Bridge-Stream Network Assessments to Identify Sensitive Structural and Hydraulic Parameters for Planning Flood Mitigation

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Abstract

The interactions between rivers, bridges and the surrounding hydrogeological features are not well-understood at the river network scale. Previous studies are limited to steady state analyses focused on a specific structure and impacts occurring up- and downstream are often not considered. Complications can arise when perturbations to specific structural or hydrogeological features attenuate and/or intensify hazards on the network scale. By attempting to quantify the dynamic interactions along a river under transient conditions we can develop a framework for assessing risks associated at the bridge-stream network scale.

Study Areas

Otter Creek

- Low Gradient
- 12 road and 8 rail bridges

Black Creek

- Low – Medium Gradient
- 3 road and 2 rail bridges

Mad River

- Medium – Very High Gradient
- 16 road bridges

Figure 3. Graduate student, Rachel Seigel collecting flow data at Warren Falls.

Computer Model

- 2D unsteady HEC-RAS models
- Calibrated to gauged Tropical Storm Irene (~Q500)
- Verified fidelity for several additional flood events (Q25, Q50, Q100)

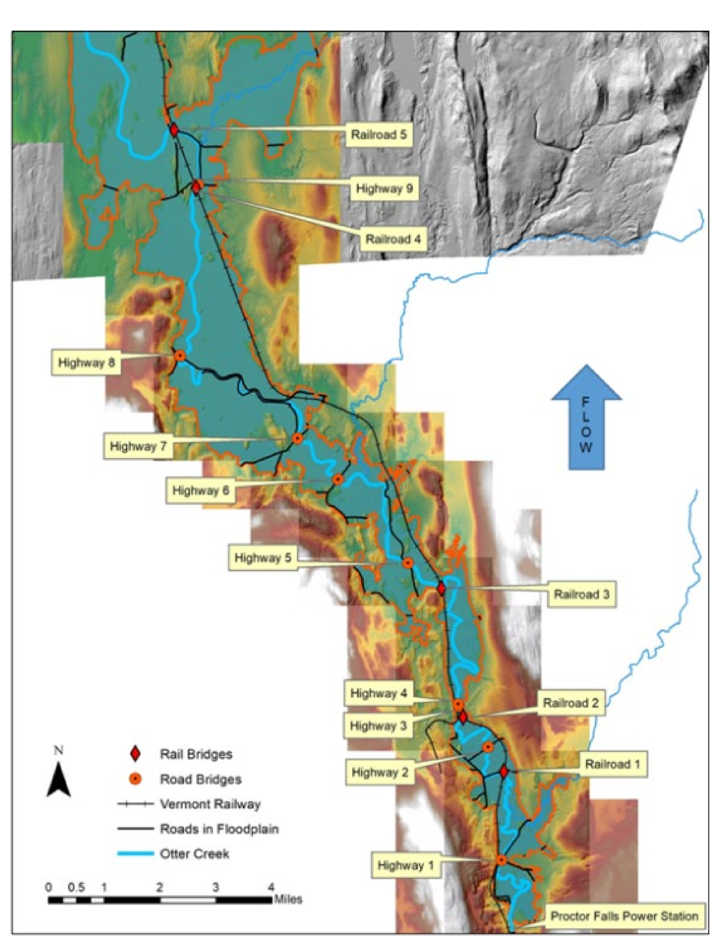

Figure 1. Otter Creek study area. The USGS operates flow gauges in Rutland and Middlebury, 46 river miles apart.

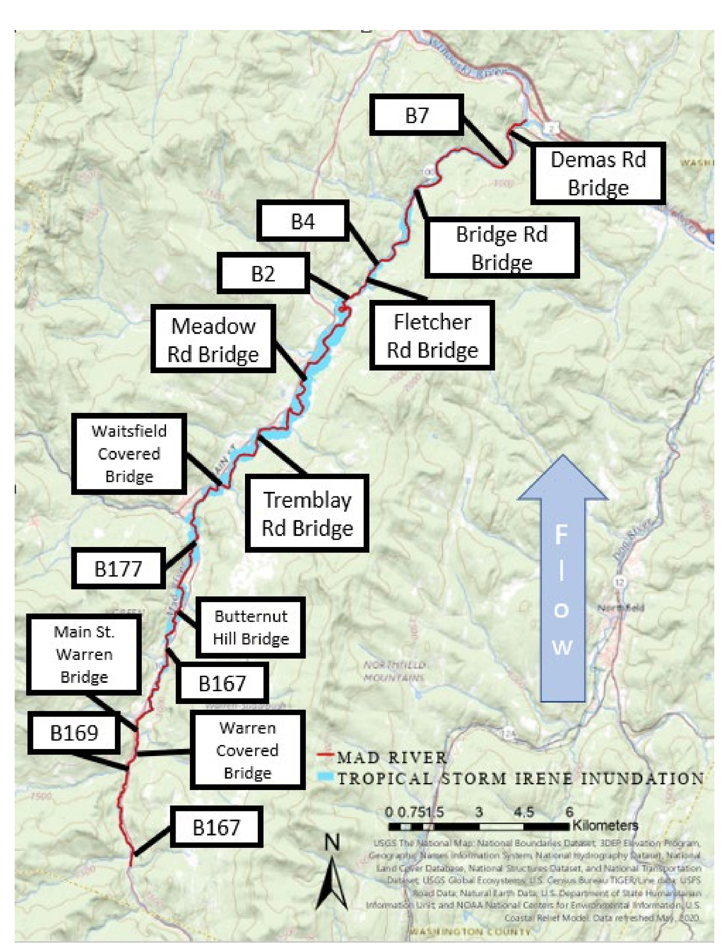

Figure 2. Mad River study area. The USGS Moretown flow gauge is the downstream boundary; Warren Falls is the upstream boundary.

Analysis

Sensitivity analyses are being performed on infrastructure within the hydrologic models to assess the bridge-stream network response. Altering transportation infrastructure by removing, adding and elevating structures within the models, we can observe the cascading impacts (e.g., the inundation area, velocity and stream power) along the river corridor and associated infrastructure.

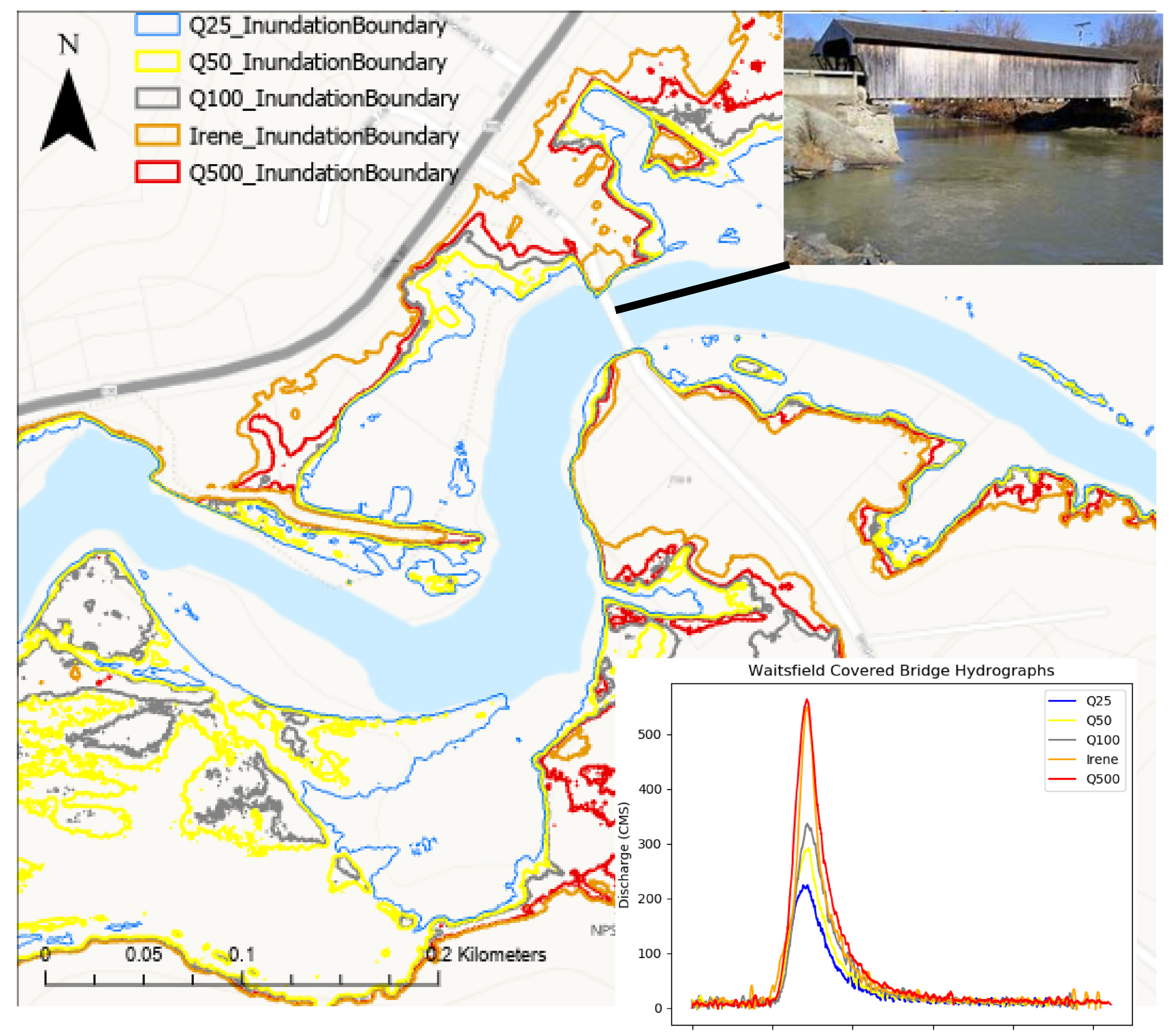

Figure 4. Flood inundation map at the Waitsfield Covered Bridge, showing the flood extents for five storm events with corresponding hydrographs.

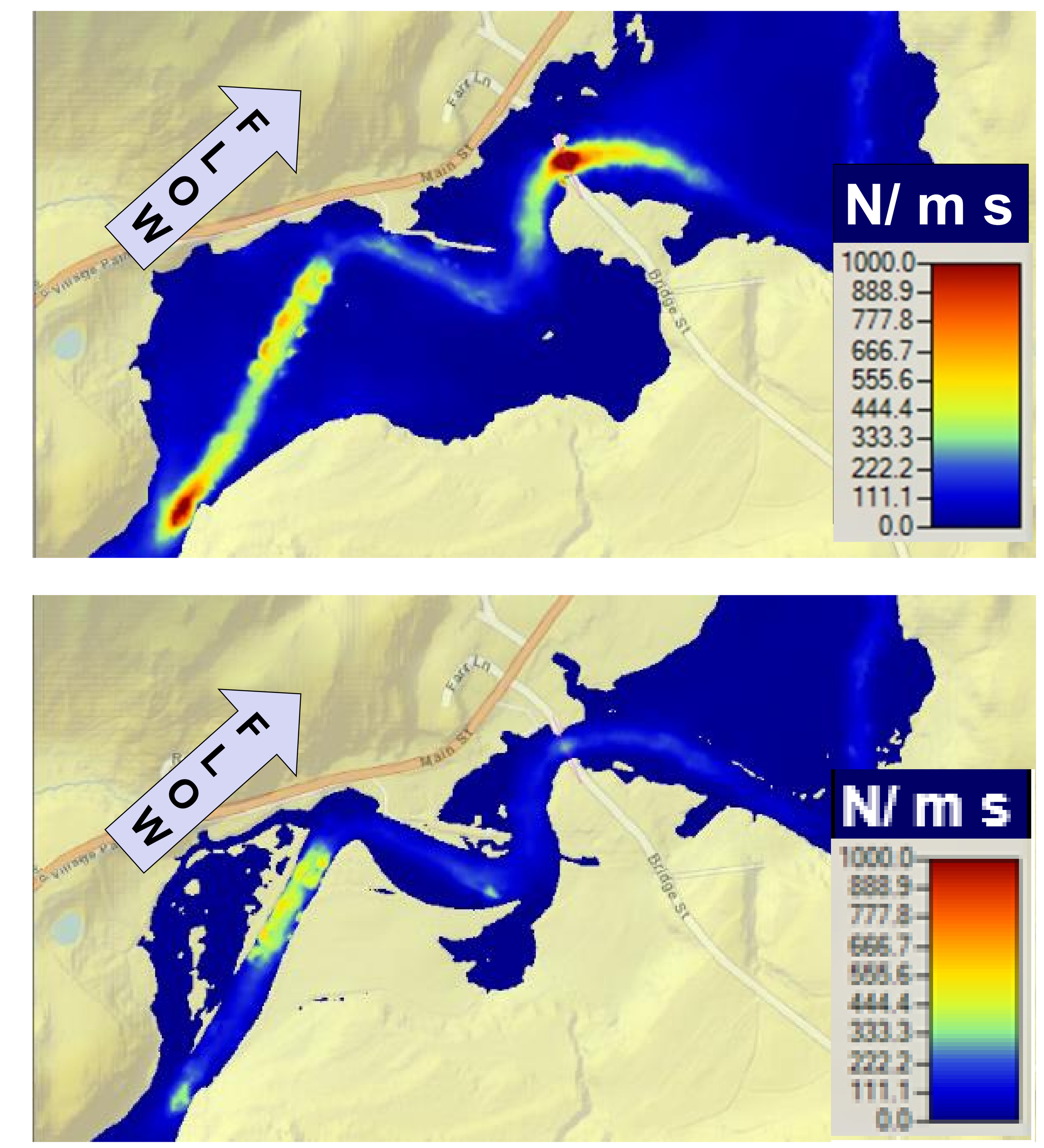

Figure 5. Map showing total channel stream power for the Waitsfield Covered Bridge during Tropical Storm Irene (Top) and a Q25 (Bottom) storm event.

Conclusions and Ongoing Research

- Development of a wrapper is underway as part of another project. The wrapper will automate the sensitivity analyses to run hundreds of mitigation scenarios (e.g., lengthening a bridge, lowering an approach road, adding culverts) to optimize a desired set of user-defined outcomes.
- The three HEC-RAS study area models will be compared to frame a simplified risk assessment. It is hoped that this framework can then be applied to other stream-bridge networks with similar geographic and climatic conditions within New England and elsewhere.

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