Integrating Environmental Considerations with Water Resource Simulations[1]

Research Need

As watersheds are subjected to escalating pressures of land development, environmental degradation, and weather-related impacts, managing reservoir and riverine systems to address environmental considerations is an increasingly complex but important task. Historically, reservoir operations have focused on balancing multiple authorized project purposes (i.e., flood control, water supply, fish and wildlife conservation, power production, navigation, and recreation). More recently, meeting environmental objectives has become an increasingly important consideration in reservoir operations, and demand for watershed scale water quality modeling is significantly increasing. However, the water resources community lacks simulation software with the capability to fully integrate environmental and ecosystem provisions into reservoir release decision-making. Due to data, time, and resource limitations, water quality models have typically been constructed to represent only a single reservoir or tributary system even though in many watersheds there are multiple reservoirs that influence system-wide water quality. To enable the most effective water management alternatives for meeting multiple objectives, new modeling tools are needed.

Project Objectives & Plan

The purpose of this project is to construct a next-generation reservoir water quality modeling system by embedding water quality capabilities within the Hydrologic Engineering Center's Reservoir System Simulation program (HEC-ResSim). HEC-ResSim is a reservoir operations simulation program that is extensively used by the Corps for water management and water resource planning. An enhanced HEC-ResSim software package with water quality modeling and analysis capabilities will fully integrate water quality into the reservoir release-decision-making process enabling improved environmental and ecosystem management. The software will be capable of performing 1D (one-dimensional) and 2D (two-dimensional) simulations. Reservoirs will be represented by 1D vertically stratified or 2D vertically stratified and longitudinally varying

water bodies, while rivers will be represented by 1D longitudinally varying water bodies. The water quality capabilities will be provided by a hydrodynamic and water quality engine, water quality libraries, and an expanded user interface developed in close collaboration between HEC and ERDC Environmental Lab (EL). The user will be able to define water quality operation rules that specify water quality objectives (either at-site or downstream) to be considered by HEC-ResSim in making reservoir release decisions. The HEC-ResSim user interface will support water quality model setup (including all relevant water quality and meteorological parameters), data visualization, analysis, and reporting. The updated HEC-ResSim program and documentation, technical reports, and validation studies will be available from the HEC's and EL's web sites.

Payoff

Integrating water quality modeling capabilities into HEC-ResSim directly supports the Corps' high priority needs for including water quality and related environmental objectives with other project purposes into reservoir operations modeling, assessment, and management. Furthermore, it facilitates cost-effective, science-based environmental impact assessment and management. Through the Corps Water Management System (CWMS) implementation project, over 200 watersheds will have HEC-ResSim models constructed and ready for deployment over the next several years. The ability to add water quality modeling and operating objectives to these watershed models and use them in CWMS for real-time decision support and in planning studies will provide an effective, efficient, and economical approach to addressing environmental requirements.

Products

- Software: HEC-ResSim Version 4.0 with Water Quality Modeling Capability
- Documentation:
    - Design Specification: HEC-ResSim Water Quality Modeling Capability Development
    - HEC (2020). HEC-ResSim Water Quality Modeling User's Manual. USACE Hydrologic Engineering Center, Davis, California.

Publications:

Steissberg, T. and L. Ostadrahimi. (2020). Water Quality Modeling Capability Development for Integrated Environmental Watershed Support. *Annual Newsletter of the USACE Committee on Water Quality*.

Steissberg, T., L. Ostadrahimi, J. DeGeorge, S. Andrews, J. Klipsch, Z. Zhang, B. Johnson. (In preparation). Integrating Water Quality Objectives into Reservoir Operations Simulations. *Environmental Modeling and Software*.

Zhang, Z. and Johnson, B.E. (2014). Application and evaluation of the HEC-RAS – nutrient simulation module (NSM I), EMRRP Technical Notes Collection. ERDC/TN EMRRP-SR-47. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

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

Zhang, Z. and Johnson, B.E. (2016b). Aquatic contaminant and mercury simulation modules developed for hydrologic and hydraulic models, ERDC/EL TR-16-8. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

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

Zhang, Z. and Johnson, B.E. (2017). Hydrologic engineer center-river analysis system (HEC-RAS) water temperature models developed for the Missouri River recovery management plan and environmental impact statement, ERDC/EL TR-17-18. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Project Activities:
- Development of HEC-ResSim unit test program with 1D WQ capabilities (temperature, conservative constituents, and eutrophication)
- EL water quality libraries developed and ready to link with HEC-ResSim
- HEC-ResSim v4.0 with Water Quality Modeling Capability
- HEC-ResSim v4.0 Water Quality Modeling User's Manual
- HEC water quality modeling tools web site: https://www.hec.usace.army.mil/software/waterquality/hec-ressim.aspx

[1]**Project Alias – Work Unit Documentation Title:** *Integrating Environmental Considerations with Water Resource Simulations*