

2026 Kentucky Water Resources Annual Symposium



September 18, 2026

Central Bank Center – Lexington, KY

 **Kentucky Water
Research Institute**

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2026 Symposium Partners



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Save the date March 24 2027 Kentucky Climate Symposium

*Co-organized with Kentucky Climate Consortium
UKY Gatton Student Center*

Our Mission

TFISE's mission is to support and spotlight transdisciplinary research that yields sustainable solutions to environmental problems and issues facing the Commonwealth, the region, the nation, and the world.



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The Kentucky Geological Survey (KGS) supports Kentucky's prosperity and resilience by advancing geological research, delivering unbiased data, and engaging the public with knowledge that strengthens communities and the University of Kentucky.



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Plenary Session

USGS Priority Research in Aquatic Ecosystems: Invasive Threats, Endangered Species, and Emerging Contaminants

*Jeff Steevens, Research Toxicologist and Director (Acting), U.S. Geological Survey
(USGS), Columbia Environmental Research Center*



Dr. Jeff Steevens is the acting Center Director and a Research Toxicologist at the Columbia Environmental Research Center in Columbia, Missouri. His research interests include the bioavailability and toxicity of environmental contaminants in water and sediments. One of his current responsibilities is leading a multidisciplinary team to determine the toxicity of contaminants of interest to the Department of the Interior, including algal toxins, critical minerals, PFAS, and tire-wear chemicals. He also leads the USGS PFAS Integrated Science Team, conducting studies on the fate, transport, and toxicology of this class of chemicals.

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September 18, 2026
Central Bank Center, Lexington, Kentucky

8:00 AM - 8:30 AM Registration (Coffee Break)

8:30 AM - 9:20 AM Plenary Session

Meeting Rooms 10 & 11

8:30 AM Welcome and Introductions

Jason Unrine, Director, KWR

8:40 AM USGS Priority Research in Aquatic Ecosystems: Invasive Threats, Endangered Species, and Emerging Contaminants

Jeff Stevens, Research Toxicologist and Director (Acting), U.S. Geological Survey, Columbia Environmental Research Center

9:10 AM Q & A

9:20 AM - 10:40 AM Session 1

Meeting Rooms 12, 13, & 14

Track 1A · Room 12

Flooding and Karst

Moderator: Md Jiad Ur Rahaman

9:20 AM Causes and Challenges of Karst Flooding

Charles (Chuck) Taylor, UK

9:40 AM Evaluating the Influence of Monitoring Well Density and Hydrologic Conditions on Potentiometric Surface Mapping in a Karst Aquifer

Quade Miles, WKU [Student]

10:00 AM Developing Partnerships and Monitoring Networks for Flooding, Water Quality, and Stormwater Management to Enhance Community Resilience

Jason Polk, WKU

10:20 AM Developing an Integrated Flood Modeling Approach for FEMA Floodplain Mapping in Karst Watersheds

*Alex Sitz, WKU [Student, 104(b)]
Lorenzo Moreno, WKU [Student]*

Track 1B · Room 13

Drinking Water

Moderator: Donna McNeil

9:20 AM Environmental Toxicity of Halogenated Cyclopentadienes: An Emerging Class of Water Disinfection-By-Products

Ryan St. Clair, UK [Student]

9:40 AM Extending Water Distribution Quality Models to the General Public Through the Use of Serious Gaming

Lindell Ormsbee, UK

10:00 AM Modeling the Formation of Trihalomethane Species in Water Distribution Systems

Hadley Burchett, UK [Student]

10:20 AM Source to Tap: Practical Tools for Understanding Source Water Data

Alicia Jacobs, & Raymond Banks, Kentucky American Water

Track 1C · Room 14

Ecology and Restoration

Moderator: Nathan Weber

9:20 AM Roots Over Reconstruction: Comparing Hydrologic Function in Urban Riparian Zones

Abigail Davidson, UK [Student]

9:40 AM Caddisflies (Insecta: Trichoptera) of the Kentucky River Palisades: a Biological Refugium in the Inner Bluegrass Region of Central Kentucky

*Michael Floyd, US Fish and Wildlife Service
Michael Compton, Office of KY Nature Preserves*

10:00 AM Validation of Gastric Lavage as a Non-Lethal Method for Diet Assessment in the Cumberland Arrow Darter (*Etheostoma sagitta*) with Implications for Imperiled Congeners

Travis Lowe, Appalachian Technical Services [Student]

10:20 AM Comparing a Regulatory Approach to Ecological Assessment-evaluating Stream Quality and Function in a Headwater Watershed

Emma Bell, WKU [Student]

10:40 AM - 11:00 AM Break

11:00 AM - 12:00 PM Session 2

Meeting Rooms 12, 13, & 14

Track 2A · Room 12**Climate and Land Use**

Moderator: Donna McNeil

11:00 AM Political Winds and Climate Work: What Shapes Priorities of Public University Climate Entities
John McMaine, UK

11:20 AM Small Towns, Big Impacts: Impervious Cover Patterns Across Rural Kentucky
Myranda Heriges, UK

11:40 AM Assessing Kentucky River's Water Budget through Hydrological Modeling
Zayed Bin Saif, UK [Student]

Track 2B · Room 13**Soils and Groundwater**

Moderator: Kimia Khanlari

11:00 AM Monitoring Water Infiltration in Shallow Karst Environments Using Time-Lapse 3D Electrical Resistivity Imaging
Bronson McQueen, UK [Student]
Junfeng Zhu, UK

11:20 AM Unraveling Long-term Soil Management Impacts on Soil Water Dynamics
Md Jiad Ur Rahman, WKU [Student]

11:40 AM Strengthening Soil Hydraulic Function Through Sustainable Agricultural Management
Sandesh Kumar, WKU [Student]

Track 2C · Room 14**Pathogens and Sanitation**

Moderator: Nathan Weber

11:00 AM Occurrence of Phenotypic Multidrug-Resistant E. coli in Kentucky Surface Waters and Evaluation of Potential Sentinel Antibiotics for One Health Surveillance
Jason Marion, ECU

11:20 AM Microbial Source Tracking in an Urban Watershed: The Utility of Long-Term MST Monitoring
Christopher Kephart, USGS

11:40 AM The Environmental Surveillance Center for Assessing Pathogen Emergence (ESCAPE): Enabling Wastewater Surveillance for All
Soroosh Torabi, UK

12:00 PM - 1:00 PM Awards Luncheon

Meeting Rooms 10 & 11

1:00 PM - 2:20 PM Session 3

Meeting Rooms 12, 13, & 14

Track 3A · Room 12**Flooding**

Moderator: Md Jiad Ur Rahman

1:00 PM Flooding in Appalachian Streams and Headwaters (FLASH) Middle School Curriculum: Collaborative Development and Delivery of Community-Engaged, Place-Based, Hands-On Learning Experiences
Katherine Bullock, UK

1:20 PM Everybody Learns: A Scoping Review of Participatory Approaches to Flash-Flood Preparedness
Daniel Bullman, UL [Student]

1:40 PM Monitoring Headwater Streams in the Kentucky River Basin: Challenges, Opportunities, and Successes
Lindsey Barnes, UL

2:00 PM Geomorphological and Hydro-Climatic Drivers of Flow Regime Signatures in Appalachian Headwaters
Hasan Taylan, UL [Student]

Track 3B · Room 13**Toxic Contaminants**

Moderator: Sandesh Kumar

1:00 PM Multi-Endpoint Characterization of PFOA and PFOS Toxicity in *Caenorhabditis elegans*
Lucca Madeo Cortarelli, UK [Student]

1:20 PM Assessment of Heavy Metals from Stormwater and Sedimentation in Class V Injection Wells in Urban Karst Groundwater Systems
Riley Summers, WKU [Student]

1:40 PM Coupled Hydrological Transport Dynamics of Microplastics and Heavy Metals in Karst Groundwater Systems
McKenzie Bertsch, WKU [Student]

2:00 PM Prevalence and Source Tracking of Perfluoroalkyl and Polyfluoroalkyl (PFAS) Substances In Kentucky Karst Groundwater Systems
Jason Polk, WKU [104(b)]

Track 3C · Room 14**Sediment**

Moderator: Isaac Oluk

1:00 PM Sediment Fingerprinting in Maysville, KY
Jackson Clark, UL [Student, 104(b)]

1:20 PM Catchment Size and Urbanization Shape Sediment Concentration-Discharge Hysteresis Loop Concavity More Than Direction
Arlax Marin-Ramirez, UL [Student]
Tyler Mahoney, UL

1:40 PM Seasonal Storm Controls on Turbidity in an Urban Watershed: Implications for Sediment Best Management Practice (BMP) Design
Andrew Day & Angelina Rangel, UL

2:00 PM Landslide Susceptibility Mapping in Martin, Pike, and Floyd Counties Using an XGBoost Machine-Learning Model and GIS
Utkarsha Basnet, KYSU [Student]

2:20 PM - 3:30 PM Poster Session

Meeting Room 9 & Hallway Corridor

- #1** Building a Community Resilience Framework Amid Flash Flooding in Letcher County, KY- Cassidy Haynes, UL [Student]
- #2** A Retrospective Environmental Assessment of Metropolis Lake (Kentucky): Quantifying Industrial Contaminant Fluxes and Inventories Using Sedimentary Records - Mary Covell, UK [Student]
- #3** The Use of Generative AI in the Prediction of TTHM and HAA5 in Water Distribution Systems - Keren Keener, UK [Student]
- #4** Conceptual Model Displays Seasonality of Dissolved and Sedimentary Carbon Fluxes in South Elkhorn Creek, Lexington, Kentucky - Joseph Ammons, UK [Student]
- #5** Detecting Groundwater-Level Change in the Jackson Purchase Region Using Ambient-Noise Interferometry from the CLIMBS Seismic Array - Md Mohimanul Islam, UK [Student]
- #6** High-Resolution GIS-Based Delineation of Sinkhole Catchments and Karst Relic Streams in the Inner Bluegrass Karst Terrane - Matthew Carmichael, UK

- #7 High-Resolution Sediment Modeling in Southeastern Kentucky Affected by Climate Variability - Nabil Al Aamery, UK [Student]
- #8 Water Quality Monitoring Through Metagenomics in Karst Agricultural Watersheds: Case Study of Camden Creek, Kentucky - Rose Mburu, UK [Student, 104(b)]
- #9 Hydrologic Modeling to Predict Flash Flood Events Under Future Rainfall Extremes and Scale Dependence in the Appalachian Region - Sarah Holt, UK [Student]
- #10 Investigating the Autogenic Diel Cycle of Sediment Transport for 84 Sites Across the Continental US - Melissa Beckman, UK [Student]
- #11 Investigating Velocity Distributions and Turbulence Structures in a Karst System - Matthew Lynch, UK [Student]
- #12 Streambank Aggradation and Degradation in a Karst Landscape - Quinn Rison, UK [Student]
- #13 Predicting Flash Flood Risk in Eastern Kentucky Using Headwater Stream Data - Evan Meyers, UK [Student]
- #14 Relationships Between Water Quality Indicators and Flooding in Southeastern Kentucky - Emelia Harris, UK [Student]
- #15 Quantifying the Hydraulic Performance of Aging Bioretention Cells - Patrick Faust, UK [Student]
- #16 Life Cycle Assessment of Urban Tree Soil Cells as Green Stormwater Infrastructure: Environmental Trade-offs and Long-Term Benefits - Kimia Khanlari, UK [Student]
- #17 The Effects of PFAS Loading on Biogeochemical Cycling, Fate, and Transport in Wetlands - Dylan McPeake, UK [Student] [104g]
- #18 Layered Flood Risk and Community Knowledge in Appalachian Kentucky and West Virginia: Using FEMA's National Risk Index to Inform Public Health Preparedness - Daniel Bullman, UL [Student]
- #19 A Numerical Investigation on the Rainfall-Induced Soil Saturation and Runoff Generation in the Appalachian Region - Shahriar Mardpour, UL [Student]
- #20 Quantifying Bias in Field Discharge Measurements and Stage-Discharge Hysteresis across CONUS - Franklin Kondum, UL [Student]
- #21 Evaluating Hybrid Differentiable Hydrologic Models for Sub-Daily Flash Flood Prediction - Arlex Marin-Ramirez, UL [Student]
- #22 Estimating Rating-Curve Parameters for Small Headwater Streams Using Watershed Attributes and Channel Geometry - Ridwan Nur, UL [Student]
- #23 Evaluating Gravity and Mechanical Filtration in Coupled Aquaponic Systems - Sandrine Umutesi, KYSU [Student]
- #24 Spatial Mapping of Soil Nutrient Distribution in Reclaimed Mine Sites - Seema Adhikari, KYSU [Student]
- #25 Fluvio-karst Dissolved Carbon Concentrations and Isotopic Ratios show Seasonal Variations Evidenced by Empirical Mode Decomposition and Isotope-Aided Modeling - Brenden Riddle, MSU
- #26 Palustrine Wetland Soil Carbon and Nitrogen Content Post-Wetland Reserve Easement Enrollment in the Northern Mississippi Embayment, Kentucky - Kayla Dunaway, UK
- #27 eDNA Metabarcoding-Based Microbial Diversity Profiling of Urban Streams in the Inner Bluegrass - Ben Brammell, Asbury University [104(b)]
- #28 Edge-of-Field Monitoring of Nutrient and Sediment Loss from Wetland Watersheds: The First Conservation Effects Assessment Program Project in Kentucky - Glynn Beck, UK
- #29 The Kentucky Geological Survey's Kentucky Groundwater Observation Network - Bryce Fleck, UK, Glynn Beck, UK
- #30 Investigating the Use of a Lignin-Derived Deep Eutectic Solvent for Nonsolvent-Induced Polymeric Membrane Fabrication - Jake Childress, UK [Student]
- #31 Hydrogeologic Tracing to Improve Karst Watershed and Floodplain Planning for Jennings Creek, Kentucky - Noah Jennings, WKU [Student]
- #32 Impact of Habitat Parameters on Macroinvertebrates - Liam Barker, NKU [Student], Kristy Hopfensperger, NKU
- #33 Jennings Creek/Lost River Karst Watershed Plan Outcomes in Warren County, Kentucky - Olivia Orner, WKU [Student]
- #34 Modeling Chlorine Decay Dynamics in Water Distribution Systems - Martins Afolayan, UK [Student]
- #35 Links Between Stream Stability, Habitat and Watershed characteristics - Abigail Todd, NKU [Student], Kristy Hopfensperger, NKU
- #36 A Real-Time Flood Monitoring Dashboard for Kentucky Communities to Bridge Data Sources and Develop Flood Awareness - Jovana Hernandez, UL [Student], Duncan Howard, UL [Student]
- #37 Accuracy Assessment of Drone-Based Lidar Measurements in Edge-of-Field Monitored Agricultural Watersheds - Leigha Eggett, UK
- #38 Development of an Ecosystem Concept Model for the Ohio River for Integration into a HAB Prediction Model - Jordan Spears, UK [Student]

3:30 PM - 4:40 PM		Session 4	<i>Meeting Rooms 12, 13, & 14</i>
Track 4A · Room 12 Flooding <i>Moderator: Sandesh Kumar</i> 3:30 PM Modeling Rainfall-Driven Infiltration and Runoff Generation Using a Validated Coupled TCA-Philip Framework <i>Mir Ali Hosseini, UL [Student]</i> 3:50 PM Beyond Streamflow Accuracy: Constraining Baseflow to Improve Process Representation in Differentiable Hydrologic Models <i>Salil Sharma, UL [Student]</i> 4:10 PM What Matters Most for Predicting Streamflow Regimes in Headwater Systems: Model Structure, Calibration, or Machine Learning? <i>Franklin Kondum, UL [Student]</i> 4:30 PM Quantifying Headwater Contributions to Downstream Discharge Across Dynamic Stream Networks: Insights From a Process-Based Hydrologic Model <i>Ridwan Nur, UL [Student]</i>		Track 4B · Room 13 Nutrients <i>Moderator: Isaac Oluk</i> 3:30 PM From CONUS to Kentucky: USGS Models for Streamflow Drought, Stream Temperature, and Watershed Nutrients <i>Jeremy Diaz, USGS</i> 3:50 PM Protecting the Source: Monitoring and Modeling Source Lake Water Quality for Central Kentucky Distilleries <i>Katherine Ristola, UK [Student]</i> <i>Tiffany Messer, UK</i> 4:10 PM Nutrient Recovery Rates from Low-Cost Mineralization Methods <i>Ilerioluwase Rhema Oyedele, KYSU [Student]</i> 4:30 PM Insights into Sustainable Nitrogen Waste Management through Biological Denitrification <i>Sagun Chhetri, KYSU</i>	
		Track 4C · Room 14 Mining <i>Moderator: Kimia Khanlari</i> 3:30 PM Depth-Wise Assessment of Soil Health in a Recently Reclaimed Mine Site in Eastern Kentucky using statistical and spatial analysis. <i>Seema Adhikari, KYSU [Student]</i> 3:50 PM Rare Earth Element Enrichment in Acid Mine Drainage Precipitate Across a Watershed Treatment and Reclamation Gradient: Insights from Wolf Creek, Eastern Kentucky. <i>Amos Akwemoh, KYSU [Student]</i> 4:10 PM Flood Susceptibility & Predictability: FEMA Benchmarking in a Mountaintop Mining Watershed, Eastern Kentucky using Machine Learning Approach <i>Asmita Satya, KYSU [Student]</i> 4:30 PM Evaluating Ecohydrological Recovery and Water-Use Efficiency of Replanted Native Trees on Geologically Ripped Mine Lands: A Combined EC and NISAR Inversion Approach <i>Ife Familusi, KYSU</i>	
4:50 PM - 5:00 PM		Student Awards	<i>Meeting Room 9</i>
5:00 PM		Adjourn	

Past Recipients of Institute Awards

William Barfield Award for Outstanding Contributions in Water Resources Research

Mark Nelson (2026)	Dibakar Bhattacharyya (2015)
Alan Fryar (2025)	James C. Currens (2014)
Jason Polk (2024)	Art Parola (2013)
Christopher D. Barton (2023)	Andrew Ernest (2012)
Lindell Ormsbee (2022)	James Dinger (2011)
Carmen Agouridis (2021)	Alice Jones (2010)
Chris Groves (2020)	Sylvia Daunert (2009)
Jimmy Fox (2019)	Gail Brion (2008)
Susan Hendricks (2018)	David White (2007)
Jim Kipp (2017)	Wes Birge (2006)
Stephen F. Higgins (2016)	Don Wood (2005)

Lyle Sendlein Award for Outstanding Contributions in Water Resources Practice

Jennifer Carey (2026)	Steven K. Hampson (2016)
Donna McNeil (2025)	Richard Warner (2015)
David Hamilton (2024)	Derek R. Guthrie (2014)
Roger Recktenwald (2023)	Sandra Gruzesky (2013)
Peter Goodman (2022)	Michael Griffin (2012)
Kurt Mason (2021)	Linda Bridwell (2011)
Richard Walker (2020)	Greg Heitzman (2010)
Jack Stickney (2019)	Susan Bush (2009)

PAST RECIPIENTS

Barry Tinning (2018)

Steve Reeder (2008)

Lynn Jarrett (2017)

Bill Grier (2007)

Jack Wilson (2005)

Robert A. Lauderdale Award for Outstanding Contributions in Water Quality

E. Glynn Beck (2026)

Paulette Akers (2016)

Steven Evans (2025)

Dale Reynolds (2015)

Tom “Fitz” FitzGerald (2024)

Brian C. Reeder (2014)

Tom Biebighauser (2023)

H. David Gabbard (2013)

Christopher Lorentz (2022)

Henry Francis (2012)

Russ Turpin (2021)

Amanda Gumbert (2011)

John Webb (2020)

Malissa McAlister (2010)

Maggie Morgan (2019)

Bruce Scott (2009)

Charles Martin (2018)

Ken Cooke (2008)

Amy Sohner (2017)

Judith Petersen (2007)

Eddie Foree (2006)

Session 1A: Flooding and Karst

Causes and Challenges of Karst Flooding

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Flooding in karst terrains differs fundamentally from flooding in non-karst areas. In typical riverine systems, flooding results from surface runoff exceeding open-channel capacity, which can be relatively easily measured and modeled using standard rainfall-runoff methods. In karst, however, flooding is governed by complex interactions between surface runoff and flow through subsurface conduit networks that cannot often be easily observed, measured, or modeled. While surface drainage at individual sinkholes and sinking streams may be contributing factors, the geometry (or internal “plumbing”) and overall hydraulic characteristics of underlying conduits are often the dominant controls that often determine whether water remains underground or backs up, causing flooding.

Without information obtained by proper hydrogeologic characterization, flooding in karst areas can appear unpredictable and unmanageable. Quantitative dye-tracing tests, groundwater level and spring discharge monitoring, and analysis of karst basin rainfall-runoff responses provide critical data needed to estimate conduit hydraulic properties, identify flood triggers, and help design effective mitigation strategies. Surface geophysical survey data are also helpful in identifying probable conduit locations, depths, and interconnections.

Many of the causes and challenges of karst flooding are illustrated by the City of Burgin in Mercer County, Kentucky, where severe flooding occurs when rapid or prolonged stormwater inflow overwhelms the underlying conduit drainage network. Ongoing investigations by the Kentucky Geological Survey are collecting data needed to fully characterize the hydrogeologic framework and drainage capacities of the karst conduit system beneath Burgin. Our study is also being conducted to help identify and test the flood mitigation strategies best suited for this unique karst setting, including possible use of dewatering wells to extract water from conduits during storm events.

Evaluating the Influence of Monitoring Well Density and Hydrologic Conditions on Potentiometric Surface Mapping in a Karst Aquifer

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Potentiometric surface maps are widely used to characterize groundwater flow directions, identify groundwater divides, and support water resource management in karst aquifer systems; however, developing accurate water table maps is labor-intensive and often requires water level measurements from a large number of monitoring and injection wells, along with natural features, collected over a short time period. This study evaluates how injection well and feature density influences the accuracy of potentiometric surface mapping and seeks to identify the ideal spatial distribution and quantity of data points needed to produce accurate mapping. Water-elevation measurements from injection wells, springs, and cave and surface streams, within the Lost River, Jennings Creek North, and Jennings Creek South groundwater basins was used to develop potentiometric surface maps representing contrasting hydrologic conditions, including wet and dry seasons. Geographic Information Systems (GIS) interpolation techniques were used to generate water table surfaces with varying spatial monitoring densities to quantify changes in map accuracy and groundwater flow interpretation. Comparisons between groundwater basins will assess the consistency and clarity of inferred groundwater divides under varying hydrologic conditions. Statistical analyses evaluate agreement among maps produced using different monitoring densities and seasonal datasets. Results will provide guidance for optimizing groundwater monitoring networks by identifying the minimum monitoring density required to produce reliable potentiometric surface maps while reducing field effort and project costs. The findings will improve understanding of spatial and temporal variability in groundwater flow within karst systems and support more efficient groundwater characterization and management.

Developing Partnerships and Monitoring Networks for Flooding, Water Quality, and Stormwater Management to Enhance Community Resilience

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This project is intended to serve the residents, businesses, and visitors of Bowling Green and Warren County, Kentucky to help better understand and manage stormwater and groundwater resources in the context of the unique karst environment upon which its developed, including underground streams, springs, and sinkholes that contribute to complex issues involving stormwater runoff, flooding, and groundwater quality. Recent flooding in spring of 2025 caused headlines due to the repeated, widespread, and intensive occurrence of flood events across the state. Collectively, these events highlight the urgent need to improve floodplain mapping and hazard response adapted to the area's unique karst hydrogeology to ensure proper flood insurance coverage and risk designations, and to protect property and life in these watersheds. Recent studies also found that current FEMA floodplain mapping methods do not include up to 50% of infrastructure in karst areas and nearly 80% of the home losses were not included in flood risk maps in Kentucky. Developing a solution for this issue will be useful in both local and regional contexts given the scale of karst landscapes across the County subject to FEMA floodplain mapping that could likely be improved with enhanced monitoring and modeling methods. The goals of this initiative are to improve monitoring, modeling, and mapping of the area's stormwater and groundwater systems toward deliverables that enhance management and mitigation of current and future water resource risks., while serving as a scalable model for other communities. Providing accurate and real-time data allow for the development of effective and accessible environmental educational materials and datasets, which, if executed correctly, can ameliorate environmental degradation over time and improve hazard awareness. Thus, to fill the existing void in public knowledge about karst landscapes and, subsequently, mitigate the ever-increasing instances of karst stormwater and groundwater impacts in the region, developing an environmental monitoring network and integrating datasets into real-time dashboards and outreach is a novel and effective way to mitigate current and future issues, while leading the way across the state in utilizing this approach. A joint effort between the City, County, and WKU CHNGES to address these pressing issues using modern technology and the best available data demonstrates a proactive and collaborative approach to advance knowledge, support sustainable community development, and standardize methods for managing groundwater and stormwater challenges unique to the region. Specific outcomes include the development and expansion of a real-time water quality and flood monitoring network, public dashboard with informational materials and datasets, improved floodplain modeling and mapping, and improved understanding of the local karst terrain and its role in groundwater quality and quantity, along with enhanced flooding and stormwater awareness.

Developing an Integrated Flood Modeling Approach for FEMA Floodplain Mapping in Karst Watersheds*

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Recent major flood events in south-central Kentucky have highlighted limitations in existing floodplain mapping approaches, particularly within karst terrains where subsurface drainage dominates hydrologic responses. Karst landscapes, which are characterized by sinkholes, sinking streams, conduits, and cave networks, are inhabited by approximately 16% of the global population. In these systems, rapid subsurface flow and complex surface-groundwater interactions challenge traditional hydrologic and hydraulic modeling techniques developed primarily for fluvial-dominated environments. As a result, modeled flood extents in karst regions often fail to accurately represent observed flood patterns, leading to increased risk for infrastructure, property, and public safety. This study applies hydrologic analysis and predictive modeling to the Lost River and Jennings Creek groundwater basins in Warren County, Kentucky. Continuous water level monitoring data from surface streams and groundwater wells will be integrated with high-resolution precipitation datasets to characterize storm response dynamics and conduit activation thresholds. Hydrograph analyses and model calibration will be conducted using real storm events to evaluate discrepancies between simulated and observed flood elevations in FEMA and karst flood models. Sensitivity testing of key parameters will be performed to determine data requirements necessary for regulatory-grade flood mapping in karst environments. The outcome of this research will be the development of a transferable framework outlining minimum data standards, calibration procedures, and performance metrics for improving floodplain mapping in karst systems across the United States.

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Session 1B: Drinking Water

Environmental Toxicity of Halogenated Cyclopentadienes: An Emerging Class of Water Disinfection-By-Products

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Drinking water disinfection-by-products (DBPs) are significantly correlated with adverse health outcomes such as bladder cancer and reproductive/developmental effects. However, the cytotoxicity of currently regulated DBPs only accounts for a fraction of the observed cytotoxicity of real-world drinking water, suggesting that uncharacterized by-products may account for a large portion of the observed toxicity. In recent years, a new chemical class of DBP contaminants has been identified which is comprised of halogenated cyclopentadienes (HCPDs) generated during water disinfection with chlorine and chloramine agents. Some of the HCPDs, including hexachloro-cyclopentadiene, have higher toxicity in model aquatic and terrestrial organisms in comparison to currently regulated DBPs. They are also predicted to have increased potential for bioaccumulation based on physicochemical properties. Characterization of the toxicity of HCPDs, including their cytotoxicity and genotoxicity, is essential for consideration of future regulations and control measures. We tested three different HCPDs for *in vitro* and *in vivo* toxicity testing using Chinese Hamster Ovary (CHO) cell cultures and the model nematode *Caenorhabditis elegans*. The cytotoxicity of these compounds is being tested to establish IC₅₀ values for CHO cells as well as the lowest observed adverse effect levels (LOAEL). LOAEL values of 0.37uM, 12.59uM, and 14.7uM were determined for hexachloro-pentachloro- and tetrachloro-cyclopentadiene, respectively. Estimated IC₅₀ values for hexachloro- pentachloro- and tetrachloro-cyclopentadiene are 3.1uM, 15.8uM, 37.8uM, respectively. Preliminary data show that exposure of CHO cells to hexachlorocyclopentadiene at IC₅₀ concentration induces genotoxicity via DNA strand breakage. In *C. elegans*, hexachlorocyclopentadiene significantly increased reproduction at 3.7uM, which is likely due to changes in resource allocation due to physiological stress. Changes in nematode's behavior, a more sensitive endpoint, occurred at lower hexachlorocyclopentadiene concentrations. The results for behavior were also impacted by the vehicle control (methanol), which is further being elucidated. The findings will further enable the apportionment of toxicity to chemical subclasses of DBPs aiding in future regulation and control measures.

Extending Water Distribution Quality Models to the General Public Through the Use of Serious Gaming

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Computer models for use in the analysis of water distribution system (WDS) hydraulics and water quality have evolved into very sophisticated platforms for use by design engineers or operators of water utilities. While certainly a benefit to the larger water utility industry, we feel like such tools remain largely incomprehensible for a large group of stakeholders associated with the water distribution and treatment ecosystem. Such stakeholders include plant and distribution operators and personnel, upper management and utility board members, and the broader community of basic water consumers. It is our hypothesis that this community of stakeholders represents an untapped source of valuable information for improving system operations and the models themselves.

This paper will explore the public introduction of a fully functional water distribution model for a small community, by providing greater access to the model using a serious gaming model interface platform. The platform will allow the community to become better informed about the operation of the local utility through an incremental series of game levels that will expose the participants to more complex system dynamics. The platform has also been designed to be able to extract useful information from the participants such as general system knowledge, water use, demand elasticity, and water use behaviors in response to different emergency situations. Such information allows for the development of different consumer profiles that can lead to an improved distribution model as well as better system operations. Such information can also be used to build agent-based models of consumer, operator, and manager behaviors, for use in forecasting future design or operational scenarios or in developing more sophisticated AI applications. The developed platform is both discussed and demonstrated through a case study with a small water utility in eastern Kentucky.

Modeling the Formation of Trihalomethane Species in Water Distribution Systems

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Disinfection by-products (DBPs) continue to be a concern for water distribution system operations, following their first regulation by US EPA in 1979. Currently USEPA regulates four different classes of DBPs which include total trihalomethanes (TTHMs), haloacetic acids (HAA5), chlorite, and bromate. Trihalomethane compounds are further divided into four sub-species: chloroform (CHCL₃), bromodichloromethane (CHBrCl₂), dibromochloromethane (CHBr₂Cl), and bromoform (CHBr₃). Previous attempts to model the formation of TTHMs in water distribution systems have typically relied on an observed correlation between residual chlorine demand at individual junction nodes and the observed concentrations of TTHMs. This modelling has assumed that the loss of chlorine residual measured between the water treatment plant and a field site is largely associated with the “consumption” of the chlorine in the production of one or more of the TTHM subspecies. Other models proposed to predict THM species are complex regression analyses with several predictors. Few studies have focused on the formation of individual trihalomethane species within in the water distribution system using simple regression analysis.

This paper will explore the development of models for predicting individual THMs, specially, individual models for chloroform, bromodichloromethane, dibromochloromethane, and bromoform. By developing more detailed species models, we show that the formation dynamics can be better understood, providing insights into improved management strategies. In developing such models, we utilized chlorine residual, total trihalomethane, and sub-species data obtained from two different rural water systems in eastern Kentucky, specifically the Martin County Water District and the Whitesburg Kentucky municipal water system using data collected between 2022 and 2025.

Source to Tap: Practical Tools for Understanding Source Water Data

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This presentation highlights a Kentucky American Water source water monitoring project being performed at its surface water treatment plants, where new monitoring equipment is helping teams better visualize and interpret real-time source water conditions. The project focuses on key parameters such as dissolved oxygen, chlorophyll, and other water quality indicators that can influence treatment decisions and operational awareness. Leaders from water quality, source water protection, and production will discuss how baseline monitoring supports trend recognition, stronger communication across teams, and valuable context for treatment related decisions. By understanding how source water conditions change over time, utility teams can better connect watershed observations and explain the “why” behind operational decisions. This session will share practical implementation insights, demonstrate the value of source water monitoring, and offer a utility perspective on the types of watershed information that could support drinking water operations. The goal is to strengthen communication and information sharing among utilities, watershed groups, and other partners so source water data can more directly inform action, from source to tap.

Session 1C: Ecology and Restoration

Roots Over Reconstruction: Comparing Hydrologic Function in Urban Riparian Zones

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Streams in urban areas frequently experience erosion and downcutting due to high flow rates and volumes of water flowing from impervious surfaces. As a result, these urban streams experience downstream nutrient loss, temperatures that are uninhabitable, and high flow volumes and peak flows. Stream restoration is a practice which has objectives of restoring some or all of these functions of streams; however, it requires significant design, construction, and cost. While this is sometimes necessary, simply reforesting the riparian area, the vegetated buffer adjacent to the stream, may provide some of the same benefits at a lower environmental and financial cost. Thus, stakeholders such as local governments, environmental agencies, and municipalities could save time, money, and effort by replacing stream restoration with a lower impact option - revegetating the riparian area. This project compares the hydrologic function of revegetated and restored riparian areas, as well as the connecting mowed green space. To assess the hydraulic function of the soil within the riparian zone and greenspace of streams, SATURO dual-head infiltrometers were utilized to measure infiltration rates at 9 restored streams and 9 reforested streams across Lexington, Kentucky. Additionally, samples were analyzed for soil moisture release curve and texture at 5 depths (0-10 cm, 10-20 cm, 20-30 cm, 30-60 cm, and 60-90 cm). The overall goal of this project is to assess the potential hydrologic improvement of reforested riparian areas compared to mowed green space, unrestored riparian area, and intensively restored streams.

Caddisflies (Insecta: Trichoptera) of the Kentucky River Palisades: a Biological Refugium in the Inner Bluegrass Region of Central Kentucky

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The Kentucky River Palisades support forested gorge streams embedded within the largely agricultural and urban Inner Bluegrass region of central Kentucky. Building on long-term light-trap sampling of caddisflies across this landscape, we set out to document the caddisfly fauna and to examine how assemblages differ between the Palisade streams and the surrounding uplands. Using multiple complementary methods, we targeted seven tributaries in the Palisades and five upland streams surrounding the City of Lexington. In the Palisades, adult caddisflies were light-trapped monthly (May–October) over a five-year period (2016–2020) at Boone, Clear, Elk Lick, Jessamine, Lower Howards, Marble, and Shaker creeks, and these collections were complemented by benthic larval surveys (April 2020) and Malaise trapping at Elk Lick and Marble creeks (March–May 2021). Upland streams—East Hickman, West Hickman, North Elkhorn, South Elkhorn, and Town Branch—were light-trapped across spring, summer, and fall. Together these efforts documented a rich Palisades fauna of 79 species in 13 families and yielded more than 118,000 adult caddisflies, and included *Agapetus gelbae* Ross, a new distributional record for Kentucky. Among the light-trapped material, the family Hydropsychidae (net-spinning caddisflies) was the most abundant, while the family Leptoceridae (long-horned caddisflies) was the most species-rich (18 species).

For the quantitative comparison between subregions, we used the standardized light-trap data, which provided effort-comparable sampling across streams. Analyzing assemblages at the stream level, we applied sample-based rarefaction to account for differences in sampling effort and multivariate analyses (including PERMANOVA) to compare community composition. The Palisades supported higher species richness (74 vs. 38 light-trap species) than the upland streams, a difference that persisted after accounting for the greater sampling effort there, and the two subregions differed significantly in community composition. This difference arose mainly because the upland fauna was a depleted subset of the richer Palisades fauna rather than a distinct set of species (i.e., high nestedness). The upland community was strongly dominated by pollution-tolerant, filter-feeding caddisflies such as *Cheumatopsyche*, whereas the Palisades retained a more balanced mix of feeding groups and a greater proportion of pollution-sensitive species, such as the grazing caddisfly *Agapetus*.

Together, these patterns indicate that the Kentucky River Palisades function as a biological refugium, sustaining a diverse and pollution-sensitive caddisfly fauna within an otherwise altered Inner Bluegrass landscape.

Validation of Gastric Lavage as a Non-Lethal Method for Diet Assessment in the Cumberland Arrow Darter (*Etheostoma sagitta*) with Implications for Imperiled Congeners

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Widespread degradation of water quality and stream habitat has contributed to declines of North American freshwater fishes. Darters (subfamily Etheostomatinae) are sensitive to environmental change and can serve as ecological indicators of watershed condition. Landscape alteration associated with forestry, mining, and development has increased conductivity, sedimentation, and nutrient loading, which have been linked to population declines of native fishes in the Appalachian Plateau, such as the Cumberland Arrow Darter (CAD; *Etheostoma sagitta*), an at-risk species endemic to the Upper Cumberland River Basin. However, the mechanisms by which these stressors are driving declines in freshwater fish distribution and abundance are not well understood. Diet studies can provide important insights into habitat quality, trophic interactions, and critical prey resources needed to evaluate the effects of habitat degradation on fish populations. To date, traditional diet analysis methods for small-bodied fishes have resulted in undesirable lethal or sublethal outcomes. However, recent studies have adapted non-lethal gastric lavage techniques for small-bodied fish, opening the door for additional investigations into their trophic ecology. Our objectives were to validate the efficacy and non-lethal impacts of gastric lavage for determining the diet of CADs. We performed gastric lavage on 88 CADs, with low post-procedure mortality (3 individuals, 4.5%). Subsequent dissection of 22 individuals revealed high extraction efficiency, recovering 150 of 164 total prey items with minimal taxonomic bias. Mayflies (Ephemeroptera) dominated CAD diets, comprising 81% of all recovered prey items, suggesting reliance on prey taxa that are often sensitive to water-quality impairment and habitat degradation. Our results provide additional support for the effectiveness of this technique for other rare darters in the region, including the federally listed Kentucky Arrow Darter. Future research can use the approach to understand darter prey selectivity across a gradient of environmental conditions and investigate the role of macroinvertebrate prey decline on fish communities and the ecosystem services these watersheds provide to human society.

Comparing a Regulatory Approach to Ecological Assessment—Evaluating Stream Quality and Function in a Headwater Watershed

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Stream mitigation banking is widely used to compensate for unavoidable impacts to aquatic resources through a range of restoration and conservation approaches designed to improve stream condition and function. Effective restoration planning depends on understanding baseline ecological conditions and identifying the factors that limit ecosystem recovery.

The *Compensatory Mitigation for Losses of Aquatic Resources* (2008) Final Rule identifies several mitigation action types that guide restoration strategies based on existing site conditions and project objectives. While these frameworks provide a consistent foundation for restoration planning, additional ecological indicators that characterize habitat quality, biodiversity, water quality, and ecosystem processes have the potential to complement existing assessment methods and provide a more comprehensive understanding of stream function.

This study establishes a pre-restoration ecological baseline for three stream reaches within a headwater watershed in south central Kentucky, each representing a different mitigation action type. By integrating assessments of physical habitat, water chemistry, biological communities, and ecosystem processes, this research explores how multiple indicators of ecological function vary among reaches and how they can contribute to a more holistic evaluation of restoration potential. The findings aim to provide practical insights that may help inform future approaches to site assessment, restoration planning, and post construction monitoring within the stream mitigation industry.

All data were collected before restoration activities commenced. Structural assessments included habitat evaluations, Bank Erosion Hazard Index (BEHI) assessments, Wolman pebble counts, canopy cover, and riparian vegetation surveys. Water quality was characterized using nitrogen and phosphorus concentrations. Biological communities were assessed through Surber sampling and standardized leaf packs, with macroinvertebrate family richness, EPT richness, and functional feeding group proportions quantified. Ecosystem function was evaluated using leaf-litter decomposition and continuous dissolved oxygen and temperature monitoring to estimate stream metabolism. Ecological differences across reaches are being evaluated using univariate and multivariate statistical analyses.

Preliminary analyses revealed differences in macroinvertebrate community composition and ecosystem function among reaches. Surber samples indicated greater family richness and EPT richness in the Re-establishment reach. Leaf-litter decomposition rates were also the highest in the Re-establishment reach. Stream metabolism and multivariate analyses are ongoing to further evaluate relationships among structural, biological, and functional indicators.

By integrating structural, chemical, biological, and functional indicators within a single assessment framework, this study provides a comprehensive baseline for evaluating post-restoration outcomes while demonstrating the value of incorporating biodiversity and ecosystem function alongside traditional habitat assessments. This work may be used to inform long-term monitoring, adaptive management, and comprehensive assessment of mitigation banking projects in Kentucky and the eastern United States.

Session 2A: Climate and Land Use

Political Winds and Climate Work: What Shapes Priorities of Public University Climate Entities

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Public universities across the United States play an increasingly central role in addressing climate resilience, adaptation, and mitigation through the creation of climate entities- centers, institutes, hubs, and collaborative groups. However, these entities operate within state political environments that could shape their missions, focus areas, and impact. Political polarization around climate science creates an uneven landscape in which some states have the support to meet the state's climate needs while others may not see it as a high priority. Climate entities in states that don't view climate as a high priority often shift their focus areas towards less controversial topics like agriculture, water resources, and catastrophic disasters- topics that see direct impact from the changing climate and can't be ignored. To better understand how these political dynamics shape the national landscape, a comprehensive inventory of university-based climate entities was developed. Organizational characteristics were assessed against state-level political indicators, to better understand how political contexts affect the formation, mission, focus areas, partnerships, and long-term viability of climate organizations across the United States. This work enhances public awareness of existing resources, highlights differences that may be a product of political priorities, and offers guidance for universities seeking to design or strengthen climate initiatives in both supportive and politically challenging states. Ultimately, this effort underscores the potential impact of politics on the trajectory of climate or climate adjacent activity and the pathways through which academic institutions can contribute to climate resilience nationwide.

Small Towns, Big Impacts: Impervious Cover Patterns Across Rural Kentucky

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Impervious cover plays an outsized role in shaping local flooding, water quality, and community resilience, yet its impact in rural areas is often overlooked. In Kentucky, about 90% of communities fall outside MS4 stormwater regulations and therefore receive little guidance, support, or regulatory requirements despite facing many of the same hydrologic pressures as larger cities. As rural communities experience incremental development, roadway expansion, and shifting population patterns, even modest increases in impervious surfaces can alter drainage, strain aging infrastructure, and amplify flood risk locally and at the watershed scale. This project provides a statewide look at impervious cover in Kentucky's non-MS4 communities to better understand how small towns contribute to broader watershed impacts. By bringing attention to rural development trends, this work highlights gaps in current stormwater planning frameworks and underscores the need for more inclusive policies, technical assistance, and resource allocation. Understanding impervious cover in these areas is essential for strengthening resilience, supporting local decision-making, and protecting water resources across urban and rural Kentucky alike. Ultimately, this effort aims to elevate the role of Kentucky's small communities in statewide water management conversations and to ensure that they are better equipped to respond to future challenges linked to land use, flooding, and climate variability.

Assessing Kentucky River's Water Budget through Hydrological Modeling

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Assessing water budget is essential for sustainable water resource management. Water budget analysis provides a quantitative estimate of key hydrologic components such as precipitation, evapotranspiration, runoff, streamflow, and groundwater recharge, helping to identify how water is partitioned and where losses or storages occur. We applied the Soil and Water Assessment Tool Plus (SWAT+) to develop hydrologic models for simulating watershed-scale water budget components for the Kentucky River Basin. The SWAT+ model was built using topography, land use, soil, and weather data and calibrated with monthly streamflow observations from five USGS gaging stations located across the basin. Calibration was performed for the period 1995–2014 and achieved Nash–Sutcliffe Efficiency (NSE) values ranging from 0.74 to 0.78, demonstrating a satisfactory match between simulated and observed stream flow. Additional model evaluation metrics, such as Kling–Gupta Efficiency and Percent Bias, confirmed the good performance of the model. The calibrated model was evaluated for a period from 2015 to 2019 and achieved similar NSE values as the 1995–2014 calibration period. A water budget analysis of the calibrated model results showed that annual precipitation was 1244 mm, of which approximately 61% (758 mm) returned to the atmosphere through evapotranspiration and 39% (482 mm) became streamflow. A very small amount (3 mm) percolated into deep aquifers. The streamflow contributions consisted of three components: surface runoff (71%), lateral flow (24%), and return flow (5%). This model will be used to simulate various scenarios to assess the impacts of different environmental conditions on surface water and groundwater components for the watershed.

Session 2B: Soils and Groundwater

Monitoring Water Infiltration in Shallow Karst Environments Using Time-Lapse 3D Electrical Resistivity Imaging

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Releases of contaminants into shallow karst environments pose a significant threat to both surface water and groundwater resources. Karst features such as sinkholes, sinking streams, and conduits expedite contaminant transport, making it important to understand how precipitation and runoff infiltrate into the subsurface. However, measuring infiltration within karst environments is highly challenging due to the natural heterogeneity of soils and epikarst. Traditional methods often fail because they assume a homogeneous subsurface, thereby neglecting the preferential flow paths and soil variability that control field-scale infiltration rates. This project utilizes time-lapse 3D electrical resistivity imaging (ERI) combined with temperature and volumetric water content measurements at multiple depths to characterize spatial and temporal infiltration dynamics at the field scale. Research was conducted at a sinkhole site located in the Cane Run watershed in central Kentucky. To overcome the labor-intensive setup and temporal limitations of traditional ERI surveys, a permanent subsurface electrode grid was installed at the Kentucky Horse Park. This setup allows for efficient data collection before, during, and after storm events. Multi-depth subsurface temperature and water content data were collected using a SoilVUE 10 sensor installed at the same site.

A total of 33 ERI surveys were conducted across a continuous 12-day period from May 2nd to May 13th, 2026, capturing a minor rain event and a larger storm event. The ERI surveys investigated an area of 15 ft by 15 ft with an investigative depth of ~5 ft. Three-dimensional volumetric block models were developed with the time-lapse ERI datasets to map temporal changes in subsurface resistivity, directly reflecting dynamic changes in soil water content. Resistivity values were temperature-corrected using onsite subsurface temperature data to ensure changes in resistivity accurately reflected changes in water content. Survey results highlighted pronounced spatial variation in resistivity changes, showing that soil and epikarst heterogeneity caused resistivity changes to occur at different rates across the site during both the wetting and drying phases. This study demonstrates the benefits of permanent ERI surveys for high-resolution monitoring of rapid water movements in the shallow epikarst environment in response to storm events.

Unraveling Long-term Soil Management Impacts on Soil Water Dynamics

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Soil water dynamics encompass entry, redistribution, and storage of water within the soil profile. These processes are highly dependent on soil physical characteristics, which are regulated by tillage and nutrient management. However, the cumulative long-term impacts of tillage and fertilizer sources on water infiltration and storage remain poorly quantified. A field experiment is being conducted at Western Kentucky University's Agriculture Research and Education Center to examine the water dynamics of a Crider silt loam soil where tillage and fertilization treatments have been applied continuously for more than 20 years. The experiment was established as a split-plot randomized complete block design with four replications. Tillage treatments (conventional, no-till) were assigned to the main plots, while fertilizer sources (inorganic fertilizer, half poultry litter and half inorganic, full-rate poultry litter) were assigned to the subplots. Undisturbed soil cores (5 cm diameter and 5 cm height) were collected from the experimental plots at 0-5, 5-10, and 10-15 cm depths. In situ water infiltration rates were measured using double-ring infiltrometers, and soil water storage along with key soil hydraulic and physical properties are being evaluated from intact soil cores. Results will provide insights into how different tillage practices and nutrient sources shape infiltration capacity and water storage, informing sustainable practices that enhance soil physical health, water-use efficiency, and long-term crop productivity.

Strengthening Soil Hydraulic Function Through Sustainable Agricultural Management

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The rate at which water infiltrates and is retained within soil influences runoff generation, erosion risk, and the amount of water available for crop uptake between rainfall events. Cover crops are a management practice that can modify these processes; however, their effects on underlying soil physical properties vary among cropping systems and environmental conditions. A field experiment was established in 2023 at Western Kentucky University's Agriculture Research and Education Center to characterize water movement and retention under contrasting cover crop types. The treatments include: a six-species cover crop mixture (cereal rye, oats, daikon radish, turnip, hairy vetch, and pea); cereal rye; hairy vetch; a combination of cereal rye and hairy vetch; and a no-cover control. The treatments are arranged in a randomized complete block design with four replications. In-field water infiltration rate was measured with double-ring infiltrometers. Undisturbed soil cores (7.5 cm diameter and 7.5 cm height) were collected from the experimental plots at 0-7.5 and 7.5-15 cm depths to determine soil water storage along with associated physical properties. Findings from this study will identify cover crop strategies that enhance soil water infiltration and retention capacity, providing management recommendations to improve soil physical health, optimize water use efficiency, and sustain agricultural productivity.

Session 2C: Pathogens and Sanitation

Occurrence of Phenotypic Multidrug-Resistant *E. coli* in Kentucky Surface Waters and Evaluation of Potential Sentinel Antibiotics for One Health Surveillance

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Background/Objectives: Antimicrobial resistance (AMR) is a persistent global public health threat, and surface waters may serve as reservoirs and/or surveillance locations for multidrug-resistant (MDR) Enterobacterales within communities. This study aimed to characterize phenotypic MDR *E. coli* in Kentucky surface waters and evaluate resistance to specific antibiotics to predict MDR. **Methods:** Surface water samples were collected at 50 locations across Central and East-Central Kentucky during 2022 and 2024. Isolates were obtained using selective differential media, with and without tetracycline (TE)-supplementation, targeting *E. coli* and TE-resistant *E. coli*. Antimicrobial susceptibility testing against 21 antibiotics representing nine classes was performed using the MicroScan autoSCAN-4 system, with species confirmation by MALDI-TOF-MS. MDR was defined as non-susceptibility to at least one antibiotic in three or more antimicrobial classes. **Results:** Of 151 isolates, 129 (85%) were identified as *E. coli*. Overall, 29 isolates (19.5%) exhibited MDR phenotypes, including one extensively drug-resistant isolate. MDR prevalence was significantly higher among *Enterobacter* spp. (77.8%) than *E. coli* (14.8%). Tetracycline non-susceptibility occurred in 25% of isolates recovered from media without TE to estimate background, and occurred in 95% of isolates recovered from TE-treated media. Ampicillin non-susceptibility occurred in approximately 30% of isolates, whereas susceptibility exceeded 98% for carbapenems and aminoglycosides. Ampicillin and cefazolin non-susceptibility demonstrated excellent predictive performance for MDR (AUC > 91%). TE-treated media did not significantly increase MDR recovery. **Conclusions:** MDR is prevalent among *E. coli* and closely-related Enterobacterales recovered from Kentucky's natural waters, supporting their role as potential environmental reservoirs of AMR. Ampicillin and cefazolin non-susceptibility demonstrated potential as sentinel markers for One Health AMR surveillance in Kentucky waters and are recommended for further study.

Microbial Source Tracking in an Urban Watershed: The Utility of Long-Term MST Monitoring

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Since the early 2000s, the reach of the Little Blue River flowing through Independence, Missouri, has been on the Missouri Department of Natural Resources 303(d) list for impairment due to fecal-indicator bacteria from urban runoff and storm sewers. The Little Blue River receives most of its discharge from the Independence municipal separate storm sewer system (MS4) during storm runoff events. Probable non-point sources of bacterial contamination in the watershed include human sources (aging or failing septic systems, illicit discharges to storm sewers, leaking sewer pipes, and infiltration to storm sewers) and animal sources (domestic pets, livestock, and wildlife). No permitted wastewater treatment facilities discharge to streams in the Little Blue River watershed.

The U.S. Geological Survey (USGS) and the City of Independence Water Pollution Control (WPC) Department have been collaborating since 2008 on a study to characterize the sources of bacterial contamination to the Little Blue River. This includes analyzing for microbial source tracking (MST) markers to identify the major human and animal sources within the Little Blue River watershed inside the city limits, as well as identifying upstream sources entering the city through the Little Blue River. In addition, streamflow data were collected for each sample to calculate constituent loadings and yields during both baseflow and storm events, which is important for understanding patterns of water-quality impairment and for establishing appropriate mitigation strategies.

This collaboration led to a 2017 publication that helped the City prioritize subbasins for remediation and help satisfy Total Maximum Daily Loadings (TMDL) requirements for fecal pollutant source allocation. Analysis and reporting of 16 years of MST, *E. coli*, and streamflow data are currently underway and is focused on highlighting long-term trends within this unique dataset. Initial findings from this analysis and planned publication will be presented in the context of significant stormwater and wastewater infrastructure improvements made by the City.

The Environmental Surveillance Center for Assessing Pathogen Emergence (ESCAPE): Enabling Wastewater Surveillance for All

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The University of Kentucky's Environmental Surveillance Center for Assessing Pathogen Emergence (ESCAPE) aims to bring “place-based” environmental/wastewater surveillance to all corners of the globe. Wastewater-based epidemiology (WBE) has emerged as a powerful tool for monitoring pathogen loads in communities and facilities (e.g., nursing homes, dormitories, prisons), providing a potential “early warning” for emerging outbreaks. Unfortunately, economic, logistical, and infrastructural barriers have limited adoption, particularly in resource-limited regions, including Appalachian Kentucky. In response, ESCAPE has developed technological innovations that empower local communities to collect their own molecular environmental data, accelerating time-to-results while simultaneously flattening existing inequities in our healthcare systems.

During its two-year history, ESCAPE has made significant progress in the development of new wastewater/environmental testing technologies while also engaging with community partners to elucidate place-based implementation strategies that are responsive to the specific needs and constraints of the community. Leveraging in-house microfluidic expertise, ESCAPE has developed chips that perform polymerase chain reaction (PCR) assays, loop-mediated isothermal amplification (LAMP) assays, and genomic sequencing (via Oxford Nanopore technology) library preparation. These chips have been extensively benchmarked in the lab and exhibit improved usability (e.g., simpler operation, cheaper devices, faster results). Using these chips, ESCAPE has interrogated environmental samples including wastewater, surface water, and animal swabs in remote/rural/underserved regions including Appalachia, Uganda, Malawi, and tribal regions of Alaska. Importantly, each of these rollout activities was accompanied by education, training, and community engagement to support implementation.

To date, ESCAPE can report a number of success stories, despite the early/pilot stage of the project. ESCAPE has monitored the level of respiratory pathogens (e.g., SARS-CoV-2, influenza, and RSV) in wastewater in 10 Eastern KY communities for the past two years, providing data to public health officials regarding the circulating levels of these viruses. Additionally, ESCAPE has evaluated antimicrobial resistant (AMR) bacteria in sewage canals in Ugandan informal settlements/slums, providing data on effective treatments for this highly vulnerable population. ESCAPE has sequenced pathogens from animal samples in Alaska and Kentucky, including hunter-harvested animals, providing information about the prevalence of H5N1 avian influenza and other pathogens within animal populations. ESCAPE has also measured bacterial levels in surface water in Perry Co., KY to evaluate fecal pollution in stream water. In support of this pilot testing, ESCAPE is also developing a number of *in silico* models, which will subsequently be used to evolve environmental/wastewater measurements into impactful public health decisions.

Session 3A: Flooding

Flooding in Appalachian Streams and Headwaters (FLASH) Middle School Curriculum: Collaborative Development and Delivery of Community-Engaged, Place-Based, Hands-On Learning Experiences

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In response to current and historic trends in flooding throughout the Central Appalachian region, the Flooding in Appalachian Streams and Headwaters (FLASH) Initiative was developed to better understand the drivers of and responses to flooding through community-engaged science. The initiative partners with local communities to identify ways to better monitor, predict, and communicate threats associated with flash flooding throughout the region. Through partnership with Breathitt County, Kentucky, middle school instructors, a science, technology, engineering, and math (STEM) curriculum related to hydrology, meteorology, and community disaster planning/response was collaboratively developed and delivered throughout the 2025-26 school year. Approximately 70 integrated math and science students participated in the year-long pilot. The pilot included multiple classroom visits from FLASH collaborators to engage students in hands-on learning and two field experiences focused on topics from the curriculum. Students participated in a PhotoVoice culminating event to showcase their understanding of curriculum topics and experiences with water. Assessment and feedback from this pilot will shape future scaling of the initiative's curriculum delivery throughout the region.

This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative.

Everybody Learns: A Scoping Review of Participatory Approaches to Flash-Flood Preparedness

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Produced as part of the FLASH Initiative. Flash floods strike with little warning and fall hardest on communities already facing infrastructural and social disadvantage, where forecasting and engineered defenses alone have proven insufficient to build durable preparedness. Communities most affected by flash floods often face inadequate infrastructure, limited access to timely information, and marginalization within formal decision-making systems. A growing body of research indicates that participatory and science-with-community approaches, which position community members as collaborators in interpreting data, identifying locally meaningful indicators, and shaping preparedness efforts, offer an alternative to the one-way dissemination of expert knowledge. However, this literature remains dispersed across hydrology, public health, education, planning, and disaster studies, limiting broader understanding of how participatory approaches cultivate flood-related literacy and strengthen resilience.

This scoping review synthesizes the literature on participatory approaches for co-creating community knowledge and strengthening understanding of flash floods and related severe weather hazards, particularly through science-with-community models in environmentally vulnerable regions. Three secondary questions guided the analysis: What methods build flood-related knowledge within communities? How is community resistance or disengagement addressed in engagement strategies? What outcomes are associated with participatory and co-produced educational interventions?

Following the frameworks of Arksey and O'Malley (2005) and the Joanna Briggs Institute, studies were identified across five databases (Scopus, Web of Science, EBSCOhost, ScienceDirect, ProQuest) and grey literature using a structured Boolean search that combined participation, hazard, and educational/communication terms. Screening followed PRISMA-ScR guidance: 158 records were identified, 142 screened by title/abstract, and 116 sought for full-text review; 56 studies published between 2000 and 2025 met inclusion criteria. Data were charted for the study design, participatory methods, and reported outcomes, and then analyzed using reflexive thematic synthesis (Braun & Clarke, 2006).

Three interrelated domains emerged: (1) knowledge co-production and participatory design, in which communities functioned as contributors of local observation and contextual knowledge rather than recipients of expert information; (2) communication and educational innovation, in which storytelling, youth-centered participatory video, and citizen science made flood information more interpretable and actionable; and (3) resilience as a process of learning and adaptation, most durable when participatory practices were institutionalized within governance, schools, or health systems rather than treated as one-off projects. Across domains, participation strengthened the local relevance, interpretability, and legitimacy of flood knowledge. Participation was not uniformly empowering, however: several studies documented symbolic or top-down engagement, nominal "sensitization," discourse-practice gaps, and the reproduction of inequality that constrained genuine community influence.

SESSION 3A: FLOODING

Science-with-community approaches are most valuable when they connect technical expertise to locally grounded interpretation and embed learning within existing community structures and governance, rather than functioning as a substitute for hydrological models, warning systems, or formal institutions. The review offers implications for researchers, policymakers, and practitioners seeking to strengthen flood literacy and resilience through genuine, sustained community engagement.

Monitoring Headwater Streams in the Kentucky River Basin: Challenges, Opportunities, and Successes

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Headwater streams constitute over 77% of global stream network length and play an important role in downstream floods and droughts. Yet, in the Appalachian region of the United States, these systems remain under-monitored, limiting our ability to detect, predict, and mitigate the impacts of extreme weather. Several critical research questions surround monitoring and prediction of hydrologic processes in headwater systems: 1) Which data is most useful for predicting floods, droughts, and other hydrologic processes? 2) Where should gauges be placed to offer early warning/detection of floods, droughts, and other hydrologic processes, and 3) How can we best incorporate and translate data with communities to maximize its uptake and understanding?

In pursuit of answering these questions, our team is deploying a semi-distributed environmental monitoring network in pilot headwater catchments through two NSF-funded EPSCoR projects: the Flooding in Appalachian Streams and Headwaters (FLASH) Initiative and the Climate Resilience through Multidisciplinary Big Data Learning, Prediction and Building Response Systems (CLIMBS) project.

This presentation will provide a progress report on deploying sensor infrastructure in various headwater environments, highlighting successes, challenges, and lessons learned. Presently, over three dozen sensors – including water level loggers, barometric pressure sensors, non-contact depth and velocity sensors, weather stations, soil moisture sensors, and water quality sondes – have been installed in the headwaters of Letcher and Breathitt Counties, KY. Several stations include live telemetry systems, whereas others rely on onboard datalogging due to limited cell phone signal. All data is available publicly.

We will additionally discuss our current sensor network, data QA/QC protocols, and real-time data visualization approaches. Furthermore, we will highlight the role of community collaborations in the implementation of success of the project thus far. As data collection continues and training expands, this work offers a model for integrating real-time monitoring and fundamental hydrology research in the headwaters of the Kentucky River Basin to enhance community resilience to floods.

This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative: Mitigating impacts of climate change and flash flooding in Appalachia.

Geomorphological and Hydro-Climatic Drivers of Flow Regime Signatures in Appalachian Headwaters

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Headwater streams constitute approximately 77% of global river networks, functioning as the foundational drivers of downstream biogeochemical cycling and watershed resilience. Despite this, these small-order systems remain under-mapped and under-studied. To address this gap, this study investigates how specific physical catchment characteristics, climatic drivers, and anthropogenic disturbances independently control flow regimes in headwater catchments. The Appalachian region, with its unique physiographic characteristics and ecological significance, represents an important area for studying these impacts and thus is the focus of this study. We specifically characterized the frequency, magnitude, duration, timing, and rate of change of streamflow regimes using hydrological signatures. We identified 417 well-monitored headwater catchments (391 USGS GAGES-II sites and 26 experimental forest basins) in Appalachia for this analysis. Each site had a watershed area less than 50 km², which is consistent with recent delineations of headwater basins. We then extracted physical and climatic properties for each site, including network density, soil permeability, annual precipitation, PET, and more from 30-meter DEMs, NHDPlus V2, USGS POLARIS, PRISM, and MODIS datasets. Cumulative anthropogenic disturbance was explicitly quantified by integrating OSMRE GeoMine surface mining footprints with NLCD hydro-ecological land cover classifications. We extracted 13 distinct hydrologic signatures from daily discharge records—including streamflow intermittency, low-flow spell duration, peak flood timing, the Richards-Baker Flashiness Index, and many more. Initial evaluations demonstrated highly divergent drivers of streamflow regimes: unmined land disturbance heavily buffers flow, whereas intensive surface mining drastically accelerates runoff to generate extreme stream flashiness. To move beyond exploratory statistics, machine learning models (Random Forest and XGBoost) paired with SHAP value analysis were implemented to empirically rank the relative influence of the extracted topographic, climatic, and anthropogenic predictors. This work is ongoing. These findings provide valuable insights into headwater hydrology in Appalachia, highlighting the significance of landscape disturbance for effective water resource management strategies in the broader Appalachian region. This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative.

Session 3B: Toxic Contaminants

Multi-Endpoint Characterization of PFOA and PFOS Toxicity in *Caenorhabditis elegans*

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Per- and polyfluoroalkyl substances (PFAS) are a class of persistent environmental contaminants that have raised significant concerns due to their widespread distribution, resistance to degradation, and potential adverse environmental and health effects. Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), also known as legacy PFAS, are frequently detected in environmental matrices due to their extensive historical use in industrial and consumer products. Understanding the mechanisms underlying the toxicity of PFOA and PFOS at environmentally relevant concentrations is essential for evaluating potential risks and for supporting the development of Safe and Sustainable by Design remediation strategies. In this study, the model nematode, *Caenorhabditis elegans* was employed as a new approach methodology (NAM) to evaluate the effects of PFOA and PFOS on survival, growth, behavior, oxidative stress, and lipid metabolism. PFOS demonstrated greater toxicity than PFOA, causing significant alterations in growth and locomotion at 0.4 mg/L, whereas comparable effects of PFOA were observed at 0.8mg/L. Both compounds induced lipid accumulation at concentrations as low as 0.15 mg/L. Among all measured endpoints, oxidative stress, quantified through reactive oxygen species (ROS) production, was the most sensitive indicator of toxicity. Although PFOA exposure caused a concentration-dependent increase in ROS levels, PFOS elicited a different response characterized by an initial decrease followed by an increase and subsequent decline at higher concentrations. Lipidomic analyses conducted at exposure levels based on ROS responses revealed compound-specific alterations in lipid composition. PFOS primarily affected cardiolipins and phosphatidylcholines, whereas PFOA altered triglycerides and sphingomyelins, suggesting distinct modes of metabolic disruption. These results indicate that differences in PFOA and PFOS toxicity can be associated with PFOA's fatty acid mimicry and membrane interactions and PFOS impact on mitochondrial function and fatty acid Beta-oxidation. In addition, methanol vehicle controls (≤ 0.05 %) were evaluated for toxicity to account for potential solvent effects. Through the integration of multiple endpoints, including survival, reproduction, growth, behavior, oxidative stress, and lipidomic responses, using *C. elegans* as a NAM, this study provides mechanistic insight into PFAS toxicity at concentrations near those observed in the environment and advances the use of NAMs for PFAS hazard characterization.

Assessment of Heavy Metals from Stormwater and Sedimentation in Class V Injection Wells in Urban Karst Groundwater Systems

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Sedimentation and heavy metal contaminants resulting from stormwater runoff lack regulation in urban karst groundwater settings. In urban karst regions where landforms like caves, sinkholes, and underground rivers serve as threat multipliers for hazardous environmental conditions, the lack of understanding of these interactions can become hazardous. This study focuses on the relationship between heavy metals, sedimentation, and Class V Injection Wells. Class V Injection Wells are for non-hazardous materials, but due to storm events, pollutants can enter groundwater systems through these features without water quality mitigation, leading to interactions between the groundwater and hydrological systems. Through the sampling of sediment cores, first flush samples, source identification, statistical, and spatial research, an assessment can provide insight into how stormwater monitoring and best management practices can be restructured based on environmental needs. As Municipal Separate Storm Sewer System permits continue to evolve as a focal point in stormwater quality assessment, this research aims to contribute to the literature by allowing for a deeper understanding of how prevalent heavy metal pollution may be in karst areas that contain injection wells. The outcomes of this work provide datasets aiming to bridge the gap between scientific understanding and the practical management of groundwater resources in urban karst areas, and findings can directly inform the refinement of Best Management Practices (BMPs) and Municipal Separate Storm Sewer System (MS4) protocols in karst regions as MS4 permits increase in normalization.

Coupled Hydrological Transport Dynamics of Microplastics and Heavy Metals in Karst Groundwater Systems

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Emerging urban karst contaminants pose potential risks to groundwater and sediments due to the high vulnerability of the environment. This study investigates the role of microplastics originating from the urban landscape, particularly Bowling Green, Kentucky, as primary vectors for the transport of adsorbed heavy metals into the regional groundwater system. Microplastics are primarily composed of polymers that undergo weathering and degradation, altering their surface and increasing their chances of adsorbing heavy metals. Sources of microplastics are dominated by urban stormwater runoff, including tire wear fragments and synthetic fibers, potentially accumulating metals throughout the Lost River Groundwater Basin and Jennings Creek Groundwater Basin. First flush sampling is implemented to collect stormwater to understand the input pollutants to the aquifer. Water and sediment samples collected at key selected sites define concentrations and characteristics of the contaminants. Microplastic quantification involves mixed methods of separation and filtration of the samples with microscopic analysis. Samples are analyzed for heavy metals with Inductively Coupled Plasma Optical Emission Spectroscopy laboratory methods, water quality parameters, and total suspended solids. Precipitation events are also sampled to analyze contamination of seasonal variability with atmospheric deposition. The findings could reveal the microplastic characteristics and a correlation between the microplastic and heavy metal concentrations within the karst aquifers. Understanding the correlation between microplastic sources, fate, and transport with heavy metals is critical for assessing the contamination and water quality in urban karst environments. This research highlights the need for microplastic sampling, analysis standardization, and management strategies to reduce urban microplastic loads to protect karst environments.

Prevalence and Source Tracking of Perfluoroalkyl and Polyfluoroalkyl (PFAS) Substances In Kentucky Karst Groundwater Systems*

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Emerging contaminants, such as perfluoroalkyl and polyfluoroalkyl substances (PFAS), are persistent synthetic chemicals in the environment. They are known to cause threats to human health, including cancer, organ damage, and reproductive issues. Research questions for this project include: 1) What are the prevalence and occurrence of PFAS and associated water quality parameters in karst groundwater systems in different basins under varying landuse types, and 2) Is it possible to conduct source tracking of PFAS from existing groundwater maps combined with federal and state databases based on water quality results. Monthly water sampling over 4 months at 21 sites in two adjacent karst areas within Warren County, Kentucky was conducted to represent differing land uses with karst groundwater features. In situ geochemistry (ph, temp, SpC, DO), COD, TSS, and PFAS (full suite) samples were collected and analyzed. This study is the first to provide a detailed dataset on PFAS contamination from karst groundwater sites under varying land use in Kentucky and indicates that urbanized, karst groundwater features contain the most PFAS contamination, while suggesting other contaminants and compound groups have complex relationships with occurrence rates and concentrations, requiring further study toward understanding sourcewater protection.

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Session 3C: Sediment

Sediment Fingerprinting in Maysville, KY*

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Excessive sedimentation is the leading cause of water quality degradation in the state of Kentucky. The City of Maysville has experienced increased sedimentation in Limestone Creek, which is a 5.5-mi², mixed land-use watershed draining into the Ohio River. The Ohio River acts as a downstream hydraulic control at the outlet of the Limestone Creek watershed, thereby causing backwater effects to occur near the confluence of the two water bodies. Consequently, it is possible for flow reversals and low velocities to occur near the outlet of Limestone Creek, which promotes deposition of sediment in the reaches adjacent to and upstream of the Ohio River. As a result, the community experiences exacerbated flooding and lost economic opportunities.

Sediment deposited within the backwater may originate from two primary sources: 1) the upstream reaches in the Limestone Creek watershed itself, and 2) sediment delivered from the Ohio River during backwater conditions. However, the degree to which each source contributes to the sedimentation is unknown. Reducing the influx of sediment to the confluence relies upon identifying and implementing best management practices which reduce sediment erosion and transport at the sediment's source. Thus, identifying the contribution of these sources is critical if the problem is to be remediated.

To answer this question, we have conducted a sediment fingerprinting study in Maysville, KY, in the backwater confluence of Limestone Creek and the Ohio River. Sediment fingerprinting is a data-driven approach which uses natural properties of the sediment to allocate sediment sources from multiple end members. We utilized in-situ suspended sediment traps to characterize sediment from Limestone Creek and the Ohio River at Maysville, KY. We used a coring device to sample deposited sediment longitudinally within the Limestone Creek confluence. Samples underwent analysis for trace metal contents via ICP-OES. We conducted an exploratory statistical analysis to evaluate which tracers were able to discriminate sediment sources and finally used a statistical mass balance unmixing model to determine the contributions of each source. Samples were collected over the course of approximately 1.5 years, spanning a range of hydrologic conditions.

We found that Aluminum, Calcium, Nickel, and Zinc were able to distinguish sediments originating in Limestone Creek and the Ohio River. Results indicate that approximately 90% of deposited sediment in the Limestone Creek backwater confluence originated from within the Limestone Creek watershed itself as opposed to the Ohio River. Results displayed little variability longitudinally within the backwater confluence. These results will help direct community efforts in implementing erosion prevention and sediment control measures within the watershed to prevent future sedimentation and flooding in downtown Maysville. We are continuing work in the area to understand how sedimentation occurs in nearby confluences with varying confluence angles and degrees of development, as well as the efficacy of nontraditional tracers to fingerprint sediment sources. **This presentation is based upon work supported by the U.S.*

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Catchment Size and Urbanization Shape Sediment Concentration–Discharge Hysteresis Loop Concavity More Than Direction

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Concentration–discharge hysteresis loops reflect the integrated hydrological and sediment transport processes operating across a watershed. These integrated signals are used to investigate sediment sources, transport pathways, and the degree of connectivity between sediment-producing areas and the watershed outlet. Hence, the analysis of these loop patterns has become a key tool for informing management strategies. However, the lack of a clear understanding of how watershed characteristics—such as topography, soil properties, and land cover—influence hydrological and sediment transport processes to produce different hysteresis patterns impairs the reliability of hysteresis-based inferences about transport mechanisms. While empirical studies have investigated associations between hysteresis patterns and watershed characteristics, they often yield contrasting conclusions. For example, urbanization has been associated with both an increased frequency of counterclockwise loops and an increased frequency of clockwise loops. Similar contrasting results have been found for the effect of watershed area.

A potential reason for the lack of consistent associations between hysteresis patterns and watershed properties is the limited way in which hysteresis loops are typically characterized. Most studies rely either on qualitative classifications (e.g., clockwise, counterclockwise, figure-eight, and complex) or on hysteresis indices that distill the entire loop shape into a single value, usually describing the transition from clockwise to counterclockwise. Both approaches oversimplify loop characterization, which may obscure relationships between watershed properties and hysteresis behavior, thereby hindering process inference.

To overcome this challenge and improve our understanding of the associations between watershed characteristics and loop shape, we developed a machine learning-based loop characterization framework that captures hysteresis variability more comprehensively than traditional hysteresis indices and qualitative classifications, allowing us to better describe both loop shape and direction. This new framework was then used to characterize hysteresis loop variability across 110 rainfall-dominated catchments in the contiguous United States (CONUS) and investigate associations between watershed properties and hysteresis behavior. By combining exploratory data analysis with Bayesian inference, our findings reveal that structural watershed properties strongly shape loop concavity, an overlooked but critical loop characteristic linked to the sedigraph width and the prevalence of high sediment concentrations during the falling limb of the hydrograph. In particular, we found that concave-up loops are more common in larger watersheds, reflecting sharper sediment pulses, whereas concave-down loops occur more frequently in small, highly developed watersheds, reflecting longer-lasting sediment pulses.

Overall, our findings demonstrate that meaningful and consistent relationships between watershed properties and hysteresis behavior can be identified, but doing so requires flexible characterization frameworks that move beyond rigid or overly simplified schemes. Incorporating loop concavity alongside loop direction provides a more complete representation of

concentration–discharge dynamics and improves the interpretability of hysteresis analyses, leading to a better understanding of sediment transport dynamics and more effective mitigation strategies.

Seasonal Storm Controls on Turbidity in an Urban Watershed: Implications for Sediment Best Management Practice (BMP) Design

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Storm-driven turbidity is a major water-quality concern in urban watersheds, reflecting the mobilization and transport of fine sediment during runoff events. This study examines how seasonal storm characteristics influence turbidity and associated sediment transport responses in the Middle Fork of Beargrass Creek, Louisville, Kentucky, over a two-year period. Forty-one erosive storm events were identified and characterized using high-resolution rainfall data to capture storm magnitude and structure. Study objectives were to: (1) quantify event-scale turbidity responses to erosive storms, (2) compare upstream and downstream turbidity behavior to assess spatial variability, (3) evaluate seasonal variation in these relationships, and (4) assess implications for sediment-focused best management practice (BMP) design. Event-based regression models related downstream turbidity to lagged upstream turbidity and downstream erosivity. Turbidity ratios characterized spatial and temporal sediment transport dynamics. Results showed that winter and spring storms exhibited longer durations, stronger upstream–downstream turbidity coupling, and more stable lag relationships, indicating integrated sediment transport. Short-duration, high-intensity summer storms produced elevated turbidity ratios, and greater model sensitivity, consistent with localized sediment mobilization. Findings support seasonally adaptive BMP strategies, with volume-reduction approaches most effective during winter–spring and source control measures critical during summer–fall.

Landslide Susceptibility Mapping in Martin, Pike, and Floyd Counties Using an XGBoost Machine-Learning Model and GIS

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The Kentucky Division of Water (DOW) Drone Team is powering data-driven decision-making across a wide range of water resource programs in the Commonwealth. The team is transforming Landslides are a significant environmental hazard in Eastern Kentucky, where steep terrain, rainfall, soil conditions, land cover, and human activities can contribute to slope instability. This study will evaluate the ability of the XGBoost machine-learning model to predict landslide susceptibility in Martin, Pike, and Floyd Counties, Kentucky, and will identify the environmental and terrain variables that contribute most strongly to the model predictions. The dataset will include landslide presence and absence locations together with terrain, environmental, hydrologic, land-cover, and proximity-based predictor variables derived from GIS datasets, with landslide presence and absence used as the response variable for model training and evaluation. Predictor variables will include slope, plan curvature, profile curvature, land cover, rainfall, topographic wetness index, distance to streams, distance to roads. Rainfall, topographic wetness index, and distance to streams will be included to represent hydrologic conditions associated with slope instability. The XGBoost model will be trained using the predictor variables to estimate the probability of landslide occurrence across the study area, and five-fold spatially blocked cross-validation will be used to reduce the influence of spatial autocorrelation and evaluate model generalizability. Model performance will be evaluated using the area under the receiver operating characteristic curve (AUC-ROC), and variable-importance analysis will be conducted to identify the terrain, environmental, and hydrologic variables that contribute most strongly to landslide susceptibility predictions. The predicted probabilities will be used to generate a landslide susceptibility map classified into five levels: very low, low, moderate, high, and very high. The resulting model and susceptibility map are expected to support hazard assessment, watershed management, infrastructure planning, and land-use decision-making in Eastern Kentucky. The study may also help identify locations where landslides could affect stream corridors, increase sediment delivery, and threaten roads or infrastructure near waterways.

Session 4A: Flooding

Modeling Rainfall-Driven Infiltration and Runoff Generation Using a Validated Coupled TCA-Philip Framework

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The increasing frequency and intensity of extreme rainfall events in the Appalachian region have heightened the risk of flash flooding and other rainfall-induced hydrological hazards. Because rainfall intensity governs the partitioning of precipitation into infiltration and surface runoff, understanding infiltration dynamics under varying storm intensities is essential for improving runoff prediction and hydrological modeling in mountainous watersheds. This study employs a transient analytical infiltration model that couples Philip's infiltration solution with the Time Compression Approximation (TCA) to simulate rainfall infiltration. The coupled model captures the transition from rainfall-controlled infiltration, where infiltration is limited by rainfall, to soil-controlled infiltration, where the infiltration rate is governed by soil hydraulic properties. The analytical model was first evaluated using a controlled in-situ rainfall simulation experiment conducted in Eastern Kentucky. Rainfall was applied over a 1.5×1.5 m test plot at a constant intensity, and infiltration was determined from the measured rainfall and surface runoff. Comparison between modeled and measured infiltration rates and cumulative infiltration demonstrated close agreement, confirming the model's ability to reproduce transient infiltration behavior under field conditions accurately. Following model evaluation, the validated TCA-Philip framework was applied to four natural rainfall events with different rainfall intensities to investigate the influence of rainfall intensity on infiltration and runoff generation. Results indicate that rainfall intensity strongly controls the partitioning of precipitation into infiltration and runoff. High-intensity rainfall exceeded the soil infiltration capacity early in the storm, producing substantial infiltration-excess runoff and a pronounced separation between cumulative rainfall and cumulative infiltration. In contrast, lower-intensity events allowed a much larger proportion of precipitation to infiltrate with minimal surface runoff. Across all events, infiltration rates exhibited a rapid initial decline followed by convergence toward a quasi-steady state, illustrating the transition from rainfall-controlled to soil-controlled infiltration. The validated coupled TCA-Philip model provides a physically based and computationally efficient framework for simulating rainfall partitioning and runoff generation under natural rainfall conditions, offering a practical tool for improving flash flood prediction. This research is funded in part by the National Science Foundation RII Track-1: Climate Resilience through Multidisciplinary Big Data Learning, Prediction & Building Response Systems (CLIMBS).

Beyond Streamflow Accuracy: Constraining Baseflow to Improve Process Representation in Differentiable Hydrologic Models

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Accurate prediction of hydrological fluxes is essential for effective water resource management, drought preparedness, and informed policy decisions. Recent advances in differentiable hydrologic modeling, also referred to as δ -modeling, have shown substantial progress in simulating daily streamflow by coupling process-based hydrologic models with deep-learning-based parameter optimization while preserving catchment-scale water balance. . However, strong performance in total streamflow simulation does not necessarily imply that internal hydrologic subprocesses are represented correctly. Because most δ -models are trained primarily or exclusively against streamflow, multiple combinations of runoff generation, storage, and subsurface-flow processes can produce similar streamflow performance. This equifinality remains a major challenge, especially in large-scale hydrologic modeling, and can lead to inaccurate partitioning of total flow into surface runoff and baseflow, particularly when subsurface processes are not directly constrained. We develop a multi-objective Long Short-Term Memory (LSTM)-based δ -model based on two hydrological models namely the Hydrologiska Byråns Vattenbalansavdelning (δ -HBV) model and the Precipitation-Runoff Modeling System (δ -PRMS) to improve baseflow simulation without compromising the performance on streamflow prediction. The study is based on investigations across multiple basins in the Contiguous United States using the CAMELS dataset. The performance of both these multi-objective δ -models was evaluated against the traditional single-objective δ -HBV and δ -PRMS models trained solely on streamflow, using Prediction in Ungauged Basins (PUB) test to assess the generalization ability of δ -models when extrapolated to ungauged basins without the necessary monitoring facilities.

The results demonstrate that the multi-objective δ -models that incorporate baseflow substantially improve the performance for baseflow simulation. The 10-fold PUB test reveals that the median Nash-Sutcliffe Efficiency (NSE) increases from 0.475 to **0.695**, while the low flow bias for total streamflow improves from 31% to 20% for the δ -HBV model. These metrics, accompanied by a minor performance depletion in simulating total streamflow with median Kling-Gupta Efficiency (KGE) dropping from 0.7 to 0.693, advocate towards the use of the multi-objective approach. For the δ -PRMS model the baseflow simulation performance improved substantially, yielding a median NSE of **0.687** compared to 0.382 for the baseline single-objective model. This incurred a minimal tradeoff on total streamflow performance with median KGE dropping from 0.698 to 0.681. These findings demonstrate that δ -models can move beyond accurate streamflow prediction toward more reliable representation of internal hydrologic processes across different hydrological models. By incorporating available but often underused baseflow information, multi-objective δ -modeling reduces the risk of achieving correct streamflow for the wrong underlying process representations in runoff partitioning and provides a practical pathway for improving subsurface-flow estimation at large scale. This approach highlights the broader potential of δ -models to assimilate multiple hydrologic signals and improve physically meaningful predictions in both gauged and ungauged basins, with PUB results indicating that learned subprocess behaviors can

transfer effectively to ungauged watersheds. (*Supported by CLIMBS*)

What Matters Most for Predicting Streamflow Regimes in Headwater Systems: Model Structure, Calibration, or Machine Learning?

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Headwater catchments dominate river-network length and are critical for sustaining downstream ecosystems and water supply, yet their high heterogeneity and scarce data make reliable hydrologic simulations a challenge. In these settings, a critical question is whether model predictive skill depends on selecting the right conceptual model structure, optimizing catchment-specific parameters in conceptual models, or abandoning process-based model architectures entirely for data-driven deep learning models. We addressed this question by comparing 38 conceptual models from the Modular Assessment of Rainfall–Runoff Models Toolbox (MARRMoT) framework with a Long Short-Term Memory (LSTM) benchmark across 81 headwater catchments in seven hydrologically distinct regions of the conterminous United States. To evaluate how these approaches predict headwater hydrologic regimes, we tested three modeling strategies representing progressively greater constraints: (1) LSTM as data-driven prediction without explicit process representation, (2) conceptual modeling without watershed-specific parameter estimation using Sobol quasi-random sampling, and (3) calibrated conceptual modeling informed by watershed-specific parameter optimization using the Dynamically Dimensioned Search (DDS) algorithm. Model performance was evaluated using the Kling-Gupta Efficiency (KGE) and a multivariate evaluation metric called the Mahalanobis Distance (MD), which was built by combining hydrologic signatures that statistically describe streamflow magnitude, frequency, duration, timing, and rate of change. KGE ranges from $-\infty$ to 1, where 1 indicates a perfect match between simulated and observed discharge, whereas MD ranges from 0 to ∞ , and 0 indicates perfect match between simulated and observed signatures. Conceptual models calibrated with the DDS algorithm produced the highest KGE and lowest MD across all regions, whereas Sobol simulations generally showed substantially greater variability and lower performance, therefore indicating that watershed-specific parameter estimation improved predictions more than conceptual model selection alone. The LSTM provided a stable baseline and frequently outperformed uncalibrated conceptual models, but it did not consistently surpass the best DDS-calibrated structures. Model rankings varied across regions, and no single conceptual model ranked highest everywhere. HBV, Echo, and several MOPEX-derived structures showed comparatively robust performance across multiple regions, whereas other models displayed pronounced regional dependence. Decomposition of MD showed that streamflow rate of change remained the most persistent source of mismatch for hydrologic signatures, regardless of model structure. This highlights the persistent difficulty of reproducing hydrograph dynamics even when conventional efficiency metrics indicate good agreement. These results suggest that there is no universally superior conceptual model to predict hydrology across headwater catchments in the US, and that predictive performance is governed more by region-specific calibration than by the choice of conceptual model structure alone. Together, these results reveal a practical hierarchy for headwater prediction: deep learning is useful when watershed information is limited, but calibrated conceptual models provide the most reliable simulations.

Quantifying Headwater Contributions to Downstream Discharge Across Dynamic Stream Networks: Insights From a Process-Based Hydrologic Model

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Non-perennial headwater streams are critical for watershed hydrology and ecosystem function, supporting water quality, habitat connectivity, and downstream flow generation. However, because these small streams often lack continuous flow to downstream rivers, their hydrologic contributions remain poorly quantified. This knowledge gap is compounded by limited field data and coarse stream maps (e.g., national hydrography datasets that omit ephemeral channels), which hinder our understanding of headwaters in larger catchment water budgets and complicate management decisions.

To address these challenges, we developed a semi-distributed process-based model that explicitly represents reach-scale discharge and streamflow intermittency. The model simulates dynamic hillslope runoff and channel flow and determines where streams flow or run dry across a field-mapped headwater network. We calibrated the model with a multi-objective genetic algorithm, jointly optimizing streamflow volume and stream presence/absence metrics, using observations from two stream gauges and 19 flow-state loggers in the 14 km² Clemons Fork watershed, located in the Robinson Forest Environmental Monitoring Network, in Breathitt County, Kentucky, United States.

Our results show that intermittent and ephemeral headwaters substantially contribute to downstream discharge. First-order streams alone contribute about 24% of total flow to the watershed outlet over the simulation period, and, combined, first- and second-order streams contribute roughly 50%. Contributions varied markedly during individual runoff events and between seasons, highlighting the dynamic role of ephemeral and intermittent streams in wet and dry periods. The multi-objective calibration was found to reduce equifinality of the model simulations, highlighting the efficacy of the additional state-loggers for reducing uncertainty. Our analysis reveals a progressive shift from perennial-dominated discharge at low flows to non-perennial-dominated discharge at high flows, indicating that the downstream hydrograph is composed of water that originates from various reaches depending on the degree of network expansion. This approach shows promise for improving representation of headwater streams in hydrologic models and supports watershed management and policy decisions in non-perennial systems across the US.

This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative.

Session 4B: Nutrients

From CONUS to Kentucky: USGS Models for Streamflow Drought, Stream Temperature, and Watershed Nutrients

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The U.S. Geological Survey has developed and is continuing to improve several CONUS-extent models for predicting water quantity, quality, and use. These efforts aim to advance our ability to anticipate and respond to emerging water-resource challenges and our ability to conduct nationally consistent assessments of water availability. In this presentation, we will overview three ongoing efforts: stream temperature prediction, watershed nutrient modeling, and streamflow drought forecasting. These models employ state-of-the-art methods to learn patterns from observational data and predict into unmonitored locations and time periods, including the short-term future and/or long-term projections. While these tools were developed with a focus on accurately representing patterns across CONUS, they can also be applied to regional and local extents. We will discuss methods and results relevant to Kentucky, such as the regional training/calibration data, accuracy, and available predictions. We hope that this presentation may lead to regional application of these models or predictions, and we invite discussion and collaboration between USGS water modelers and regional-to-local scientists and water managers.

Protecting the Source: Monitoring and Modeling Source Lake Water Quality for Central Kentucky Distilleries

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Water is one of the five essential elements defining bourbon's character, yet it remains the most vulnerable to environmental change. Increasing occurrences of harmful algal blooms (HABs) in Kentucky's lakes and streams threaten the reliability and purity of distillery source waters. These blooms degrade water quality by depleting dissolved oxygen, altering nutrient balances, and promoting the growth of cyanobacteria capable of producing geosmin. Geosmin is an earthy smelling compound that can affect both the aroma and flavor profile of the final spirit. To address this emerging risk, this project developed a proactive, data-driven framework to detect, predict, and ideally prevent geosmin formation in distillery water sources. We hypothesized that

continuous monitoring of key water quality indicators could identify early warning signals of cyanobacterial activity and potential geosmin formation. The objectives of this project are to: (1) collect baseline water quality and nutrient data (e.g., nitrogen, phosphorus, ammonium, algae, pH, dissolved oxygen, water temperature, specific conductance, and oxidation–reduction potential); (2) characterize nutrient and hydrological patterns influencing bloom dynamics; and (3) develop an early detection model for algal bloom occurrences.

A full year of data collection was conducted across several lakes supplying source water for two Central Kentucky distilleries. Multiple in situ parameters were continuously monitored, while nutrient concentrations were analyzed from grab and soil samples collected at each site. Preliminary observations indicated that dissolved oxygen, temperature, dissolved organic carbon, and nitrate-nitrogen were key indicators of impending algal occurrences. These data formed the foundation for the next phase, which focused on building and validating an early detection model capable of predicting geosmin events based on environmental and nutrient dynamics. By uniting environmental monitoring, predictive modeling, and preservation research, this work provides a scalable framework to protect the integrity of source waters essential to the future of bourbon and distilled spirits production.

Nutrient Recovery Rates from Low-Cost Mineralization Methods

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Sustainable aquaponics depends on nutrient cycling between fish and plant components, yet a substantial fraction of feed-derived nutrients remains locked in solid fish waste and unavailable for plant uptake. As fish feed is both the primary nutrient source for plant growth and one of the highest reoccurring costs for farmers, maximizing use of feed-derived nutrients is critical. Mineralization, the microbial breakdown of organic solids into soluble nutrients, offers a potential pathway to recover these nutrients for plant growth. However, many mineralization approaches rely on controlled reactor conditions or specialized equipment, a financial challenge for small- and mid-scale aquaponic operations, creating a need for simpler, lower-cost alternatives. This study evaluated low-cost mineralization for nutrient recovery from aquaponic effluent under aerobic and anoxic conditions over a 28-day trial at the Aquatic Research Center, Kentucky State University. Eight 208-L mineralization tanks were each filled with 160 L of effluent drawn from the solids filters of 6 active 5,600-L tilapia systems fed at 60 g/m²/day. Four mineralization tanks were continuously aerated with air stones, heated to 28°C, and circulated at 1,135 L/h; four were left unaerated and sealed to establish anoxic conditions. Water quality parameters, including temperature, dissolved oxygen, pH, conductivity, oxidation-reduction potential, total ammoniacal nitrogen, nitrite, nitrate, alkalinity, and total suspended solids, were monitored using a YSI handheld meter and Hach spectrophotometer. Dissolved elemental concentrations (B, Na, Mg, P, S, K, Ca, Fe, Cu, and Zn) were quantified via ICP-MS. Results revealed clear divergence between treatments; the aerobic tanks achieved substantially higher nitrate recovery, averaging 57.3 mg/L compared to just 1.3 mg/L in anoxic tanks, alongside lower total ammoniacal nitrogen (5.1 mg/L versus 28.2 mg/L), indicating efficient conversion of organic nitrogen into plant-available forms. Anoxic systems showed nitrate loss and overall reduction in total nitrogen but also increased ammonia levels, indicating simultaneous denitrification and dissimilatory nitrate reduction to ammonium. Total suspended solids were roughly five times higher in anoxic tanks (173.3 mg/L versus 32.8 mg/L), suggesting incomplete solids breakdown and floc accumulation. Alkalinity rose substantially in anoxic tanks (270.3 mg/L versus 33.3 mg/L), reflecting strongly reducing conditions and elevated pH. Aerobic tanks also showed greater micronutrient recovery, including phosphorus (26.4 mg/L versus 9.7 mg/L), calcium (98.9 mg/L versus 67.2 mg/L), and zinc (0.64 mg/L versus 0.04 mg/L), while conductivity remained similar between treatments. In conclusion, these results suggest that low-cost aerobic mineralization setups, requiring only basic aeration, heating, and circulation equipment, can enhance nutrient recycling in aquaponic systems without the capital investment of more complex reactor designs. Aerobic treatment consistently outperformed anoxic treatment across nearly all measured parameters, supporting its practical value for producers looking to reduce feed waste and input costs while improving nutrient use efficiency. Anoxic mineralization, while less effective at overall nutrient recovery, may still hold value where

alkalinity recovery is a specific management goal. Future work should examine longer trial durations, scaled tank volumes, and integration of mineralized effluent into live plant production to confirm agronomic benefits at commercial scale.

Insights into Sustainable Nitrogen Waste Management Through Biological Denitrification

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The global demand for seafood continues to rise as consumers seek healthy and high-quality sources of protein. Meeting this growing demand while minimizing environmental impacts remains a major challenge for the aquaculture industry. As a result, recirculating aquaculture systems (RAS) are increasingly being adopted as it supports intensive production, while improving the water-use-efficiency. Inland RAS allows the production of fresh, locally grown seafood in landlocked states like Kentucky, reducing dependence on imported products while providing consumers with high-quality seafood year-round. One of the primary challenges in inland RAS is the accumulation of nitrate generated through the biological nitrification of ammonia from aqua feed. Nitrate levels are typically lowered through water exchange, however in marine RAS discharging high salinity, high nitrate effluent can cause environmental concerns while also increasing operating costs due to salt replacement. To address these concerns, denitrification has emerged as an effective biological strategy in RAS. Denitrification is a process where bacteria in low oxygen conditions utilize organic carbon sources and convert nitrate to nitrogen gas, however low-cost implementation in RAS is under-researched. Over the past few years, Kentucky State University (KSU) has focused on developing and evaluating low-cost denitrification strategies to enhance nitrate removal efficiency in RAS. Previous research includes examining both batch and inline denitrification reactors to determine their effectiveness under intensive production conditions. In addition, the role of carbon-to nitrogen (C: N) ratio optimization has been studied to support stable denitrification performance. Various organic carbon sources, including sugar, ethanol, and wood products have been evaluated for sustaining denitrification activity. In addition, industrial by-products from the Kentucky bourbon industry (heads and tails from distillation), have also been utilized as alternative carbon inputs, highlighting the opportunities for cost-effective and regionally integrated nutrient management strategies. In a large-scale pilot study, we used an inline denitrification reactor supplied continuously with ethanol as a carbon source while culturing olive flounder, a high-valued marine fish under intensive conditions in a 12,000-liter system. Despite the use of a high-protein diet that would normally promote substantial nitrate accumulation (~100mg/L/week), the denitrification system maintained effective nitrate control throughout the study period, maintaining the concentration at an average of around 65 mg/L and also supported high biomass production (~386 kg) without water exchange. The future research efforts are focused on further improving the sustainability of biological nutrient management in RAS by integrating nutrient removal with waste recovery strategies. One of the studies at KSU will investigate anaerobic digestion of system sludge to convert concentrated organic waste into the methane (CH₄) rich biogas for energy recovery. Evaluating this process will provide valuable insights into microbial transformation pathways, and overall system efficiency supporting the development of sustainable, low-discharge intensive aquaculture.

Session 4C: Mining

Depth-Wise Assessment of Soil Health in a Recently Reclaimed Mine Site in Eastern Kentucky Using Statistical and Spatial Analysis

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Mining is good for the economy, but it damages the soil badly. It removes plants, takes away the topsoil, and changes how the land looks. After mining stops, companies try to fix the land using a process called reclamation. This is supposed to bring the soil back to a healthy condition. But most research only checks the top part of the soil. They don't look at what happens deeper down. When land is reclaimed, the soil is placed and packed unevenly. So the surface soil may look fine, but a few inches below, the condition can be very different. Because of this, we still don't know the real condition of the recently reclaimed mine soil below the top layer.

This study looks at soil health in a coal mine site in Martin County, Eastern Kentucky, which was reclaimed recently. The main goal was to check how soil properties change at three depths: 0-5, 5-10, and 10-15 inches. This research also sees how soil nutrients are spread across the site using GIS mapping. Soil samples were collected using a stratified random sampling method. At each point, samples were taken and combined by depth. To check if there were differences by depth, we used one-way ANOVA and correlation analysis. We also made maps using Inverse Distance Weighting (IDW) in ArcGIS Pro to show how nutrients were spread across the land.

The results showed clear differences by depth. Total organic carbon was highest near the surface and became lower as depth increased. This means carbon is still building up mostly in the top layer since the site is new. Phosphate stayed high and did not change much with depth. This shows that nutrients are available early, but depth has not affected them much yet. Molybdenum also stayed almost the same at all depths. Manganese changed a little depending on depth, which may show it is more sensitive to local site conditions. Organic matter was lower compared to older reclaimed land, and it also became lower with depth. This shows that soil development is still in an early stage. The maps also showed that nutrients were not spread evenly. Some areas had higher amounts, especially closer to the surface.

Overall, this study shows that a recently reclaimed mine site is still developing. Most nutrients stay near the surface, and deeper layers show fewer changes. Carbon and phosphate results show that soil-forming processes are still happening. Manganese and molybdenum behave a little differently and depend more on location than on depth. These results show why it is important to keep monitoring newly reclaimed land. Understanding these early conditions can help in making better management decisions, so the soil can recover well and stay healthy in the long term.

Rare Earth Element Enrichment in Acid Mine Drainage Precipitate Across a Watershed Treatment and Reclamation Gradient: Insights from Wolf Creek, Eastern Kentucky.

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Rare earth elements (REEs) are critical to modern energy, defense, and technology sectors, yet their primary global supply chains face increasing geopolitical and environmental scrutiny. Acid mine drainage (AMD), a widespread legacy of coal mining across Appalachia, produces Fe-oxyhydroxide precipitates such as ferrihydrite and schwertmannite that have been shown to scavenge and concentrate REEs from mine-impacted waters. These precipitates represent a potential secondary, domestically available REE resource, but the degree to which REE enrichment varies across different stages of mine impact, engineered treatment, and land reclamation remains poorly characterized at the watershed scale, particularly in central Appalachian coalfields. This study addresses that gap through a geospatial and geochemical assessment of REE-bearing AMD precipitate across the Wolf Creek Watershed in Martin County, Kentucky, a watershed with a long legacy of surface and underground coal mining and documented water quality impairment. Sampling sites were selected to represent a gradient of mine-impact conditions, including actively discharging AMD sources, engineered passive and active treatment systems, reclaimed mine lands of varying reclamation age, and unimpaired reference streams identified through Kentucky's 305(b) impairment records and aerial imagery-based iron oxide mapping. At each site, surface precipitate was collected from the top 0–2 cm using non-metallic tools to avoid trace metal contamination, following a standardized field protocol. Samples are being analyzed via inductively coupled plasma mass spectrometry (ICP-MS) at the University of Tennessee Knoxville's Department of Earth, Environment, and Planetary Sciences to quantify total and individual REE concentrations, alongside supporting field-measured geochemical parameters including pH, specific conductance, and dissolved metal concentrations collected with a calibrated multiparameter sonde. This research is part of a broader thesis investigating whether spaceborne hyperspectral sensors (EnMAP) can detect and predict REE enrichment patterns in AMD precipitate using diagnostic spectral absorption features, with the site gradient described here providing the geochemical ground-truth dataset needed to evaluate that relationship. By comparing REE concentrations across active discharge, treatment, reclamation, and reference conditions, this study aims to clarify where along the mine drainage lifecycle REE enrichment is greatest, and whether specific treatment chemistries or reclamation practices unintentionally concentrate or deplete REEs relative to untreated discharge. Findings from this work are expected to inform two practical applications: first, identifying which mine-drainage conditions and locations may warrant further investigation as candidate REE resource sites; and second, establishing a defensible geochemical baseline against which remote sensing-based REE detection methods can be validated across varying site conditions. This has direct relevance to watershed management, mine reclamation prioritization, and the broader effort to identify domestic, environmentally linked sources of critical minerals in historically mined Appalachian landscapes.

Flood Susceptibility & Predictability: FEMA Benchmarking in a Mountaintop Mining Watershed, Eastern Kentucky Using Machine Learning Approach

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The Big and Little Sandy, Tygart Creek Basins in eastern Kentucky will be evaluated for flood risk and susceptibility using a machine learning approach. The terrible July 2022 storm and surface coal mining have caused recurrent floods in this Appalachian watershed. The region's steep slopes, limited valleys, mining history, and vulnerable rural communities necessitate a thorough, data-driven flood analysis that goes beyond the current regulatory maps. Using the NOAA Storm Events Database, the study will first create a flood inventory using GPS to verify field positions. Additionally, it will produce two kinds of non-flood sample points. To capture the primary factors influencing flooding, eleven geographic variables will be derived from LiDAR-based elevation data, land cover, soil groups, and precipitation. Python will be used to train and compare six supervised machine learning models: logistic regression, random forest, K-nearest neighbors, support vector machine, AdaBoost, and XGBoost. A stacking ensemble will combine the probabilistic predictions from all six models into a unified output, with a meta-learner trained on their out-of-fold predictions to maximize overall classification accuracy. The models' performances will be evaluated using ROC-AUC, F1, sensitivity, and specificity. The results will then be compared to FEMA's National Flood Hazard Layer. A comparison of machine-learning predictions with FEMA flood zones and a 30-meter-resolution flood-susceptibility map broken down into five risk levels will be produced. In addition, the study will test whether social vulnerability (SoVI) and mining disturbance variables can themselves predict flood susceptibility class by comparing physical-only, social/mining-only, and combined predictor models before integrating flood risk, population exposure, mining footprint, and SoVI into a combined compound risk map. Together, these products will help identify areas where flood hazard, mining impacts, and social vulnerability overlap, offering practical guidance for emergency management, land-use planning, and climate change adaptation and mitigation practices in eastern Kentucky.

Evaluating Ecohydrological Recovery and Water-Use Efficiency of Replanted Native Trees on Geologically Ripped Mine Lands: A Combined EC and NISAR Inversion Approach

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Compacted mine soils limit root penetration and water infiltration, undermining vegetative recovery. In the Appalachian coal-mining region of Eastern Kentucky, a novel reclamation approach uses geologic cross-ripping to create artificial infiltration networks that support the growth of native tree species planted at structural intersections. This study will evaluate the ecohydrological recovery of this site by coupling 15 months of ground-based eddy covariance (EC) data with high-resolution soil moisture maps derived from NISAR satellite imagery. High-frequency latent heat flux and net radiation data from the EC tower will be used to calculate localized Evapotranspiration (ET) and Ecosystem Water-Use Efficiency (WUE). NISAR's dual-frequency radar will be processed via a surface-roughness inversion model to track spatial soil moisture dynamics across the cross-ripped furrow networks. The integration is expected to reveal a strong coupling between NISAR-derived surface moisture availability and tower-measured WUE. We anticipate that areas directly inside the cross-ripped furrows will exhibit superior moisture retention and optimized vegetative water-use efficiency during peak summer stress. This study will demonstrate the capability of pairing ground-level water fluxes with orbital radar to track the multi-scale hydrological rehabilitation of highly disturbed landscapes.

Poster Session

1. Building A Community Resilience Framework amid Flash Flooding in Letcher County, Kentucky

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Steep topography, dense headwater stream networks, and socioeconomic vulnerability combine to make many Appalachian communities like Letcher County, Kentucky particularly susceptible to flash floods. As a result of human-driven climate change, severe weather events and hazards like floods will become more frequent and disruptive. The objective of this study was to use geographic information systems (GIS) to build a context-specific, precedent-informed framework to estimate community flash flood resilience in Letcher County. Experts recommend indicators and metrics (I and M) for measuring phenomena like resilience, adaptation, and transformation to promote disaster mitigation and political and financial accountability. Frameworks such as this one demonstrate the current state of resilience such that community members can direct efforts to boost resilience through adaptation and transformation. This work incorporates factors such as soil erosion, residential retention, and flood prediction services to represent three frames of resilience—risk, response, and readiness— respectively. Outputs of the framework include a choropleth map permitting a visual comparison of resiliency across hydrologic units within the study area. In the process of creating this framework, the research will provide the FLASH Initiative with a specific definition of resilience (i.e., What is resilience to FLASH?). This framework represents a procedure researchers can apply to the larger Appalachian region. The outcome of this project will involve broadening access to this and other products of the FLASH Initiative via a comprehensive ArcGIS StoryMap. This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative.

2. A Retrospective Environmental Assessment of Metropolis Lake (Kentucky): Quantifying Industrial Contaminant Fluxes and Inventories Using Sedimentary Records

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Metropolis Lake in McCracken County, Kentucky, is one of only three documented naturally formed shallow floodplain lakes in the Commonwealth. As a dedicated state nature preserve, the basin serves as a critical ecological refugium for rare native fish species and ancient bald cypress trees. However, its geographic proximity to major industrial energy facilities—specifically the Tennessee Valley Authority Shawnee Fossil Plant and the Paducah Gaseous Diffusion Plant (PGDP)—places this aquatic ecosystem at a critical intersection with regional industrial development. This study utilizes the lake’s sedimentary record to provide the first quantifiable evidence of how industrialization has shaped this biodiverse fluviolacustrine environment.

Understanding the lake’s environmental evolution requires evaluating its surrounding hydrogeological setting. The site is situated near the regional gravel aquifer, the area’s principal aquifer, which possesses a well-documented history of trichloroethene and technetium-99 contamination from legacy PGDP operations. Additionally, the lake is located near Little Bayou Creek, a local surface drainage system that is also heavily impacted by PGDP legacy waste, specifically polychlorinated biphenyls. To investigate potential surface and subsurface transport pathways into the lacustrine environment from these sources, our study also addresses two active groundwater seeps identified along the shoreline of Metropolis Lake, evaluating them as modern hydrogeological interfaces where regional contamination could interact with the surface water system.

The primary focus of this research centers on deciphering the sedimentological record. To track the long-term “human fingerprint” on this body of water, a continuous ~3 m sediment composite sequence was successfully recovered from the center of Metropolis Lake. This high-resolution sedimentary archive allows us to reconstruct the dynamic life history and depositional evolution of the lake since the mid-20th century. Our multiproxy approach integrates sedimentology, geochemistry, and limnology to evaluate contaminant fluxes and inventories. We aim to establish a robust geochronological framework using ¹³⁷Cs, ²¹⁰Pb, and spheroidal carbonaceous particles to compare stratigraphic changes with regional industrialization.

Preliminary stratigraphic analyses characterize the upper sediment matrix as massive, organic-rich muds containing abundant diatoms, sponge spicules, and charcoal fragments, indicating a productive, well-mixed lentic ecosystem influenced by Ohio River flood pulses. Sediment core geochemical profiles are currently being evaluated to differentiate localized industrial point-source inputs—such as mercury and heavy metals from fossil fuel combustion—from regional atmospheric background levels. By anchoring modern environmental baseline data within the historical records preserved in the lake’s sediments, this research addresses an important

knowledge gap regarding the basin's long-term environmental trajectory. Ultimately, this sedimentary baseline provides a critical framework for predicting ecosystem resilience and guiding future conservation management at the site.

3. The Use of Generative AI in the Prediction of TTHM and HAA5 in Water Distribution Systems

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Since the discovery of disinfection by-products (DBPs) in 1974, DBPs have continued to be a focus of study in the water resources sector. The fact that most water treatment plants in the United States employ some form of chlorine in the disinfection process, means that most water treatment plant in the United States are susceptible to DBP problems. Although there are over 600 types of DBPs that have been discovered, the primary types that concern most researchers and the EPA are trihalomethanes (TTHMs) and haloacetic acids (HAA5).

As proven by previous research, the formation of DBPs is deeply influenced by incoming raw water quality parameters, treatment conditions, and distribution system dynamics. This means that DBP production looks different in varying water distribution systems and predicting DBPs should therefore be tailored to the parameters and dynamics of specific distribution systems. However, previous attempts to develop such predictive models as a function of different water quality variables have mainly focused on using empirical regression equations, which are typically developed from controlled lab conditions or site-specific datasets. The process of tailoring a prediction model to specific varying conditions can be time consuming and difficult to understand and achieve which can limit the practicality and usability of those models, especially when it comes to extending the models to real day to day use in the hands of operators. These models can also fall short when attempting to capture the full complexity of DBP formation under real operational conditions, particularly when raw water quality fluctuates significantly across seasons or when a system may be withdrawing water from different sources with significantly different water chemistry

As is commonly known, the emergence of AI has shifted the way in which society operates. However, the water research field in large has yet to fully tap into the use of this tool. This paper will explore the use of AI as an assistant in the development of different modeling approaches, through testing it's capability to enhance multiple linear regression using a more systematic variable selection approach, automatic cross-validation, and statistical optimization of models. This paper will also discuss AI's capability to identify complex, multivariate relationships within large amounts of observational datasets that would be time consuming or entirely missed through a traditional human approach. Effectively, this paper seeks to see if AI assisted prediction models can take monitoring records that most utilities already collect for regulatory compliance and transform them into usable predictive toolsets. To test the application of AI in this context, we used AI to help develop predictive models for TTHMs and HAA5s leaving the Martin County water treatment plant.

4. Conceptual Model Displays Seasonality of Dissolved and Sedimentary Carbon Fluxes in South Elkhorn Creek, Lexington, Kentucky

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Watersheds in combined surface-groundwater systems are important for processing and transporting carbon within the global carbon cycle, acting as an intersection between the terrestrial and aquatic continuum. The processes within these systems can be expressed as fluxes between major carbon pools, such sediment and dissolved material. Stable carbon isotopic ratios ($\delta^{13}\text{C}$) have been commonly utilized in tracer studies focused on elucidating the source, fate, and transport of material within these pools. Interaction between pools and the resulting impact on carbon isotope ratios can provide insights into lotic system responses to environmental stressors. However, there is still a notable lack of knowledge regarding the interactions of various carbon pools and the subsequent impact on carbon isotopic ratios.

Once such interaction occurs through primary production. Primary producers, such as benthic algae, uptake dissolved inorganic carbon (DIC) through photosynthesis. Algal material may slough and decompose, assimilating into in-stream sediment deposits through stabilization. This stabilized organic sediment is more ^{13}C depleted than the source DIC, though the degree shows variability. There have been many studies focused on direct causes to variability of $\delta^{13}\text{C}$ signatures within periphyton. Controls influencing carbon uptake, fractionation, and stabilization include the taxa makeup of the periphyton and environmental conditions such as temperature, sunlight, flowrate, and nutrient availability.

The purpose of this research is to assess the seasonal variability of carbon quantity and $\delta^{13}\text{C}$ within dissolved, sedimentary, and algal carbon pools. The goal is to quantify this variability and develop a conceptual model on instream carbon cycling within the inner blue grass region. The current hypothesis is that variability within instream carbon cycle is seasonally dependent on flowrate and benthic algae growth.

Current work includes biweekly sampling of benthic algae, sediment samples, and water samples within South Elkhorn Creek. Organic sediment carbon readings from 2015 to 2020 show a small degree of seasonal variability. Initial assessments of dissolved inorganic carbon from 2020-2025 present inverse seasonal variability between carbon concentrations and carbon signatures. Supplementary data will include annual source (soils, banks) sampling and weekly monitoring of benthic algae biomass and taxa makeup. The use of a portable field instrument (BenthosTorch) enables real-time estimates of benthic algal species (green algae, cyanobacteria, and diatoms) and relative concentrations. Initial results from data collection indicate cyanobacteria and diatoms are prominent benthic species in South Elkhorn Creek, with diatoms potentially dominating in the late winter and spring. Future algal carbon measurements will be paired with continued biweekly sediment and water sampling.

5. Detecting Groundwater-Level Change in the Jackson Purchase Region Using Ambient-Noise Interferometry from the CLIMBS Seismic Array

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Groundwater from the Upper Mississippi Embayment aquifer system is the primary water resource for municipal, agricultural, industrial, and private water supplies in western Kentucky's Jackson Purchase Region (JPR). Demand is increasing, especially from center-pivot irrigation, yet regional groundwater monitoring remains sparse. To complement traditional well-based monitoring, we are testing whether continuous seismic recordings provide regional-scale spatiotemporal constraints on volumetric groundwater change. Detecting small variations in continuous recordings of the ambient seismic wavefield may allow us to identify groundwater-related changes over areas not directly sampled by monitoring wells. As part of the Climate Resilience through Multidisciplinary Big Data Learning, Prediction and Building Response Systems (CLIMBS) project, we deployed a dense 35-station seismic array with approximately 10 km station spacing across the southern portion of the JPR to continuously record ambient seismic noise. By comparing small travel-time changes in scattered seismic waves from ambient noise, we can estimate relative seismic velocity changes, or dv/v , through time. Because seismic velocity is sensitive to changes in pore pressure, saturation, and effective stress, we are evaluating dv/v as an indirect measure of groundwater-related subsurface changes across the array footprint.

We present preliminary dv/v results from CLIMBS array data and compare them with nearby Kentucky Groundwater Observation Network (KGON) monitoring wells, Mississippi River stage, and meteorological observations. Cross-correlations of ambient seismic noise between station pairs produced stable waveforms using 20-day stacking windows, demonstrating that the array can recover repeatable subsurface signals over relatively short periods. The cross-correlation functions (CCF) are generally coherent, but their stability varies with station-pair orientation, indicating directional ambient-noise sources and basin-related wavefield complexity that must be considered in future analyses. Initial dv/v estimates in the 0.2–0.8 Hz frequency band show measurable dv/v changes of approximately 0.1 to 0.2%. These velocity changes vary across the array and appear to reflect differences in aquifer setting. For example, we found significant velocity changes for the station pair C102-CUSSO located close to the Mississippi River that are highly correlated with the groundwater level in the unconfined Mississippi River valley alluvial aquifer. Also, we observed an absent dv/v trend for the pair C206-C307, located above the Claiborne aquifer group, consistent with the small groundwater level decline recorded in the upper and middle Claiborne aquifers between December 2025 and January 2026. These preliminary observations suggest that ambient-noise seismic monitoring can detect subtle groundwater-related subsurface changes in the JPR. Continued observations over this four-year project, integrated with meteorological and groundwater data, will help separate groundwater signals from seasonal, temperature, atmospheric pressure, and Mississippi River effects. This

will strengthen interpretations of mechanisms controlling groundwater-induced seismic velocity changes and advance passive seismic interferometry toward a scalable framework for regional groundwater monitoring in western Kentucky.

6. High-Resolution GIS-Based Delineation of Sinkhole Catchments and Karst Relic Streams in the Inner Bluegrass Karst Terrane

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Accurate delineation of surficial karst drainage features such as sinkhole catchments is essential for characterizing groundwater recharge and potential vulnerability in karst terranes such as the Inner Bluegrass. We present an improved, automated, GIS-based workflow utilizing 2 ft digital elevation models (DEMs) to delineate sinkhole catchments and map relic stream valleys. While traditional methods of sinkhole delineation focus on identifying and mapping the spatial extent of a depression itself, catchment delineation takes a more comprehensive approach that identifies the boundaries of the entire topographic area or “subbasin” that contributes runoff to a specific sinkhole. Our methodology begins by utilizing lidar sinkhole coverage from the Kentucky Geological Survey (KGS) to identify and isolate previously mapped, internally drained sinkhole depressions. We then refine this surface by employing a controlled technique wherein a subtraction raster (DEM minus sinkhole raster multiplied by a 20 ft vertical threshold) is generated to minimize spurious depressions that are a common challenge when terrain processing high-resolution lidar data. The resulting lidar surface model is next processed using flow direction and sink identification algorithms to isolate potential swallow holes or open throats—all of which are hydrologically significant drainage points. The identified sinkhole throats are converted using the raster to point tool in ArcGIS Pro and then spatially joined with the verified KGS sinkhole inventory using a 50 ft buffer to ensure accurate feature attribution. Sinkhole catchment boundaries are then generated by executing the ArcGIS Pro watershed mapping tool, ensuring that each resulting catchment polygon is explicitly linked to its corresponding sinkhole feature. Concurrently, relic stream valleys, which are surface geomorphic features composed of aligned sinkholes that represent ancestral surface-flow routes, are identified using a method of artificially filling sinkhole depressions to overflow and analyzing the resulting spillover routes. This approach offers a reproducible, scalable framework for enhanced mapping of karst surface drainage characteristics and assessing karst’s potential vulnerability to flooding and groundwater contamination.

7. High-Resolution Sediment Modeling in Southeastern Kentucky Affected by Climate Variability

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This research focuses on the modeling and uncertainty analysis associated with sediment production in the hydrologically volatile region of Southeastern Kentucky, particularly those areas affected by flash flood events expected to intensify in the future. High-resolution flow and turbidity data were collected from two sites: one with a drainage area of 223 km² and another encompassing 15 km². Data collection commenced on July 1, 2025. Connectivity theory was applied to identify regional erosion hotspots, which include mining sites and steep slopes influenced by both anthropogenic activities and topography. By integrating connectivity analysis with the unit sediment graph model, we effectively simulated future sediment yield production and timing within the study area. Climate data extracted from the Coupled Model Intercomparison Project Phase 6 (CMIP6), incorporating results from 11 General Circulation Models under three emissions scenarios, were utilized in the simulations.

Our results show that the CMIP6 projections indicate average annual precipitation increases of 6.42%, 7.62%, and 9.43% for RCP2.6, RCP4.5, and RCP8.5, respectively, with the peak increase occurring in July across all scenarios, a period corresponding with historically observed severe floods. In the smaller catchment (15 km²), our observations noted that maximum streamflow occurred on August 3, 2025, reaching approximately 47 cms in a stream with an average flow of 0.16 cms. The hydrograph time to peak at this site (Cowan Elementary) was 80 minutes. During this hydrological event, turbidity and streamflow measurements indicated that the sediment graph closely mirrored the hydrograph, showing minimal lag between rising and falling limbs, suggesting an almost immediate sediment transport process. The investigation on the large subbasin is an ongoing effort. Field assessments additionally identified hotspots with significant potential to be used to define the structural connectivity within the system.

8. Water Quality Monitoring Through Metagenomics in Karst Agricultural Watersheds: Case Study of Camden Creek, Kentucky*

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Karst watersheds are vulnerable to microbial and nutrient contamination due to the rapid and unpredictable transport through the underground conduits. In Kentucky, the karst landscape is widespread and identifying the contaminants and their effects on water quality is essential to protect the water resources. Camden Creek watershed, which is a karst agricultural sub watershed in Glenss Creek, was identified as a significant contributor to nitrate and *E.coli* loading. Previous studies have suggested agricultural activities, manure management practices, sanitary sewer leakages and groundwater transport contribute to the impairment but relative contribution remains uncertain. This study will investigate the water quality and microbial contamination in Camden Creek sub watershed through the convectional water quality monitoring techniques and metagenomic sequencing.

Monthly and seasonal sampling is being conducted at three pre-selected monitoring locations to represent hydrologic and land use influences in Camden Creek sub watershed. Field measurements include pH, dissolved oxygen, temperature and conductivity while laboratory measurements include Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), nitrates, nitrites, phosphorus, alkalinity UV₂₅₄ and *E.coli* concentrations using R-Cards. In addition, 30L of sample is collected in carboys and transported to the lab for microbial analysis. The sample is filtered through 2µm and 0.22µm sequential membrane filters followed by microbial deoxyribonucleic acid (DNA) extraction and quantification. Shotgun metagenomic sequencing of the DNA will be integrated to characterize microbial community composition and through bioinformatics analysis, potential pathogens and communities from different sources will be distinguished using strain specific markers.

Initial sampling results have suggested differences in the water quality characteristics in the monitoring sites. Additional sampling is ongoing and will provide further insight into temporal variability, contaminant sources and transport processes. Metagenomic bioinformatics workflows have been established for microbial communities' analyses.

Metagenomic analysis will provide high resolution characterization of the microbial communities, potential contamination sources and enable detection of microorganisms including pathogens and antibiotic resistance genes (ARGs) that cannot be captured in other convectional monitoring approaches which threaten water quality and public health. The findings will support the development of targeted data driven watershed management practices, improve microbial source tracking efforts for protecting ground and surface water resources in the karst regions.

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9. Hydrologic Modeling to Predict Flash Flood Events Under Future Rainfall Extremes and Scale Dependence in the Appalachian Region

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Flooding is the most widespread form of natural disaster, with flash flooding becoming an increasingly large proportion of these occurrences. The devastation from loss of lives, homes, and other property has signaled the need for predictive measures, particularly in vulnerable communities such as the Appalachian region in Kentucky. In the Appalachian region, there are small and often ephemeral headwater streams in steep terrain, growing urbanization, mining disturbances, and a lack of protective infrastructure which make the area particularly subjected to flash floods. In such a region where observation data such as climate, discharge, and runoff are limited, there is a clear need for continuous predictive hydrologic modeling. In this study, we aim to identify the scale at which flash floods are prevalent and the future conditions in which flood and flash flood occurrences may become more frequent and extreme.

We have compiled high-resolution observations and constructed a Soil and Water Assessment Tool (SWAT) model across scales covering four orders of magnitude (1.5 km² to nearly 3,000 km²) in Eastern Kentucky, which we used a range of climate scenarios from the Couples Model Intercomparison Project Phase 6 (CMIP6) to estimate potential flood events in the watersheds, as well as highlight the variability in future predictions. We extracted climate results for this region from 11 global climate models (GCMs), each under three emission scenarios to investigate future rainfall extremes from 2045 to 2065. The change in the 100th percentile of annual months is +15.5%(+ 36% std), +15.5%(+38% std), and 14.75% (+30% std) for RCP26, RCP45, and RCP85 respectively. The maximum increase is projected to be +47% (+ 81% std) in the month of July. We also downscaled the precipitation to a sub-hourly (15 minute) time step using temporal disaggregation. Using the unit hydrograph method, we can then build hourly hydrographs for the different watersheds.

USGS data for the two largest watersheds was compared to data from monitored headwater streams to create an analysis of the watershed scale at which flash events occur. We evaluated the following watersheds: Jackson (drainage area of 2,853 km² and mining coverage of 8%), Whitesburg (drainage area of 172.3 km² and mining coverage of 7%), Franklin Branch Creek (drainage area of 11.5 km² and mining coverage of 9%), Sandlick Creek (drainage area of 10.8 km² and mining coverage of <2%), and Island Branch Creek (drainage area of 1.5 km² and mining coverage of <1%). Hydrographs of the same event were plotted across the different scales and the time to peak was calculated, qualifying the event as a “flash event” when the time to peak occurred in 6 hours or less. Preliminary findings indicate that at the outlet point, Whitesburg had the potential to have flash floods, while Jackson was too large to experience flash floods, and Franklin Branch, Sandlick, and Island Branch watersheds all had frequent flash events.

We also concluded that overall, Appalachian headwater streams typically display a faster response behavior than larger rivers downstream, however mining impacts on response time are under investigation via modeling analysis.

10. Investigating the Autogenic Diel Cycle of Sediment Transport for 84 Sites Across the Continental US

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Low flow sediment transport is not well researched, due to the assumption that low flows do not account for considerable fluid transport capacity. During low flow periods, the sediment being transported within the system can be considered autogenic sediment transport. Autogenic sediment transport is the study of sediment being transported that originated from within the stream. During autogenic sediment transport, we believe that the macroinvertebrates are a significant driver of sediment transport and of the diel cycle of turbidity. To better understand the macroinvertebrates' role in various watersheds across the US, we are going to investigate the diel cycle of 84 different sites across the US to see how the turbidity cycle shifts. Other possible influences of the sediment diel cycle include aggregate structure, heterotrophy/autotrophy, and TOC concentrations. The hypothesis is that during the autogenic regime the sediment transport in the low-gradient system is driven by geophysical, biogeochemical, and biological processes; mainly crayfish as a driver of sediment transport. This analysis is being done through the use of USGS gage locations and sensors, each site has discharge, turbidity, conductivity, and precipitation data. The sites range in drainage area from 1.83 mi² to 9181 mi². The data will be processed to remove all the events and any flow that is above the low flow threshold for the site. Results will include (i) a map of the study sites, (ii) visualization of the diel cycle for some of the watersheds, (iii) empirical mode decomposition to see the seasonal trends, (iv) a six-year analysis of the South Elkhorn watershed, and (v) we place autogenic diel in comparison to total sediment transport for these systems.

11. Investigating Velocity Distributions and Turbulence Structures in a Karst System

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Turbulence theory is well-developed in controlled lab settings, i.e. in flume research. This theory has been used in many applications but has not been satisfactorily investigated in karst phreatic cave systems. The objective of this research is to investigate the velocity distribution and turbulence structure with data taken from the Royal Springs karst basin in Lexington, KY. This watershed begins in central Lexington and flows northwest towards Georgetown. Water passes through the Kentucky Horse Park in an estimated 8m x 1.4m conduit before daylighting as a spring in Georgetown.

Data were obtained in the cave with an acoustic doppler velocimeter, lowered into a well dug by the Kentucky Geological Survey. The results were hypothesized to resemble pipe flow, i.e. a logarithmic-type velocity distribution. Initial results indicate a distinct peak about ¼ of the way up from the bed. Reynold's stresses were hypothesized to follow rough pipe flow, i.e. a V-shaped curve. The velocimetry results show an S-shaped curve. Despite this seeming lack of similitude with rough pipe flow, distributions in the upper half of the conduit match known pipe flow distributions. The deviations at the bed are hypothesized to be due to a backwards-facing step present at the measurement site, verified with downhole video in collaboration with the Kentucky Geological Survey. This highlights the unique aspects of phreatic karst pipe flow, since limestone weathering and fluid dislodgement leads to varying roughness at the roof and bed of the system.

A major component of this research is the macroturbulent motions present within the conduit. In general, turbulent motions, or eddies, are vortical motions which act to spread out energy and momentum. Macroturbulent motions are the largest eddies, on the order of the stream depth or pipe diameter. There are two generally recognized sizes of macroturbulence: Large Scale Motions, associated with the bursting phenomenon, and Very Large Scale Motions. We have implemented a method for studying macroturbulence involving the pre-multiplied spectra of the streamwise velocity component, allowing us to quantify the "length" of the largest eddies using a two-peak contour plot. This method has been applied to lab data successfully but has never been applied to cave systems.

Future research will involve an investigation into the energy contained within macroturbulent motions. We hypothesize that the backwards-facing step will pollute the spectra near the bed. The upper half of the cave data is hypothesized to resemble the largest roughness element flume in our lab. As a component of this research, we will be mentoring an undergraduate in the topical area, i.e. karst features, turbulence, and ADV data collection and quality control. This student will help with data collection in the field and in the lab and will learn about data analysis techniques. These techniques are both general to turbulence research (spectrum analysis, velocity

profiles, Reynolds stresses) and specific to ADV data (despiking, noise filtering). The hope is that the undergraduate could become a leader in this area in the future and would begin with a head start in future graduate research.

12. Streambank Aggradation and Degradation in a Karst Landscape

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Karst landscapes, dominated by limestone topographies, create unique challenges for water resources management. Limestone allows for unique hydrological features like caves, springs, underground conduits, and sinkholes to form over time. Sediment transport can be different from erosion and deposition in surface runoff dominated streams. The source and dynamics of sediment in a karst dominated system require different management approaches and it is important to understand and characterize how sediment source affects channel dynamics. A stream with contribution from both urban and ag, overland flow, and karst was assessed to understand sediment dynamics and riparian geomorphology. The stream is located on the University of Kentucky research farm in Woodford County, Kentucky. Seven years of continuous turbidity data and discrete LiDAR will be used to assess channel evolution and sediment dynamics over time. Currently, work is being done to collect pressure data from multiple stilling wells placed throughout the creek. Ideally this data will provide insight to flood inundation frequency which will provide a framework to collect soil characteristic data from. More information on how this karst system interacts with the riparian buffer is valuable as the traditional use for riparian buffers is to help mitigate overland sediment transport. While riparian buffers are important for overall stream health and function, it is likely that their role in karst dominated landscapes is different than surface runoff dominated systems.

13. Predicting Flash Flood Risk in Eastern Kentucky Using Headwater Stream Data

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Flash flooding is an increasingly prevalent hazard in Appalachia, where many communities face economic disadvantages that heighten their vulnerability to natural disasters. Despite the complex and multifactorial drivers of flash flooding, many contributing variables remain difficult to monitor in real time. While long-term mitigation strategies are essential, improving early warning systems represents an immediate and actionable approach to reducing loss of life.

This research aims to develop a predictive model for flash flood risk using data from headwater streams. Although numerous environmental variables are known to influence flash flooding, their relative contributions and interactions remain poorly understood, particularly in data-limited regions. We hypothesize that elevated soil moisture levels significantly increase the likelihood of flash flood occurrence.

To test this hypothesis, we integrate historical streamflow and meteorological data with newly collected observations of flow state and soil moisture. The objectives of this study are to (1) quantify the relationships between headwater stream conditions and flash flood events, and (2) improve short-term flood risk estimation through data-driven modeling.

By enhancing our understanding of the role of headwater streams in flash flood dynamics, this work seeks to enable earlier and more reliable flood predictions, thereby supporting timely evacuation decisions in vulnerable communities. A key challenge moving forward is the scalability of data collection, as current methods are resource- and time-intensive.

14. Relationships Between Water Quality Indicators and Flooding in Southeastern Kentucky

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Estill County, Kentucky is known for its persistent flooding in watersheds surrounding the Kentucky River, especially in the agricultural fields that cover the majority of developed land in the county. While these floods regularly result in boil warnings signifying microbial contamination, the larger impact on nutrient and ecosystem changes are poorly understood. In this study explores the spatiotemporal differences in water quality before and after rainfall-induced flooding events. A multi-method approach of quantitative bacterial analysis, stable isotope tracers, and geochemical analysis is utilized to assess the extent of flood water movement throughout different land use types. Initial water reports indicate sulfate and nitrate concentrations ranging from 772 – 8.52 mg/L and 169 mg/L – less than method detection limit (MDL), respectively, with an overall decrease in nitrate, but an increase in sulfate concentrations, between baseline and flooding conditions. The sites responsible for the highest nitrate concentrations come from areas around the wastewater treatment plant (WWTP), two coming directly from the WWTP outflow point. The sites with nitrate concentrations less than MDL show moderate consistency both before and after storm events. Highest sulfate concentrations come from sites located in areas surrounding the landfill. To isolate source contributions, ongoing work uses stable isotope ratios of both sulfate and nitrate to constrain specific sources of the contamination. Additionally, bacterial analysis detected contamination in all sites except from the WWTP outflow, indicating proper water sanitation. Overall, our results show both spatial and temporal impacts of recurring flooding on water quality.

15. Quantifying the Hydraulic Performance of Aging Bioretention Cells

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Urban development and impervious surfaces shift the water balance from infiltration dominated to runoff dominated. Bioretention cells (BRCs) are widely implemented as stormwater best management practices (BMPs) to reduce runoff volume and peak flow. While BRCs are an established BMP, long-term performance data is lacking. This gap in knowledge leads to lower implementation of BRCs, inability for long-term planning, and uncertainty about maintenance. This study will evaluate the performance of up to 20 different BRCs that range in age from recently installed to 20 years old. This study will quantify how water movement into the BRC surface and through the media is different at different ages of system. It is anticipated that sediment may clog pore space, or settling or traffic may cause compaction. Conversely, performance could be improved with improved soil structure or development of macropores through root channels or earth worm burrows. To measure performance, each BRC will be monitored in two spatial zones: proximal to the inlet and outlet. Field saturated hydraulic conductivity and infiltration will be measured at three points in each zone using a SATURO (Meter Group). Soil texture will be assessed across five discrete depths (0-10cm, 10-20cm, 20-30cm, 30-60cm, and 60-90cm) using the PARIO Plus method (Meter Group). A cone penetrometer (Eijkelkamp) will be used to assess cone penetration resistance to 60cm depth at five locations in each zone. Finally, intact soil cores will be collected at the soil surface at one point in each zone and analyzed for soil moisture release characteristics (field capacity, wilting point, and plant available water). The results from this study will help stormwater professionals understand long-term performance of BRCs, potential performance thresholds, and maintenance activity and timing priorities. This will lead to more informed policy and guidance related to BRC design and implementation.

16. Life Cycle Assessment of Urban Tree Soil Cells as Green Stormwater Infrastructure: Environmental Trade-offs and Long-Term Benefits

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Urban tree soil cells are increasingly used as multifunctional green stormwater infrastructure to support tree growth and manage stormwater in dense urban environments, yet their environmental sustainability across the full product life cycle remains poorly understood. This study applies life cycle assessment (LCA), following the ISO 14040/14044 standards, to quantify the environmental impacts of soil cell systems with a functional unit of twenty urban trees over a 100-year assessment period. Environmental impacts are quantified across five life cycle phases: materials and resource extraction, transportation, construction, operation and maintenance, and end-of-life. The framework is demonstrated using a potential soil cell installation on the University of Kentucky campus as an example application. Across all ten environmental midpoint impact categories, the materials and resource extraction phase dominated the life cycle, contributing approximately 85–95% of the total life cycle impacts. Furthermore, polypropylene soil cell components contributed approximately 45–70% of the impacts associated with material production, making materials and resource extraction phase the largest contributor in most impact categories. In contrast, the PVC underdrain pipe was found to be the primary contributor to ozone depletion.

Monte Carlo simulation was used to quantify uncertainty, and sensitivity analysis was performed to identify the key parameters influencing environmental impacts. Scenario analysis showed that reducing transportation distance, modifying structural soil composition, and changing the underdrain pipe material could reduce global warming impacts by up to 11% as individual strategies or up to approximately 25–30% across most impact categories when all strategies are employed concurrently. Operational benefits, including carbon sequestration and hydrologic benefits, were estimated using i-Tree Planting 2.8.4, with additional stormwater storage provided by the soil cell system incorporated into the hydrologic assessment. Carbon sequestration was compared with life cycle greenhouse gas emissions to determine the carbon payback period, while hydrologic benefits were compared with life cycle water consumption to compare the system's water footprint to avoided runoff benefits. Carbon payback occurred after 39–70 years depending on tree species and mortality rate, whereas avoided runoff benefits surpassed the water footprint within 22–33 years. These findings highlight material sourcing and transportation logistics as priority targets for reducing the environmental footprint of soil cell-based green infrastructure, while confirming the long-term climate and hydrologic benefits of tree-based stormwater systems.

17. The Effects of PFAS Loading on Biogeochemical Cycling, Fate, and Transport in Wetlands*

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Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants detected in various environmental compartments, including soil, surface water, and groundwater. PFAS has been associated with negative human health impacts, including hyperlipidemia, weakened immunotoxicity, endocrine disruption, decreased fertility, hypertension, worsened early child development, and increased risks of kidney and testicular cancer. Two of the more common ways that PFAS can enter the environment in Kentucky are through wastewater treatment plant (WWTP) effluent and urban runoff, threatening local water supplies. Therefore, there is a critical need to remove the PFAS through wastewater treatment processes to minimize exposure and costs for removal in downstream environments that utilize this water as drinking water. One popular, sustainable, and low-cost option currently used for bioremediation for various water quality impairments is constructed and floating-treatment wetlands. Therefore, this study aims to determine PFAS removal and implications on biogeochemical processes using mesocosm-scale wetlands. During the growing seasons in 2026 and 2027, 30 wetlands, 15 constructed and 15 floating-treatment, will be assessed using five treatments: four with varying levels of PFAS and nitrate, and one containing WWTP effluent. Wetland compartments will be periodically sampled for PFAS as well as various water quality parameters to determine physical and biogeochemical processes that affect PFAS and nutrient removal throughout the study. Findings from this study are critical for determining how PFAS impacts removal processes in wetland systems and determining potential solutions for WWTP operators and urban planners to combat PFAS contamination in water sources.

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18. Layered Flood Risk and Community Knowledge in Appalachian Kentucky and West Virginia: Using FEMA's National Risk Index to Inform Public Health Preparedness

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Product of FLASH Initiative. Flooding is a recurring and intensifying concern across Appalachian communities, where hydrologic exposure intersects with rural geography, transportation barriers, infrastructure limitations, housing vulnerability, and uneven access to public health and emergency preparedness resources. In Appalachian Kentucky and West Virginia, recent flood events have underscored the need for preparedness approaches that go beyond identifying where water is likely to accumulate. Effective flood preparedness also requires understanding how residents interpret risk, communicate warnings, identify vulnerable households, and mobilize local knowledge before, during, and after flood events. This poster presents a secondary data analysis that builds from prior conceptual work on community knowledge development and uptake around flooding events. That framework argues that flood preparedness is strengthened when technical risk information is connected to local interpretation, trusted communication networks, and community-based knowledge.

Using FEMA's National Risk Index county-level dataset, this project examines inland flooding risk across Appalachian Kentucky and West Virginia. The analysis includes 109 counties: 54 Appalachian Kentucky counties and all 55 West Virginia counties. County-level indicators were used to describe inland flooding risk, expected annual loss, social vulnerability, and community resilience. The analysis then identified counties where moderate-to-high inland flooding risk overlapped with high social vulnerability and low community resilience. This layered-risk approach was used to move beyond flood exposure alone and identify counties where flooding may pose broader preparedness and recovery challenges.

Findings suggest that inland flooding risk, social vulnerability, and community resilience identify different geographies of concern. Only three counties were rated as having relatively high inland flooding risk, yet high social vulnerability and low community resilience were more widespread across the region. A broader layered risk profile identified 20 counties where moderate-to-high inland-flooding risk overlapped with high social vulnerability and low community resilience. These counties included 10 in Appalachian Kentucky and 10 in West Virginia. The results also showed that expected annual loss and relative loss burden do not always align with layered vulnerability profiles, suggesting the importance of interpreting flood risk through multiple indicators rather than relying on a single measure.

This project contributes to water resources planning and public health preparedness by demonstrating how secondary risk data can be paired with a community knowledge framework. FEMA's National Risk Index provides a useful planning-level tool for identifying counties where flood-related risks may be concentrated, but formal risk data alone cannot explain how preparedness works on the ground. Community knowledge can help clarify which roads flood first, which households face transportation or medical access barriers, which warning channels

are trusted, and which local institutions are most effective during response and recovery. Treating community knowledge as public health infrastructure can support more locally grounded preparedness strategies, including participatory mapping, community listening sessions, targeted outreach, and partnerships among water-resource professionals, public health agencies, emergency managers, and Appalachian communities. The poster argues that flood preparedness in Appalachia should integrate formal risk assessment with community-engaged knowledge to produce more actionable, trusted, and equitable planning.

19. A Numerical Investigation on the Rainfall-Induced Soil Saturation and Runoff Generation in the Appalachian Region

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One of the most destructive natural hazards in the Appalachian region is flash flooding. It causes damage to the infrastructure and endangers lives. Rainfall runoff formation results from rainfall water that does not infiltrate into the ground and consequently contributes to flooding. In this study, a multiphysics numerical model was developed in COMSOL software to simulate the water, heat, and vapor transport in the soil vadose (unsaturated) zone. The model used non-isothermal and non-equilibrium phase-change behavior for simulating water infiltration in the unsaturated media to determine the amount of rainfall water infiltrated into the soil layers. The model implements a variety of soil hydraulic parameters, including the soil-water characteristic curve and soil porosity, resembling the Eastern Kentucky sites of the Appalachian region. Parametric studies were conducted to simulate water infiltration in different types of soils with different degrees of compaction under different rainfall rates. The results showed that variations in soil porosity resulting from different compaction levels, as well as differences in soil type, result in changes in soil permeability and water-retention ability. A parametric study outcome showed that changing the type of soil from Fine Sand to Bonny Silt will result in a variation of infiltrated water into the soil. Moreover, changing (lowering) the porosity in soils due to compaction leads to a decrease in the amount of water infiltration and the resulting degree of saturation in the soil (Figure 1). Another parametric study was conducted by changing the rainfall rate while keeping the soil parameters constant. The results showed that rainfall intensity affects the amount of water infiltration into the soil and leads to changes in runoff formation (Figure 2). The results of this research also indicated that runoff formation depends on the soil degree of saturation, and thus, the developed numerical model, in addition to the laboratory and field studies, is a useful tool to assess the flash flooding conditions in the Eastern Kentucky sites of the Appalachian region with varying soil characteristics and changing climate conditions. This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative.

20. Quantifying Bias in Field Discharge Measurements and Stage-Discharge Hysteresis across CONUS

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Stage-discharge rating curves are used at nearly all USGS stream gages to represent discharge as a single-valued function of stage. Often, rating curves are monotonic power-law relationships, implying that there is a unique discharge for every stage. However, the effects of unsteady flow, changes in flow energy slope, flood-wave propagation, instream hydraulic controls, and channel and floodplain storage can produce hysteresis, whereby a single stage corresponds to two or more distinct discharges depending on whether the measurement occurs on the rising or falling limb of the hydrograph. Rating curves are maintained through periodic field discharge measurements, yet the position of these measurements on the hydrograph is rarely examined systematically. If field visits disproportionately sample baseflow or recession conditions – due to for example logistical and safety constraints – then the resulting rating curves may also be constrained to falling-limb flows, thereby misrepresenting the true stream discharge during the rising limb. Therefore, it is possible that existing rating curves systematically over or underestimate flows during portions of the hydrograph, which is consequential for flood forecasting, peak-flow estimation, and infrastructure design. This study seeks to answer the following questions: 1) when are field discharge measurements most often taken during hydrographs? 2) in what types of watersheds does measurement bias, for example to rising- or falling-limb, occur? and 3) what are the implications for using monotonic stage-discharge relationships in watersheds where h-Q hysteresis might occur? To answer these questions, we analyse the archive of USGS stage-discharge field measurements at stream gages in the Geospatial Attributes of Gages for Evaluating Streamflow, version II (GAGES-II) dataset across the conterminous United States, pairing each measurement with the continuous stage-discharge prediction at its site. Using the continuous stage and discharge records, we classify each field measurement as occurring during rising-limb, falling-limb, or baseflow conditions and quantify the distribution of sampling conditions at each gage and across regions, basin sizes, and hydroclimatic settings. We quantify the magnitude of hysteresis by comparing observed discharges at equivalent stages between rising and falling limbs, expressing the discrepancy as a stage-dependent discharge difference relative to the standard rating. Comparisons are restricted to periods with sufficiently stable rating curves, for example to reduce the influence of long-term stage-discharge shifts due to changes in channel bathymetry. Preliminary results indicate that field measurements are strongly skewed toward baseflow and falling-limb conditions at most sites, and that rising- versus falling-limb discharge differences at a given stage can be substantial at hysteresis-prone gages. The findings of this study will identify the components of hydrographs when measurement of stage-discharge is most limited, where stage-discharge hysteresis is most pronounced, and where additional rising-limb measurements or dynamic rating approaches may improve discharge estimation.

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21. Evaluating Hybrid Differentiable Hydrologic Models for Sub-Daily Flash Flood Prediction

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Flash floods are among the most destructive natural hazards, causing substantial loss of life and property each year throughout the US. Their rapid onset makes them particularly difficult to predict, and they often occur in relatively small, ungauged catchments where observational data are scarce. Hybrid differentiable models, which integrate process-based hydrologic models with neural networks (NNs), have recently emerged as a promising approach for streamflow prediction in ungauged basins. By leveraging backpropagation—the optimization algorithm used to train neural networks—these models enable the simultaneous calibration of the process-based model and the training of an NN-based regionalization scheme, allowing model parameters to be estimated as functions of watershed characteristics and climate signatures. This joint optimization has demonstrated strong potential for regional prediction in ungauged catchments, often achieving accuracies comparable to state-of-the-art machine learning models while preserving some advantages of process-based models, such as the ability to estimate unobserved variables such as soil water storage. However, most previous studies evaluating hybrid differentiable models have focused on daily streamflow prediction, a temporal resolution that is often insufficient to accurately capture the timing and magnitude of flash flood events. Consequently, their suitability for sub-daily flash flood prediction remains largely unexplored.

In this study, we evaluate the performance of a hybrid differentiable model for hourly streamflow prediction, with particular emphasis on flash flood events. Using meteorological and streamflow observations from more than 700 catchments across the contiguous United States (CONUS), together with a database containing over 34,000 previously identified flash flood events, we assess the model's ability to reproduce hourly streamflow. Model performance is evaluated with particular emphasis on the timing and magnitude of high-flow events, as well as its ability to be generalized for ungauged catchments. To place the model performance in the context of current operational forecasting capabilities, we compare its predictions against those of the National Water Model retrospective simulations. This comparison provides a benchmark for assessing whether hybrid differentiable models can improve the prediction of flash flood timing and peak discharge while maintaining physically consistent representations of watershed processes. The results will provide insight into the capability of hybrid differentiable models to represent the processes governing flash flood generation at sub-daily timescales and will help advance the development of accurate and physically consistent flood prediction models for ungauged basins.

This research is funded in part by the National Science Foundation RII FEC Program: The Flooding in Appalachian Streams and Headwaters (FLASH) Initiative as well as the NSF RII Track 1 Program: CLIMBS.

22. Estimating Rating-Curve Parameters for Small Headwater Streams Using Watershed Attributes and Channel Geometry

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Hydrological rating curves translate stage to discharge and underpin flood forecasting, streamflow record construction, and water-resource decisions. However, these curves may take many years and measurements to develop. Recent continental-scale efforts successfully used machine learning to predict rating-curve parameters from watershed and channel attributes across the contiguous United States, but these approaches excluded small streams with a mean annual discharge below roughly 5 m³/s, where predictions were found to be unreliable. Yet, headwater streams make up the vast majority of the river network and are the reaches where continuous gauging is the sparsest.

The objective of this study is to develop a data-driven framework for estimating rating-curve parameters (α and β in $Q = \alpha H^\beta$) for small headwater streams below the 5 m³/s threshold that previous continental-scale models excluded. We pursue two aims: first, to establish a workflow for extracting clean, physically consistent stage-discharge relationships from raw field measurements at small-stream gauges; and second, to predict the resulting rating-curve parameters for ungauged headwater catchments using watershed attributes and channel geometry.

We assembled raw USGS field measurement (H–Q) pairs, for 4,448 active gauges with a mean annual discharge below 5 m³/s. Because many long-record gauges exhibit multiple distinct rating curves over time as channel geometry shifts, we applied a temporal segmentation to each station and retained only the latest stable gauging segment, ensuring the fitted curve reflects the current channel regime. For every station we then fit a traditional least-squares power law alongside a Bayesian model tournament spanning the power-law (PLM) and generalized power-law (GPLM). Stations were characterized by fit quality (R^2 , RMSE, and percent bias). We then trained tree-based models (random forest and gradient boosting trees) to predict α and β from catchment physiographic, hydro-climatic, and channel-geometry attributes using an 80/20 train–test split.

Stable rating curves were identified for only 64% of the 4,448 gauges originally identified, of which about three-quarters were adequately described by a single power function. The remainder required a two-limb form joined at a transition stage (median $h_0 \approx 0.9$ m). A tournament (traditional power laws plus the Bayesian PLM/GPLM family) on the latest segment showed that the generalized power law gave the best fits, highest median R^2 (≈ 0.975) and lowest relative error, and outperformed the traditional power law at the low-flow end for about 61% of stations. Ongoing work includes training the machine-learning models that predict α and β from watershed and channel attributes and characterizing where the fitting methods systematically break down (for example, arid or engineered channels with unusual hydraulics).

This work extends rating-curve estimation for headwater, and demonstrates that temporal segmentation combined with a power-law/generalized-power-law tournament yields physically

consistent parameters for streams below 5 m³/s. Once complete, the predictive models will support stage-discharge estimation in ungauged headwater catchments, aiding watershed management and streamflow prediction across the US.

23. Evaluating Gravity and Mechanical Filtration in Coupled Aquaponic Systems

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Aquaponics is a food production system that integrates recirculating aquaculture and hydroponic plant culture, where waste from fish production is used as a nutrient source for the cultured plants. While fish waste is necessary for the operation of aquaponic systems, excess solid fish waste can clog plant roots, decreasing growth or causing plant mortality. Therefore, efficient filtration is necessary to maintain water quality, support fish growth, and ensure plant development. Various methods of filtration are available, ranging from simple settling chambers that rely on gravity to efficient but costly mechanical filtration systems like bead filters. However, there is little information on the efficacy of different filtration methods, particularly in the contexts of water quality and food safety. The aim of the study was to compare the filtration performance of gravity-driven settling filtration system coupled with a biofilter and a mechanical bead filter in coupled aquaponic systems stocked with tilapia (*Oreochromis niloticus*) and Bibb lettuce (*Lactuca sativa*). Six replicated coupled aquaponic systems were used, three with gravity filtration and three with mechanical bead filtration. Each system was stocked with 14 tilapia at an average weight of 383 g and 66 lettuce plants. The tilapia were fed at a rate of 60g/m²/day (60 grams of feed per m² of plant bed). Water quality parameters were measured throughout the 21-day study including settleable solids, turbidity, total ammonia nitrogen (TAN), nitrite, nitrate, alkalinity, pH, temperature, Dissolved Oxygen (DO) and Electrical Conductivity (EC). The lettuce growth was measured by plant height, number of leaves, fresh weight and root biomass. The fish growth was measured by final biomass and fish weight gain. 16S analyses for microbial abundance data are still underway and will be presented alongside water quality and production data. Data analysis was conducted with R software using a mixed effects model for repeatedly measured parameters like water quality and a t-test for data collected at harvest including plant and fish production metrics. There were no significant differences ($P > 0.05$) among settleable solids, turbidity, TAN, nitrite, nitrate, alkalinity, pH, temperature, DO, EC, lettuce fresh weight, lettuce root biomass, or fish production between the two treatments. Overall, the findings indicate that the two filtration systems performed similarly across all metrics. This shows that gravity filtration can be an effective and low-cost solution to maintain water quality for fish and plant health in a coupled aquaponic system. However, bead filters may still have advantages at higher feed rates and reduced discharge compared to gravity filtration. Future research will investigate long term use of different filtration methods and examine cost effectiveness, water and waste discharge, and water quality dynamics.

24. Spatial Mapping of Soil Nutrient Distribution in Reclaimed Mine Sites

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Surface mining has drastically transformed the landscape in Eastern Kentucky, creating vast tracts of reclaimed land that are generally poorly utilized due to compaction and nutrient deficiencies in soils. From the perspective of land management and economics, these defects cause the establishment of productive post-mining land uses and regional redevelopment. This study characterizes the spatial variability and depth-wise nutrient distribution of reclaimed mine soils in Martin County, Kentucky, to provide a data-driven framework for assessing land values and reclamation efficiency.

In summer 2024, stratified random sampling was carried out at 41 locations, with soil samples taken at three depths: 0-5, 5-10, and 10-15 inches. Laboratory analysis is conducted for significant indicators of land productivity, such as soil pH, organic matter, total carbon, nitrogen, phosphorus, and cation exchange capacity. This study used ArcGIS Pro for spatial mapping and statistical analysis in SPSS and R Studio to reveal depth-wise trends and nutrient hotspots.

Instead of a generalized index, this research provides high-resolution spatial data that can be used to optimize resource allocation for soil amendments and reduce the overhead costs of land restoration. The resulting spatial variability maps serve as a decision-support tool for stakeholders, helping to bridge the gap between environmental stabilization and the sustainable economic revitalization of Kentucky's reclaimed landscapes.

25. Fluviokarst Dissolved Carbon Concentrations and Isotopic Ratios show Seasonal Variations Evidenced by Empirical Mode Decomposition and Isotope-Aided Modeling

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The fate and transport of dissolved carbon is particularly complex in fluviokarst due to hydrogenic, biogenic and geogenic processes and interactions. Behavior of fluviokarst systems have been studied from a regional and data based-perspective for many decades in Kentucky because of the widespread and dynamic karst topography. A variety of sources and sinks show control to carbon cycling including biogenic soil respiration and geogenic weathering sources, CO₂ evasion, as well as in-stream processes govern stream DIC (Campeau et al., 2017). The dominant biogenic source of DIC in fluviokarst environments is recognized to be from soil-respired CO₂. Soil CO₂ represents a mixture of atmospheric CO₂ and soil-respired CO₂ and CO₂ respired from the dominant plant species (C3).

Few, if any studies combine the conceptual knowledge of hydrology and biogeochemistry in tandem with a long-term continuous data set of carbon concentration and isotopic composition across multiple sampling locations in a fluviokarst watershed.

The objectives are to (i) present 7-year fluvial sediment elemental and isotopic dataset, (ii) use empirical mode decomposition methods, and (iii) characterize seasonal patterns in dissolved carbon species using tracer-aided numerical modeling to better represent carbon cycling in fluvial-dominated stream system.

Six years of dissolved inorganic carbon (DIC) elemental concentration (mg/L) and isotopic signature ($\delta^{13}\text{C}$ ‰) data was collected from a biweekly grab sampling routine in the fluviokarst basins of Cane Run Creek in the central Kentucky karst bluegrass region, USA. We observe distinct isotopic measurements during wetter winter-spring (January-March) and drier summer-fall (August-October) periods, with $\delta^{13}\text{C}$ DIC averaging $-12.2 \pm 0.9\text{‰}$ in winter-spring, and $\delta^{13}\text{C}$ DIC averaging $-13.4 \pm 0.5\text{‰}$ in summer-fall.

Results of time series analyses and empirical mode decomposition suggest the seasonality of the isotopic ratios in the aquifer are controlled by intra-annual variability of soil carbon isotopic composition, with leaching of dissolved carbon from soil as the dominate flux of carbon to the karst aquifer. Model simulations from accepted parameters sets are used to access the seasonal distribution of aquifer carbon sources in the fluviokarst system.

26. Palustrine Wetland Soil Carbon and Nitrogen Content Post-Wetland Reserve Easement Enrollment in the Northern Mississippi Embayment, Kentucky

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Landowners that farm in floodplains have the option to enroll their frequently flooded land and floodplain-adjacent land into the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Agricultural Conservation Easement Program (ACEP) Wetland Reserve Easement (WRE). When land is enrolled in this program, the USDA purchases the right to farm from landowners and reverts the land back to wetlands by removing drainage structures and planting native vegetation. We determined the concentration of total soil carbon and nitrogen across a chronosequence of agricultural lands converted to wetlands via the USDA NRCS ACEP WRE in the northern Mississippi Embayment of western Kentucky. The study sites were sampled post-enrollment in one of three stages of wetland vegetative growth: 1) final crop and initial bottomland hardwood tree planting (0 years; n = 2), 2) intermediate tree growth (7 years after tree planting; n = 2), and 3) mature bottomland forest (30+ years; n = 1). Just over 3,300 soil samples were collected by pneumatic soil corer (Wintex 3000, WintexAgro) or hand auger on a 10-meter grid (with minor adjustments made to avoid existing trees) at three depth intervals: 0–10 cm, 10–30 cm, and 30–60cm. Soil samples were dried at 53°C, ground to less than 2 mm with a mortar and pestle followed by a rolling mill, then analyzed for total C and total N via combustion. Data were analyzed using a Type III ANOVA, which found depth and field maturity to be statistically significant factors. This was followed by post-hoc pairwise comparisons of field maturity within each depth interval using estimated marginal means with a Tukey adjustment. In all wetlands, the soil C and N concentrations were higher in the 0–10 cm depth interval than in the underlying depths. The highest concentration of soil C was in the mature wetland. We anticipate repeating this soil sampling and analysis after a decade of vegetation growth.

27. eDNA Metabarcoding-Based Microbial Diversity Profiling of Urban Streams in the Inner Bluegrass*

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Biological contamination from animal and human fecal material is a major contributor to water quality deterioration in the U.S., particularly in rural states where water infrastructure may lag behind current standards. Fecal contamination can introduce pathogenic organisms into aquatic ecosystems, increasing the potential for human exposure. Urban lotic systems often facilitate the transport of these microorganisms, distributing them broadly throughout highly populated areas. The relatively new field of environmental DNA (eDNA), and particularly the recent coupling of eDNA with high-throughput sequencing, has emerged as a highly effective method of pathogen detection and fecal source tracking, yet its application to urban freshwater systems remains relatively limited. We collected water samples (2-L) in December, March, and June from nine sites within the Lexington, KY urban service boundary representing varying degrees of anthropogenic disturbance, as well as from three relatively undisturbed reference sites. Samples were filtered in the laboratory and DNA extracted utilizing established protocols. Library construction and analysis were divided into two stages: an initial assessment to validate the methodology was completed utilizing Nanopore sequencing, while Illumina high-throughput sequencing is being utilized for the full analysis to provide substantially greater sequencing depth. Initial analysis utilized primers targeting the full-length (1,465 bp) prokaryotic 16S rRNA gene, while the full analysis utilized primers targeting the V4 hypervariable region (293 bp) of the same gene. Initial analysis utilizing Nanopore sequencing identified 180 prokaryotic genera, as well as 61 species-level identifications within those genera. Ecological niche associations were assigned for 80% of the identified bacteria species. Of these, 79% of bacterial species had previously been isolated from non-fecal associated environmental sources. However, 9% of bacterial species were associated with mammalian gastrointestinal tracts, and another 6% were exclusively associated with human gastrointestinal tracts. An additional 6% of species had documented associations with wastewater, including sewage sludge. The full analysis will be completed utilizing Illumina NovaSeq to achieve an expected sequencing depth of 60,000 reads per sample. Previous eDNA metabarcoding work in our laboratory identified 71 vertebrate species across these sites, including 10 mammal species, representing potential sources of the fecal-associated bacteria. Integrating microbial community profiling with vertebrate eDNA data offers a novel opportunity to simultaneously evaluate microbial diversity and potential vertebrate sources of fecal contamination in urban streams, providing valuable information for water quality assessment and watershed management.

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28. Edge-of-Field Monitoring of Nutrient and Sediment Loss from Wetland Watersheds: The First Conservation Effects Assessment Program Project in Kentucky

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Between 2018 and 2023, researchers from the University of Kentucky Martin-Gatton College of Agriculture, Food and Environment and the Kentucky Geological Survey partnered with the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS) to conduct an edge-of-field monitoring study on Agricultural Conservation Easement Program Wetland Reserve Easements in the northern Mississippi Embayment, Kentucky. The goal of this project was to evaluate the effectiveness of conservation practices related to nutrient and sediment losses from agriculture row-crop fields returned to wetlands during a five-year period. The monitored wetlands were in one of three stages of wetland vegetative growth: 1) final crop and initial tree planting (0 years; $n = 2$), 2) intermediate herbaceous growth (5 to 7 years after tree planting; $n = 2$), or 3) mature bottomland forest (30+ years; $n = 2$). Rain-generated surface runoff samples were collected from the six wetland watersheds, each less than 12 acres in area. Except for the mature bottomland forest wetlands, the outlet of each watershed was instrumented with a flume, an ultrasonic flow meter, an automated composite water sampler, and a rain gage. The mature bottomland forest wetland watersheds were instrumented with laser flow meters rather than flumes due to the tendency of the watersheds to flood. Water samples collected from each runoff-generating precipitation event were analyzed for nutrients (ammonium, nitrate, total nitrogen, orthophosphate, and total phosphorus) and total solids, which are the major agricultural pollutants of concern in this study's watersheds and surrounding water bodies. Additionally, surface water discharge and precipitation were recorded. During one year of the limited study, total nitrogen, total phosphorus, and total sediment loads for the mature bottomland forest wetlands were greater than loads discharged from the initial and intermediate wetlands. These results were counter to expectations and indicated that additional data are needed to adequately evaluate nutrient and sediment losses from these wetlands. In July 2026, the first USDA NRCS Conservation Effects Assessment Program project in Kentucky will begin, which will involve the resumed sampling of the previously mentioned wetlands for five years. Results from continued monitoring will aid in determining the effectiveness of wetland conservation practices for mitigating nutrient and sediment losses in the northern Mississippi Embayment, which could lead to water quality improvements in the Mississippi River watershed and the Gulf of America.

29. The Kentucky Geological Survey's Kentucky Groundwater Observation Network

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Groundwater resources play an important role in Kentucky's public and private water supply as agricultural and industrial usage expands and as the state's population grows. The Kentucky Geological Survey (KGS) is mandated by the Kentucky legislature to "characterize the quality, quantity, and distribution of Kentucky's groundwater resources" across the state through implementation of a groundwater monitoring network. KGS initiated the Kentucky Groundwater Observation Network (KGON) in 2015 by instrumenting 10 water wells (4 newly installed and 6 existing wells) completed in aquifers in six western Kentucky counties and one Inner Bluegrass county. Monitored aquifers include the upper and middle Claiborne, lower Wilcox, McNairy, St. Genevieve Limestone, glacial outwash gravel aquifer, and Lexington Limestone. Continuous groundwater level data were recorded and collected quarterly until July 2025, when 9 of the 10 wells began transmitting real-time data to the KGS KGON Wells website. In 2025, four wells located in the Jackson Purchase Region (JPR) were added to KGON. Three wells were instrumented to collect continuous groundwater level data, and one well is visited quarterly to collect periodic groundwater water level data. In 2026, one well has been instrumented to collect continuous groundwater level data, and two to three additional wells are scheduled to be instrumented by the end of the year. Long-term continuous groundwater level data indicates that regional groundwater levels are not decreasing. Groundwater levels do decrease locally during periods of extended pumping associated with pivot irrigation in western Kentucky; however, levels increase during periods of recharge (wet season). In addition to collecting groundwater level data, work is underway to collect groundwater samples for total metals, anions, nutrients, and herbicides from all monitored water wells. All groundwater level data and sample analyses will be uploaded to the Kentucky Groundwater Data Repository, and summary data will be made available through the KGS KGON Wells website. Current KGON partners include Mammoth Cave National Park, Murray State University, Kentucky Horse Park, University of Kentucky Research and Education Center at Princeton, Harold L. Disney National Guard Training Center, Kentucky Division of Water, University of Kentucky Martin-Gatton College of Agriculture, Food, and Environment, and eight private landowners. Groundwater level data from KGON wells in the JPR are being used by KGS seismic researchers as part of the Kentucky NSF EPSCoR Climate Resilience Through Multidisciplinary Big Data Learning, Prediction and Building Response Systems (CLIMBS) seismic array project to evaluate the effectiveness of using seismic data to determine regional groundwater level changes in the JPR.

30. Investigating the Use of a Lignin-Derived Deep Eutectic Solvent for Nonsolvent-Induced Polymeric Membrane Fabrication

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Deep eutectic solvents (DES) are emerging as a promising and sustainable alternative to traditional solvents in various industrial processes. They offer distinct advantages, including low toxicity, biodegradability, cost-effectiveness, and the ability to be tailored to specific applications. This study investigated the fabrication of polysulfone (PSf) membranes using a lignin-derived, hydrophobic deep eutectic solvent (DES) composed of thymol and 2,6-dimethoxyphenol (Thy:Dmp) in a 1:1 molar ratio via non-solvent induced phase separation (NIPS). Hansen solubility parameter calculations confirmed thermodynamic compatibility between PSf and the DES (RED = 0.6), while cloud point measurements established the ternary phase behavior for the PSf/Thy:Dmp/ethanol system. Fourier Transform Infrared spectroscopy (FTIR) spectroscopy confirmed complete solvent removal and polymer structure preservation after membrane formation. The resulting membranes exhibited asymmetric morphology with finger-like macrovoids and $81.2 \pm 1.80\%$ porosity. Contact angle measurements indicated moderately hydrophilic membrane surfaces ($64.0 \pm 1.20^\circ$). Membrane performance evaluation displayed water permeability of 58.3 LMH/bar and protein rejection of 94.4%. Preliminary trials with Cellulose Acetate (CA) show similar results in protein rejection at the same polymer contents. These results demonstrate that lignin-derived hydrophobic DES can serve as a functional alternative to conventional solvents for polysulfone membrane fabrication.

31. Hydrogeologic Tracing to Improve Karst Watershed and Floodplain Planning for Jennings Creek, Kentucky

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Jennings Creek flows through the City of Bowling Green, Kentucky, and contains complex subsurface interconnectedness characteristic of a karst landscape, including underground springs and subsurface flow. This results in rapid water infiltration and underground movement, which can cause extensive flooding throughout the flowpath of Jennings Creek with short notice. The objective of this study is to utilize precipitation data, water level monitoring, and dye tracing to further delineate the Jennings Creek basin, identify flow travel time, and calculate recovery dye mass to determine the storage capacity of Jennings Creek for flood mitigation. Results suggest that storage modulates the aquifer response and flowpaths may vary under differing antecedent hydrologic conditions.

32. Impact of Habitat Parameters on Macroinvertebrates

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Macroinvertebrates are valuable bioindicators when determining stream health. Increased sedimentation, temperature, and flooding, can decrease the diversity of aquatic macroinvertebrates. This study addressed the relationships between macroinvertebrate diversity and physical stream characteristics. The five study sites were located on two streams with differing watershed land uses including agriculture, exurban and forested. We sampled macroinvertebrate communities and performed the Qualitative Habitat Evaluation Index and Hydromodification Survey at all sites during fall 2025. We found low macroinvertebrate diversity at all sites. This data is the beginning of a multi-year study that will teach us more about climate change impacts on streams.

33. Jennings Creek/Lost River Karst Watershed Plan Outcomes in Warren County, Kentucky

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Bowling Green has been the subject of concerning groundwater and surface water contamination, often exceeding levels deemed safe by the EPA. Since 2019, Bowling Green's water has faced contamination issues due to a rapidly growing population and related factors pose a threat to the Jennings Creek watershed, a vital water source for Bowling Green and surrounding areas, and without regulation, the rampant contamination will persist. Jennings Creek's watershed includes the karst influence of Lost River, a major underground stream network, which creates added complexity in developing a watershed plan. Results from the planning process indicate a variety of impairments and BMPs needed to address the influences from the karst watershed and associated contaminant sources.

34. Modeling Chlorine Decay Dynamics in Water Distribution Systems

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Because of the need to maintain a minimum chlorine disinfectant residual in the water distribution system (i.e., 0.2 mg/L), it is important for water system operators to know the rate of decay of free chlorine (i.e., HOCl and OCl⁻) in their water distribution system. Technically, this decay includes two components, the interaction of chlorine with the bulk water moving through the distribution pipes and the interaction of chlorine with any inorganic or organic materials affixed to the walls of the pipes. The former decay rate is known as the bulk decay rate while the latter is known as the wall decay rate. The bulk decay rate is determined using water samples collected at the treatment plant, and the wall decay rate is determined with calibration with distribution system water samples and the calculated bulk decay rate. In pipe systems containing PVC pipes, the bulk decay rate represents the dominant contributor to the aggregate chlorine decay.

This paper will explore the use of four different bulk decay rate sampling and storage protocols with a goal to identify the most efficient. The four methods combine different sampling techniques (one bottle used for all time points or multiple bottles used for multiple time points) and different temperatures (refrigeration temperature or distribution water temperature). The paper will also explore the accuracy and precision of three different commercial meters for measuring free chlorine with a goal of identifying the best meter. The three meters include: 1) a Hanna HI701 meter (\$75), 2) a Hach DR300 meter (\$711), and 3) a Hach SL1000 meter (\$5500). Finally, the paper will explore five different models for predicting chlorine bulk decay over time: two simple exponential decay models, and three different second order decay models. The goal of the analysis will be to determine if one method gives consistently better prediction performance than the other methods.

These analyses will be conducted using a database of six different chlorine decay datasets collected from the Martin County, Kentucky water treatment plant between 2022 and 2026.

35. Links Between Stream Stability, Habitat and Watershed characteristics

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Many factors were used to determine the quality and stability of stream ecosystems and to provide insight to ongoing channel evolution. Qualitative Habitat Evaluation Index, Habitat Assessment Survey, and Hydromodification survey were performed at five sites in Ohio. Study sites were located on two streams with differing land cover. Our results show steep slopes, loss of vegetation, and large variation in pebble size. This can be attributed to land use, tree cover, and soil type in the area. Our data serves as the first in a multi-year study, where channel evolution can be determined.

36. A Real-Time Flood Monitoring Dashboard for Kentucky Communities to Bridge Data Sources and Develop Flood Awareness

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Streams across the Appalachian region remain under-monitored, leaving communities with limited ability to anticipate and respond to floods. More broadly, what flood-related data is available to the public is often difficult to find, fragmented across numerous agencies, and often is inaccessible to non-experts. While locally deployed sensors can fill some gaps in streamflow coverage, data from these sources is external to federal monitoring networks, necessitating custom platforms to be accessible to communities. Our objective was to develop a web-based flood monitoring dashboard that would consolidate and normalize data and model predictions from the USGS, NOAA/NWS, FEMA, as well as local lab-deployed sensors into accessible and actionable flood information for community members throughout KY. Designed around an interactive web map, the dashboard integrates live USGS stream gauge readings and catchment delineations, lab-based stream and rain gauge readings and catchment delineations, National Weather Service alerts, flood stage thresholds and impact summaries, current and forecasted precipitation and flood inundation extents, and hazard outlooks, and FEMA flood risk zones and disaster history. We designed the dashboard with direct feedback from community partners in Letcher County, KY throughout multiple phases of development. The dashboard prioritizes summaries of locally relevant and urgent flooding information, which are designed to be attention-grabbing and communicate the underlying data quickly, plainly, and explicitly to Kentucky residents without a hydrological background. The dashboard offers one approach for improving sparse hydrologic monitoring infrastructure, translating that data for non-expert community members, and expanding flood awareness throughout the Commonwealth.

37. Accuracy Assessment of Drone-Based Lidar Measurements in Edge-of-Field Monitored Agricultural Watersheds

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Accelerated soil erosion remains a serious problem around the world. The UK Martin-Gatton College of Agriculture, Food, and Environment and the Kentucky Geological Survey, in partnership with the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS), the Kentucky Soybean Promotion Board, the Kentucky Agricultural Development Board, and several cooperating Kentucky farms, initiated an edge-of-field (EOF) water quality monitoring project to measure nutrient and sediment loss from active row-crop fields during precipitation-generated runoff events. This is part of a national effort by the USDA NRCS to evaluate the effectiveness of agricultural best management practices (BMPs; e.g., reduced tillage, cover crops, and grassed waterways). Within Kentucky, there is currently a network of 22 active stations, collectively known as Blue Water Farms, distributed throughout western Kentucky.

EOF water quality monitoring requires substantial capital and labor costs. In contrast, digital elevation model (DEM) differencing utilizing lidar from small uncrewed aerial vehicles (sUAVs; drones) promises to be a quicker and more cost-effective erosion quantifying method. To validate erosion estimates utilizing DEM differencing, we are developing sUAV-based lidar methods to document areas of erosion in two EOF watersheds, one with a grassed waterway and one without a grassed waterway. Both ground control points (GCPs) and real-time kinematic (RTK) measurements were used to georeference lidar data. Georeferencing methods were analyzed for accuracy and efficacy. Additional GCPs were added to fallow winter fields between cropping seasons to assess the ideal number of GCPs. Accuracy was measured using horizontal and vertical root mean square error calculations.

All flights had high horizontal accuracy at 95% confidence regardless of GCP usage. Vertical accuracy increased using GCPs compared to only RTK analysis. However, increased point cloud computational noise affected the ideal number of GCPs, as more GCPs did not always increase vertical accuracy. Only three strategically placed GCPs were needed to reasonably maintain overall vertical accuracy on these small watersheds (4 to 7 acres). Erosion was detected down to the centimeter scale after removing computational noise.

If erosion estimates derived from sUAV-based lidar are comparable to those derived from total sediment values collected at the Blue Water Farms, erosion estimates can be made across a wider area with less labor and cost, expanding field-scale erosion estimates across Kentucky. In turn, sUAV-based lidar data may aid in determining the effectiveness of BMPs that reduce soil loss, improve on-farm nutrient retention in western Kentucky, and potentially decrease nutrient loads in local and regional streams.

38. Development of an Ecosystem Concept Model for the Ohio River for Integration into a HAB Prediction Model

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Harmful algal blooms (HABs) in large, regulated rivers like the Ohio River are controlled by hydrologic, sediment transport, nutrient cycling, and ecological processes. Due to the interactions between these processes, they are difficult to represent using flow metrics alone. We develop a conceptual process-based framework describing the hydrologic and biogeochemical processes linking seasonal flow regimes to cyanobacterial bloom development in the Ohio River, considering progression of these processes through the uplands of the watersheds, the tributary systems including lakes, estuaries, and streams, and in the mainstem of the Ohio River. We are currently formulating two distinct and interconnected phases governing bloom evolution, including growth and stress phases.

The growth phase is initiated by early summer high-flow events generated by spring runoff, tributary flooding, and storm events in the basin. Elevated discharge increases velocity and boundary shear stress, which mobilizes hillslope, bank, and bed sediments that transport particulate phosphorus, nitrogen, and organic carbon to tributaries and the mainstem of the Ohio River. Hillslope runoff is represented using infiltration and runoff formulations, and sediment production is described using excess shear stress relationships, rill and interrill erosion, and sediment continuity equations for sand and cohesive particles. Tributary transport incorporates hydraulic bank erosion, cohesive sediment dynamics and deposition, and coupled nutrient transport equations that incorporate remineralization to quantify the particulate and dissolved nutrient loads available for algae and phytoplankton uptake as well as delivery to the mainstem.

The stress phase of our model follows sustained discharge decreases caused by droughts in the basin that lead to increased residence time of water, increased sediment deposition, internal nutrient cycling, and stable water-column conditions favorable for cyanobacterial dominance. Recycling of nutrients (phosphorus and nitrogen) from bed sediments coupled with reduced flushing and increased light availability is hypothesized to promote toxin production in *Microcystis* populations, allowing for continued growth of the cyanobacteria in the stress phase while these environmental and nutrient stresses inhibit the growth of competing phytoplankton. Biomass dynamics are represented as functions of nutrient availability, irradiance, water temperature, respiration, mortality, and hydrologic flushing.

By combining watershed hydrology, sediment transport, nutrient cycling, and biomass accumulation within a unified conceptual framework, this model provides a mechanistic explanation for the observed relationship between early summer water discharge peaks, subsequent sustained low flow, and HAB development. The framework establishes a foundation for future implementation of a fully coupled eco-hydrologic model capable of evaluating how changing flow regimes and climate-driven extremes influence bloom initiation and persistence in large river systems.