Meeting Summary: Hydrodynamic Modeling of New Year Creek at FM 1155

The meeting was held virtually on Thursday 1 May 2025 from 10AM to 12 noon. Those participating were Jon Nelson (River Mechanics); Jody Avant, Nam Jeong Choi, Sam Matschek, Andrew Teeple and Sam Wallace (USGS); and David Maidment, (UT Austin). The research reported here supports Task 3.4, Velocity-Stage Height Interaction, of TxDOT RTI Project 0-7095-01, with USGS and UT Austin.

Introduction

The meeting consisted of a slide presentation by Jon Nelson (shown in the appendix to this report), and a live demonstration of an iRIC hydrodynamic model for water flow in the channel and flood plain of USGS site 08111110, New Year Ck at FM 1155 nr Chappell Hill, TX. A screen capture of the hydrodynamic model is shown in Figure 1. The International River Interface Cooperative (iRIC) https://i-ric.org/en/ was started in 2007 by Professor Yasuyuki Shimizu (Hokkaido University) and Dr. Jonathan Nelson (USGS) with the purpose of (1) developing a software platform called iRIC for numerical simulation of flow and morphodynamics in rivers and (2) providing seminars and educational material to support that software. After retiring from the USGS, Dr Nelson now supports iRIC through his firm, River Mechanics. The key feature of iRIC that makes it different from other hydrodynamic modeling programs is that iRIC provides a common database and graphical interface for using a number of different hydrodynamic model solvers on a common base of geospatial and hydraulic data describing the study area. In this study, two solvers have been used, FaSTMECH, and Nays2dFlood. FaSTMECH provides a quick 2D steady flow solution which can be used with a series of fixed steady discharges to produce a set of output flood inundation depth, velocity and water surface elevation maps. Nays2dFlood provides a 2D time-varying discharge solution that can simulate the passage of a flow hydrograph through the gauging site area. Nays2dFlood requires much more computation time than FaSTMECH but is used in this study because of the time-varying hydrodynamics of flow at this site.

The RQ-30 radar gauge at this location has seen several flood inundations of the FM 1155 road since its installation. Water bursts out of New Year Creek upstream of the gauge, then flows downstream through the gauge at the bridge, and also in parallel across the floodplain and the road, as shown in Figure 1. The complexities of the hydrodynamics in the stream and floodplain and the frequency of road flooding make this an ideal site for studying the complexities of the hydrodynamics of flow at RQ-30 radar gauge sites. It is often observed at this and other RQ-30 gauge sites that as the flood hydrograph rises, the flow velocity also rises, but more rapidly than the water surface elevation, and a comparable pattern occurs during the falling limb of the hydrograph. The interactions between flow velocity and water surface elevation do not proceed in a lock-step connected fashion as conventional USGS rating curves assume. The velocity-water surface elevation relationships are further complicated by the topographic form of the stream and floodplain, making each RQ-30 gauge site unique. The intent of this study is to clarify the hydrodynamic character of the flow at this site, and attempt to find a way that hydrodynamic modeling could be used to improve the calibration of the RQ-30 gauge so that it more accurately measures discharge and maps road flooding at this location.

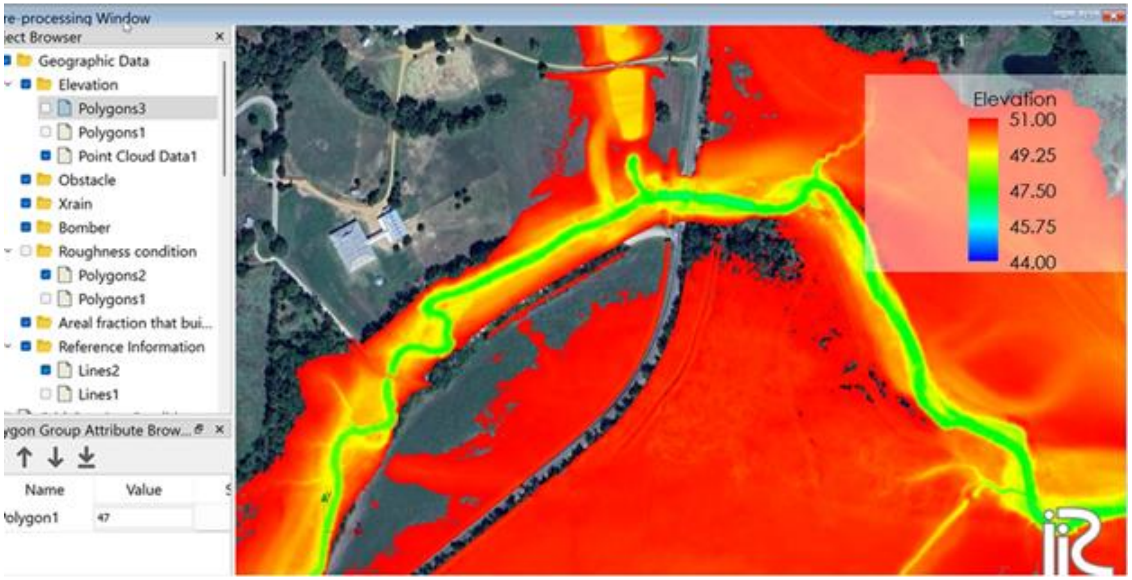

Figure 1. Water surface elevation computed by an iRIC Nays2dFlood hydrodynamic model of New Year Creek at FM 1155.

Methodology

The conceptual framework of the research is summarized in Slide 5 in the Appendix, entitled “Library Approach”. What we are now measuring at each RQ-30 gauge is Es (water surface elevation) and Us (surface velocity). We are presently computing discharge, Q, using Equation (1):

$$Q = A * k_c * U_s \qquad (1)$$

where A is cross-sectional area, and kc is a k-factor (0-1) that relates the mean velocity in the channel cross-section to the surface velocity at the measurement point. Because both A and kc are functions of Es, it follows that Equation (1) can be rewritten as:

$$Q = f(E_s, U_s) \qquad (2)$$

In comparing this approach to that conventionally used for USGS streamflow gauging, the conventional approach uses a simplified form of Equation (2), namely:

$$Q = g(E_s) \qquad (3)$$

where the function, g(Es), is the conventional rating curve determined from field measurements. In transitioning from Equation (2) to Equation (3), the assumption is made that water surface and velocity are rising and falling in lock-step with one another, so that more complex function, f(Es ,Us), in Equation (2) can be transformed into the more simplified form, g(Es), in Equation (3)

Dr Nelson has conducted an extensive series of tests using the Nays2dFlood model in which he has simulated simplified triangular flow hydrographs with varying ramping rates of the discharge up and down. He has demonstrated that the hysteresis pattern between velocity and water surface elevation observed at the RQ-30 gauge at site 08111110 can reasonably be represented by a library of curves in which the discharge, Q, is a function not only of Es and Us, but also of their time derivatives dEs/dT, and dUs/dT. Hence, we can extend Equation (2) to:

$$Q = h\left(E_s, U_s, {dE_s}/{dT}, {dU_s}/{dT}\right) \qquad (4)$$

where the discharge is now computed by what might be called a "*dynamic rating curve*", function h (…). It may occur that a longer history than just the current values of these variables is needed to accurately determine Q. Dr Nelson suggests that the library of curves that he has developed for this RQ-30 site might be used as a teaching set for machine learning, and that perhaps by extension a more robust dynamic rating curve equation could be determined by AI.

Conclusion

The purpose of this meeting record is to document the main points of the discussion and to provide a basis for determining the next steps in the research. It is apparent that the great effort required to set up the Nays2dFlood model at site 08111110, and the long computation times needed to make each flow computation (many hours per simulation) mean that a simpler approach is needed to extend this work to other RQ-30 sites.

One possibility is to characterize the spatial pattern of site inundation using the 2D HEC-RAS hydrodynamic models at the RQ-30 sites presently incorporated into the Flood Decision Support Toolbox. A steady-state inundation map library is being computed at each of these sites for increments of discharge or stage-height.

During the FAST project, the USGS field hydrologist staff have created a very large database of more than 250 ADCP measurements of discharge at RQ-30 sites. A long history of the paired time series (Es, Us) is known at each site. It may be feasible to insert these data into Equation (4) and apply machine learning to this dataset to characterize the nature of the required dynamic rating curve function for the gauge.