Enhancing Large-Scale 2D BLE Models to Refined Local Models with Floodways

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compass

Identify Hazards, Interpret Risks, Integrate Mitigation

CDM Smith

Shout outs!

FEMA Region 8 Staff:

- Brooke Conner, PE
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JV Partner AECOM

- Amanda Brooks, PE – Project Manager
- Brian Cahill, PE – Co-technical Lead

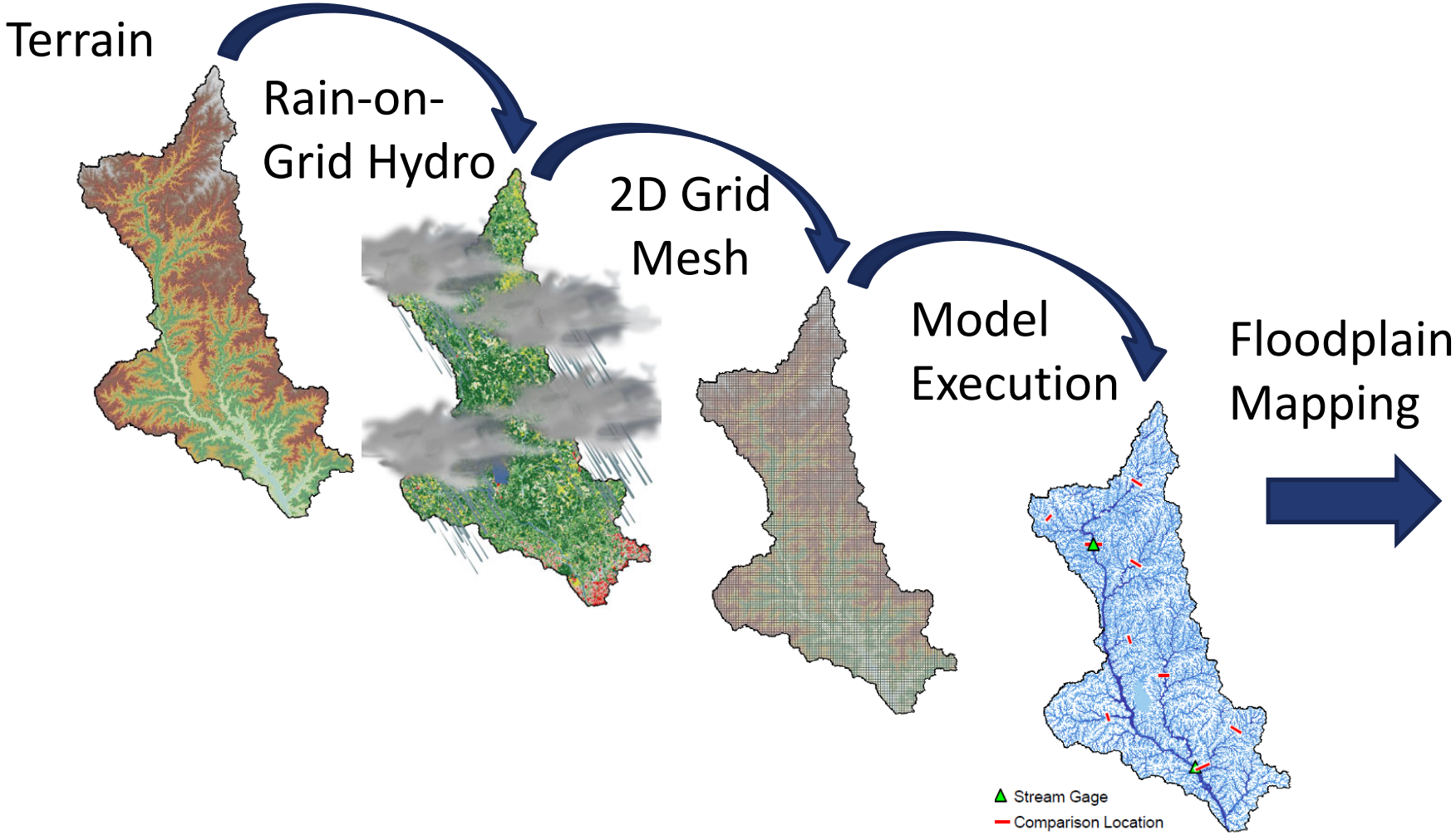
Terrain Data Sources:

- USGS National Elevation Dataset
- South Dakota Department of Environment and Natural Resources

Overview

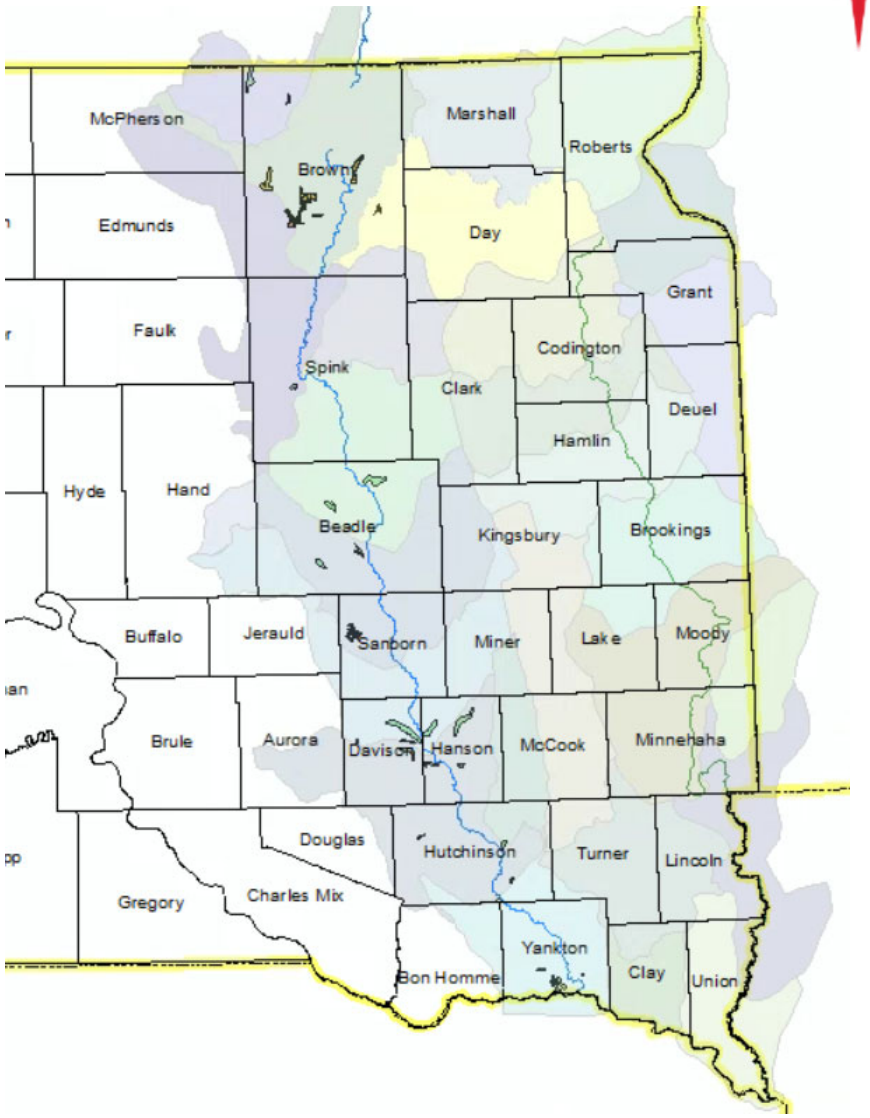
- Define 2D BLE
- Project details
- Enhancement modeling techniques & preliminary results
- 2D Floodways
  - Methods
  - Challenges
- Takeaways

2D BLE Modeling Concept

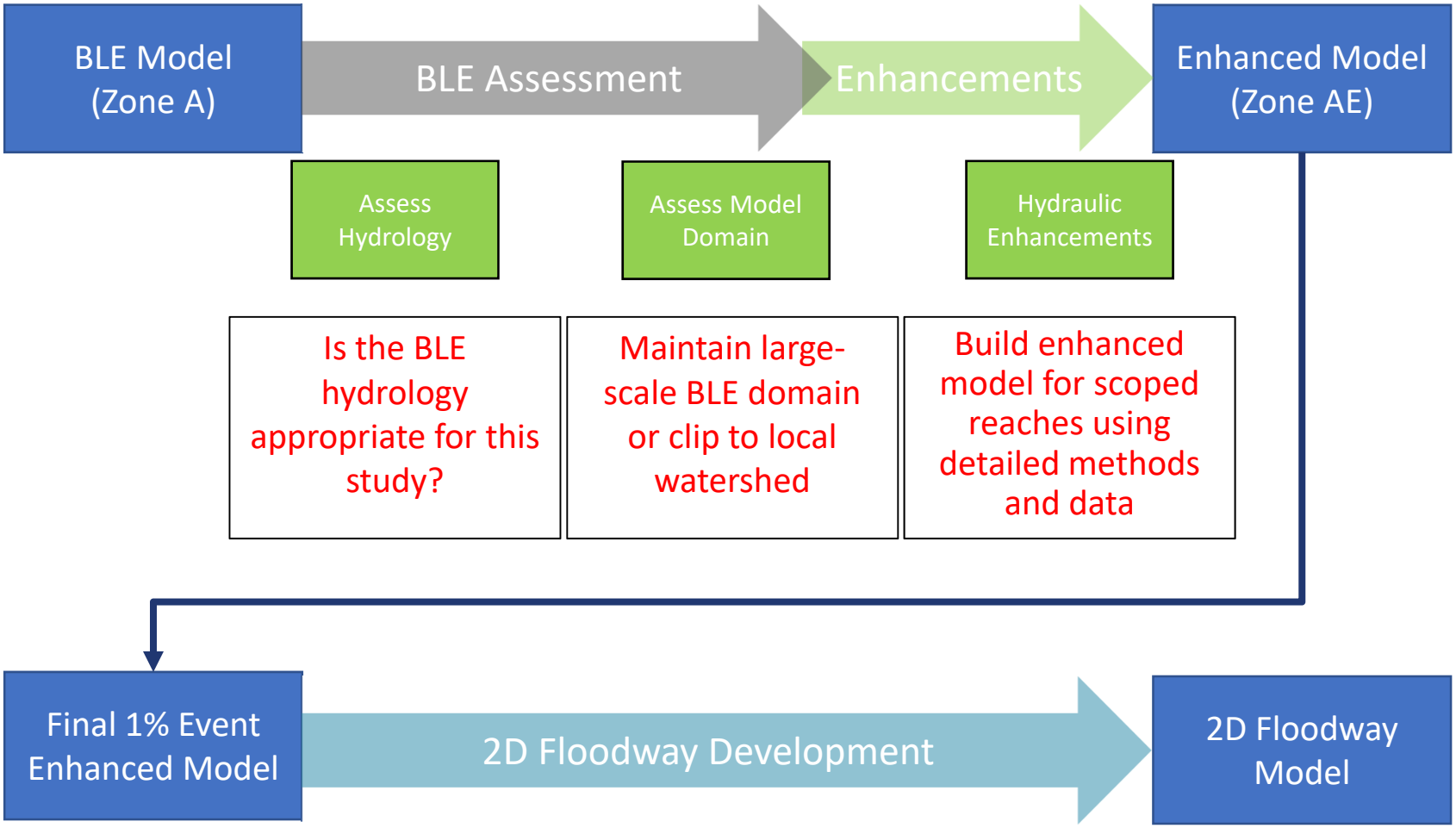


Project Scope

- Enhance streams within 2D BLE study for Eastern South Dakota
  - Zone A regulatory-ready products to Zone AE-ready products
  - Apprx. 175 stream miles including ~75 stream miles with floodway
- Purpose
  - BLE models a scalable jump start
  - Lower cost & increase efficiency in production of Zone AE products

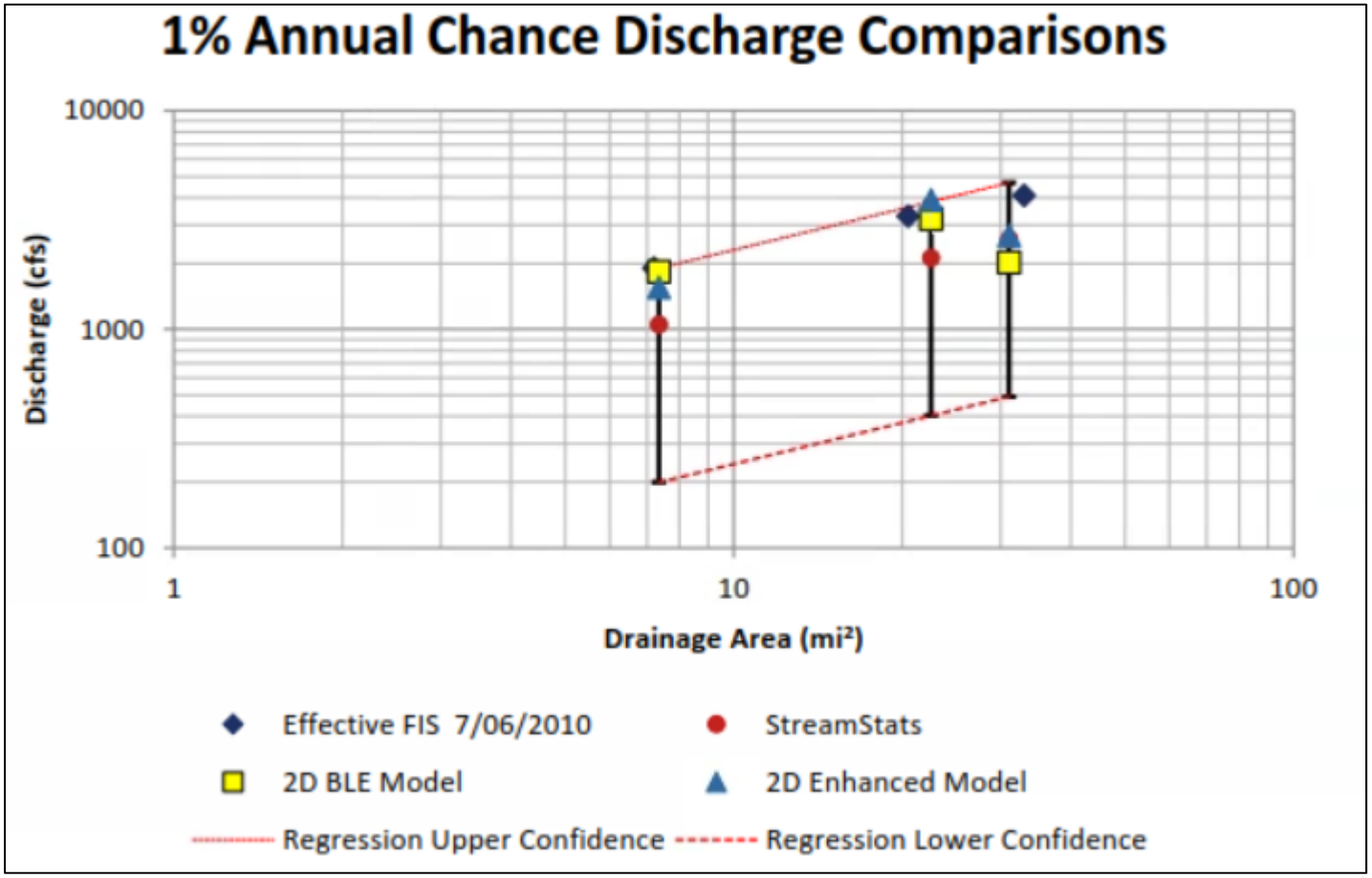


Upgrading BLE Models



Hydrology

- Compare to gage or regression eq. calculated flows
  - Within + or - 1 Standard Error of Prediction (SEP)



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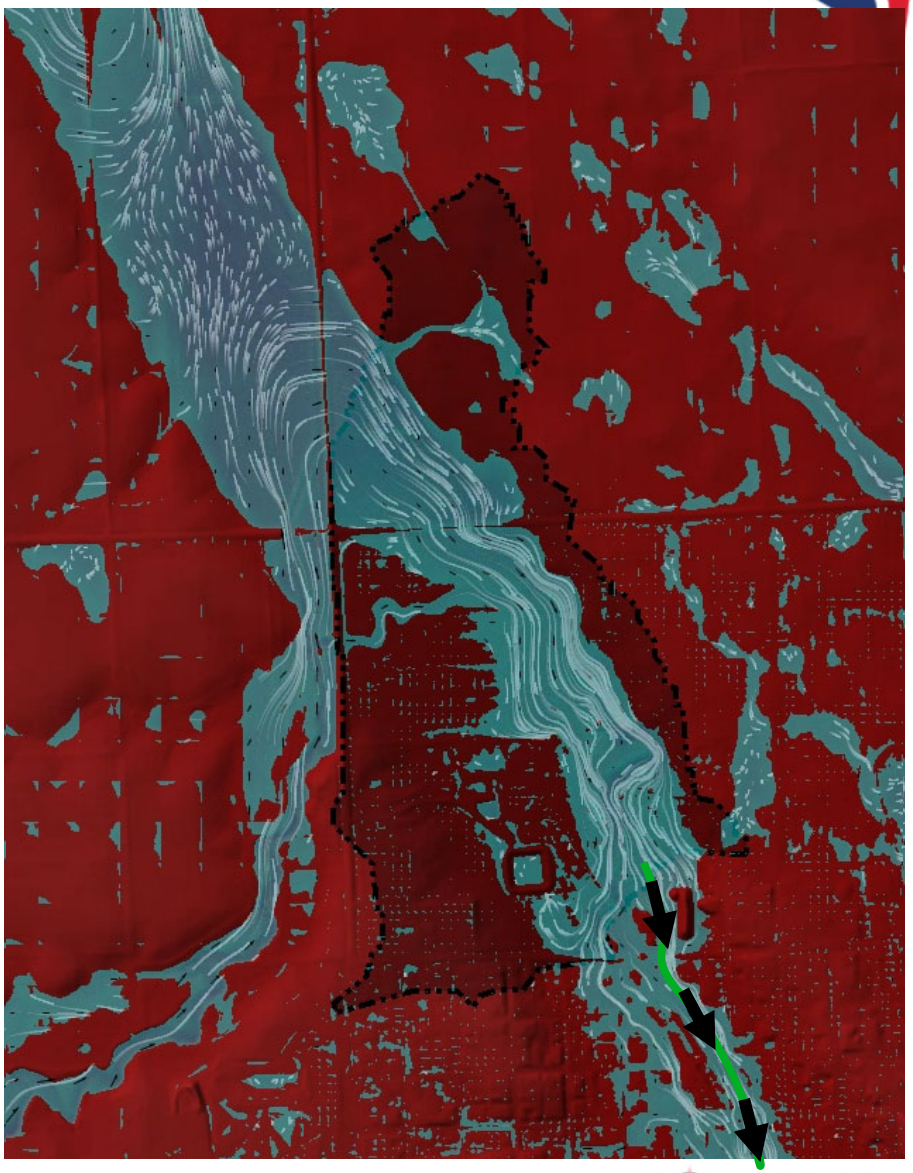
Hydrology Considerations

Source	Minus 1-SEP (cfs)	Target (cfs)	Plus 1-SEP (cfs)
Regression Equation	92	236	380

Model Version	1% Modeled Flow (cfs)
Original BLE	1,500
Adjusted Mesh	725

- Considerations
  - Upstream BLE hydraulics
  - Contributing area consistency



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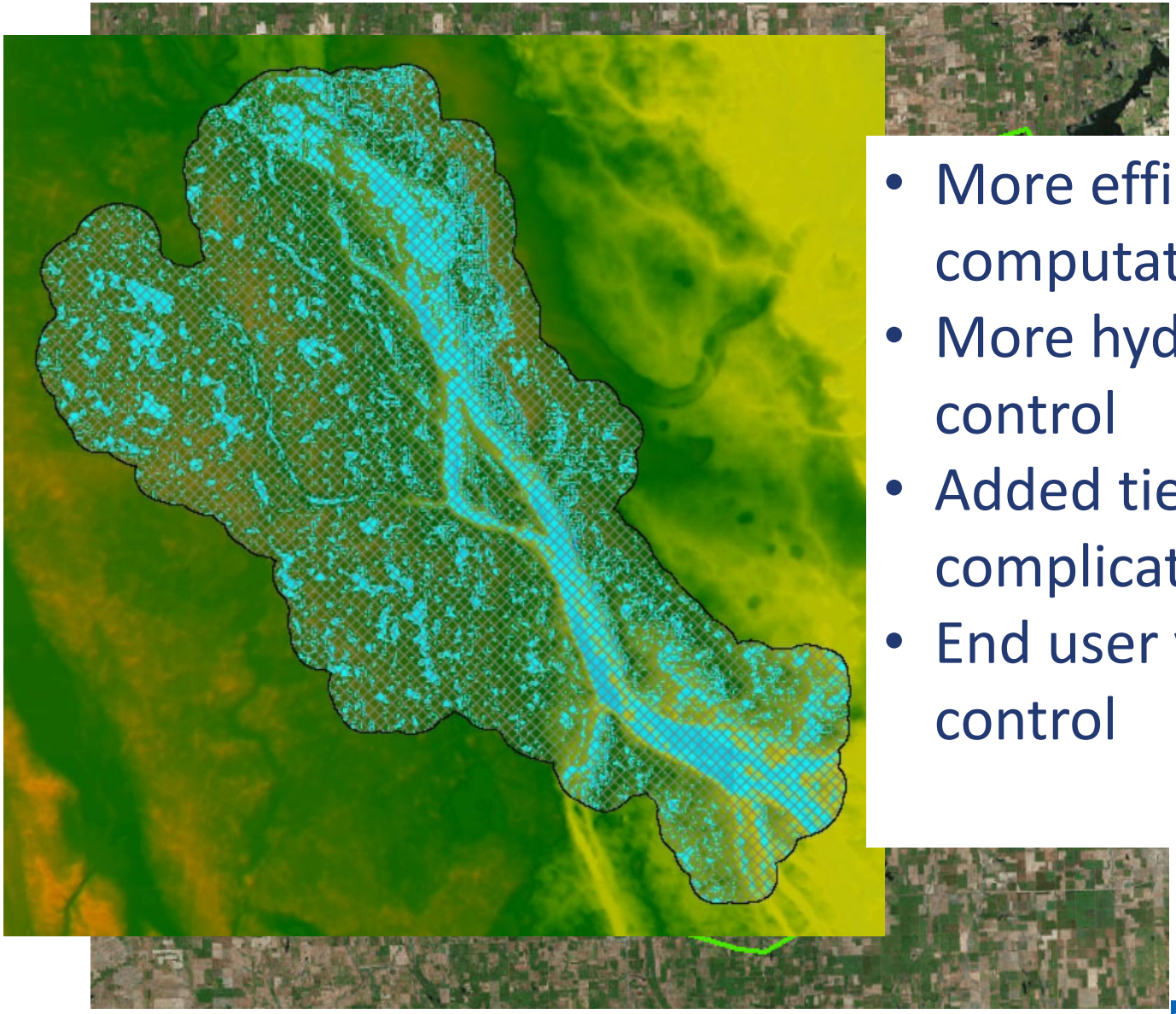
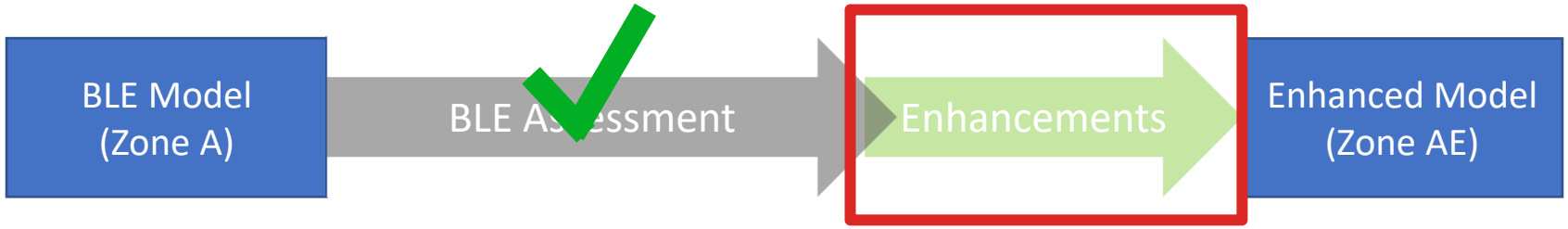
Model Domain



- More efficient computationally
- More hydrologic control
- Added tie-in complications
- End user version control

Hydraulic Enhancements

Hydrology and domain are set!

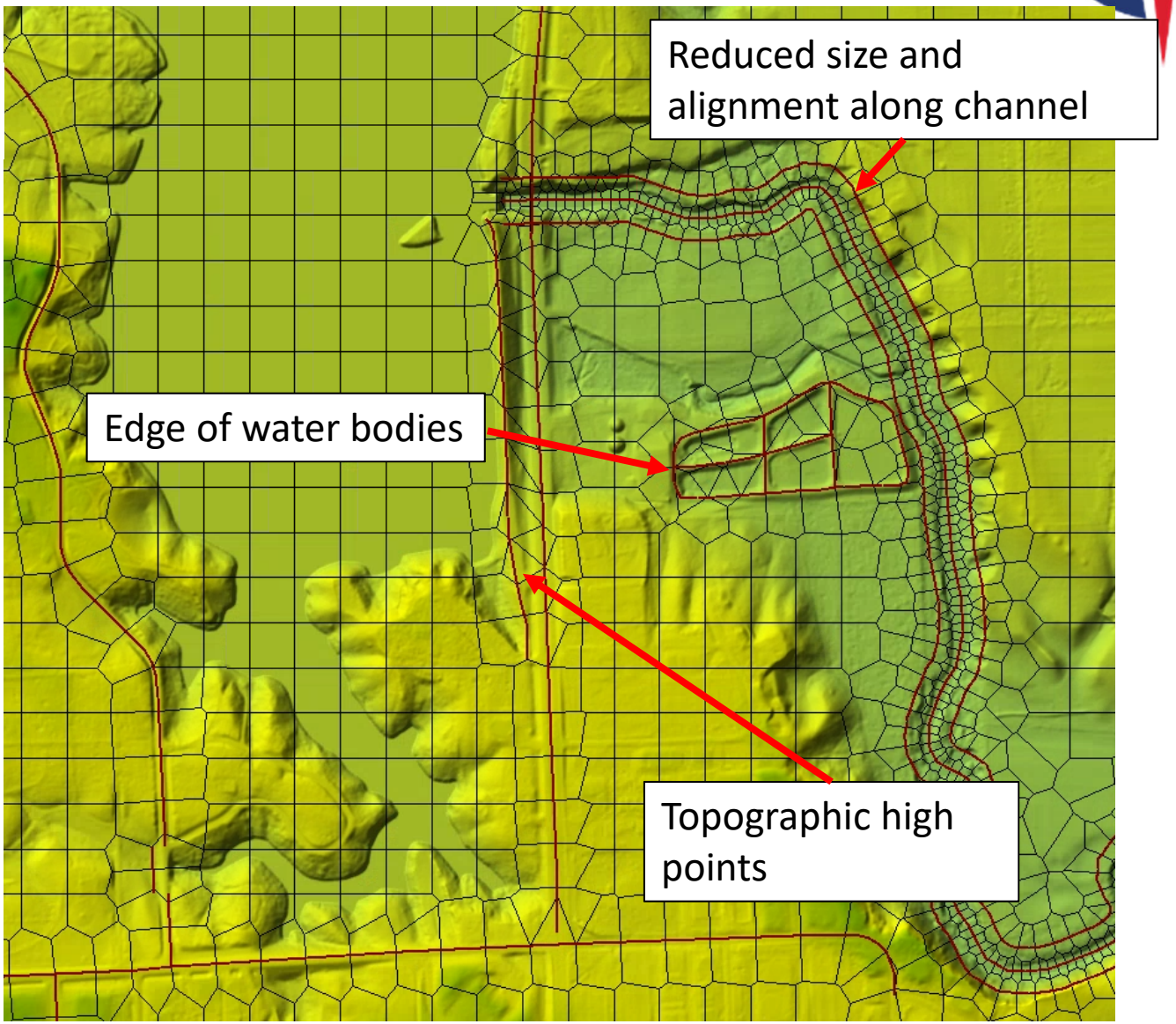


1. Mesh refinements
2. Detailed Structures
3. Computational parameters
4. Detailed Manning's n

Mesh Enhancements

Enhanced Mesh

- Reduced grid cell size in enhancement area
- Mesh alignment via breaklines
- GIS methods to automate breakline placement



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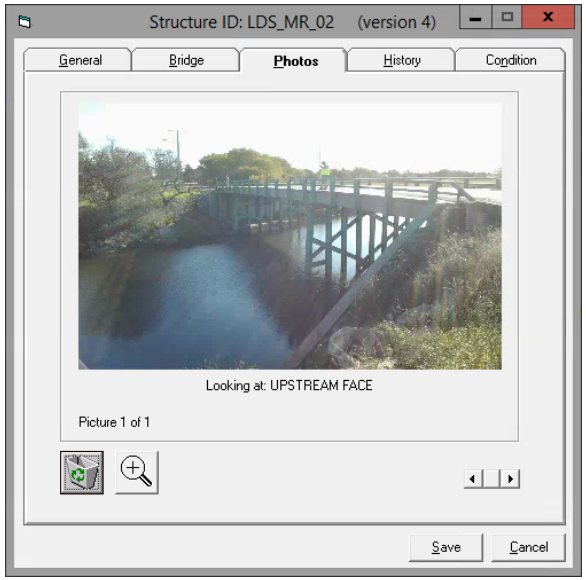
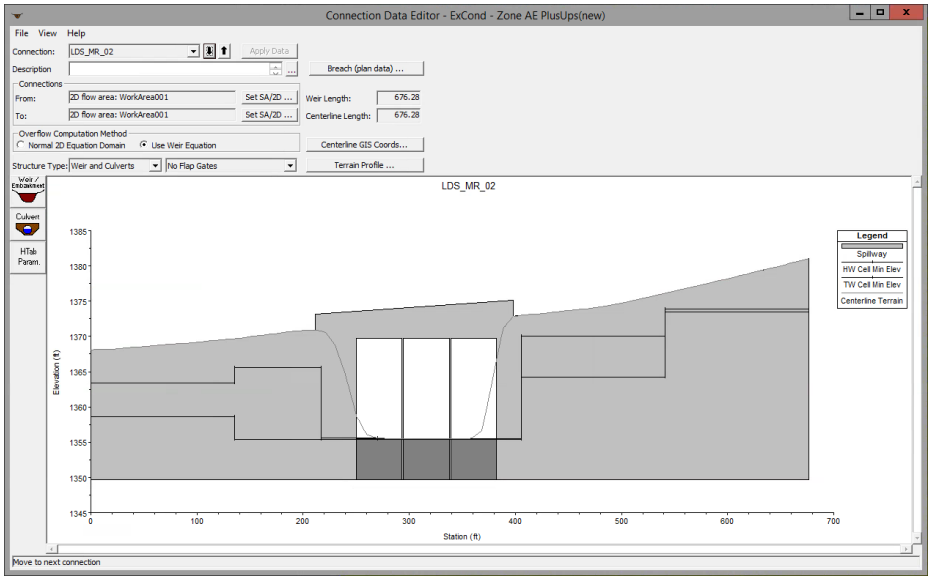
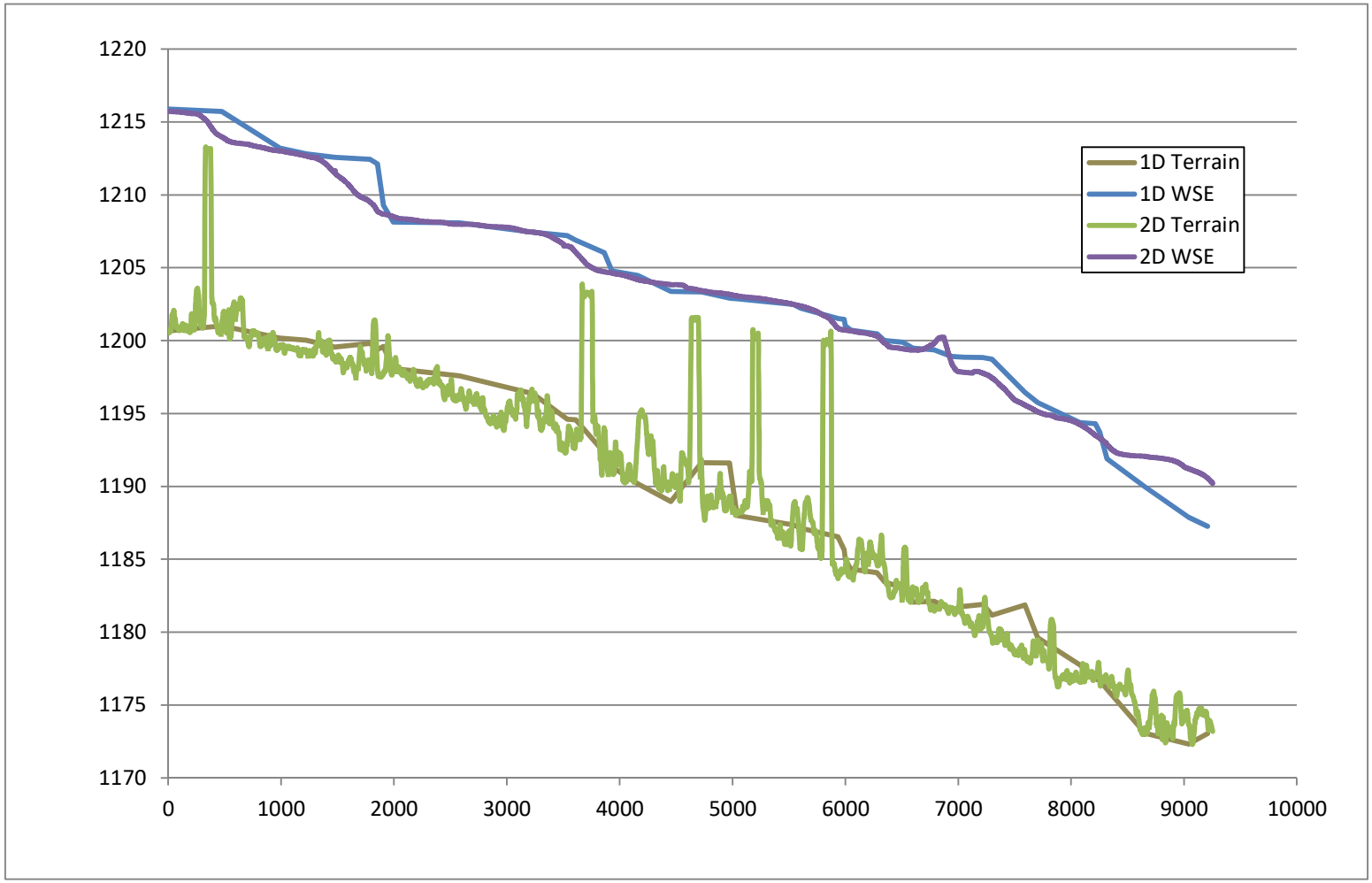
Field Survey Data & Internal Connections

- Rapid field survey performed for all structures (enhancement reach)
  - Bridge deck (or culvert) dimensions, piers, abutments, adjacent channel geometry for tie-in
- Current software limitations do not allow bridges within a 2D mesh
  - Simulate bridges as a culvert(s) or gate(s)
  - Verify/calibrate results through small scale 1D analysis



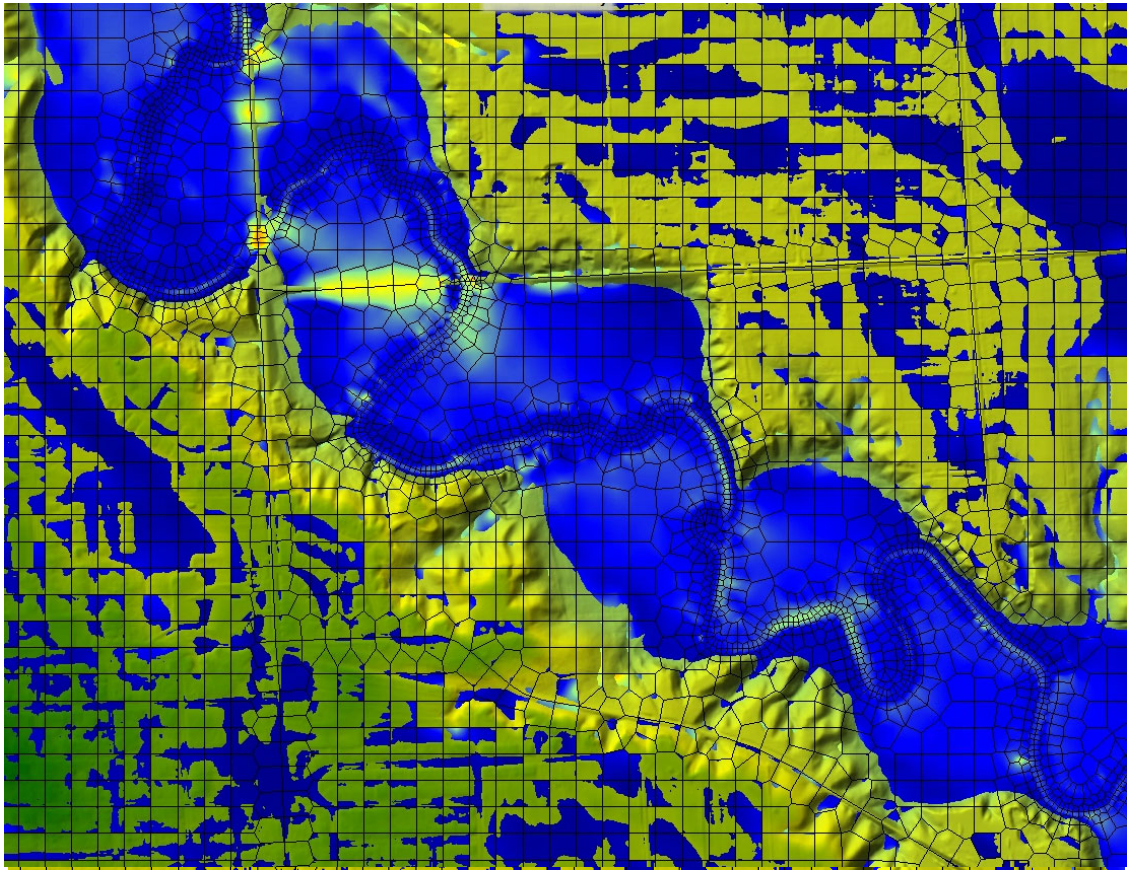


1D Structure Results Verification

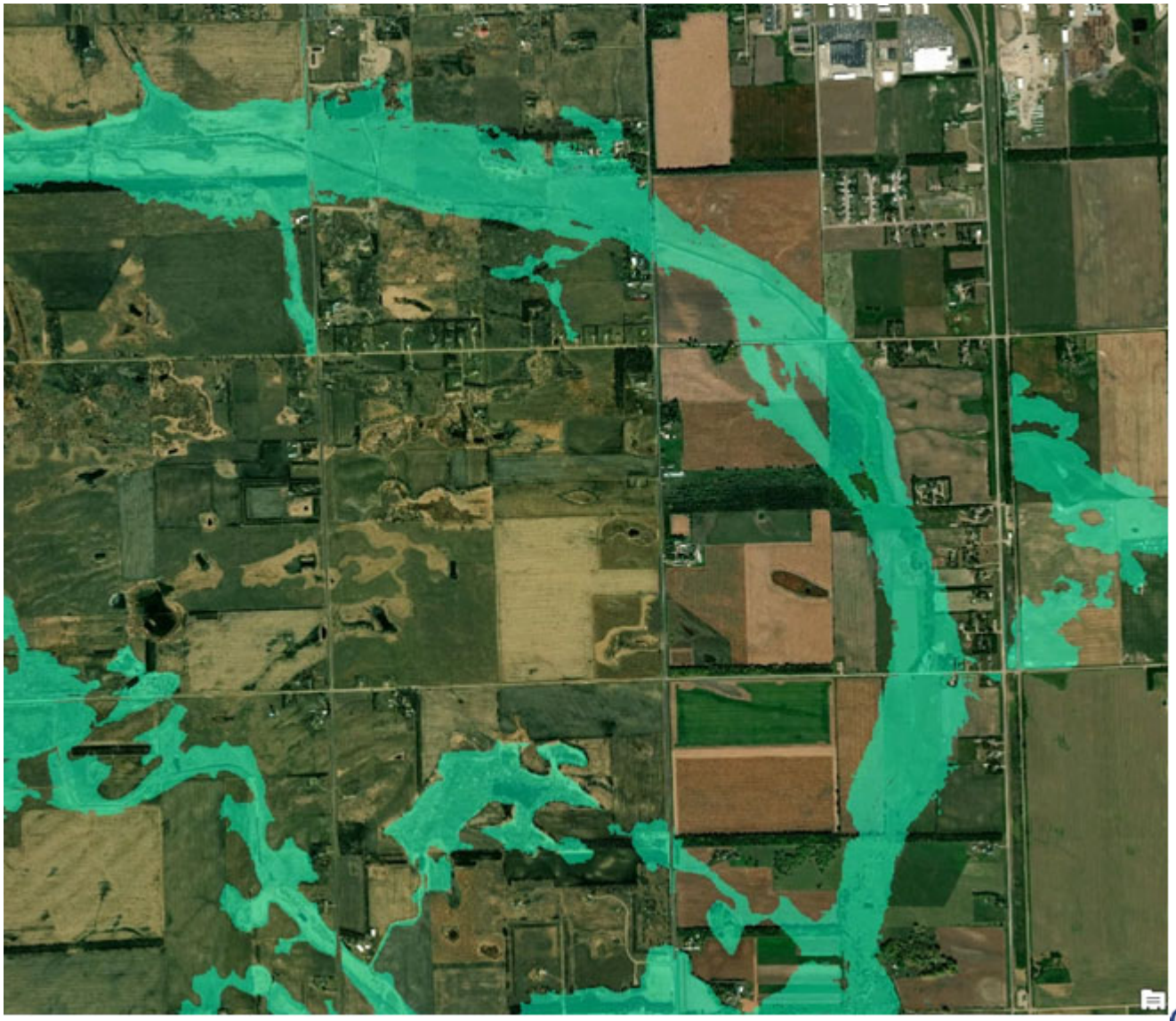


Computational Parameters

- Smaller grid cells = smaller timestep
  - Variable timestep
- Full Momentum Equation
  - Minimize model instability



BLE to Enhanced BLE



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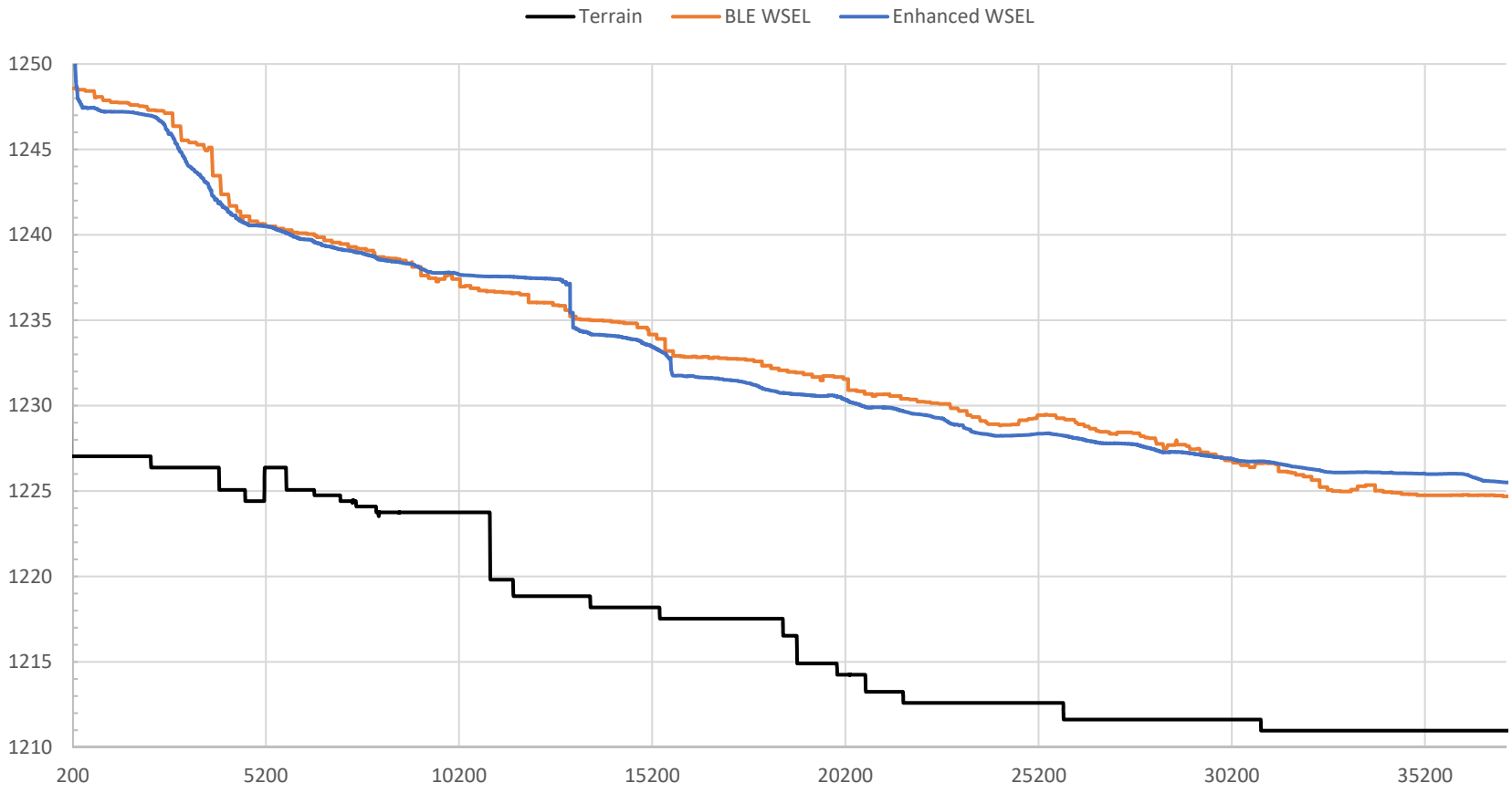
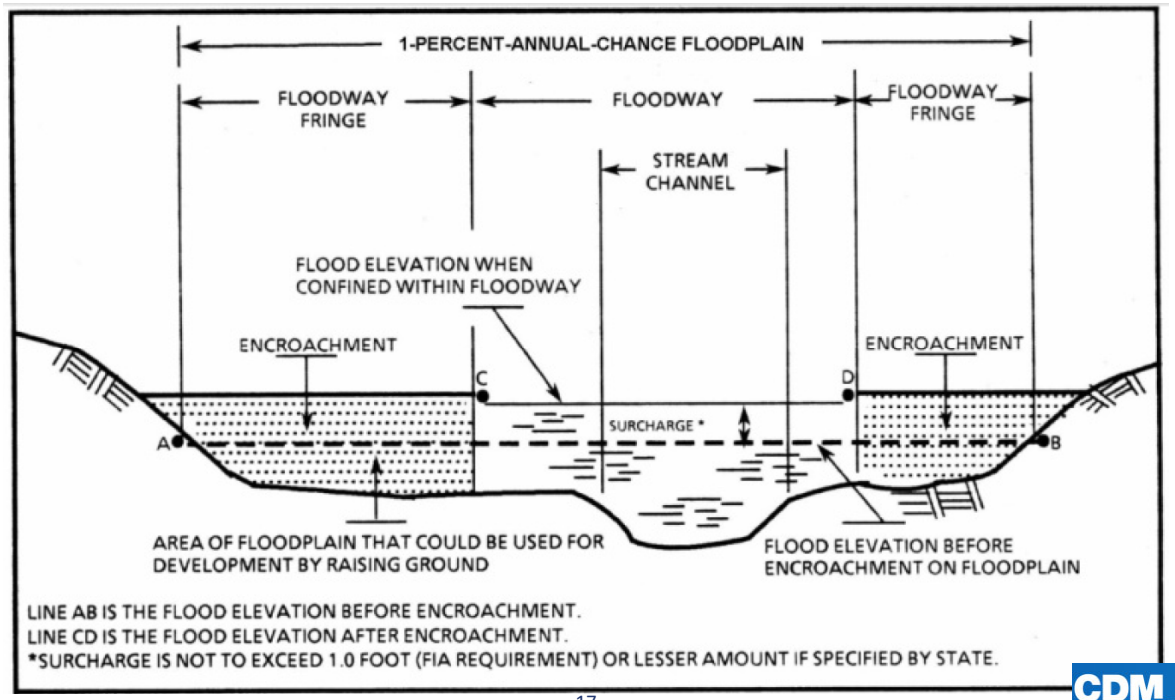
Model Profile Comparisons



2D Floodways

- Challenges
  - Floodway regs designed within 1D steady flow context years ago
  - No FEMA-specific 2D regulatory floodway standards
  - Process is subjective



2D Floodway Hazard Classifications

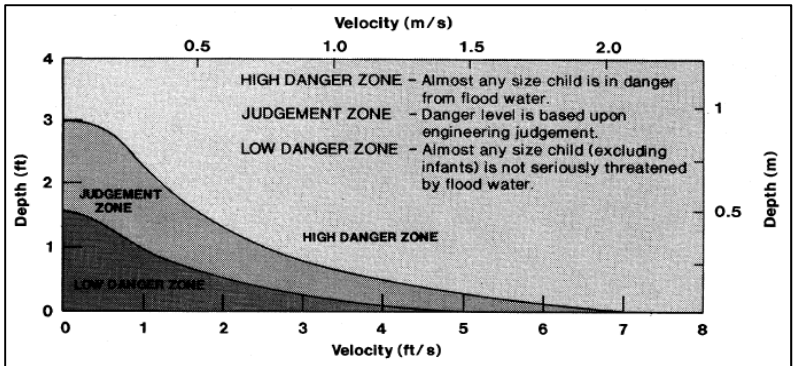
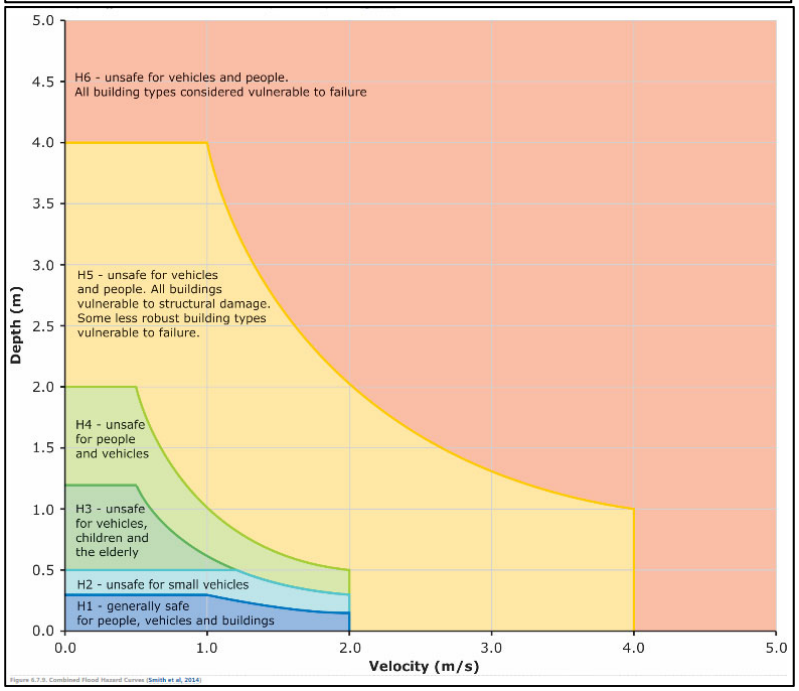


Figure 6. – Depth–velocity flood danger level relationship for children.



FLOOD HAZARD MAPPING

Method of calculating Flood Hazard

The Flood Hazard is calculated using the following equation:

$$HR = d \times (v + 0.5) + DF$$

where,
- HR = (flood) hazard rating;
- d = depth of flooding (m);
- v = velocity of floodwaters (m/sec); and
- DF = debris factor calculated using Table 4.1

Critical values of Flood Hazard are shown in Table 4.2. These are used to categorise the hazard in terms of danger to people.

Table 4.1 Guidance on debris factors for different flood depths, velocities and dominant land uses

Depths	Pasture/Arable	Woodland	Urban
0 to 0.25 m	0	0	0
0.25 to 0.75 m	0	0.5	1
d>0.75 m and/or v>2	0.5	1	1

Ref: FD2321/TR1 Table 3.1

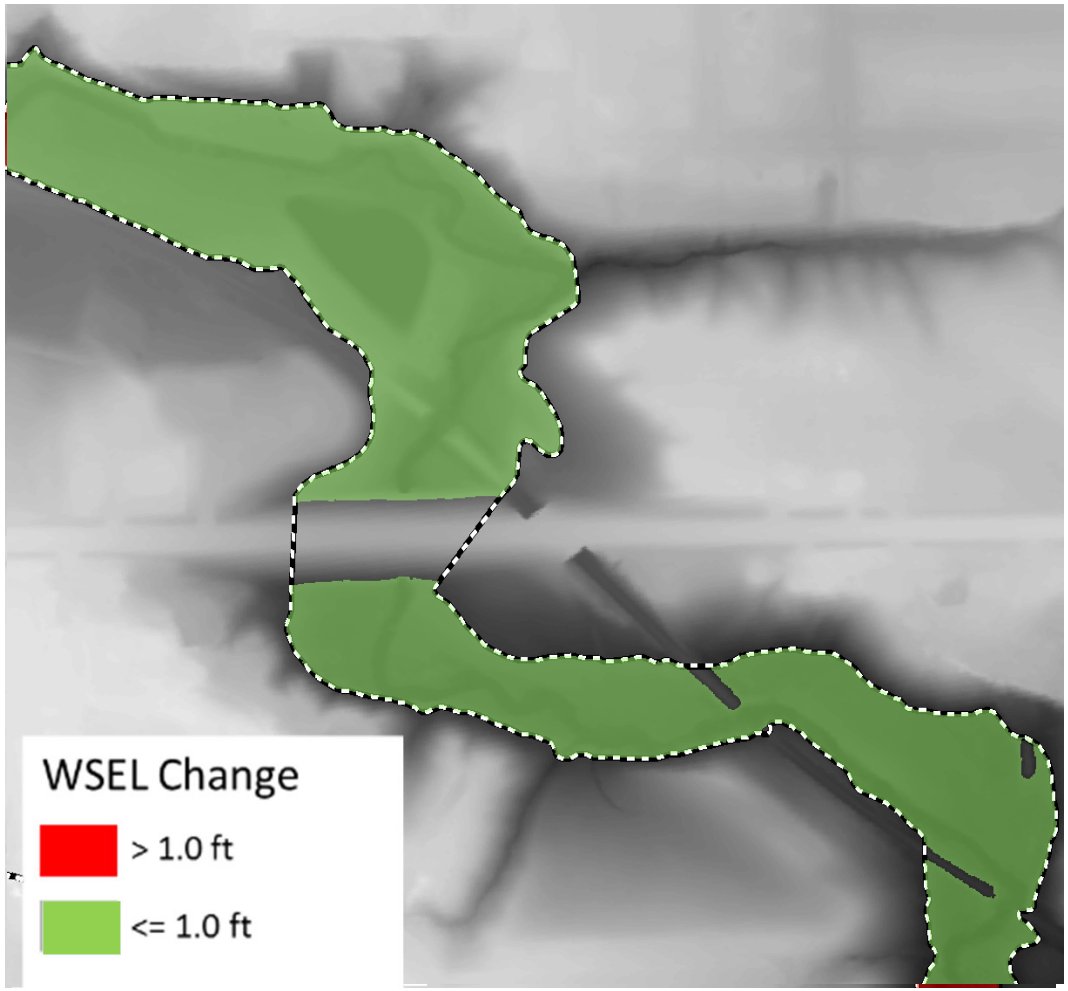
Table 4.2 Hazard to People as a Function of Velocity and Depth

d x (v + 0.5)	Degree of Flood Hazard	Description
<0.75	Low	Caution *"Flood zone with shallow flowing water or deep standing water"*
0.75 - 1.25	Moderate	Dangerous for some (i.e. children) *"Danger: Flood zone with deep or fast flowing water"*
1.25 - 2.5	Significant	Dangerous for most people *"Danger: flood zone with deep fast flowing water"*
>2.5	Extreme	Dangerous for all *"Extreme danger: flood zone with deep fast flowing water"*

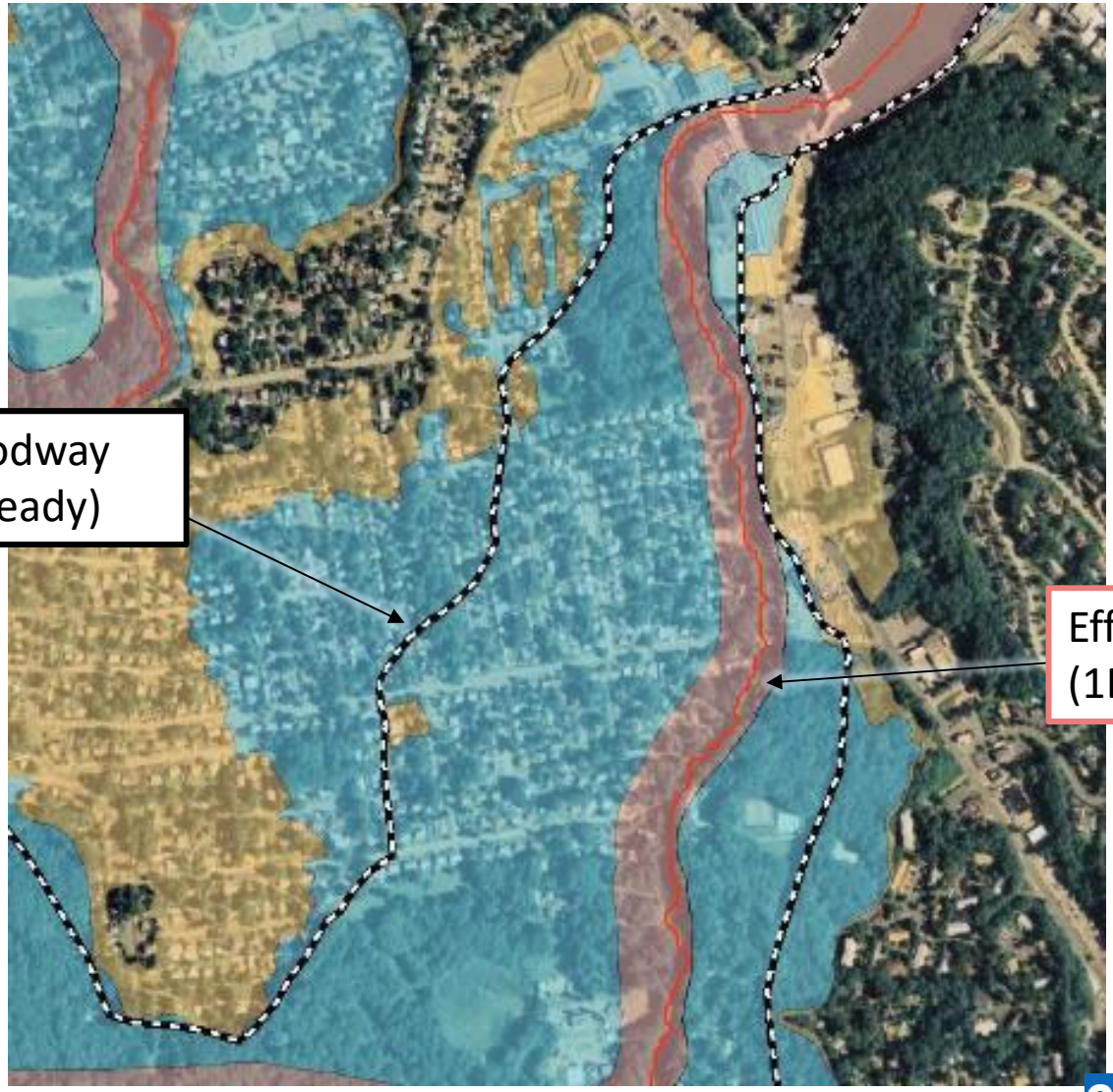
Ref: FD2321/TR1 Table 3.2

2D Floodway Development Process

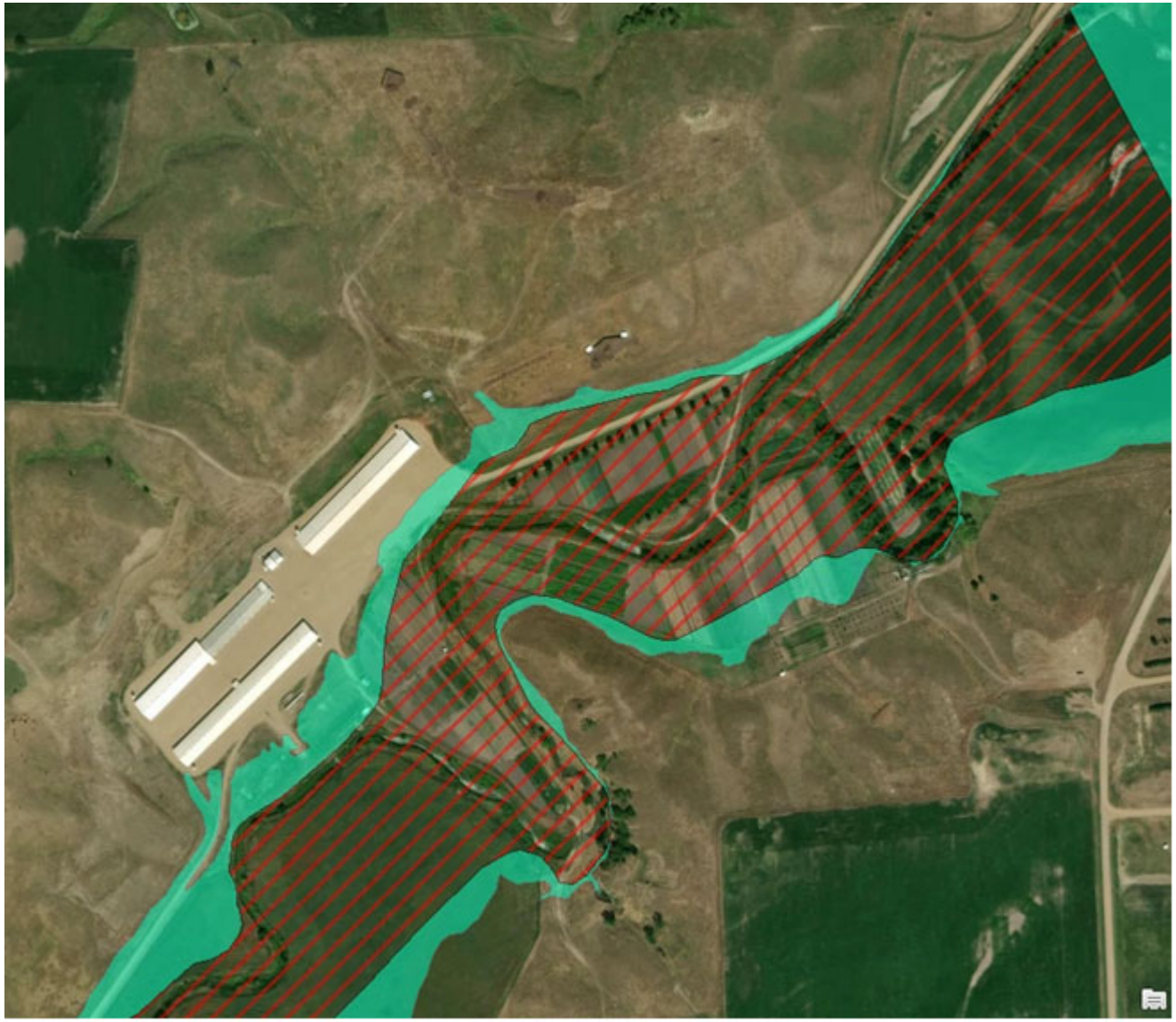
- Targeted 2D floodway model scenario (clipped domain)
- Convert rain-on-grid to inflow hydrographs- run model (Floodway baseline)
- Manually delineate floodway based on high DxV values – re-run model (Floodway)
- Calculate WSEL change
- Iterate until surcharge is acceptable



More 2D Floodway Challenges



Preliminary 2D Floodway Results



Final Takeaways

- Advantages to the process:
  - Efficiency gains in model development
  - Easy tie-in and integration to adjacent Zone A
  - High-resolution hydraulics
- Limitations:
  - Long run time
  - 2D Structure limitations
  - Limited hydrologic flexibility
- The 2D floodway conversation is only beginning

Questions?

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