# Multi-dimensional Modeling of Interactions between Nutrients and Riparian Vegetation for Improved Riverine Ecosystem Management[1]

## Research Need

Current capabilities allow one to model fully mixed riverine systems with riparian vegetation growth and mortality being a function of flow and sediment. Improvements to the system will allow two-dimensional (vertically averaged) simulations, thus improving model results in large river and estuary systems, enabling modeling of interactions between flow, nutrient fate and transport, and riparian vegetation life cycles in the floodplain.

## Project Objectives & Plan

The general purpose of the project is to improve the current nutrient simulation and riparian vegetation module formulations and integrate them into the latest HEC-RAS-2D program.

Riparian vegetation formulations will be improved to incorporate the effects of nutrient uptake on plant growth and mortality, thus allowing one to evaluate the effects of wetlands and backwater areas on recycling nutrients and reducing nutrient loads in downstream water bodies. These improvements in modeling capability will improve the science, economics, and decision support for ecosystem management and restoration.

The primary product of this research will be an improved HEC-RAS-2D model with more advanced nutrient and riparian vegetation dynamics. The advanced nutrient capabilities will be accomplished with updates to the Nutrient Simulation Module (NSM), and improved riparian vegetation dynamics will be accomplished through improvements to the Riparian Vegetation Simulation Module (RVSM). Technical reports, testing, validation studies, and updated versions of the HEC-RAS User's Manual and Applications Guide will be available from the HEC website.

## Payoff

The updated HEC-RAS-2D model will support the Corps' most pressing need for a cost-effective science-based impact assessment for ecosystem restoration and management. Because of its widespread use in flood analysis and other hydraulic studies, most large river systems as well as many smaller rivers and streams in the U.S. have already been modeled with HEC-RAS. The overall cost to stakeholders interested in modeling water quality and interactions of flow, nutrients and vegetation for improved riverine and estuarine ecosystem management and restoration is dramatically reduced due to leveraging these analyses against existing modeling efforts.

## Products

### Technical Reports (TRs)

Zhang, Z. and Johnson, B.E. (2016). Testing and validation studies of the NSMII-benthic sediment diagenesis module (ERDC/EL TR-16-11), Technical Report. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Zhang, Z. and Johnson, B.E. (2016). Aquatic nutrient simulation modules (NSM) developed for hydrologic and hydraulic models (ERDC/EL TR-16-1), Technical Report. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

### Technical Notes (TNs)

Zhang, Z., Johnson, B. and Greimann, B. (2019). HEC-RAS-RVSM (Riparian Vegetation Simulation Module), (ERDC/TN EMRRP-SR-87), Technical Note. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Zhang, Z., Johnson, B. and Greimann, B. (2019). Riparian vegetation simulation module (RVSM) (ERDC/TN EMRRP-SR-88), Technical Note. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Zhang, Z., Johnson, B., Wang, J., & Greimann, B. (2019). Application and validation study of the HEC-RAS-RVSM model to the Sacramento River (ERDC/TN EMRRP-SR-88), Technical Note. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

### Conference Presentations/Webinars/Workshops

Zhang, Z., Johnson, B.E. and Greimann, B.P. (2017). Application and evaluation of HEC-RAS – RVSM to the Sacramento River, Presentation. CWEMF Conference, Folsom, California.

Zhang, Z. and Jensen, M. (2022). HEC-RAS One-Dimensional Riverine Water Quality Modeling. Environmental Water Resources Institute (EWRI), American Society of Civil Engineers (ASCE) Conference. June, 2022.

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Steissberg, T.E., Johnson, B.E., Zhang, Z., Jensen, M.A., and Sanchez, A. (2022). ClearWater-Riverine: An Integrated Water Quality Modeling Framework for Riparian and Floodplain Ecosystems. iEMSs 2022 Conference. International Environmental Modelling and Software Society. Brussels, Belgium. June 2022.

Zhang, Z., Steissberg, T.E., and Johnson, B.E. (2022). Linked Riverine and Reservoir Hydraulic and Water Quality Modeling for Ecological Impact Assessment. American Geophysical Union (AGU) Frontiers in Hydrology Conference. Session: Working with Nature-Based Features in Inland and Coastal Tropical Environments. American Geophysical Union. San Juan, Puerto Rico. June 2022.

Steissberg, T.E., Johnson, B.E., Zhang, Z., Jensen, M.A., and Sanchez, A. (2022). ClearWater-Riverine: A New Two-Dimensional River and Floodplain Water Quality Model. American Geophysical Union (AGU) Frontiers in Hydrology Conference. Session: Working with Nature-Based Features in Inland and Coastal Tropical Environments. American Geophysical Union. San Juan, Puerto Rico. June 2022.

## Models and Applications
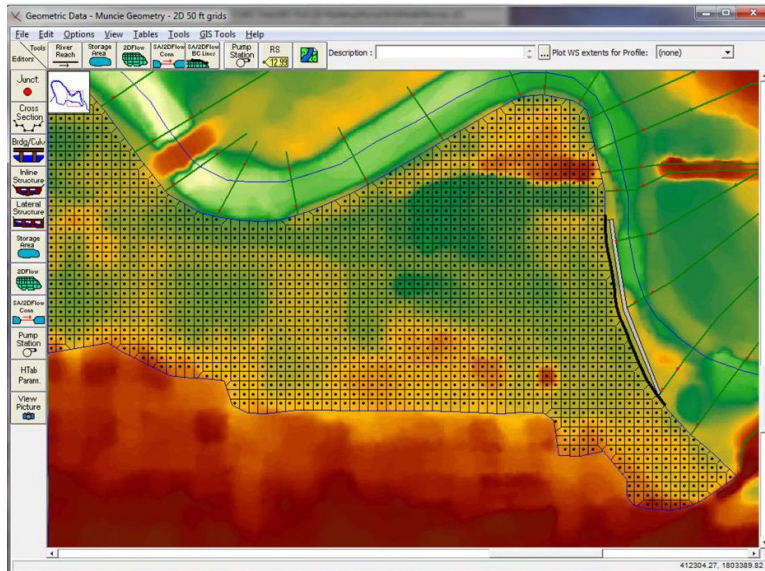- Columbia River System Operations (CRSO) Project, USACE Northwest Division (2020)



Figure 1. HEC-RAS-2D hydraulics model, Muncie, Indiana.

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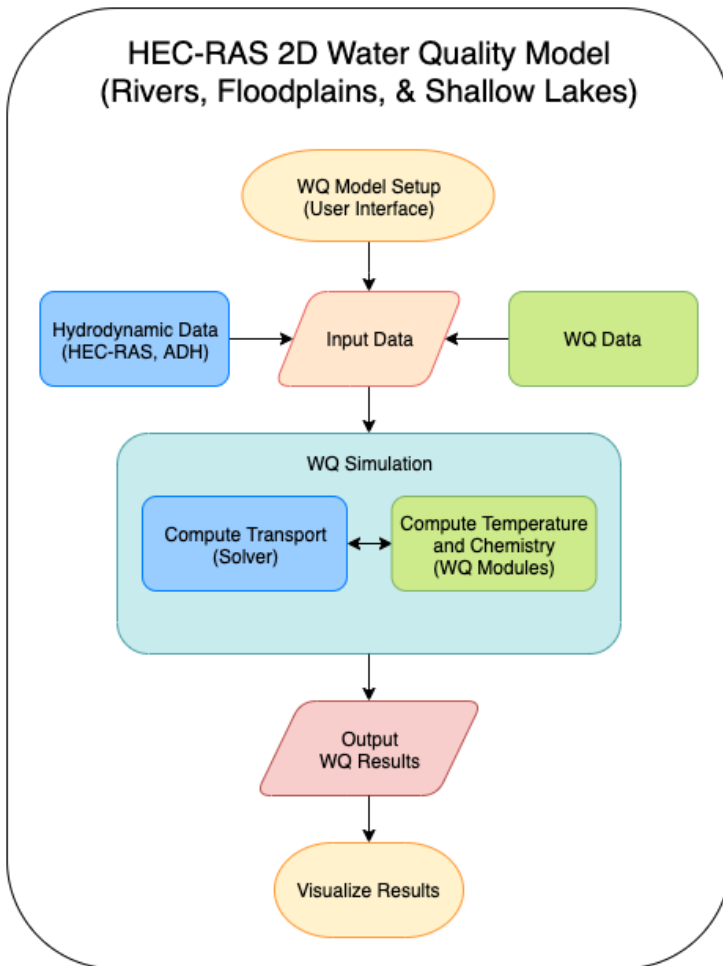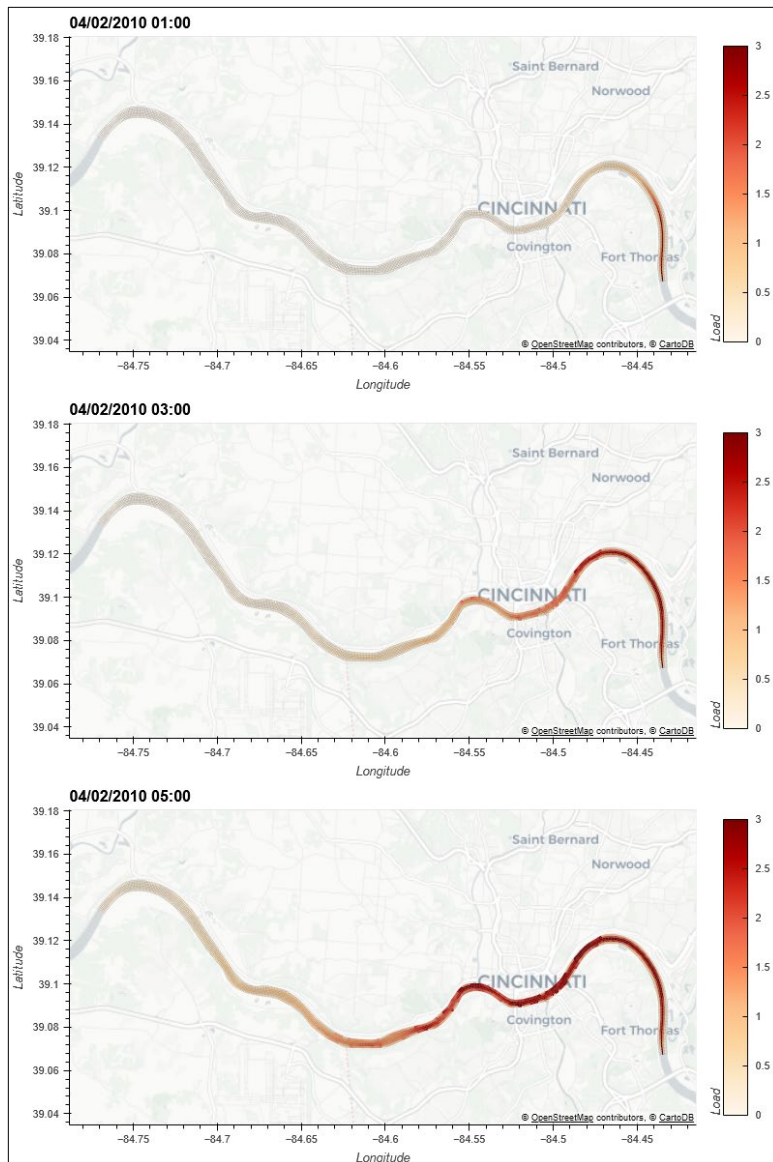Figure 2. ClearWater-Riverine modeling schematic.

Figure 3. Advection and diffusion of a tracer in the Ohio River using the ClearWater-Riverine water quality model linked with a HEC-RAS-2D hydraulics model. Water quality was modeled using a constant kinetics rate to simulate its decay due to assimilation as it is transported and spread through the Ohio River system. Note that the concentrations vary across the channel as well as in the direction of flow. This figure also demonstrates the new visualization capabilities of ClearWater-Riverine.

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