Reliability of Two-Dimensional (2D) Hydrodynamic Models for Assessing Susceptibility of Stream Restorations to Flood Damage and Potential Effects of Climate Change

Research Question: How can different restoration approaches or techniques reduce the impacts of future climate change?

Presenter: Art Parola, PhD, PE, Director, University of Louisville Stream Institute

Collaborators and contributors: Anne Arundel, County, Prince Georges County, Maryland Department of Natural Resources, Maryland State Highway Administration, RK&K, Greenvest, Underwood & Associates, Berrywood Community

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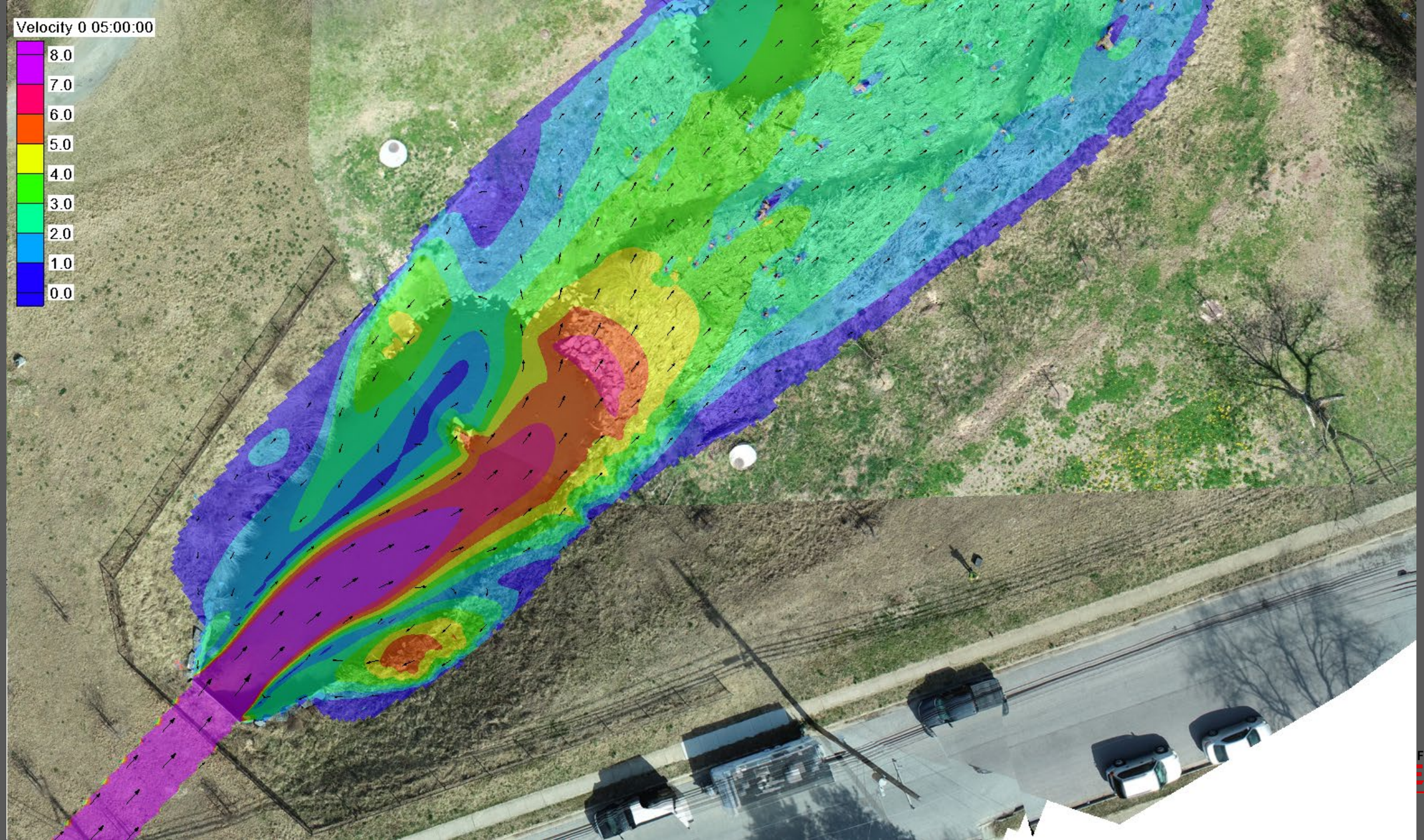
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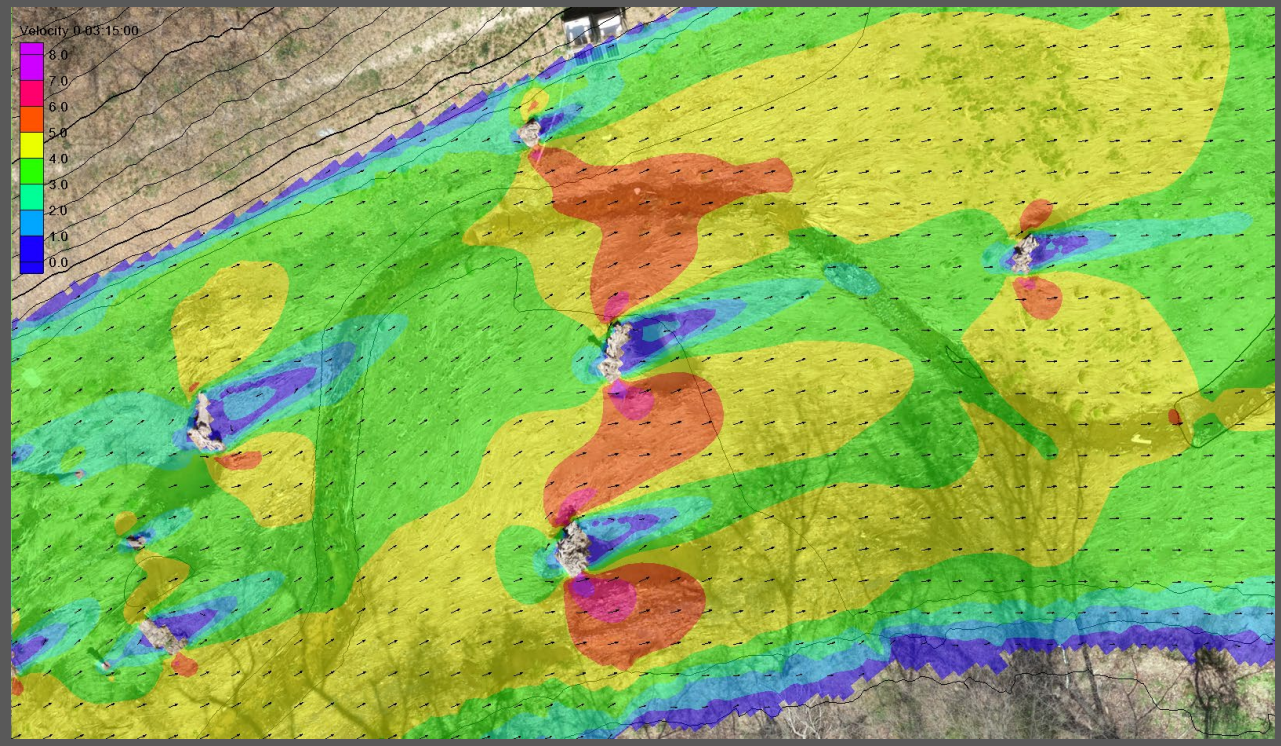
Motivation: Reliable 2D models would be useful under current and future climate conditions

Reliable models can be useful for:

Stable Restoration Design

- Identify components of restoration that are vulnerable to damage
- Determine if rock protection or additional structures are necessary to prevent damage
- Remove unnecessary rock and structures
- Minimize excavation and tree removal necessary for stability
- Compare the stability of restoration alternatives



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Motivation: Reliable 2D models would be useful under current and future climate conditions

Reliable models can be useful for:

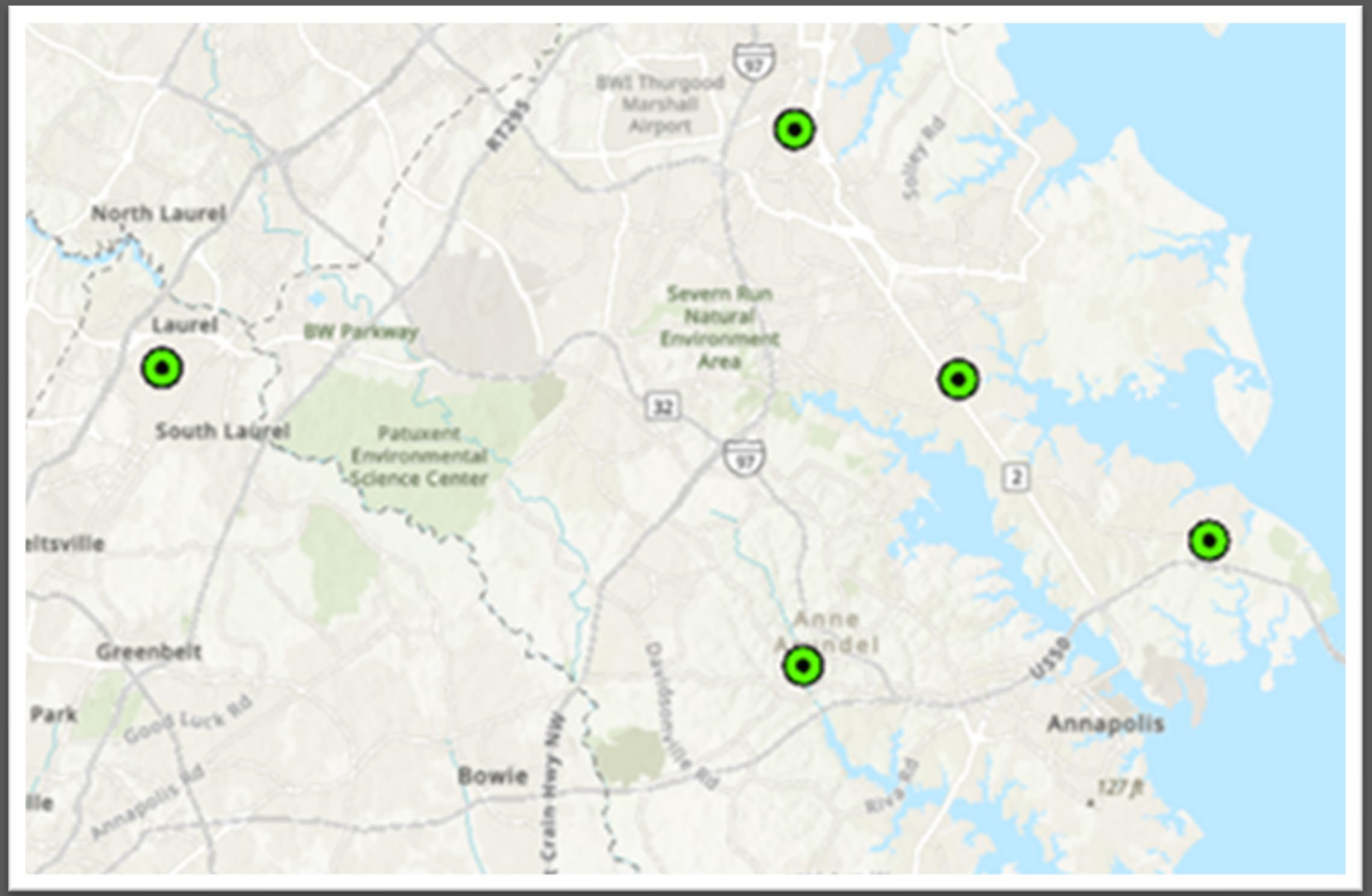
Climate Change Resilience

- Identify components that would be vulnerable to increased flow
- Estimate the increase in extent of damage caused by increased flow
- Compare resilience of alternative methods to increased flow

Research Approach

- Phase I: Evaluate 2D model reliability at 5 sites

- Phase II: Evaluate the susceptibility of restorations to damage under current and future climate conditions



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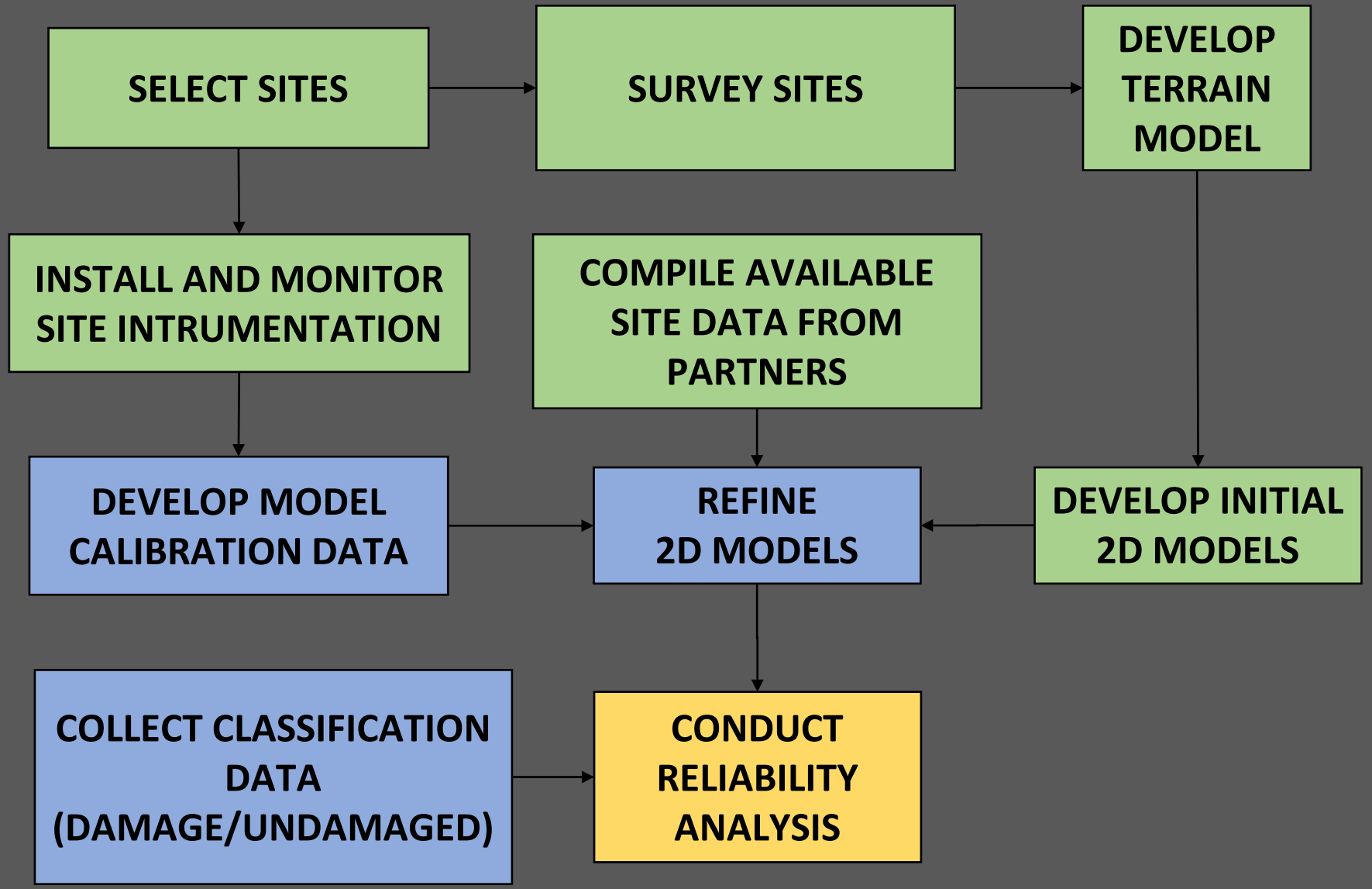
Phase I: 2D Model Reliability Analysis



Project Status

COMPLETED

IN PROGRESS

NEXT STEPS

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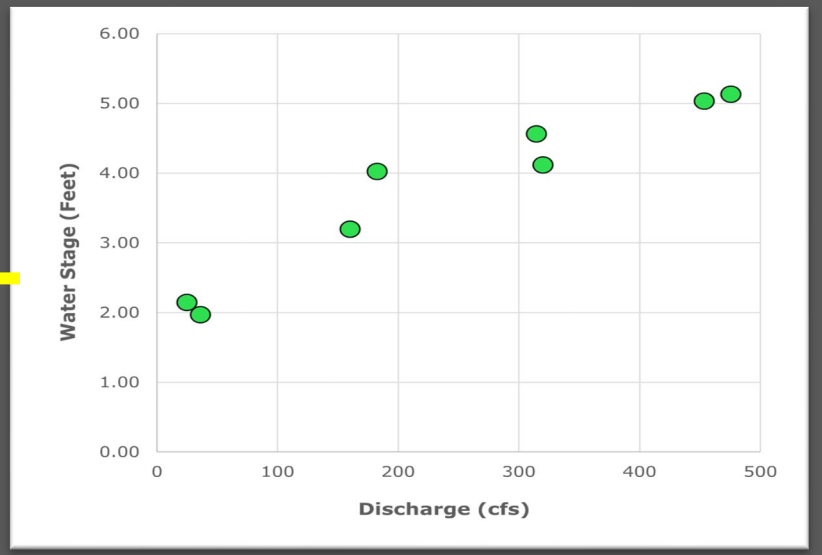
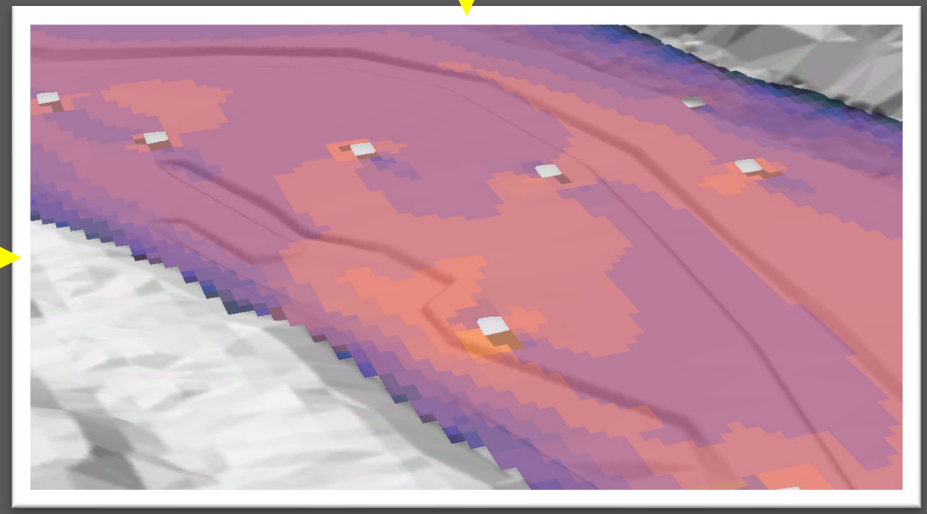
Phase I: Refining 2D Models (in progress)

- Direct observations of floods at sites are used to evaluate and refine model parameters
- Also useful for comparing flow patterns predicted by the model to the observed flow patterns

Above: imagery during a flood at CBT research site.



Above: flow during a flood using data collected in partnership with Anne Arundel County



Low Velocity *Moderate Velocity* *High Velocity*

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Phase I: Collect classification data for damaged and undamaged areas (in progress)

- Classification data is based on common indicators in the ground and vegetation

No Surficial Damage - depositional area of floodplain

Surficial Damage - Rilled area of floodplain

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Phase I: Collect classification data for damaged and undamaged areas (in progress)

- Classification for structures is based on structure failure modes

Scour and undermining of footer rocks

Bank erosion and outflanking of structure

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Phase I: Collect classification data for damaged and undamaged areas (in progress)

- Structure damage classified by failure mode

Undamaged beaver dam analog (BDA)

Bank rills from floodplain return flow downstream of BDA

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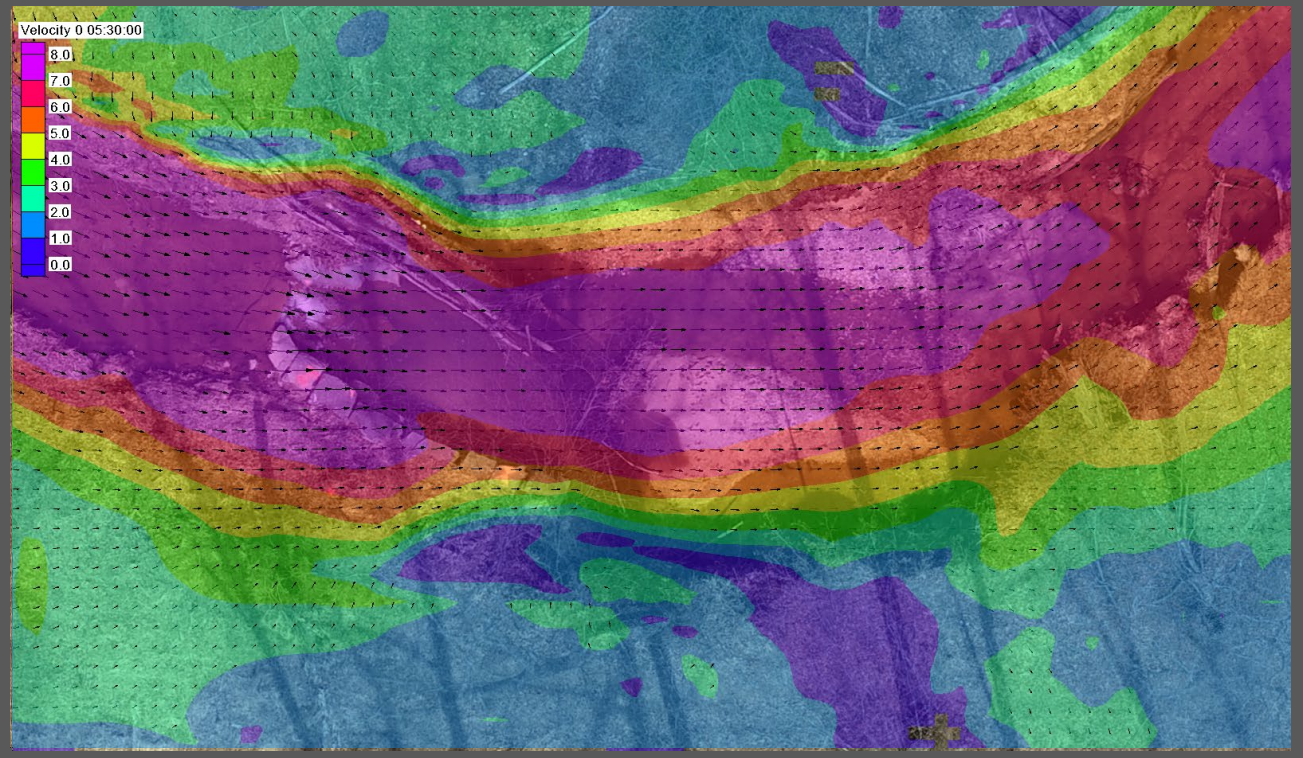
Phase I: Preliminary Results

- Across the 5 sites, 2D model predicted velocities show general agreement with the observed velocity conditions during floods



Above left: high velocities observed at cross vane during a flood.
Above right: high velocities predicted at same location using 2D models.

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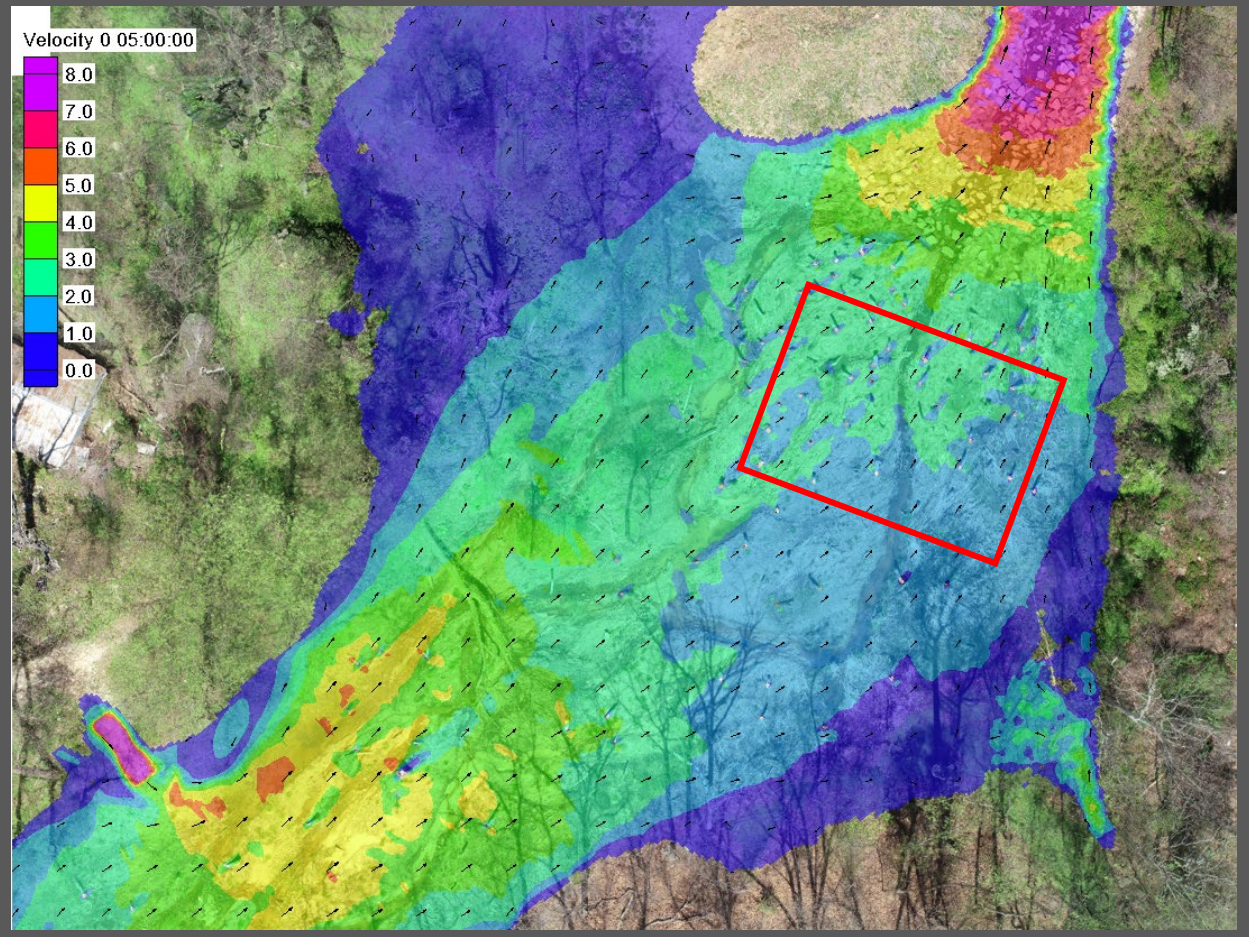
Phase I: Preliminary Results

- Across the 5 sites, model low and high velocity regions correspond to undamaged and damaged areas in the classification data



Above left: depositional area of floodplain
Above right: low velocities predicted correlate with area of deposition and coarse and fine organic material accumulation

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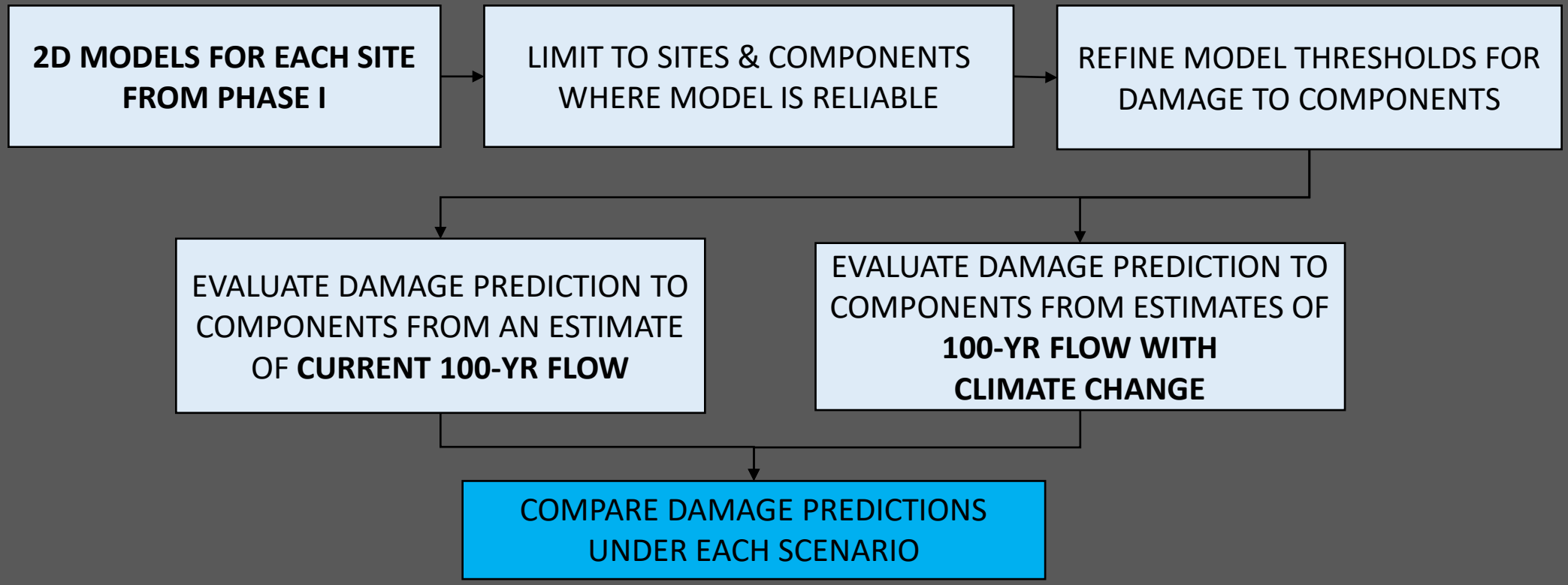
Phase II: Current and Future Conditions Analysis (Next Steps)



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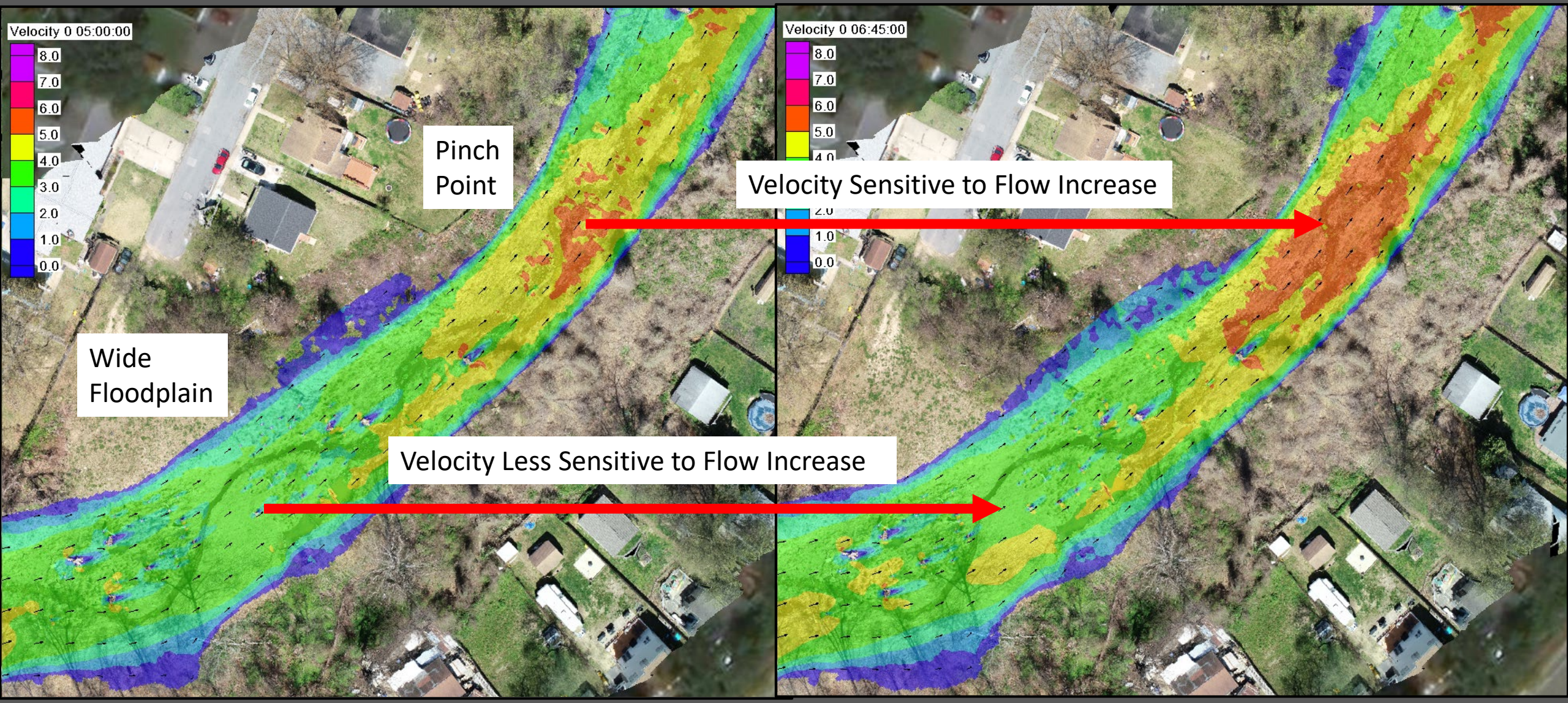
Phase II: Very Preliminary Results

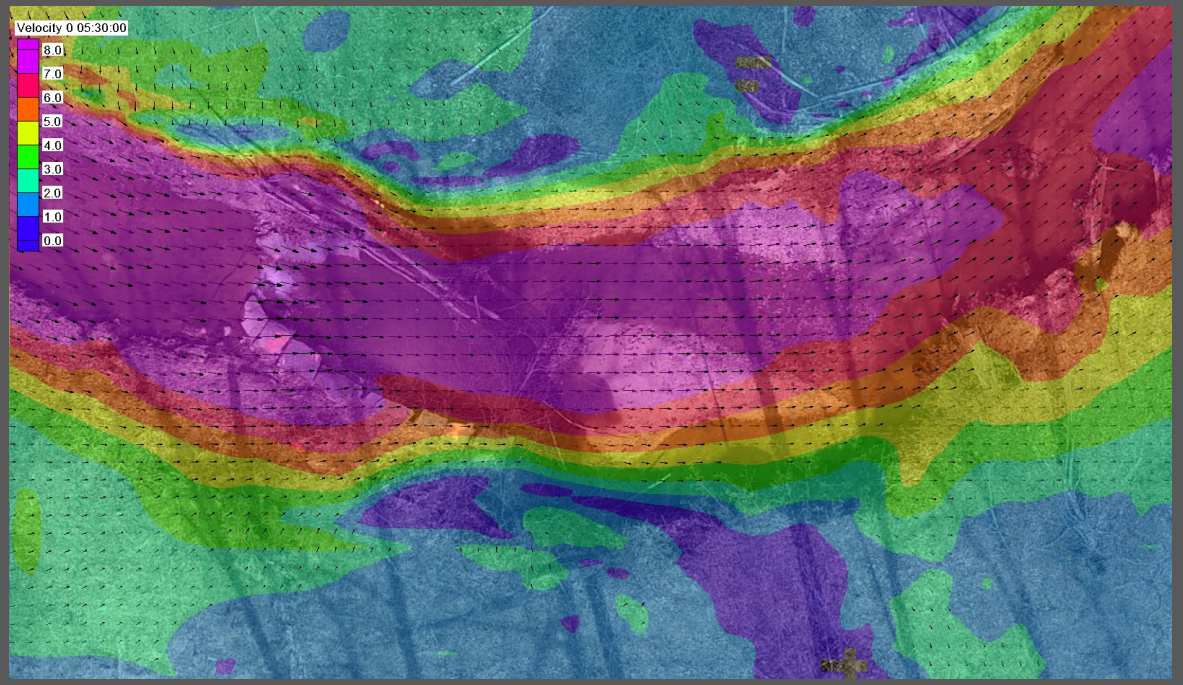
Current Climate
100-Year Flow

Estimated Climate Change
100-Year Flow

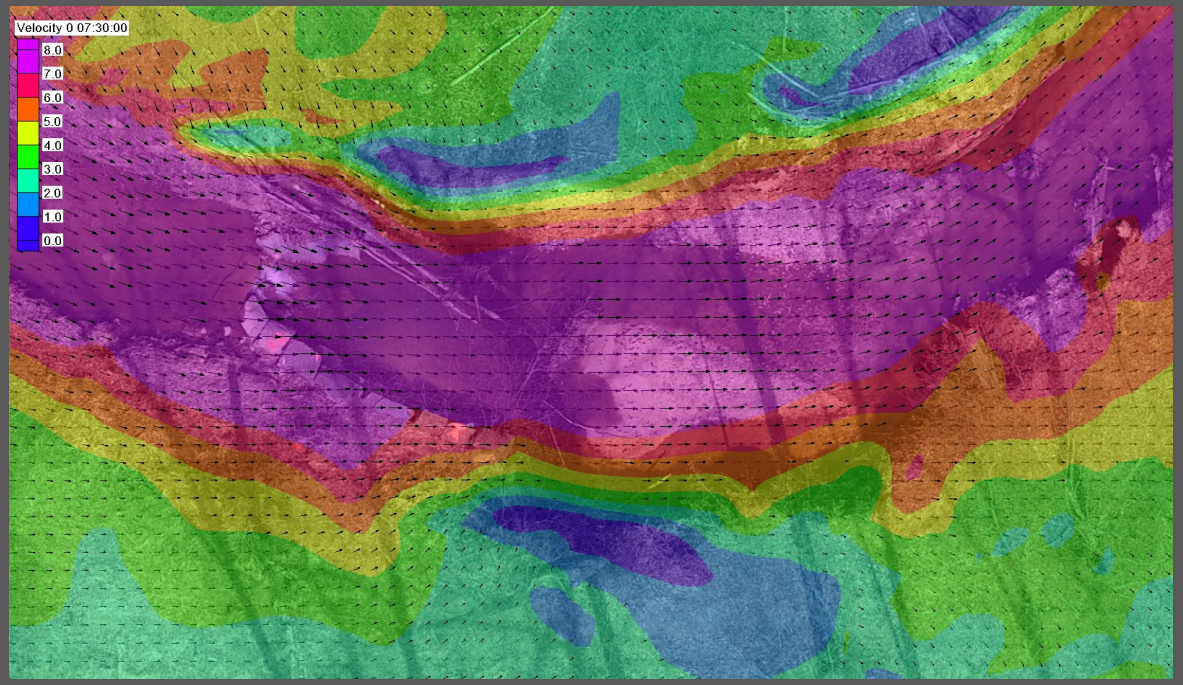


Phase II: Very Preliminary Results

Current Climate
100-Year Flow



Estimated Climate Change
100-Year Flow



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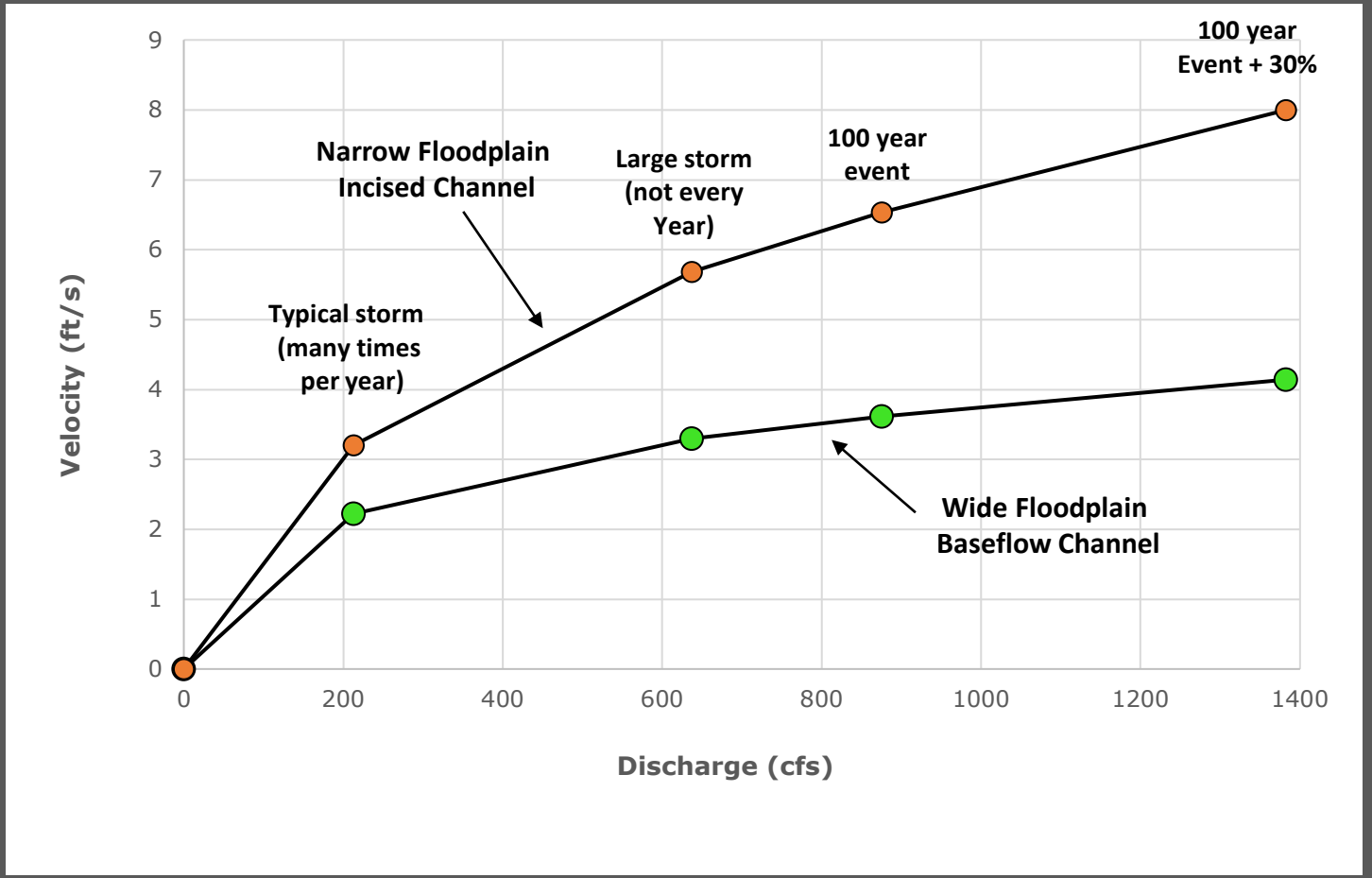
Phase II: Expected Results

- Increasing flows due to climate change will increase flood velocities
- The % increase in velocity and % damage will vary depending on site conditions and restoration methods
- Some restoration approaches will be more resilient to increased peak flows



Above right: Two observed flows at a CBT research site (typical storm and large storm- Hurricane Ida) shown with a 100-yr event predicted by regional regression equations. Highest flow is the 100-yr event scaled by 30%

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McCormick Taylor: Scott Lowe
EQR: Katrina Davis

2D Modeling Translation Slides

What are the take home points? What does this mean for me?

Translation Slides by Erik Michelsen, Anne Arundel County Department of Public Works

What does this mean for me?

- This work continues to demonstrate the utility of 2D modeling as an integral stream and wetland restoration design tool. Not as one that should be applied at the completion of design, but as one that should be used iteratively throughout the initial design process to inform grading and the placement of erosion resistant material, if necessary.

- As storm intensities increase, systems that are designed to allow for a shallow depth of flow across a broad cross section – rather than within a highly armored, narrower cross section – are likely to prove more resilient to higher flows.

What does this mean for me?

What do I take from this if I am a practitioner:

- That 2D modeling can be a powerful tool for more resilient restoration design, and can reduce our adaptive management and repair costs if built into the initial design.
- That in terms of surface stability, we have to consider not only the vegetatively mature “final” product, but the 12-18 months of the temporarily stabilized site (e.g., don’t skimp on matting).

What do I take from this if I am a regulator:

- Ask questions about what sorts of modeling applicants have done on their project surfaces to try to anticipate further instability.
- If applicants are providing 2D model runs, regulatory agencies may want to request some professional development training to be able to better understand those analyses.