IMPROVING FLOODPLAIN ACCURACY WITH A COMBINED 1D/2D MODEL

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CBB

VILLAGE OF WHEELING ILLINOIS

Presentation Outline

1. Project Overview – Buffalo Creek, Wheeling, IL
2. Recap of Previous Modeling Approach
3. Updated Modeling Approach
4. 2D Split Flow Model Area
5. Additional Considerations
6. Sensitivity Analysis
7. 2D Modeling Summary
8. Next Steps

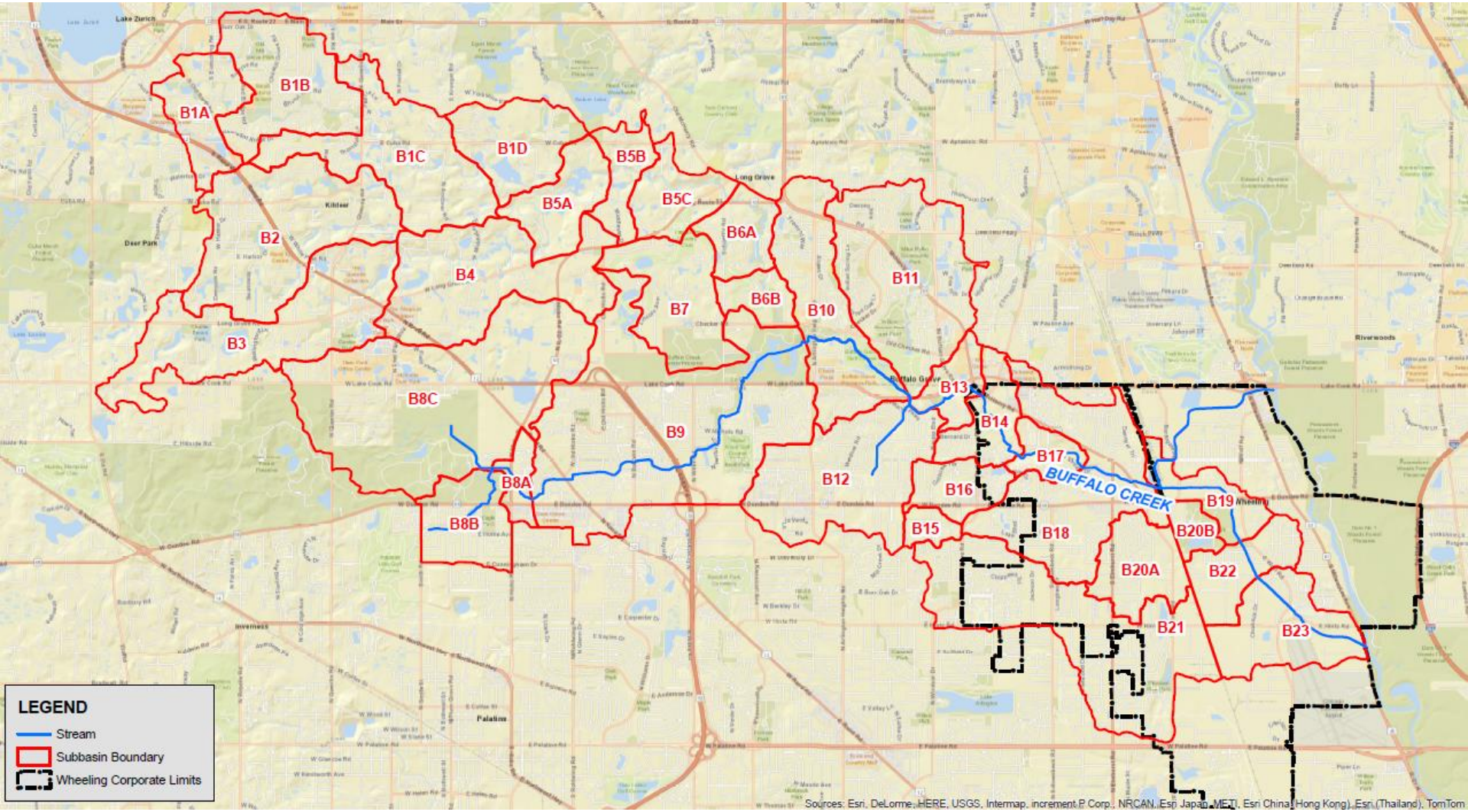

Jo Daviess
Stephenson
Winnebago
Boone
McHenry
Lake
Carroll
Ogle
De Kalb
Kane
Du Page
Cook
Whiteside
Lee
Kendall
Will
Rock Island
Henry
Bureau
La Salle
Grundy
Mercer
Putnam
Kankakee
Stark
Marshall
Knox
Warren
Livingston
Peoria
Woodford
Henderson
Iroquois
Fulton
Tazewell
McLean
Ford
Hancock
McDonough
Mason
Schuyler
Logan
De Witt
Champaign
Vermilion
Adams
Brown
Cass
Menard
Piatt
Macon
Douglas
Edgar
Pike
Scott
Morgan
Sangamon
Moultrie
Christian
Coles
Greene
Shelby
Calhoun
Montgomery
Cumberland
Clark
Macoupin
Jersey
Fayette
Effingham
Jasper
Crawford
Madison
Bond
Clay
Marion
Richland
Lawrence
Clinton
St. Clair
Wayne
Wabash
Washington
Jefferson
Edwards
Monroe
White
Randolph
Perry
Hamilton
Franklin
Jackson
Saline
Gallatin
Williamson
Union
Johnson
Pope
Hardin
Pulaski
Alexander
Massac

Wheeling

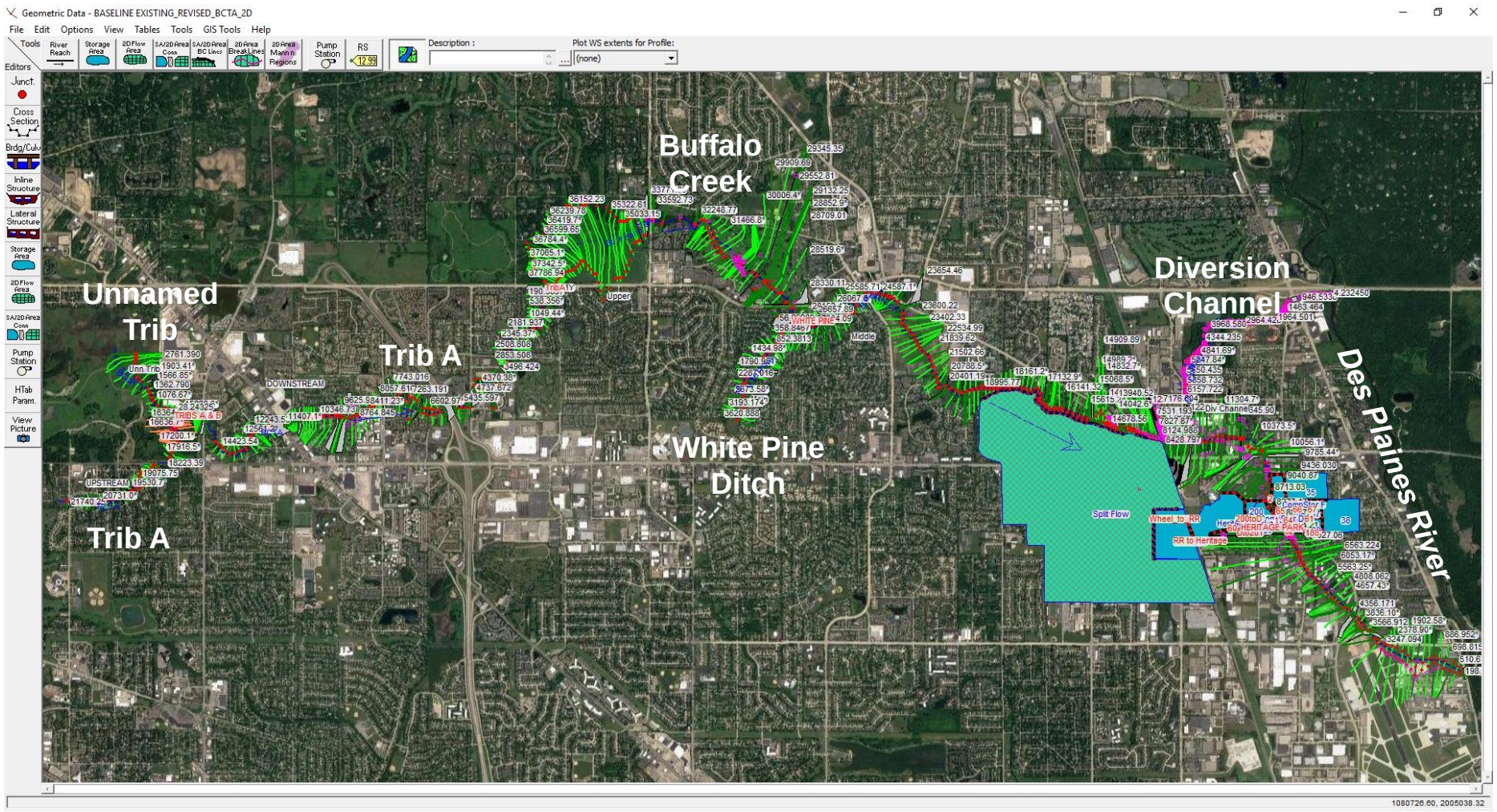
History of Buffalo Creek Floodplain

- Original analysis and mapping effective in 1981
- 2008 PMR
- Conveyance floodway agreement
- 2011 MWRD Lower Des Plaines Detailed Watershed Plan
- Current LOMR request was identified as #1 project in 2015 Wheeling Stormwater Master Plan

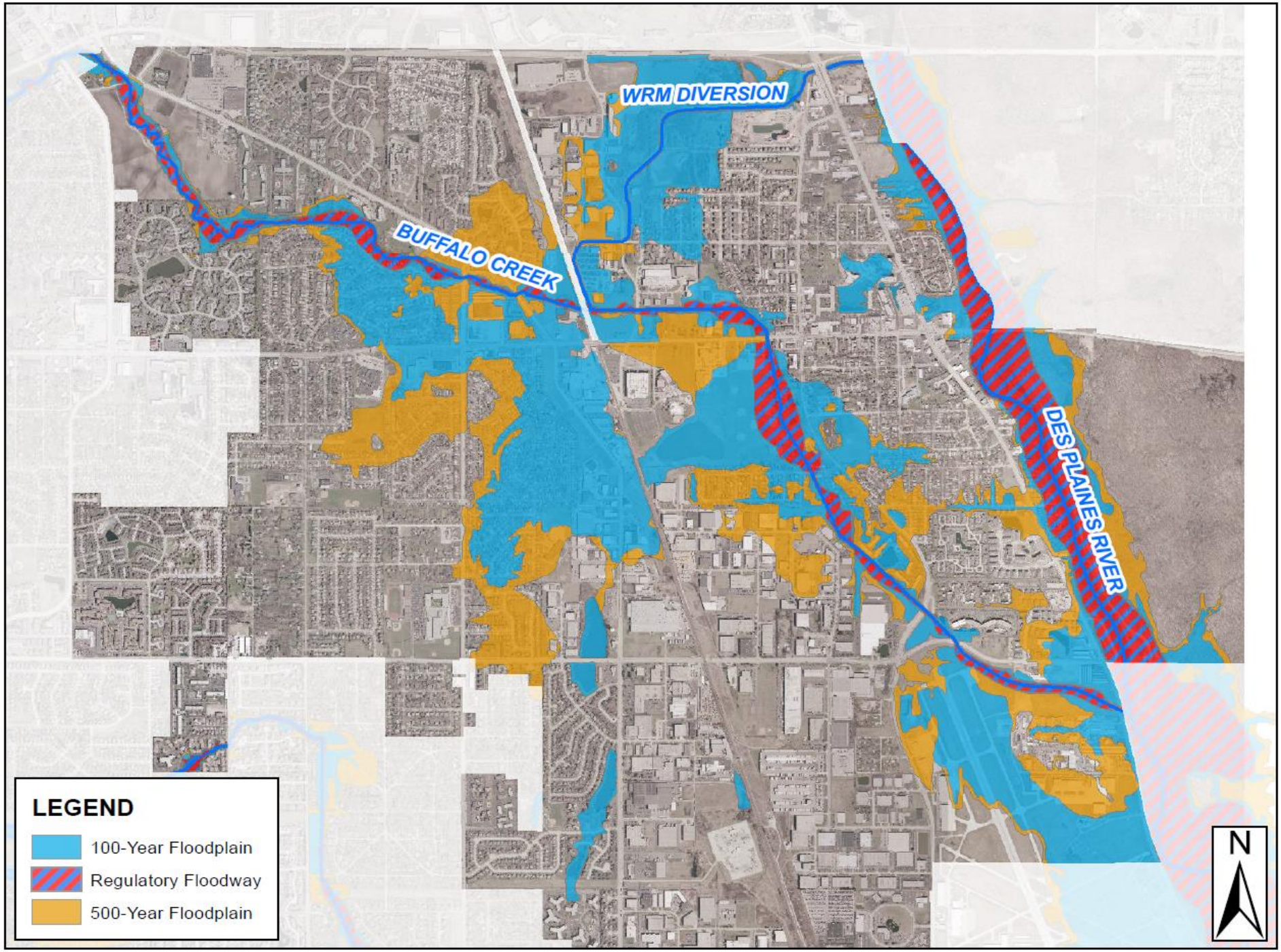
Buffalo Creek Drainage Area

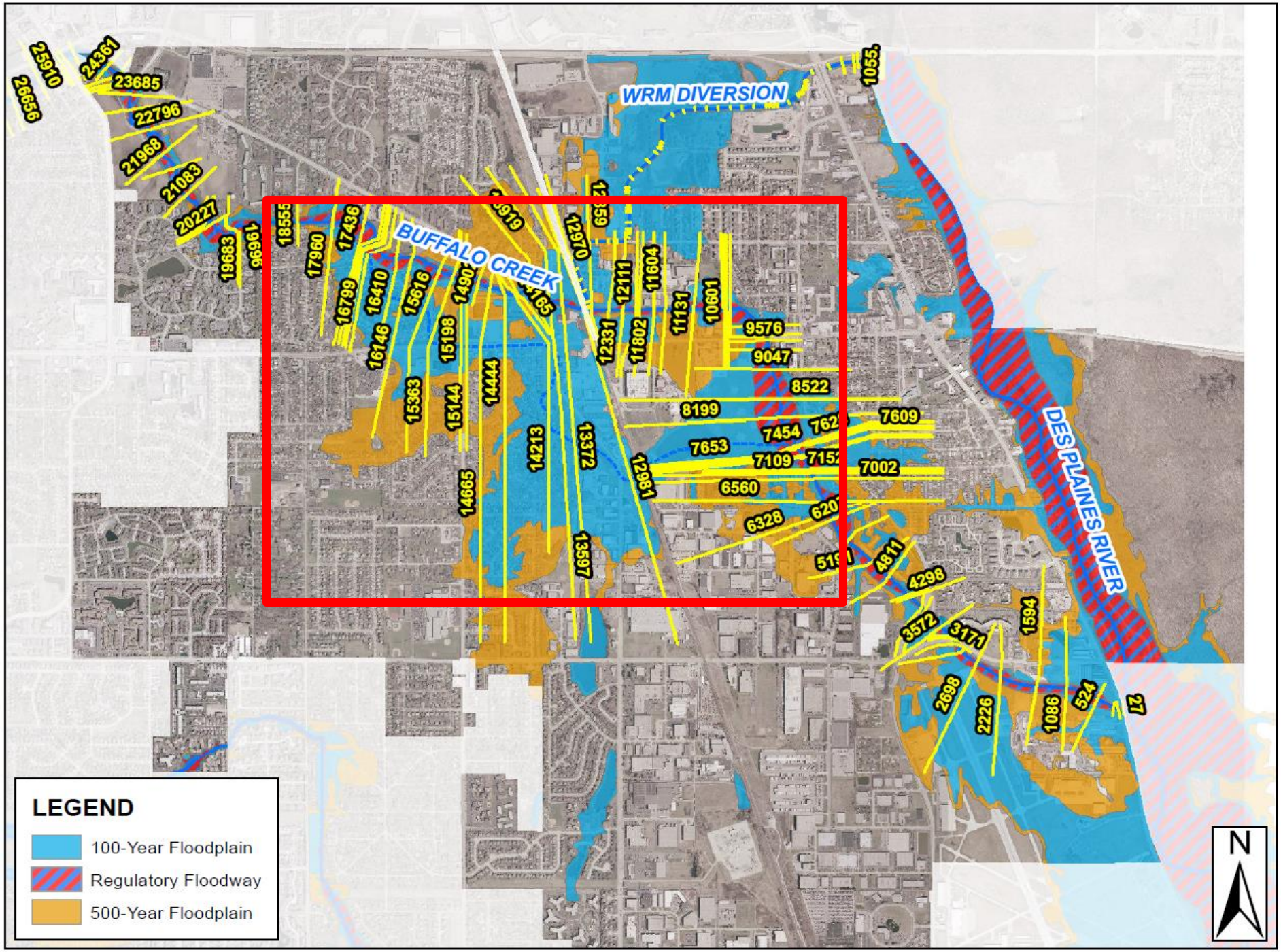


Buffalo Creek HEC-RAS Model Schematic



- 6 independent reaches modeled
- 15 miles of total stream length


WRM DIVERSION
BUFFALO CREEK
DES PLAINES RIVER
LEGEND
100-Year Floodplain
Regulatory Floodway
500-Year Floodplain
N


WRM DIVERSION
BUFFALO CREEK
DES PLAINES RIVER
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24361
23685
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22796
21968
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20227
19683
19696
18555
17960
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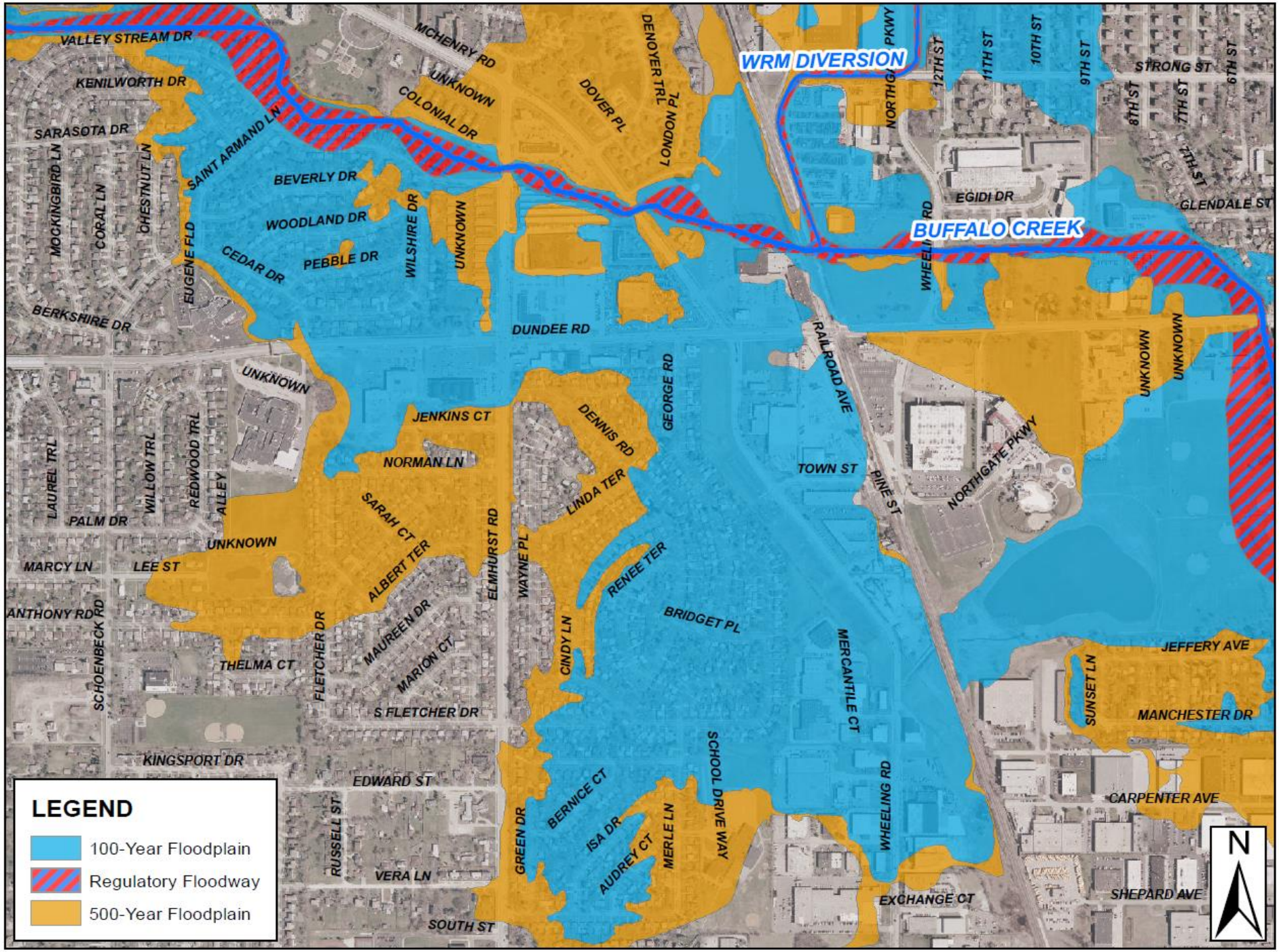
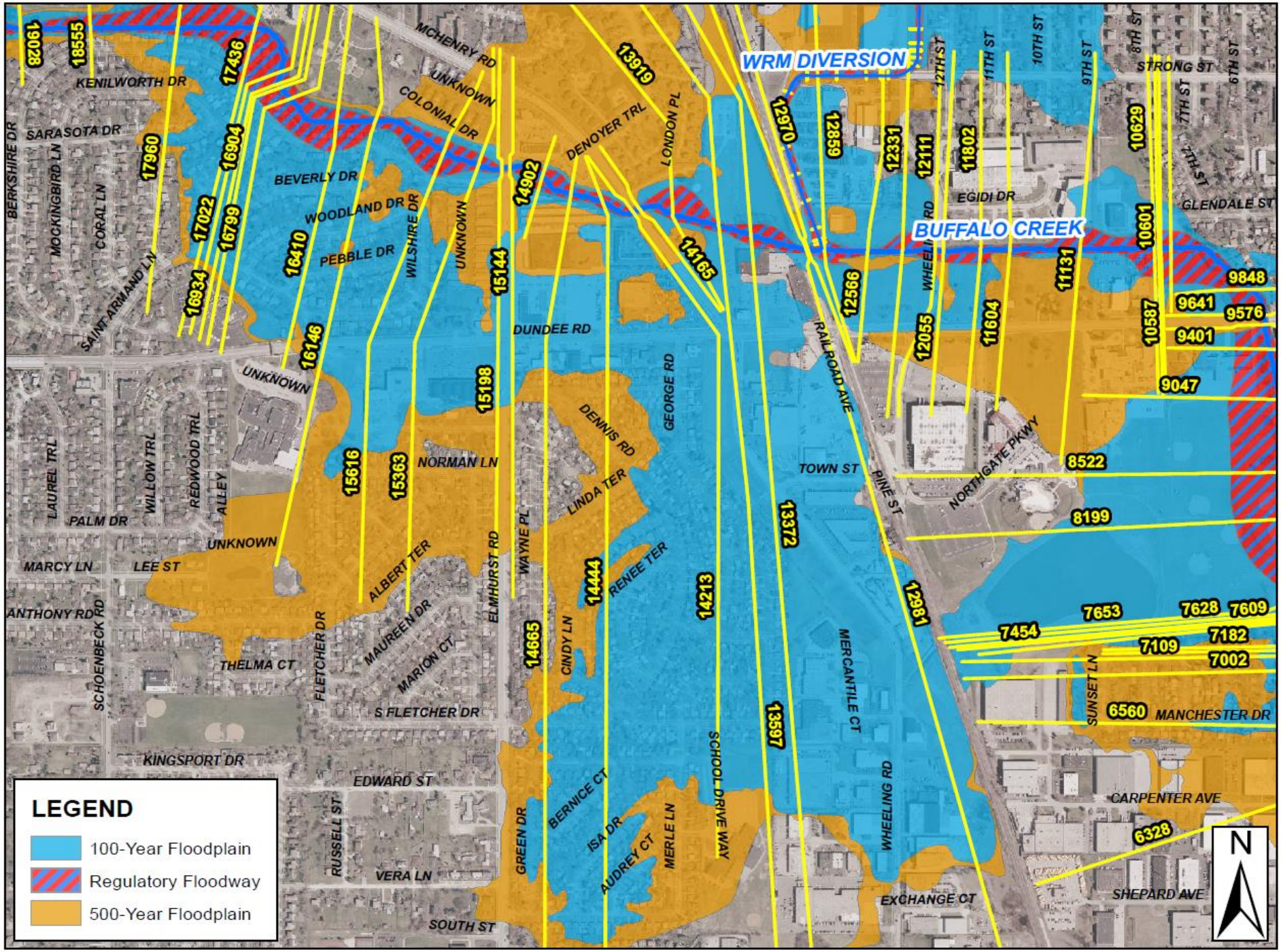
LEGEND
100-Year Floodplain
Regulatory Floodway
500-Year Floodplain


WRM DIVERSION
BUFFALO CREEK
VALLEY STREAM DR
KENILWORTH DR
SARASOTA DR
SAINT ARMAND LN
MOCKINGBIRD LN
CORAL LN
CHESTNUT LN
BEVERLY DR
WOODLAND DR
CEDAR DR
PEBBLE DR
EUGENE FLD
BERKSHIRE DR
WILSHIRE DR
UNKNOWN
MCHENRY RD
COLONIAL DR
DOVER PL
DENOYER TRL
LONDON PL
DUNDEE RD
EGIDI DR
WHEELING RD
NORTHGATE PKWY
12TH ST
11TH ST
10TH ST
9TH ST
8TH ST
7TH ST
6TH ST
STRONG ST
GLENDALE ST
RAILROAD AVE
GEORGE RD
DENNIS RD
JENKINS CT
NORMAN LN
LINDA TER
SARAH CT
ALBERT TER
ELMHURST RD
WAYNE PL
RENEE TER
BRIDGET PL
CINDY LN
TOWN ST
PINE ST
NORTHGATE PKWY
LAUREL TRL
WILLOW TRL
REDWOOD TRL
ALLEY
PALM DR
MARCY LN
LEE ST
ANTHONY RD
SCHOENBECK RD
THELMA CT
FLETCHER DR
MAUREEN DR
MARION CT
S FLETCHER DR
KINGSPORT DR
EDWARD ST
RUSSELL ST
VERA LN
SOUTH ST
GREEN DR
BERNICE CT
ISA DR
AUDREY CT
MERLE LN
SCHOOL DRIVE WAY
MERCANTILE CT
WHEELING RD
EXCHANGE CT
SHEPARD AVE
CARPENTER AVE
MANCHESTER DR
SUNSET LN
JEFFERY AVE
LEGEND
100-Year Floodplain
Regulatory Floodway
500-Year Floodplain
N


WRM DIVERSION
BUFFALO CREEK
MCHENRY RD
KENILWOOD DR
SARASOTA DR
BERKSHIRE DR
MOCKINGBIRD LN
CORAL LN
SAINT ARMAND LN
COLONIAL DR
BEVERLY DR
WOODLAND DR
PEBBLE DR
WILSHIRE DR
DENOYER TRL
LONDON PL
DUNDEE RD
GEORGE RD
DENNIS RD
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WAYNE PL
ELMHURST RD
ALBERT TER
RENEE TER
CINDY LN
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WILLOW TRL
REDWOOD TRL
ALLEY
PALM DR
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KINGSPORT DR
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SOUTH ST
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BERNICE CT
ISA DR
AUDREY CT
MERLE LN
SCHOOL DRIVE WAY
RAILROAD AVE
TOWN ST
PINE ST
NORTHGATE PKWY
MERCANTILE CT
WHEELING RD
EXCHANGE CT
SUNSET LN
MANCHESTER DR
CARPENTER AVE
SHEPARD AVE
EGIDI DR
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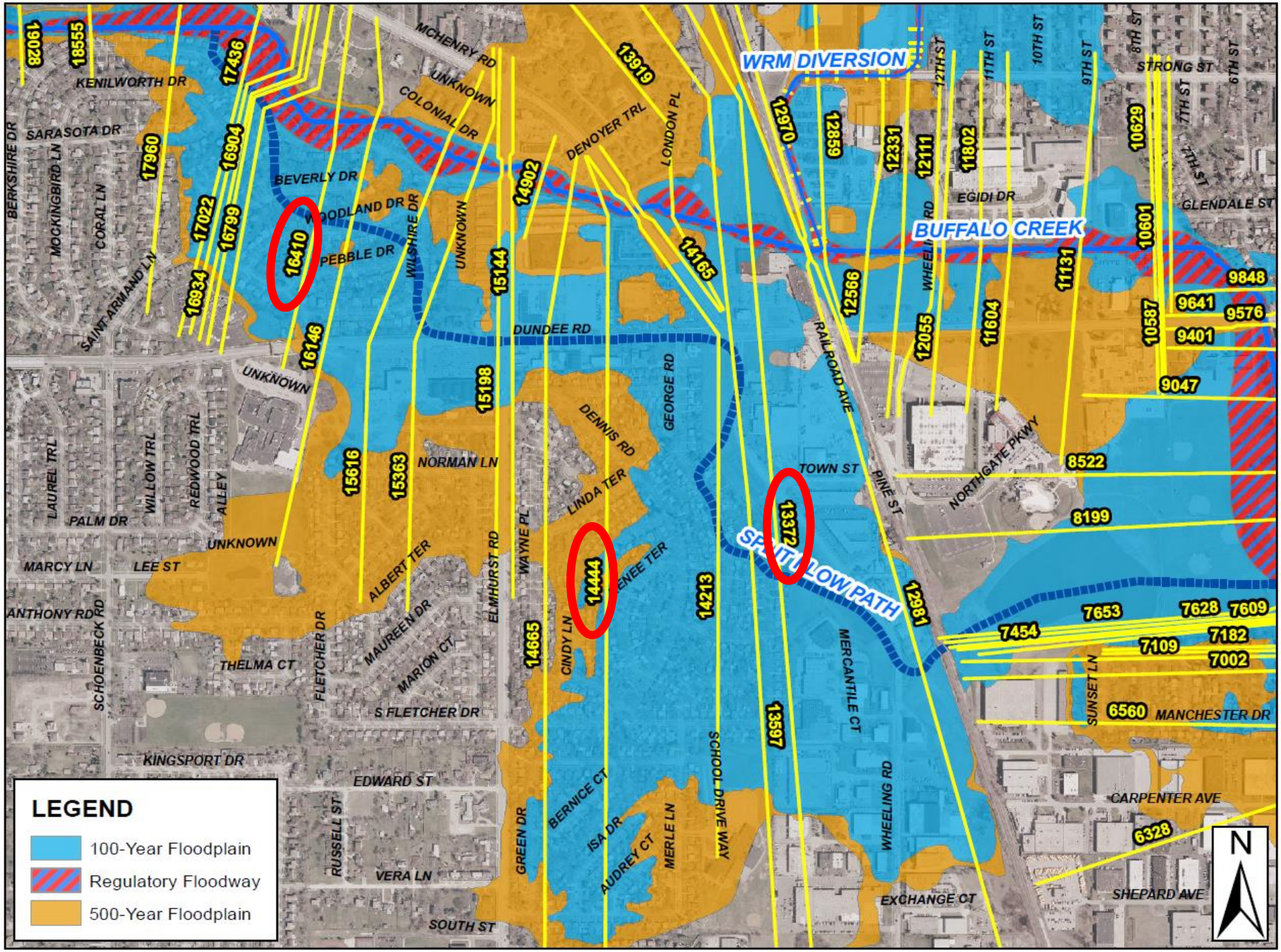
LEGEND
100-Year Floodplain
Regulatory Floodway
500-Year Floodplain
N


WRM DIVERSION
BUFFALO CREEK
SPLIT FLOW PATH
KENILWORTH DR
SARASOTA DR
BERKSHIRE DR
MOCKINGBIRD LN
CORAL LN
SAINT ARMAND LN
BEVERLY DR
WOODLAND DR
PEBBLE DR
WILSHIRE DR
MCHENRY RD
COLONIAL DR
UNKNOWN
DENOYER TRL
LONDON PL
DUNDEE RD
NORMAN LN
DENNIS RD
GEORGE RD
LINDA TER
WAYNE PL
ELMHURST RD
ALBERT TER
MAUREEN DR
MARION CT
FLETCHER DR
S FLETCHER DR
THELMA CT
SCHOENBECK RD
ANTHONY RD
MARCY LN
LEE ST
PALM DR
LAUREL TRL
WILLOW TRL
REDWOOD TRL
ALLEY
KINGSPORT DR
EDWARD ST
RUSSELL ST
VERA LN
SOUTH ST
GREEN DR
BERNICE CT
ISA DR
AUDREY CT
MERLE LN
SCHOOL DRIVE WAY
CINDY LN
RENEE TER
RAILROAD AVE
TOWN ST
PINE ST
NORTHGATE PKWY
MERCANTILE CT
WHEELING RD
EXCHANGE CT
SUNSET LN
MANCHESTER DR
CARPENTER AVE
SHEPARD AVE
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STRONG ST
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7182
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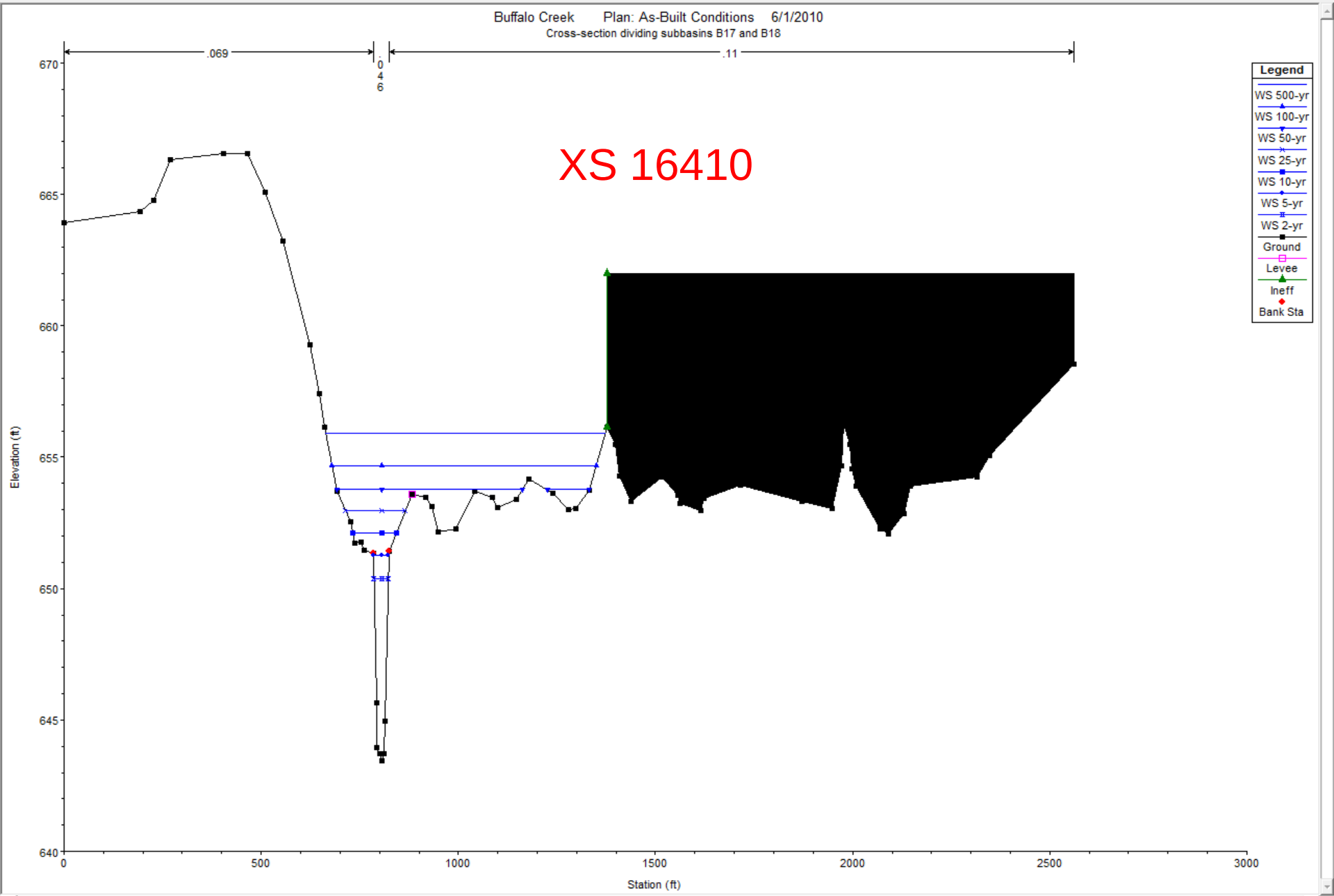
6328
LEGEND
100-Year Floodplain
Regulatory Floodway
500-Year Floodplain
N

Cross Section

File Options Help

River: Buffalo Creek Reach: Buffalo Wheeling River Sta.: 16410 Reload Data



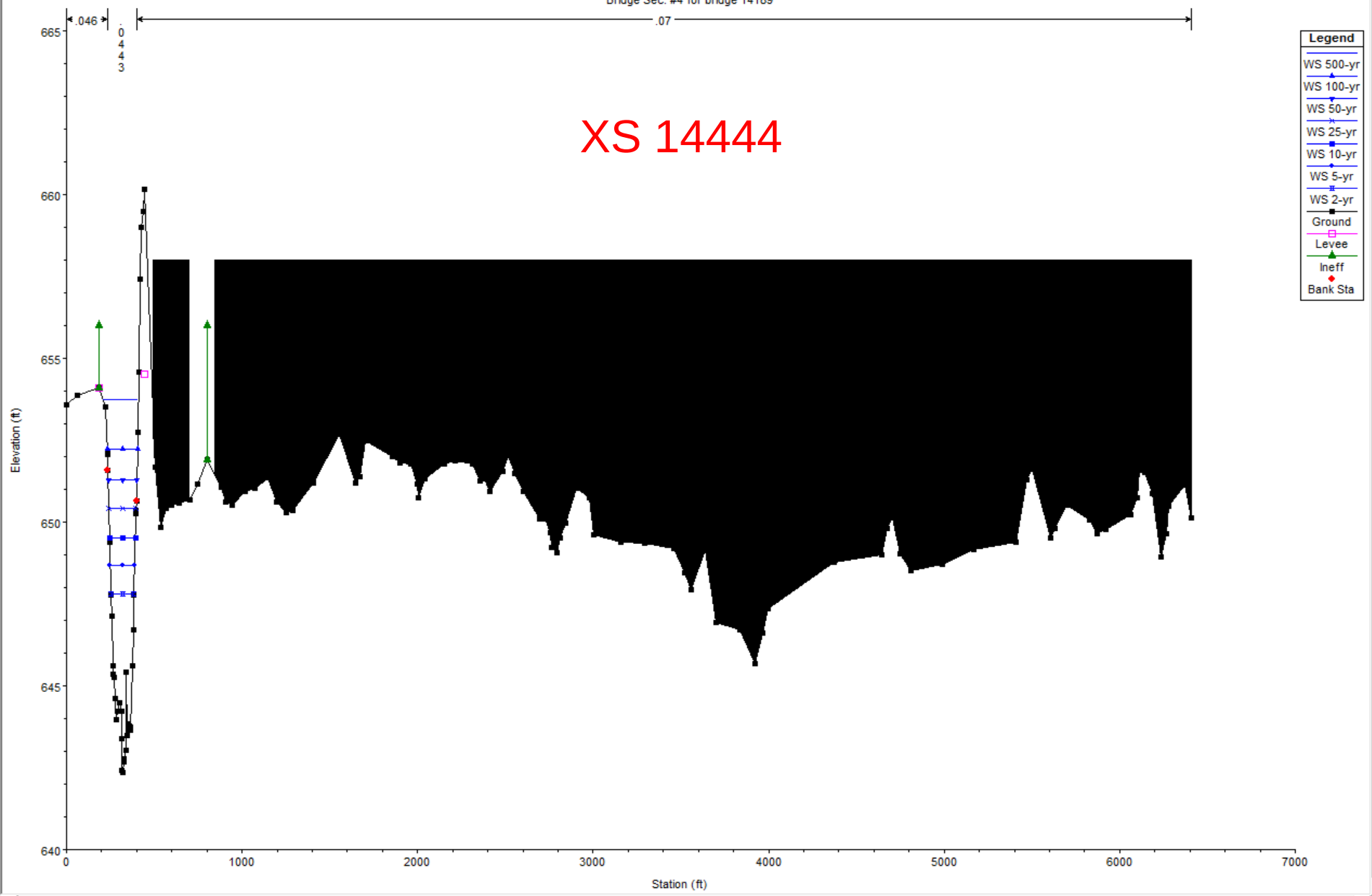
Cross Section

File Options Help

River: Buffalo Creek Reach: Buffalo Wheeling River Sta.: 14444 Reload Data

Buffalo Creek Plan: As-Built Conditions 6/1/2010

Bridge Sec. #4 for bridge 14189

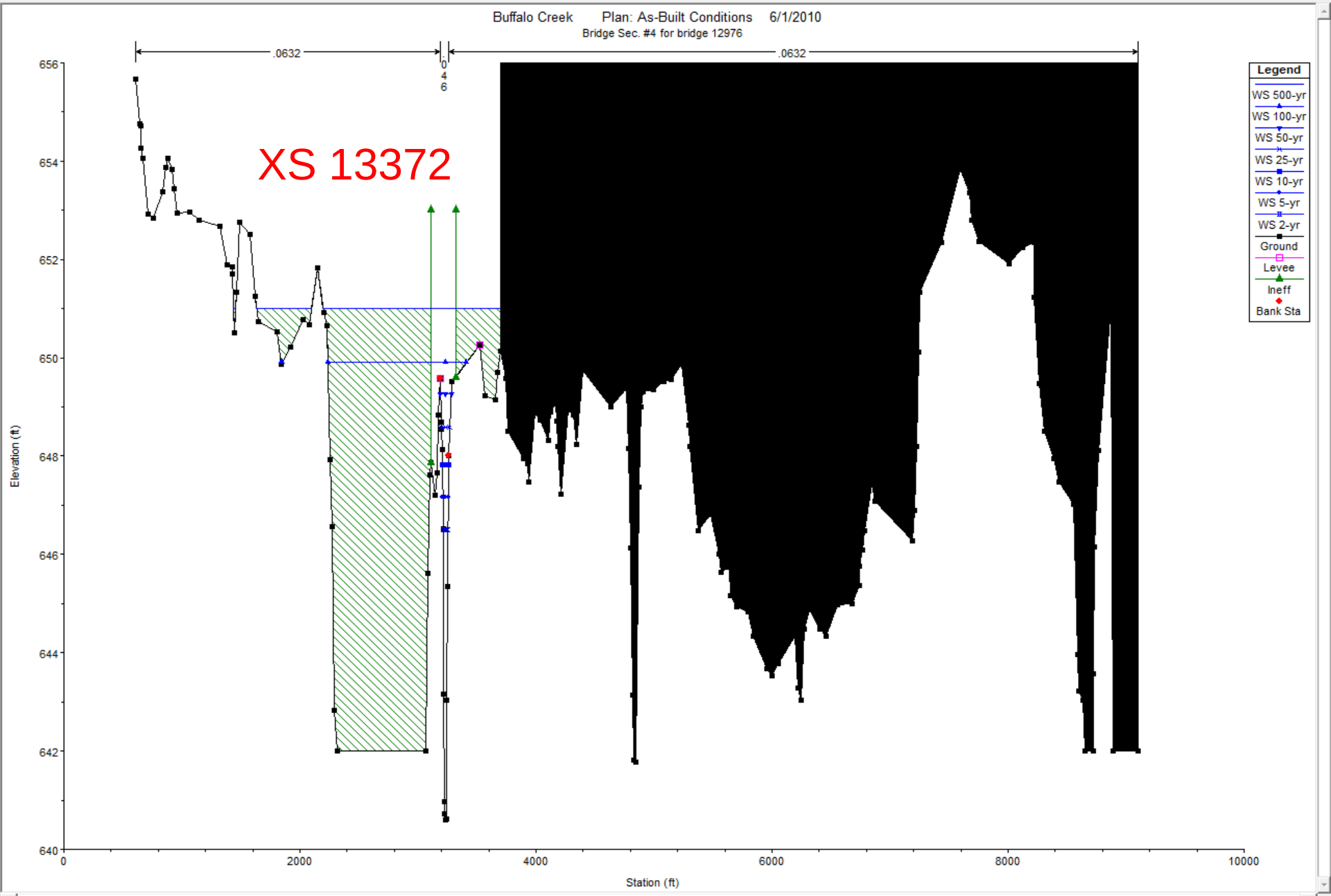


Cross Section

File Options Help

River: Buffalo Creek | 1629.96, 655.92 | Reload Data

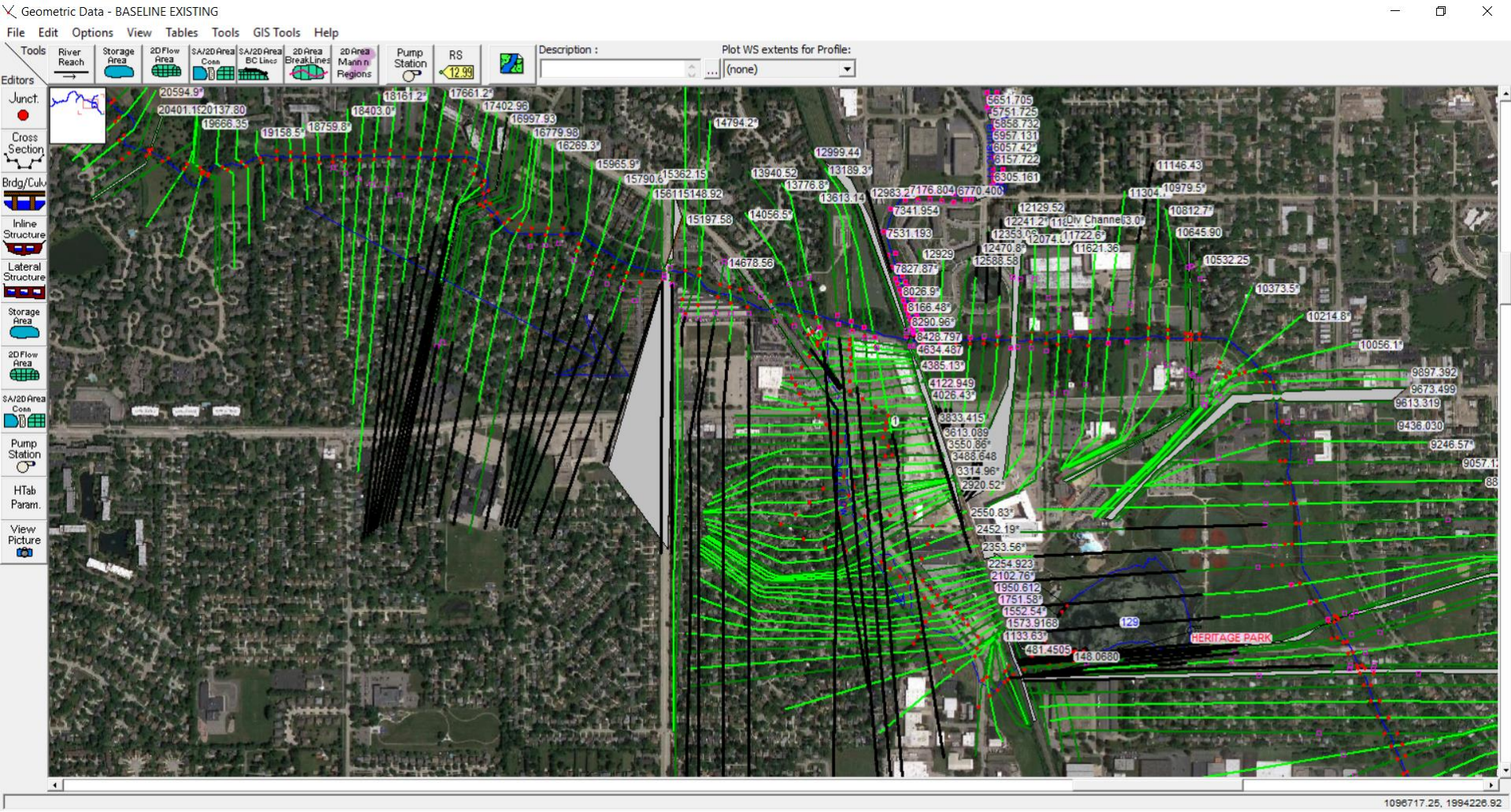
Reach: Buffalo Wheeling | River Sta.: 13372

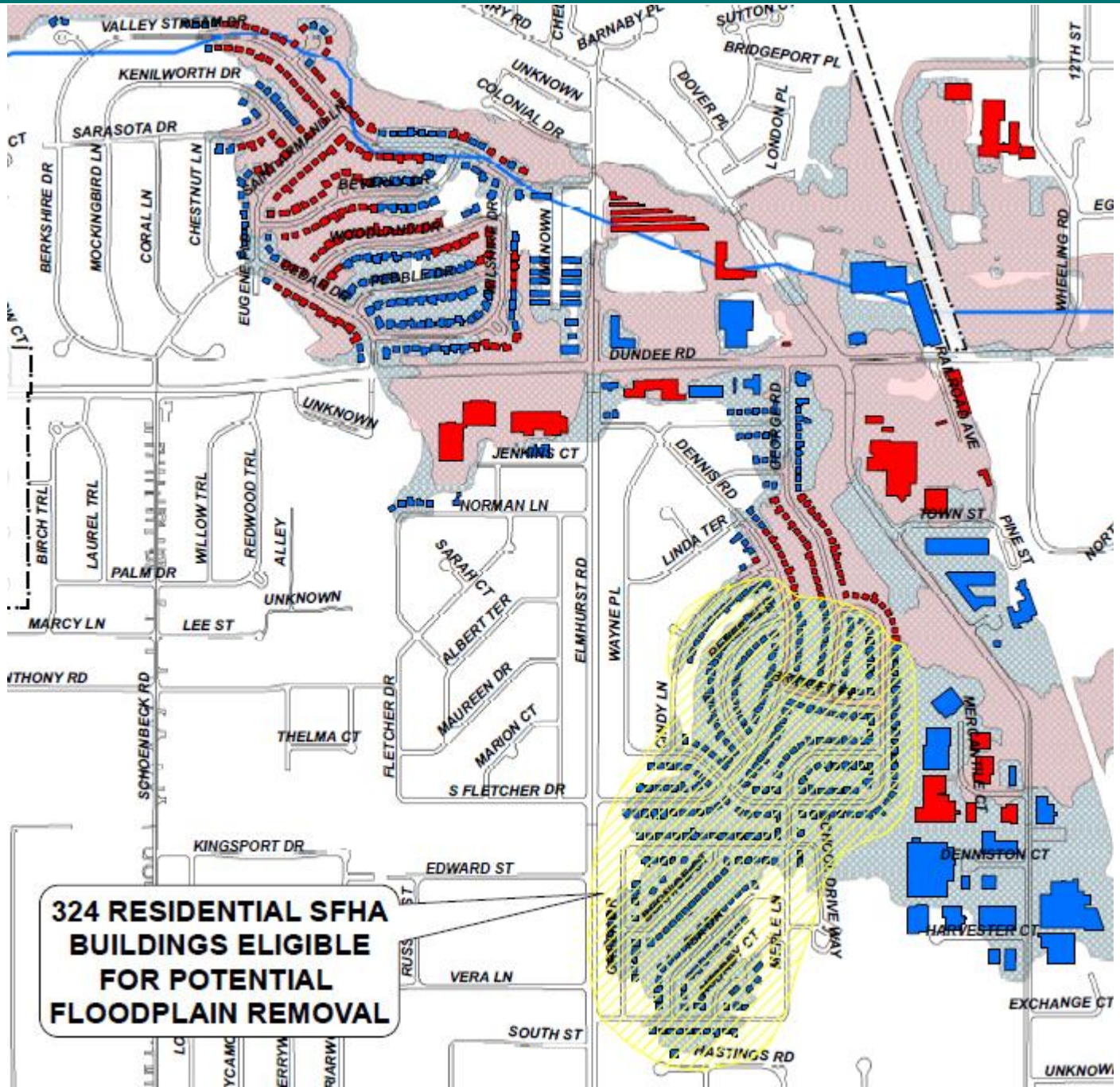


MWRD Detailed Watershed Plan (DWP)

- MWRD DWP for the Lower Des Plaines River completed in 2011.
- Developed updated HEC-HMS hydrologic models and unsteady HEC-RAS hydraulic models for the Des Plaines River and all major tributaries.
- Buffalo Creek modeling revealed “split-flow” condition that improved the accuracy of floodplain mapping through the Village.

MWRD DWP Model Schematic



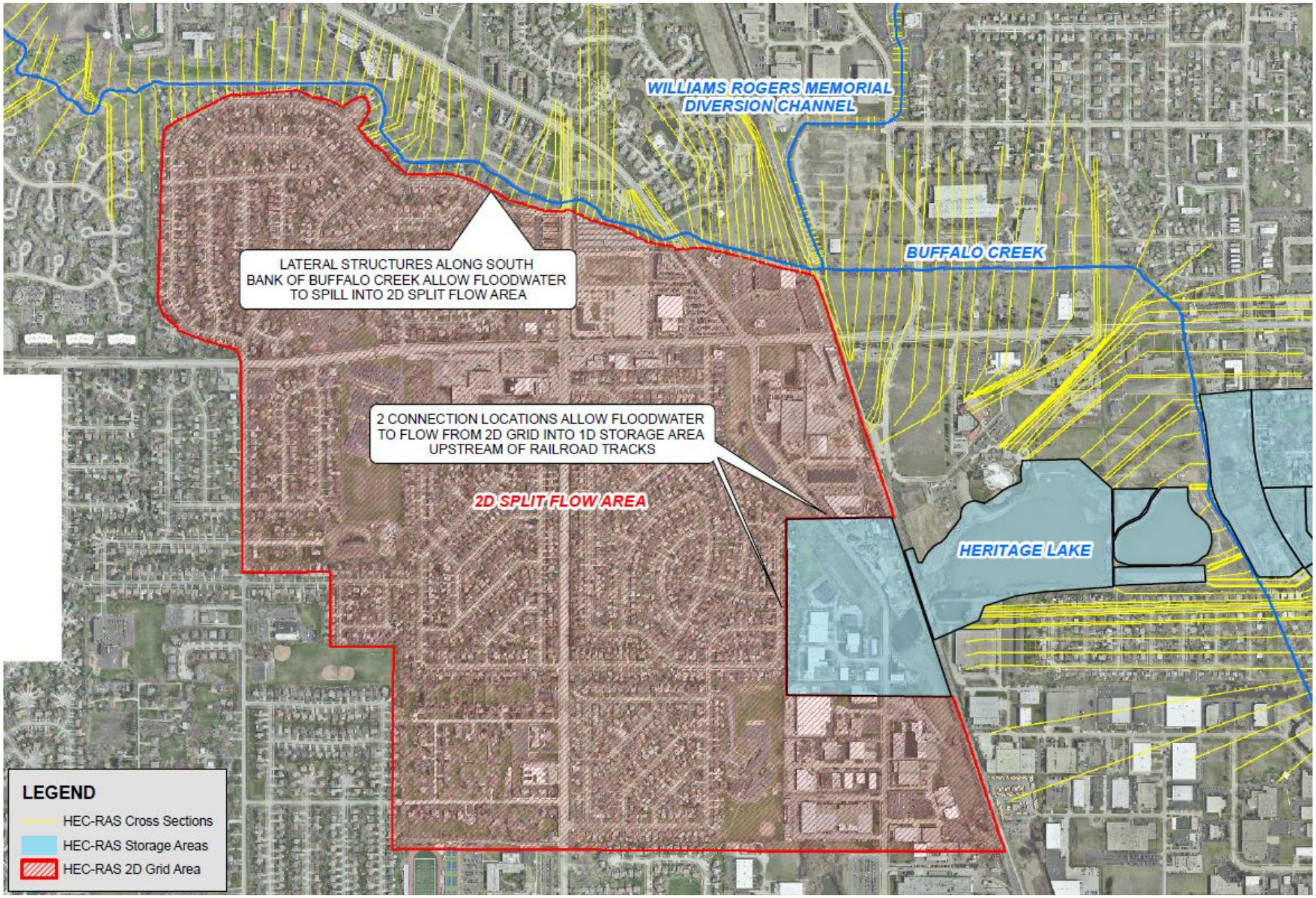

VALLEY STREAM DR
KENILWORTH DR
SARASOTA DR
BERKSHIRE DR
MOCKINGBIRD LN
CORAL LN
CHESTNUT LN
EUGENE DR
SAINT ARMANDS DR
BEVERLY DR
WOODLAND DR
PEBBLE DR
WILLOW DR
UNKNOWN
COLONIAL DR
BARNABY PL
BRIDGEPORT PL
DOVER PL
LONDON PL
SUTTON
12TH ST
WHEELING RD
DUNDEE RD
TRANSFORD AVE
GEORGE RD
DENNIS RD
LINDA TER
TOWN ST
PINE ST
JENKINS CT
NORMAN LN
BIRCH TRL
LAUREL TRL
PALM DR
WILLOW TRL
REDWOOD TRL
ALLEY
MARCY LN
LEE ST
SCHOENBECK RD
SARAH CT
ALBERT TER
MAUREEN DR
MARION CT
ELMHURST RD
WAYNE PL
CINDY LN
FLETCHER DR
THELMA CT
S FLETCHER DR
KINGSPORT DR
EDWARD ST
VERA LN
SOUTH ST
E HASTINGS RD
MERCHANDISE CT
DENNISTON CT
HARVESTER CT
EXCHANGE CT
CONCORD DRIVE WAY
MEADOW LN
324 RESIDENTIAL SFHA BUILDINGS ELIGIBLE FOR POTENTIAL FLOODPLAIN REMOVAL

Buffalo Creek Re-mapping

- FEMA modeling: steady-state HEC-RAS model
- MWRD modeling: unsteady HEC-RAS modeling with a split flow condition through the Village
- Approximately 960 structures within FEMA 100-year regulatory floodplain in Village
- Approximately 300 structures shown within MWRD 100-year floodplain in Village
- **Possibly up to 660 structures may be removed from floodplain if additional refinements are included**

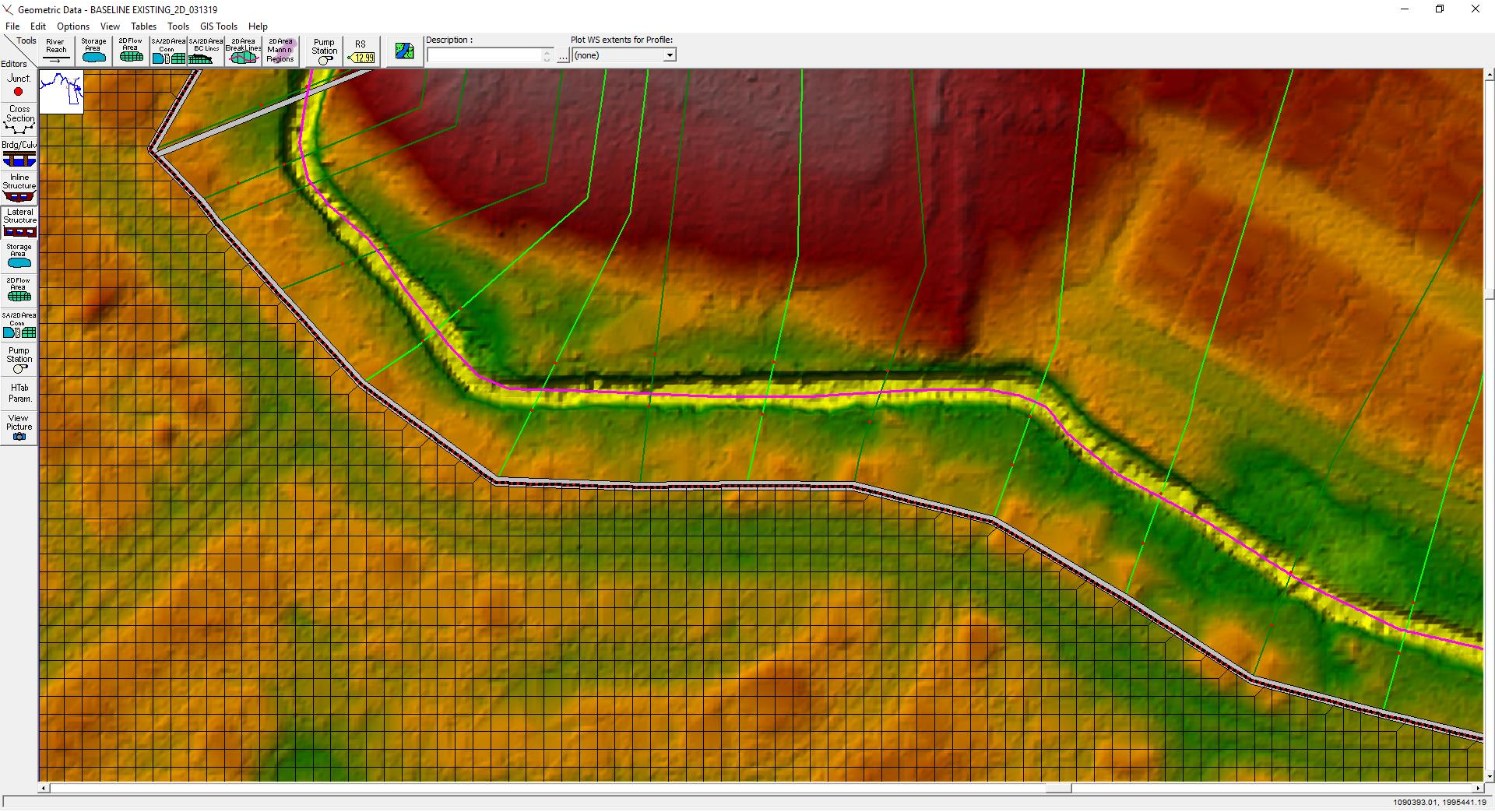
LOMR Request Modeling Approach

- Modeling approach for main channel:
  - Runoff hydrographs generated in HEC-HMS
  - Reach and storage routing performed in unsteady HEC-RAS model
  - Maximum flows from unsteady HEC-RAS model input in steady HEC-RAS model
  - Floodway computed with steady HEC-RAS model
- Split flow area modeled with unsteady 2D HEC-RAS model:
  - Overflow along south channel bank along Valley Stream Drive to Railroad modeled as lateral structures based on DTM
  - 2D area connected to storage area upstream of Railroad culvert crossing to Heritage Lake with SA/2D area connection

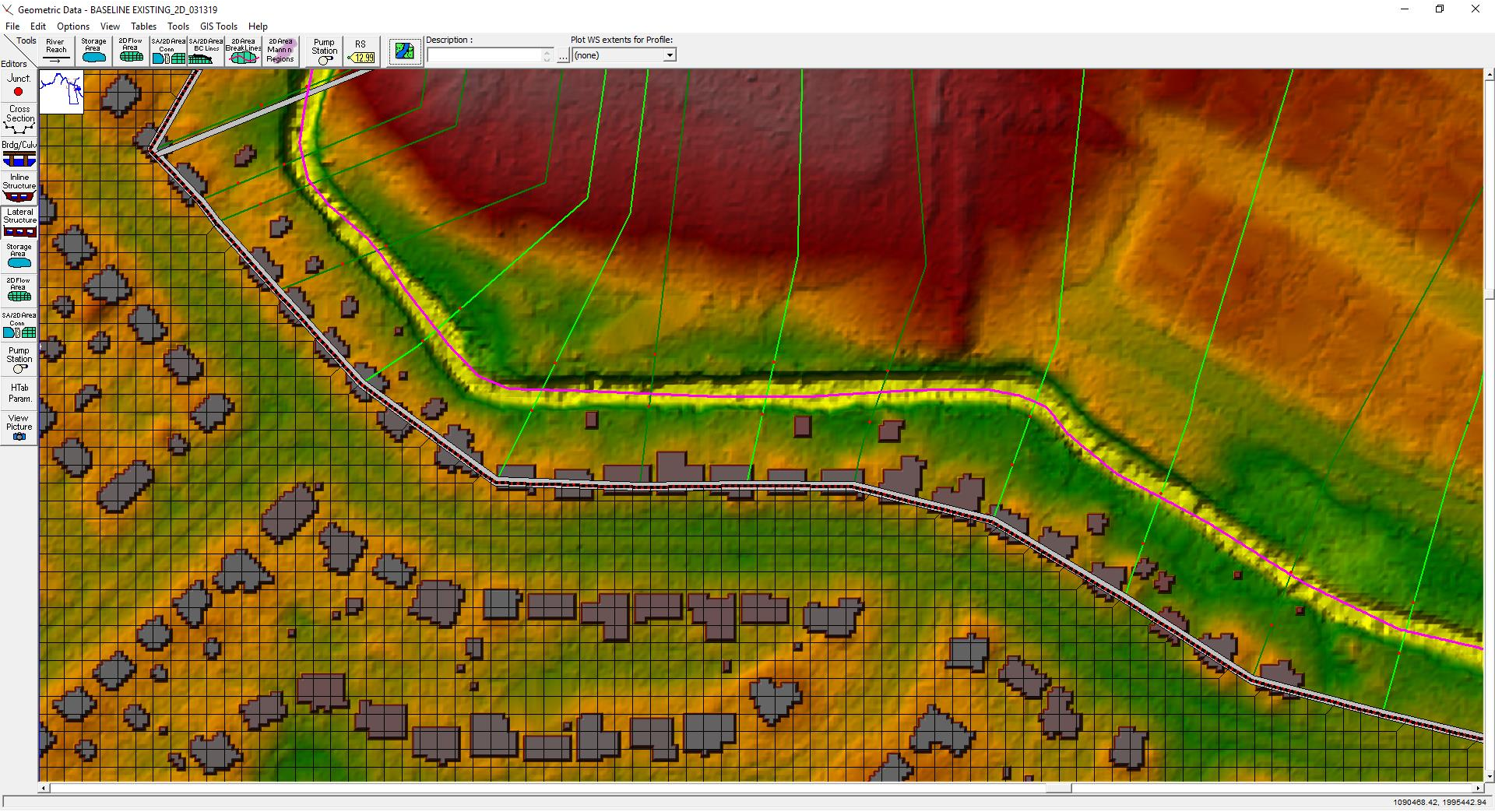

WILLIAMS ROGERS MEMORIAL DIVERSION CHANNEL
BUFFALO CREEK
LATERAL STRUCTURES ALONG SOUTH BANK OF BUFFALO CREEK ALLOW FLOODWATER TO SPILL INTO 2D SPLIT FLOW AREA
2 CONNECTION LOCATIONS ALLOW FLOODWATER TO FLOW FROM 2D GRID INTO 1D STORAGE AREA UPSTREAM OF RAILROAD TRACKS
2D SPLIT FLOW AREA
HERITAGE LAKE
LEGEND
HEC-RAS Cross Sections
HEC-RAS Storage Areas
HEC-RAS 2D Grid Area

Link 1D/2D with Lateral Structures

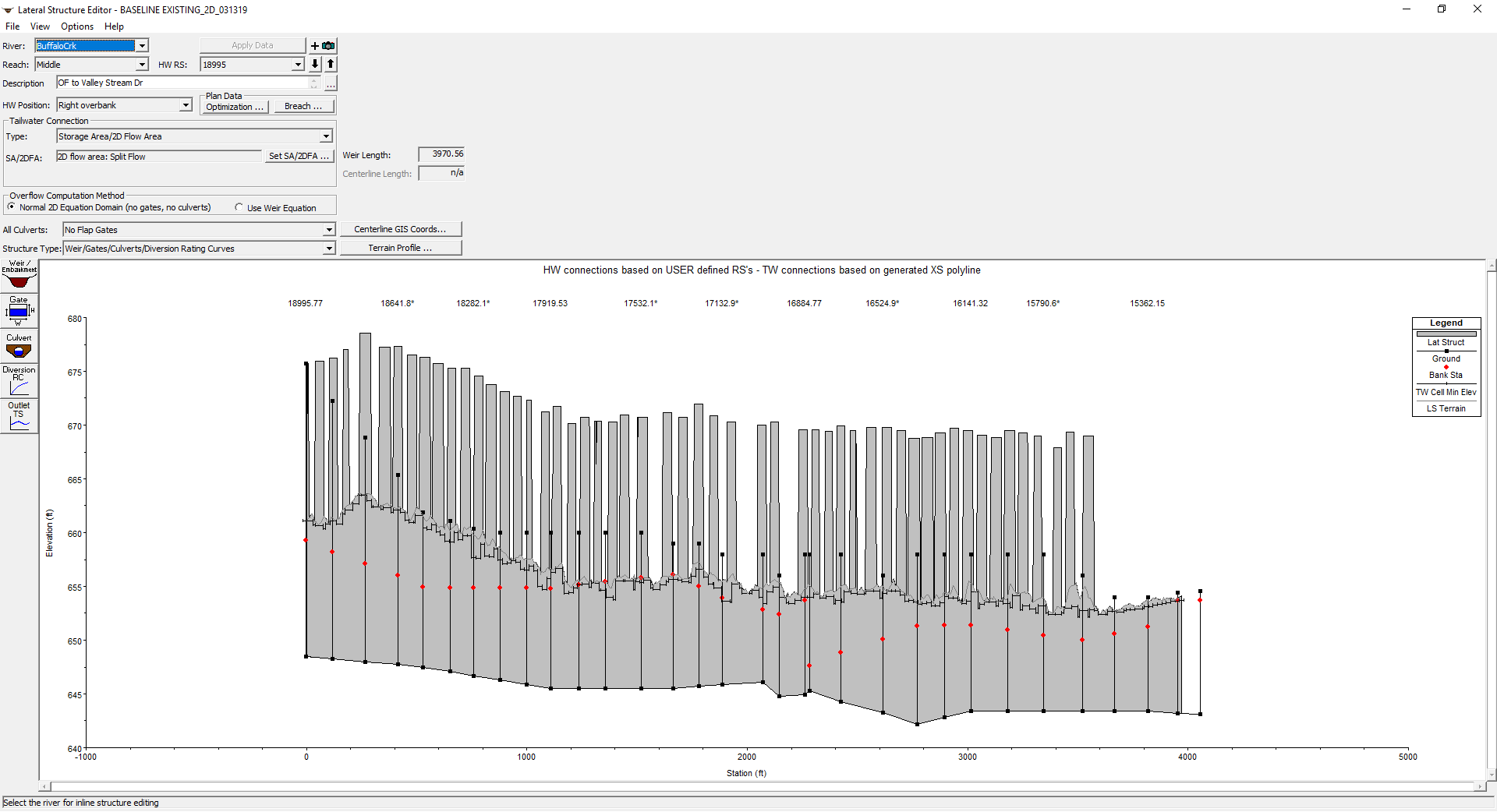
Link 1D/2D with Lateral Structures



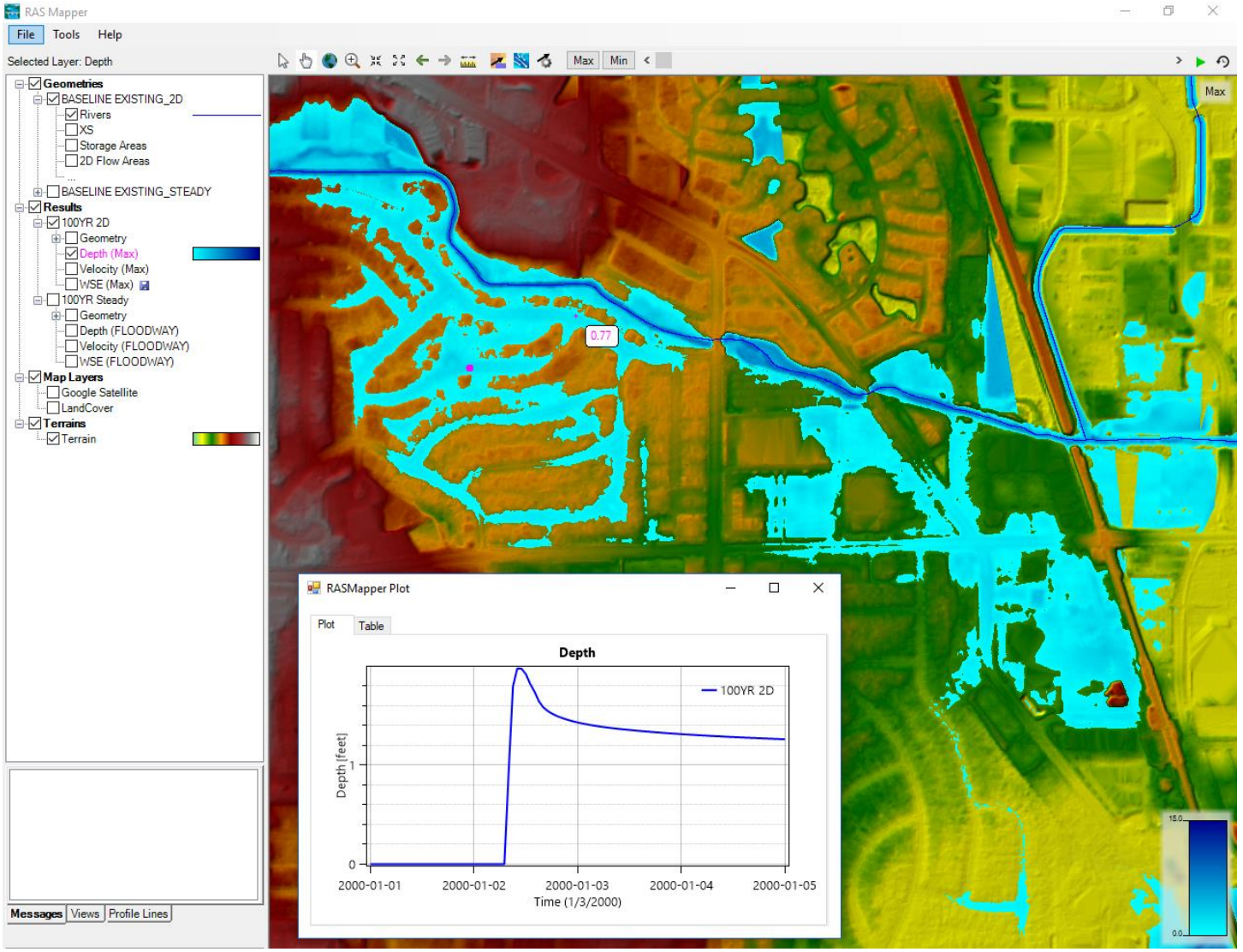
Link 1D/2D with Lateral Structures

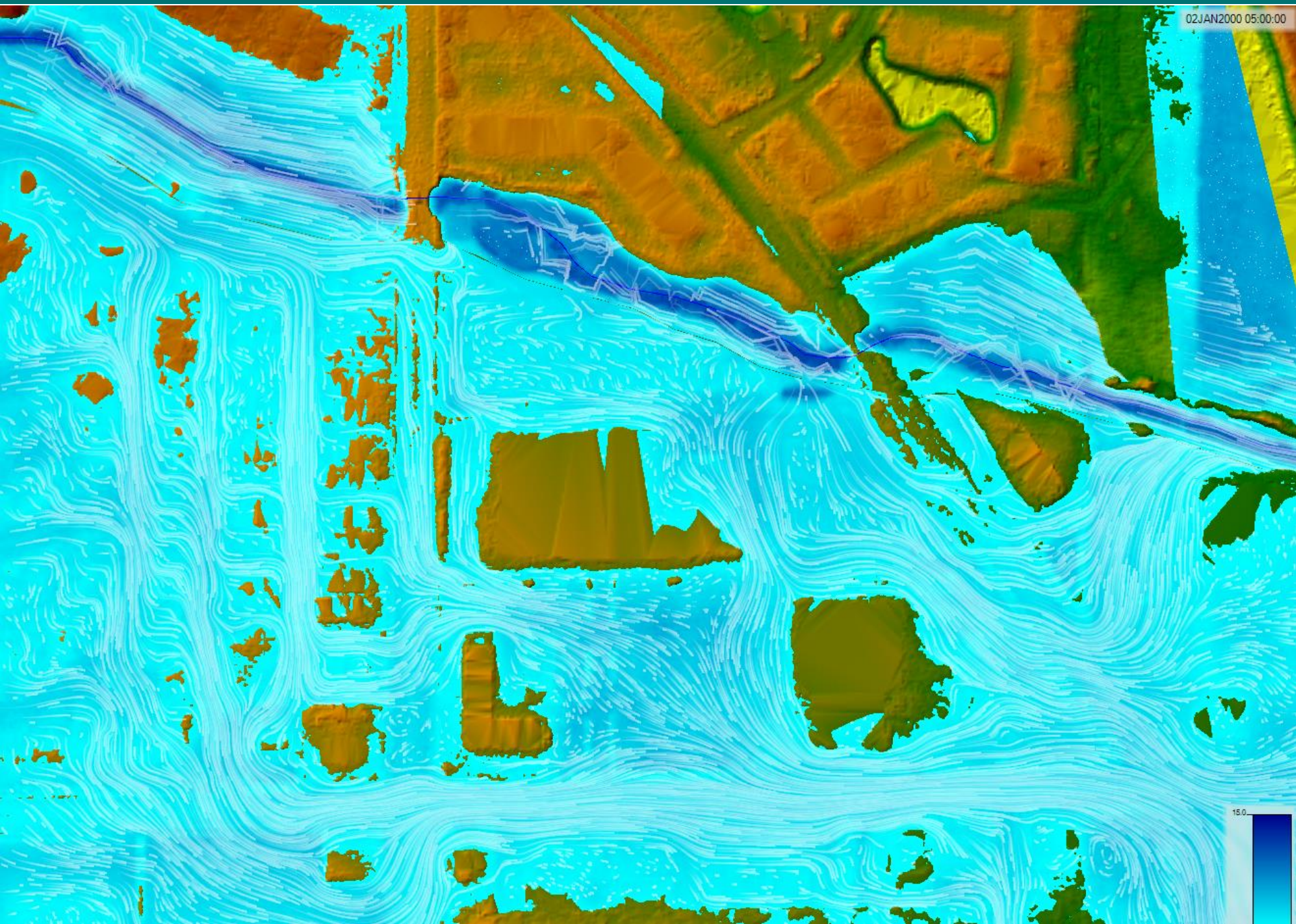


Link 1D/2D with Lateral Structures



2D Results


RAS Mapper
File
Tools
Help
Selected Layer: Depth
Max
Min
Geometries
BASELINE EXISTING_2D
Rivers
XS
Storage Areas
2D Flow Areas
BASELINE EXISTING_STEADY
Results
100YR 2D
Geometry
Depth (Max)
Velocity (Max)
WSE (Max)
100YR Steady
Geometry
Depth (FLOODWAY)
Velocity (FLOODWAY)
WSE (FLOODWAY)
Map Layers
Google Satellite
LandCover
Terrains
Terrain
Messages
Views
Profile Lines
0.77
RASMapper Plot
Plot
Table
Depth
100YR 2D
Depth [feet]
Time (1/3/2000)
2000-01-01
2000-01-02
2000-01-03
2000-01-04
2000-01-05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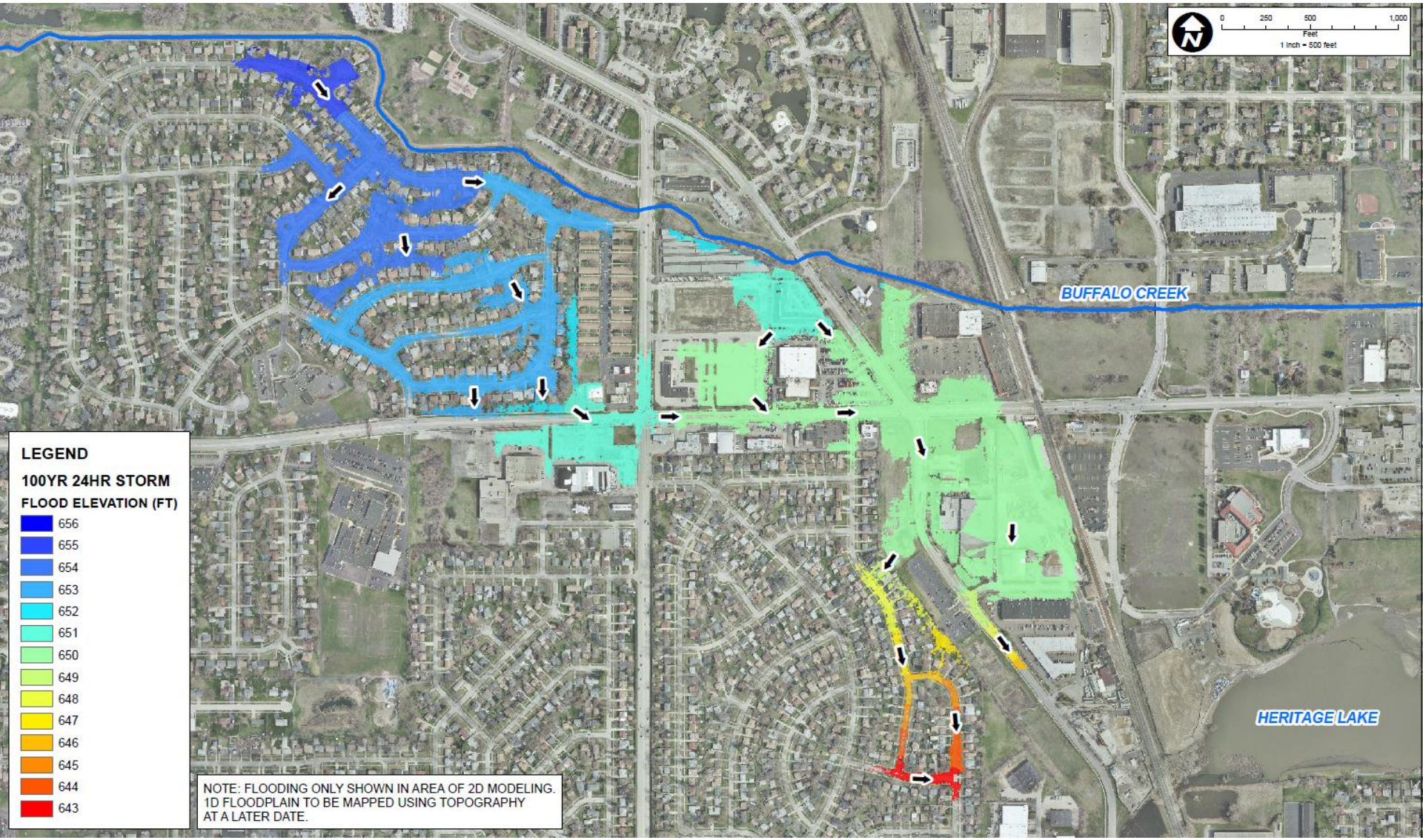
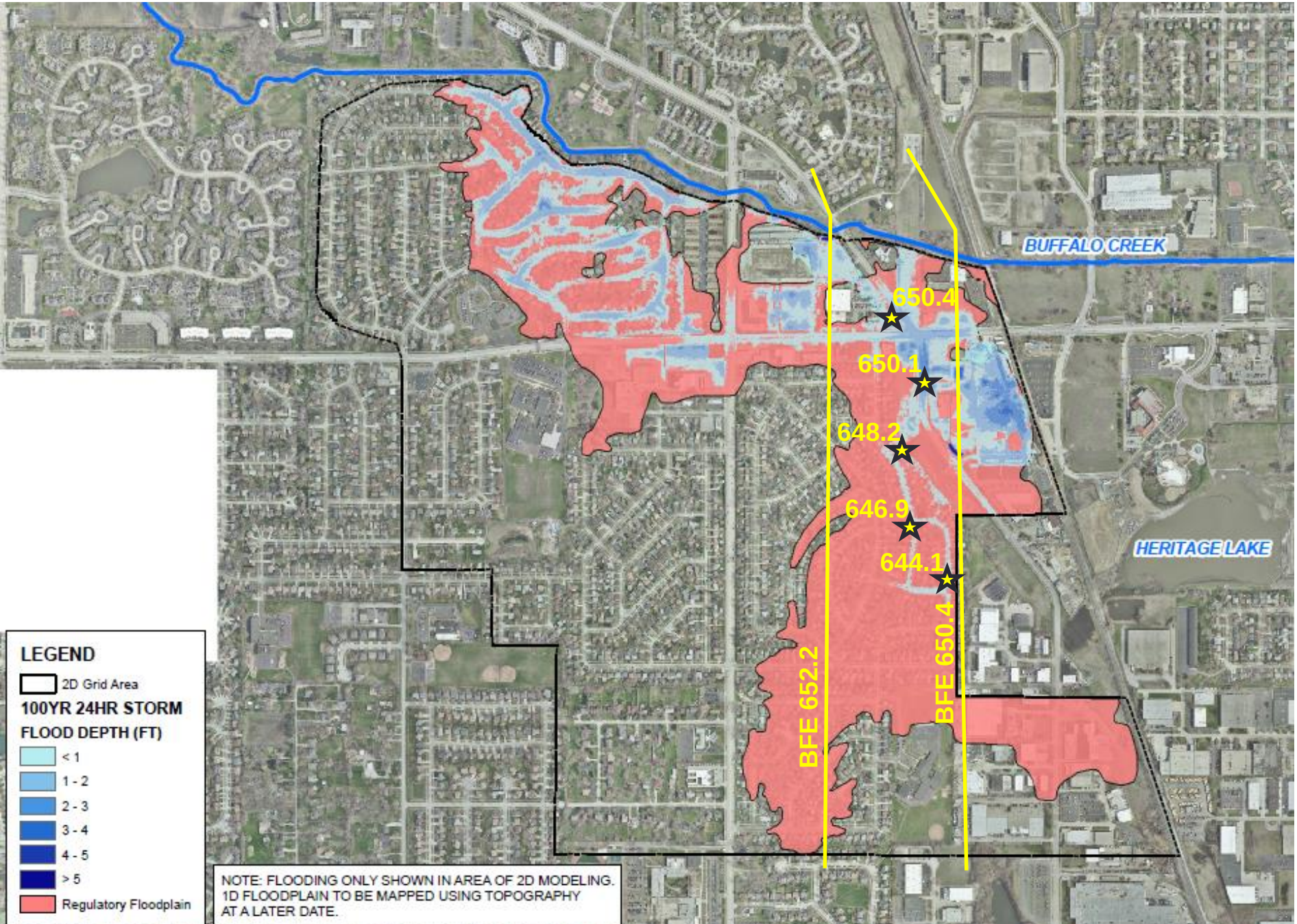
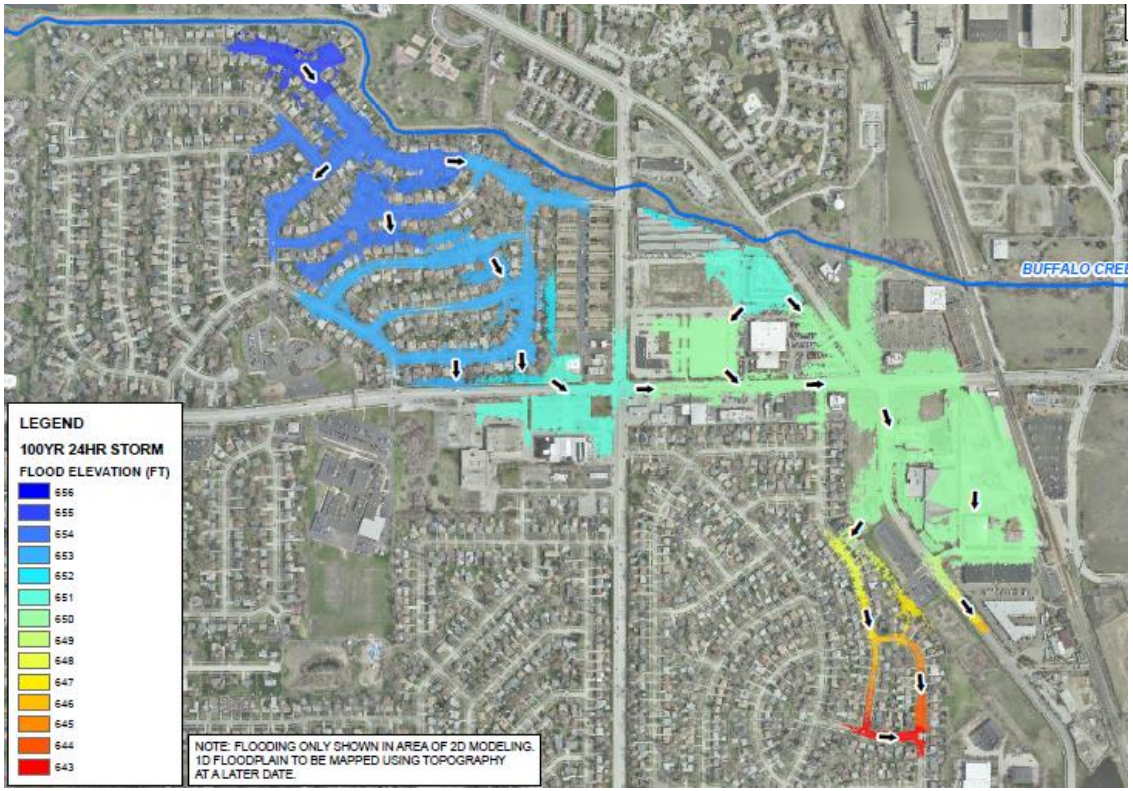

0 250 500 1,000
Feet
1 Inch = 500 feet
BUFFALO CREEK
HERITAGE LAKE
LEGEND
100YR 24HR STORM
FLOOD ELEVATION (FT)
656
655
654
653
652
651
650
649
648
647
646
645
644
643
NOTE: FLOODING ONLY SHOWN IN AREA OF 2D MODELING.
1D FLOODPLAIN TO BE MAPPED USING TOPOGRAPHY
AT A LATER DATE.


BUFFALO CREEK
650.4
650.1
648.2
646.9
644.1
HERITAGE LAKE
BFE 652.2
BFE 650.4
LEGEND
2D Grid Area
100YR 24HR STORM
FLOOD DEPTH (FT)
< 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
Regulatory Floodplain
NOTE: FLOODING ONLY SHOWN IN AREA OF 2D MODELING.
1D FLOODPLAIN TO BE MAPPED USING TOPOGRAPHY
AT A LATER DATE.

Additional Considerations

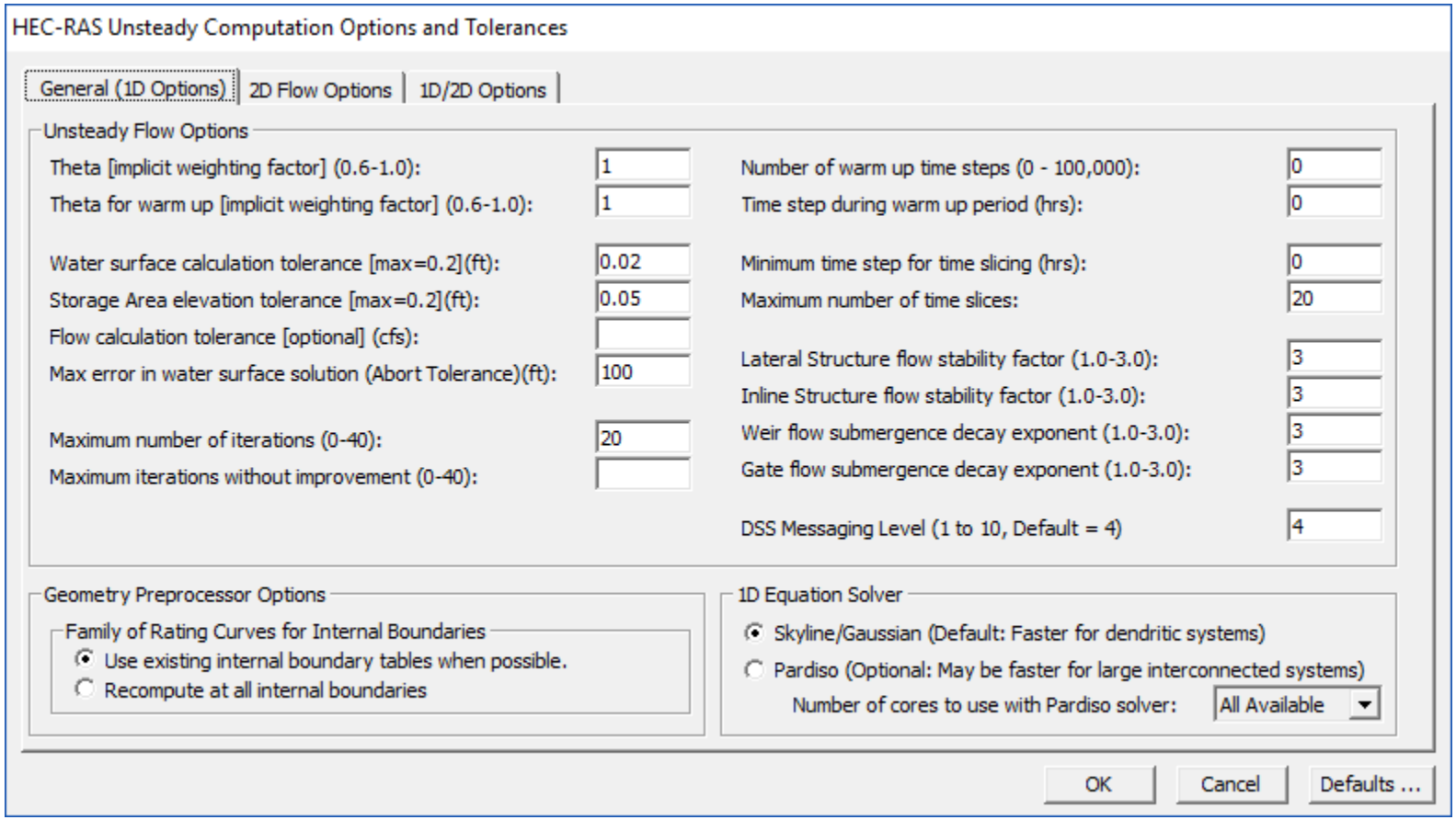
- Development of regulatory floodplain through the 2D split flow area
- Sensitivity analysis (next slide)
- How to model structures?
- Calibration data



Sensitivity Analysis

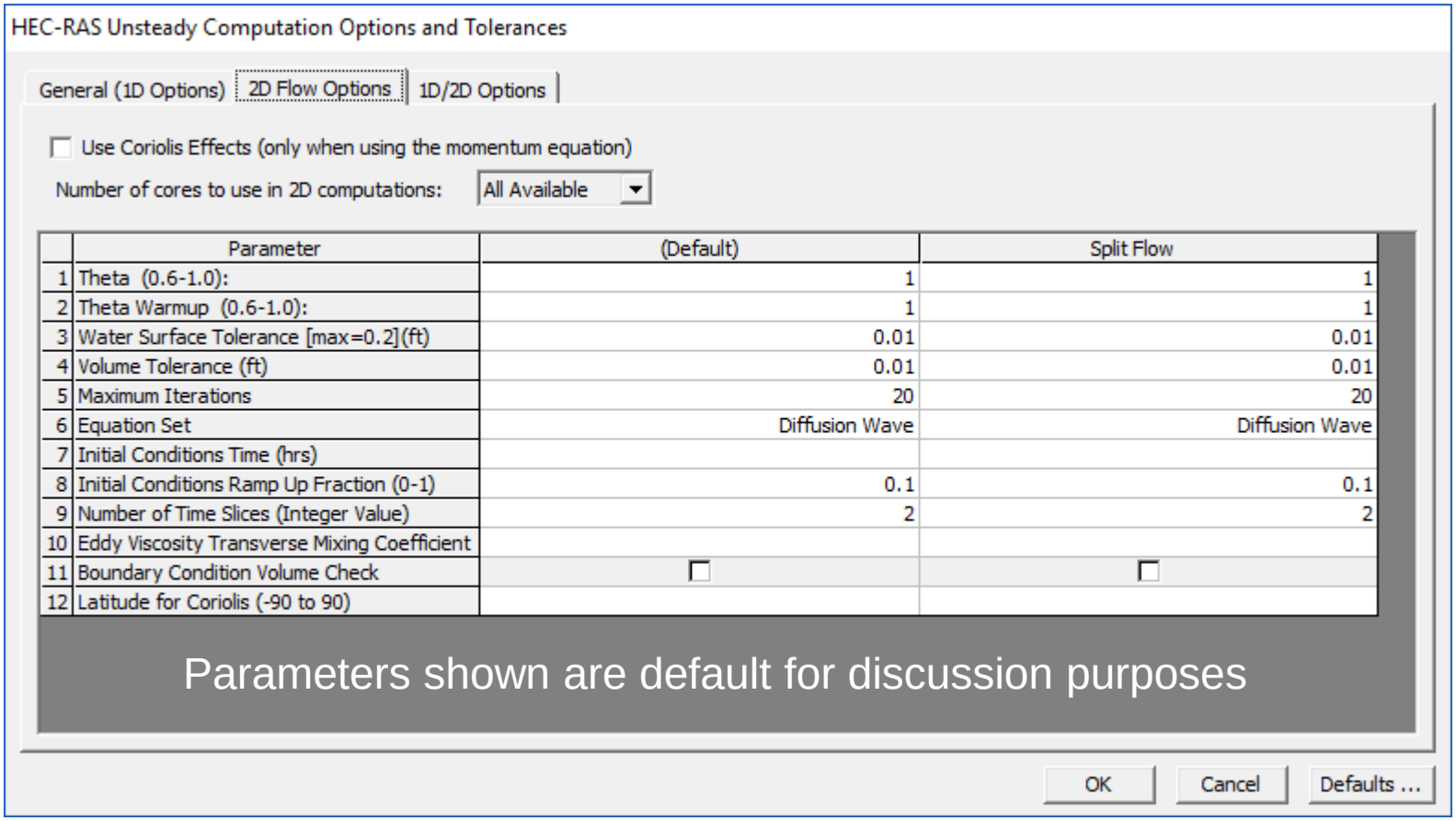
- Variable Manning's n versus averaged n value
  - Global n = 0.04; or n = 0.02 paved & n = 0.05 grass
- Diffusion Wave versus Full Momentum
- Cell size
- Time step
- Courant Number
- Theta value for 1D & 2D analysis
- Additional parameters?

1D Unsteady Modeling Parameters



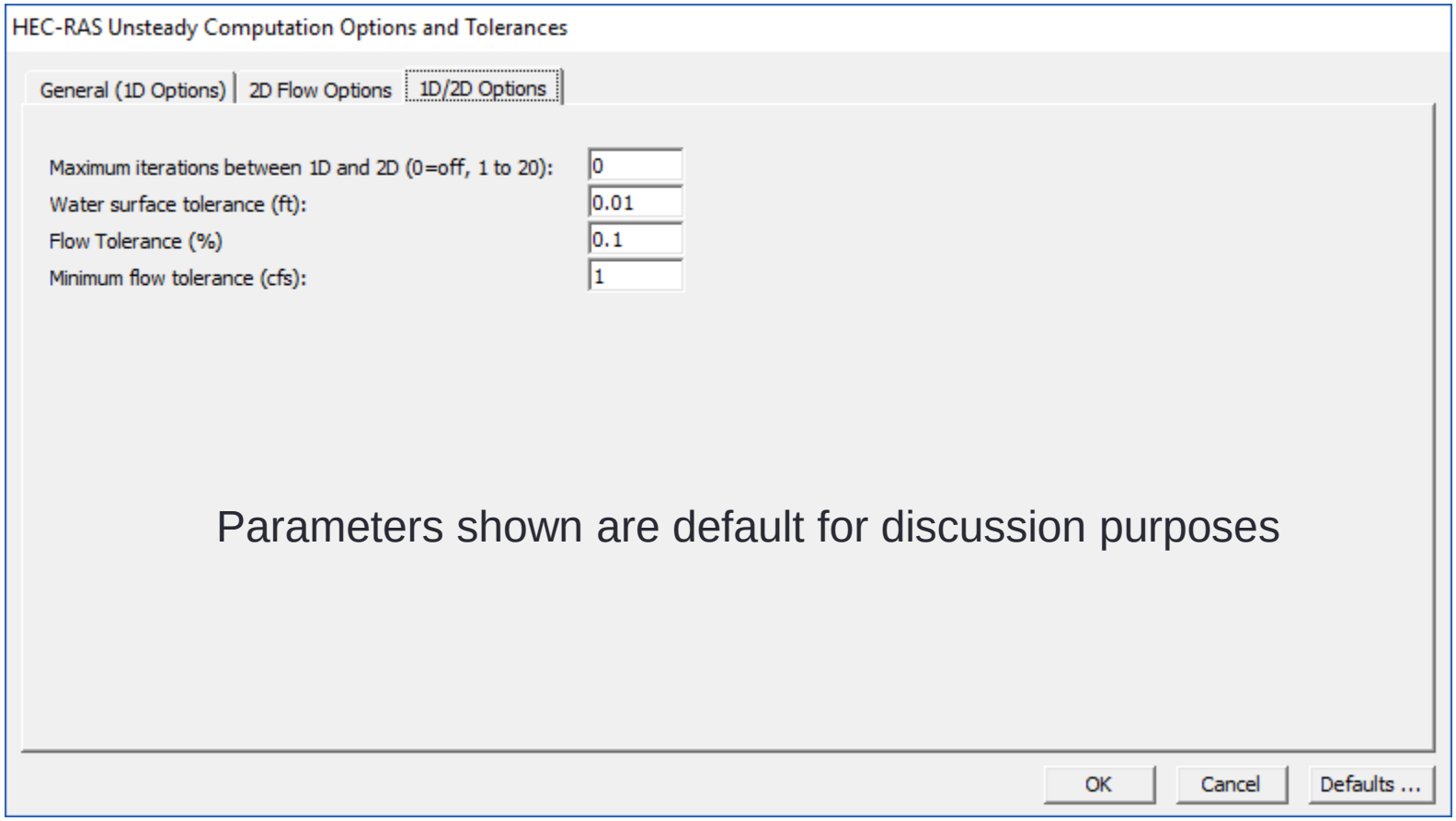
Parameters shown are default for discussion purposes

2D Modeling Parameters



	Parameter	(Default)	Split Flow
1	Theta (0.6-1.0):	1	1
2	Theta Warmup (0.6-1.0):	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1
9	Number of Time Slices (Integer Value)	2	2
10	Eddy Viscosity Transverse Mixing Coefficient		
11	Boundary Condition Volume Check	☐	☐
12	Latitude for Coriolis (-90 to 90)		

2D Modeling Parameters

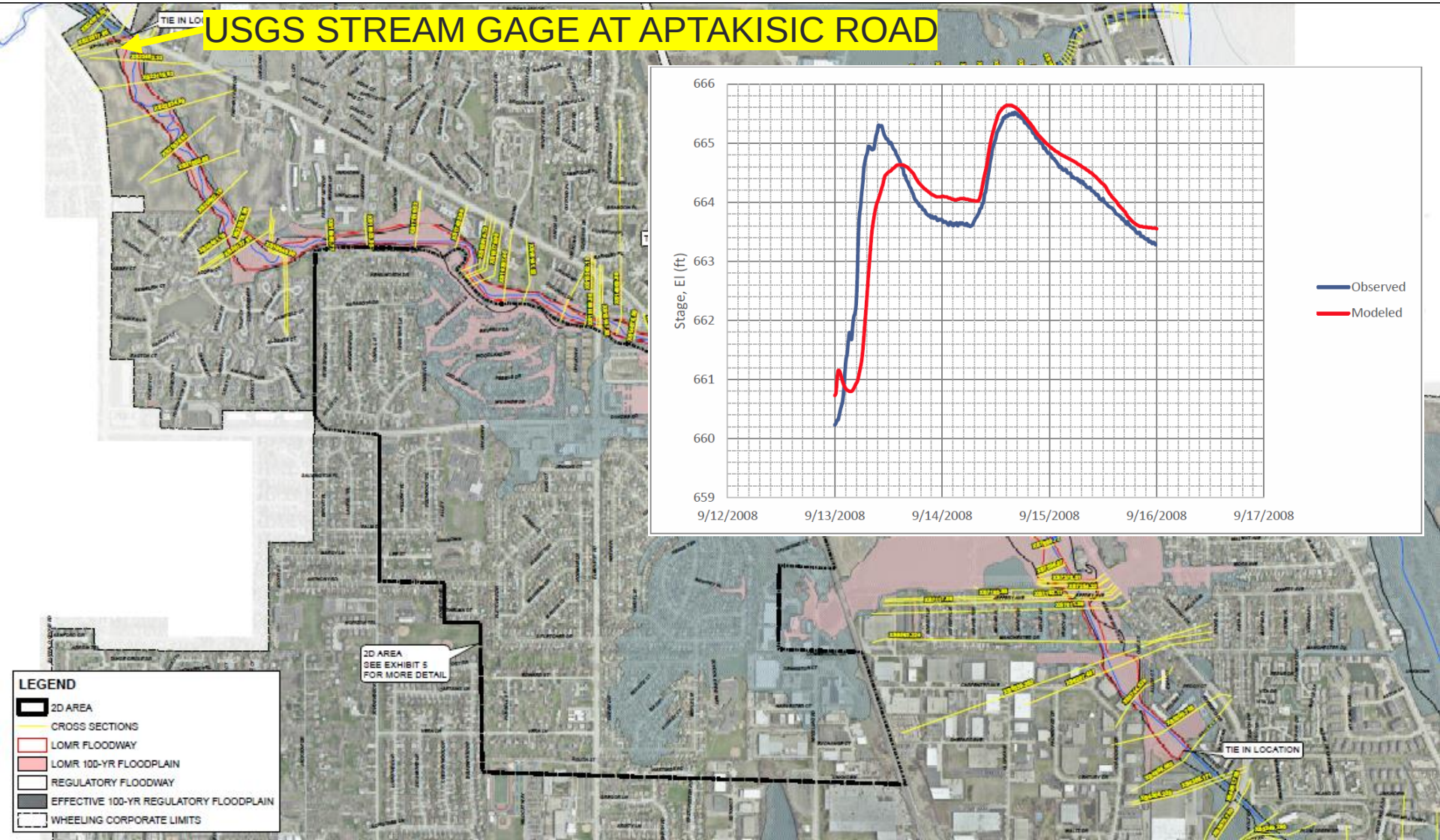


Modeling Structures

Structures built in to DTM

Structures accounted for in land use

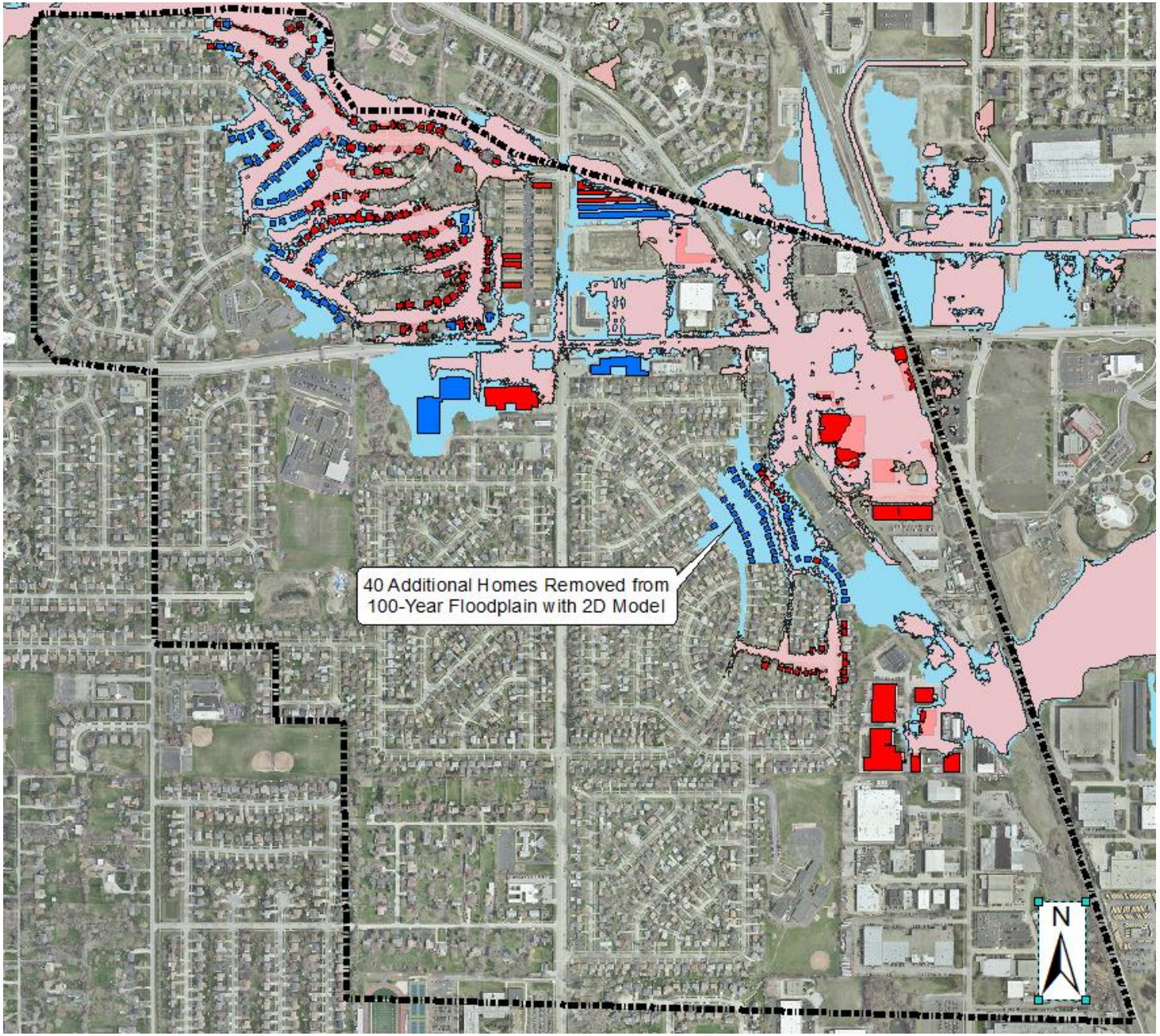
Calibration



2D Summary

- 20-foot grid size
- 12 second timestep
- 1D Theta = 0.9; 2D Theta = 0.8 (Range 0.6 – 1)
- Land use – 3 types
  - Structures
  - Grass
  - Pavement
- Lateral Structure flow stability factor = 2.0 (Range 1.0 – 3.0)

- 100-year, 24-hour storm model volume error = 0.57%


40 Additional Homes Removed from
100-Year Floodplain with 2D Model
N

Thank you

Questions?