2-Dimensional Urban Floodplain Modeling

A Case Study of Smokes Creek

Erie County NY

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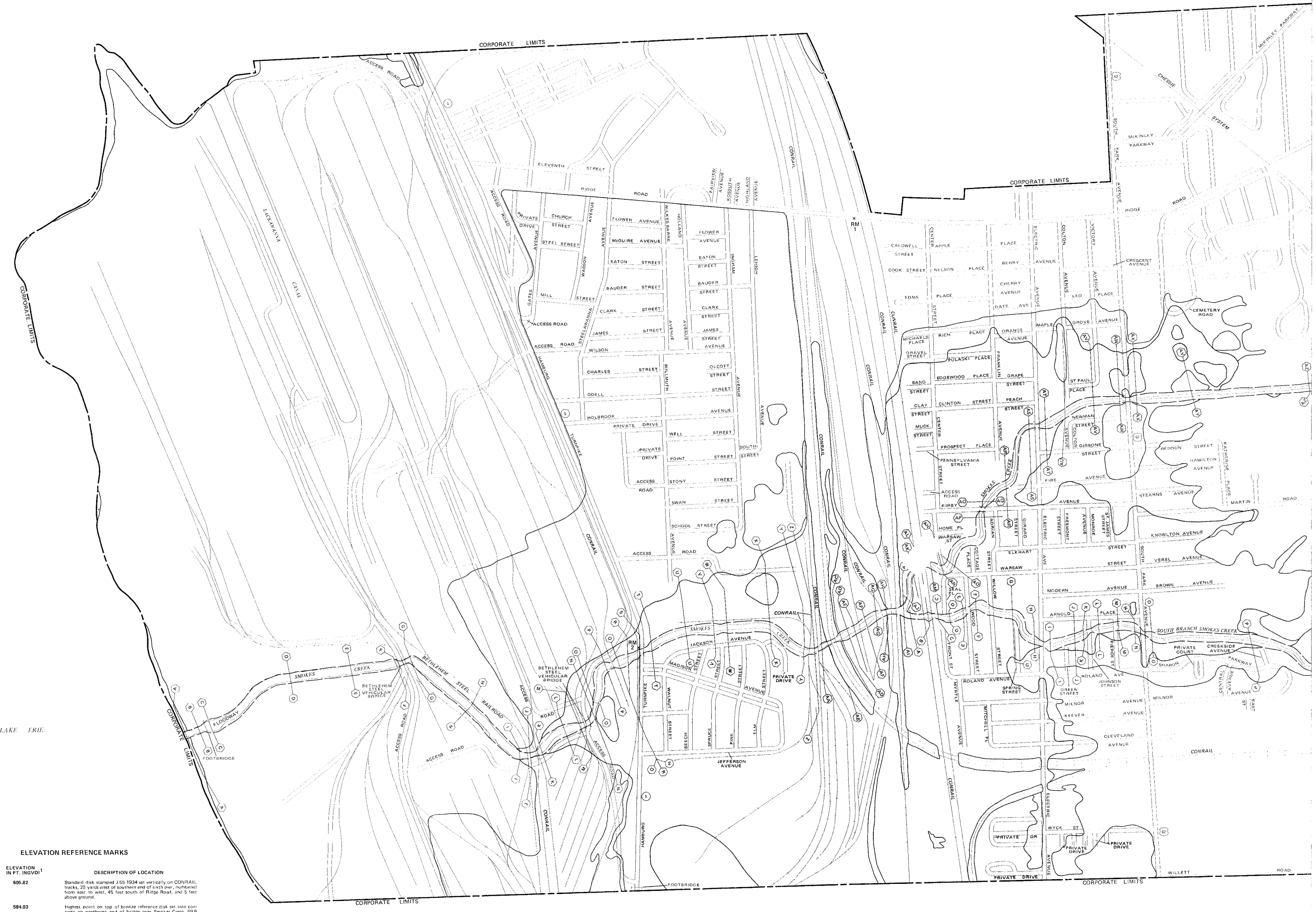
Stantec

AGENDA

- Project Scope
- Modeling History of Smokes Creek
- Methodology Selection
- Challenges Encountered and Lessons Learned
- Results
- Conclusions

Smokes Creek Hydraulic Study

Project Objective: Incorporate recent stream channel improvements into the hydraulic analyses used as the basis for FEMA's flood hazard maps for Smokes Creek within the City of Lackawanna, NY



KEY TO MAP

500-Year Flood Boundary
100-Year Flood Boundary
FLOODWAY FRINGE
FLOODWAY
100-Year Flood Boundary
500-Year Flood Boundary
Approximate 100-Year Flood Boundary
Cross Section Line
Elevation Reference Mark RM7 ×
River Mile • M1.5

NOTES TO USER

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the Federal Insurance Administration.

This map was prepared to support minimum flood plain management regulations; it may not show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Index To Map Panels.

APPROXIMATE SCALE
500 0 500 FEET

ELEVATION REFERENCE MARKS

REFERENCE MARK	ELEVATION IN FT. (NGVD)[1]	DESCRIPTION OF LOCATION
RM 1	605.82	Standard disk stamped J 55 1934 set vertically on CONRAIL tracks, 25 yards west of southern end of sixth pier, numbered from east to west, 45 feet south of Ridge Road, and 5 feet above ground.
RM 2	584.93	Highest point on top of bronze reference disk set into concrete on northwest end of bridge over Smokes Creek, 69.9 feet north of utility pole No. NM 2643, 38 feet west of centerline of State Highway 5, flush with concrete abutment.

[1] National Geodetic Vertical Datum of 1929

NATIONAL FLOOD INSURANCE PROGRAM

FLOODWAY
FLOOD BOUNDARY AND FLOODWAY MAP

CITY OF
LACKAWANNA, NEW YORK
ERIE COUNTY

PANEL 1 OF 2
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
360247 0001

EFFECTIVE DATE:
JULY 2, 1980

U.S. DEPARTMENT OF HOUSING
AND URBAN DEVELOPMENT
FEDERAL INSURANCE ADMINISTRATION

Project Location

- City of Lackawanna is located in Erie County, New York
- Part of the Buffalo-Niagara Metropolitan Area
- FEMA Region II
- U.S. Army Corps of Engineers Buffalo District

Smokes Creek Modeling History

Late 60s – USACE Buffalo District constructs flood control project on Smokes Creek

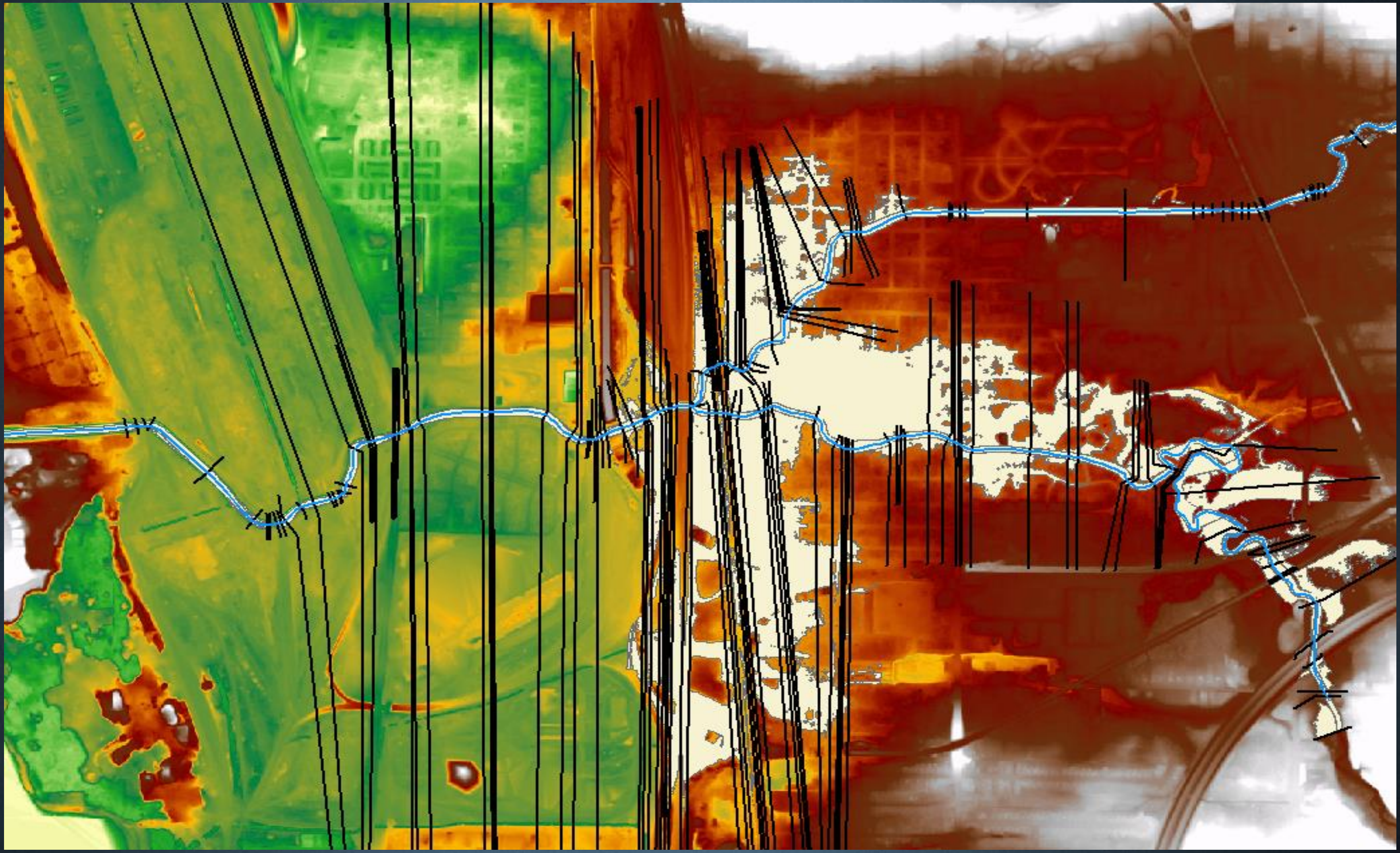
1980 – FEMA issues FIS for Smokes Creek

1991 & 2002 – USACE conducts Special Flood Hazard Evaluation (SFHE) on Smokes Creek

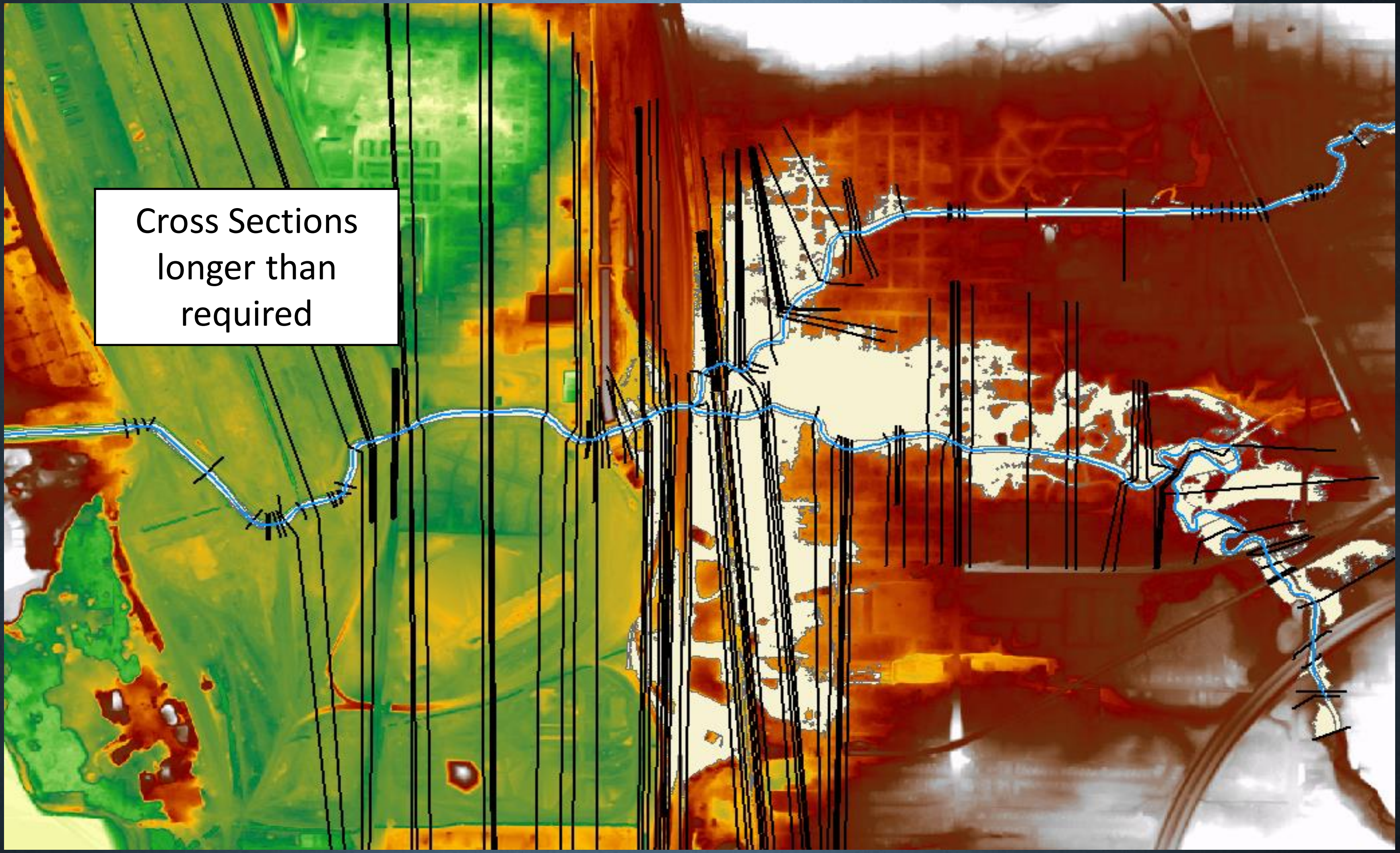
2009 & 2016 – USACE updates SFHE model to account for recent channel dredging and incorporate new LiDAR-based terrain elevation data

2017 – Model given to FEMA to utilize for updating Flood Hazard Mapping

SFHE Model



Noted Deficiencies in SFHE Model



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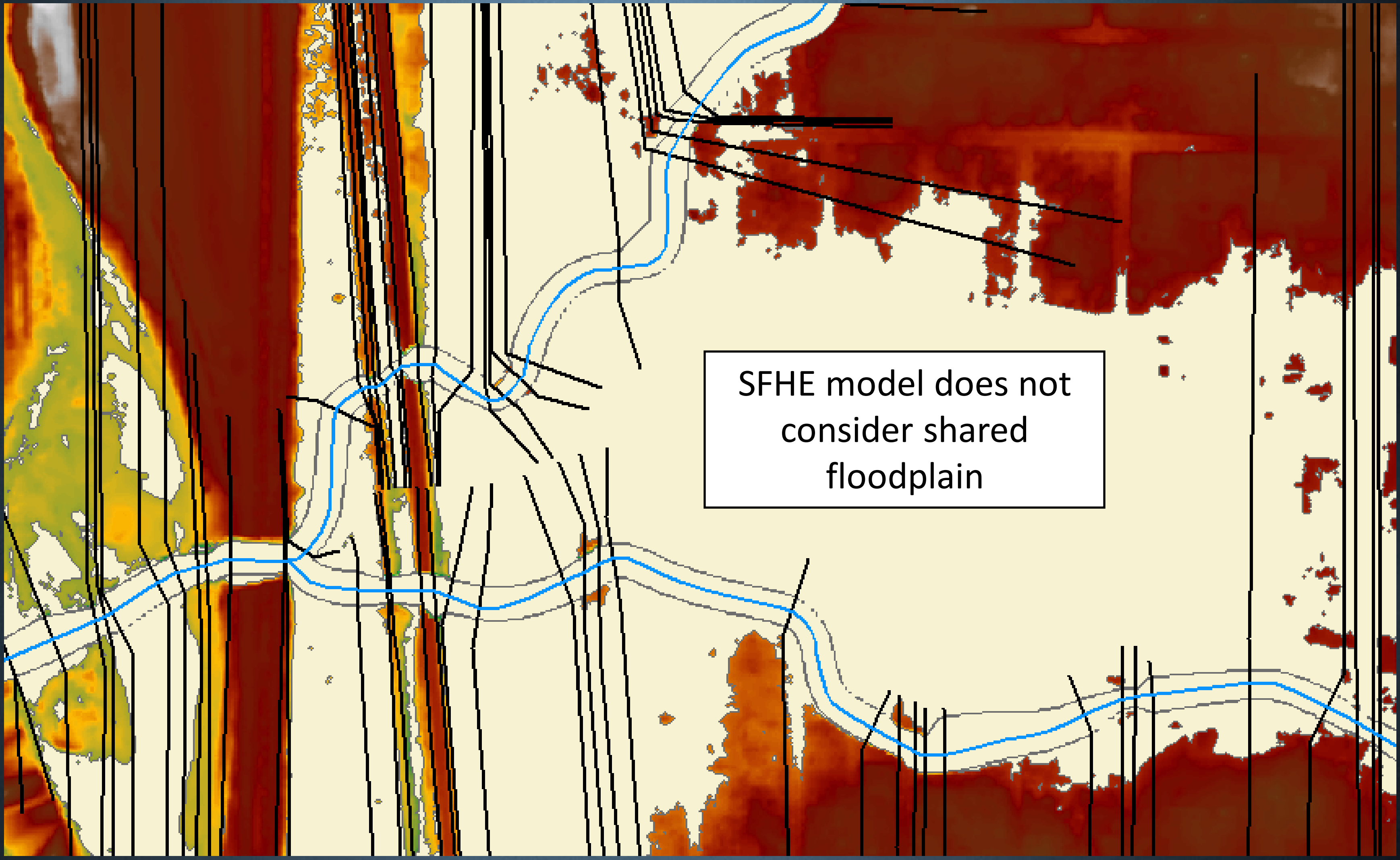
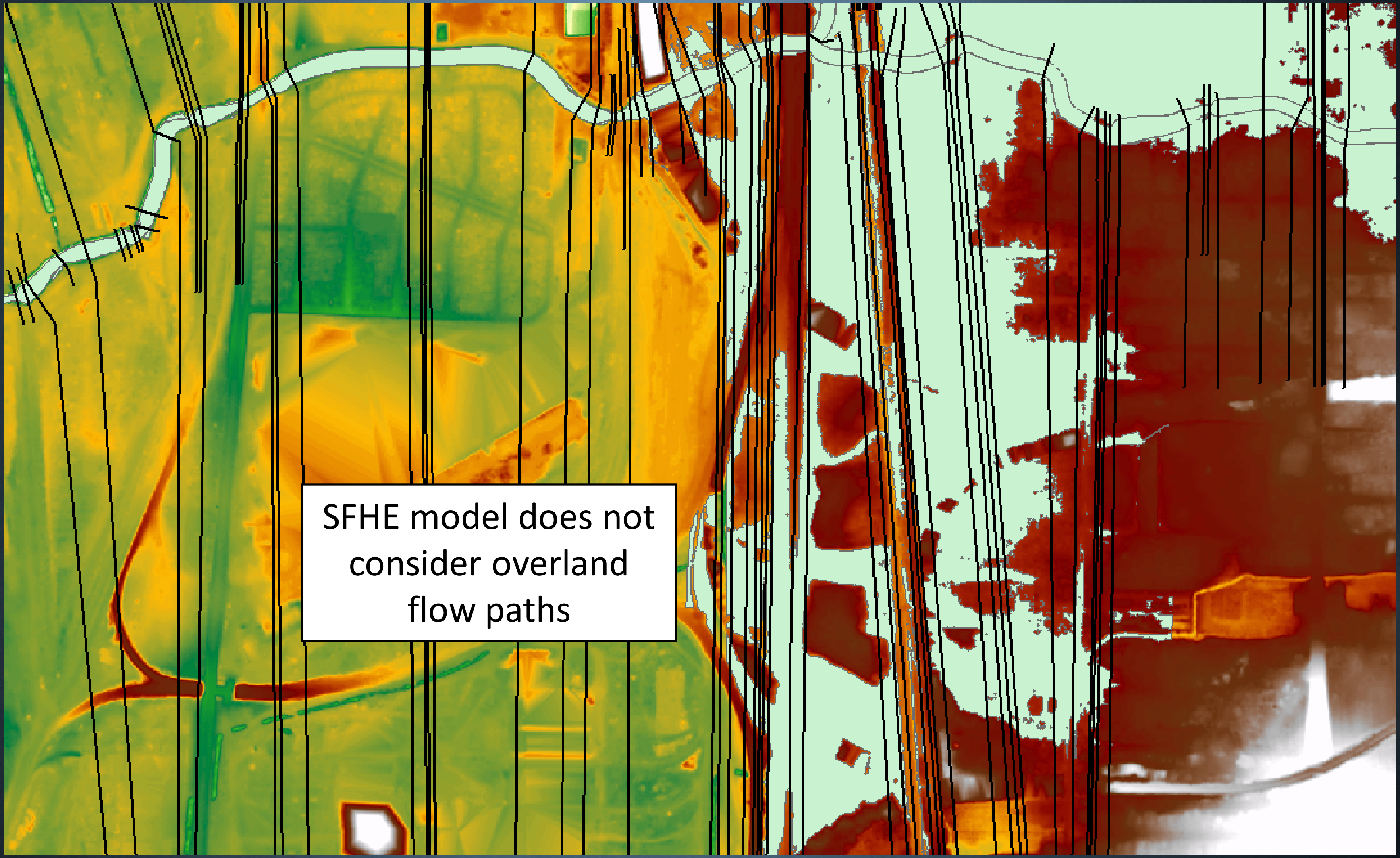


Noted Deficiencies in SFHE Model



Hydraulic Modeling Approach for Smokes Creek

1D Modeling

Pros:

- Existing model to be leveraged, reducing need for rework
- Computationally simple
- Defined Floodway analysis procedures

Cons:

- Complex floodplain potentially not resolvable by 1D methods

2D Modeling

Pros:

- More accurate for modeling complicated hydraulics

Cons:

- Grid resolution often insufficient to capture capacity directly within channel.
- Unable to capture structures impeding flow through the channel
- Computationally expensive
- FEMA floodway procedures poorly defined for 2D models

1D/2D Modeling

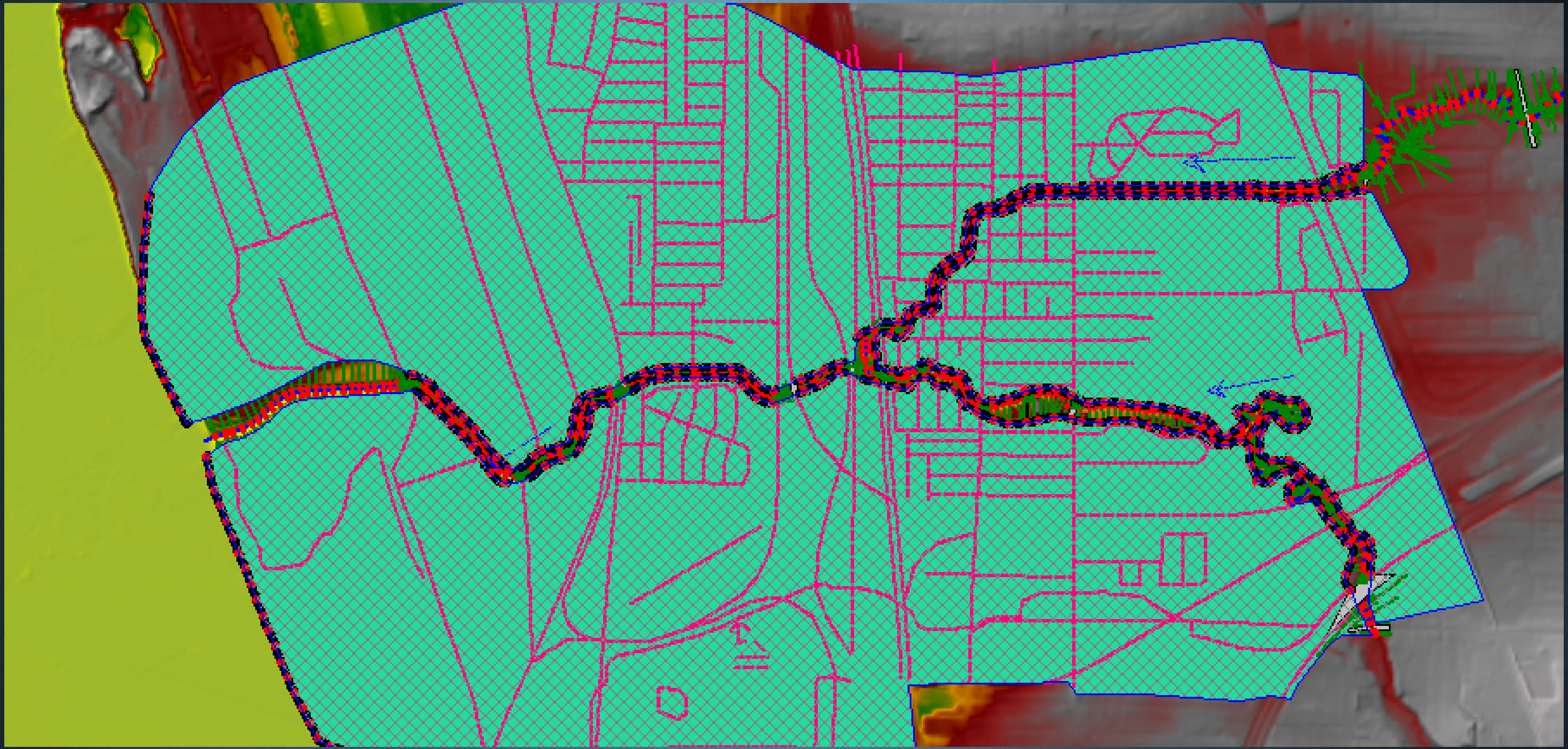
Pros:

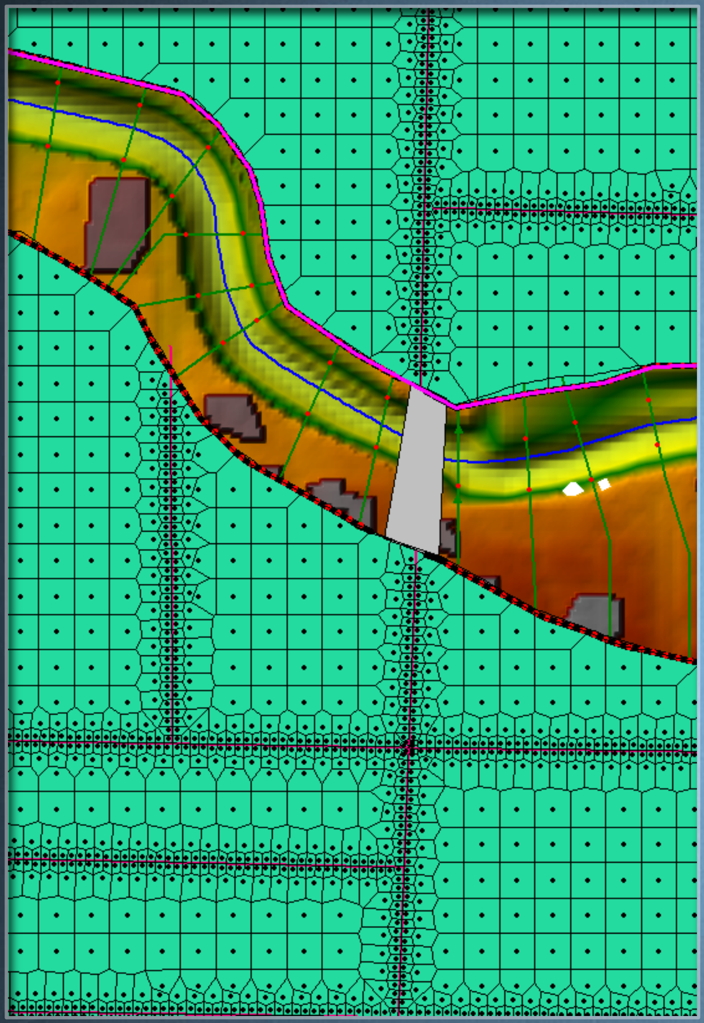
- Leverages the benefits of both 1D and 2D only methods

Cons:

- Computationally expensive
- Potential Floodway Implications

1D/2D Model





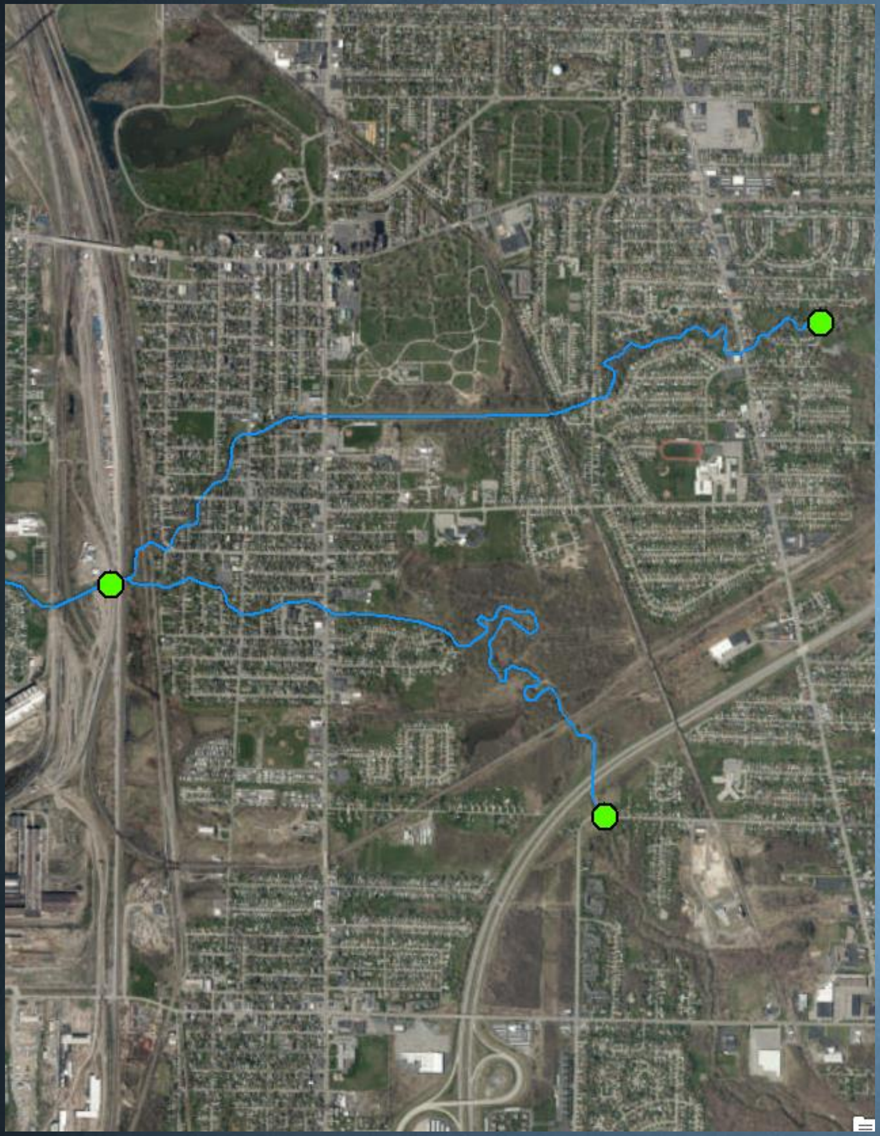
Base Flood Model Characteristics

1D Cross Sections roughly every 100-ft

“Lateral Structures” utilized to facilitate flow transfer from 1D model elements to 2D model elements

2D grid size of roughly 40-ft x 40-ft

Breakline enforcement in 2D grid to capture acute changes in elevation (e.g. roads, drainage ditches)

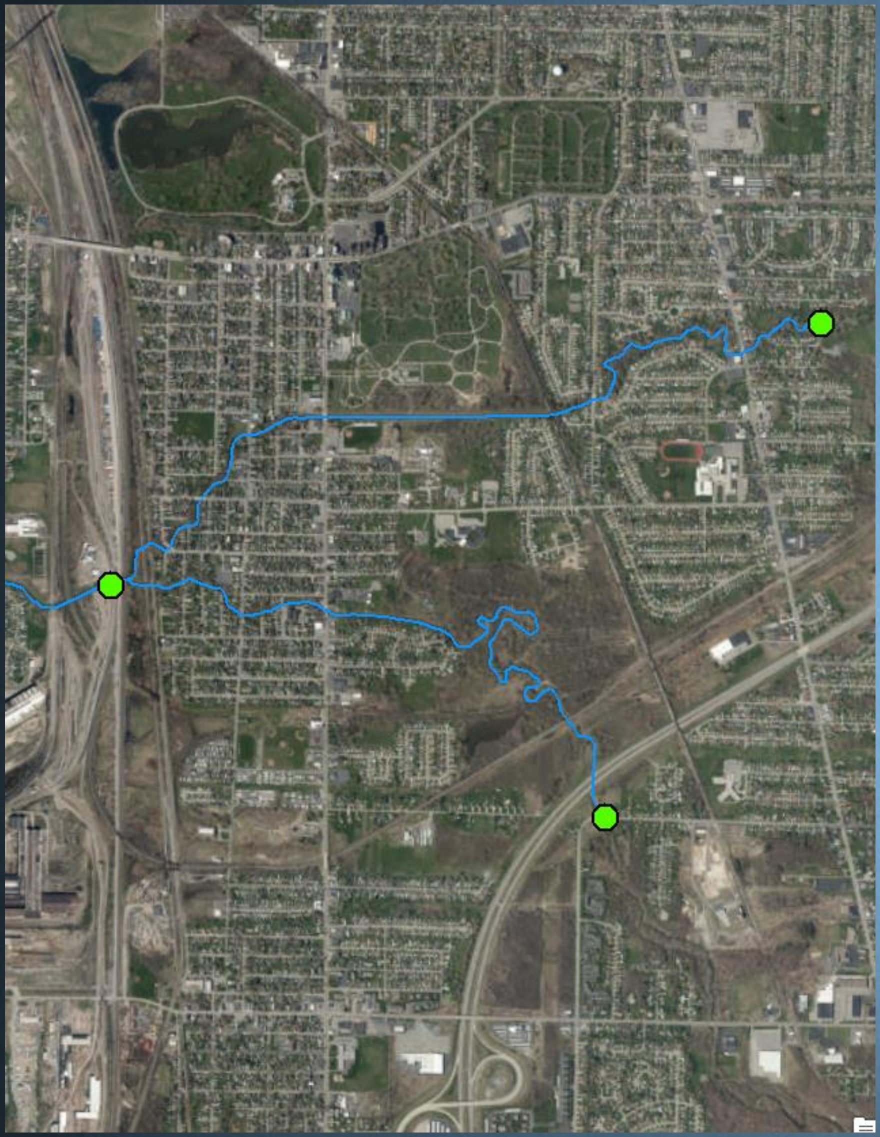


Challenges Encountered
Implementing Hydrology

USACE Model was a steady-state model with flow changes locations

Defining characteristic of 2-D models are that they are unsteady and hydrodynamically route flow from upstream to downstream

Scope of project was to have modeled discharges match effective discharges at all defined locations

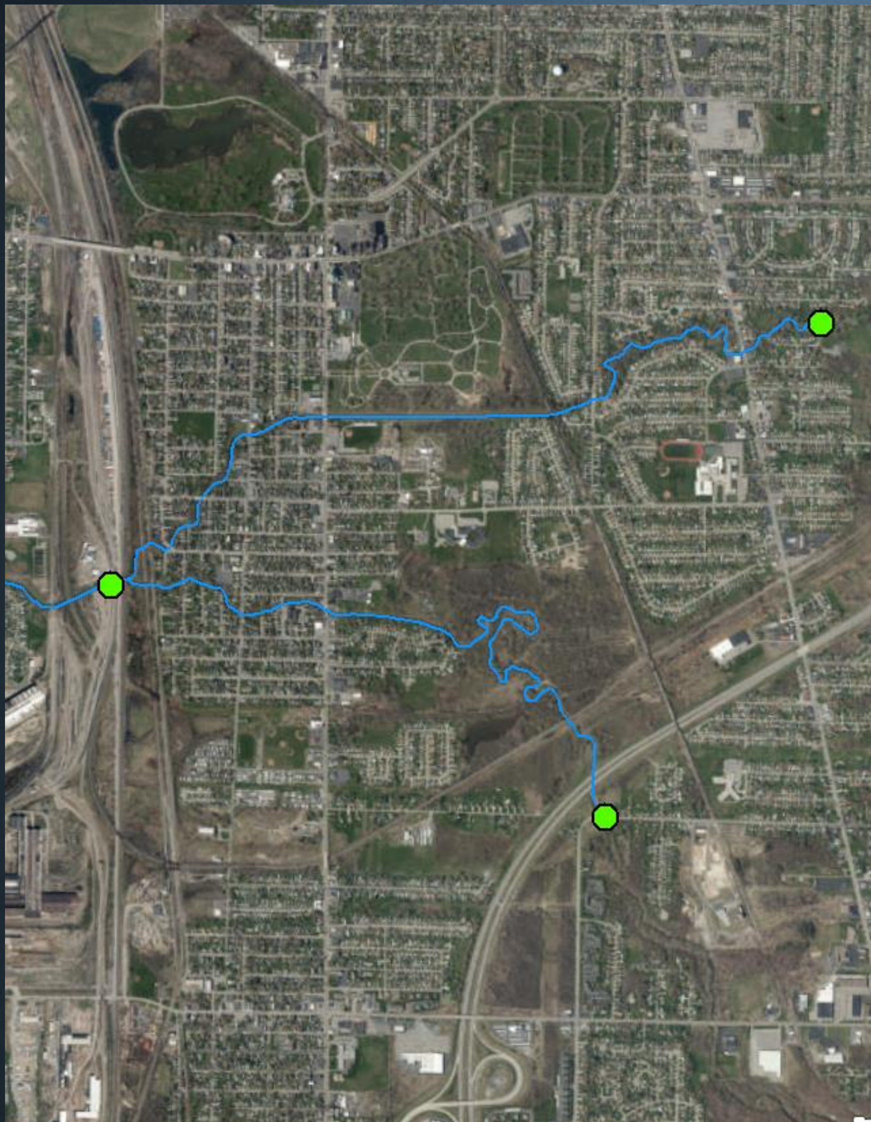


Attempted Solution
Implementing Hydrology

Attempted to develop hydrographs utilizing basin characteristics from StreamStats implemented into a simple HEC-HMS model

Found that the 1D/2D model routing losses were so significant that could not match discharge at confluence

No amount of calibration could yield effective discharge



Final Solution
Implementing Hydrology

Constant discharge hydrographs were instead utilized (essentially steady state)

Due to lack of routing loss, discharges at confluence exceeded effective

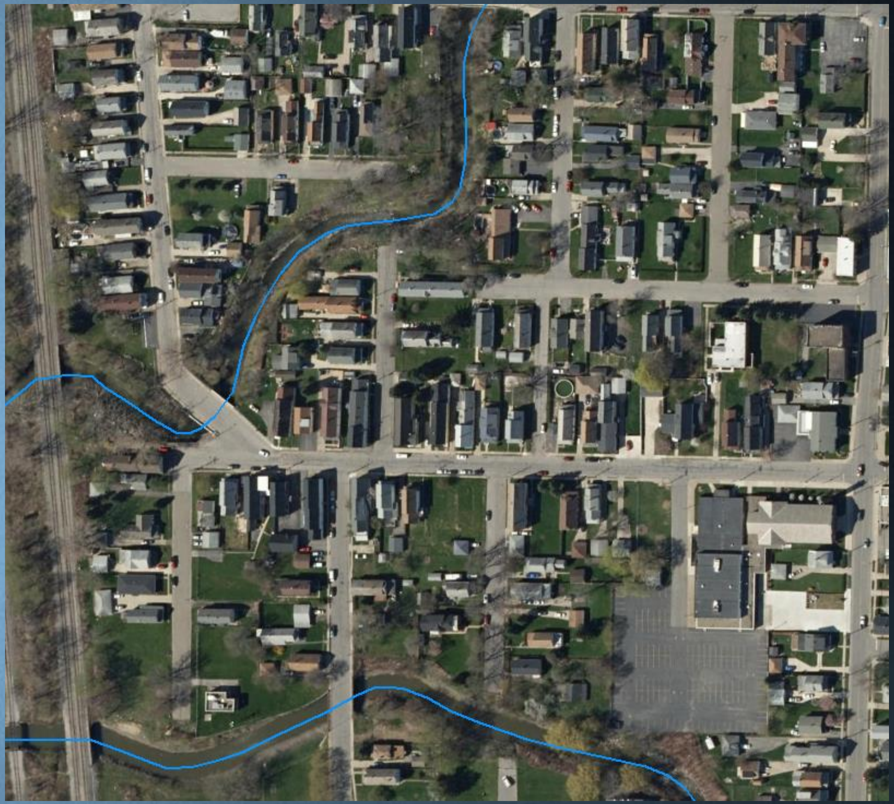
Resolved by implementing negative lateral inflow into cross sections immediately upstream of confluence

Challenges Encountered
Hydraulic Impact of Buildings

Floodplain is highly developed with many houses and other buildings abutting the streams

Buildings are not reflected in general land-use layers or in bare earth DEMs derived from LiDAR

Blocked obstructions utilized in 1D models were not available for 2D grids at time of model development

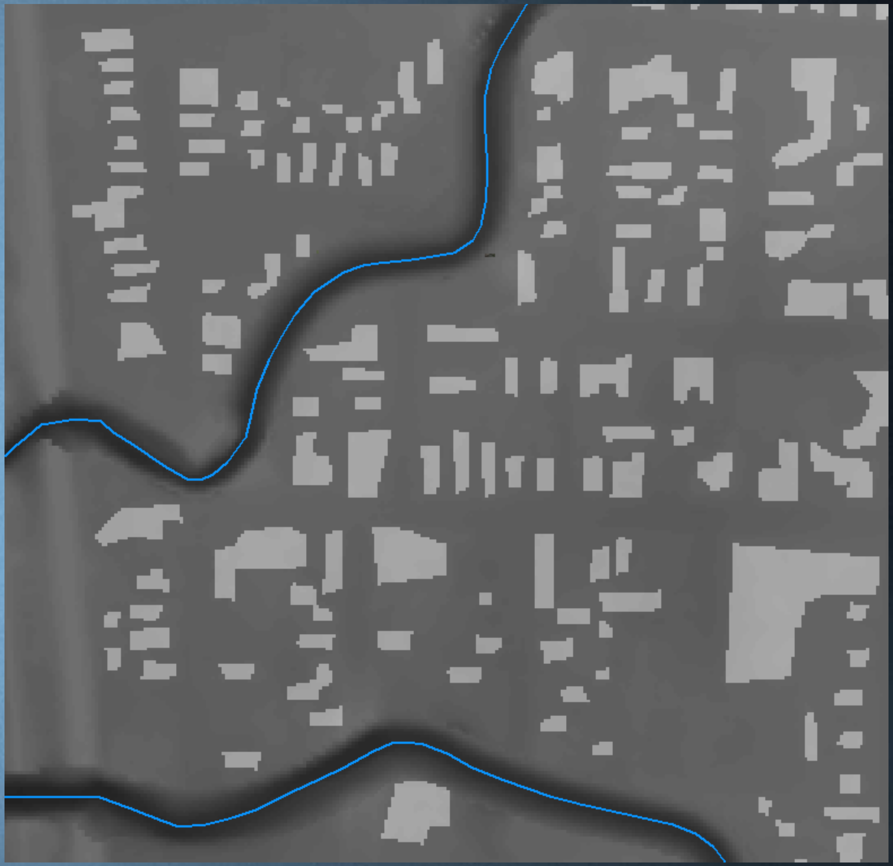


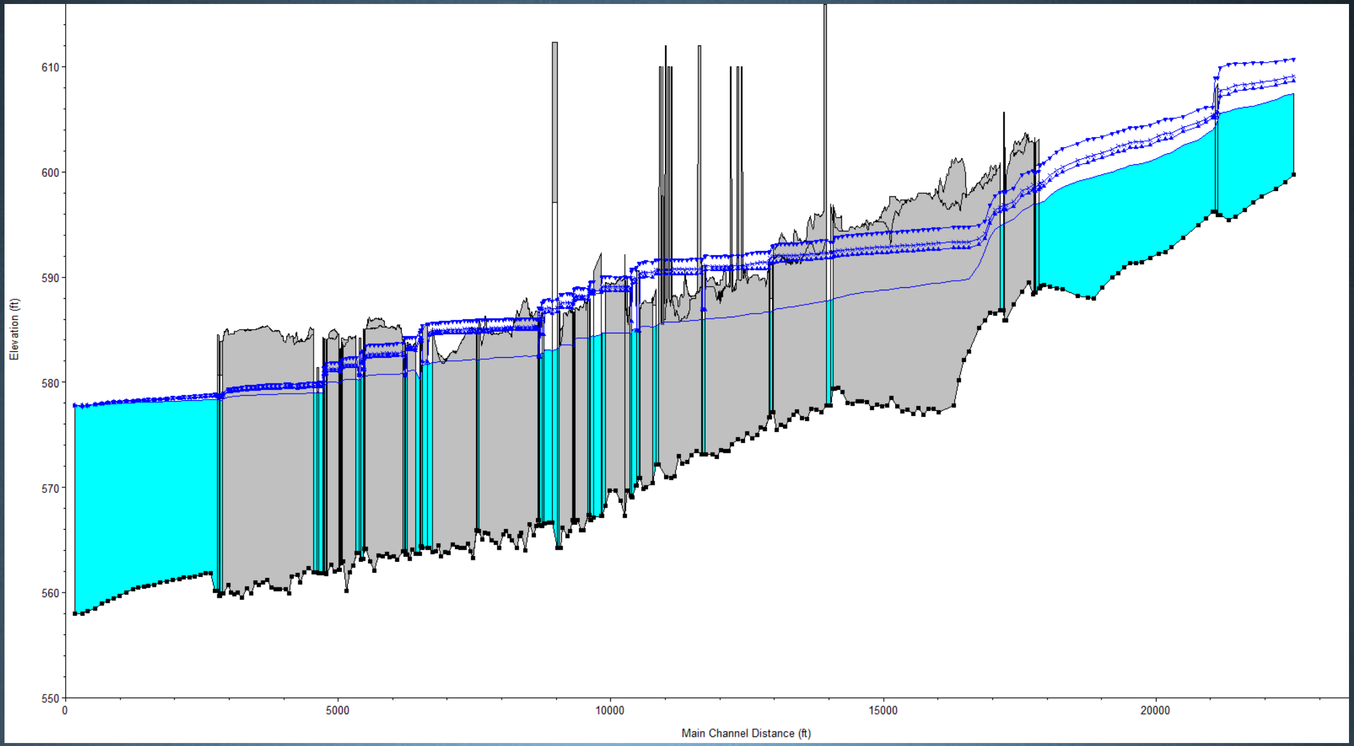
Solution
Hydraulic Impact of Buildings

It was assumed that water could not freely flow through buildings (floodway implications)

Building footprints were digitized referencing orthoimagery

Using ArcGIS tools, elevation was added to DEM at building locations, representing a physical block/obstruction to flow



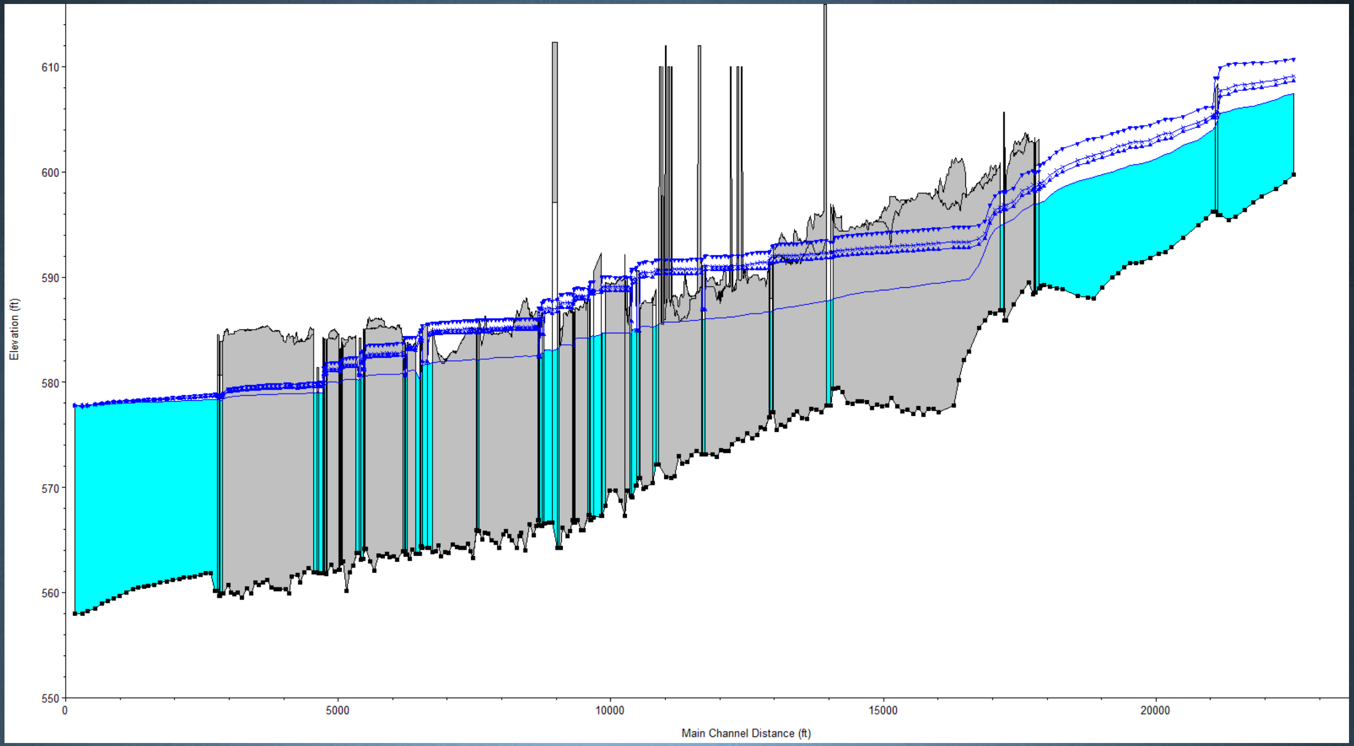


1D / 2D model with significant number of lateral weirs and narrow cross sections lead to model routinely failing to achieve stable solution

When stable solution was yielded, drawdowns and crossing profiles were often a result

Challenges Encountered

Achieving a Stable Model



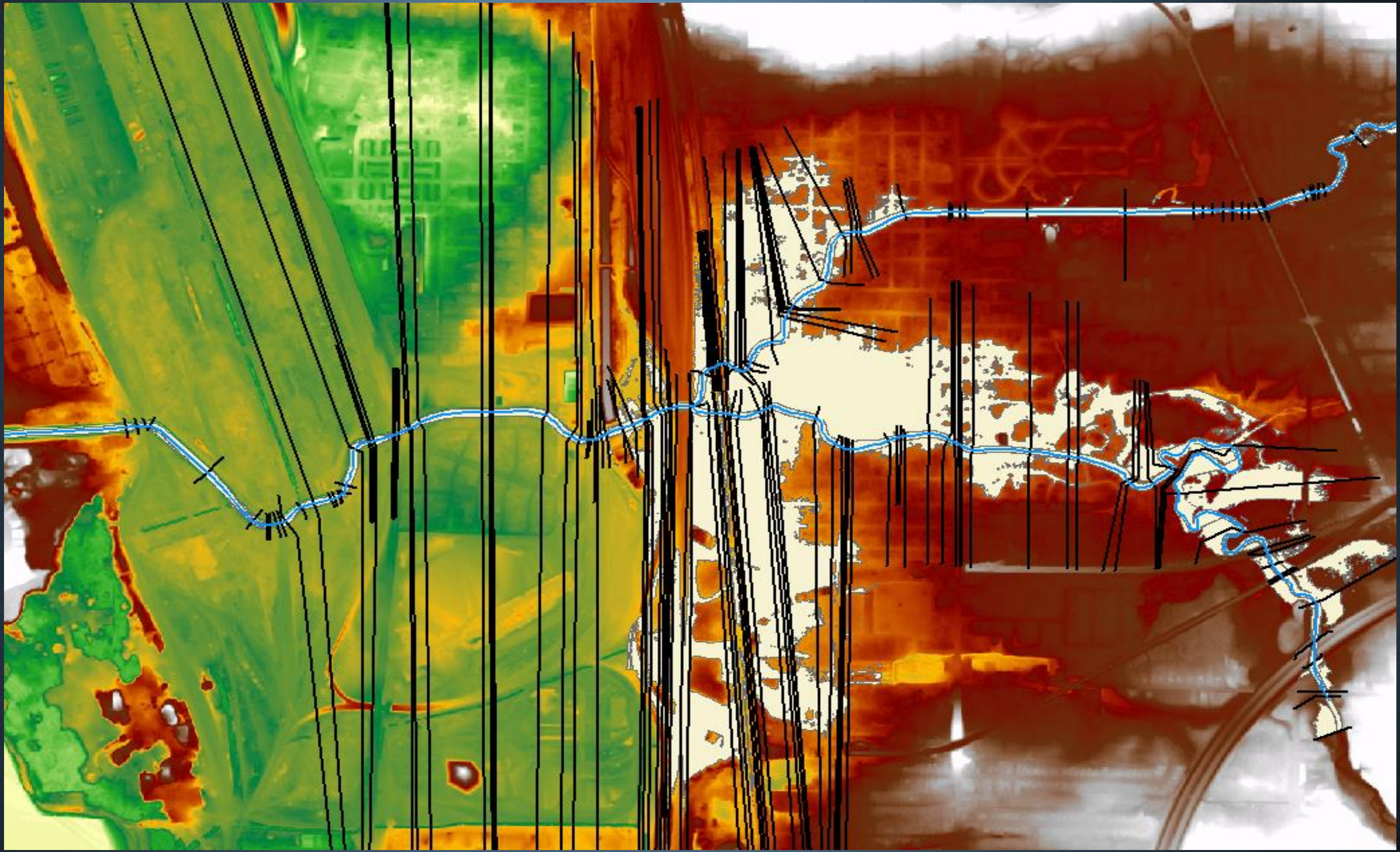
1D Unsteady warm-up period was utilized to 'pre-fill' the model

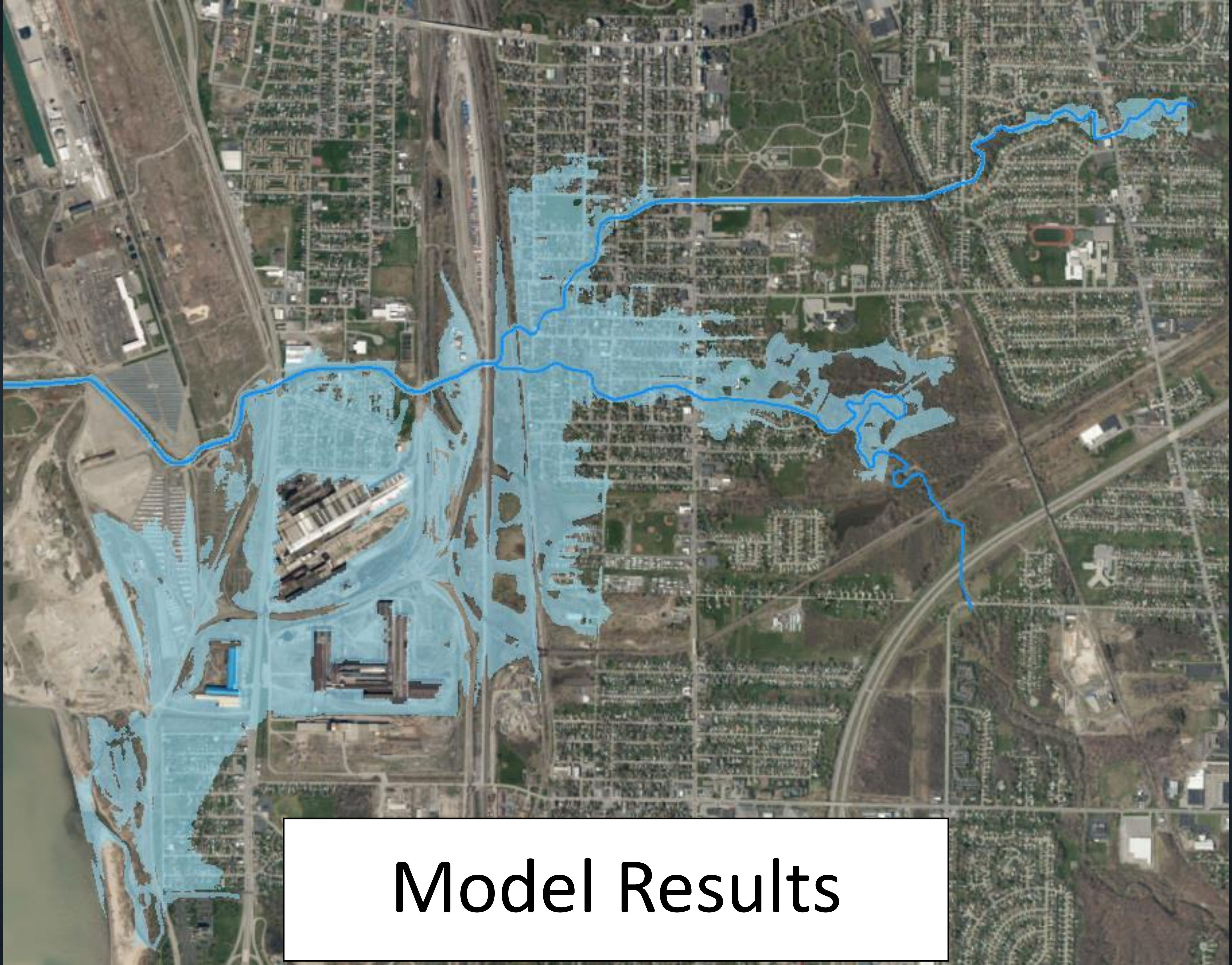
Model was extremely sensitive to cross section and ineffective area placement, requiring significant iterations to resolve

Solution

Achieving a Stable Model

SFHE Model



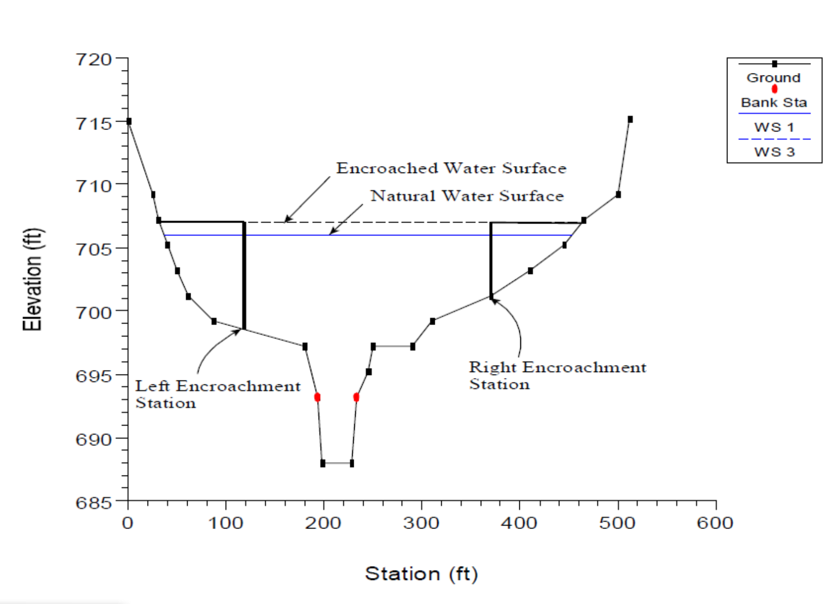


Model Results

Challenges Encountered
Floodway Development

Challenges Encountered

Floodway Development



Source: HEC-RAS 5.0 Reference Manual, Figure 9-1 (Brunner, 2016)

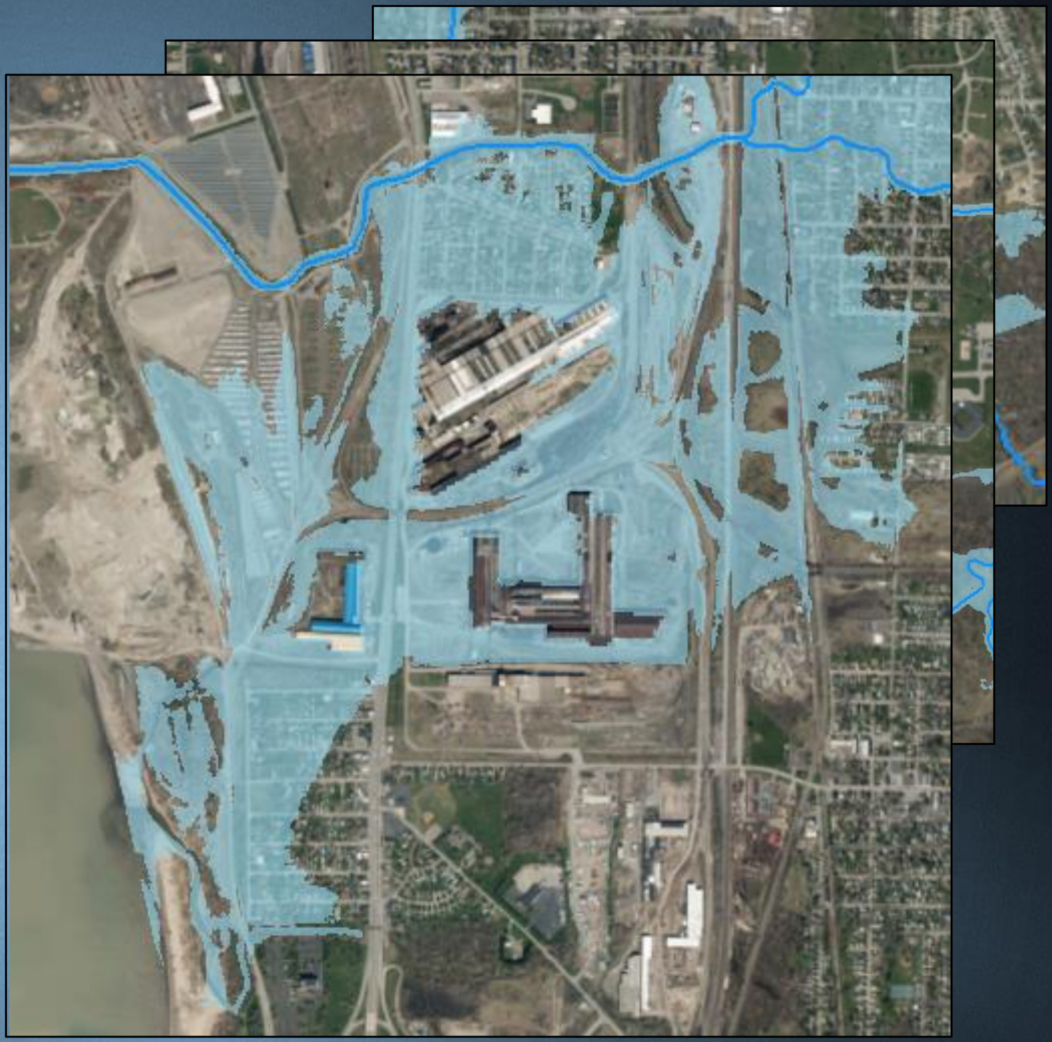
FEMA's definition:

A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

In practice, this refers to a strip of land adjacent to a stream which conveys the majority of flow from upstream to downstream

1D ASSUMPTION!!!!

- More complicated to compute floodway extents in 2-D area
- Does not account for flow balancing between streams
- Does not account for flow diverting away from the channel



Challenges Encountered

Floodway Development, Cont.

In the state of New York, the floodway must not result in water surface elevations in excess of 1-ft above the base flood elevation

Constraining flow to the channel resulted in a rise in water surface elevations in excess of 3-ft

Anywhere a floodway is defined, a profile baseline and floodway data table must be defined and generated

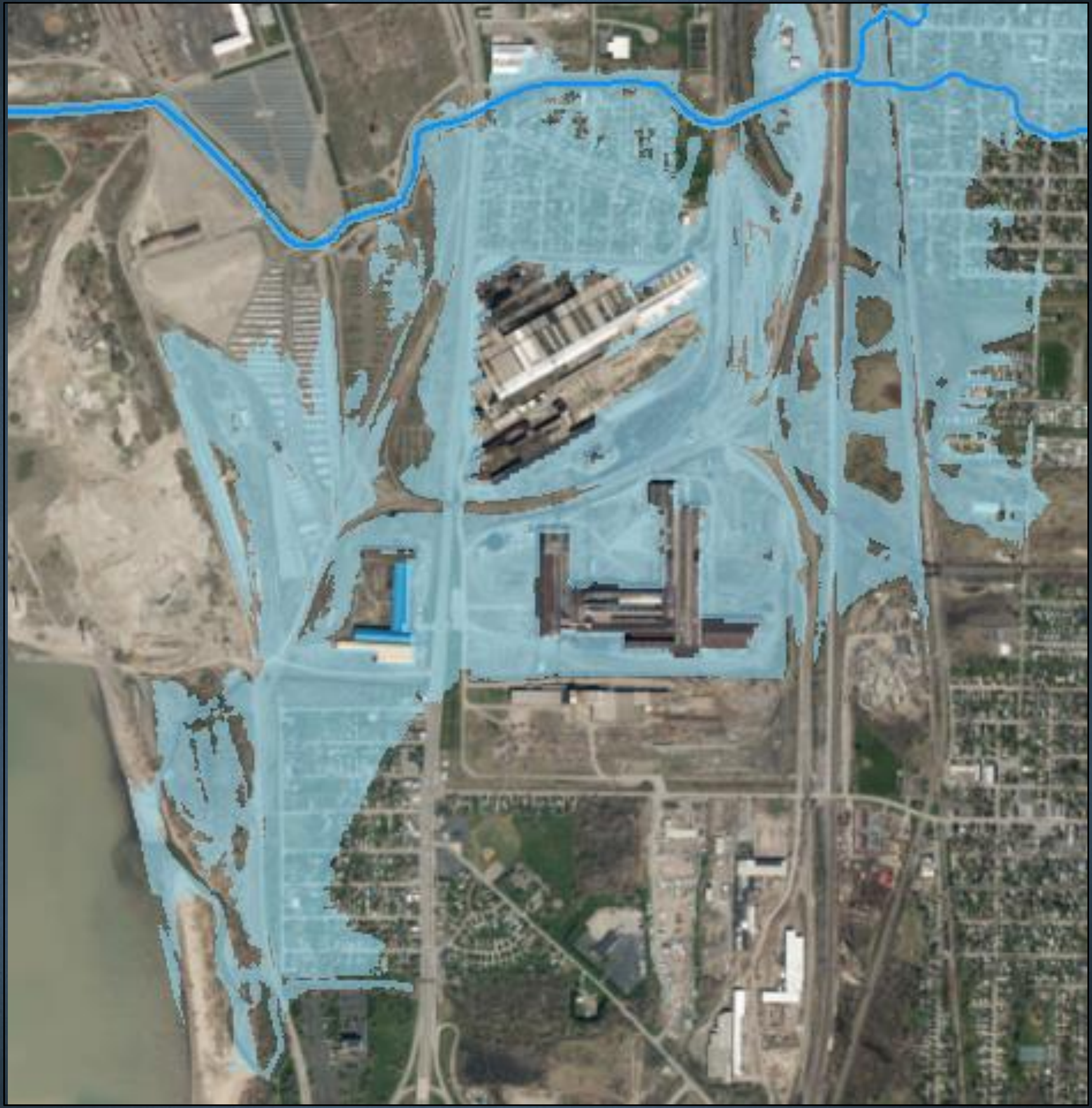
A profile baseline would be difficult to define when describing overland flow along roads and past buildings

Any development inside a defined floodway must demonstrate to FEMA that there will be no adverse impacts to water surface elevations

How do you tell municipalities, business owners and home owners nowhere close to the stream that they are not allowed to do any construction in their properties because water is escaping the channel?

Challenges Encountered

Floodway Development



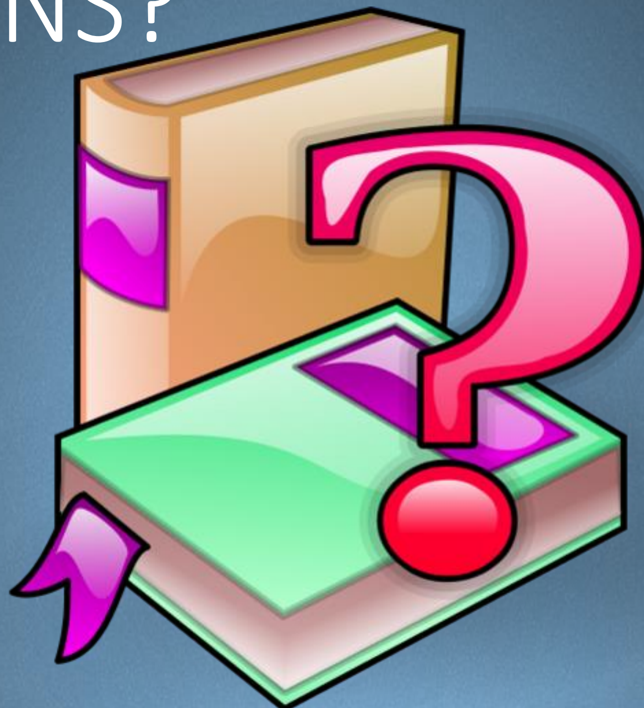
- Problem was raised to FEMA Region II representatives through Regional Service Center
- Significant amount of evidence was required to demonstrate that no simple solution was available
- FEMA agreed to accept a floodway constrained to the channel utilizing the rationale that flow exiting the stream would continue to follow existing overland flow paths such as roads

Solution
Floodway Development

Project Conclusions

- The hydraulic model for Smokes Creek provides a very detailed and robust representation of the risk of flooding to the City of Lackawanna, NY
- It is unlikely that utilizing a 1D-only model would be able to achieve the same level of accuracy given the complicated overland hydraulics
- Development of the Smokes Creek model took significant time and effort, and is not easily modified for future model users
- Strongly recommend that the cost/benefit analysis of pursuing 2D models for floodplain mapping be seriously consider – would not recommend pursuing 2D models if not required

QUESTIONS?



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