of stormwater are impacting the ENPs' behavior. We noticed that particles in runoff—regardless of the addition of MENPs—tend to aggregate initially (potentially heteroaggregation), while extended turbulence in the system showed disaggregation of the earlier aggregates. The addition of MENPs evidenced larger aggregates forming while also persisting in the system for longer periods of time. These observations are extremely useful for the design of stormwater treatment systems aiming to effectively remove MENPs—a task that has proven quite challenging due to their size. The findings here suggest there is a window of time for when MENPs can best be treated with conventional methods, but also illuminate their behavior so target treatment technologies may be adapted for better ENPs' control and mitigation in surface runoff.

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A NEW ASTM STANDARD FOR DETERMINING TRASH AND DEBRIS CAPTURE PERFORMANCE BY SCMS

Mark Miller

The topic of plastics and trash waste in the aquatic environment is fast becoming a top issue of concern for the environmental field, policy makers and the general public. It is estimated that over 80% of ocean plastics originate from land-based sources. As experienced stormwater program managers know, trash and plastics can frequently clog inlets and drains as well as reduce the efficacy of stormwater control measures (SCMs) by their accumulation within these critical water quality facilities. Trash capture technologies have existed for many years with varying degrees of effectiveness.

A consensus-based ASTM standard has been developed to objectively measure the performance of these technologies to provide improved assurance on the efficacy of tested and verified technologies. ASTM recently published the E3332 standard, Determining Trash and/or Debris Capture Performance of Stormwater Control Measures. This presentation will briefly discuss the ASTM process and how it produces quality standards, then it will describe the E3332 standard in depth. The standard includes six different tests and each one will be addressed. The presentation will further explore the potential benefits of using the standard as part of an SCM regulatory approval program, and what implementation of the standard could look like.

The Stormwater Testing and Evaluation of Products and Practices (STEPP) program plans to launch a national validation program in March 2023 with trash capture devices as the first SCMs to be verified. What this means for regulators interested in requiring E3332 testing will be covered in the presentation.

RESIDENTIAL RAIN GARDENS TO PROTECT WATER QUALITY: APPLICATIONS AND TOOLS

Andrea Ludwig[1] and Mike Ross[2]

Rain gardens are planted depressions positioned in the landscape to capture runoff from impervious surfaces (like rooftops or driveways) and designed to infiltrate it into the ground. Rain gardens can be used to enhance natural elements of outdoor spaces and minimize impacts of runoff on local waterways. Rain gardens, like all green stormwater infrastructure, is best applied proximate to the source of generated runoff, which could result in rain gardens in residential areas being located on private property. Applying a strategy of small rain gardens used in a diffuse network throughout a developed landscape keeps the water volume spread out and in quantities that can be handled (infiltrated) with native soils. The alternative of larger rain gardens treating runoff from multiple properties results in relatively larger volumes, which often requires specifically-engineered media and additional infrastructure. In addition to these functional considerations, interest in voluntary water stewardship practices is on the rise as homeowners become more aware of how their properties are part of the greater watershed and ecosystem, creating further opportunities for residential rain gardens. There is also a growing number of municipal governments and organizations that provide incentives or reduction in stormwater utilities fees for properties that manage stormwater runoff on site and do not contribute to the storm sewer system. Property owners need tools to help them plan, construct, and care for residential rain gardens. This presentation will cover a new publication from UT Extension and the science behind the recommendations it presents.

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INVESTIGATING TEMPORAL TRENDS IN URBAN STORMWATER QUALITY TO IMPROVE MODELING AND MANAGEMENT

Ian M. Simpson, John S. Schwartz, Jon M. Hathaway, and Ryan J. Winston

Identifying watershed sources of pollutants is critical to accurately predict resulting stormwater quality. Software used to model stormwater quality typically relies on decades-old datasets which may not represent current runoff quality in the United States. Because of water and air quality regulations promulgated at the federal level over the past five decades, there is a need to understand long-term trends in runoff quality to better parameterize models. Pollutant event mean concentrations (EMCs) from the National Stormwater Quality Database were combined with those from other recent sources and were analyzed to understand if stormwater quality has changed over 1980-2020. The dataset was manipulated to account for variables that affect its data and to account for statistical limitations in temporal trend analyses. A significant decreasing monotonic trend (i.e., continually decreasing in a nonuniform fashion) was observed in EMCs total suspended solids (TSS), total phosphorus (TP), total Kjeldahl nitrogen (TKN), total copper (Cu), total lead (Pb), and total zinc (Zn), suggesting that runoff quality is becoming cleaner with time. Significant step trend reductions (i.e., abrupt decreases) often aligned temporally with advancements in clean manufacturing, amendments of the Clean Air Act, and other source control efforts which would impact e.g., atmospheric deposition; this study suggests that management strategies unrelated to stormwater management have had a positive impact on stormwater quality. Results indicate a temporal factor should be adopted in stormwater quality modeling and that historical stormwater quality data may not accurately represent current conditions.

MWS STORMWATER MASTER PLAN

Matt Tays[1] and Adrian Ward[2]

Metro Water Services (MWS) is responsible for a stormwater service area of 514 square miles which is currently divided into 63 sub-basins. The MWS stormwater service area includes over 75,000 culverts and pipes and 95,000 structures. MWS last inventoried the stormwater infrastructure in 2000. To date, no city-wide master plan has been performed.

Nashville has seen explosive population growth between 2000 and the present. The influx of people and limited land resulted in the need for new types of developments. Zero-lot-line and mixed-use buildings, often called “infill developments,” are designed to accommodate a large number of people in a small footprint. Infill developments often replace traditional quarter-acre residential lot subdivisions and create more impervious area per acre of land in the City, which reduces the ability of the current topography to infiltrate rainwater and leads to more runoff. These larger runoff volumes have increased stress on Nashville’s aging stormwater infrastructure, as the system was initially designed with much different criteria in mind. This added stress can create flooding in areas which never previously had issues or worsen existing areas. In 2022, the City decided to establish a plan to handle these increased densities in development and implement a strategy or master plan to prioritize stormwater drainage system improvement projects.

The presentation will review the early stages of the master planning process through the pilot study which will be completed in Spring 2023. We will present (1) the review of existing data, (2) key decisions when selecting between inventorying and modeling requirements, (3) basin prioritization, (4) schema creation for data collection, and (5) condition assessment metrics. For the pilot study area, we will review the (6) existing conditions hydraulic model, (7) alternatives development and evaluation process, and (8) final recommendations. Additionally, we will review project-specific tools created for data management. This is an important project to MWS’ ongoing efforts to protect their investments, respond to aging and undersized infrastructure, and prepare for the future growth of Nashville.

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[1] Metro Water Services

[2] Barge Design Solutions

TRACKING AND QUANTIFYING THE BENEFITS OF NASHVILLE'S STORMWATER CONTROL MEASURES IN A WATERSHED-BASED FRAMEWORK

Michael Hunt[1] and Dustin Bambic[2]

As programs have matured and Clean Water Act regulations have evolved, many large municipal separate stormwater sewer systems (MS4s) have become responsible for thousands of stormwater control measures (SCMs) and numerous nonstructural control measures such as sweeping, inspections, illicit discharge programs and more. Most SCMs have been built by developers in response to land development ordinances adopted by cities in response to MS4 permit requirements. In Nashville, Tennessee, SCMs have been a development requirement for well over three decades, with most of the focus on detention of stormwater runoff. However, with the most recent MS4 permit, the city was required to incorporate stormwater retention of the first inch of runoff through infiltration, evaporation and/or harvesting. Nashville had already been incentivizing green infrastructure techniques prior to requiring the use of LID in 2016. As a result, there are now over 5000 SCMs in Nashville, ranging from green roofs to detention ponds. Metro Nashville Water Services (MWS) is responsible for tracking the SCMs and quantifying their performance for reducing pollutant loading across 35 watersheds.

To support annual reporting, Metro Water Services (MWS) developed a tracking and quantification system for Nashville/Davidson County called the Watershed Improvement and Evaluation System (WIES). WIES is a full-stack web system that performs numerous pollutant reduction calculations for both SCMs and non-structural control measures based on MWS monitoring data, peer reviewed literature, and continuous simulation modeling. WIES is built in the .NET framework and populated with thousands of “performance curves” generated using USEPA software SUSTAIN (System for Urban Stormwater Treatment Analysis and Integration). The performance curves represent multiple types of green infrastructure SCMs and vary by location/rain gage, soil type, imperviousness and more. The influent concentrations are based on years of wet weather outfall monitoring performed by MWS for 17 pollutants. Non-structural estimate pollutant reduction benefits are also estimated. WIES includes dynamic visualization dashboard that displays the cumulative performance by all SCMs across Nashville. This presentation will describe the motivation behind WIES and demo its functionality which has enabled MWS to quantify program effectiveness city-wide.

[1] Metro Water Services

[2] Paradigm Environmental

SMART STORMWATER TECHNOLOGIES FOR WATERSHED MANAGEMENT

Jon M. Hathaway

The world is increasingly urbanizing. By 2050, approximately two thirds of the world's population will live in urban areas. This represents a critical concern for surface waters and ecological systems worldwide. Urban runoff is responsible for a host of perturbations, from erosion to ecological degradation to a fundamental shift in hydrology. These impairments have been deemed the "urban stream syndrome," a term that encapsulates this slate of effects on waterways. Combining this with the specter of climate change and the deterioration of infrastructure in the United States, we face a daunting challenge as to how to sustainably manage urban water systems into the future. In this seminar, recent research into "smart" stormwater will be highlighted, where sensors, real time control, and data analytics are used for a variety of tasks from improving green infrastructure function to informing maintenance tasks. Ultimately such tools may unlock a host of new possibilities, allowing a systems approach to urban watershed management and the promise of improved outcomes.

WHEN DRY CREEK GETS WET - FLOOD MITIGATION AT DRY CREEK WRF

Aaron Thomas[1] and Clayton Foster[2]

During the flood of May 2010, the Metro Water Services' (MWS) Dry Creek Water Reclamation Facility (WRF) experienced approximately $4 million in equipment damages and was without service for nearly two months. MWS and Barge Design Solutions worked together to prepare a Hazard Mitigation Proposal (HMP) for the Federal Emergency Management Agency (FEMA) which was approved in 2019 for federal funding under the Disaster Assistance Policy. This presentation will review the damage and repair of the facility, the analysis of mitigation alternatives, the preparation of the benefit cost analysis, the development of the hazard mitigation proposal, and details of the design including the design evolution from HMP through design completion. The protection level selected by MWS was the 500-year flood event plus 2 feet. The design consists of a perimeter concrete flood wall, flood closure gates, internal drainage, pumping system modifications, 30-inch and 42-inch sewer and manhole replacements, and relocation of 1,200 total feet of two creeks. Design began in 2021 and construction is expected to begin in late 2022. This is an important project in Metro Water Services' ongoing efforts to protect their investments and the health and safety of Nashville's communities from natural disasters.

[1] Metro Water Services

[2] Barge Design Solutions

PROACTIVE MANAGEMENT OF FLOODING WITH INNOVATIVE TECHNOLOGY FOR EVERY BUDGET

Brent Register[1]

As water managers and engineers, it's important to understand our watersheds, urban landscapes, their response to extreme events like heavy precipitation, and efficient ways to protect and inform the public with the resources we have available. Of the numerous tools at our disposal, there are many benefits to a flood warning system, including knowing in time where flooding issues could occur, enabling proactive action, and protecting lives while maintaining a high level of water quality. Many communities know they need to modernize their water data management, but shy away for cost, implementation pains, or the learning curve as they move away from a legacy client-server application.

In this presentation, the discussion will include urban flooding, the value of data collection for flood warning, water quality monitoring, and water data management.

Together, we'll examine what the range of flood monitoring and warning systems might look like in your community and how data can help your community be prepared for a flooding emergency.

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EVALUATING FLOOD HAZARDS IN A RURAL TN WATERSHED THROUGH A COMMUNITY-UNIVERSITY PARTNERSHIP

Maci Young[1], Tania Datta[2], Alfred Kalyanapu[3], and Kelly Moore[4]

Effective watershed-wide stormwater management may be accomplished through a combination of community support and a thorough investigation and understanding of the local watershed. Stormwater management issues have negatively impacted the Doe Creek watershed of Jackson County, Tennessee since 2018. As an economically disadvantaged region, residents lacked the technical or economic resources necessary to investigate the flooding. Therefore, this study initiated the development of a community-university partnership between Tennessee Technological University and community leaders of the Doe Creek watershed in 2019. Initial work of the partnership characterized the watershed and addressed data gaps related to flow of Doe Creek and its tributaries, meteorological data, and stormwater infrastructure information. This initial watershed characterization is continued through the development of a two-dimensional unsteady hydraulic model using the United States Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 6.1. Through calibration and validation of this model, flood hazard maps may be developed to better understand potential flood hazards within the watershed. In addition to the continued watershed characterization, the community-university partnership was extended in 2022 to include engineering outreach efforts with students from Jackson County High School. This engineering outreach included watershed-education lessons and hands-on engineering activities to enable the students to become more familiar with and connected to their watershed. Ultimately, this study highlights the importance of using a community-university partnership to elevate community capacity to engage in more-informed stormwater management planning and inspire the next generation of engineers and scientists.

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A WEST TENNESSEE PERSPECTIVE ON THE WAVERLY FLOOD OF 2021

Md Nowfel M Bhuyian[1], David Blackwood[1], and Kris Gordon[1]

The devastating 2021 Middle Tennessee flood was caused by a historic rain event. According to National Weather Service, 20.73-inch rain poured into the city of McEwan setting a record for the highest 24-hr rainfall for Tennessee. The National Oceanic and Atmospheric Administration reported 20 fatalities and more than 100 million USD in property damages. The city of Waverly was the worst affected that accounted for 19 deaths. The proximity of Waverly from Trace Creek, steep channel gradient, and narrow valley made this city especially vulnerable to flash flooding. Most of this city is located within the Federal Emergency Management Agency (FEMA) flood zone AE which might have given a misleading sense of safety to the residents. This explains the disproportionate damages in Waverly although the historic rain spread over multiple counties. Such event leaves a mark for lesson learning against the increased frequency of catastrophic disasters due to climate change. West Tennessee being a flat terrain is known for frequent and prolonged flooding. An analysis conducted on 18 counties (except Shelby and Chester) shows there are more than 22000 residential properties located in FEMA zone AE. There are additional 24000 commercial, agricultural, educational, religious, and government properties in this FEMA hazard zone. Therefore, these properties worth approximately 1.7 billion USD are at the highest risk of being flooded. This study aims at highlighting the need for local-level flood awareness among the residents and community leaders in West Tennessee.

[1] West Tennessee River Basin Authority, State of Tennessee Department of Environment and Conservation, Humboldt, Tennessee 38343.

SESSION 2-B

Thursday, April 13th at 8:30 am - 10:00 am
HYDROLOGY AND KARST WATERSHEDS
(Moderator: Rodney Knight, USGS)

Karst Water Resources at Rocky Mount Historic Site
I. Luffman, R. McSweeney, and E. Afriyie

The karst hydrology of the Little Sequatchie watershed of southern Tennessee
B. Miller and A. Hourigan

Improving the Accuracy of Source Water Protection Areas by Mapping Karst Groundwater Flow with Fluorescent Dye Tracing
A. Hourigan, B. Miller, and B. Ham

Duck River High Definition Stream Surveys: A Summary of 10 completed Projects since 2016
J. Parham and B. Connell

Thursday, April 13th at 10:30 am - 12:00 pm
WATER QUALITY
(Moderator: Angel Fowler, RES)

Proposal for a Watershed Prioritization Methodology for Community Riparian Restoration in Tennessee
M. Johnson

Air Deposition of Microplastics in High Elevations of the Great Smoky Mountains NP
J. Schwartz and K. Leffler

River Monitoring Network: Predicting Real-Time Escherichia coli Densities at River Access Points in Middle Tennessee
R. Jackwood

Microbiome-Scale Identification of Potential Microbial biomarkers in Streams Impacted by Urbanization
C. Swanson, C. Cianciolo, and Q. He

Thursday, April 13th at 1:30 pm - 3:00 pm
NUTRIENTS
(Moderator: JR Rigby, USGS)

Effects of Nutrient Pollution and Urbanization on Diel Cycles and Stream Metabolism in Two Middle TN Streams
J. Ayers, W. Jing, K. Chen, E. Daugherty, G. Perez, and J. Gomez-Velez

Nutrient delivery, retention, and processing in a reconnected floodplain forest: Implications for greenhouse gas flux
R. Brown

Restoration design decisions can produce ecosystem service trade-offs in agricultural wetland restorations
J. Murdock, R. Brown, S. Duwadi, and S. Womble

Patterns and drivers of nutrient trends in flood-impacted surface waters
E. Fidan

Thursday, April 13th at 3:30 pm - 5:00 pm
ALGAE AND AQUATIC VEGETATION
(Moderator: Daniel Saint, TVA)

Risks of Harmful Algal Blooms to Wildlife
M. Huddleston and S. Samoray

Success of Hydrogen Peroxide for Algal Management
S. Alpert, C. Myers, E. Crafton-Nelson, and D. Jones

Measurements of the Trophic State of Littoral Sites in Tennessee Reservoirs
J. Lebkeucher, J. Atma, H. Conn, and D. Redwine

Floating Aquatic Vegetation on Wheeler Reservoir, Alabama (Field Campaign Results)
M. Boyington

KARST WATER RESOURCES AT ROCKY MOUNT HISTORIC SITE

Ingrid Luffman*[1], Robert McSweeney[1], and Emmanuel Afriyie[1]

INTRODUCTION

Rocky Mount is a 35-acre State Historic Site in east Tennessee's Valley and Ridge province dating to the late 1700s and was the First Capitol of the US Southwest Territory. Bedrock consists of Knox Group carbonates, prone to karst landforms like springs and sinkholes. In fall 2021, Rocky Mount acquired an adjacent tract with several water sources: artesian spring, ditch, and cattle pond. Plans to develop a Memorial Garden near the artesian spring prompted water quality assessment; the spring was a potential source of irrigation water. The aim of this study was therefore to assess Rocky Mount's new hydrologic resources to:

1) determine compliance with state water quality standards; and
2) identify subsurface hydrologic connectivity between water sources.

METHODS

In winter 2022, four sampling sites were selected: 1) artesian rock basin spring (AS); 2) drainage ditch along adjacent road (D); 3) cattle pond (CP); and 4) residential spring on an adjacent residential property (RS) (Figure 1).

Figure 1. Sampling locations and property boundary, Rocky Mount State Historic Site

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Sampling occurred during winter 2022 (01-27-22 to 02-10-22) and winter 2023 (02-02-23 to 02-16-23) and was completed using a five-samples-in-thirty-days approach, following 5-in-30 sampling protocol for bacteriological sampling. All sites were sampled for pH, turbidity, Dissolved Oxygen (DO), conductivity, temperature, fecal coliform and *E. coli* bacteria. Physicochemical parameters were measured *in situ* with handheld meters. Grab samples were collected in 100 mL sterile bottles and bacterial concentration was measured using the Colilert QuantiTray 2000 ® process. Findings were compared to state water quality standards. Similarities in water quality parameters was compared between sites using the Kruskal Wallis non-parametric Analysis of Variance to identify unique water resources.

RESULTS AND DISCUSSION

Samples at all sites met state recreational water standards for all parameters except pH. Values in Table 1 are means for the combined 2022-2023 data except for the bacteriological data, which are 2023 geometric means. Individually, the 2022 and 2023 data have similar trends for most parameters and sites. High *E. coli* measured in single grab samples at the Artesian Spring and Residential Spring in May 2021 was not replicated during 5-in-30 sampling in 2022 and 2023. Further, in the 2023 sampling round the Artesian Spring met drinking water standards for *E. coli* (Table 1). During 2022, the Ditch site had the best water quality over all sites, and appeared to be fed by a series of small artesian seeps. We later determined that the water main running under the adjacent road was leaking. Following water line repair, the second round of sampling in 2023 indicated that high water quality at the Ditch site was a result of the water leak; flow was greatly reduced and bacterial loads were increased in 2023.

Precipitation occurred periodically preceding and during the sampling periods (Figure 2) and was associated with increased fecal coliform bacteria at all sites except the Artesian Spring. Precipitation did not impact *E. coli* concentration.

Table 1. Water quality results (five sample mean; geometric mean for *E. coli* and Fecal Coliform) and EPA/TDEC standards* for recreational water use.

	Turbidity (NTU)	**DO (mg/L)**	**SPC (µs/cm)**	**Water Temp (°C)**	**pH**	***E. Coli* ** (CFU/100mL)**	**Fecal coliform** (CFU/100mL)**
Artesian Spring	2.7	9.6	294.3	5.5	9.7	<1	199.2
Cattle Pond	29.7	10.2	136.9	7.4	8.9	17.3	1011.2
Ditch	11.8	10.9	337.2	12.1	9.1	14.9	870.4
Residential Spring	3.2	6.0	567.3	16.6	9.0	1.8	960.6
Recreational standards	1-5	>5	<800	<30.5	6 - 9	126.0	---

* USEPA. 2014. Rules of the Tennessee Department of Environment and Conservation Chapter 0400-40- 03 General Water Quality Criteria. Retrieved September 20, 2021 https://www.epa.gov/sites/default/files/2014-12/documents/tn-chapter1200-4-3.pdf

**Geometric mean for 2023.

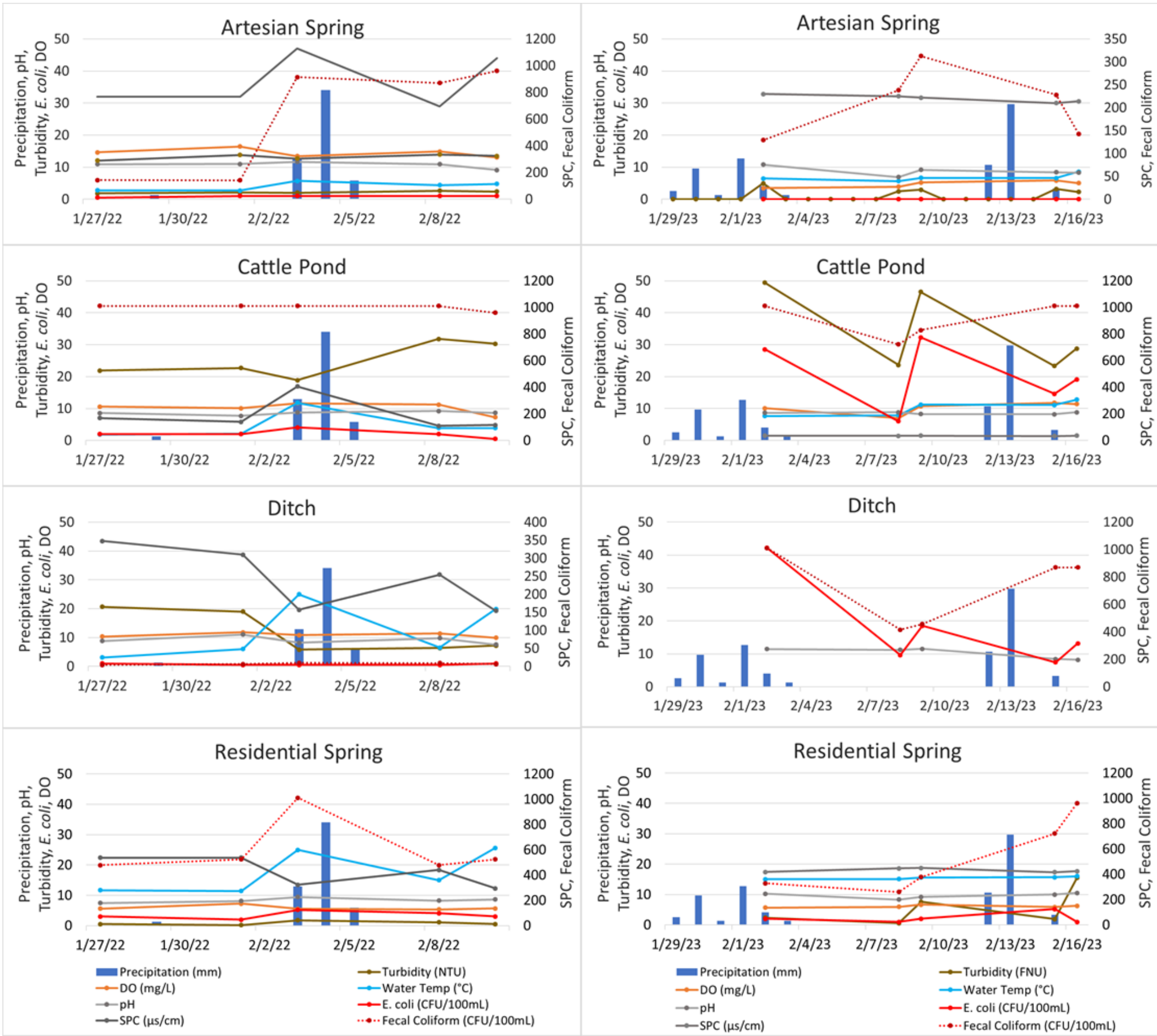

Figure 2. Water quality results for 2022 (left) and 2023 (right). Insufficient flow in the Ditch site during 2023 limited the parameters that could be measured.

Kruskal Wallis tests indicated significant differences in water chemistry between sites for all parameters. Pairwise comparisons revealed consistent differences (Table 2). From these results, computed for each sampling period separately and for both sampling periods combined, we determined that the Artesian Spring, Residential Spring, and Cattle Pond have significantly different physicochemical and bacteriological water properties (using a threshold of 4 parameters being significantly different between sites). These results indicate there are different water sources for the two springs and pond. The differences between springs and the Cattle Pond are likely related to the surface runoff/direct precipitation recharge sources for the pond. Increased turbidity at this site was highly correlated with *E. coli* bacteria, particularly in 2023 (Figure 2), suggesting that the bacteria is resident in pond sediments which were disturbed during sampling of the shallow pond.

Table 2. Kruskal-Wallis Post-hoc pairwise comparison of the combined 2022-2023 water quality dataset identifies parameters that are significantly different (or nearly so, as indicated by p-values slightly above p=0.05) between the four sites.

	Residential Spring	**Cattle Pond**	**Ditch**
Artesian Spring	DO (p=0.064) Temp SPC *E. coli*	Turbidity SPC (p=0.056) Fecal coliform *E. coli*	*E. coli*
Residential Spring		Turbidity DO Temp SPC Fecal coliform	Turbidity DO SPC
Cattle Pond			SPC (p=0.053) Fecal coliform

CONCLUSION AND RECOMMENDATIONS

Two rounds of water quality sampling of water resources at Rocky Mount State Historic Site found high water quality at all sites, meeting state Recreational Water Standards. Preliminary sampling in 2021 identified *E. coli* in the Artesian and Residential springs in May 2021, and its near absence in the January 2022 and January 2023 sampling, prompts a recommendation of seasonal 5-in-30 sampling of the Artesian and Residential springs to determine seasonal variability in water quality, particularly for pathogens.

We conclude that the two springs and Cattle Pond are fed by different sources, with the springs fed by karst groundwater and the pond fed by surface runoff and direct precipitation. Little is known about the groundwater sources supplying the two springs, and although precipitation does not seem to influence the water quality at either spring, we noted changes in water level following rain events at the Artesian Spring. We therefore recommend monitoring water levels in the Artesian and Residential springs and comparison with precipitation measured on site and regionally to assess influence of precipitation and runoff/shallow groundwater flow on the two springs. These water quality findings will be helpful in future land use planning at the Rocky Mount Historic Site.

THE KARST HYDROLOGY OF THE LITTLE SEQUATCHIE WATERSHED OF SOUTHERN TENNESSEE

Benjamin V. Miller[1] and Amy Hourigan[1]

Located on the southern Cumberland Plateau in Tennessee, the Little Sequatchie valley is a 120 square mile drainage where the hydrology has been largely altered by karst processes. The Little Sequatchie River drains the eastern escarpment of the Cumberland Plateau as the stream flows south to join the Sequatchie River near the confluence with the Tennessee River. Karst processes have caused the majority of the streams in the drainage (tributaries and main stem streams) to sink at the contact between the Mississippian Pennington Formation and the underlying Mississippian Bangor Limestone. This karstification has created extensive dry reaches of streambeds downstream of major swallets. Large springs drain these reaches and swallets, creating sustained perennial flow in the main stream. In the intervening reaches between the sinks and springs are numerous cave systems, many located below the elevation of the valley floor. Beginning in late 2021, a dye tracing study has sought to delineate recharge areas for springs in and near the Little Sequatchie to better understand areas that may impact water quality and quantity at critical habitats for Threatened and Endangered Species, such as the Royal Marstonia (Pyrgulopsis ogmorhaphe) and Sequatchie Caddisfly (Glyphopsyche sequatchie). Springs in and near the Little Sequatchie also serve as sources for both drinking water and for agricultural practices. To date, this work has delineated recharge areas for six major springs, ranging from 7 to 65 mi2 in area. The majority of the dye traces have remained sub-surface from stream sink point to spring resurgence, often travelling underground for miles before resurging. Additionally, many of the traces have rapid travel times, often travelling miles per day. Work is still ongoing, largely focusing on delineating a recharge area for nearby Jasper Blue Spring. Jasper Blue Spring is a large spring utilized as a drinking water source for a nearby community and is mapped to 144 feet-deep and 2.46 mile-long. The goal of this project is to provide scientific data that private landowners and state and federal partners can use to make informed decisions on the protection and preservation of this unique and vulnerable karst system.

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IMPROVING THE ACCURACY OF SOURCE WATER PROTECTION AREAS BY MAPPING KARST GROUNDWATER FLOW WITH FLUORESCENT DYE TRACING

Benjamin V. Miller[1], Brian Ham[2], and Amy M. Hourigan[3]

Sixty-six community public water systems within the state of Tennessee use springs as a primary or secondary water source. These groundwater resources are critical for these communities, serving over 711,000 people statewide. Public water systems are required to identify the area that contributes water to the water supply, also known as the source water protection area (SWPA). A recent partnership between the U.S. Geological Survey (USGS) and Tennessee Department of Environment and Conservation (TDEC) seeks to examine previously identified SWPA for community drinking water springs and then conduct groundwater tracing to confirm recharge area boundaries for higher priority karst springs. In fall 2021, SWPA were reviewed by USGS and TDEC staff using a rubric scoring system. The review helped to identify possible vulnerabilities or complexities that may exist based upon maturity of karst development, underlying geology, or logic used to delineate the initial SWPA. Using this scoring system, the springs were then ranked and priorities for fieldwork were established. In late winter 2021, fieldwork began in areas surrounding the Tennessee communities of Cowan, Jasper, Vanleer and Woodbury. These communities lie within three physiographic provinces; Cowan and Jasper are near the Cumberland Plateau, while Vanleer and Woodbury are located on the Western and Eastern Highland Rim, respectively. These systems are in areas where the hydrology has been significantly altered by karst processes and thus the groundwater pathways are complex and unpredictable. Groundwater traces both within and adjacent to established SWPA have shown the systems to be more complex than previously depicted and the results have helped community public water systems draft new and more accurate SWPAs for the springs. SWPAs are then used to assess the susceptibility of the drinking water source to potential contamination. The partnership is a five-year study which uses research results to provide public water systems with information to better manage their drinking water resources.

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DUCK RIVER HIGH DEFINITION STREAM SURVEYS:
A SUMMARY OF 10 COMPLETEDPROJECTS SINCE 2016

Jim Parham and Brett Connell

The Duck River is the most biologically diverse river in the United States and the source of drinking water for 250,000 people in Middle Tennessee leading to numerous water management challenges. Beginning below Normandy Dam on the Duck River, Trutta has completed 155 miles of High Definition Stream Survey (HDSS) and over 500 bathymetric cross-sections for different public and private organizations. Data from the 10 different projects have been used to support TMDL modeling, reservoir capacity and siltation studies, prioritize locations for potential drinking water intakes, and determine low-flow impact on mussel habitat. While some of these projects only required cross-sectional bathymetric data collection, we also gathered continuous HDSS longitudinal river corridor data during each survey.

The HDSS method integrates GPS, video, depth, side scan sonar, and other sensors, to provide a continuous inventory of baseline conditions. With each second of video and other sensor data linked to a specific GPS point, the HDSS approach facilitates the identification, selection, and prioritization of areas of the river most suitable for different management goals. For example, the HDSS results can be used to determine the most economical location and methods for mitigation, monitor restoration results, assist MS4 stormwater permitting, determine the extent and distribution of instream habitat, define the geomorphic condition for the stream, identify infrastructure impacts, and provide a powerful "virtual tour" experience. Discussions are currently in progress to re-survey all 155 miles which will provide a comparable data set to measure the changes occurring over time within the Duck River.

This presentation will highlight the issues, collaborative partners, and solutions derived from the HDSS approach and discuss ways to use the 155 miles of available HDSS data to answer new questions.

A PROPOSAL FOR A WATERSHED AND STREAM SITE PRIORITIZATION METHODOLOGY FOR RIPARIAN RESTORATION IN TENNESSEE

Madison Johnson

Riparian forests are unique ecosystems that act as transitional areas between land and water, and are a vital part of a healthy and functional stream ecosystem. As Tennessee's urban areas grow in the coming years, it will become progressively important to preserve functional riparian zones, to increase riparian plantings to mitigate anthropogenic sources of pollution and stream degradation, and to incorporate more natural riparian vegetation to improve aquatic habitats. It is also essential to target these efforts in historically low-income neighborhoods, as these communities are more detrimentally affected by poor stream quality and reduced access to healthy recreational green spaces. The Community Riparian Restoration Program for Tennessee (CRRP) is funded by the Tennessee Division of Forestry, and aims to identify stream sites in Tennessee that are highly susceptible to poor stream quality, and where the physical and social benefits of restoration initiatives will be the greatest. Tennessee Macro-Invertebrate Index scores were used in conjunction with land cover statistics to support established theories of land-cover effects on water quality, and helped inform a data-driven prioritization model locating high-priority watersheds for restoration. High-priority watersheds were combined with census tract household income data and land-cover characteristics to locate specific locations that present the greatest opportunities for restoration in disadvantaged areas. The CRRP will connect with individuals and organizations in these locations to drive community-centered restoration and educational initiatives that will encourage stewardship of these essential riparian areas and waterways.

AIR DEPOSITION OF MICROPLASTICS IN HIGH ELEVATIONS OF THE GREAT SMOKY MOUNTAINS NP

John S. Schwartz, PhD, PE[1] and Kelly M. Leffler[2]

Recent discoveries of microplastics in atmospheric deposition samples collected in remote mountain areas suggest that microplastics are surprisingly pervasive in environments far removed from the industrialized urban areas, downstream waterways, and oceans where the accumulation of microplastics is well documented. These discoveries were made in the mountains in both Europe and western North America, but similar studies had not yet been conducted in the eastern North American mountains. The purpose of this study was to determine if microplastics can be found in atmospheric deposition samples collected at the Noland Divide research site and Elkmont research site in the Great Smoky Mountains National Park (GSMNP). A deposition collection device, made entirely of metal and wood, was designed to trap both wet and dry deposition within a 3-foot by 3-foot area and gather in a metal bucket. The samples were carried out of the site in glass containers and filtered in a lab under a hood at The University of Tennessee, Knoxville. Filters were observed for microplastics using a Leica microscope with maximum 400X magnification. Suspected microplastics were observed in samples from both GSMNP sites. This suggests that atmospheric deposition of microplastics occurs in areas away from urban development.

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RIVER MONITORING NETWORK: PREDICTING REAL-TIME ESCHERICHIA COLI DENSITIES AT RIVER ACCESS POINTS IN MIDDLE TENNESSEE

Ryan Jackwood, PhD[1]

Excessive fecal contamination (indicated by densities of Escherichia coli) of surface waters threatens environmental and human health. Popular recreational beaches and rivers may post swim advisories when E. coli levels are elevated. Nashville is home to some highly recreated rivers such as Mill Creek, Richland Creek, and Harpeth River, which are destination areas for over 500,000 visitors annually. Warnings or advisories for elevated levels of E. coli in Tennessee's recreational waters are reactionary and don't feature a predictive or forecast component, which would help prevent recreational water-related illnesses. Predicted E. coli densities can serve as an "early warning" system to advise members of the public when microbial contamination is unsafe for swimming in surface waters due to the threat on human health. Conditions are considered unsafe when densities of E. coli are above the Environmental Protection Agency's Recreational Water Quality Criteria (235 colony forming units [CFUs]/100 mL). Citizen volunteers collected weekly water samples throughout the recreational season (May – October) over three years from highly recreated locations in the greater Nashville region. Samples were analyzed for densities of E. coli and the results were then correlated with real-time meteorological and environmental data using multiple linear regression. 299 samples were collected from 10 different locations with 121 (40%) of those samples exceeding 235 CFUs/100 mL. Thus, an advisory system based on water quality predictions will help inform citizens when E. coli exceedances will occur so they can make an informed decision about where and when to recreate safely.

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MICROBIOME-SCALE IDENTIFICATION OF POTENTIAL MICROBIAL BIOMARKERS IN STREAMS IMPACTED BY URBANIZATION

Clifford S. Swanson[1]*, Charlie Cianciolo[1], and Qiang He[1]

Urbanization has significant impact on water resources, exemplified by the large number of urban streams classified as being impaired on the 303(d) list. Tremendous effort has been made to improve these impaired streams, requiring the development of effective and efficient techniques for the evaluation of stream impairment and response to mitigation efforts. In this study, the stream microbiome was investigated as potential biomarkers for the impact of urbanization on stream impairment. The advantage of microbiome-scale analysis is the ability to survey all microbial constituents in a stream water sample and identify potential biomarkers, which is not possible with traditional indicator-based techniques. Stream water samples were collected from reference streams with minimal impact from urbanization as well as streams impacted by urbanization to various extent in East Tennessee. The stream microbiomes were characterized by high-throughput sequencing. In addition, E. coli was also enumerated as an indicator for microbiological impairment following standard methods. that the presence of E. coli was found to average 31 CFU/100mL in reference streams and 1,260 CFU/100mL in urban streams, indicative of the significant impact of urbanization on stream water quality. Microbiome analysis showed that the most abundant constituents of the stream microbiome was represented by Burkholderiaceae and Flavobacterium in both reference and urban streams. However, microbial populations abundant in reference streams, particularly Sediminibacterium and Rhodoluna, exhibited significantly reduced abundance the urban streams, decreasing from 2.2% to 1.3% and from 2.2% down to 1.1%, respectively. In contrast, Pseudomonas, Hydrogenophaga, and Massilia were three major microbial populations showing significant increases in abundance in urban streams in comparison with reference streams. Findings from this study provide important insight into potential biomarkers specifically associated with the impact of urbanization. Ongoing analysis is focused on the identification of microbial biomarkers specific to various types of stream impairments.

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* Presenting author

EFFECTS OF NUTRIENT POLLUTION AND URBANIZATION ON DIEL CYCLES AND STREAM METABOLISM IN TWO MIDDLE TN STREAMS

John C. Ayers, Weizhuo Jing, Kevin Chen, Ella Daugherty, Gabriel Perez, and Jesus Gomez-Velez

The effects of pollution and urbanization on diel cycles, stream metabolism, and CO2 emissions were assessed by comparing measurements in a rural headwater stream East Fork Creek (EFC) and the urban Mill Creek (MC) in middle TN in 2022. In EFC diel cycles were observed for temperature, pH, and PCO2 and concentrations of Ca, Mg, Se, Fe, Ba, Cl, SO4, NO3, DIC, O2, DOC, and total algae (TAL). Light intensity, Se, and TAL show the largest relative changes.

Daily mean values of Gross Primary Productivity (GPP) and Ecosystem Respiration (ER) were calculated using the diel dissolved oxygen (DO) curves approach. GPP was positively correlated with temperature and ER was negatively correlated with DO because O2 is consumed during photosynthesis. ER was always greater than GPP, indicating EFC was heterotrophic and therefore a continuous source of CO2 to the atmosphere, with a daily average of -2.85 gC m-2 d-1 in July 2022.

Our measurements show that MC has higher PO4, NO3, and DO concentrations than EFC. As MC flows from suburban to urban setting, no systematic changes in water quality parameters occur except that conductivity decreases downstream. In March 2022 GPP > ER, but in November 2022 ER > GPP. The larger, urban Mill Creek has higher photosynthesis rates and lower respiration rates than EFC, which may be due to its being further downstream or having higher nutrient concentrations. We plan to conduct indirect measurements of CO2 emissions from MC in spring 2023.

NUTRIENT DELIVERY, RETENTION, AND PROCESSING IN A RECONNECTED FLOODPLAIN FOREST: IMPLICATIONS FOR GREENHOUSE GAS FLUX

Robert Brown

The USDA Natural Resources Conservation Service has implemented levee breaks to reconnect a channelized stream to a forested easement enrolled in the Wetlands Reserve Program to promote nutrient retention. We collected floodwater samples over the duration of floods using automated water samplers and measured concentrations of total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) to infer spatial and temporal patterns of nutrient deposition and retention in the floodplain. Both TN and TP were positively correlated with TSS but this relationship was stronger for TP. Molar TN:TP ratios increased with flood duration and distance from levee breaks, suggesting that P was deposited and retained within the forest more readily than N. We collected and incubated intact soil cores from the site in a flow-through system to measure flux of PO_4, NO_3, N_2, N_2O, and CH_4 from inundated soils over the course of a simulated 48-hour flood. Flux averaged -0.532 and -11.752 mg/m2/h for PO_4 and NO_3, respectively, indicating net uptake of dissolved nutrients in soil. Flux averaged 3.467 mg/m2/h for N_2, indicating net N removal from the system. Flux averaged 1.759 and 0.906 µg/m2/h for N_2O and CH_4, respectively. Both N_2O and CH_4 flux in this study were lower than expected for wetlands, while nutrient uptake and N removal rates were relatively high. More frequent inundation of this floodplain is likely to promote nutrient retention and removal without substantially increasing greenhouse gas release.

RESTORATION DESIGN DECISIONS CAN PRODUCE ECOSYSTEM SERVICE TRADE-OFFS IN AGRICULTURAL WETLAND RESTORATIONS

Justin Murdock[1], Robert Brown[1], Shrijana Duwadi[1], and Spencer Womble[1]

Improved wetland function such as nutrient retention is a major goal in wetland restoration. Structural characteristics including vegetation and hydrologic regime often dictate the soil conditions that promote specific nutrient transformations such as phosphorus absorption/release or denitrification. However, wetland conditions the promote nutrient retention also inherently can increase the production of greenhouse gases (GHG) such as methane and nitrous oxide. Long-term post-restoration monitoring data in agricultural floodplain wetlands is needed to identify potential trade-offs in nutrient transformations and GHG release, and help predict how rates differ under varying restoration strategies as the restorations age. We are conducting a space-for time intensive assessment measuring nutrient retention potential of 35 restored floodplain agricultural wetlands in the USDA Natural Resources Conservation Service's Wetlands Reserve Program in Tennessee and Kentucky. Wetland age ranged from 0 to 23 years post restoration. Results from 1024 soil core incubations show continuously inundated areas have some of the highest dissolved nitrogen and phosphorus retention rates, but the lowest denitrification rates. These wet areas also have the highest rates of methane and nitrous oxide release. Conversely, areas that routinely dried and rewet had the lowest nitrate retention, but highest denitrification rates. Despite different recovery trajectories during the first 10 years after restoration, nutrient retention rates stabilized within and across all habitats, coalescing into a state of consistent, but lower nutrient removal from 10 – 20 years post-restoration. Thus, trade-offs observed early in succession may not be consistent over decades of recovery. Understanding these functional recovery trends and trade-offs can help managers create both optimal initial wetland restoration designs, but also assess if adaptive management such as localized resetting of plant succession or more complex hydrology modifications can optimize floodplain wetland functions to optimize for multiple ecosystem services.

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PATTERNS AND DRIVERS OF NUTRIENT TRENDS IN FLOOD-IMPACTED SURFACE WATERS

Emine Fidan

Extreme events, including regional floods caused by hurricanes, have the potential to mobilize and transport nutrients across the landscape, creating public and environmental health concerns. Several studies have characterized the contaminants in floodwaters, but few studies offer insights into which watershed characteristics explain flood water quality signatures. To address lack of understanding on flood water quality descriptors, we aimed to explain floodwater nutrient concentrations as a function of different environmental variables. Specifically, we quantified nitrogen and phosphorus concentrations in floodwaters across the Atlantic Coastal Plain of North Carolina (USA) after Hurricane Florence, a major tropical storm that delivered up to 700 mm of rainfall to the region during September 2018. We also constructed a multivariate, spatial Bayesian model to explain nutrient responses as a function of different hydroclimatic factors, land use classifications, and nearby pollution point sources. Nutrient samples were collected at 51 different sites at four different time points spanning a year after Hurricane Florence impact: during major flood conditions and after floodwaters had receded. Samples were assessed for total Kjeldahl nitrogen, total ammonia nitrogen, nitrate and nitrites, total phosphorus, and orthophosphate. Results from this analysis show that nutrient concentrations were very low in floodwaters, with the exception of several sites that exhibited excessively high total Kjeldahl nitrogen, total phosphorus, and orthophosphate concentrations. Furthermore, modeling results indicate that swine production facilities (concentrated animal feeding operations; CAFOs), wastewater treatment plant (WWTP) proximity, and precipitation variables were important in explaining nutrient concentrations in floodwaters. This research suggests that swine CAFOs and WWTPs were likely sources of nutrient exports associated with Hurricane Florence, with rainfall amount being a primary driver.

RISKS OF HARMFUL ALGAL BLOOMS TO WILDLIFE

Matt Huddleston[1] and Steve Samoray[1]

There are some types of algae that produce toxins. “Algae” in this context refers collectively to organisms living in water that include both plants and certain bacteria, protists, fungi and archea. The common feature shared by these organisms is their aquatic habitat and their ability to produce oxygen through photosynthesis. Only a few types of algae produce toxins. Under normal circumstances, these algae do not pose a threat to wildlife. However, when toxin-producing algae grow excessively, they may release enough toxin to pose ecological risks. Algae flourish when environmental conditions support rapid growth, resulting in what are commonly referred to as harmful algal blooms (HABs). Warm water temperature, light, and high-nutrient content are ideal conditions for algal growth. Evidence suggests that climate changes are leading to HABs that occur more frequently, are longer in duration, and have a wider geographic range than in the past. HABs have been directly linked to adverse effects on wildlife in some cases, but even when toxins have been detected in animal tissue, their contribution to mortality and other effects is unclear. For example, the toxic dose of many algal toxins in wildlife species is unknown, and the microscopic lesions (if any) particularly in birds, have not been well described. This presentation will examine the ecology of HABs, provide case studies of HAB effects on wildlife, and identify measures for decreasing HAB risks to wildlife.

[1] Copperhead Environmental Consulting, Inc.

SUCCESS OF HYDROGEN PEROXIDE FOR ALGAL MANAGEMENT

Elizabeth Crafton-Nelson, PhD[1], Danielle Jones2, Cody Meyers[3], and Scott Alpert, PhD[2]

The City of Franklin utilizes a terminal reservoir for storage to feed their WTP during low flow or low dissolved oxygen conditions that are observed in the Harpeth River. The terminal reservoir frequently is subjected to high cyanobacteria densities with spikes in total organic carbon. Historically, the City used copper-based algaecides to reduce growth in the terminal reservoir that feeds its WTP. There was limited success with controlling algal growth and an alternative approach was pursued, hydrogen peroxide (H2O¬2). The treatment area was outlined with a targeted dose of 3 mg/L H2O2 in the photic zone. This treatment area and dose served as the benchmark and was adjusted based on reservoir conditions. Based on two years of hydrogen peroxide treatments (2020 - 2021), the average dose 2.3 mg/L H2O2 in the treatment area, with highest dose of 3.3 mg/L H2O2. Treatment frequency was a key factor with an average of 40 days between treatment in 2020 and 22 days in 2021; similar results were observed in additional case studies. The City of Franklin also reduced algaecide costs by 42% from 2019 to 2021. The similar outcomes observed in multiple case studies, including Franklin, showcase hydrogen peroxide as a promising management strategy for algal growth. These outcomes also validate the investment in source water management for reducing treatments costs.

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1 Hazen and Sawyer Columbus, Ohio

2 Hazen and Sawyer Nashville, Tennessee

3 City of Franklin, Franklin, TN

MEASUREMENTS OF THE TROPHIC STATE OF LITTORAL SITES IN TENNESSEE RESERVOIRS

Jefferson Lebkuecher[1], Jenna Atma, Haley Conn, and Daniel Redwine

The biomass of infralittoral periphytic algae may provide information on trophic state yet is understudied due partially to the historical emphasis on pelagic water-column characteristics to evaluate the integrity of lentic systems. Evaluations of infralittoral reservoir sites may be particularly valuable given the flow characteristics of many reservoirs relegate nutrient and chlorophyll (chl) a concentrations of water less meaningful as benchmarks of trophic state. Concentrations of epilithic chl a and water concentrations of chl a, total phosphorus (TP), and total nitrogen (TN) were determined at one infralittoral site in ten reservoirs in Middle and East Tennessee. Concentrations of epilithic chl a correlate significantly with concentrations of TP but not with TN. The concentrations of chl a of water do not correlate significantly with concentrations of TP, TN, or epilithic chl a. These results suggest that concentrations of epilithic chl a are more accurate indicators of the trophic state of the sites relative to the concentrations of chl a of water. The results also indicate the reservoir sites may be divided into two distinct groups, mesotrophic and eutrophic, based on the significant differences of the concentrations of epilithic chl a. For this study, mesotrophic sites are designated by concentrations of epilithic chl a that range from 5.6 mg chl a.m-2 to 8.0 mg chl a.m-2. These sites have concentrations of TP that range from 9 µg TP.L-1 to 11 µgTP.L-1 and include the Chilhowee, Norris, Tellico, Parksville, and McKamy sites. Eutrophic sites are designated by concentrations of epilithic chl a that range from 17.5 mg chl a.m-2 to 23.5 mg chl a.m-2. These sites have concentrations of TP > 17 µg TP.L-1 and include the Nickajack, Swan, Percy Priest, Green Cove, and Old Hickory sites.

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FLOATING AQUATIC VEGETATION ON WHEELER RESERVOIR, ALABAMA (FIELD CAMPAIGN RESULTS)

Matt Boyington

In recent years, TVA has seen an increase in aquatic vegetation on several reservoirs such as Wheeler Reservoir, Guntersville Reservoir, and Melton Hill Reservoir. Large amounts of this vegetation can be broken and uprooted from the reservoir bottom and form large floating mats. These mats have been ingested at power plant intakes causing outages and reductions in power generation. To address these incursions and gain an improved understanding of the variables involved, TVA has conducted regular field monitoring on Wheeler Reservoir, Alabama, since July 2020.

In July 2020, TVA embarked upon an extensive field campaign to sample and document the distribution of aquatic vegetation in Wheeler Reservoir. A sampling grid was developed and at each point the substrate was raked. Field crews recorded numerous characteristics such as vegetation amount, species distribution, and Secchi depth, to name a few. A subset of points was selected for revisiting on a regular basis. Field crews have returned to these points every 3 to 4 weeks. This presentation will provide an analysis of the field data and discuss how this dataset will assist in supporting power generation on Wheeler Reservoir.

SESSION 3-A

Friday, April 14th at 8:30 am - 10:00 am
STREAM RESTORATION
(Moderator: Ken Barry, S&ME)

eDNA Sampling for the Streamside Salamander (A. barbouri) at a Tennessee Mitigation Site
A. Brais

Updates to the Tennessee Stream Quantification Tool
J. Schwartz

Restoring Urban Streams Reevaluating Measures of Success
A. Spiller

Aquatic Organism Passage (AOP) Guidance
A. Hangul

EDNA SAMPLING FOR THE STREAMSIDE SALAMANDER (A. BARBOURI)
AT A TENNESSEE MITIGATION SITE

Anthony Brais, PE[1]

The state endangered streamside salamander (A. barbouri) is known from a stream & wetland mitigation site in Tennessee. Individuals are difficult to locate given restricted surface activity within intermittent streams during the Dec.– Apr. breeding season. Environmental DNA (eDNA) is a passive presence or absence survey technique. eDNA samples were collected at 14 locations in Mar. 2022 to establish baseline reach occupancy. Four control eDNA samples were collected at a reference location in Mar. 2022. For each sample, we attempted to extract ~1000 mL through a SterivexTM filter. GenidaqsSM developed three clade specific assays for each subpopulation of A. barbouri in Tennessee. Samples were analyzed by a GenidaqsSM against the clade specific assays as well as a previously published assay (Witzel et al. 2020). Physical surveys were conducted at each sampling point to identify adults, larvae, or egg masses. The clade specific assay achieved positive eDNA detection at one reach on the mitigation site. A positive eDNA detection occurred at the control site for both the clade specific assay & Witzel assays. Adults, larvae and egg masses were observed at both sites in locations of positive eDNA detection. Water quality allowed extraction of >1000 mL per sample at the control site. Increased turbidity prevented collection of 1000 mL from all samples at the mitigation site. Late season surveys may have resulted in a lower concentration of genetic material per sample and additional sample volume may have been required for positive detection at the mitigation site with the Witzel assay.

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UPDATES TO THE TENNESSEE STREAM QUANTIFICATION TOOL

John S. Schwartz, PhD, PE[1]

The U.S. Army Corps of Engineers (USACE) and Tennessee Department of Environment and Conservation Division of Water Resources (TDEC) currently require compensatory mitigation for certain permitted impacts to Tennessee's streams. The USACE require compensatory mitigation for unavoidable impacts to aquatic resources under Section 404 of the Clean Water Act and/or Sections 9 or 10 of the Rivers and Harbors Act of 1899. Tennessee's Aquatic Resources Alteration Permit (ARAP) rules establish TDEC's mandatory requirements for mitigation under Rule 0400-40-07-.04(7), and modified in 2018 requiring mitigation sufficient to compensate for the loss of resource values from existing conditions. In 2008, the USACE and the U.S. Environmental Protection Agency (USEPA) issued joint regulations clarifying mitigation compensation requirements for losses of aquatic resources {USACE: 33 CFR Part 332/40 CFR Part 230, Subpart J.; and USEPA: 33 CFR Part 230]. The new rule recognizes three mechanisms for providing compensatory mitigation: mitigation banks, in-lieu fee programs, and permittee-responsible mitigation. The 2008 rule established performance standards and criteria for the use of permittee-responsible compensatory mitigation, mitigation banks, and in-lieu programs to improve the quality and success of compensatory mitigation projects. It provided guidance on planning, implementation and management of compensatory mitigation projects by emphasizing a watershed approach in selecting project locations; requiring measurable, enforceable ecological performance standards; and specifying regular monitoring for all projects. Historically per the 2004 federal guidelines, the USACE and TDEC employed a ratio driven credit and debit system based on the activity or work proposed to determine stream resource value loss and lift.

The Tennessee Stream Quantification Tool (TN SQT) was developed and to be used for evaluating the functional change between an existing and proposed stream condition. One of the goals of these tools are to produce objective, verifiable and repeatable results by consolidating well-defined procedures for objective and quantitative measures of defined stream functions. The Tennessee Debit Tool (TN Debit Tool) is a methodology developed to calculate the functional loss (debit) of permitted impacts to stream ecosystems. The 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. Because the TN SQT scores an existing condition and a proposed or post project condition, it can be used to calculate functional lift and loss if both conditions are monitored. The TN Debit Tool operates with the same basic principles.

Finalized in 2019, the TN SQT has been implemented for over two years. Practitioners, academics, and some state agencies have found multiple issues with the first version of the TN SQT. Because of these issues/concerns, USACE and TDEC formed a TN SQT Review Working Group. This Working Group consisting of the USACE, TDEC, and consultants met for about one-year starting in August 2020, and ideas for revision have been discussed. This presentation summarizes the outcome of that effort, and the updates for the TN SQT version 2.0.

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[1] Professor, Dept of Civil & Environmental Engineering, University of Tennessee, Knoxville and Director, Tennessee Water Resources Research Center

RESTORING URBAN STREAMS
REEVALUATING MEASURES OF SUCCESS

Adam Spiller[1]

Urban stream restorations have been implemented by the stream restoration community for decades. Over that period of time, urban streams have been restored with varied success. Before using broad brush strokes to describe urban stream restoration, we need to look at each individual project's goals and potential for uplift. While we all are supportive of restoring urban streams, we must discuss how success is defined. We can't look at urban stream restorations through the same lens as stream restoration occurring in rural environments or minimally disturbed watersheds. These projects need to be viewed in the context of location, setting, and other site constraints. A pure ecological functional uplift approach may also not be the right measure of success. When we're examining the uplift in urban streams, we may need to reevaluate the weight of ecological function with the benefits gained in social functions. This talk will look at examples of various urban projects and examine them in the context described above. The presentation will re-frame our discussions of urban stream restoration, so that as a community we can feel comfortable working in an urban setting and balancing expectations with reality.

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AQUATIC ORGANISM PASSAGE (AOP) GUIDANCE

Ali Hangul

TDOT has been developing a new Aquatic Organism Passage Guidance to provide to designers. An extensive background effort has been substantially completed and current industry best practices identified. While many states developed guidance to address the same common goal, the progress and level of detail varied from state to state. While states like Washington focused on Salmon migration, designing low flow channels at specific depth limiting stream velocities to meet this, TN needs will be different focusing on smaller organisms like trout, darter, mussel, or salamander. The department's goal is to understand the needs and requirements for AOP during project development, starting with data collection, studying stream morphology, stream classification, size, bed slope, bank full dept and width, pool and riffle locations dimensions, grade control structures, bed material, then documenting the existing impaired conditions effecting a stream's health operation, undersized existing structures, encroachments to flood plains, eroded banks, lack of bank vegetation, outlet scour, excessive aggregation or degradation, debris loading, and head cuts. This would allow the proposed design to include improving conditions while also designing a stream crossing to adequately address individual project goals concerning AOP and water quality.

The presentation will share the current state of the work by sharing the background research, current practices, identified best practices, sharing examples of site assessment check lists, project objectives, draft decision matrix, selecting a design methodology (Geomorphic Simulation, Hydraulic simulation, hydraulic design), site and/or construction limitations and qualifications, replacement structure cost and long-term maintenance considerations and training needs.

POSTERS

Spatiotemporal analysis of flash flooding in Tennessee counties: 1996-2021
E. Afriyie and I. Luffman

Effectiveness of "living shoreline" bank stabilization methods as a solution for stormwater mitigation
J. Armitage

Understanding watershed history through a microsedimentological analysis of floodplain sediments in the Ocoee River, Tennessee
E. Butler, L. Davis, R. Lombardi, and M. Gage

Algal Toxins in the Shells and Sediments from Tennessee State University Wetland, Nashville, Tennessee
A. Cotton, D. Young, D. Moore, and T. Byl

Impacts of Microcystin-LR on Photosynthetic Productivity and Algal Community Structures in Center Hill Reservoir
T. Crawford

Did Algal Toxins Played a Role in the Death of Mosasaurs Found in the Upper Cretaceous Coon Creek Formation, Tennessee?
C. Cunningham, M. Gibson, N. Kelley, M. Bradley, J. Self-Trail, K. Gardner, K. Jabanoski, J. Oster, and T. Byl

Flood Early Warning Systems Using Machine Learning Techniques: The Case of the Cumberland River at Ashland City, Tennessee
G. Fordjour, G. Darkwah, and A. Kalyanapu

Using natural flood records to understand flood variability over long timescales
B. Gutierrez, L. Davis, R. Lombardi, and M. Gage

Preliminary occurrence and distribution of cyanotoxins in under-investigated, high-value locations in Tennessee
K. Hill and T. Kyl

Microplastics Sampling and Identification in Wastewater Treatment Plants around Middle Tennessee
C. Hitchcock, J. Murdock, and T. Datta

Increasing Diversity in the Geosciences through Community Projects such as Harmful Algal Blooms in Urban Environments
D. Moore, R. Archer, K. Hill, T. Byl

The Scientific Way to Soil Your Undies
B. Moyers, V. Vuong, A. Walker, S. Rosen, C. Vanags

Application of Triton-Lite, a Deep-learning Surrogate Model for Flood Risk Management
F. Nur, G. Darkwah, S. Gangrade, G. Ghimire, S.C. Kao, A. Kalyanapu

Shallow Water Depth Estimation in Inland Wetlands Using Landsat Imagery
C. Owusu and A. Kalyanapu

Third Creek Enhancement Initiative
M. Roark, M. Ross, and A. Ludwig

Surface and Ground Water Quality of the Snail Shell Cave Drainage Basin
J. Stem

Initiative Mapping Groundwater in the Mississippi Embayment System using a Random Forest Downscaling of GRACE
G. Williford

Microplastics in Urban Runoff
M. Woody

SPATIOTEMPORAL ANALYSIS OF FLASH FLOODING IN TENNESSEE COUNTIES: 1996-2021

Emmanuel Afriyie*[1] and Ingrid Luffman[1]

INTRODUCTION

Globally, flash floods are becoming the most disastrous natural hazard (Band et al., 2020; Zanchetta & Coulibaly, 2020; Linscott et al., 2022), with Tennessee having a long history of flash floods. It is imperative to look at trends to ascertain if there is a significant change in recent flood regimes versus past flood events in the face of climate change and variability. Trend Analysis and Emerging Hotspot Analysis are useful geospatial tools that can effectively display changes over time and space. The aim of this study is to evaluate spatiotemporal trends in flash flooding events and damages in Tennessee counties.

METHODS

A dataset of 2777 flash flood records covering all Tennessee counties from 1996-2021 was downloaded from the National Oceanic and Atmospheric Administration (NOAA). Two 26-year space-time cubes were built in ArcGIS Pro using an annual time step and with counties as the spatial unit. Trend Analysis and Emerging Hotspot Analysis was conducted to assess spatiotemporal trends in flash flooding events and damages (in dollars).

RESULTS AND DISCUSSION

Trend analysis revealed an increasing trend in flash flood events in two counties (Shelby and Madison) and a decreasing trend in ten counties (Anderson, Bedford, Cocke, Grainger, Fayette, Johnson, Lincoln, Montgomery, Stewart, and Warren), all at a 90% or greater confidence level (Fig. 1). Increasing trends in flash flood damages were identified in middle Tennessee (Davidson, Grundy, Jackson, Maury, Wilson, and Cumberland counties) and east Tennessee (Hawkins county). Decreasing trends were identified in Haywood and Fayette counties in the southwestern portion of the state.

Middle Tennessee was identified as a flash flooding hot spot with one new hot spot, a consecutive hot spot, and several sporadic hot spots (Fig. 2). A new hot spot is significant in the most recent time step only, while a consecutive hot spot is significant in several most recent time steps. A sporadic hot spot is a region identified as a hot spot in multiple discontinuous time steps, without an intermediate cold spot. The second map in Fig. 2 shows new hot spots for flash-flood-related damages in west-central Tennessee (Humphreys, Houston, and Benton counties). The new hot spot in Humphreys and surrounding counties (Fig 3) is likely a result of $100,005,000 damages associated with the Waverly flood on August 8, 2021.

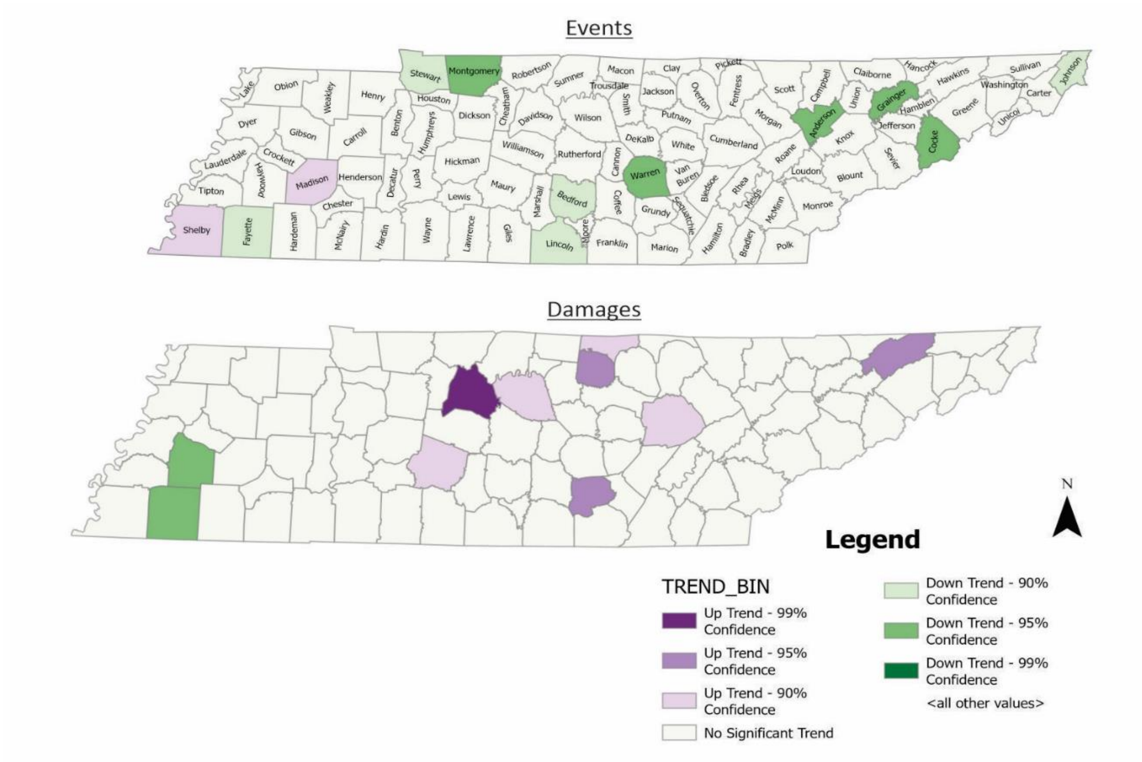

Fig. 1: Increasing and decreasing trends in Flash floods events and damages in Tennessee counties.

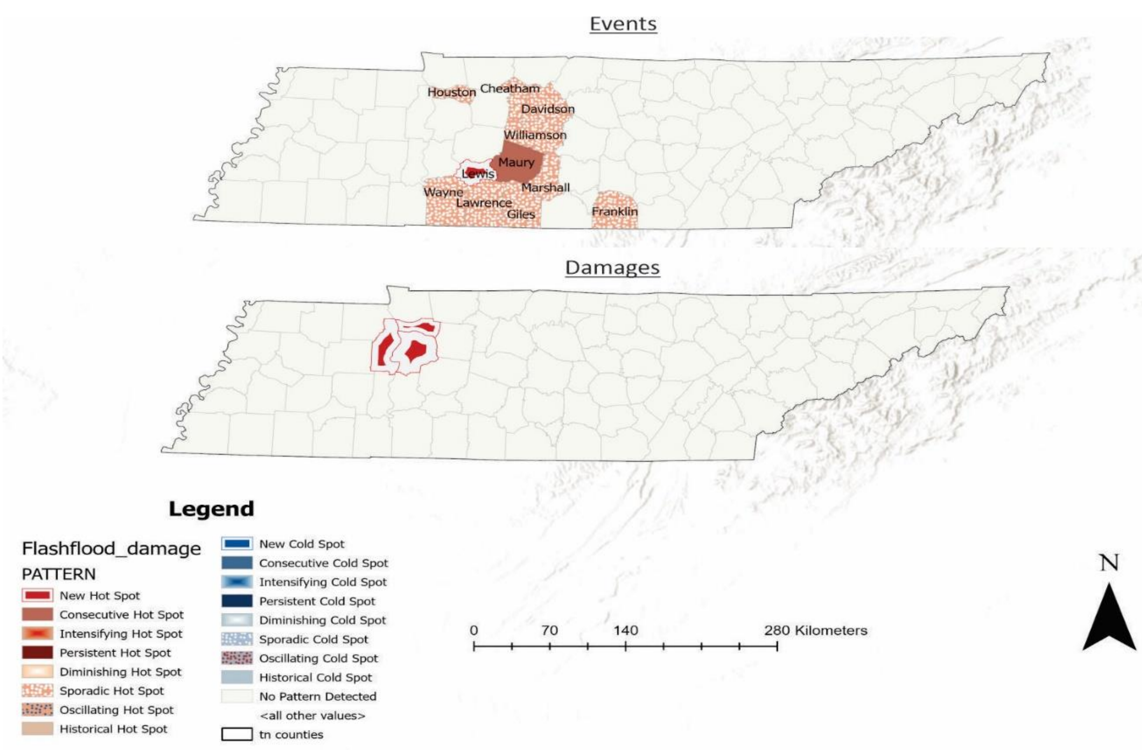

Fig. 2: Flash flood hazard events and property damage hot spots in Tennessee counties.

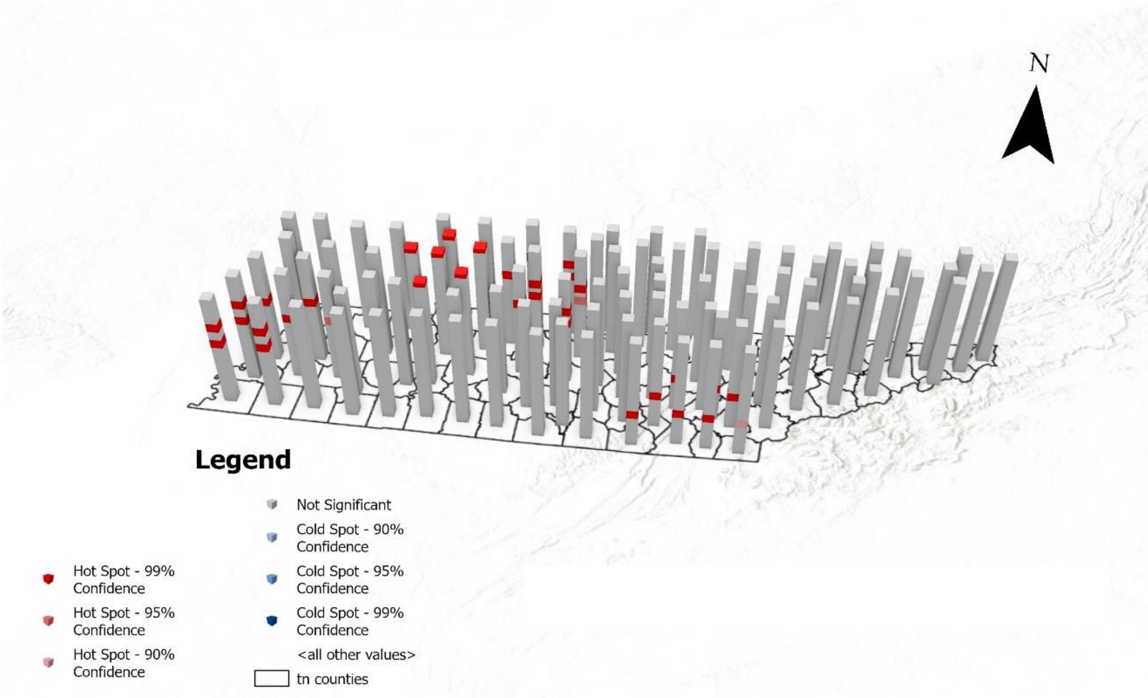

Fig. 3: Flash flood property damage hot spots in Tennessee counties in 3D

These results show that, while changes in the number of flash flood events by county is mixed (both increasing and decreasing) damages associated with these floods is increasing, particularly in middle Tennessee. However, these results may be skewed by the magnitude of damages for the Waverly floods in 2021, and omission of these outlier data may help to tease out additional lesser hot spots in other counties.

FUTURE DIRECTIONS

Tennessee's long and narrow shape results in many border counties, which can enhance boundary effects in spatial analyses. Adding flash flooding data for contiguous counties in neighboring states could help to assess and mitigate boundary effects. Further, examining each of the three regional divisions in Tennessee (East, Middle, and West) independently may be useful in teasing out minor trends and hot spots obscured by the magnitude of the 2021 events in middle Tennessee

This research is part of a larger study to evaluate meteorological hazards in Tennessee counties, including spatiotemporal trends in floods, flash floods, heavy precipitation events, and droughts. This study is an important step to better understand spatiotemporal trends in flash flooding and flash flooding damages. It will be useful in hazard mitigation planning in Tennessee at both the state and county levels.

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EFFECTIVENESS OF "LIVING SHORE" BANK STABILIZATION METHODS AS A SOLUTION FOR STORMWATER MITIGATION

Jaimie Armitage

The University of Tennessee has an off-site stormwater mitigation crediting program that capital projects on campus may participate in if they meet a specific set of requirements. Often, mitigation projects will be constructed in the form of green infrastructure that can take up large amounts of land area relative to overall campus size. Bank stabilization using "green" living shoreline methods will be assessed as an option for potential future mitigation projects as part of the stormwater mitigation crediting program. Erosion along the length of the Tennessee River is a major contributor to poor water quality. The contribution of total suspended solids (TSS) from a linear foot of eroding shoreline will be quantified and compared to that of a stabilized area using my proposed methods. The prevention of further increased levels of TSS in the Tennessee River will be equated to the typical amount of TSS that would be required to be removed from stormwater through the use of traditional green infrastructure. In addition to the prevention of water pollution, using living shoreline methods along the bank of the Tennessee River rather than the more conventional hard armoring methods will add functional aquatic and riparian habitat back to the shoreline, stop future loss of valuable land and increase overall aesthetics.

UNDERSTANDING WATERSHED HISTORY THROUGH A MICROSEDIMENTOLOGICAL ANALYSIS OF FLOODPLAIN SEDIMENTS IN THE OCOEE RIVER, TENNESSEE

Emma Butler[1], Lisa Davis[2], Ray Lombardi[3], and Matthew Gage[4]

Abstract: Sediment cores extracted from floodplains are archives of past environmental changes. We sampled and analyzed sediment cores from the Ocoee River in Tennessee (USA) to reconstruct past watershed changes. We examined Holocene environmental changes using high resolution (1 cm) mircosedimentological data, including particle size distributions and total inorganic and organic matter content. We used change point analyses and end member modeling of sediment characteristics to discern changes in sedimentation processes and patterns through time. Results of the microsedimentologic analyses demonstrated changes produced by river regulation, flood frequency changes, and prehistoric human settlement. These results show potential for detailed sedimentological analyses to help quantify fluvial response to a variety of human and natural watershed changes.

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[3] Assistant Professor, Department of Earth Sciences, University of Memphis

[4] Director, Office of Archeological Research, University of Alabama

ALGAL TOXINS IN THE SHELLS AND SEDIMENTS FROM TENNESSEE STATE UNIVERSITY WETLAND, NASHVILLE, TENNESSEE

Aaliyah Cotton[1*] , De'Etra Young[1], Devin Moore[1], and Tom Byl[1]

Beavers developed and expanded a series of wetland ponds on Tennessee State University's main campus in Nashville, Tennessee. This wetland system has experienced eutrophication and harmful algal blooms in recent years. In September of 2022, a serious drought dried a section of the wetland, leaving snail shells, algae and aquatic macrophytes (Myriophyllum) drying on the surface. Samples were collected and analyzed to determine if algal toxins concentrated in the dried detritus. A 14-inch soil core was also collected and cut into 1-inch sections and analyzed for toxins. The dried algae and shells contained microcystin toxin concentrations above 5 micrograms per gram dry weight. The soil cores ranged from a high of 1 microgram per gram sediment in the top two inches to a low of 0.17 micrograms per gram six inches below the surface. Ongoing research will determine if the toxins in the detritus and sediments can redissolve when water returns to the wetland.

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* Presenter

IMPACTS OF MICROCYSTIN-LR ON PHOTOSYNTHETIC PRODUCTIVITY AND ALGAL COMMUNITY STRUCTURES IN CENTER HILL RESERVOIR

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Microcystin-LR (MC-LR) is a hepatotoxin produced by a variety of bloom-forming cyanobacterial species that can lead to adverse health effects and death in aquatic species, livestock, pets, and humans. Despite numerous studies focusing on photosynthetic and zooplankton-grazing inhibition factors of MC-LR, little is known about the ultimate reasons for toxin production in cyanobacterial blooms. Understanding the ecological reasons for toxin production can help with the identification of ultimate causes and prediction of potential toxin occurrences in water bodies. We explored the ecological impacts of MC-LR on algal growth in competing non-cyanobacterial phytoplankton by measuring photosynthetic productivity and community composition responses. Mixed assemblages from the Center Hill Reservoir in central Tennessee were exposed to a combination of three levels of MC-LR, 0, 5, and 50 µg/L, and three levels of nutrients, no NO3 or PO4 added, 5mg/L NO3 and 1mg/L PO4, and 10mg/L NO3 and 1mg/L PO4, in order to create nine combinations of MC-LR and nutrient exposure. High concentrations were utilized to ensure maximum productivity in a nutrient-saturated system. Water samples were collected and tested to determine chlorophyll-α every other day during the incubation period. Additional water samples were collected before and after the incubation period and were filtered for chlorophyll-α and phycocyanin determination. Additionally, relative abundances, percent biomass, and particle counts of cyanobacteria, diatoms, green algae, and detrital matter groups were obtained via flow cytometry. Preliminary analysis suggests no relationships exist between MC-LR concentrations and photosynthetic productivity, general community composition, or nutrient uptake/release at concentrations of up to 50 µg/L MC-LR, regardless of ambient nutrient concentrations for already-eutrophic systems.

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DID ALGAL TOXINS PLAYED A ROLE IN THE DEATH OF MOSASAURS FOUND IN THE UPPER CRETACEOUS COON CREEK FORMATION, TENNESSEE?

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The Upper Cretaceous Coon Creek Formation (CCF) of western Tennessee has been designated a lagerstätte because of its exceptionally well-preserved and diverse assemblage of shallow marine fossils. Microfossils have been identified and confirm a Late Cretaceous (Campanian) age for this unit and include a combination of warm and cool-water calcareous nannoplankton. The occurrence of several mosasaur fossils and a plesiosaur fossil in close association at the type locality raises the question of what caused the death of multiple air-breathing marine reptiles in such proximity that they were preserved in the same small area of the seafloor. In modern ecosystems, marine vertebrate mass die-offs are often ascribed to red tide or harmful algal bloom (HAB) events. Mollusk shells, sediments, and microfossils from multiple horizons within the CCF were collected to test whether algal toxins may have played a role in the deaths of marine vertebrates at the site. Forty-two dinoflagellate cysts were identified in the mosasaur stratum and consist primarily of gonyaulacoid-peridiniods. Extant dinoflagellates from these groups are capable of producing several algal toxins. Scanning electron microscope images of the CCF mollusks have confirmed that they are exceptionally well-preserved, consisting of primary aragonite prisms and fiber, which suggests very little diagenesis of the shells has occurred. CCF shells and modern shells with and without known exposure to algal toxins were analyzed for three toxins: microcystin (MC), brevetoxin (BVT), and saxitoxin (SXT). The modern shells raised under clean conditions had no detectable toxins, but the shells exposed to BVT or SXT red tides were positive for their respective toxins. Fossil shells from the mosasaur stratum were positive for all three toxins, and filter feeding mollusks showed higher toxin levels than non-filter feeding taxa. The concentration range of SXT in CCF shells (0.18 to 4.1 ng/gram) was equivalent to modern SXT-exposed shells (0.12 to 5 ng/gram). The concentration range of BVT in CCF shells (0.09 to 0.41 ng/gram) was below the range of modern BVT-exposed shells (0.55 to >3 ng/gram). The BVT concentration range in the sediment strata ranged from less than 0.025 to 0.188 ng/gram. There was a linear correlation (slope = 0.0008) between dinoflagellate cysts and sediment BVT concentration (R-sq = 0.83). These preliminary results support the hypothesis that HABs may have played a role in the death of the large marine reptiles at CCF.

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FLOOD EARLY WARNING SYSTEMS USING MACHINE LEARNING TECHNIQUES: THE CASE OF THE CUMBERLAND RIVER AT ASHLAND CITY, TENNESSEE

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Flood disasters continue to be significant type of natural disasters worldwide, with their scope varying from neighborhood scale to continental scale. One of the important components for mitigating flood impacts is to have effective flood warning systems. These flood warning systems typically relied on conventional physically-based hydrologic and hydraulic models such as HEC-HMS and HEC-RAS models. More recently, Machine Learning (ML) techniques are applied either in conjunction with or in lieu of these conventional modeling systems. In this study, we present a flood early warning system based on machine learning methods and apply it on the Lower Cumberland-Sycamore (HUC 05130202) watershed near Nashville, TN, which is a part of the larger Cumberland River Basin. The model was designed to estimate water levels at the downstream Ashland City USGS gauge station (Station No: 03431790) in the Cumberland River basin. These ML techniques adapted in the model are Long Short-Term Memory (LSTM), Random Forest (RF), and Support Vector Regression (SVR). To perform the simulation, water level data from 12 USGS gauges (period of record: 2017 – 2021) within the watershed were used to train the model, test it, and predicted the water level at the target location (Ashland City Gauge Station) for one-day in the future. A comparative analysis indicated that the SVR algorithm and the LSTM methods (LSTM 1 and LSTM 2) outperform the RF method, based on the result of the floodwater level prediction. The Nash-Sutcliffe Efficiency (NSE) values for the LSTM 1, LSTM 2, SVR, and RF methods for the one-day-ahead prediction are 0.761, 0.733, 0.724, and 0.598, respectively. These results indicate that the LSTM and SVR machine learning techniques are reliable options for predicting flood-water levels due to their improved precision. As a result, when trained and tested with large datasets, these models exhibit promising performance for flood early warning systems.

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USING NATURAL FLOOD RECORDS TO UNDERSTAND FLOOD VARIABILITY OVER LONG TIMESCALES

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Extreme floods, floods with recurrence intervals of 100 years or greater, are thought to be caused by climatogical processes operating at centennial and millennial timescales, making most streamflow records too short for understanding them. Luckily, rivers are self-recording systems. The sediments stored in their floodplains and terraces contain long archives of flood and environmental histories. Flood information derived from natural records that pre-date the historical record are called 'paleofloods.' We analyzed paleoflood deposits captured in sediment core samples taken from a floodplain on the lower French Broad River near Kodak, Tennessee. These deposits were dated using radiocarbon dating, archeological artefacts, and optically stimulated luminescence. The particle size distribution and organic matter content were measured every 1 cm using a Bettersizer Laser Granulometer and loss on ignition, respectively. We combined several statistical models, including change point analysis, end member modeling, and LOESS regression to determine which flood deposits were deposited by extreme, large, moderate, and small floods. These analyses showed how flood frequency and magnitude changed through time in response to regional and global climate change processes and watershed scale changes. Paleoflood records provide a longer perspective of flood variability that span multiple hydro-climate regimes that are not accessible by other means. They are an underutilized source of hydrologic data that could be used to help forecast future flood occurrence under changing climate.

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PRELIMINARY OCCURRENCE AND DISTRIBUTION OF CYANOTOXINS IN UNDER-INVESTIGATED,HIGH-VALUE LOCATIONS IN TENNESSEE

Kristi Hill[1] and Thomas Byl[2]

Cyanotoxins (CT) are algal toxins produced by cyanobacteria during harmful algal blooms (HABs) and are of growing concern for public and environmental health. The mechanisms for distribution and release of CT in freshwater are not well understood, but their effect on major water sources can be detrimental. It is known that nutrient rich waters and warm temperatures tend to provide conditions conducive to HABs, and Tennessee is known for its long, warm summers and nutrient-rich run-off due to land development and agriculture. Middle Tennessee has abundant surface water and is composed of primarily limestone bedrock, resulting in a karstic subsurface (unconfined). Thus, surface water and groundwater resources may interact despite bodies appearing isolated at the surface. The U.S. Geological Survey, in collaboration with the Tennessee Department of Environment and Conservation, are investigating potential threats to drinking water and recreational reservoirs due to CT by collecting raw water and placing passive samplers (SPATTs) at water utility intakes in middle Tennessee and their hydrologic connections. The CT concentrations found in reservoirs with hydrologic connections are being compared to look for correlations to identify whether the toxin is moving throughout unconfined hydrologic units in the subsurface, and to determine whether they may be a threat to public supply and recreation in vital water bodies. Additionally, water-quality data are being collected in conjunction with collection of passive samplers to explore correlations in order to better understand possible relationships between water-quality parameters and toxin production in the algae.

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MICROPLASTICS SAMPLING AND IDENTIFICATION IN WASTEWATER TREATMENT PLANTS AROUND MIDDLE TENNESSEE

Caroline Hitchcock, Justin Murdock, and Tania Datta

Research shows that microplastics (MPs) are present ubiquitously in natural and drinking water systems. One of the possible sources of MPs are municipal wastewater treatment plants (WWTPs). Because of their key role in maintaining public health, WWTPs give insight into how much MPs are disposed by human activities, and if existing treatment plants can process these emerging pollutants. The goal of the research study was to address the inconsistencies present in other research methodologies by determining the efficacies of collection and preparation methods for MPs in wastewater. To accomplish this, samples were collected via grab, composite, and pump filtration from two WWTPs in middle Tennessee to be processed and analyzed. The facilities chosen for this study were selected to account for variables such as population density, hydraulic capacity, treatment processes, and receiving streams where wastewater effluent is discharged. Through experimentation, this study will process the samples using hydrogen peroxide oxidation and zinc chloride density separation. The future outcomes from analysis of the collected and processed samples using epifluorescence microscopy and Fourier transform infrared spectroscopy to quantify and identify MPs will give results to the adequacy of research methodologies for the overall goal of understanding the fate of MPs in WWTPs.

INCREASING DIVERSITY IN THE GEOSCIENCES THROUGH COMMUNITY PROJECTS SUCH AS HARMFUL ALGAL BLOOMS IN URBAN ENVIRONMENTS

Devin Moore[1], Reginald Archer[1], Kristi Hill[1,2], Tom Byl[1,2]

The geosciences are one of the least diverse of all the science and technology disciplines. Many agencies and university programs are trying to address this problem through scholarships and recruitment. These programs are helpful, but another avenue that would help recruiting would be to conduct more earth and environmental studies in under-represented communities. Going into the communities would increase awareness in the value and importance of geosciences. One example would be to develop a program to support research on harmful algal blooms (HABs) in urban waterbodies. Waterbodies in urban areas are a significant resource to the community serving as a focal point for social interaction and recreational activities such as fishing. Currently, there are no national, regional, and state programs that target HABs in urban waterbodies with the exception of a U.S. Environmental Protection Agency (EPA) program in Kansas. Tennessee State University (TSU), in partnership with the US Geological Survey (USGS) and Tennessee Department of Environment and Conservation, are conducting HABs research in urban ponds in Nashville, TN. Inspired by the various interactions of African American communities with urban waterbodies, the project seeks to increase water quality monitoring while increasing community engagement with USGS and the natural environment in an urbanized landscape. Preliminary monitoring found greater than 5 micrograms per liter concentrations of microcystin in wetlands draining an historically black neighborhood in north Nashville, which is greater than EPA's drinking advisory, and approaching the recreational water advisory. The project has successfully provided many excellent opportunities to connect with under-represented communities to discuss water quality issues, field work activities, and the geosciences. Also, leveraging the available resources at TSU and its status as a Historically Black College and University, planning with the Metro Nashville Parks Service is under way to expand the number of urban waterbodies to be included as this project moves forward.

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THE SCIENTIFIC WAY TO SOIL YOUR UNDIES

Victoria Vuong[1], Brianna Moyers[1], Alison Walker[1], Sydney Rosen[1], and Chris Vanags[1]

The benefits of healthy soil have gained increasing awareness, and the soil's microbiome is a key factor in maintaining soil health. Enhancement of soil microbiota has frequently been linked to improving soil health by promoting nutrient cycling, encouraging pollutant filtering, and increasing its water holding and carbon sequestration abilities. The function of the soil microbiome is reflected by soil respiration rates and soil organic carbon dynamics, but the process of tracking this is both costly and invasive, making it a difficult property to visualize and manage, particularly on a large scale. Proxies are a useful tool for overcoming these challenges, relying on practical, indirect measurements to inform more complex variables. Soil respiration proxies rely on the decomposition rates of leaf litter, teabags, and even cotton undergarments to provide a snapshot of soil's organic matter content and overall health.

In an effort to improve land stewardship and soil health awareness, we implemented the Soil Your Undies Challenge across Tennessee. Over 250 Tennessee residents volunteered to bury at least one pair of cotton underwear in their yards and gardens between August 2021 and November 2022. After 2 months of exposing them to carbon-degrading microorganisms, we asked participants to "harvest" their degraded undies and submit photos of them. We visually graded each of the harvested undies' decomposition levels to serve as proxies for soil health and organic matter content. To account for variation in undie images received and possible discrepancies in visual ratings, we designed a robust data collection strategy that reliably assigns decomposition rates using an image classification algorithm. To gain a thorough understanding of the processes connected to the burial, we implemented a smaller-scale study in which we buried six pairs of undies in varying soil environments across Vanderbilt's campus. We conducted in-depth biological analyses of their microorganism populations and respiration rates, and we examined the relationship between various physical and chemical properties of the soils and the degree to which the buried undies decomposed.

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APPLICATION OF TRITON-LITE, A DEEP-LEARNING SURROGATE MODEL FOR FLOOD RISK MANAGEMENT

Faria Nur[1], George Darkwah[2], Sudershan Gangrade[3], Ganesh R. Ghimire[3], Shih-Chieh Kao[3], and Alfred J. Kalyanapu[1]

In recent years, innovative modeling approaches such as machine learning applications are being developed to best use available data. The current study implements machine learning techniques to develop a surrogate model for an existing flood inundation model called TRITON (Two-dimensional Runoff Inundation Toolkit for Operational Needs). TRITON is a physics-based inundation model that solves full 2D shallow water equations through parallel computation using multiple graphics processing units. Despite TRITON's enhanced speed and accuracy, it may still be computationally expensive to implement a large-scale 2D hydrodynamic model. Though machine learning models may not capture large flood events, they may provide a sufficient and efficient approximation under most flow conditions. This study assesses the feasibility of developing a deep learning-based surrogate model named "Triton-Lite" that combines convolutional neural networks (CNN) and long short-term memory (LSTM) techniques to sufficiently approximate the outputs of TRITON. Triton-Lite is developed and tested for the Conasauga River Watershed located in southeastern Tennessee and northwestern Georgia, using existing ensemble TRITON simulations from prior studies. The trained surrogate model show maximum water depth error ranging from 0.1 m to 0.8 m and Mean Absolute Error (MAE) (per pixel) ranging from 0.03 m to 0.6 m. The output from Triton-Lite is expected to be informative enough to identify the need to trigger a full TRITON simulation during operation. Above all, Triton-Lite development shall perform a key role to improve the application of 2D hydrodynamic model simulations for effective flood risk management.

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SHALLOW WATER DEPTH ESTIMATION IN INLAND WETLANDS USING LANDSAT IMAGERY

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In wetlands, the timing and availability of water is a key determinant in wetland processes. The available water extent, depth, duration, and frequency of inundation greatly affect the quality of wildlife habitat and other functions wetlands provide in sustaining the ecosystem. The management of wetlands for optimal functionality can be improved with the ability to monitor and understand the spatial extent and depth distribution of inundation but this is hampered by the lack of monitoring systems at a fine resolution to generate sufficient information. To solve some of the challenges in obtaining information on wetland water depth over broad areas, this study used Landsat 8 imagery together with existing satellite-derived bathymetry (SDB) techniques and machine learning methods to generate a time series of water depths for ten selected wetlands in Kentucky in Google Earth Engine cloud computing platform. The SDB techniques used are the Lyzenga and Stumpf methods while the machine learning methods are the random forest and k-nearest neighbor regressor models. The water levels in the selected wetlands are being monitored using HOBO MX2001 water level loggers to assess the effectiveness of wetland restoration practices implemented by the Natural Resources Conservation Service (NRCS) under the Wetland Reserve Program (WRP). Our results show that the depth estimation methods employed yielded accurate results, with mean absolute errors (MAE) between 0.13 – 0.28 m for depths 0 – 3 m but performed satisfactorily in deep waters for depths 3 – 7 m with MAE of 1.10 – 1.25 m. The results obtained affirm the potential of using satellite imagery to estimate shallow water depths in wetlands in helping to address some of the challenges of wetland research and management.

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THIRD CREEK ENHANCEMENT INITIATIVE

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The University of Tennessee in Knoxville, TN lies within the watersheds of two urban streams, Second and Third Creek. Like many urban waterways, both creeks are heavily impacted by a myriad of pressures. Over time anthropogenic and economic influences have resulted in the contamination and degradation of Second and Third Creek. A leading source of this contamination is stormwater runoff from rooftops and pavement, which may be a direct conduit of pollution into these waterways. Due to the intense pressures that contribute to contamination and the increased rate of water movement, Second and Third Creek are also facing complications such as low biodiversity and stream bank erosion. Moreover, as time progresses and these concerns still need to be addressed, the concern by local leaders over public perception and usability of Second Creek, Third Creek, and their associated greenways has risen. These impending complications led the University of Tennessee to initiate the revitalization and stabilization efforts towards Second Creek. Over the last few years, the University of Tennessee and its Knoxville city partners have worked aggressively to restabilize and vegetate the portion of Second Creek that runs through the University of Tennessee. Now, the Third Creek Enhancement Initiative proposes an extension of the efforts bestowed upon Second Creek to remediate Third Creek and its greenway. Approximately, two miles of Third Creek runs through the University of Tennessee's campus, offering an opportunity for the university to further demonstrate its sustainable and innovative values and practices. Through the refinement of Third Creek's community spaces, ecological functions, and recreational opportunities, the University of Tennessee can restore Third Creek as a refined, expanded green space for its campus.

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SURFACE AND GROUND WATER QUALITY OF THE SNAIL SHELL CAVE DRAINAGE BASIN

Jonathan Stem

Karst watersheds are prone to contamination due to soluble limestone that forms caves, sinkholes, and sinking streams. These features allow surface water contaminants to flow rapidly into the groundwater system, with little natural attenuation. Groundwater contamination often occurs when urban and agricultural land uses intersect with karst features. In this study, groundwater and surface water quality was monitored in the Snail Shell Cave drainage basin, slightly west of Murfreesboro, Tennessee. The drainage basin consists of rural pasture and farmland in the southwestern portion. With a rapidly growing urban and residential land to the northeast. Murfreesboro city limits keep progressing towards the cave system. The city limits are now less than two miles away from the main entrance to the cave. Eleven sampling sites were chosen across the basin and water samples were collected at various karst water features. Two rounds of sampling were conducted, one immediately after a 5-cm rain event in June, and the second during base flow conditions in September of 2022. The parameters tested for include E. coli, Oil/ Diesel range organics (ORO/DRO), Nitrate, and Phosphate. The average concentration of E. coli doubled from 736 MPN at base flow conditions to 1319 MPN after a 5-cm rain event. After the 5-cm rain event, four of the sites exceeded the TDEC criteria for E. coli for a single sample maximum (941 MPN per 100ml). At baseflow conditions, only one site exceeded the E. coli criteria. Oil and diesel range organics slightly increased after the 5-cm rain event. Results from this study show that karst groundwater quality is highly impacted by runoff after rain events. Future studies would be beneficial to better understand contamination sources and the fate of these contaminants in the local area.

MAPPING GROUNDWATER IN THE MISSISSIPPI EMBAYMENT SYSTEM USING A RANDOM FOREST DOWNSCALING OF GRACE

George M. Williford[1]

Monitoring and conservation of groundwater are matters of ever-increasing importance, as the demands of agricultural irrigation, urban life, and industrial extraction continue to deplete this resource. The Mississippi Embayment aquifer system is one of the principal systems in the United States, yet detailed mapping of groundwater in the region is lacking. With the advent of remote sensing platforms like the Gravity Recovery and Climate Experiment (GRACE), we have a means of studying large-scale water storage with an accuracy error of less than 1cm. Yet despite GRACE's accuracy at this scale, its implementation for local water resource management has been hindered by its coarse spatial resolution ($111km^2$, or roughly 1˚). While there have been numerous efforts, both statistical and dynamic, at downscaling GRACE data to date, this study chooses to adopt a random forest machine-learning model, which has shown promise in other studies and has the advantage of accommodating multiple input variables, while being less prone to overfitting than other regression models. With hydrologic variables gathered from the Global Land Surface Assimilation System (GLDAS) (precipitation, runoff, soil moisture, snow water equivalent), as well as measures of vegetation coverage and evapotranspiration, the downscaling brings the resolution of the GRACE groundwater storage (GWS) data from 1◦ to 0.25◦ (approximately $25\ km^2$), yielding monthly maps from January 2003 to December 2016. USGS monitoring well data, in situ measurements, and geophysical logs are then consulted to validate the GRACE observations and to infer the presence of water-bearing strata. The goal of this mapping is to serve as a reference for groundwater vulnerability and to aid in determining the spatio-temporal characteristics of long-term water storage trends for regional resource management.

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MICROPLASTICS IN URBAN RUNOFF

Meggie Woody

Microplastics (MPs) are fragments of plastic ranging from five millimeters to one micrometer. They can be categorized as either primary, designed, or secondary, result of shed from larger plastic materials. MPs have been detected in various environmental settings with no particular source. Samples are currently being collected from various locations with the purpose of characterizing microplastics and nanoplastics. Additionally, evaluation of urban green infrastructure is being conducted with regards to what control they might possess.