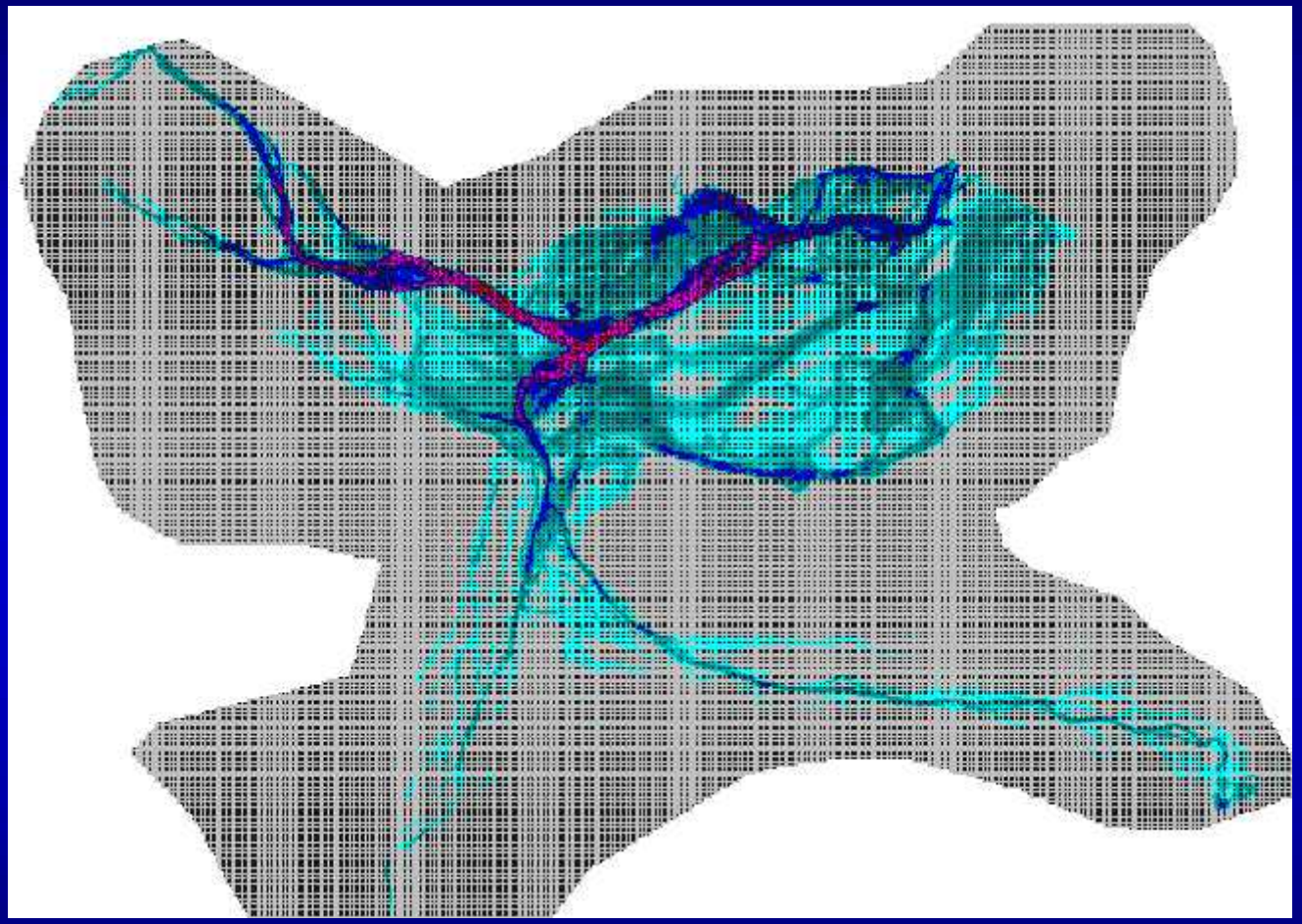
Dam Breach Inundation Modeling with Lidar



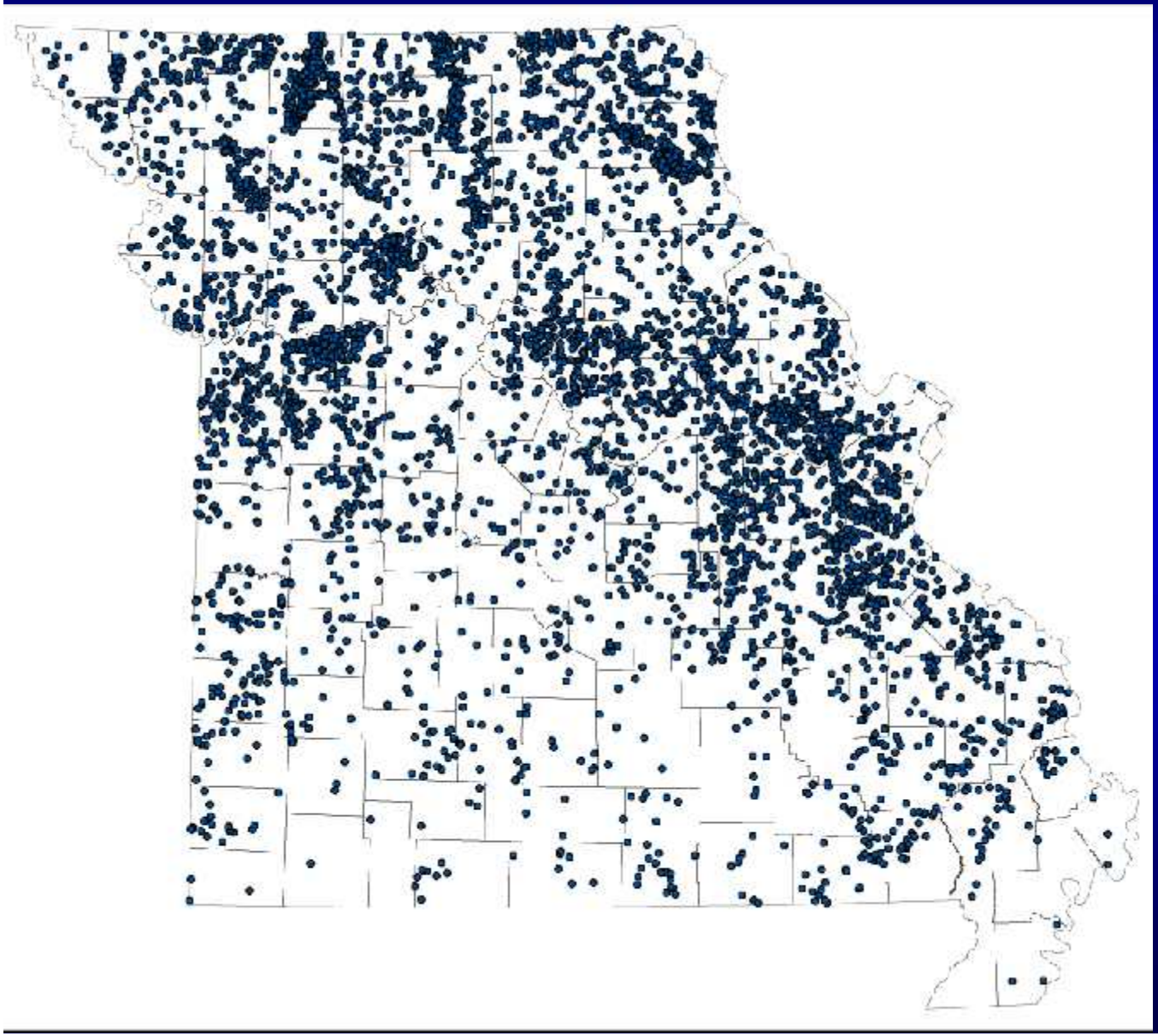
Michael Weller, P.E.

Water Resources Center

Missouri Department of Natural Resources

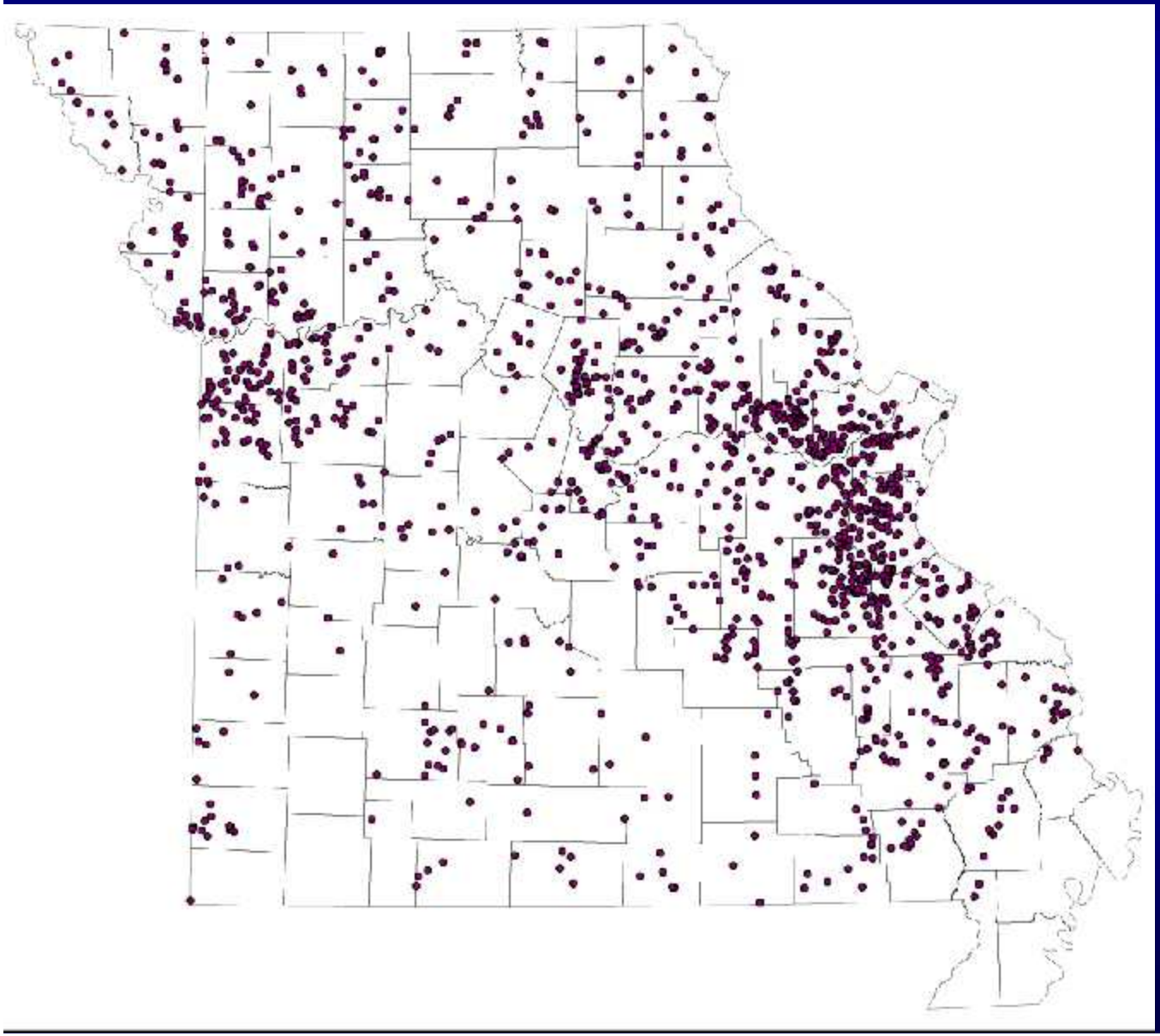
November 5, 2014

National Dam Inventory



- There are over 5200 inventoried dams in Missouri
- It is estimated that over 1500 “high hazard” dams exist throughout the state
- Missouri currently regulates over 660 dams. The regulated dams are 35 feet tall and higher.

High Hazard Dams



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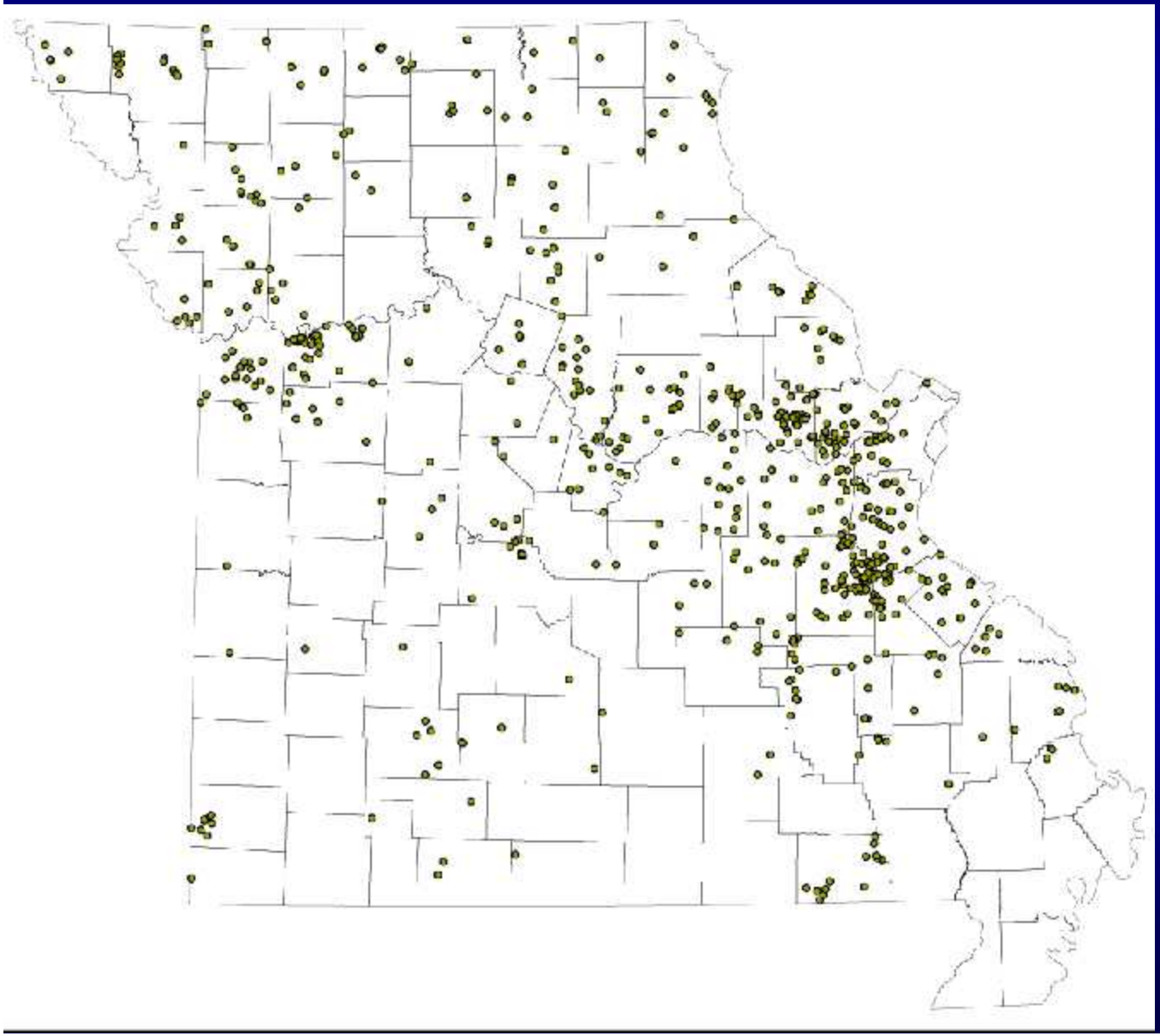
DNR Regulated Dams



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- It is estimated that over 1500 “high hazard” dams exist throughout the state
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Silverlake Enterprizes Dam MO20051

Height: 30 ft
Storage: 851 ac-ft
near Raymore, Cass County

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Height: 30 ft
Storage: 851 ac-ft
near Raymore, Cass County

An inundation map is not an Emergency Action Plan

- An EAP is a written plan which provides guidance for evaluation, evacuation, and emergency response.
- Main focus is to reduce likelihood of property damage and loss of life.
- State requirement to have an emergency action plan

  CSR 22-3.030 (B)

Elements of an EAP

- Dam facts summary
- Emergency level guidance
- Emergency notification flow chart
- Emergency services contacts
- At-risk entities contact list
- Available resources
- Inundation map

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- Emergency level guidance
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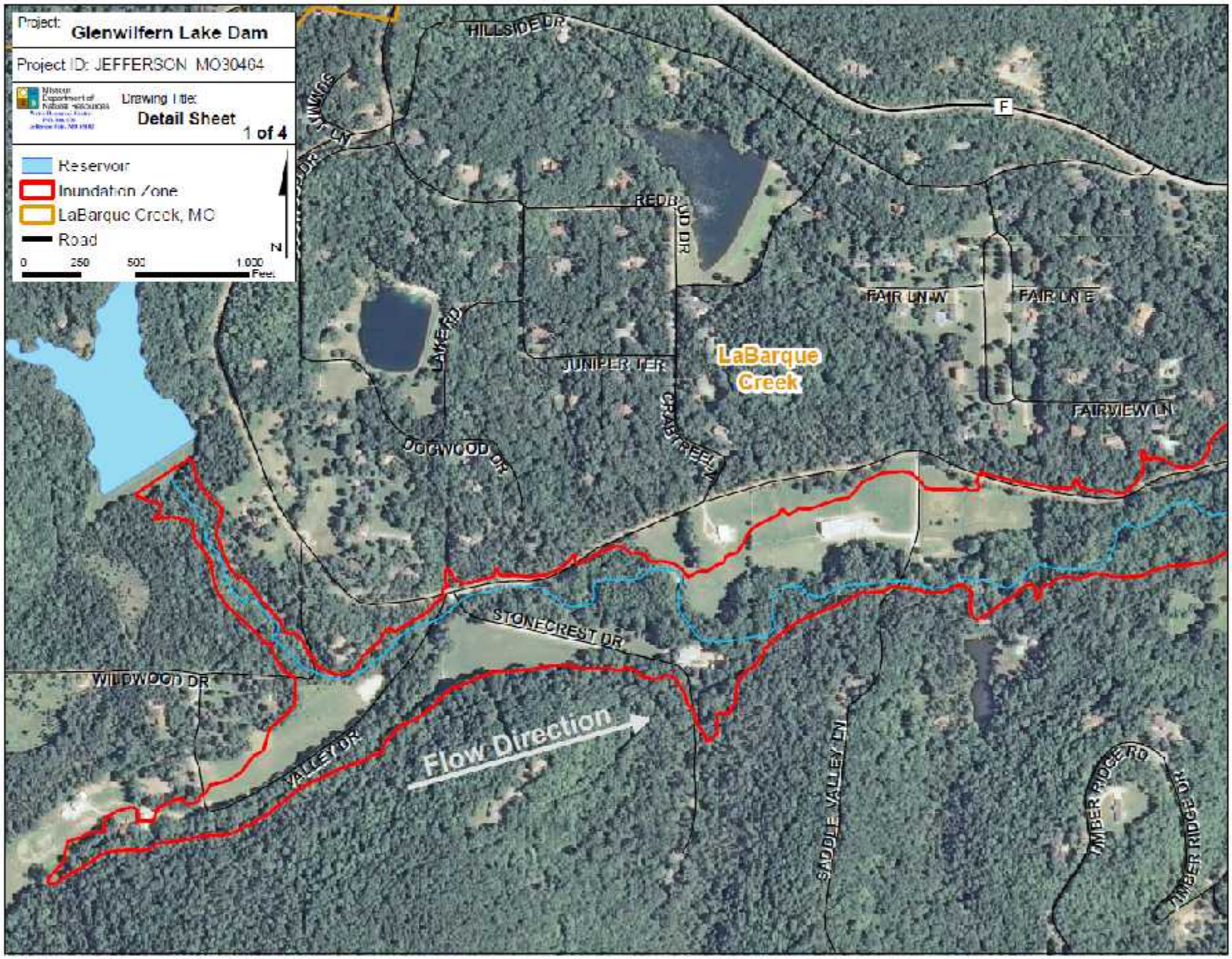
- **Inundation map**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Project ID: JEFFERSON MO30464
Drawing Title: Detail Sheet
1 of 4
Reservoir
Inundation Zone
LaBarque Creek, MO
Road
N
0 250 500 1,000 Feet
HILLSIDE DR
F
REDBUD DR
FAIR LN W
FAIR LN E
FAIRVIEW LN
LAKE RD
JUNIPER TER
CRABTREE LN
DOGWOOD DR
LaBarque Creek
STONECREST DR
WILDWOOD DR
VALLEY DR
Flow Direction
SADDLE VALLEY LN
TIMBER RIDGE RD
TIMBER RIDGE DR

Dam Breach Characteristics

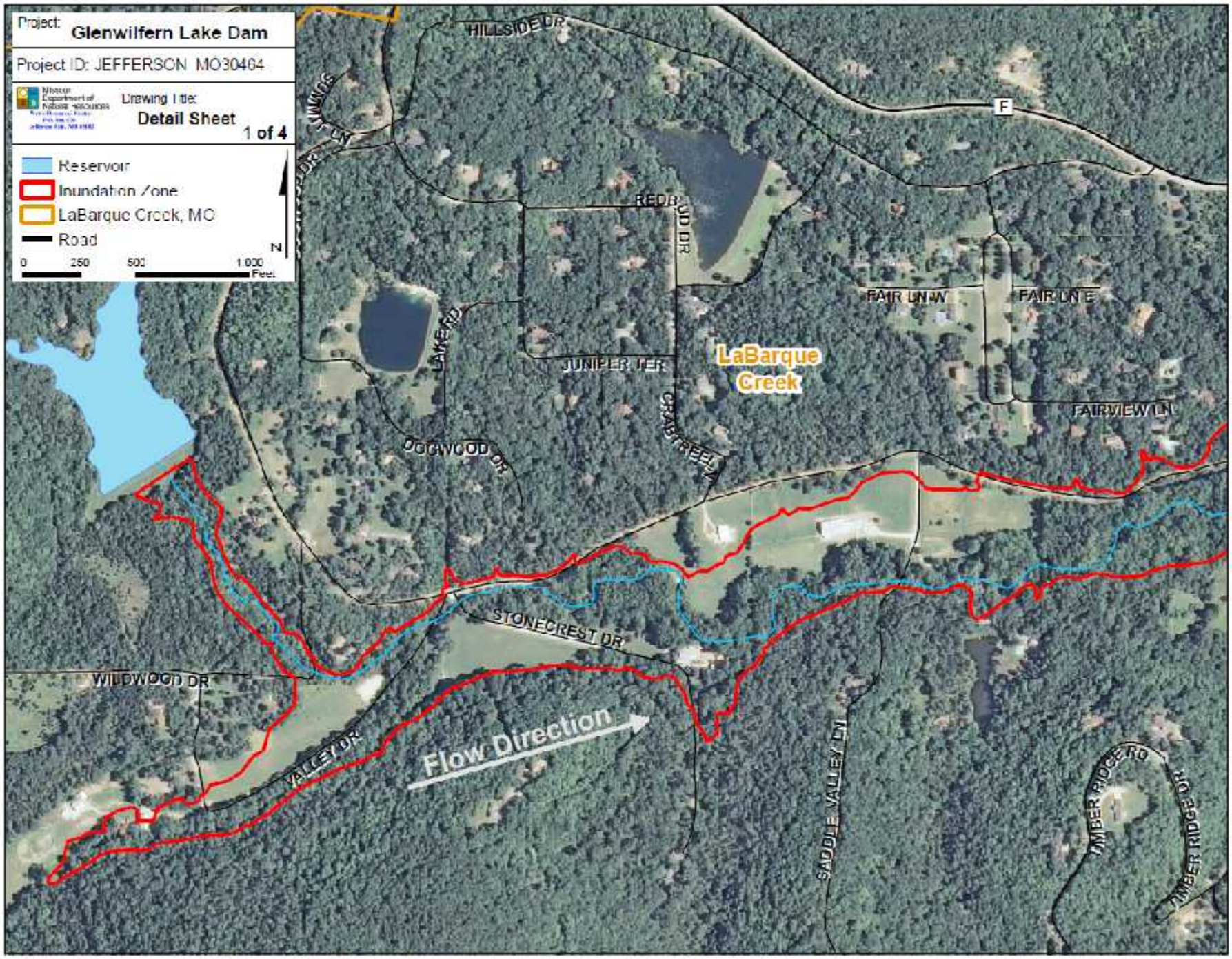
Photo by Mrs. Eunice Olson, 5 June 1976.

- Rapid release of water
- Surging wave traveling downstream
- Includes debris
- Generally exceeds normal flood elevation

Warren County, Missouri, May 27, 2008

Maries County, Missouri, June 11, 2009

Maries County, Missouri, June 11, 2009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SADDLE VALLEY LN
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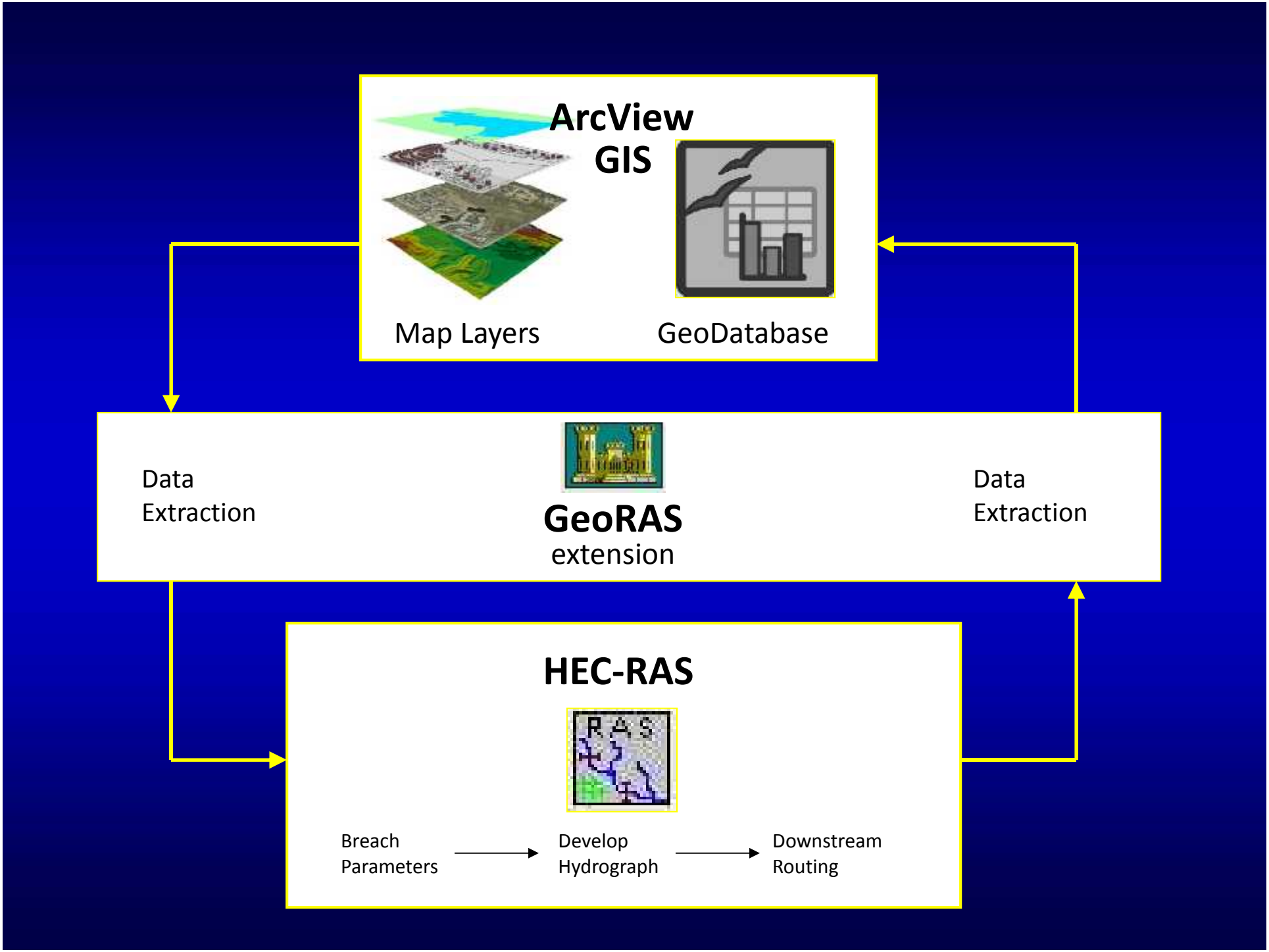
TIMBER RIDGE DR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GIS
Map Layers
GeoDatabase
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GeoRAS
extension
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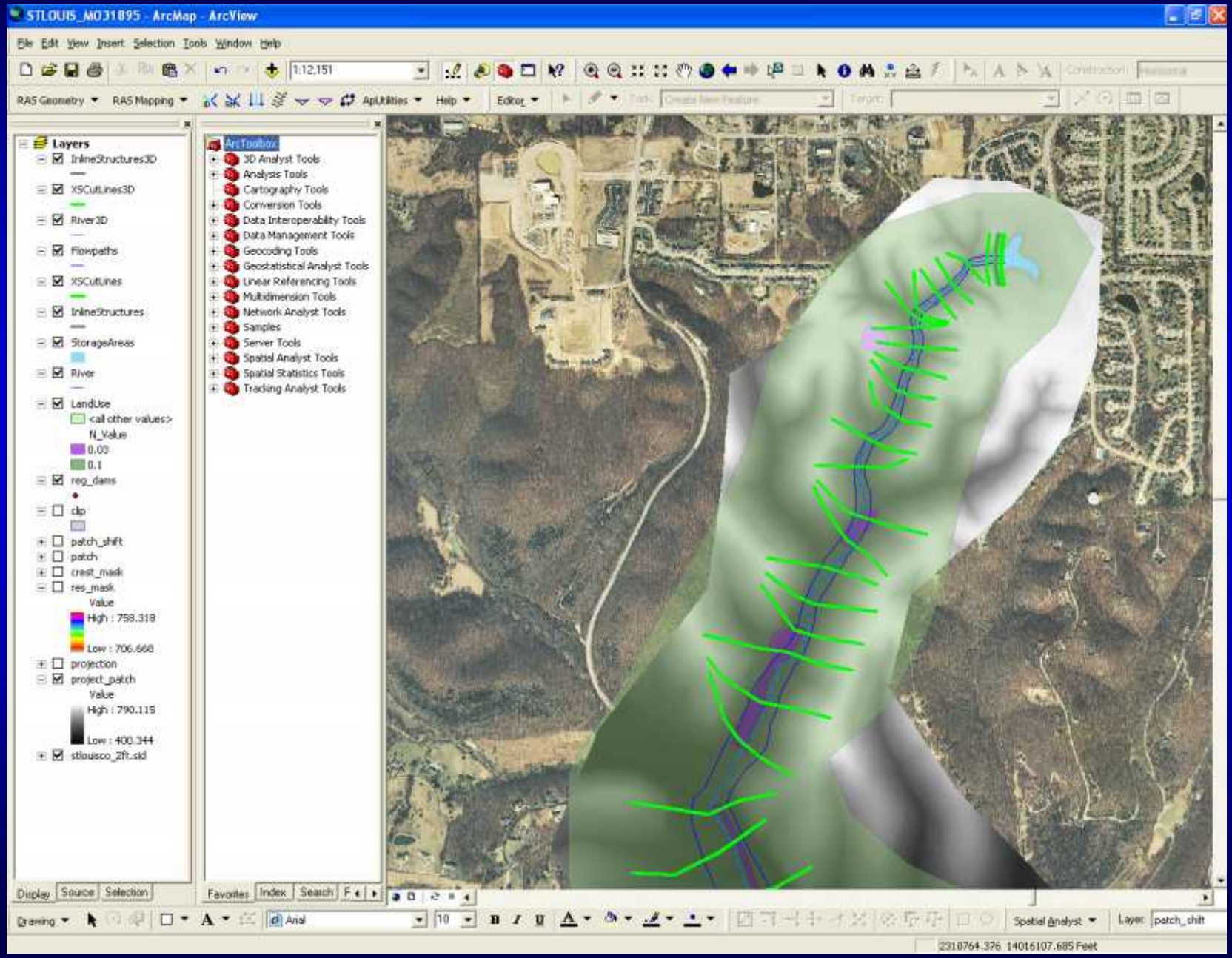
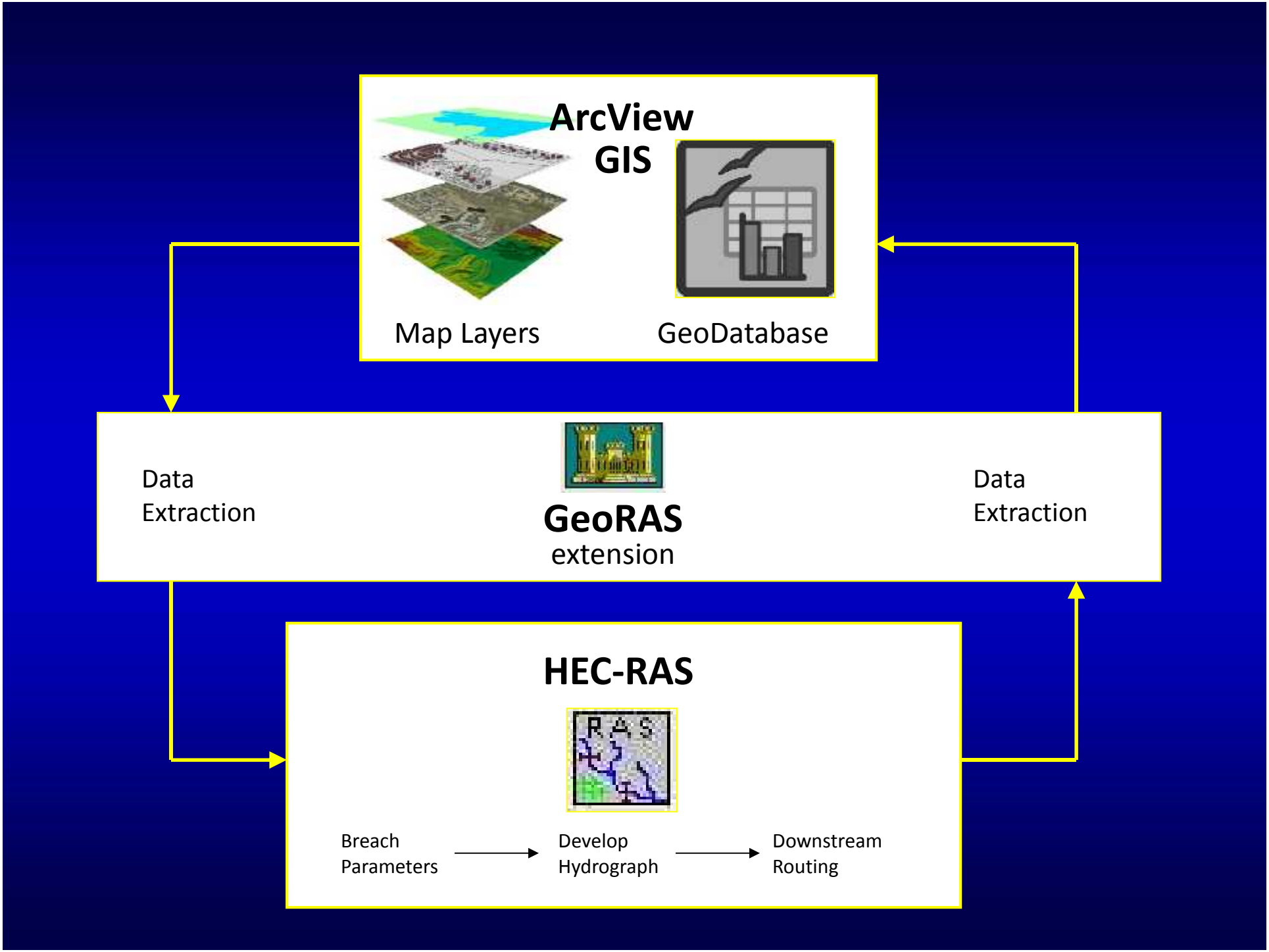
HEC-RAS
Breach
Parameters
Develop
Hydrograph
Downstream
Routing

ESRI ArcView

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GIS
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Breach
Parameters
Develop
Hydrograph
Downstream
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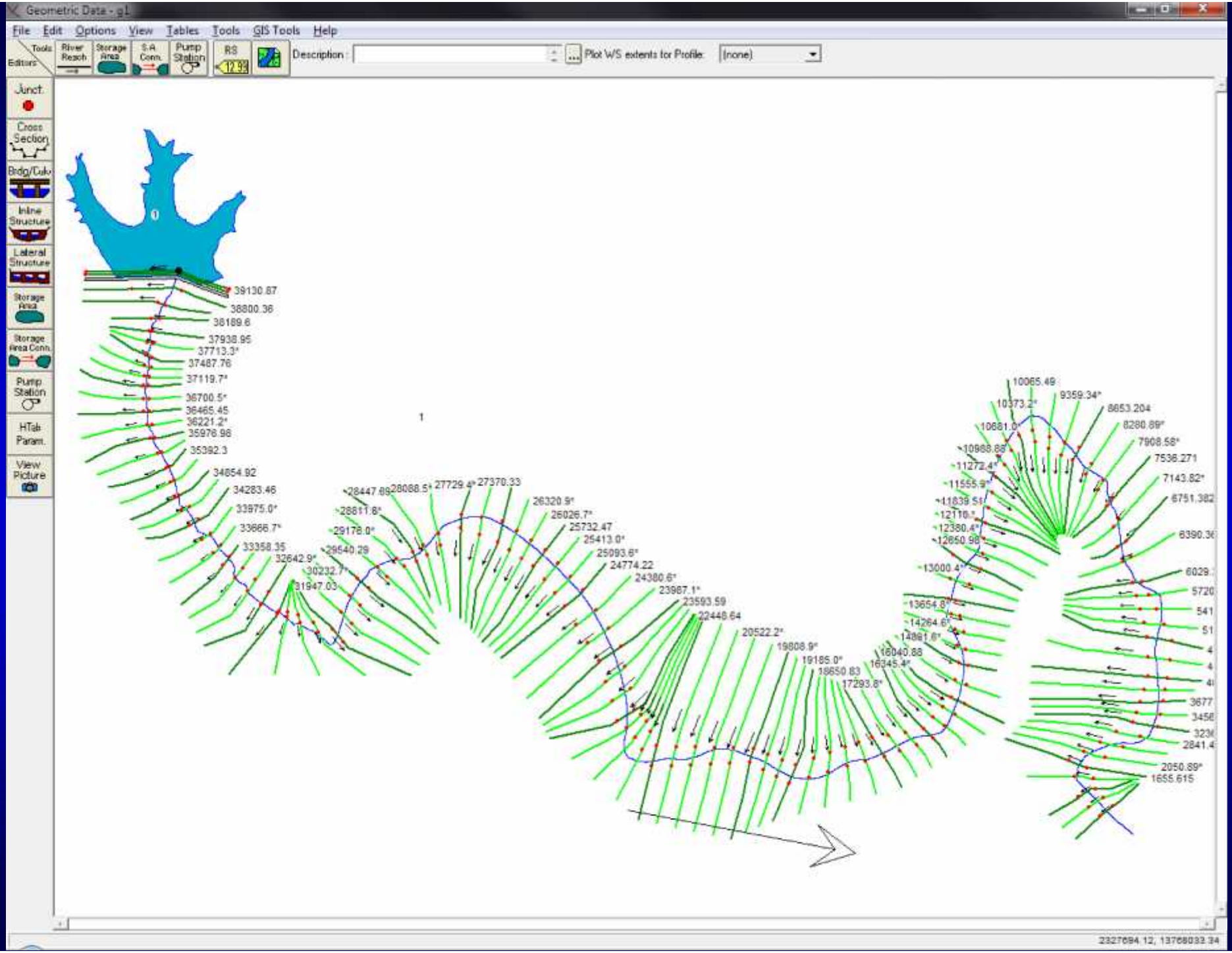
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File Edit Options View Tables Tools GIS Tools Help
Tools Editors
River Reach
Storage Area
S.A Conn.
Pump Station
RS
12.95
Description :
Plot W/S extents for Profile:
(none)
Junct.
Cross Section
Brdg/Culv
Inline Structure
Lateral Structure
Storage Area
Storage Area Conn.
Pump Station
HTab Param.
View Picture
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38800.36
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37938.95
37713.3*
37487.76
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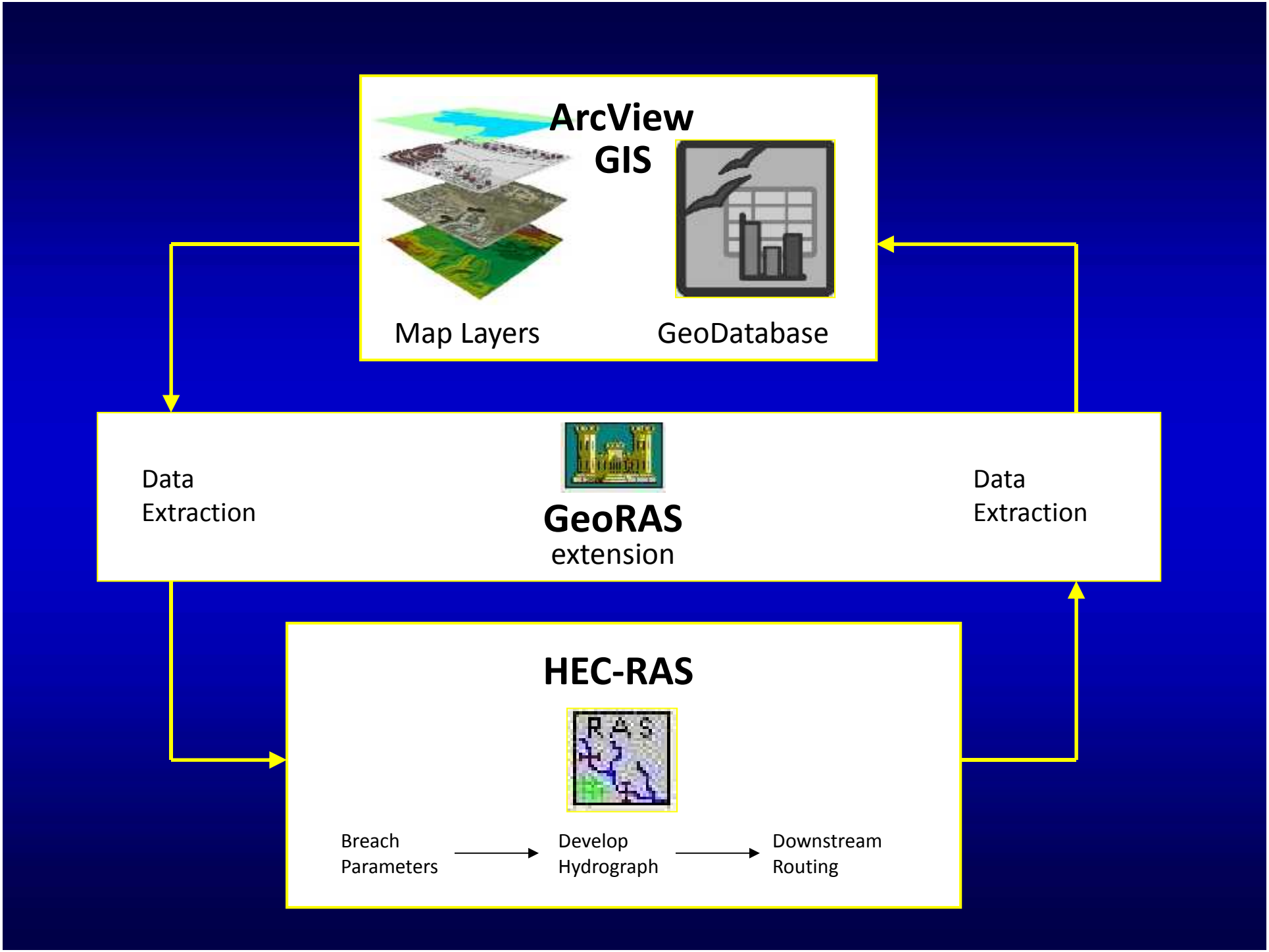
ArcView
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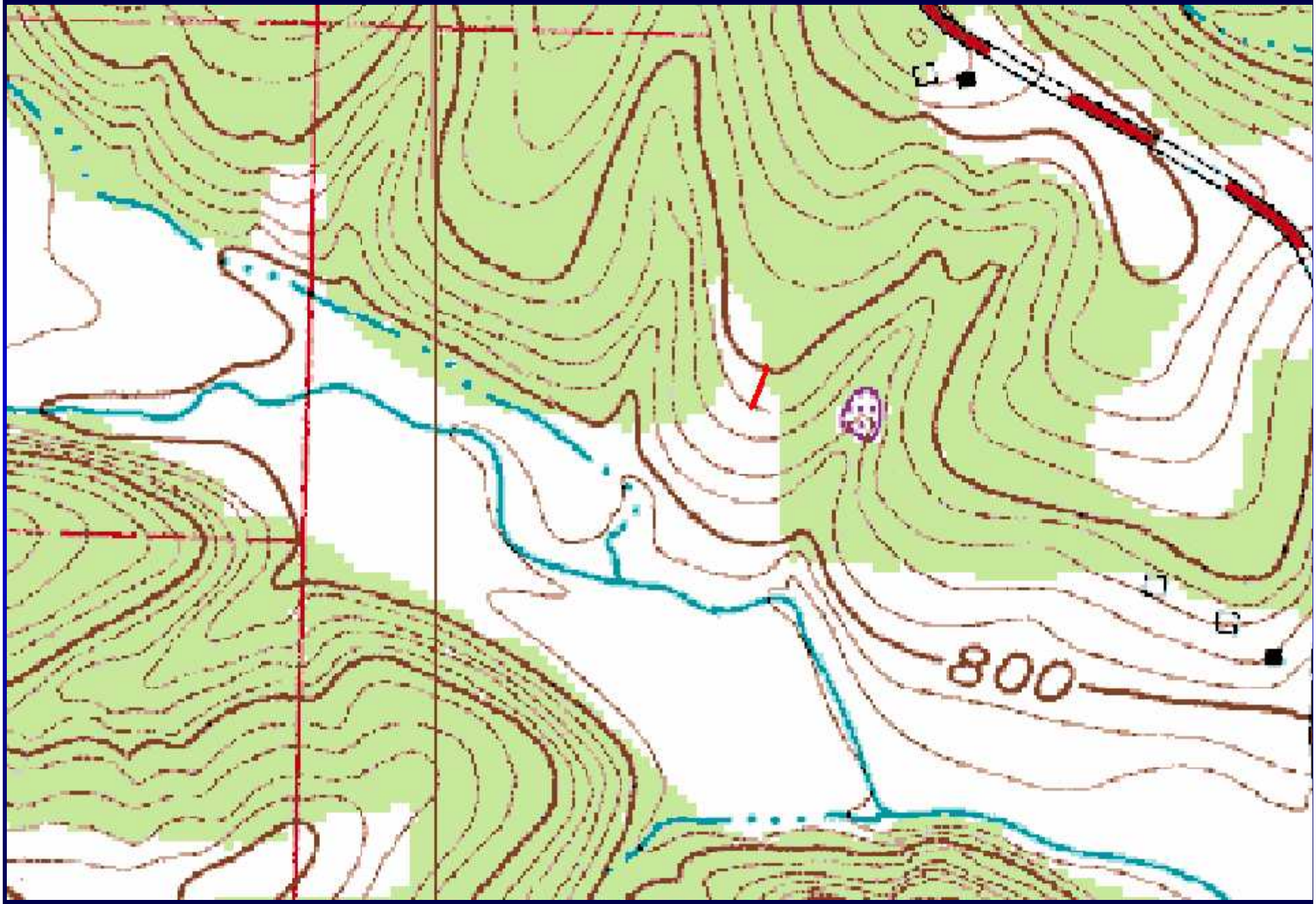
Hydrograph
Downstream
Routing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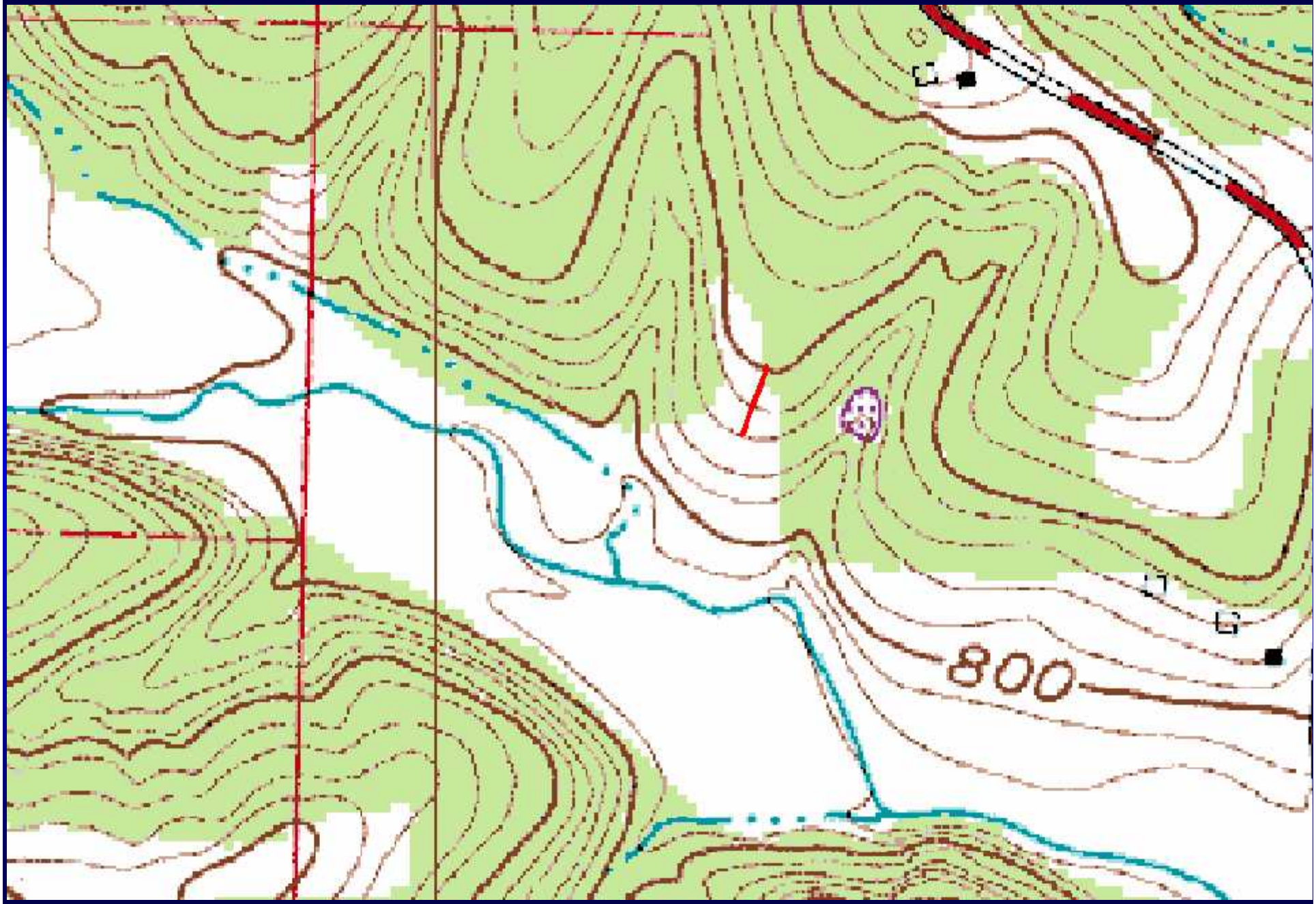
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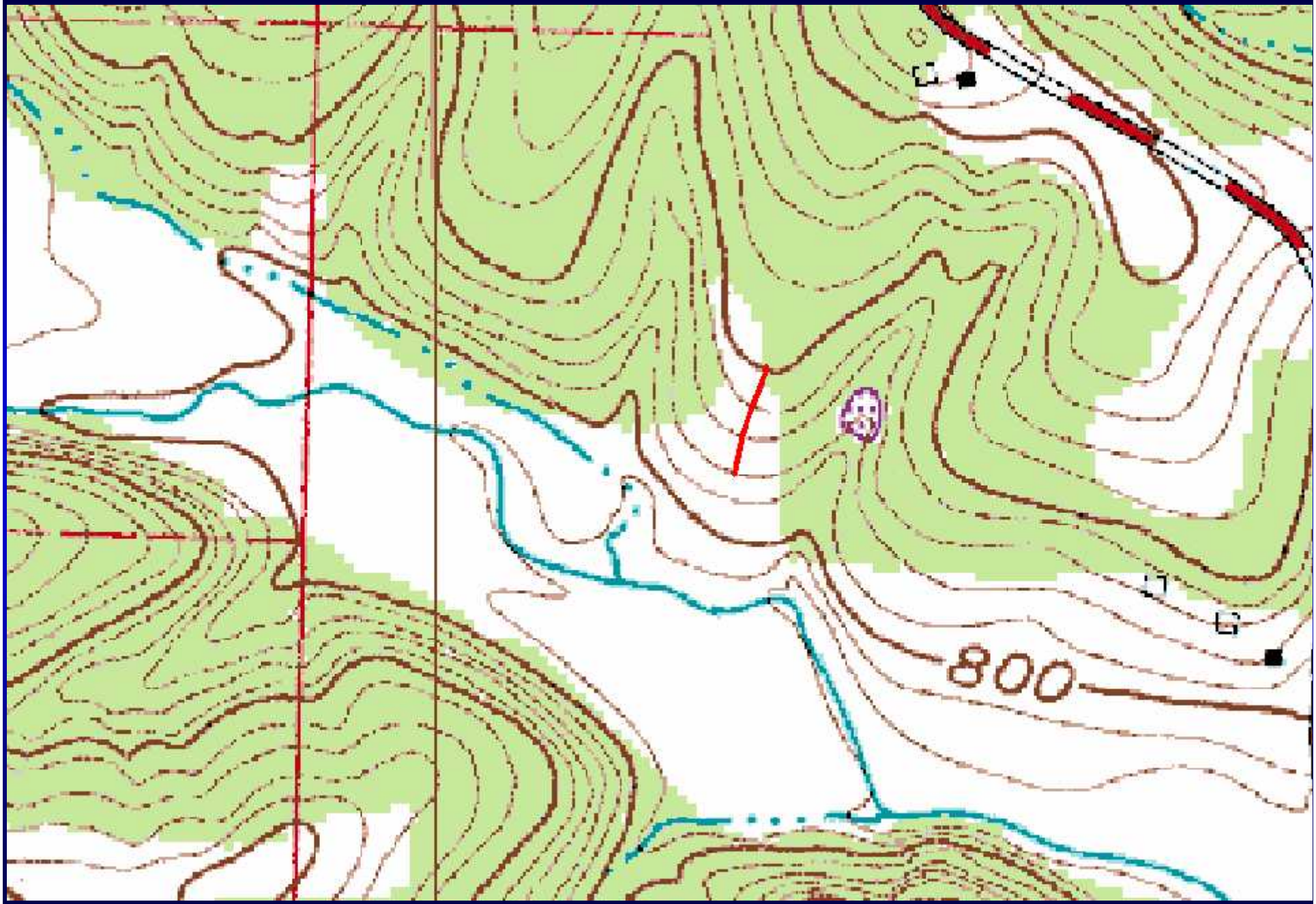
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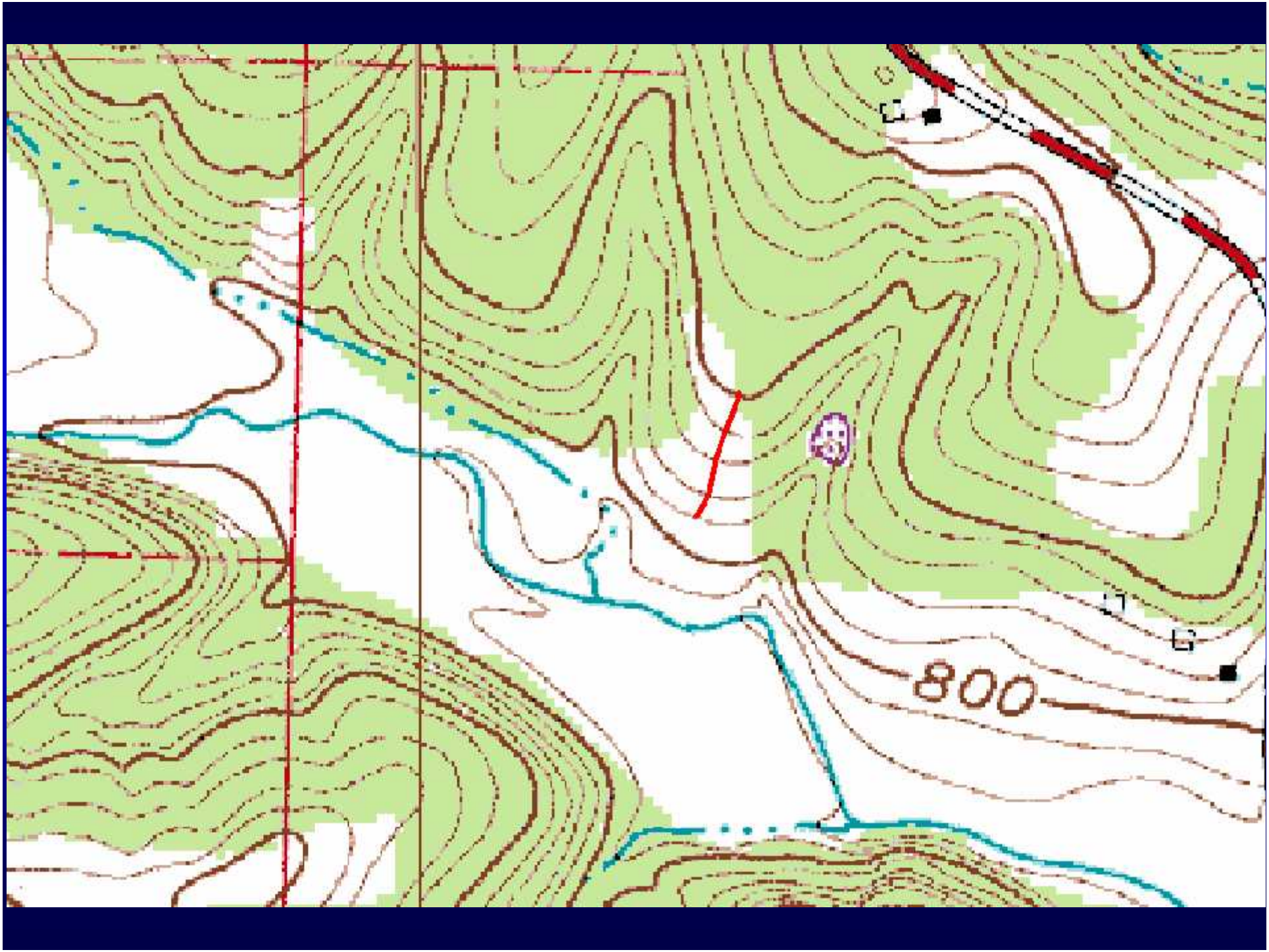
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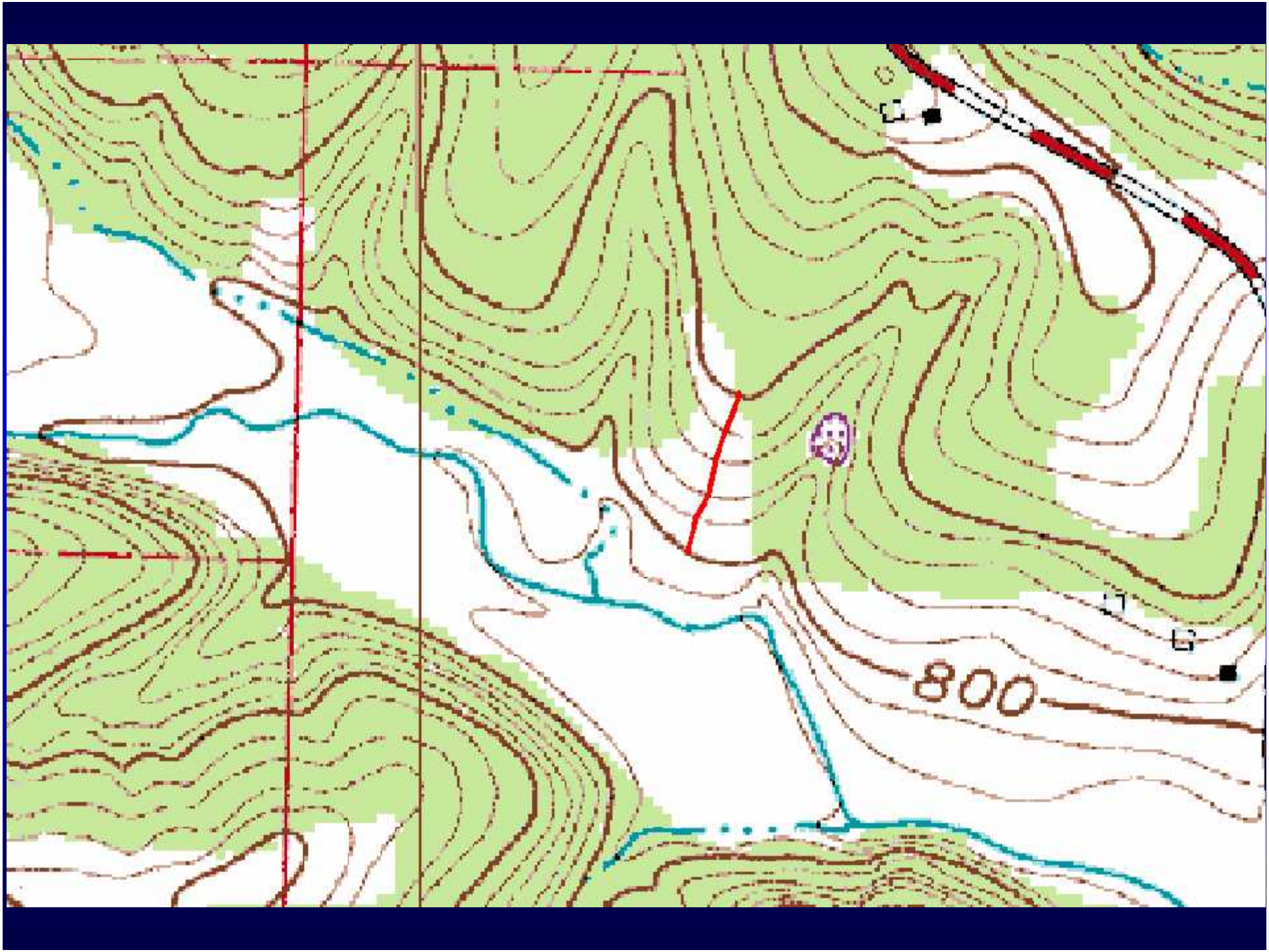
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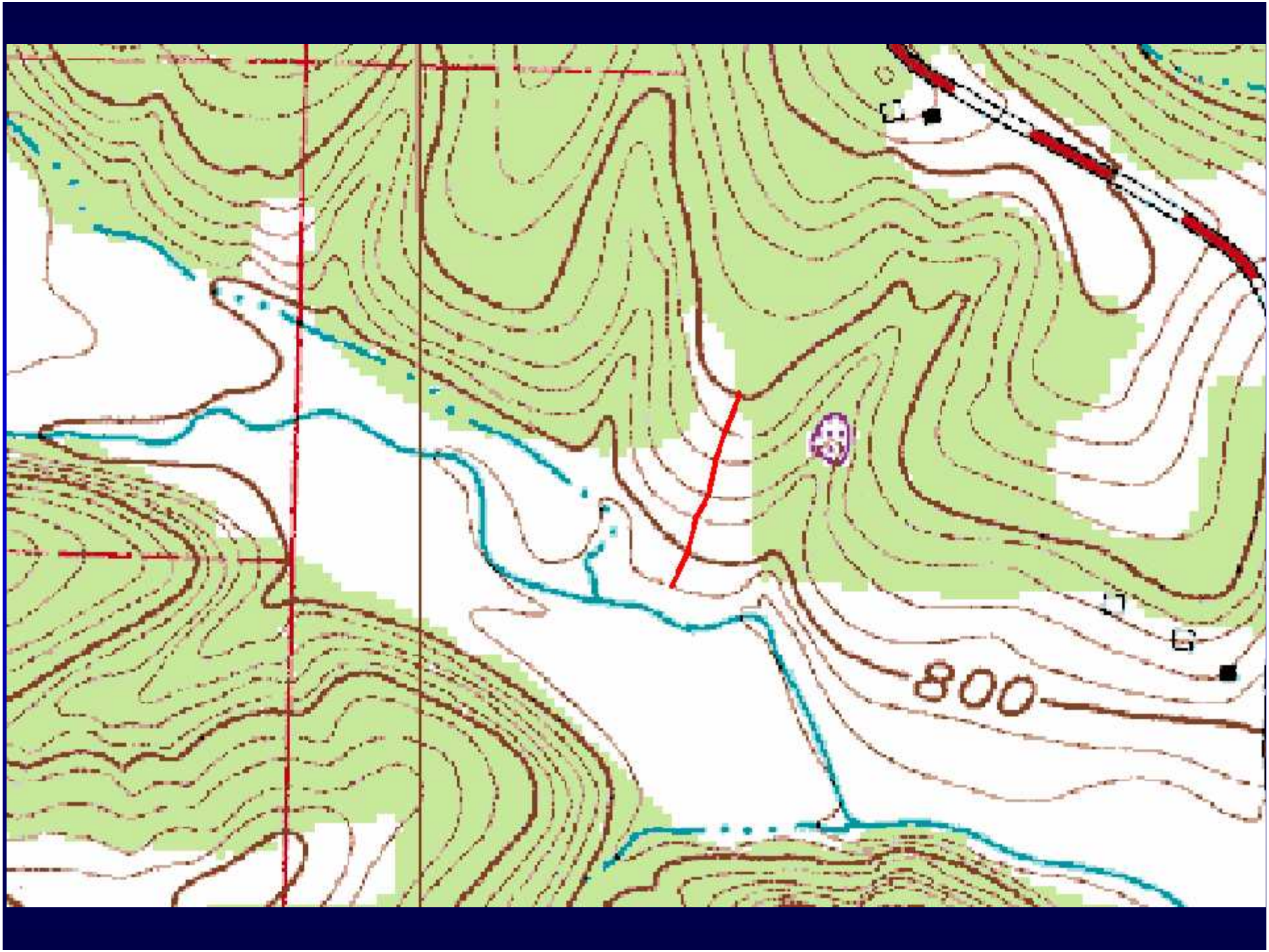
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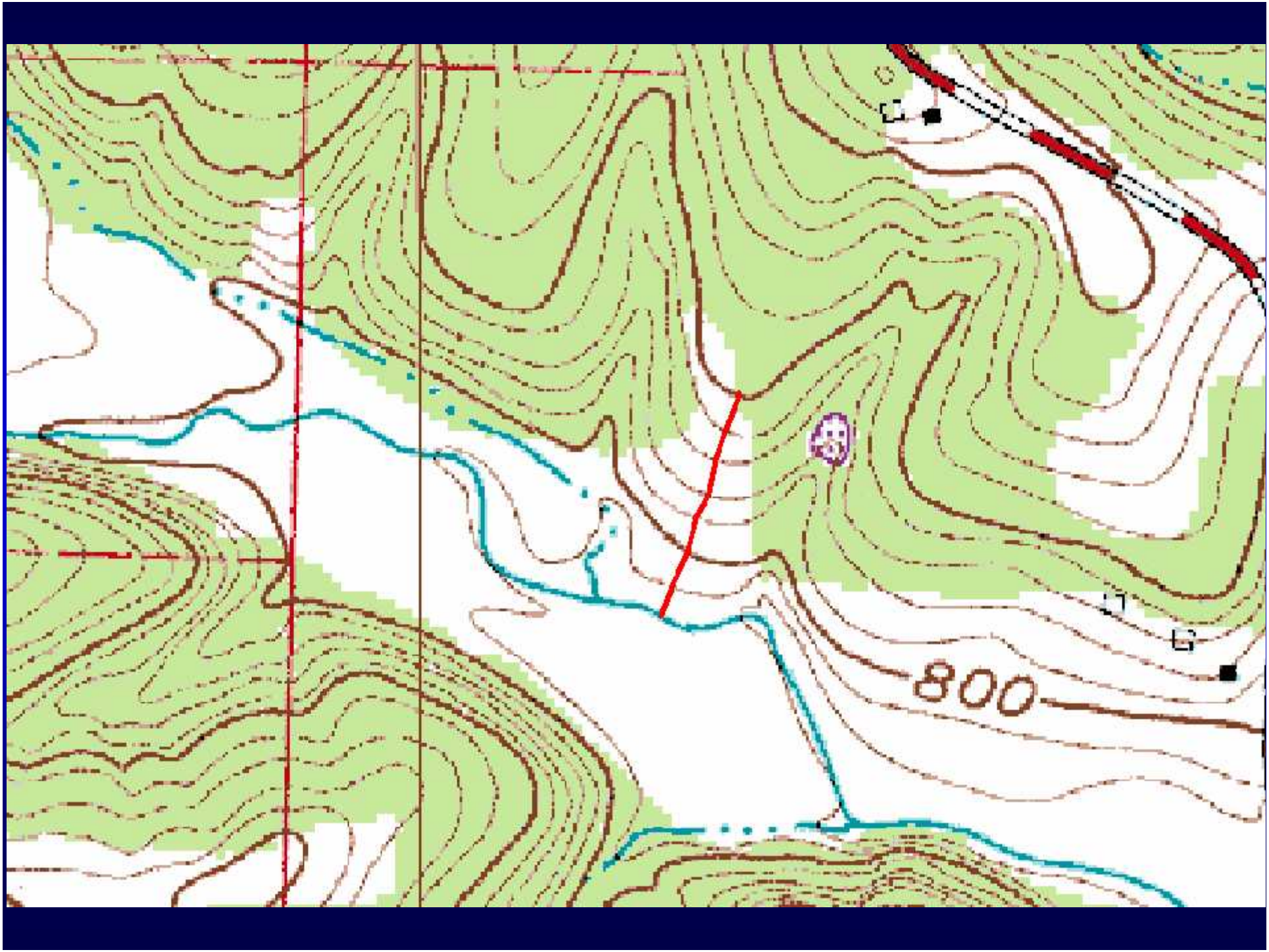
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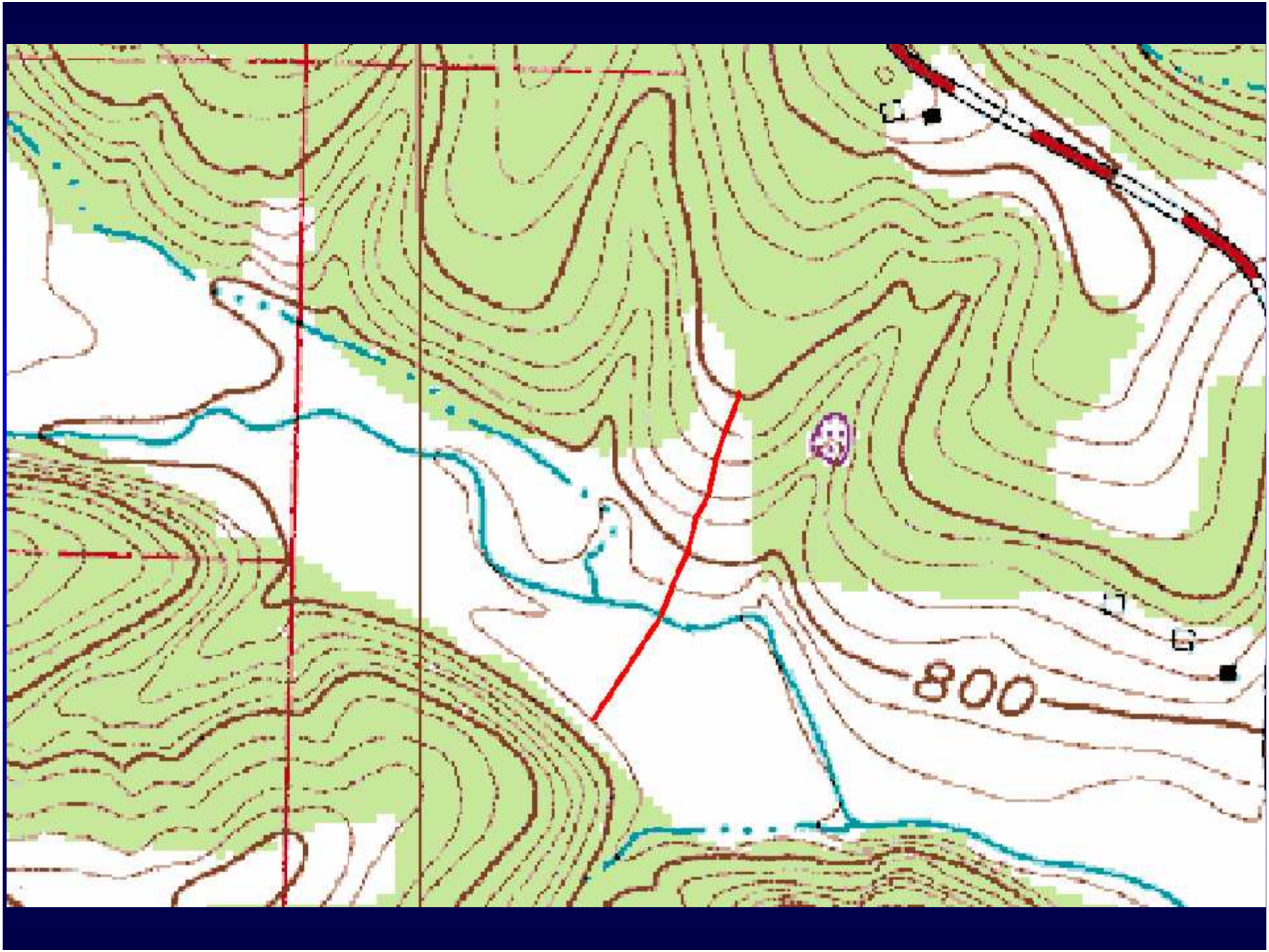
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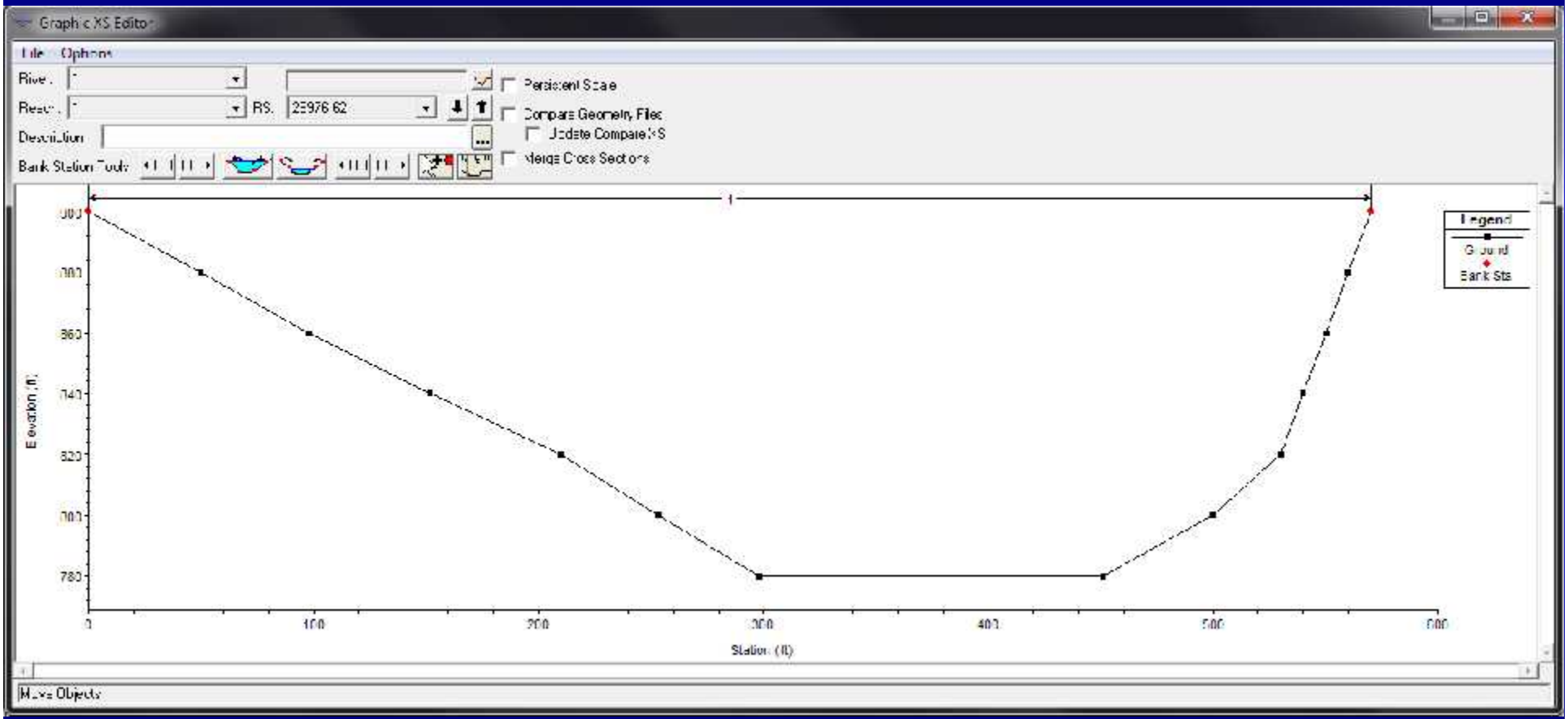
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Reach:
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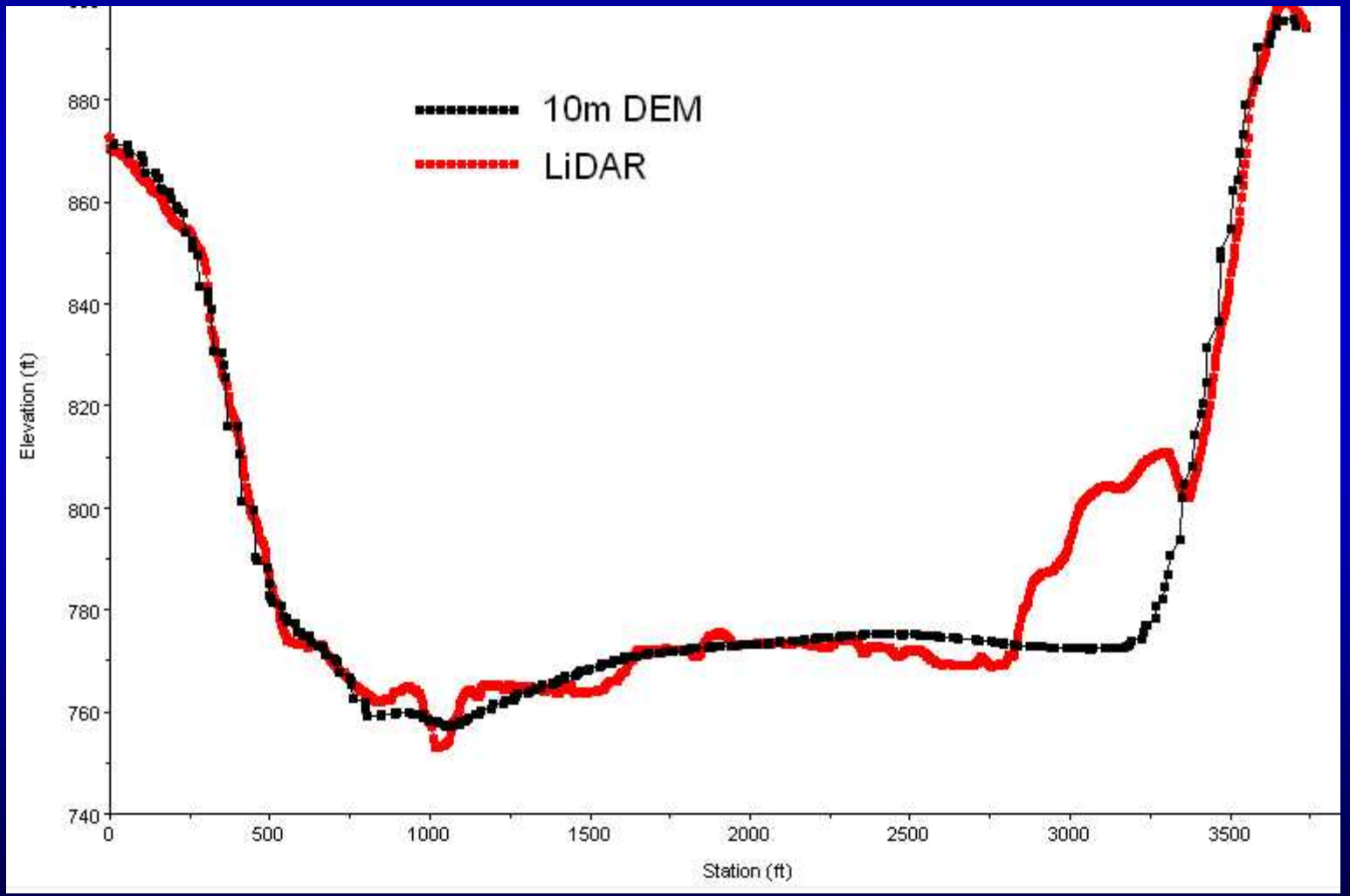
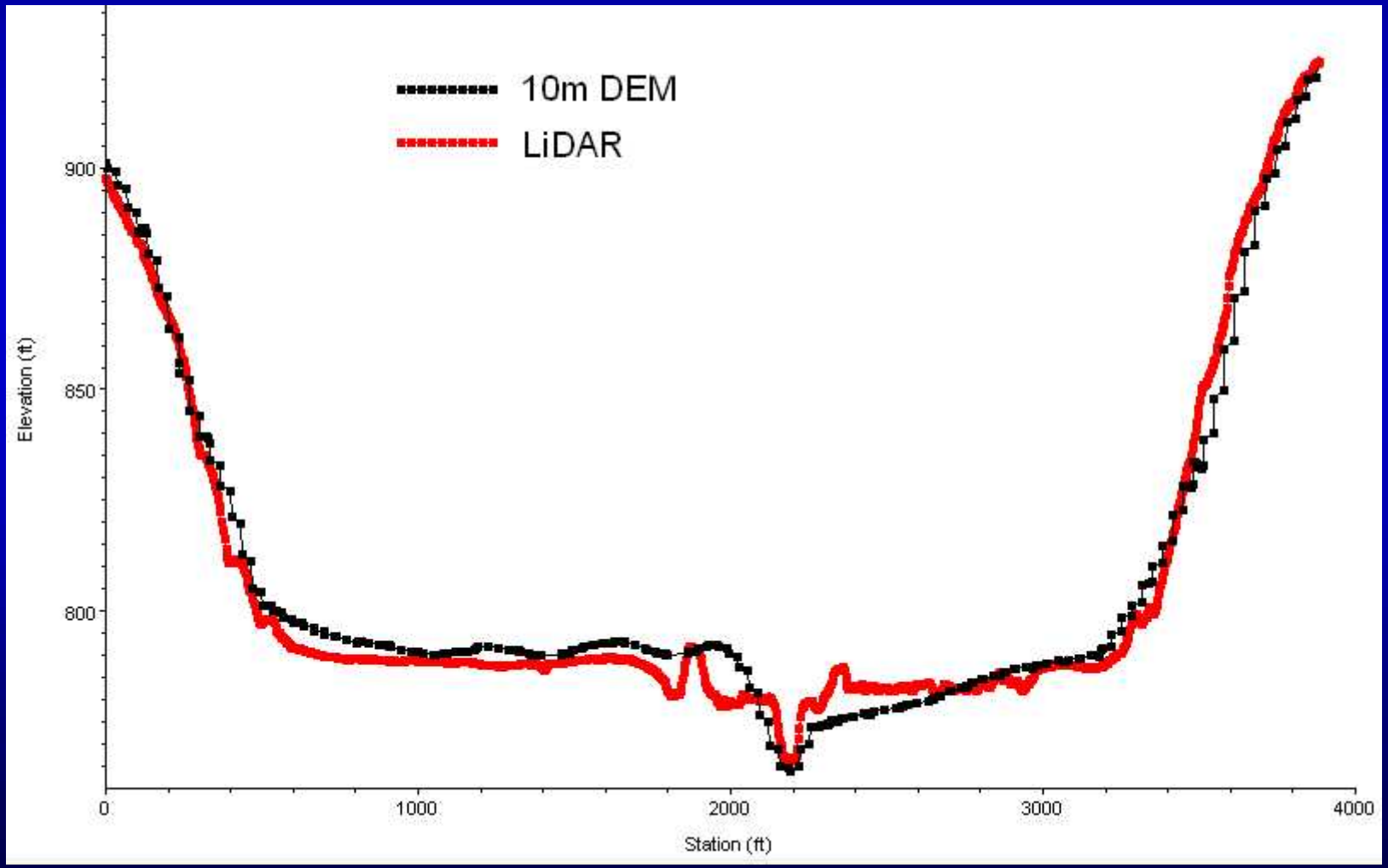
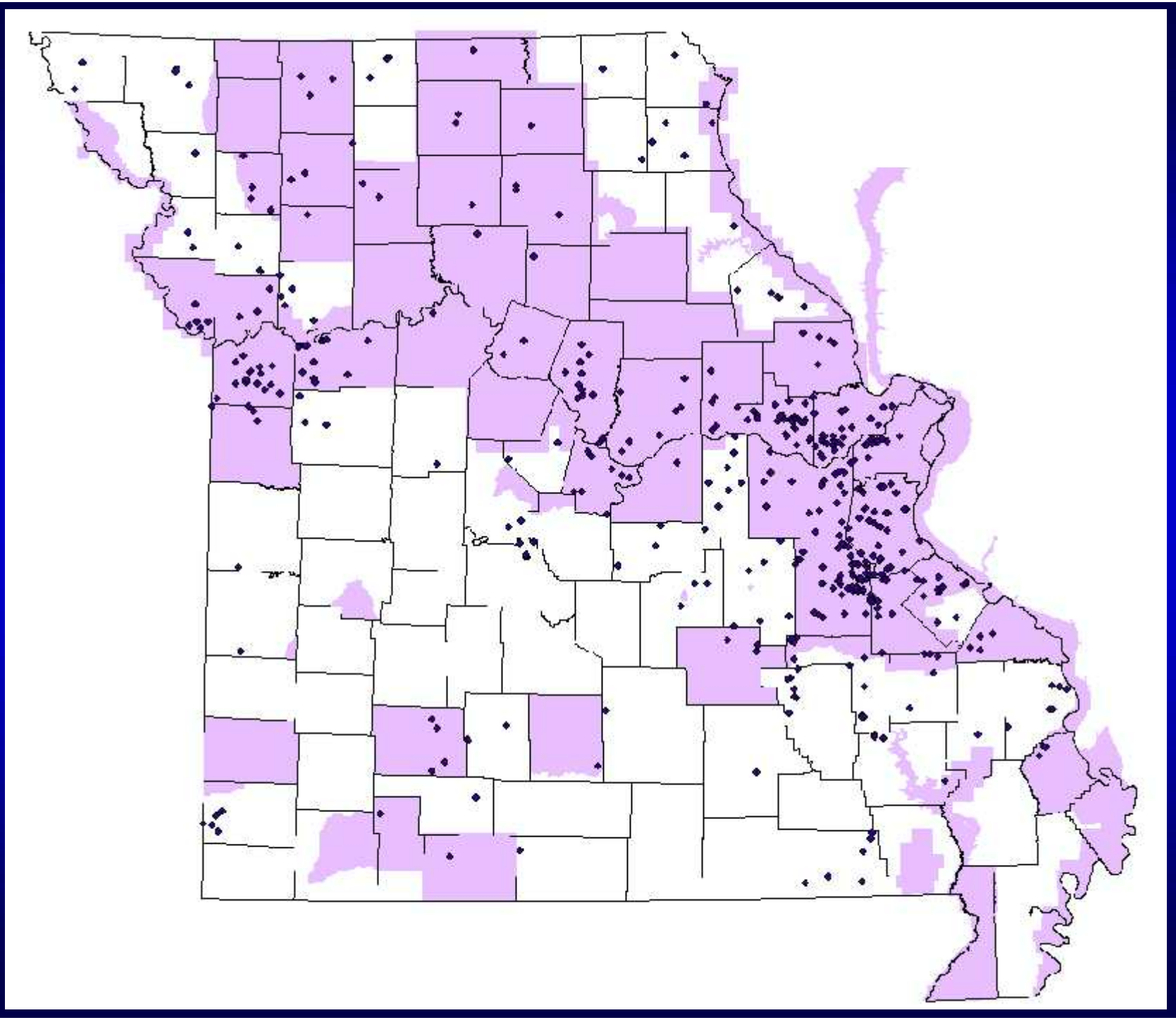
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)
Move Objects

LiDAR vs 10m DEM

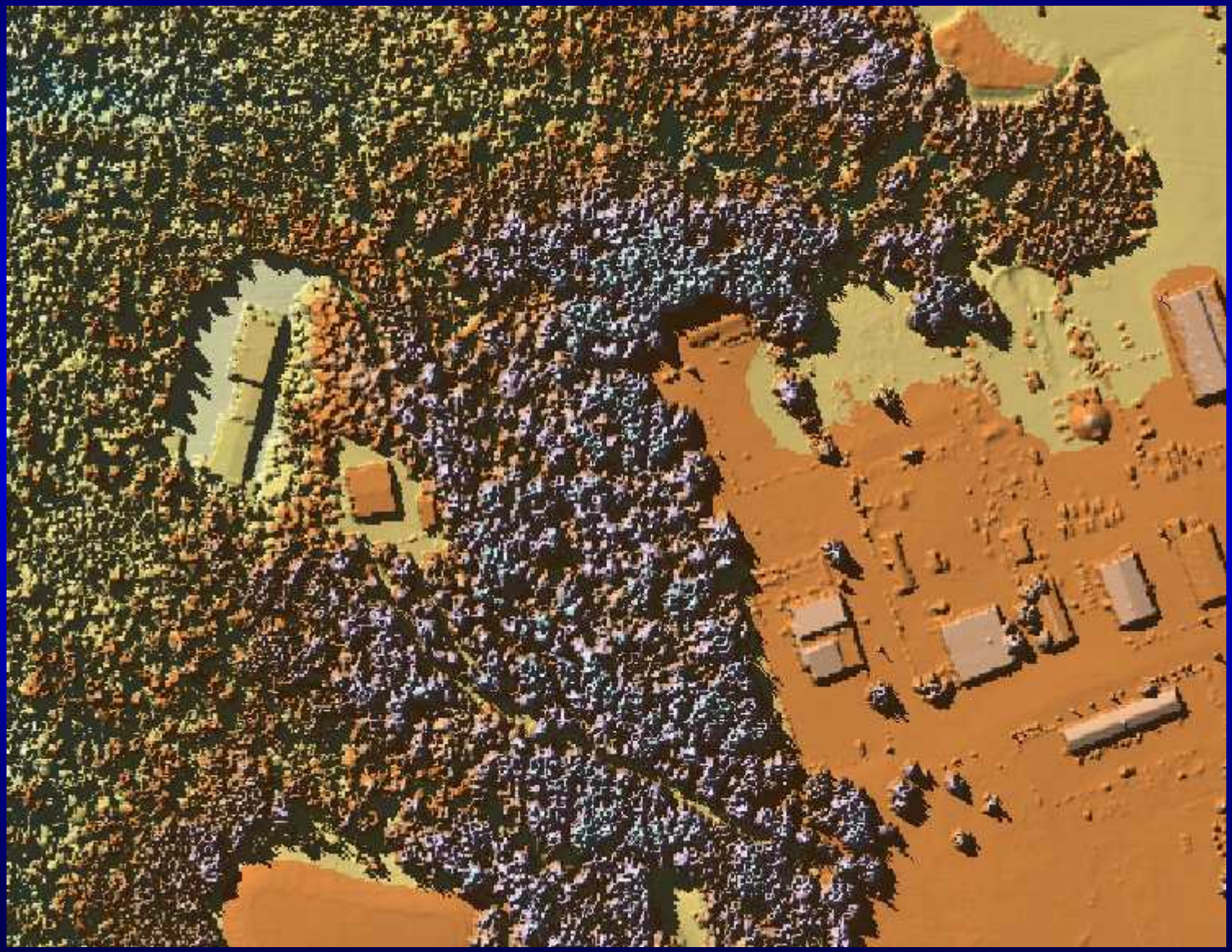


LiDAR vs 10m DEM



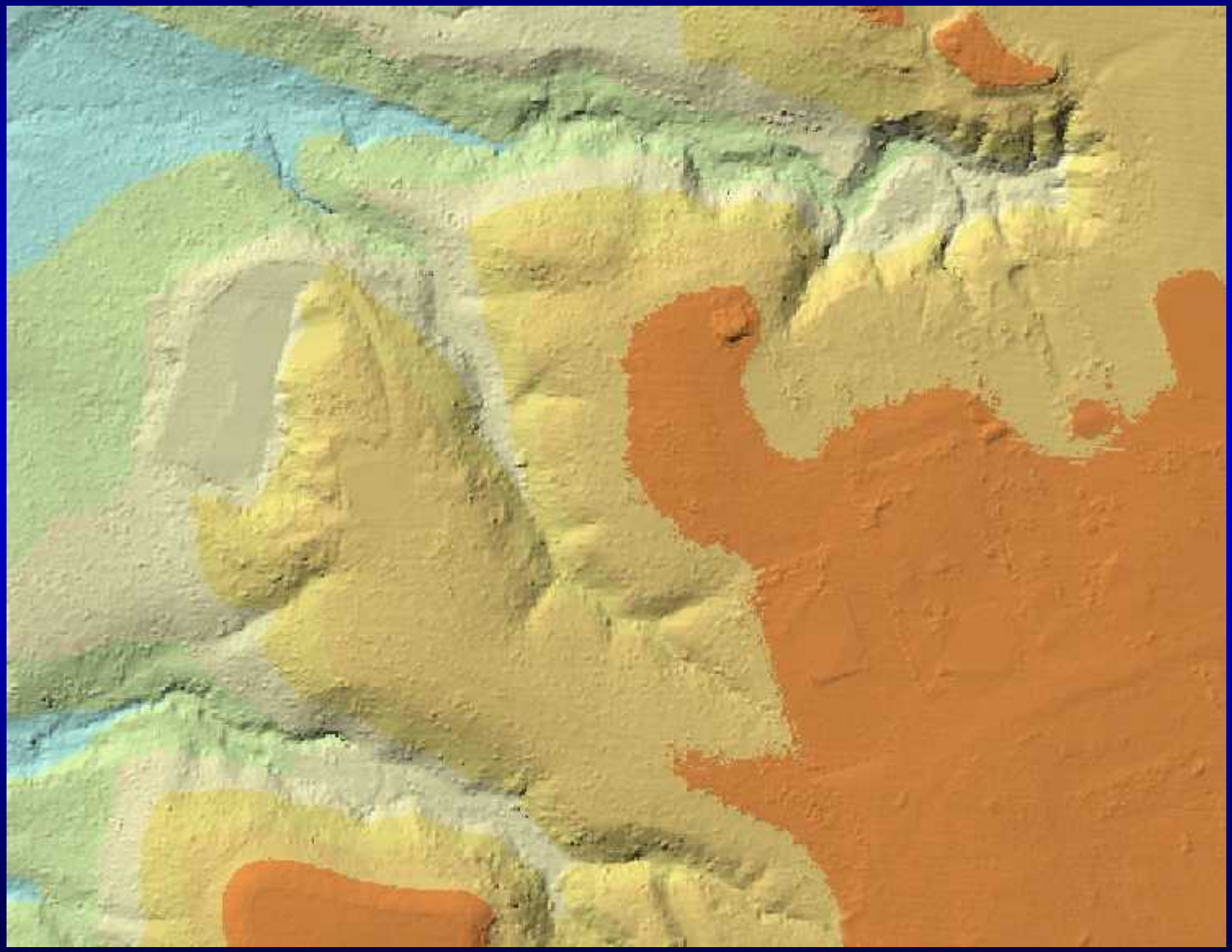


LiDAR First Return



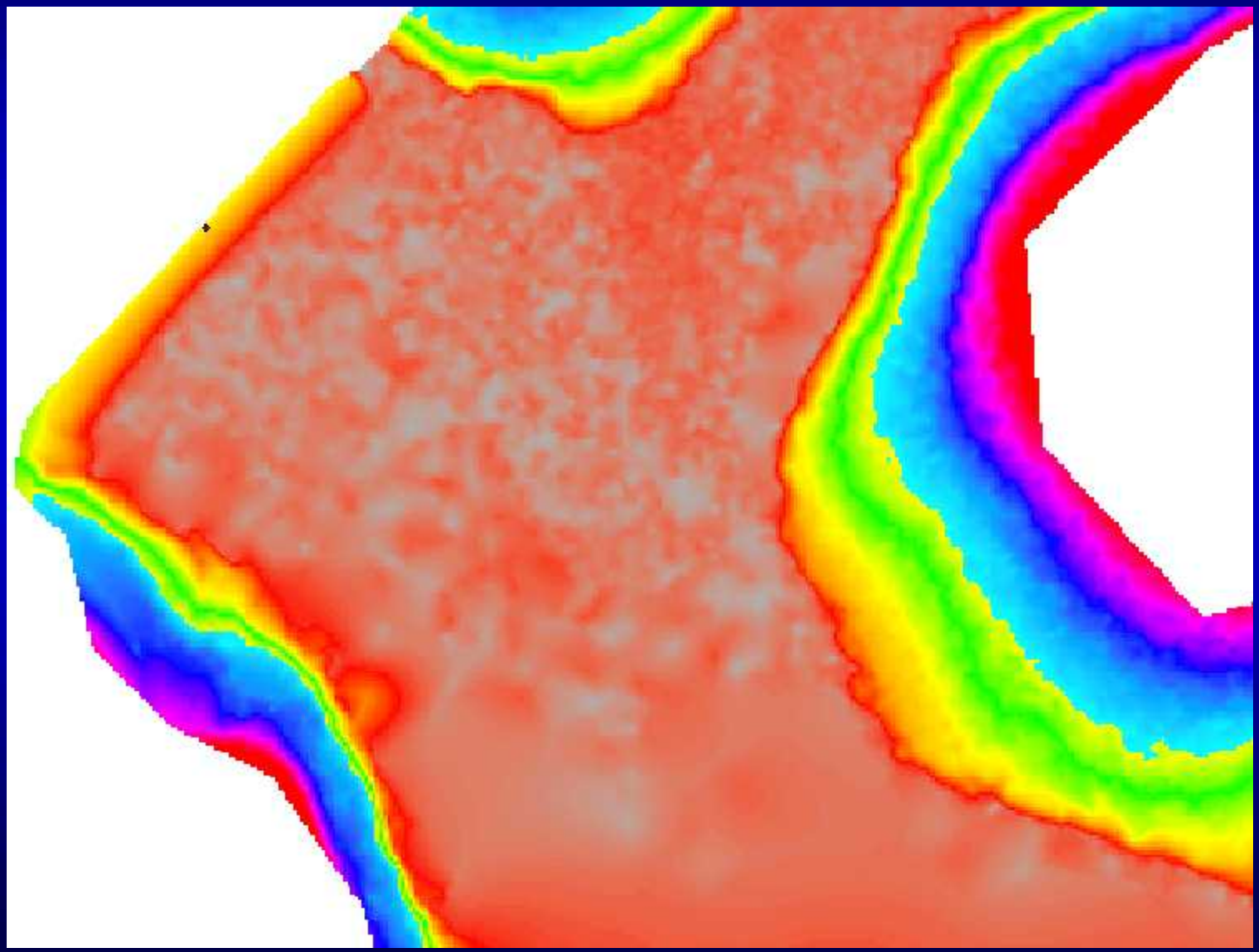
Courtesy Surdex Corp

LiDAR Bare Earth



Courtesy Surdex Corp

Flattening



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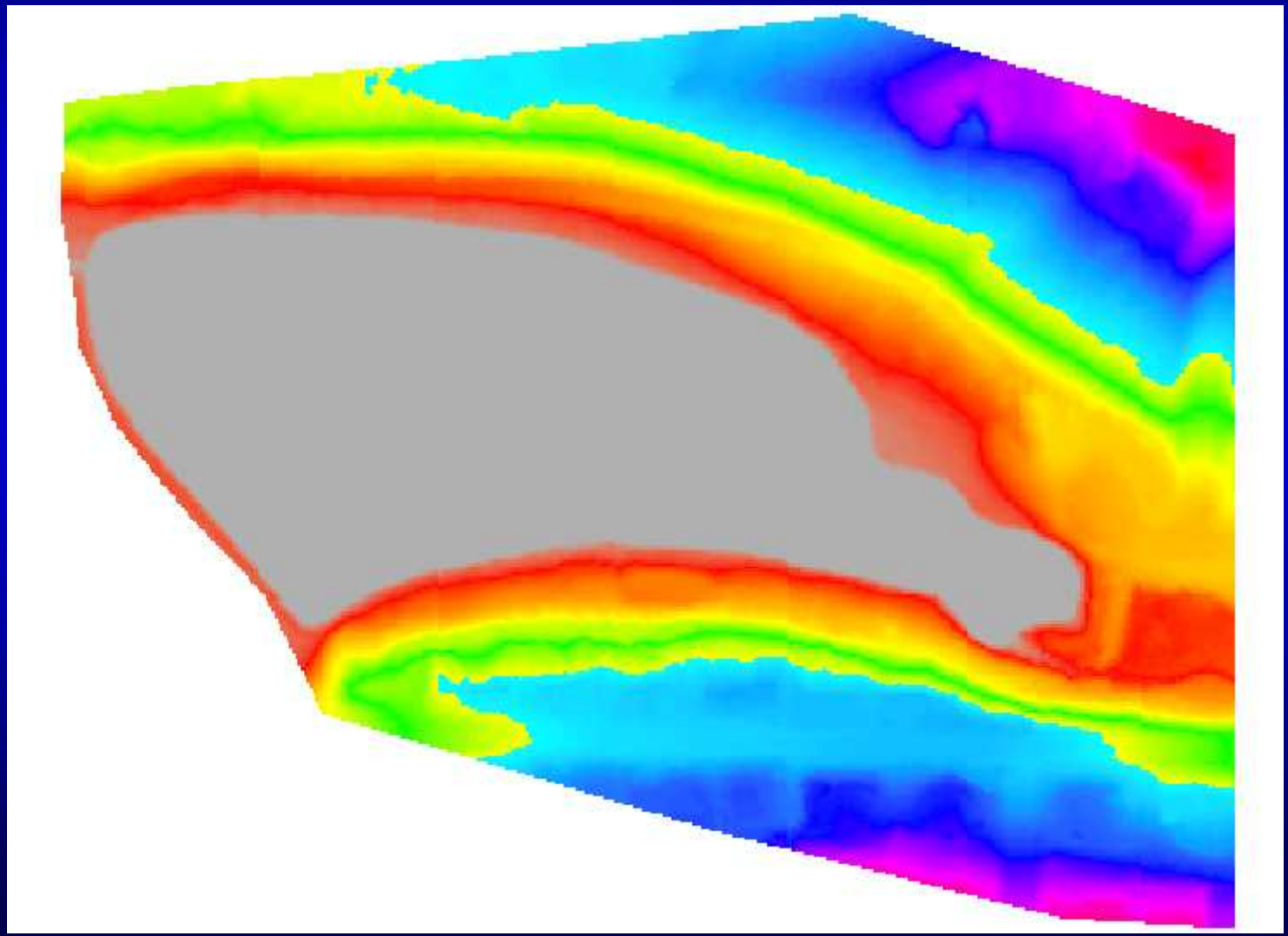
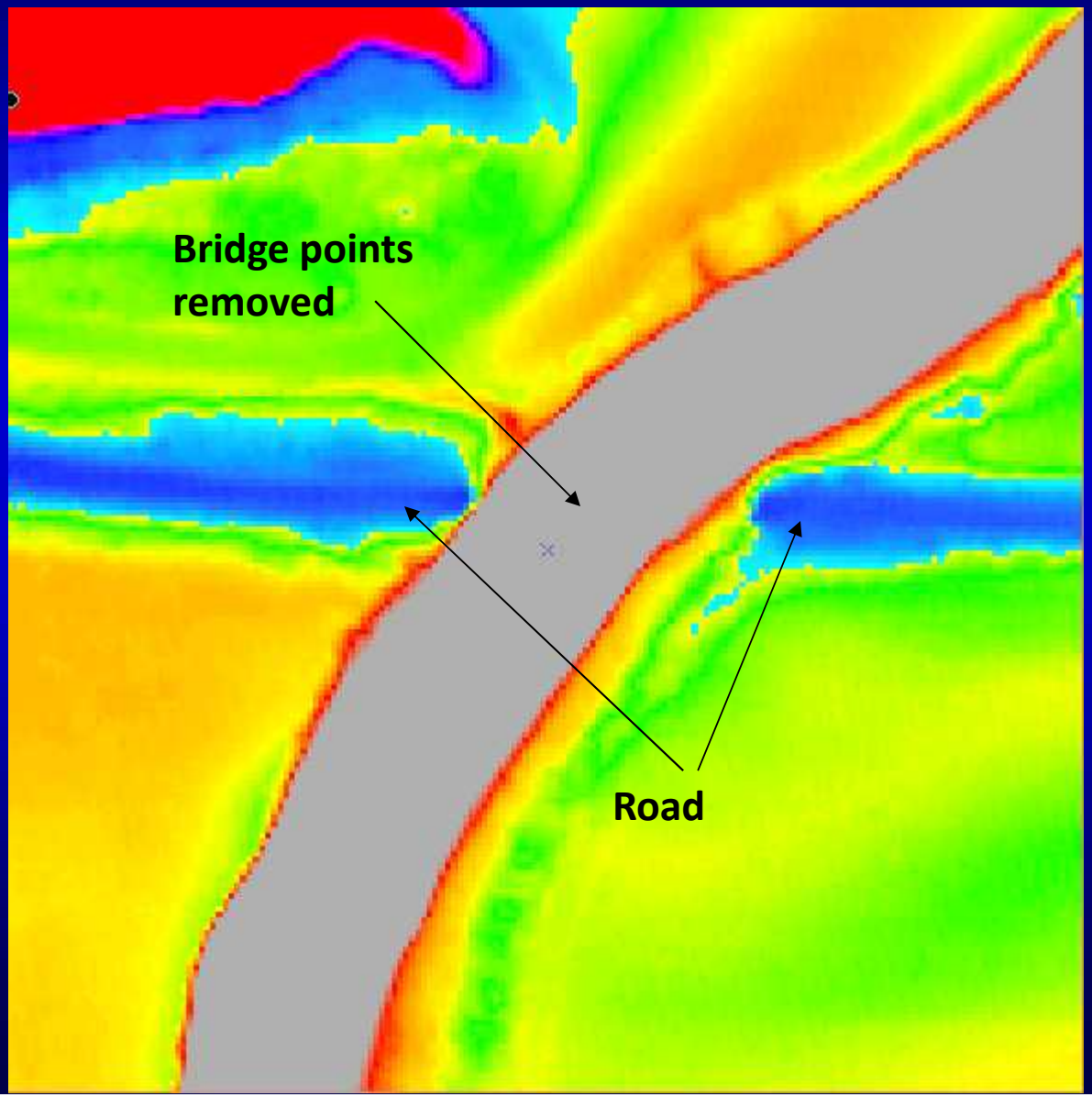
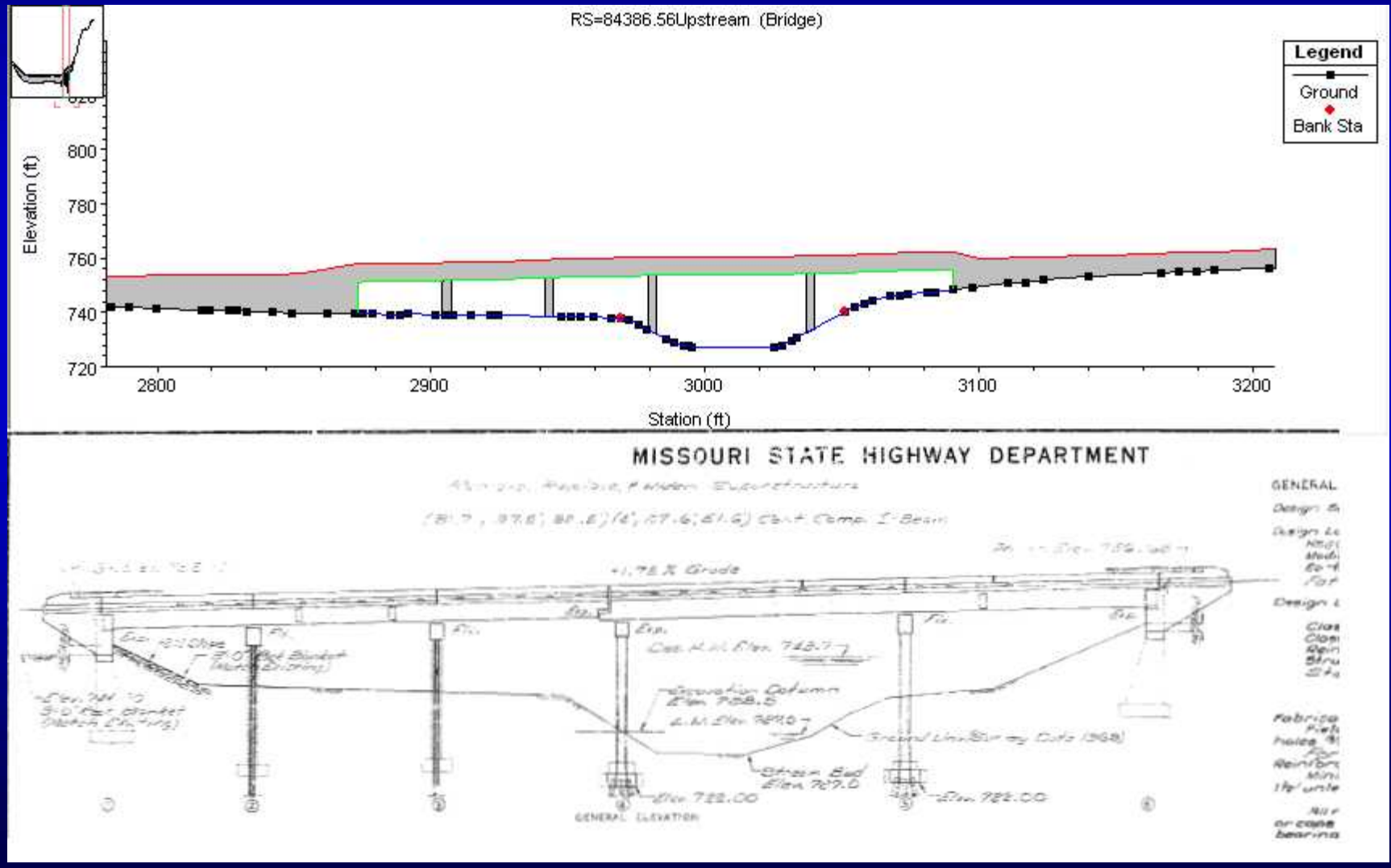


LiDAR Hydro-Enforcement

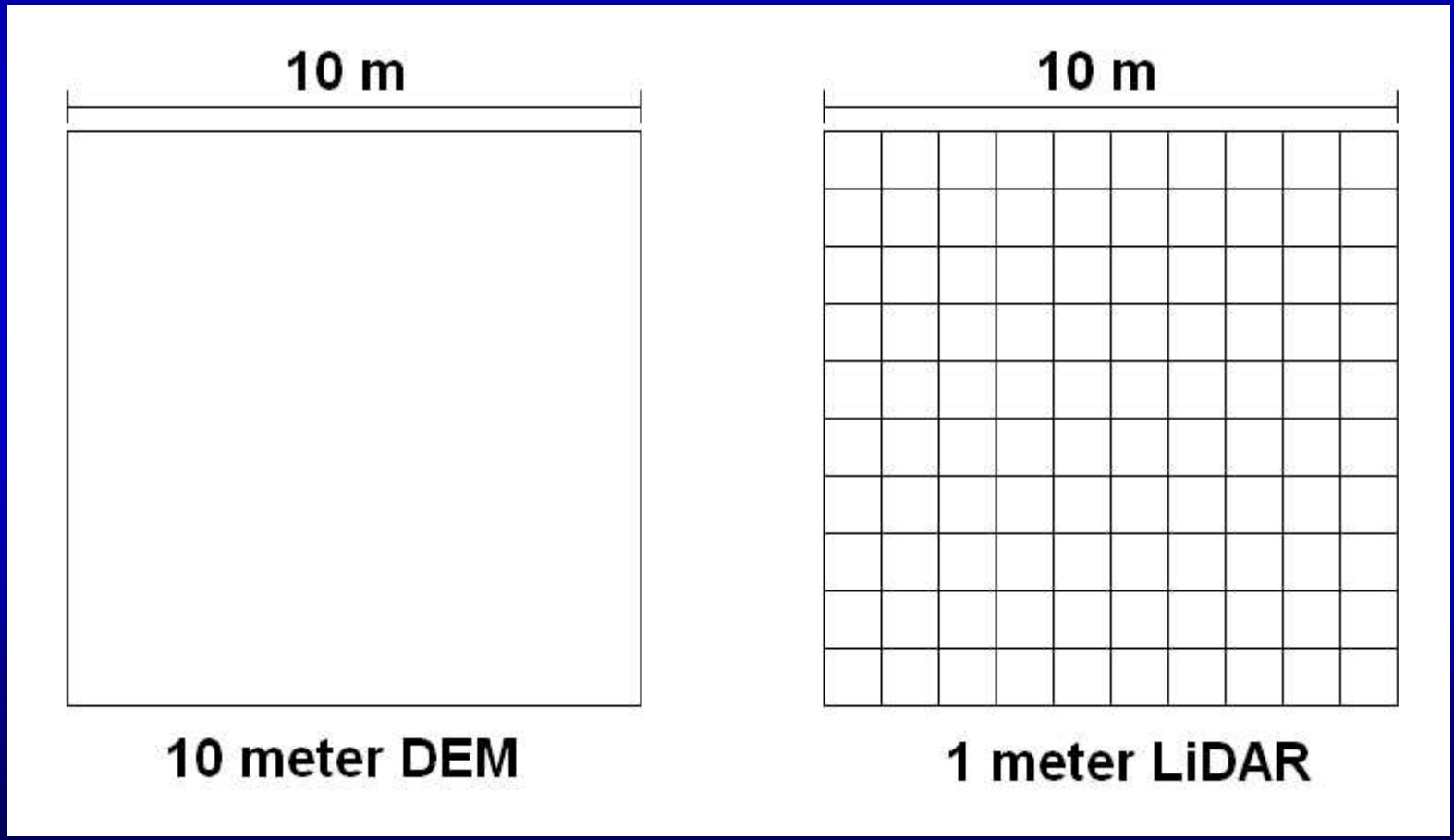
LiDAR Hydro-Enforcement



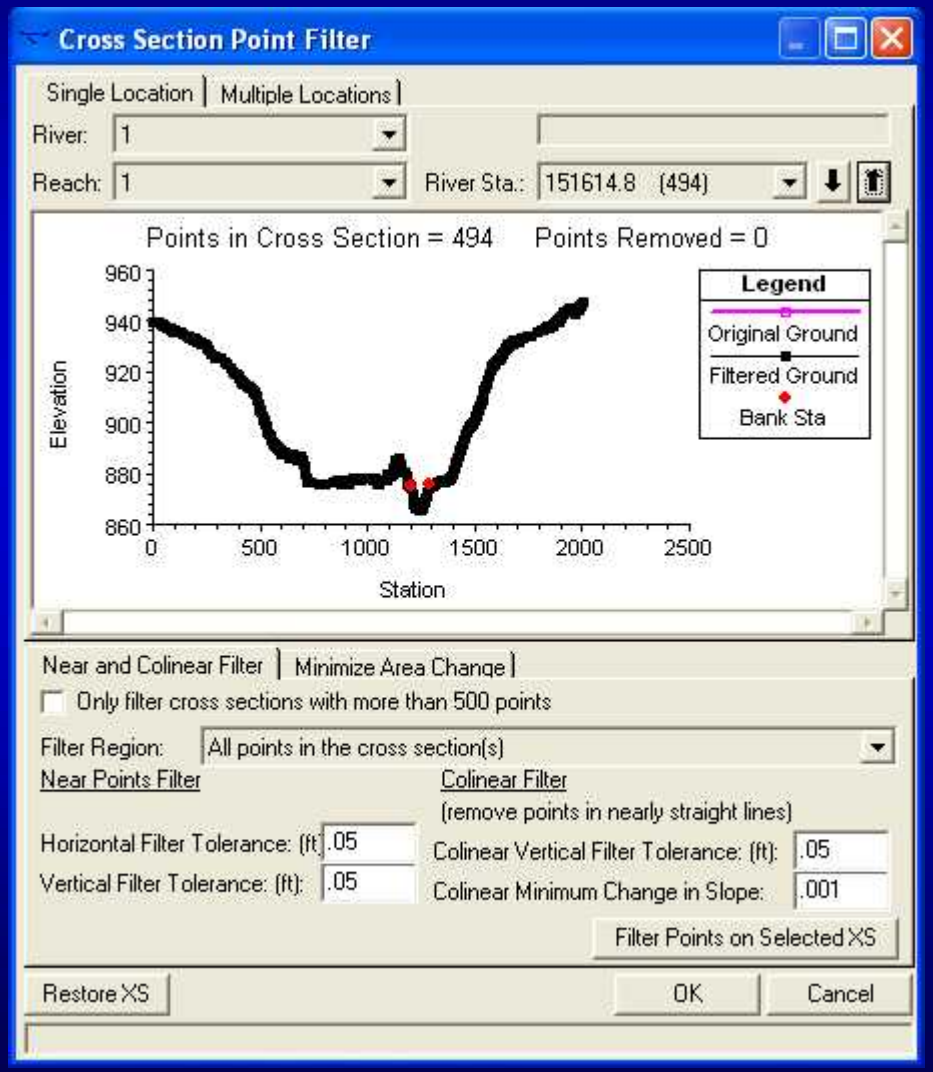
Bridge Modeling



LiDAR vs 10m DEM



Cross Section Points Filtering



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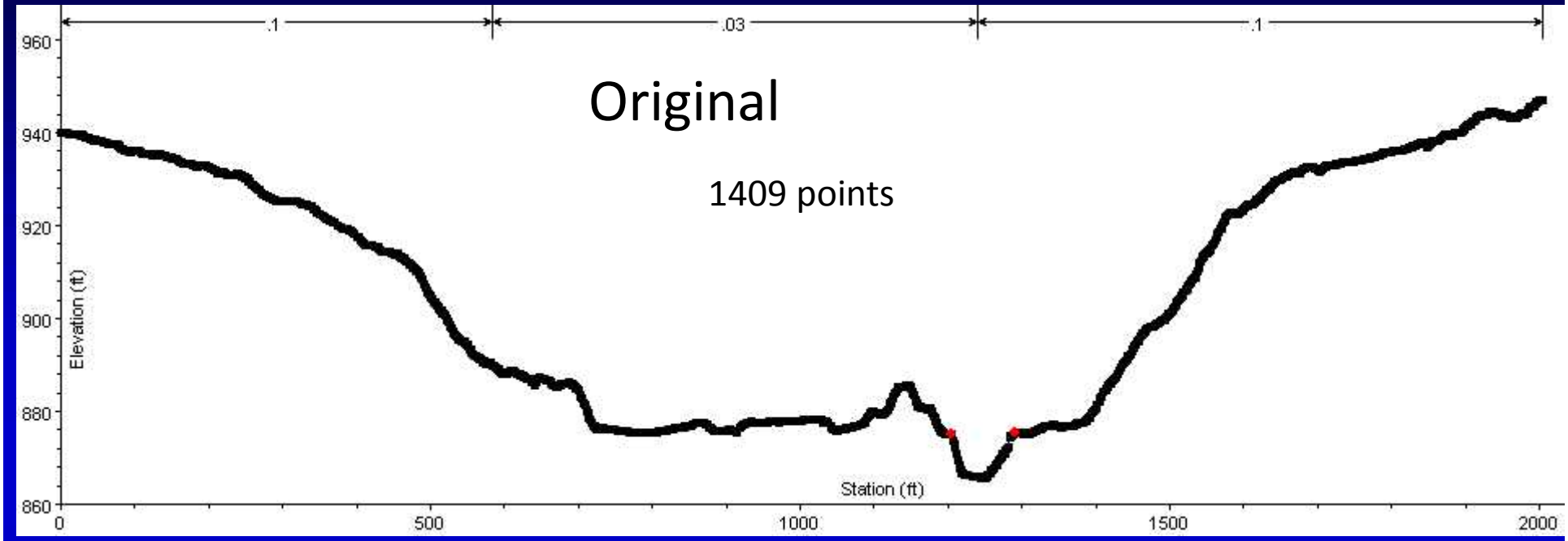

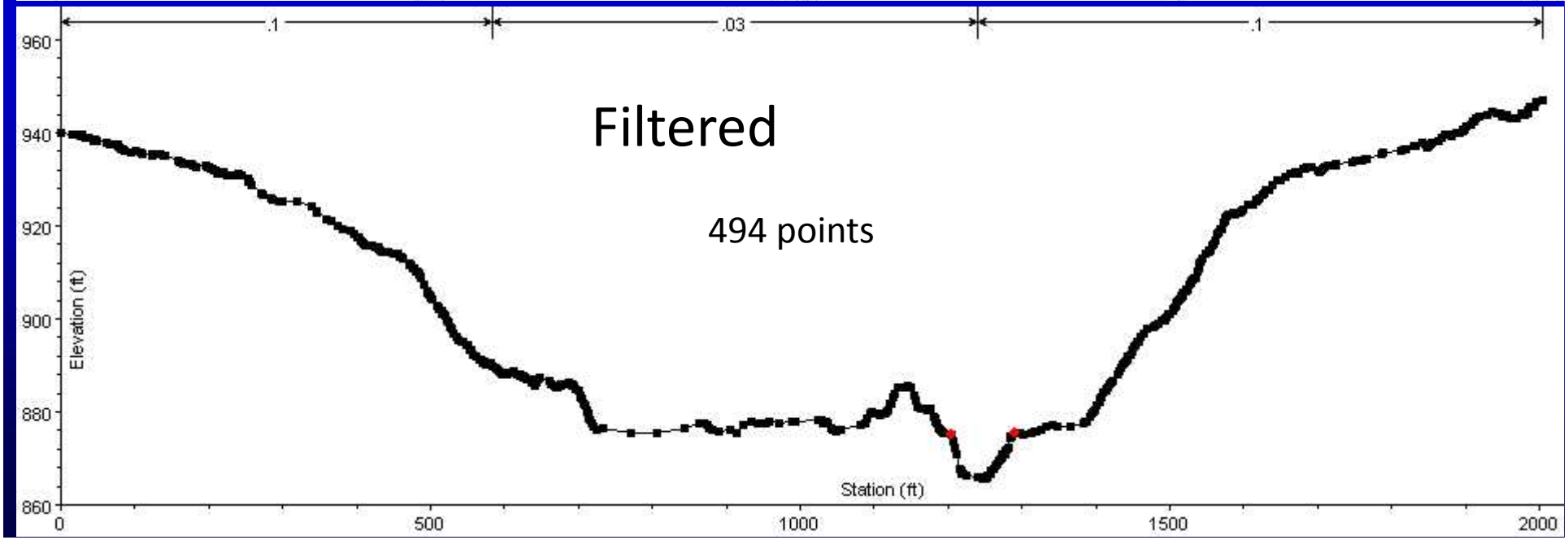

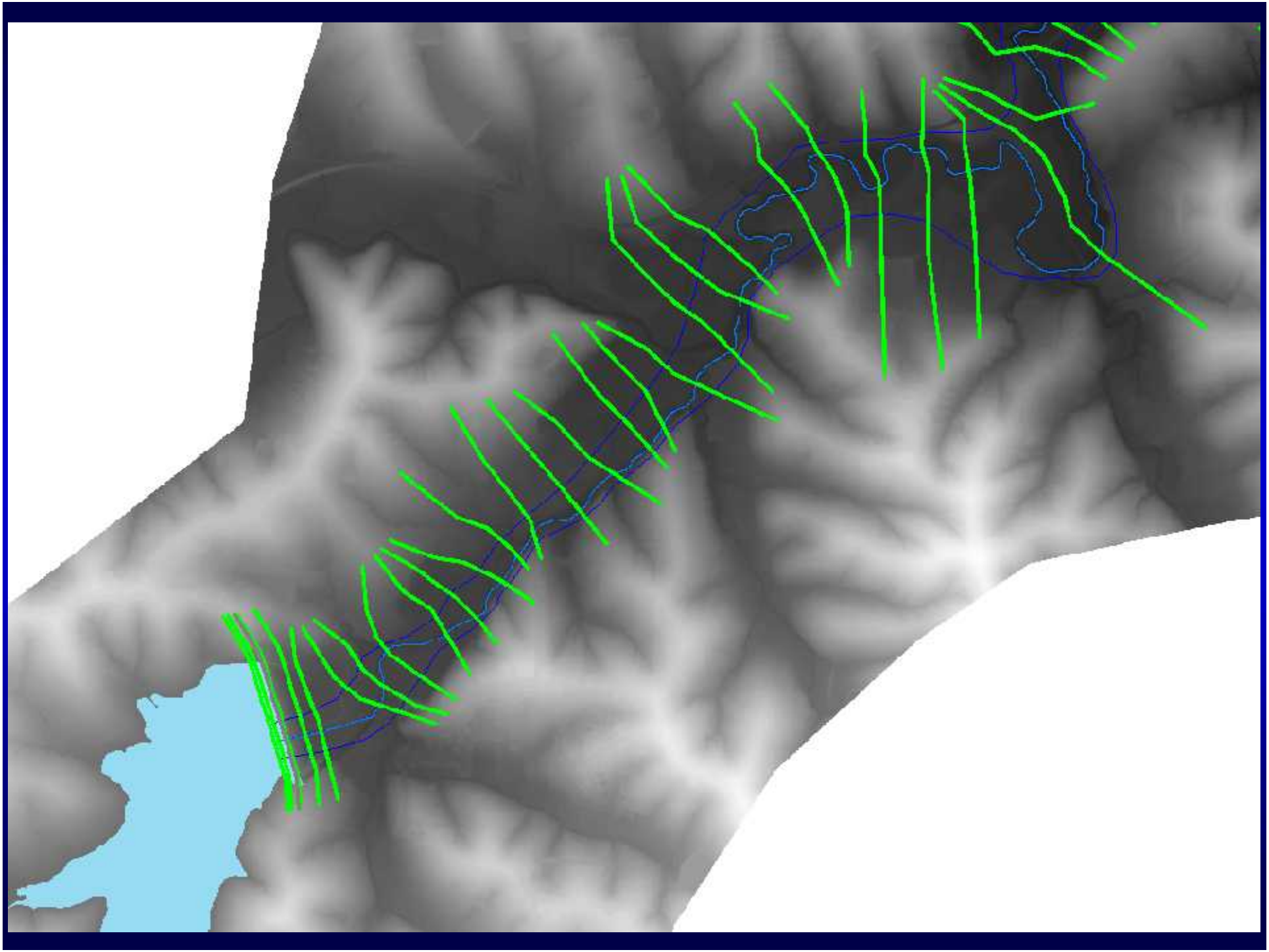

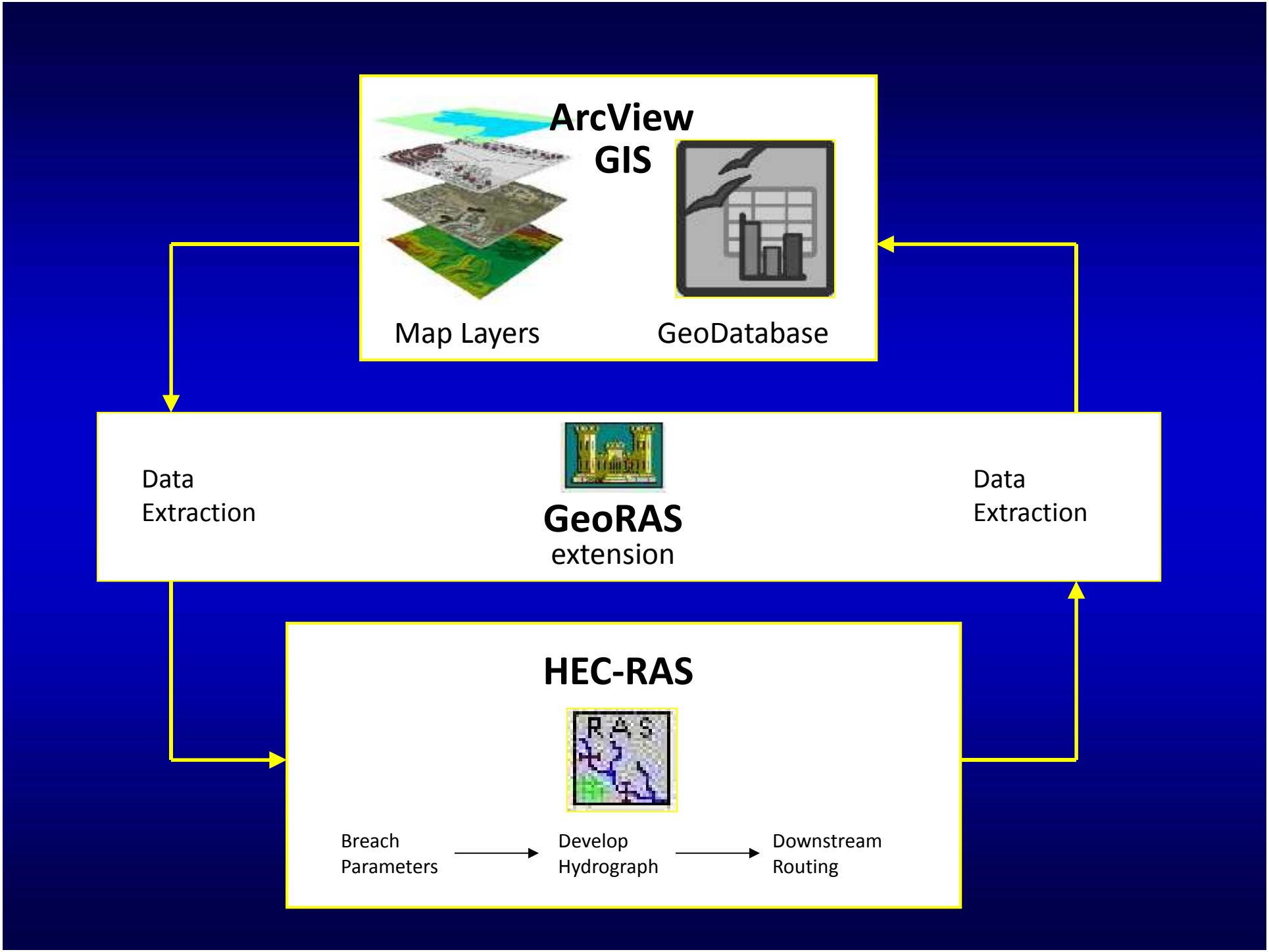
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GIS
Map Layers
GeoDatabase
Data
Extraction
GeoRAS
extension
Data
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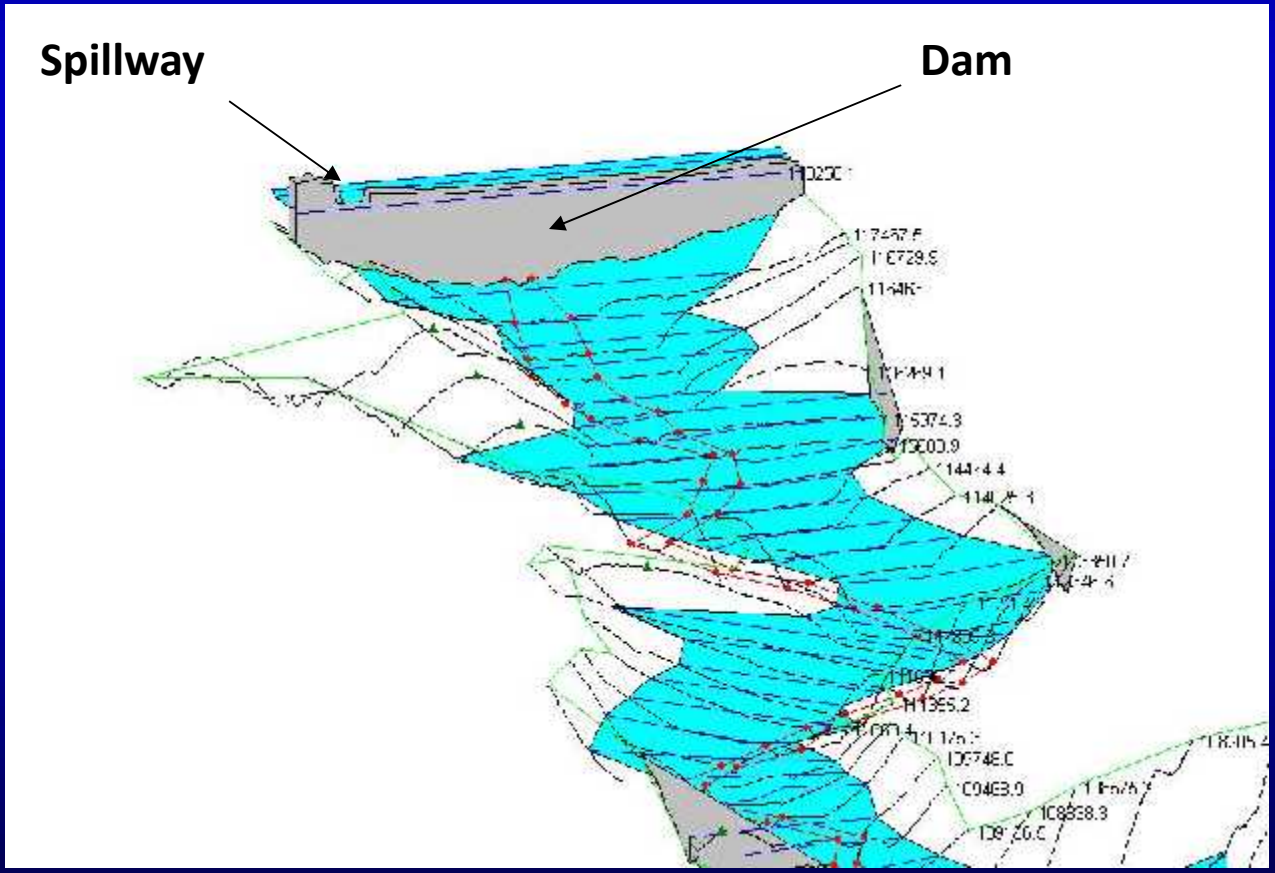
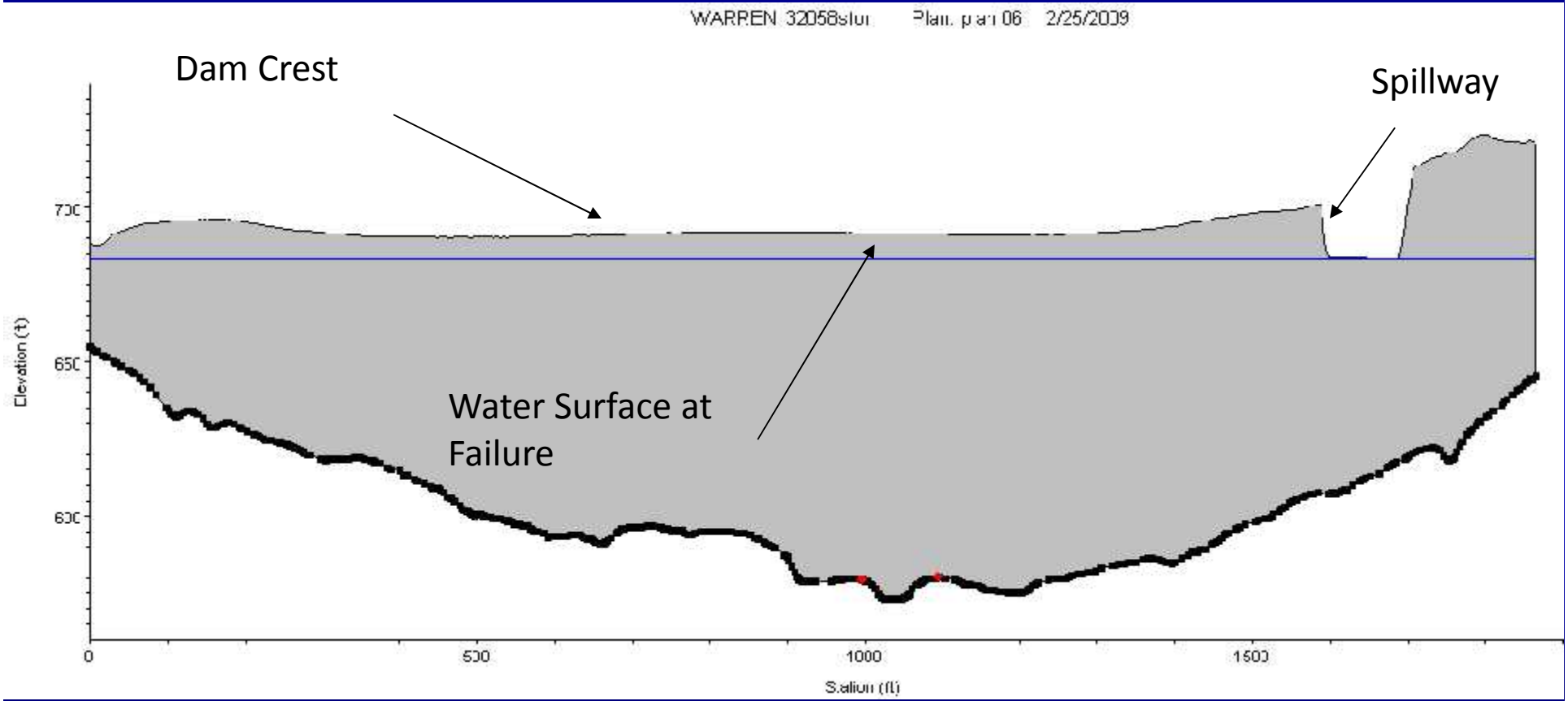
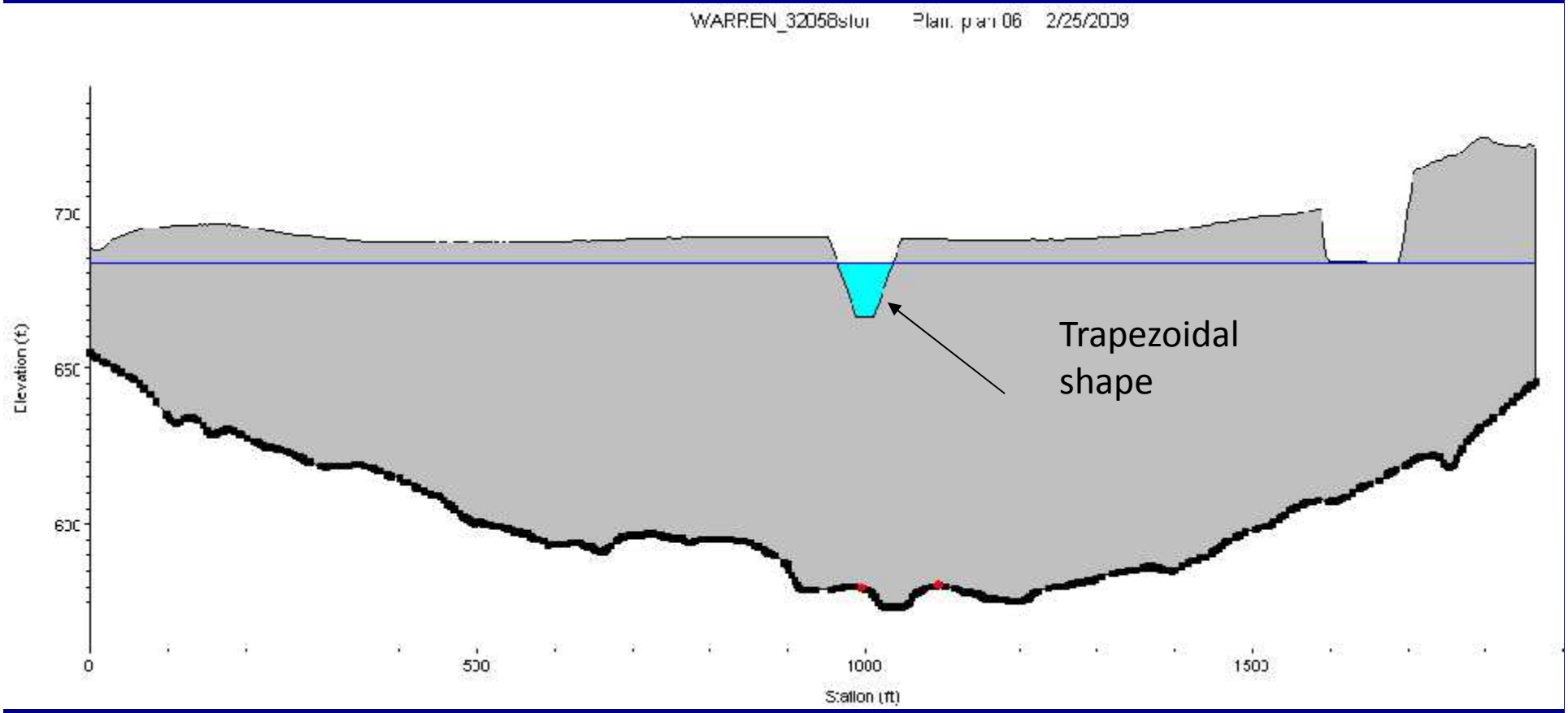
HEC-RAS
Breach
Parameters
Develop
Hydrograph
Downstream
Routing

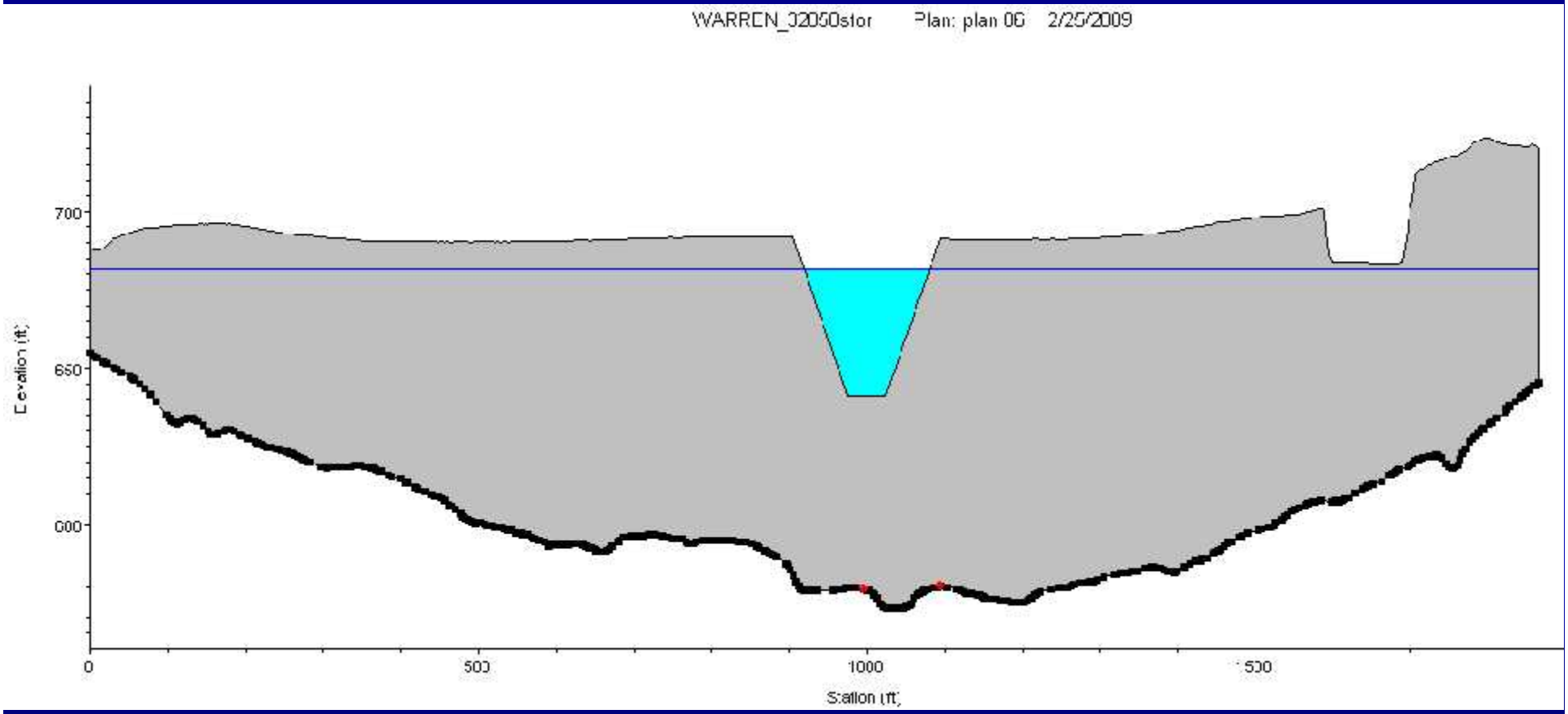
HEC-RAS

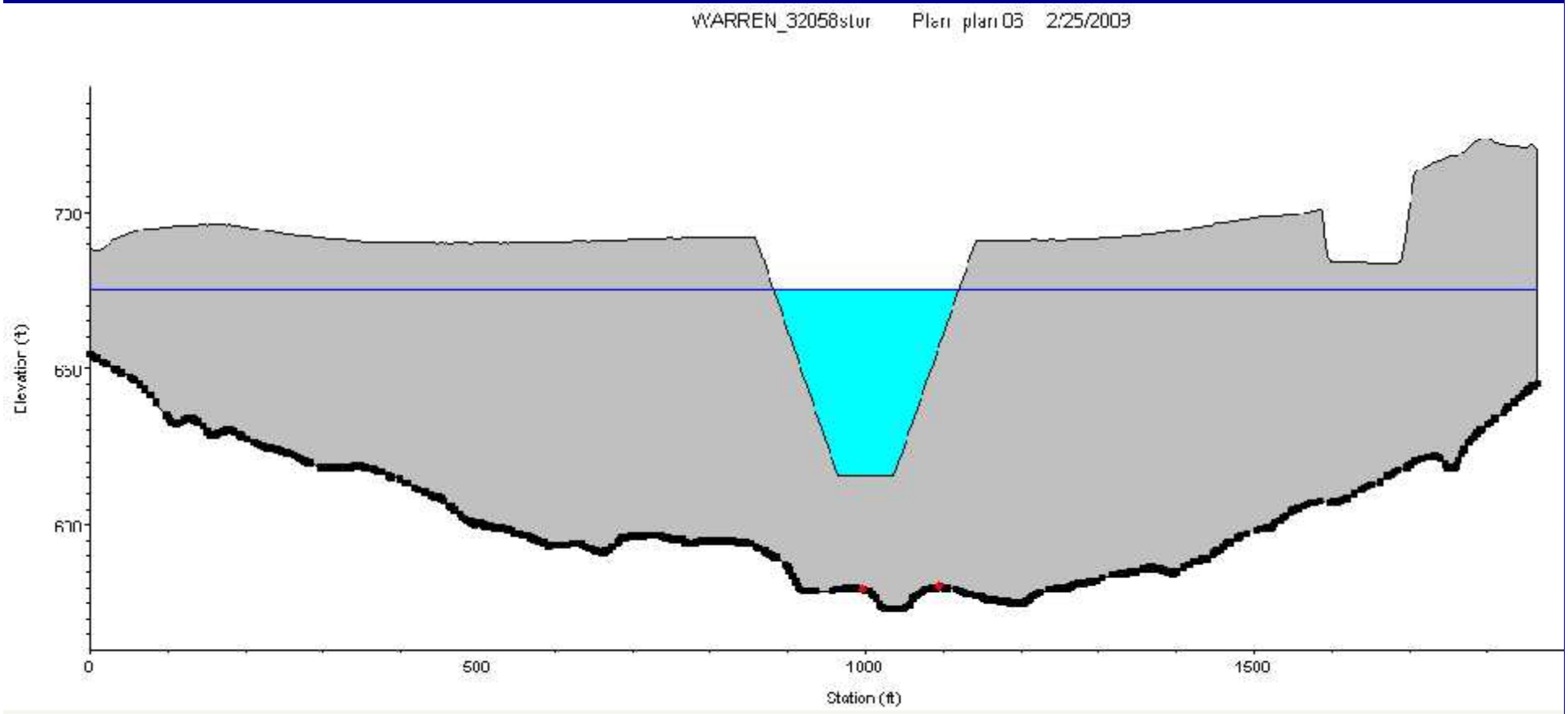
- Free download from USACE
- One dimensional model
- Steady and Unsteady flow
- Widely used and accepted
- Flexible, but consistent




WARREN 32058slor Plan: plan 06 2/25/2009
Dam Crest
Spillway
Water Surface at Failure
Elevation (ft)
700
650
600
0
500
1000
1500
Station (ft)


WARREN_32058slor Plan: plan 06 2/25/2009
Elevation (ft)
700
650
600
0
500
1000
1500
Station (ft)
Trapezoidal shape


WARREN_2050stor Plan: plan 06 2/25/2009
700
650
600
0
500
1000
500
Station (ft)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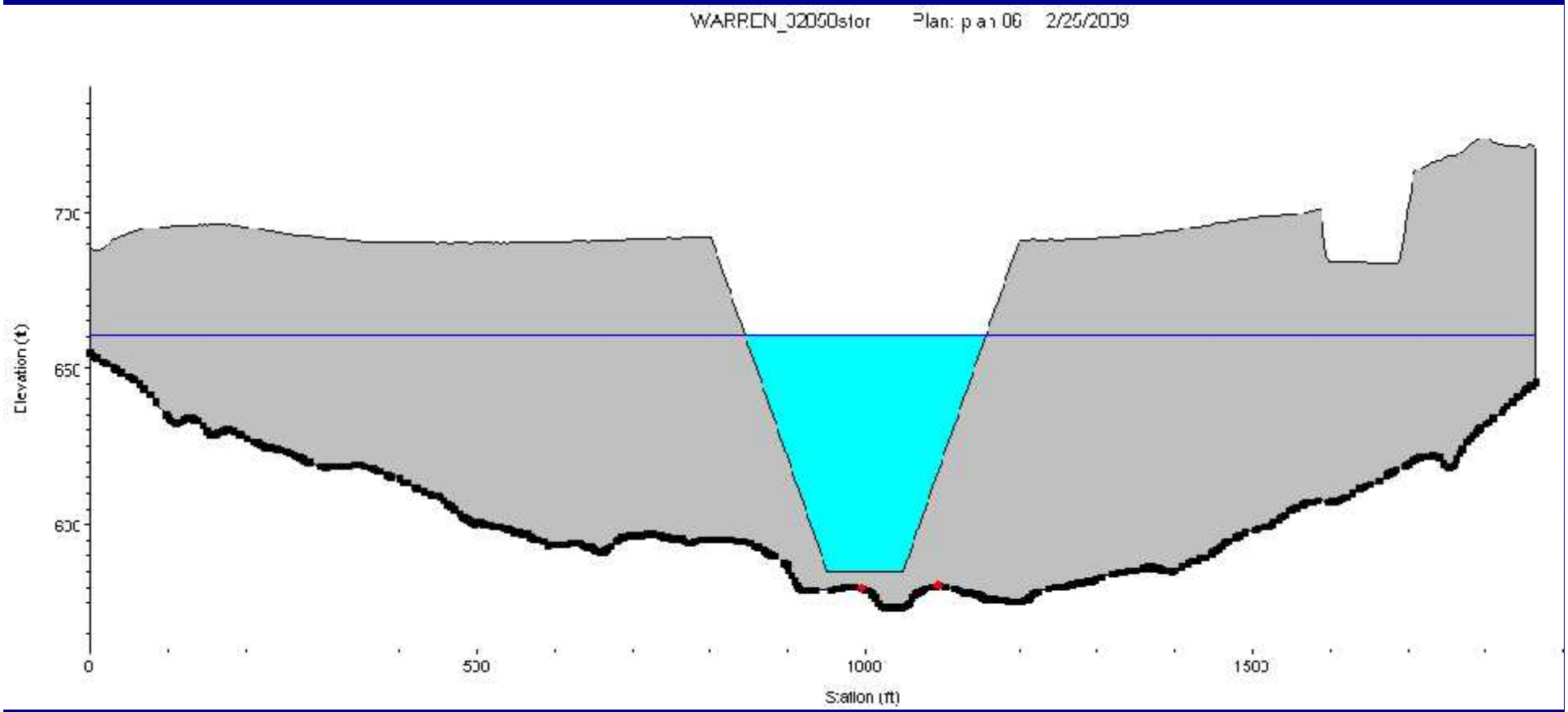
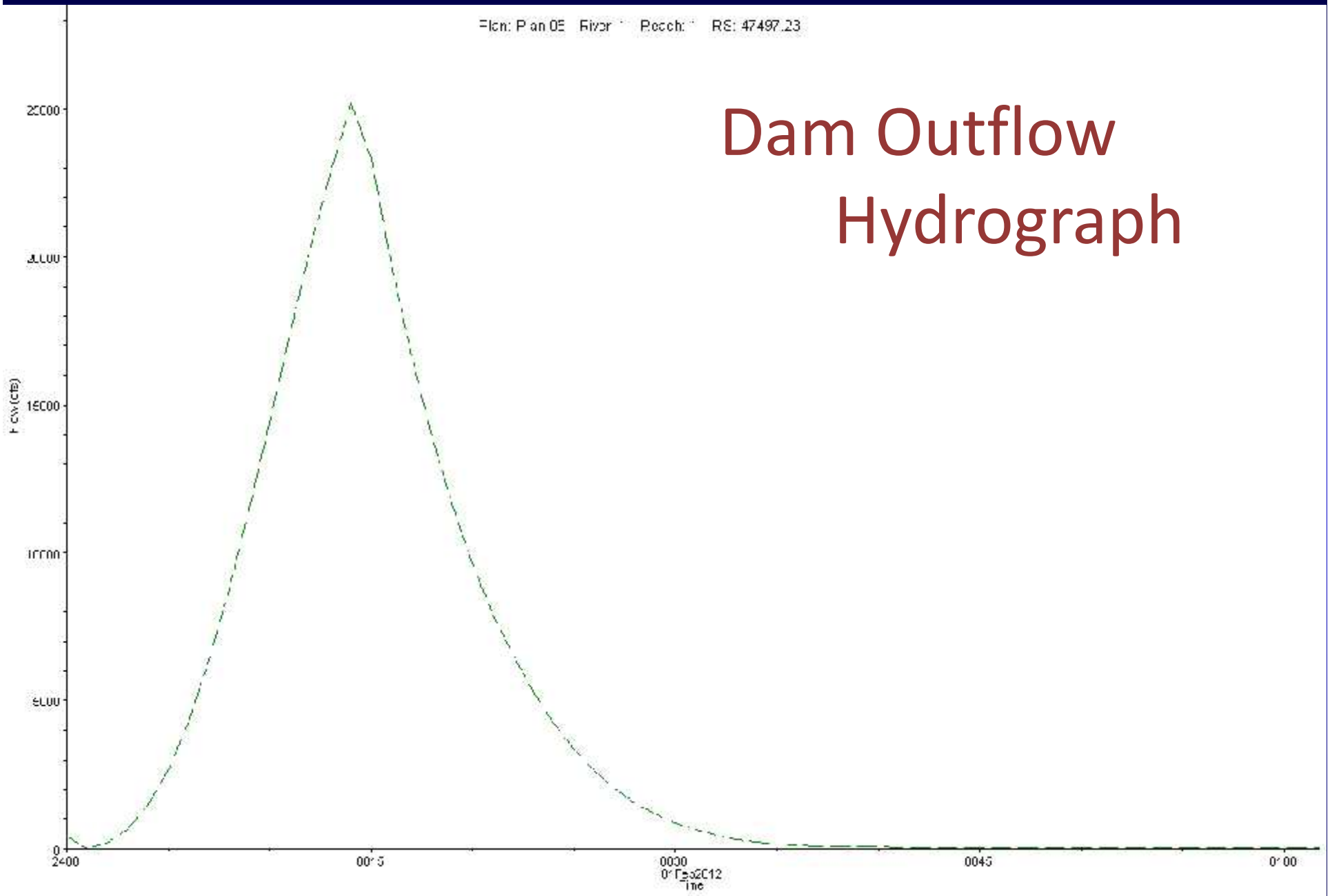
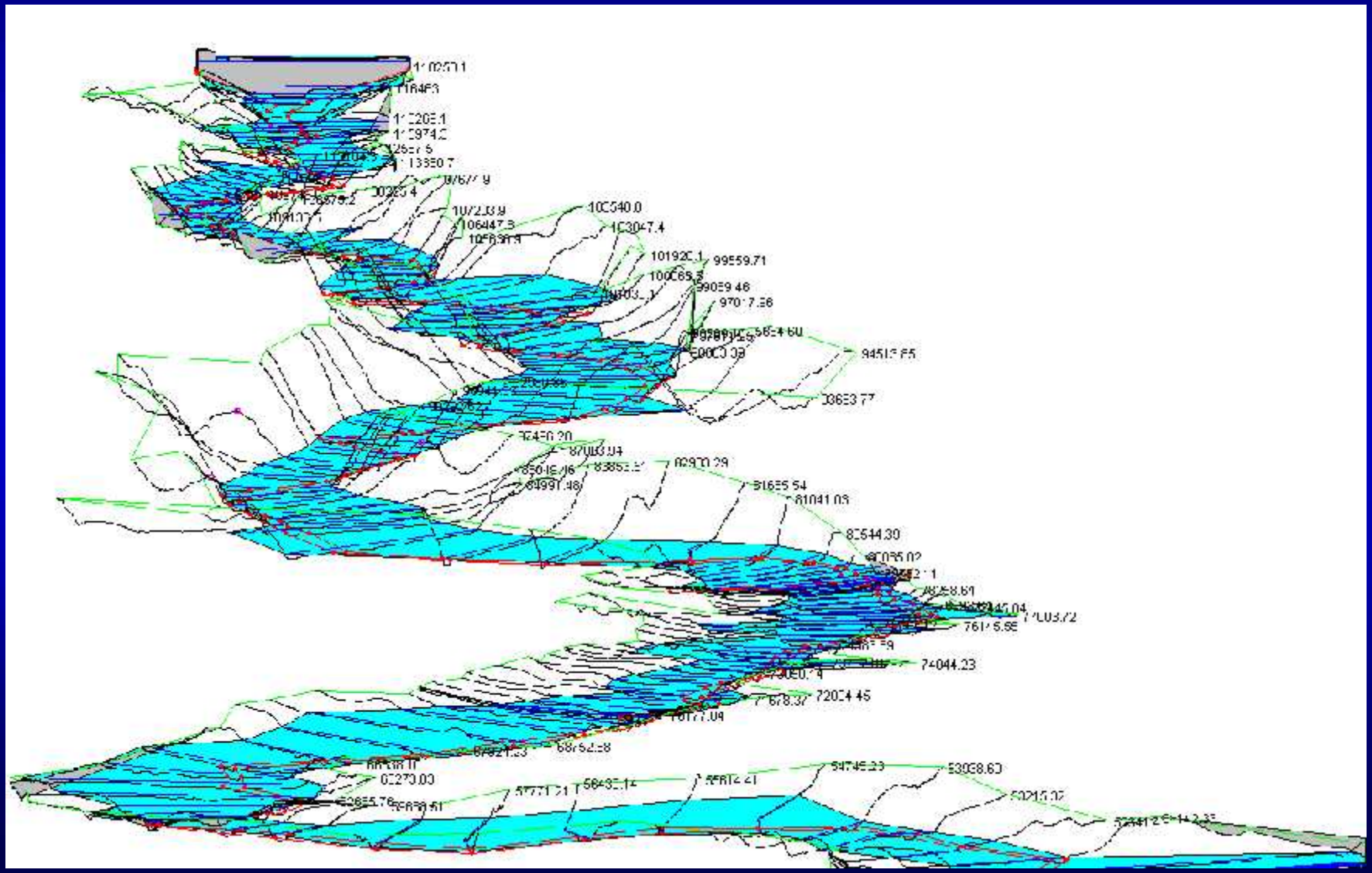
700
650
600
Elevation (ft)
0
500
1000
1500
Station (ft)

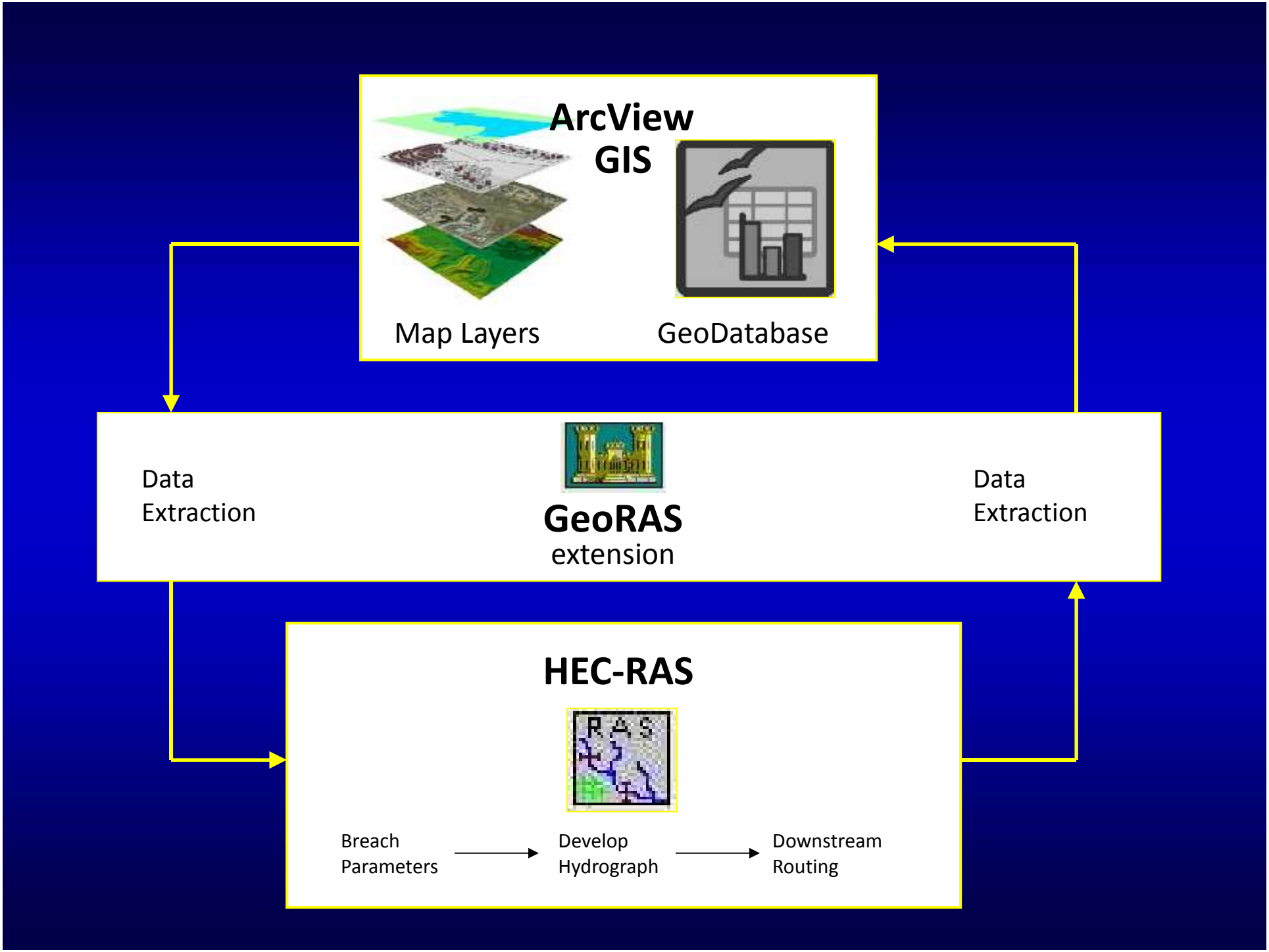

WARREN_2050stor Plan: plan 06 2/25/2009
700
650
600
Elevation (ft)
0
500
1000
1500
Station (ft)

Dam Outflow Hydrograph



HEC-RAS Maximum WS

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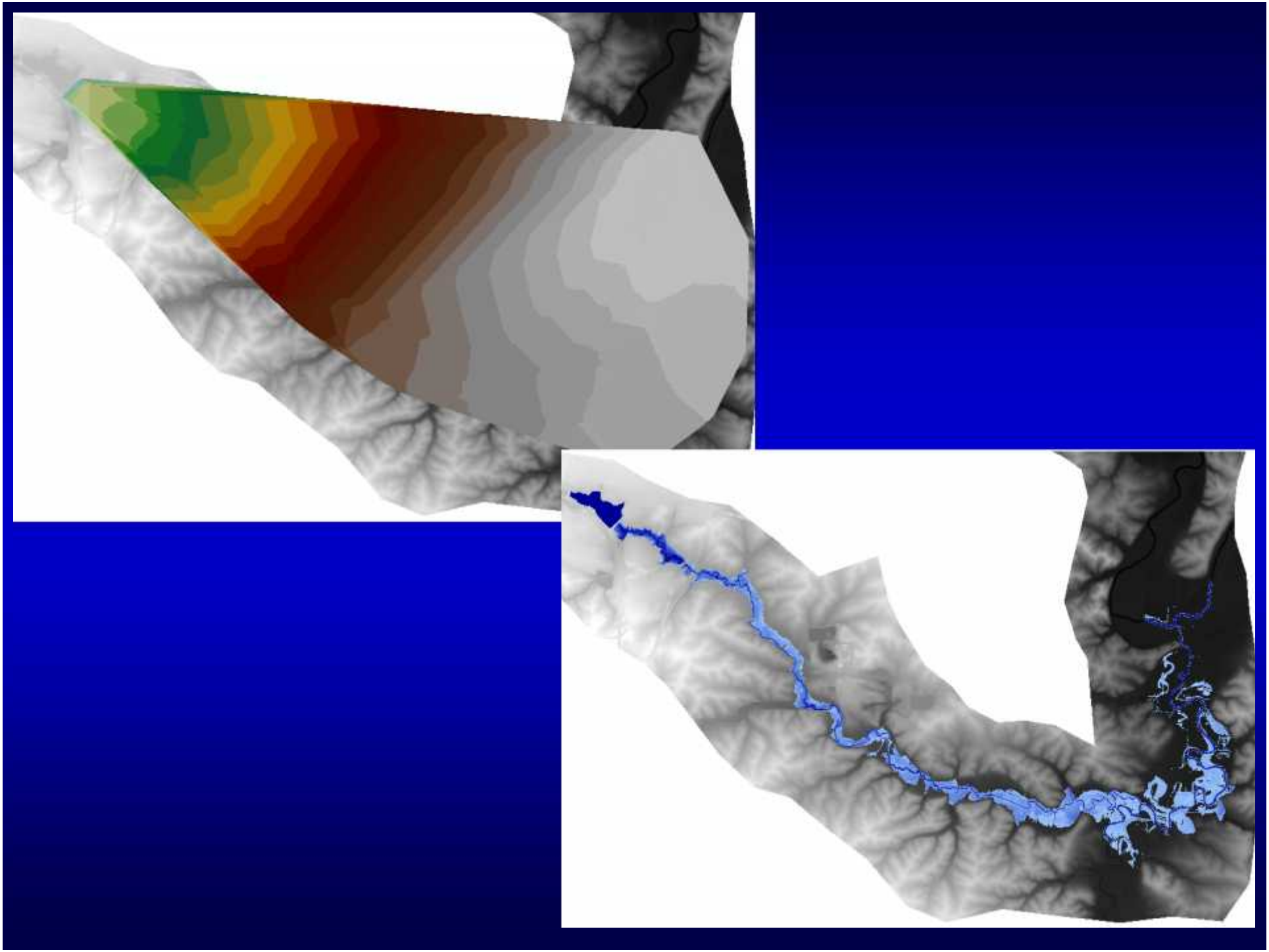
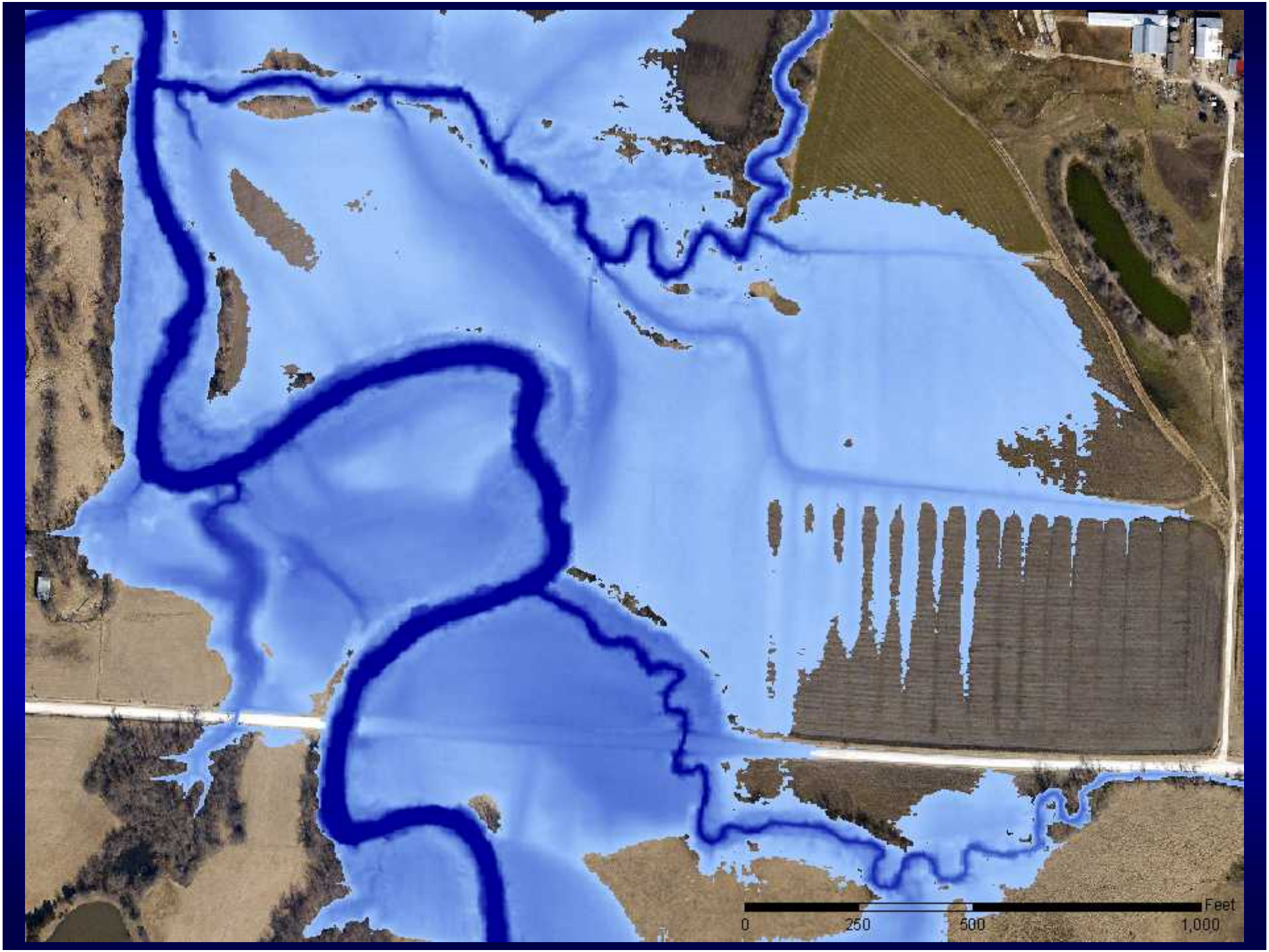
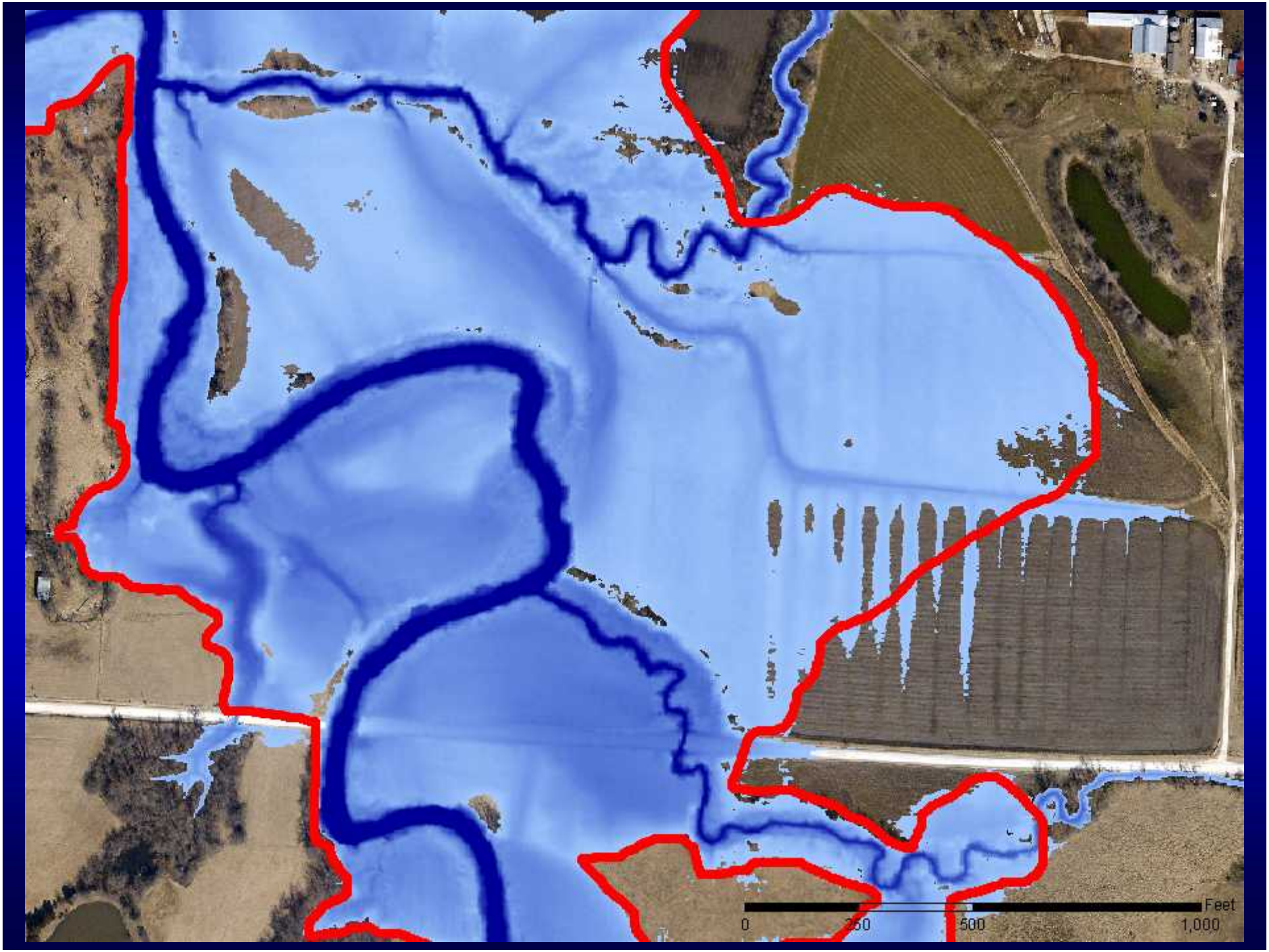
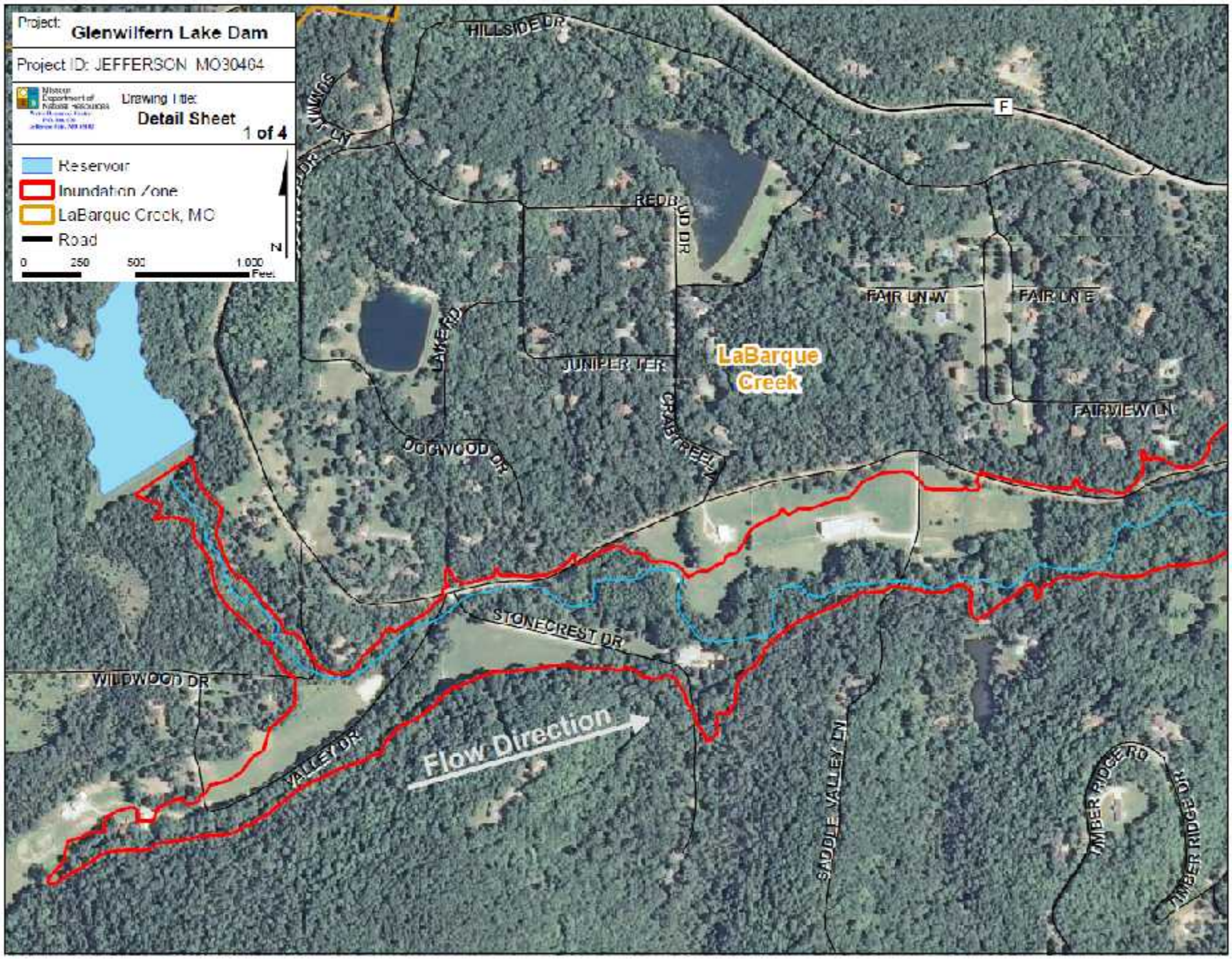
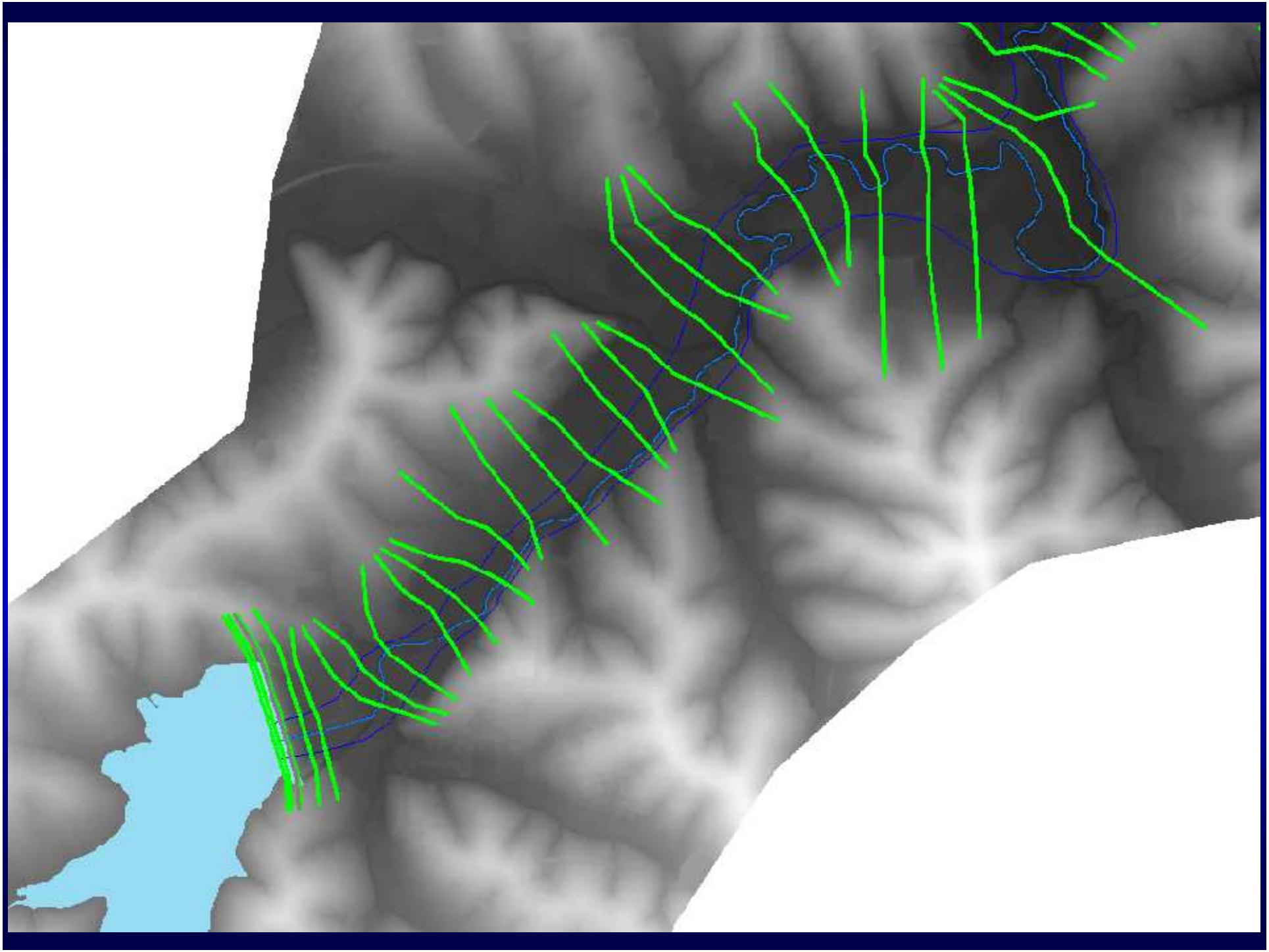
Downstream
Routing

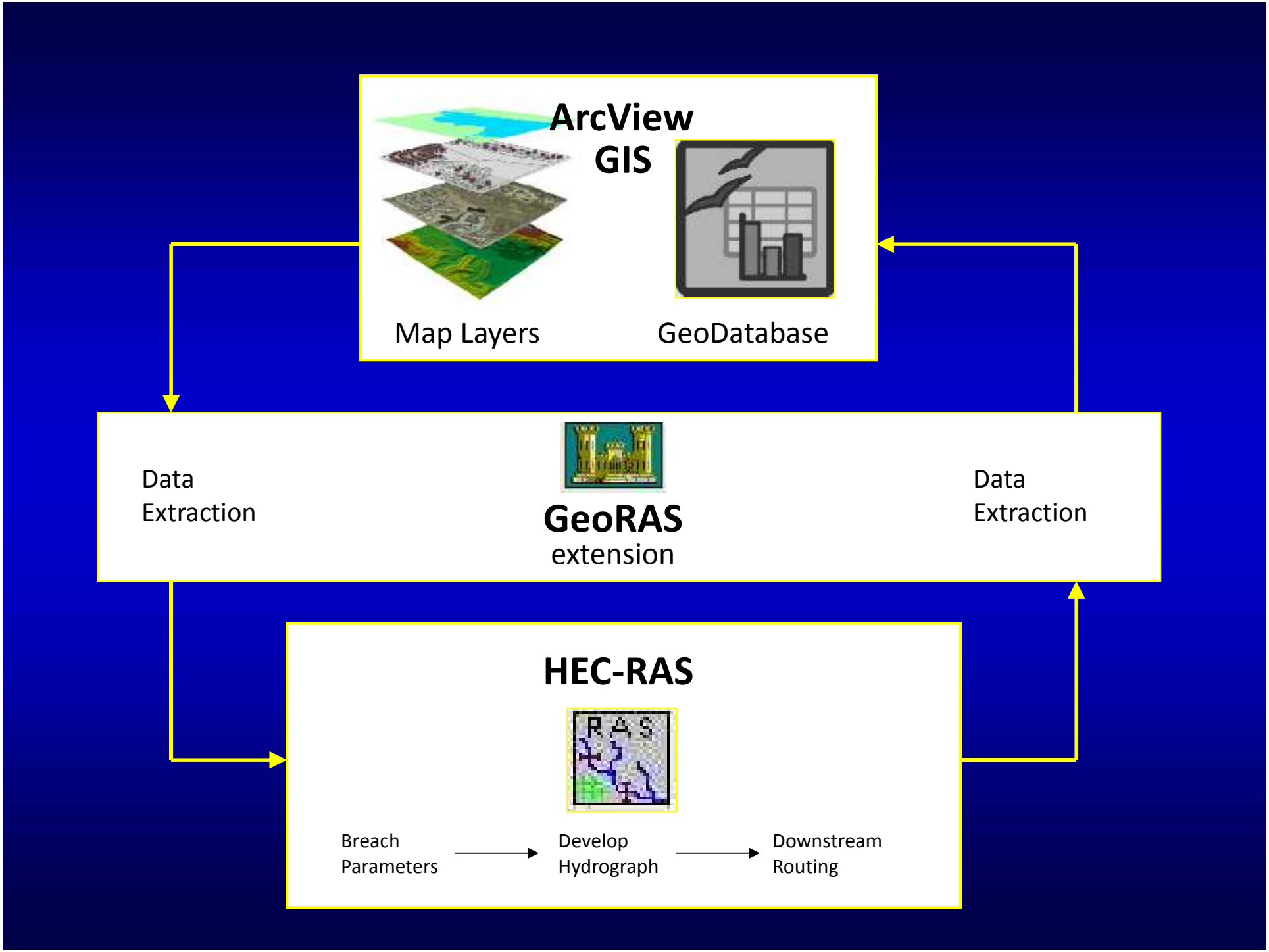


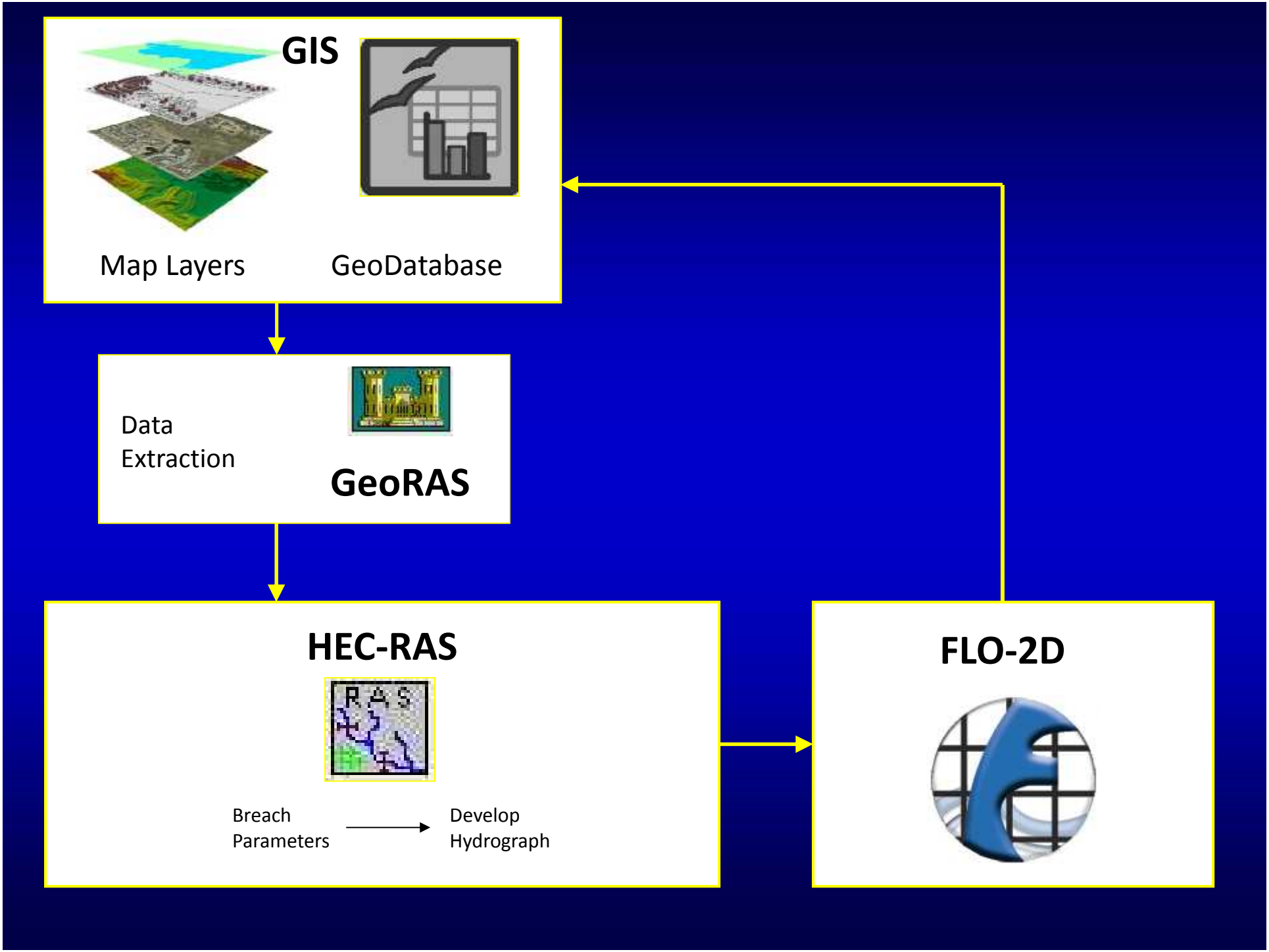

Feet
0
250
500
1,000


Feet
0
250
500
1,000


Project: Glenwilfern Lake Dam
Project ID: JEFFERSON MO30464
Drawing Title: Detail Sheet
1 of 4
Reservoir
Inundation Zone
LaBarque Creek, MO
Road
N
0 250 500 1,000 Feet
HILLSIDE DR
F
REDBUD DR
FAIR LN W
FAIR LN E
FAIRVIEW LN
LAKE RD
JUNIPER TER
CRABTREE LN
DOGWOOD DR
LaBarque Creek
STONECREST DR
WILDWOOD DR
VALLEY DR
Flow Direction
SADDLE VALLEY LN
TIMBER RIDGE RD
TIMBER RIDGE DR

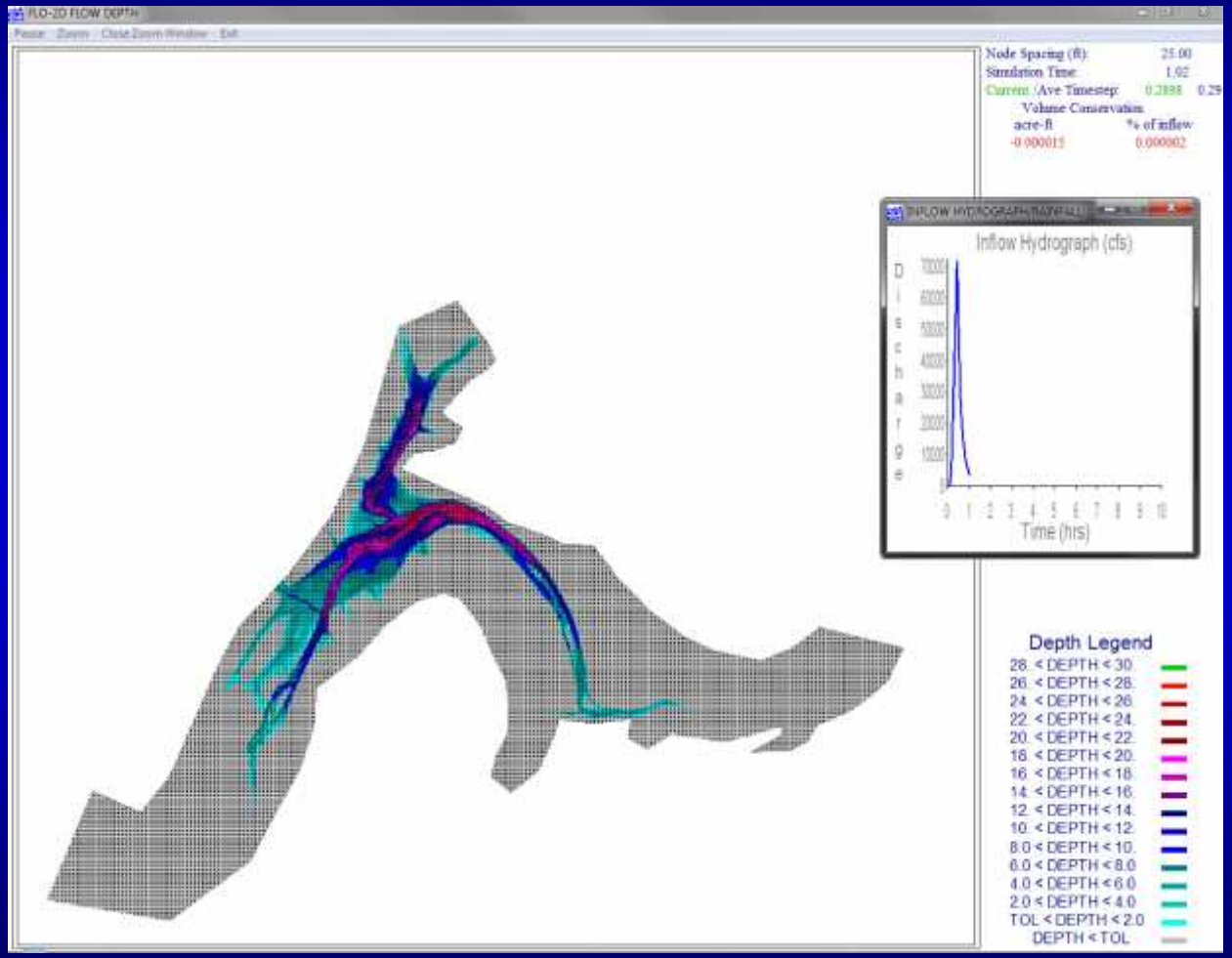


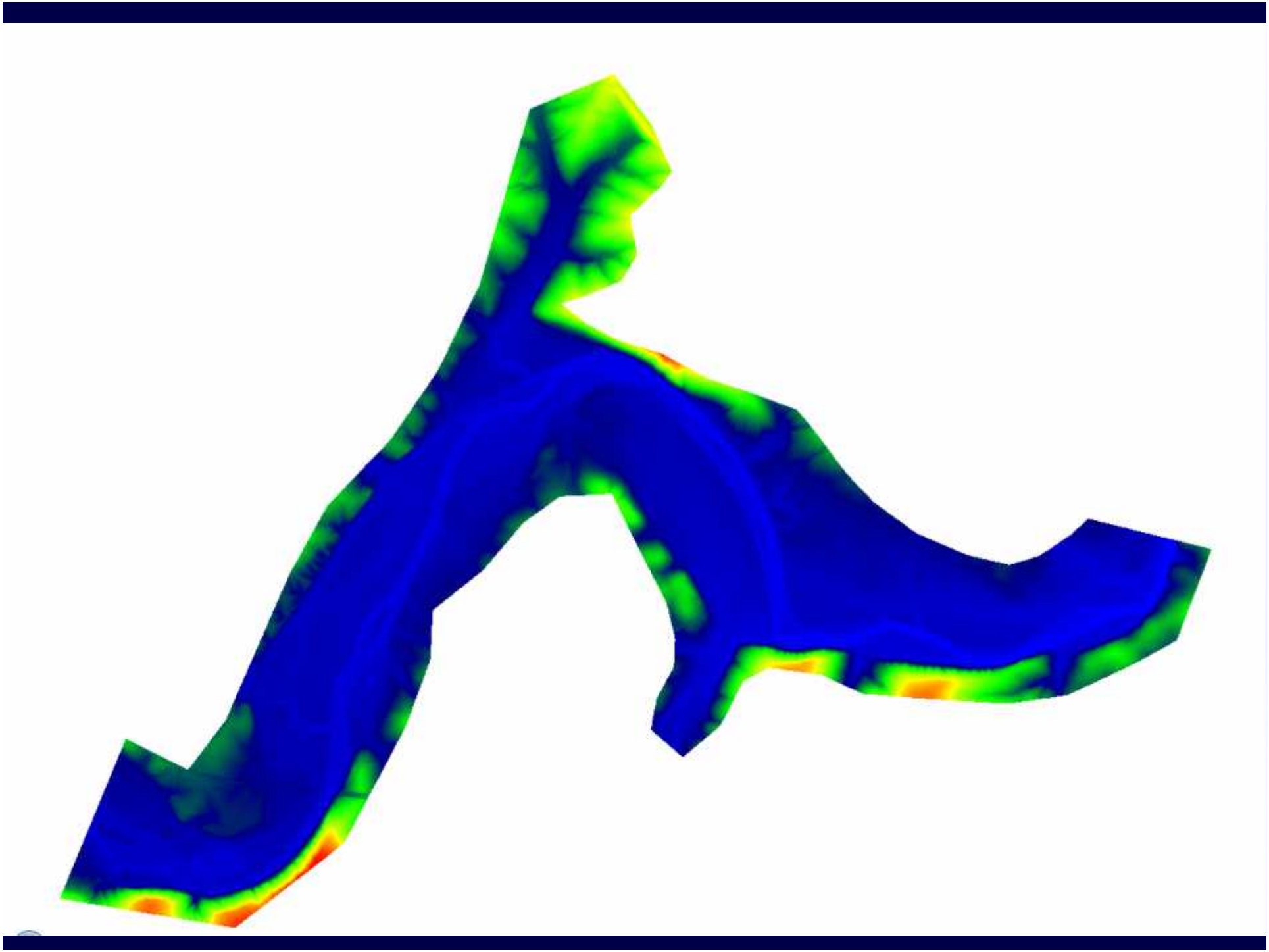

ArcView
GIS
Map Layers
GeoDatabase
Data
Extraction
GeoRAS
extension
Data
Extraction
HEC-RAS
Breach
Parameters
Develop
Hydrograph
Downstream
Routing

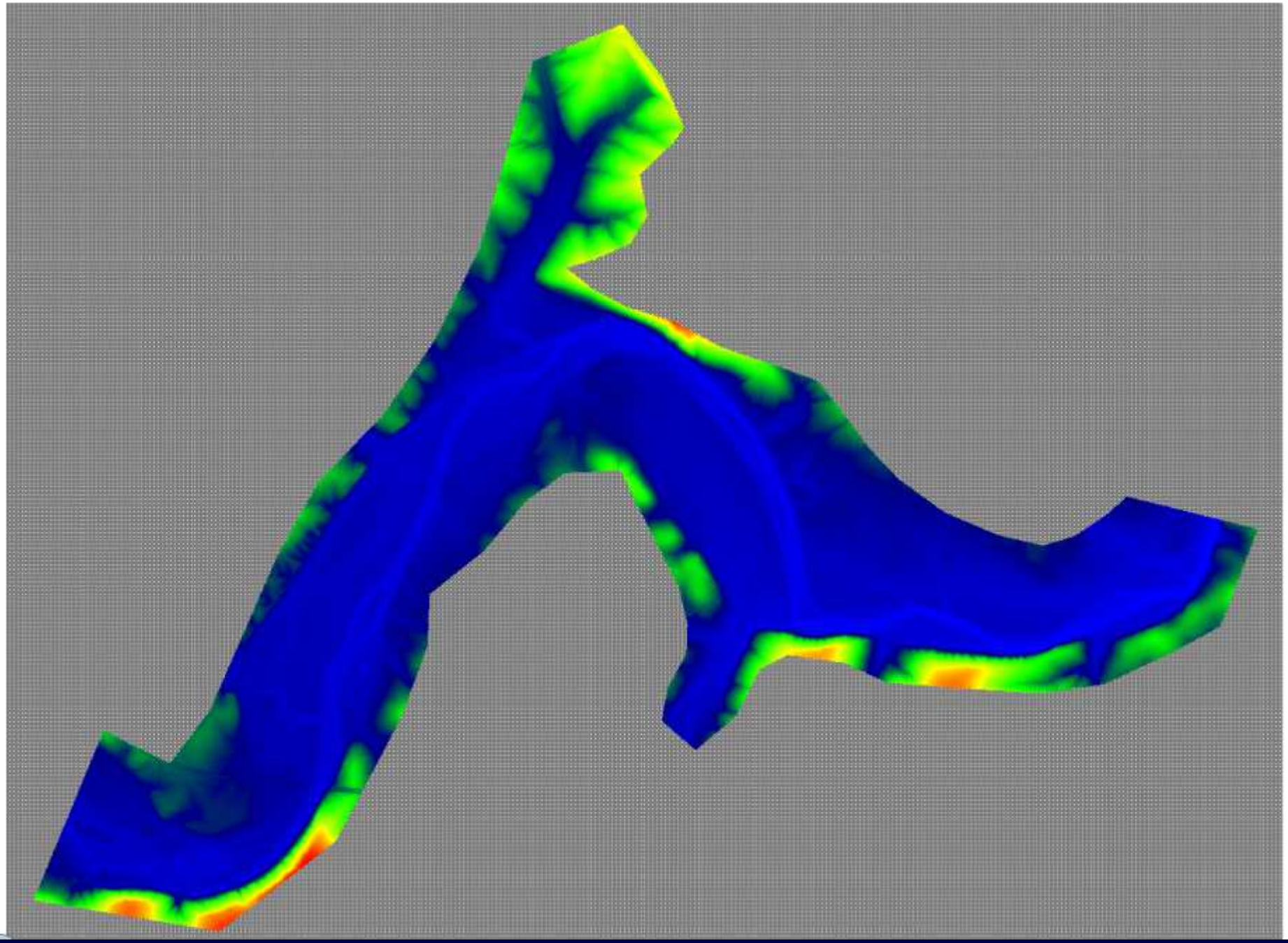

GIS
Map Layers
GeoDatabase
Data
Extraction
GeoRAS
HEC-RAS
Breach
Parameters
Develop
Hydrograph
FLO-2D

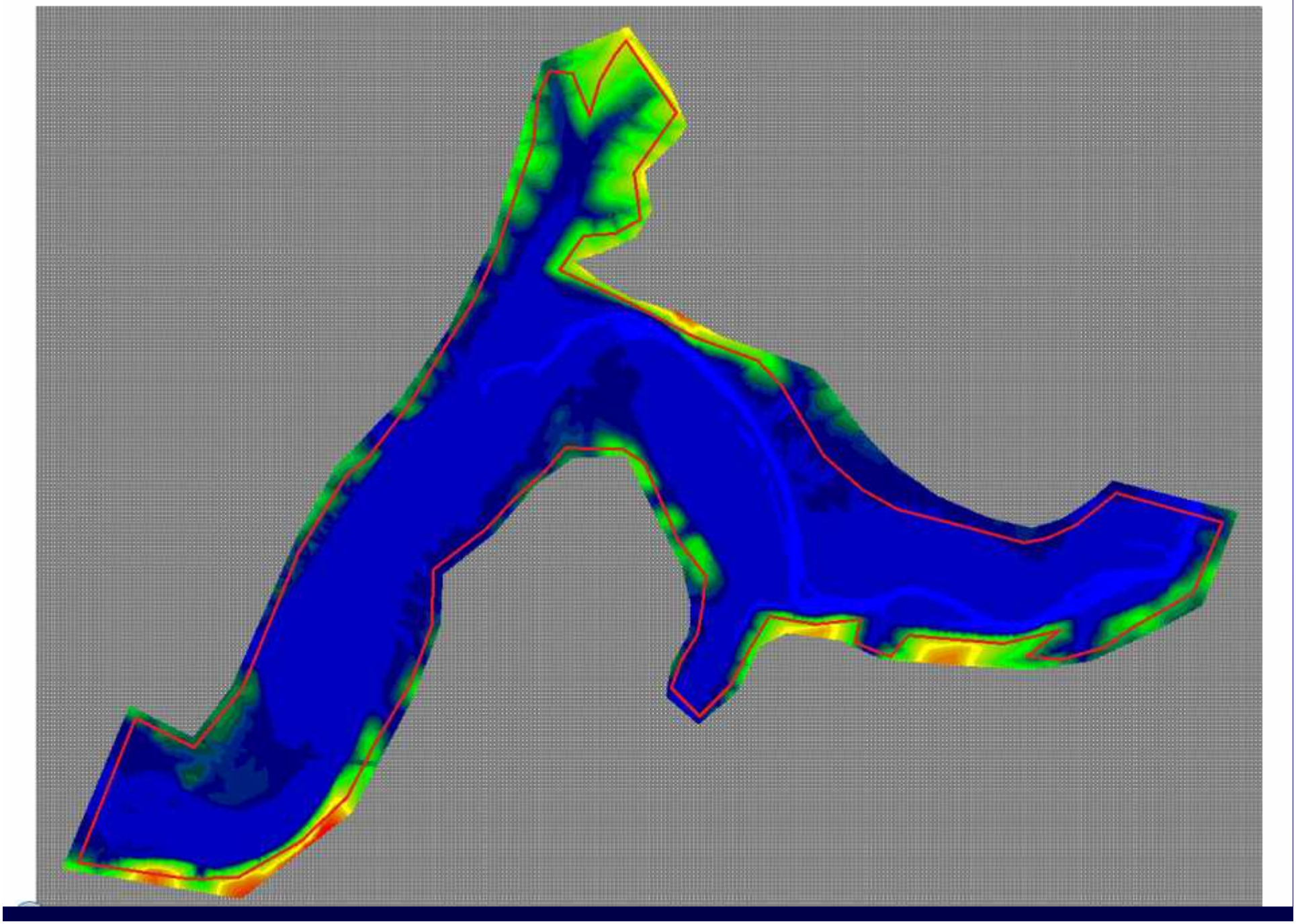
FLO-2D

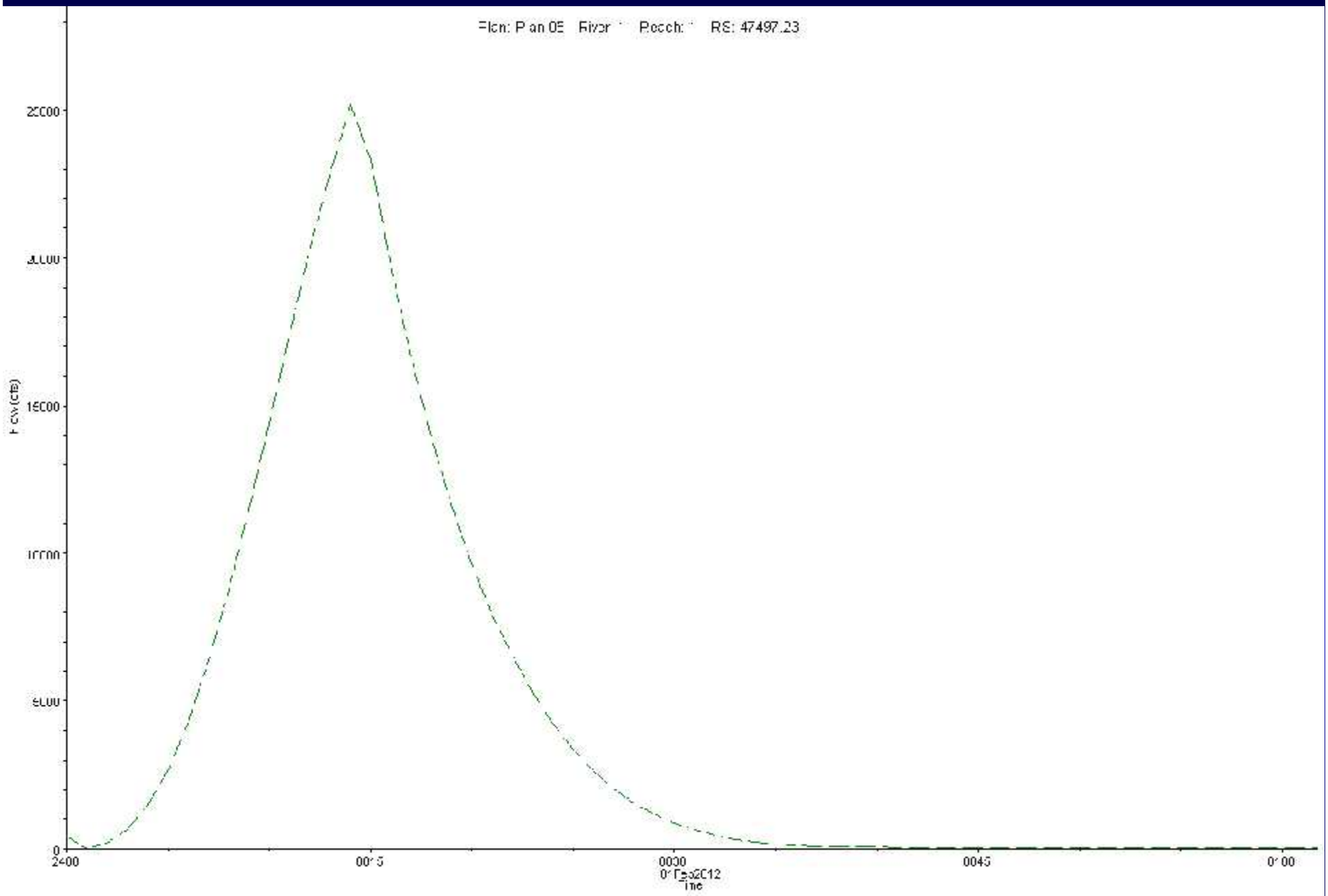
- Not free
- Two dimensional model
- Non-Newtonian flow capabilities
- Widely used and accepted

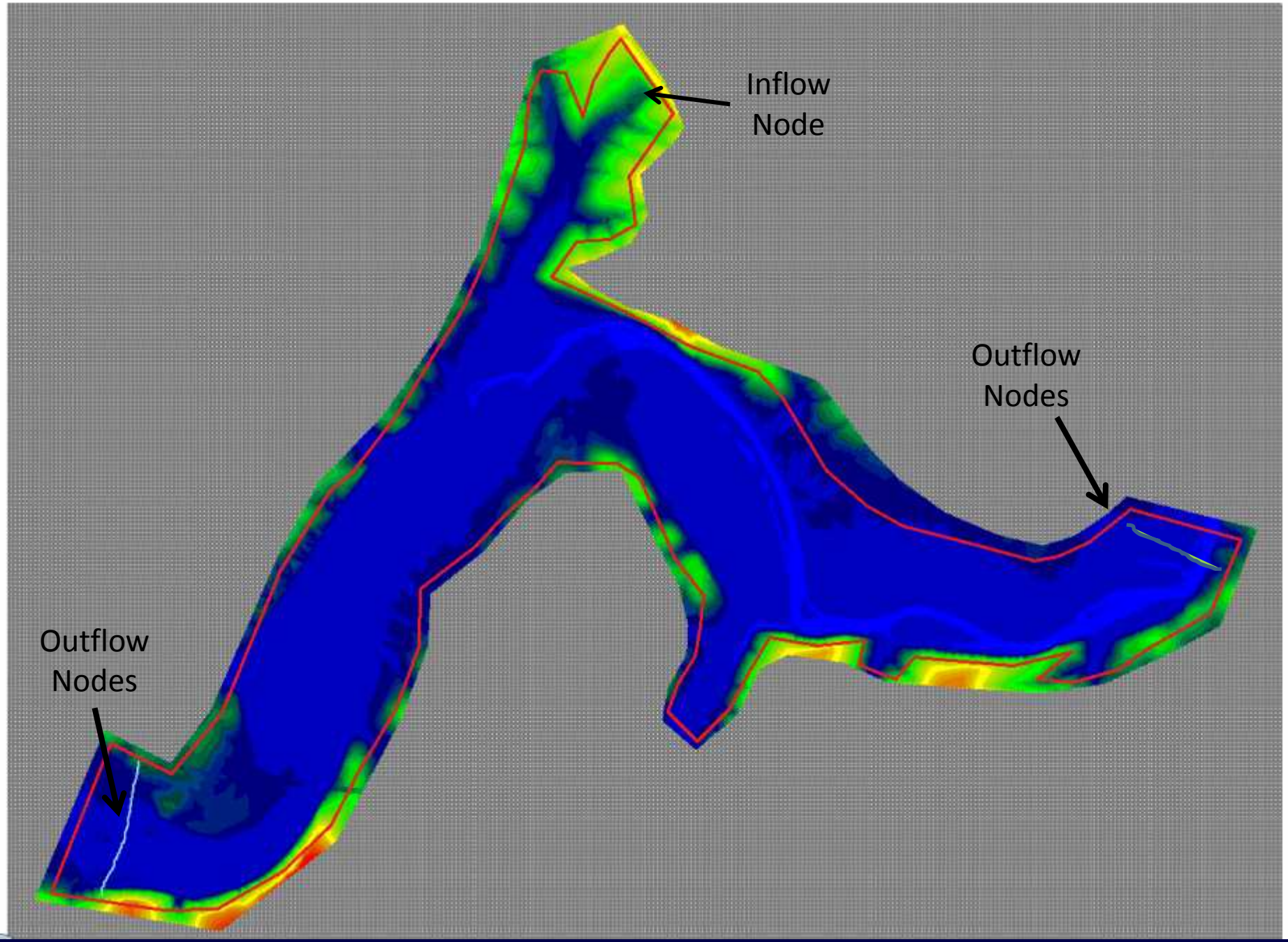


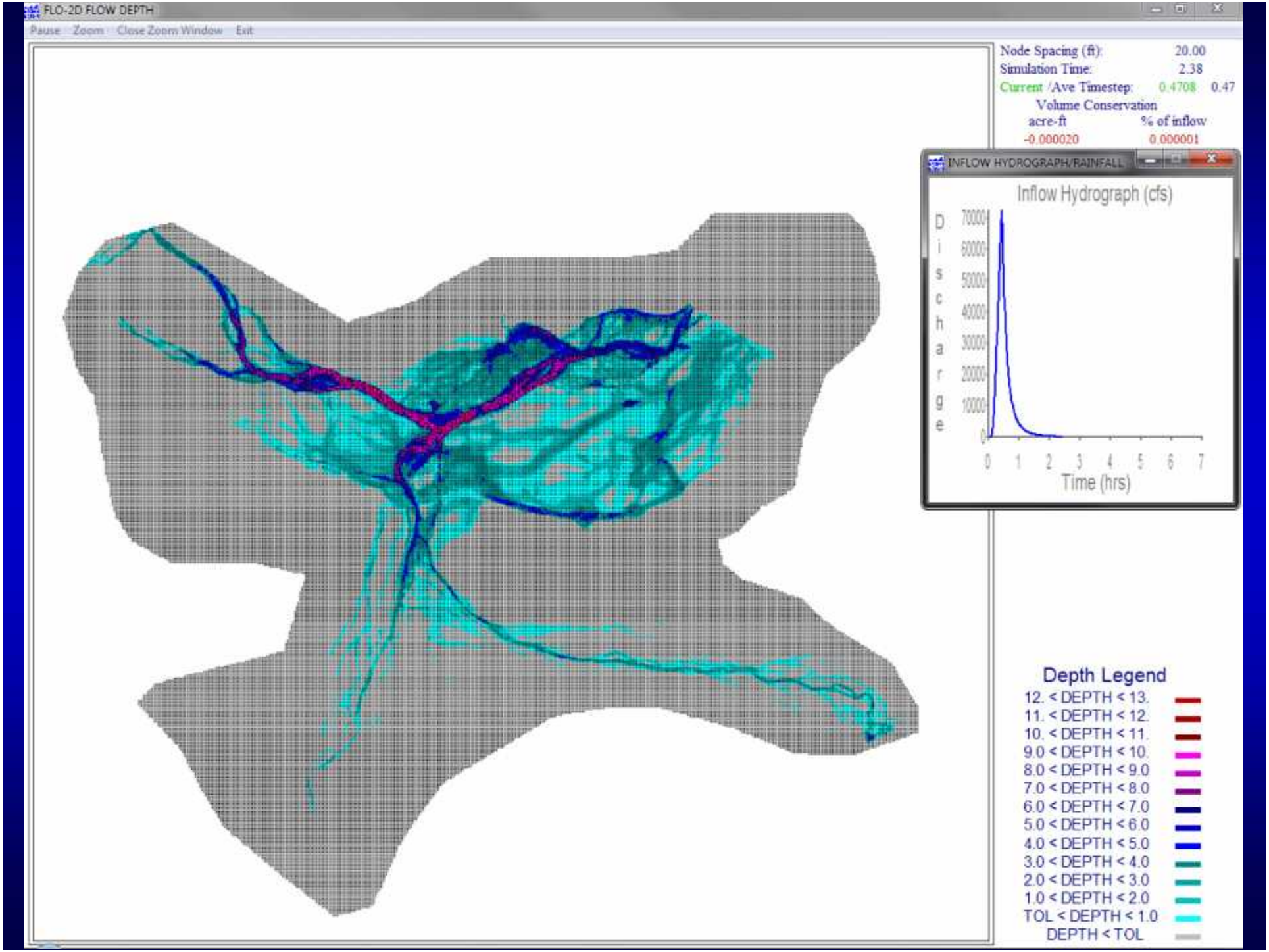




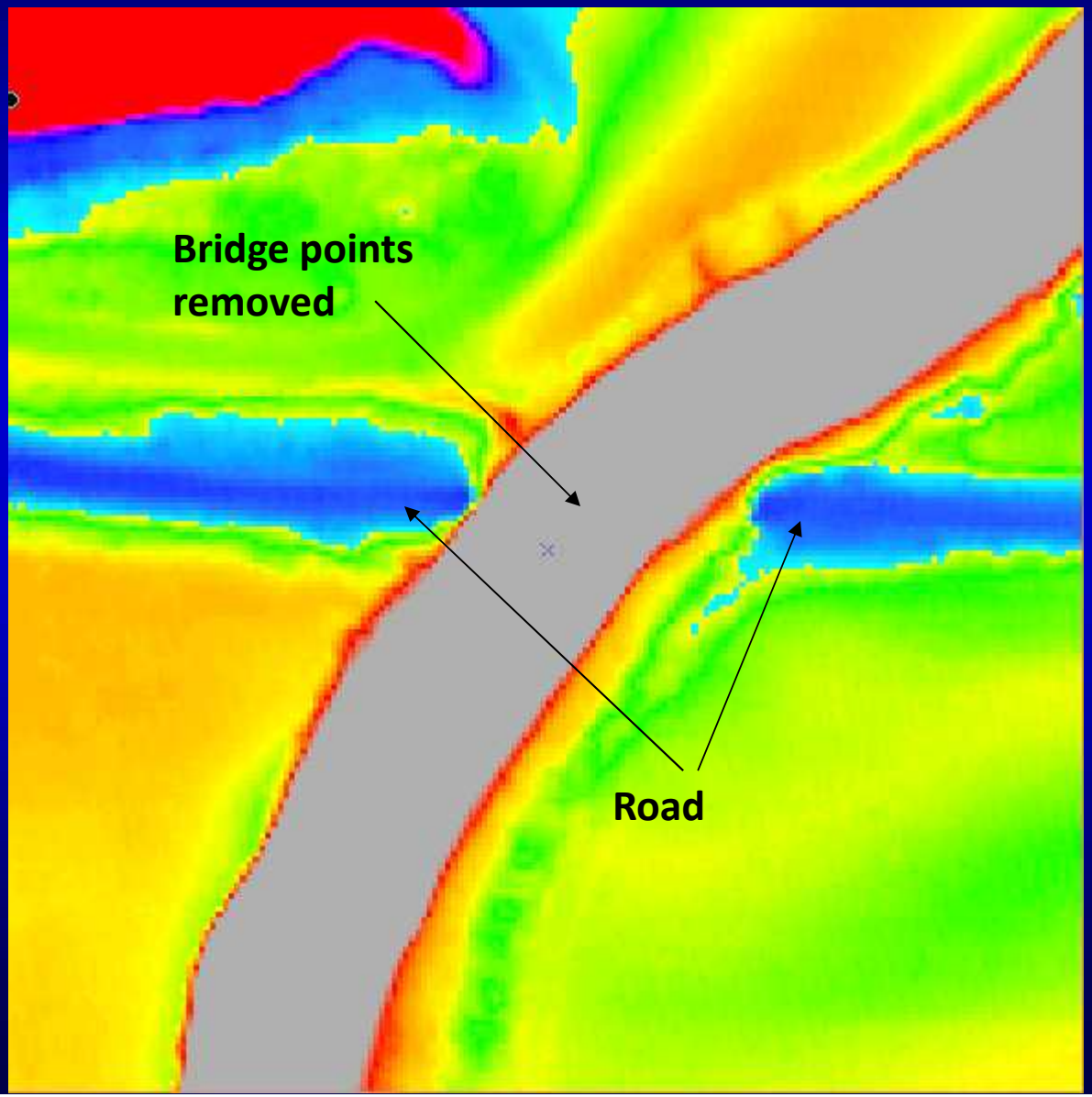


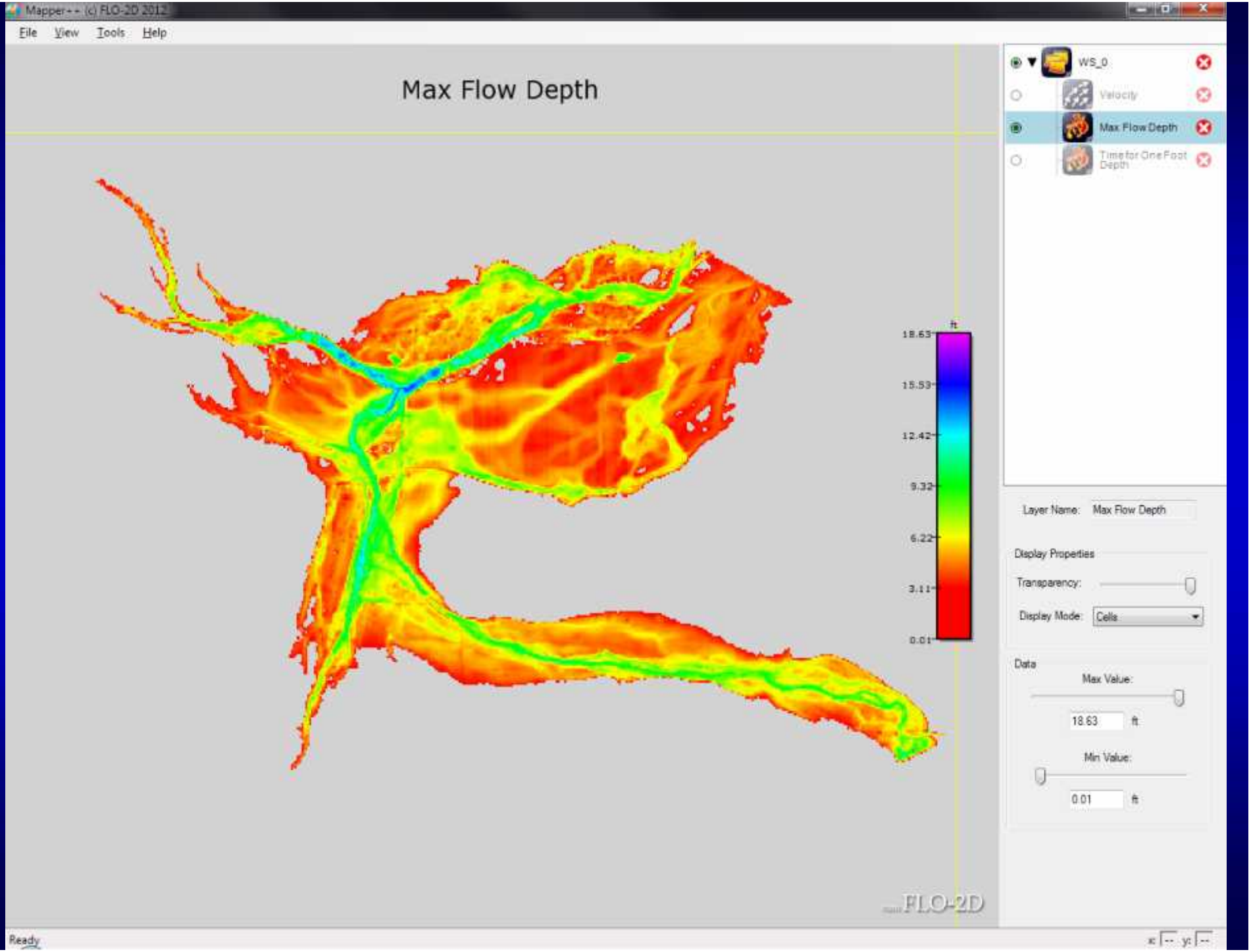

Plan: Plan 05 River: Reach: RS: 47497.23
20000
15000
10000
5000
0
2400
0000
0048
Time

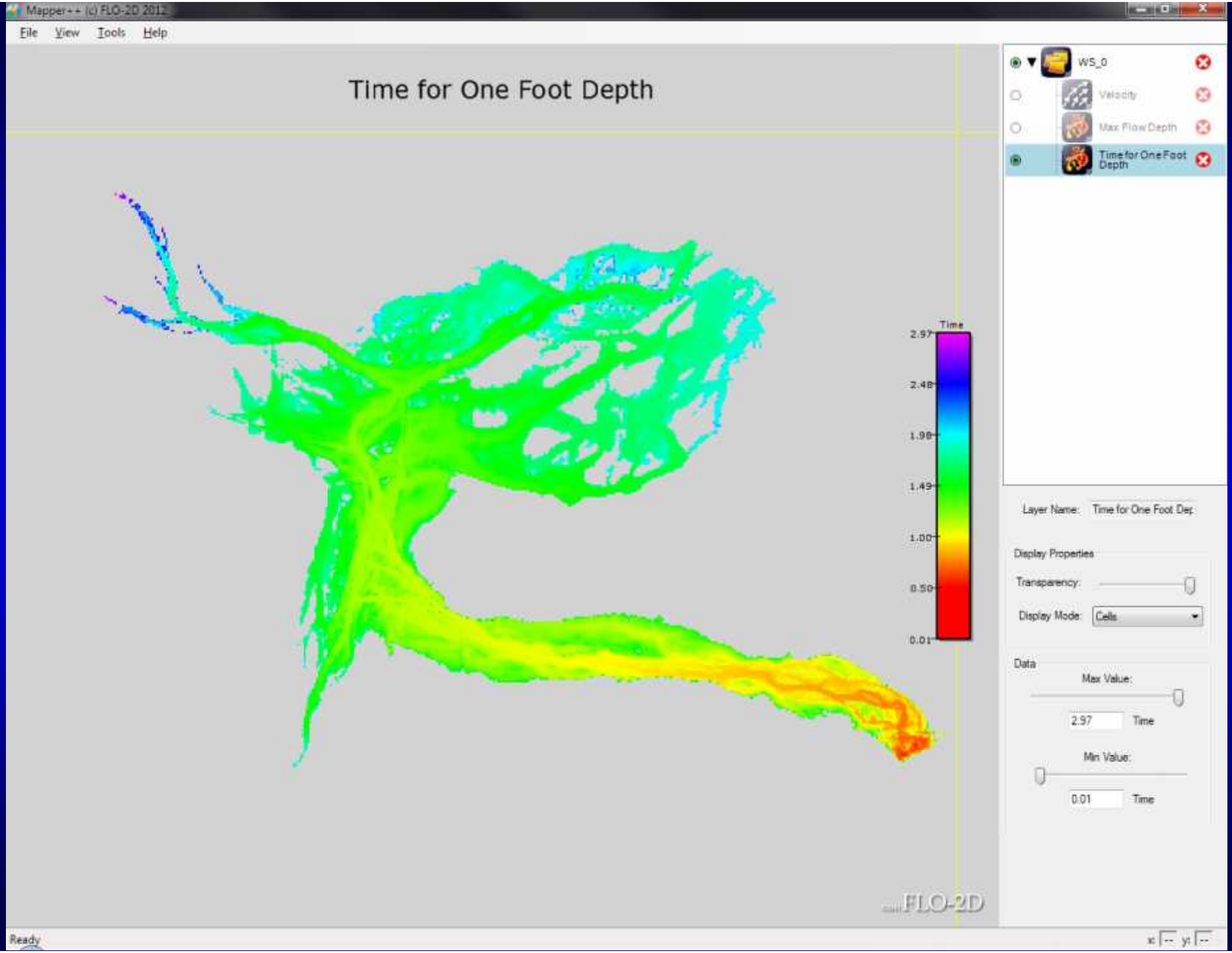

Inflow
Node
Outflow
Nodes
Outflow
Nodes

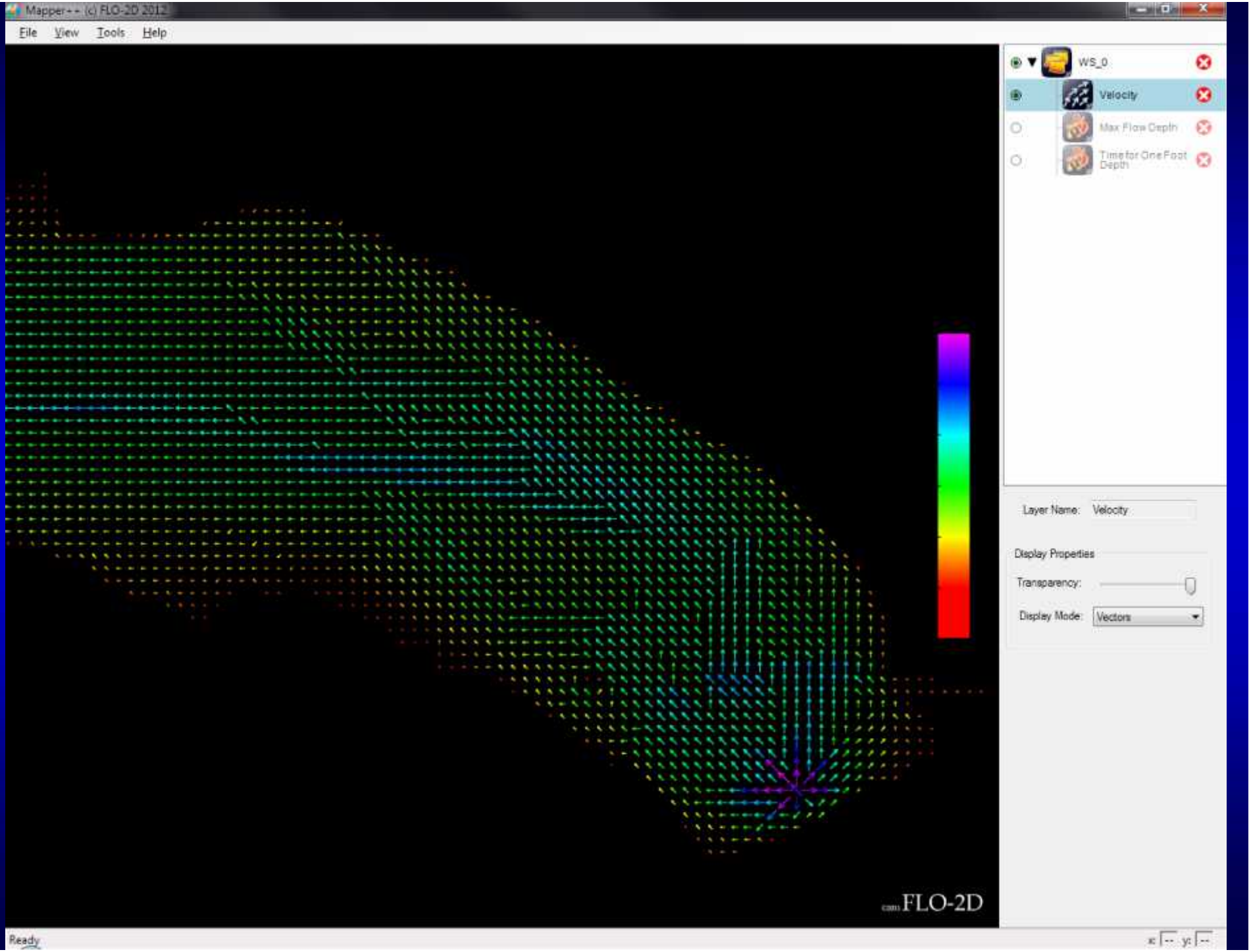

FLO-2D FLOW DEPTH
Pause Zoom Close Zoom Window Exit
Node Spacing (ft): 20.00
Simulation Time: 2.38
Current /Ave Timestep: 0.4708 0.47
Volume Conservation
acre-ft % of inflow
-0.000020 0.000001
INFLOW HYDROGRAPH/RAINFALL
Inflow Hydrograph (cfs)
Discharge
70000
60000
50000
40000
30000
20000
10000
0
0 1 2 3 4 5 6 7
Time (hrs)
Depth Legend
12. < DEPTH < 13.
11. < DEPTH < 12.
10. < DEPTH < 11.
9.0 < DEPTH < 10.
8.0 < DEPTH < 9.0
7.0 < DEPTH < 8.0
6.0 < DEPTH < 7.0
5.0 < DEPTH < 6.0
4.0 < DEPTH < 5.0
3.0 < DEPTH < 4.0
2.0 < DEPTH < 3.0
1.0 < DEPTH < 2.0
TOL < DEPTH < 1.0
DEPTH < TOL

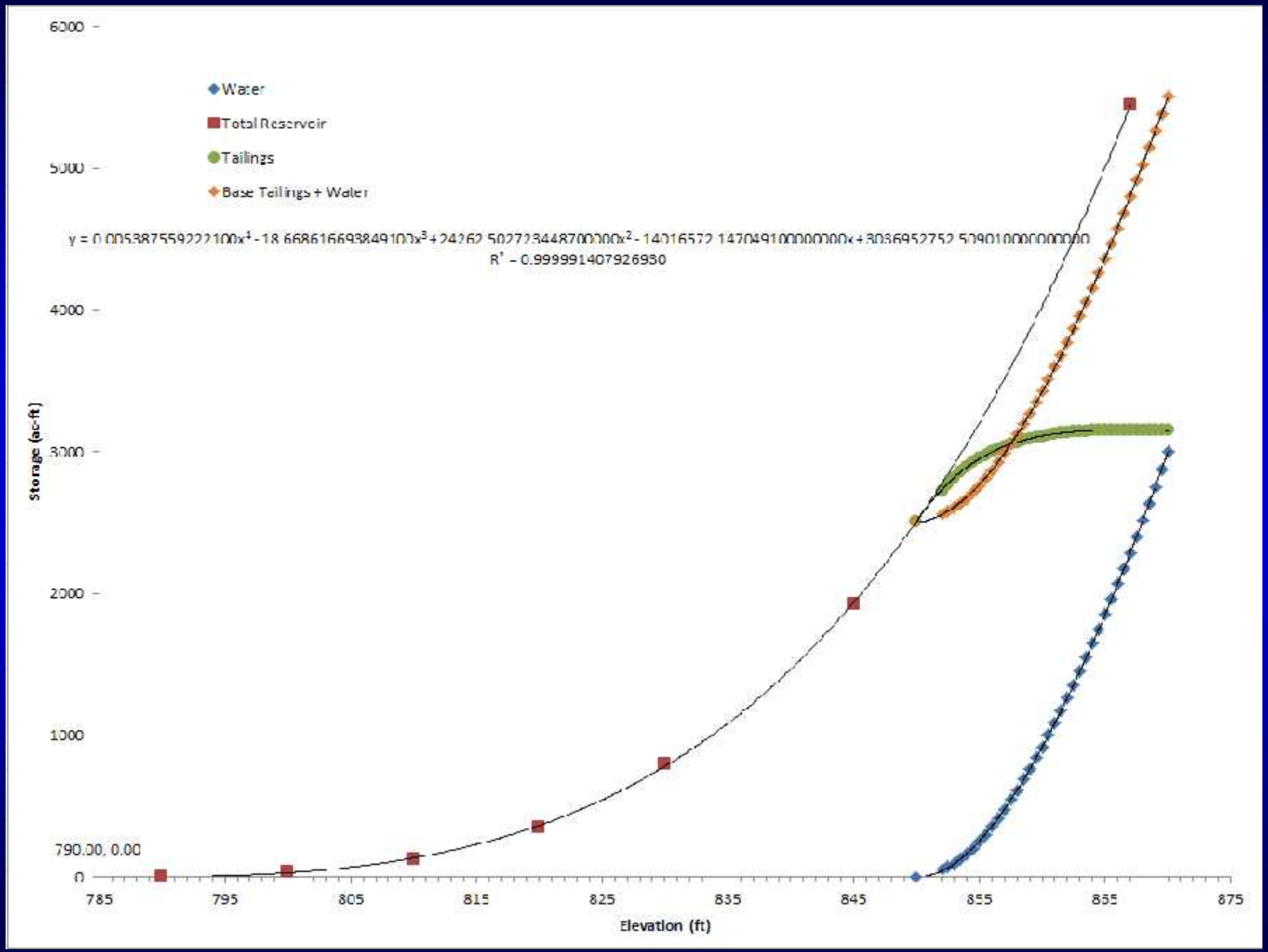
LiDAR Hydro-Enforcement

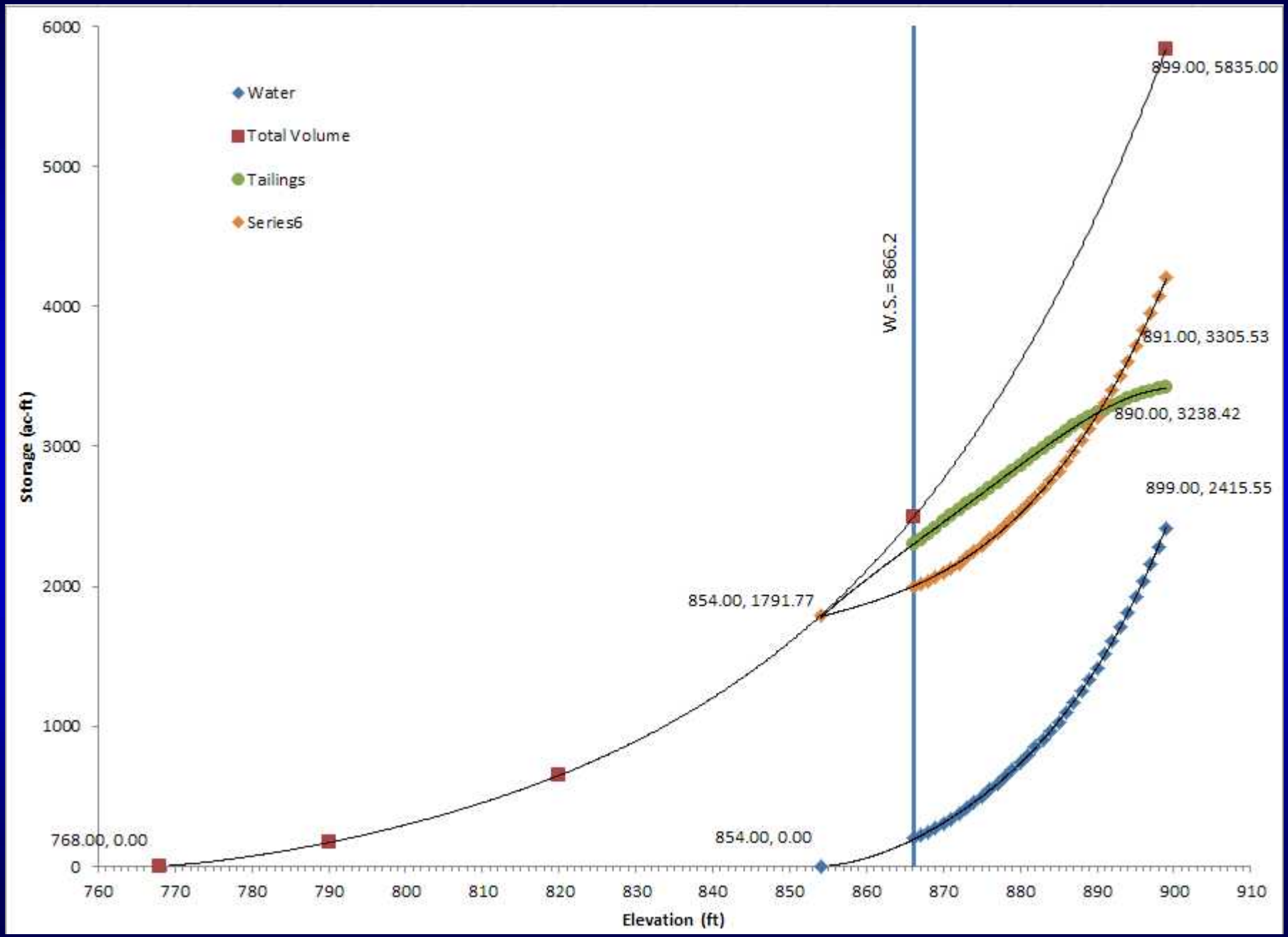


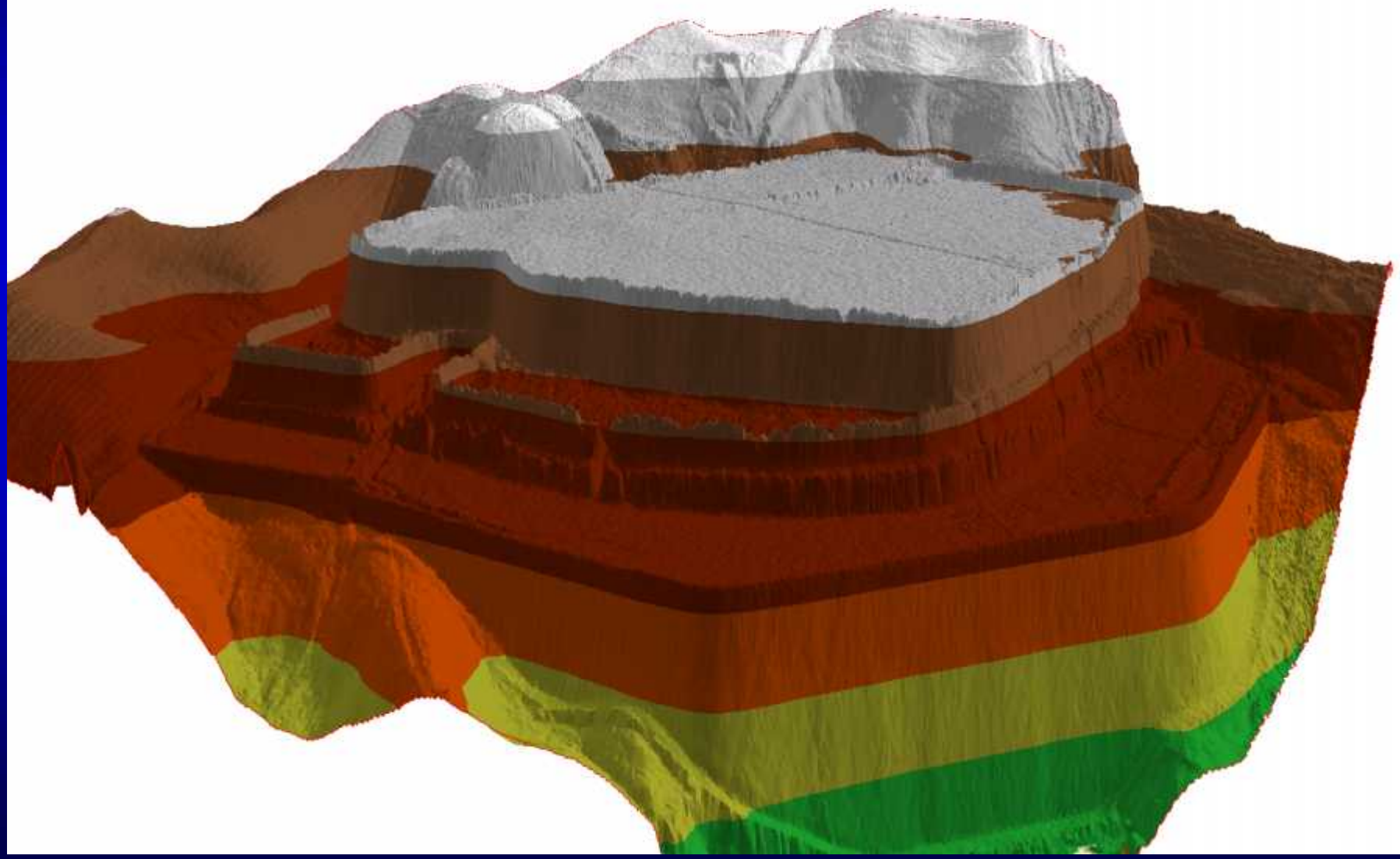

Mapper++ (c) FLO-2D 2012
File View Tools Help
Max Flow Depth
WS_0
Velocity
Max Flow Depth
Time for One Foot Depth
ft
18.63
15.53
12.42
9.32
6.22
3.11
0.01
Layer Name: Max Flow Depth
Display Properties
Transparency:
Display Mode: Cells
Data
Max Value:
18.63 ft
Min Value:
0.01 ft
FLO-2D
Ready
x: -- y: --

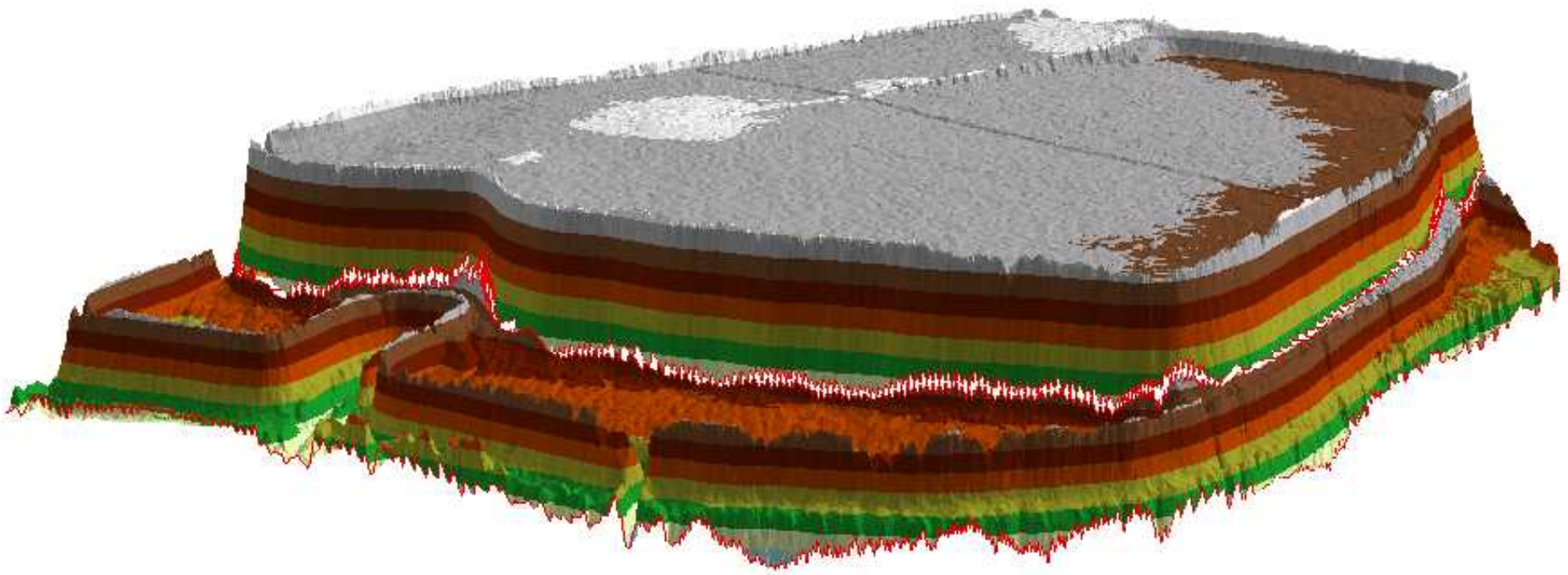

Mapper++ (c) FLO-2D 2012
File View Tools Help
Time for One Foot Depth
WS_0
Velocity
Max Flow Depth
Time for One Foot Depth
Time
2.97
2.48
1.98
1.49
1.00
0.50
0.01
Layer Name: Time for One Foot Dep
Display Properties
Transparency:
Display Mode: Cells
Data
Max Value:
2.97 Time
Min Value:
0.01 Time
FLO-2D
Ready
x: -- y: --

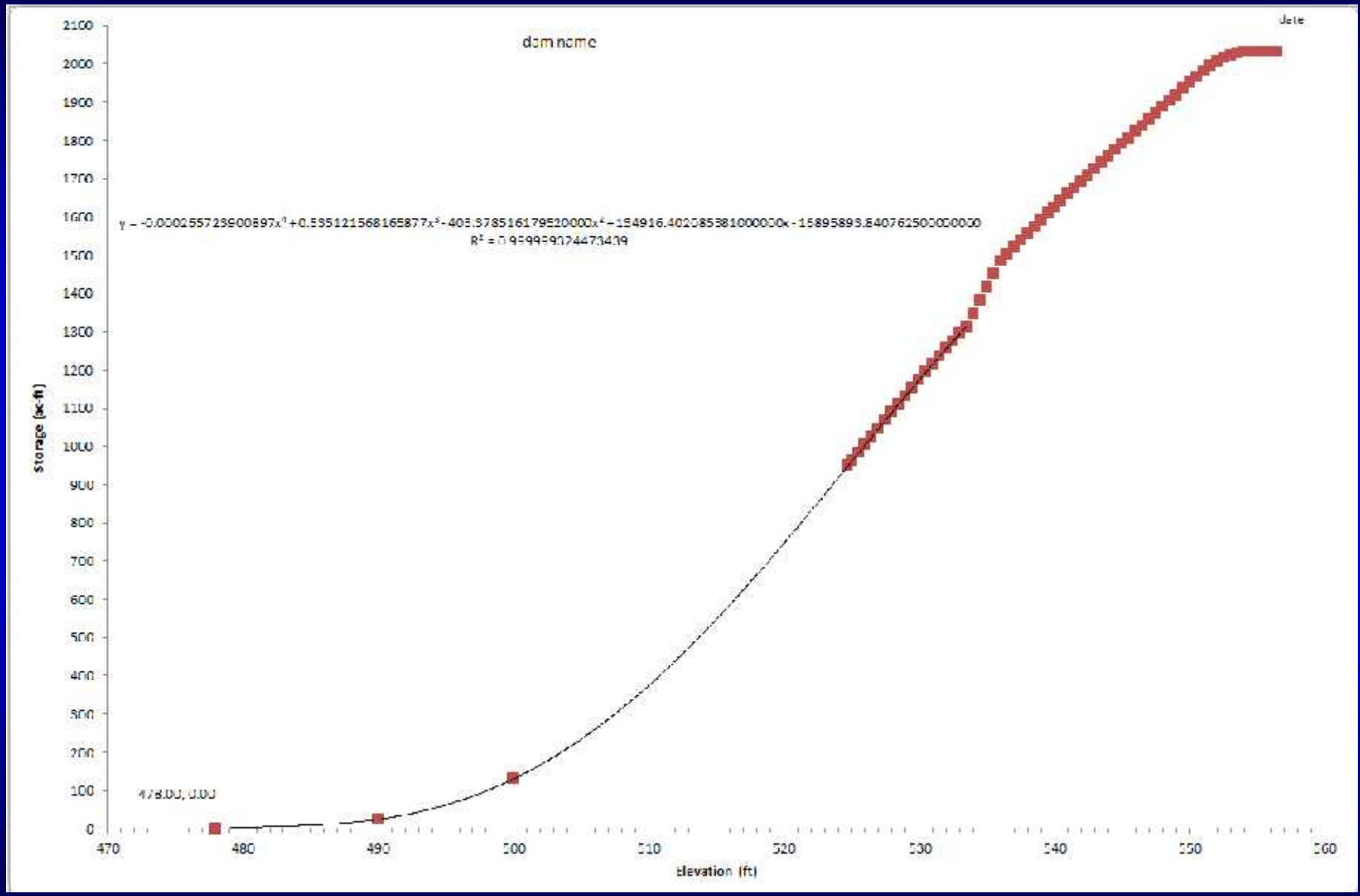

Mapper++ (c) FLO-2D 2012
File View Tools Help
WS_0
Velocity
Max Flow Depth
Time for One Foot Depth
Layer Name: Velocity
Display Properties
Transparency:
Display Mode: Vectors
FLO-2D
Ready


6000
5000
4000
3000
2000
1000
0
Water
Total Reservoir
Tailings
Base Tailings + Water
y = 0.0053875592221100x⁴ - 18.668616693849100x³ + 24262.502723448700000x² - 14016572.147049100000000x + 3036952752.509010000000000
R² = 0.999991407926930
Storage (ac-ft)
790.00, 0.00
785
795
805
815
825
835
845
855
865
875
Elevation (ft)


Water
Total Volume
Tailings
Series6
W.S.= 866.2
899.00, 5835.00
891.00, 3305.53
890.00, 3238.42
899.00, 2415.55
854.00, 1791.77
768.00, 0.00
854.00, 0.00
Storage (ac-ft)
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
760
770
780
790
800
810
820
830
840
850
860
870
880
890
900
910






dam name
Date
y = -0.000255729900897x⁵ + 0.535121568165877x⁴ - 403.578516179520000x³ + 154916.402085381000000x² - 15895893.640762500000000x
R² = 0.959959024473439
Storage (ac-ft)
Elevation (ft)
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
470
480
490
500
510
520
530
540
550
560
478.00, 0.00

Contact Information

michael.weller@dnr.mo.gov

Missouri
Department of
Natural Resources

Water Resources Center

www.dnr.mo.gov/env/wrc

Thank You

Missouri
Department of
Natural Resources