Mapping Rivers and Lakes for Highways:

4 Uses for Hydrography in Transportation

2014 National Hydraulic Engineers Conference

Petra DeWall

August 21st

4 Uses for Hydrography in Transportation

1. Scour Evaluation and Repair
2. Pre-design Mapping for Waterway Modeling
3. Flood Monitoring at Bridges
4. Iron Mine Bathymetry

- hy•drog•ra•phy -ies, | **hī'drägrəfē** | noun,
- 1. science of surveying of bodies of water and waters-related information;

2. a) depth measurement of waters (esp. of oceans), bathymetry;
b) surveying of bodies of water;

3. a) descriptive hydrology;
b) characteristic features of bodies of water, descriptive set of waters-related data and information;

4. (register of the) totality of the waters in an area, waters index;

5. a) map element; b) cartographic depiction of waters;

6. shape of the bottom of a water, topography covered by water, morphology;

7. art technique; b) artwork.

Why do hydrographic mapping?

To support highway safety and construction.

MnDOT Bridge Waterways/Hydraulics has hydrographic mapping for 16 years

River Mapping Equipment

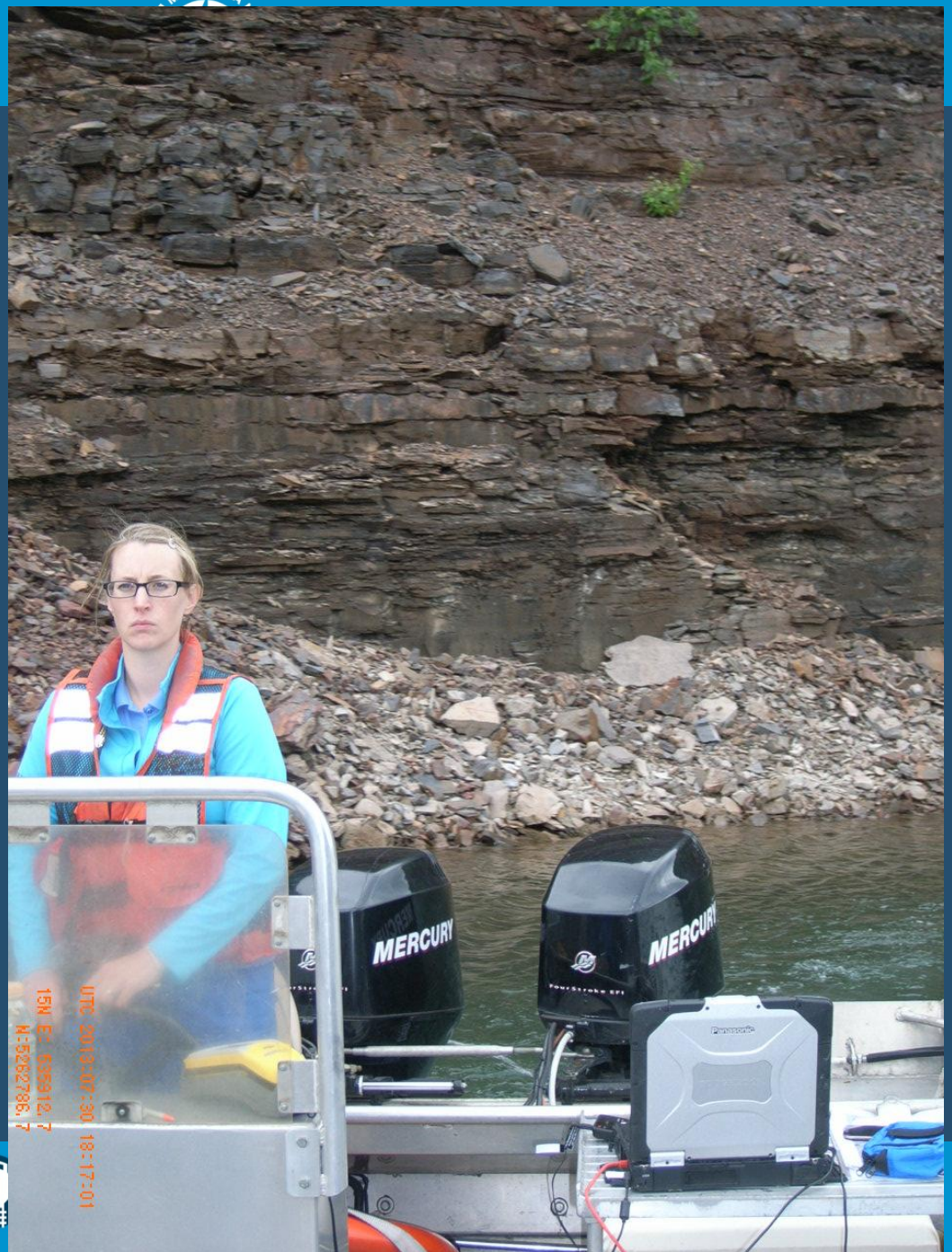
Vessels

- Big water – Kann Boat
- Little water – 4’ Oceanscience RiverBoat
- Low water – Rowboat (with 6 hp motor)

Row Boat

- New 6 hp Evinrude motor
- Oar and duct tape mount
- 12 foot jonboat
- Floatation suits

20’ Kann boat with two 50 HP Mercury 4-stroke motors

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TOUGHBOOK
Panasonic
CF-30
HORIZON
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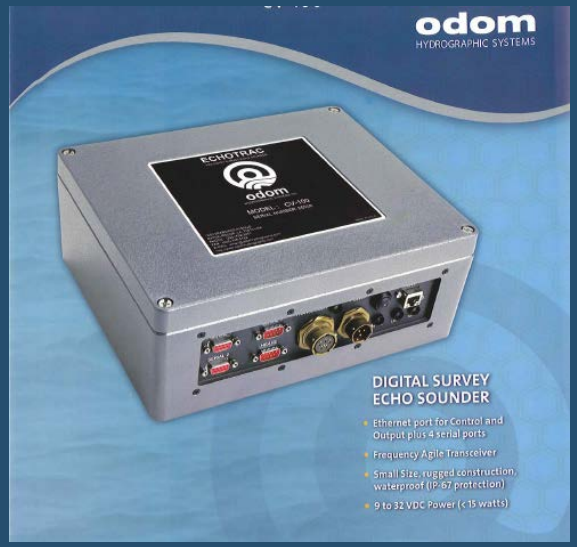
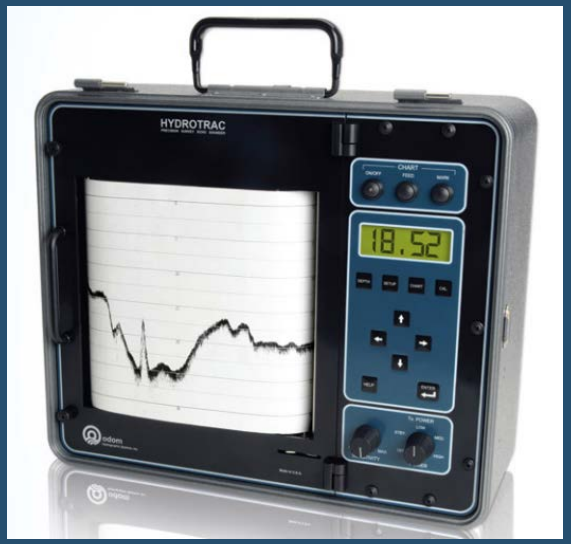
2 Survey-grade Depthsounders and Sidescan imaging



Echotrac CV-100



Hydrotrac

Sidescan Sonar
Humminbird 898C
(images only)

ADCP on the RiverBoat Trimaran

ADCP Flowrate Measurement

Software

- Hypack -- collect and edit depth data
- WinRiver II – measure flow velocities and Q
- Excel – data editing
- Microstation – CADD design mapping
- Geopak – create TINs, contours, X-sections
- ArcGIS – mapping with earth layers
- MNCON – coordinate system conversion
- HEC-RAS – 1-D modeling
- SMS – 2-D modeling

Hypack Export XY & depth

Br9036_01APR10HypackExportUTMEnglish.xyz - Notepad

File Edit Format View Help

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1617529.52,16327814.18,48.10
1617540.48,16327819.39,48.40
1617550.63,16327824.21,49.50
```

Then convert to MN county coordinates for project.

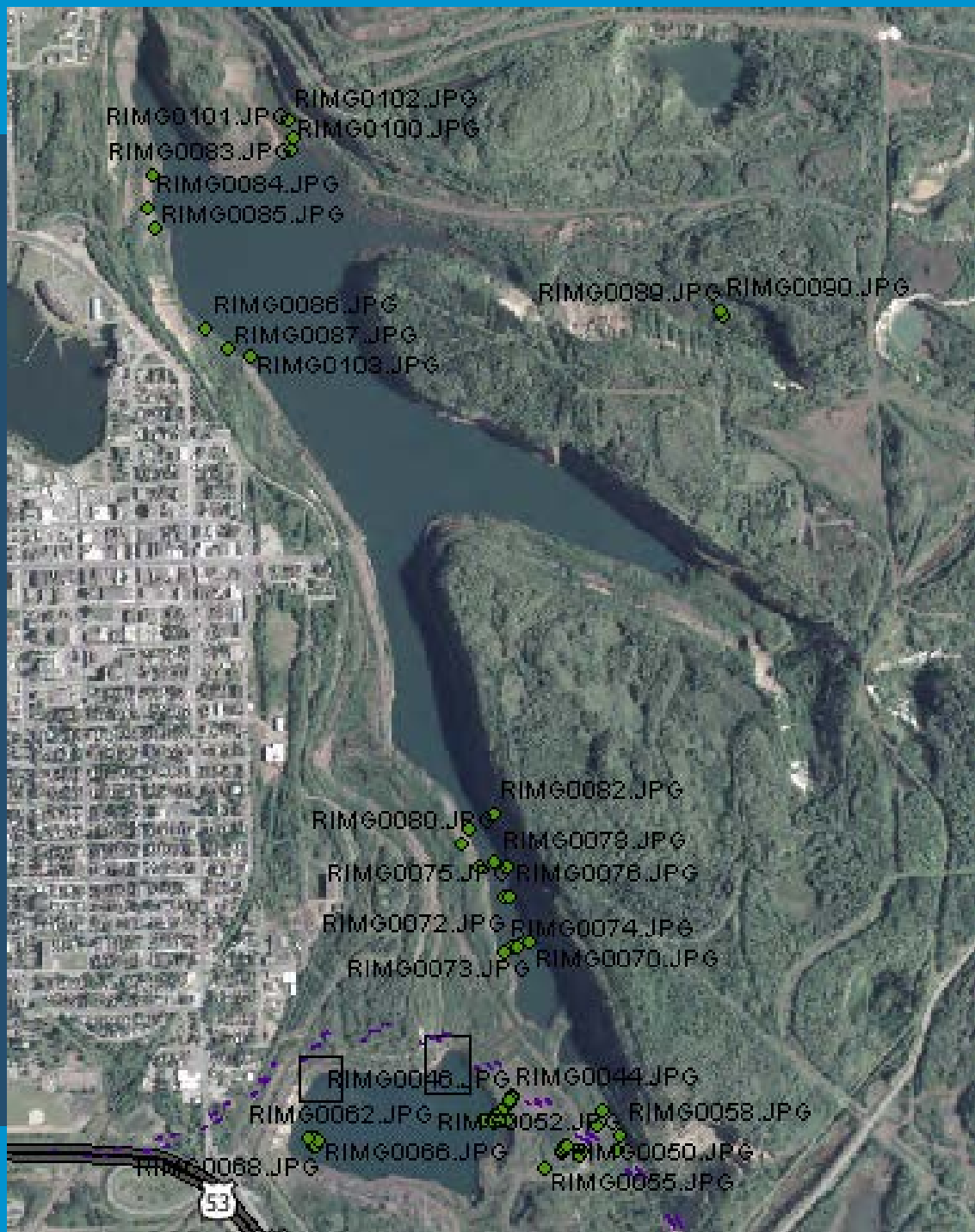
Winriver II Export X,Y, depth and flows

	A	B	C	E	F	G	Q
1	Ensemble	Beams avg	River Dep	GGA Lat	GGA Long	water speed bt	Flowdirection
2	919	18.17422	18.17422	44.94389	-93.0854	2.77131639	74.14239461
3	920	18.7896	18.7896	44.94389	-93.0854	2.79247841	68.84965386
4	921	19.37237	19.37237	44.9439	-93.0854	3.1209418	77.89890972
5	922	19.74637	19.74637	44.9439	-93.0855	2.67948176	69.23905604
6	923	20.04485	20.04485	44.94391	-93.0855	3.29011708	76.78080169
7	924	20.3584	20.3584	44.94391	-93.0855	2.92499413	66.76176839
8	925	20.60413	20.60413	44.94391	-93.0855	2.91952854	72.33009605
9	926	20.79856	20.79856	44.94391	-93.0855	3.25023316	73.50764374
10	927	20.93144	20.93144	44.94391	-93.0855	3.33582222	67.26114563
11	928	21.57589	21.57589	44.94391	-93.0855	3.26798228	76.65199258
12	929	22.07212	22.07212	44.94392	-93.0855	3.32995619	72.63476072
13	930	22.37047	22.37047	44.94392	-93.0856	3.12052784	81.77942693
14	931	23.1685	23.1685	44.94393	-93.0856	2.40365852	66.89324853
15	932	23.88568	23.88568	44.94393	-93.0856	2.91430027	84.55031078
16	933	25.24175	25.24175	44.94395	-93.0856	3.00762017	95.12690511
17	934	25.94218	25.94218	44.94396	-93.0856	2.27878283	47.78582128

GPS camera

photos have location and direction –

plotted in ArcMap



Scour Evaluation and Repair

Which Scour?

- Pier and Abutment Scour
- Lateral Migration
- Contraction Scour

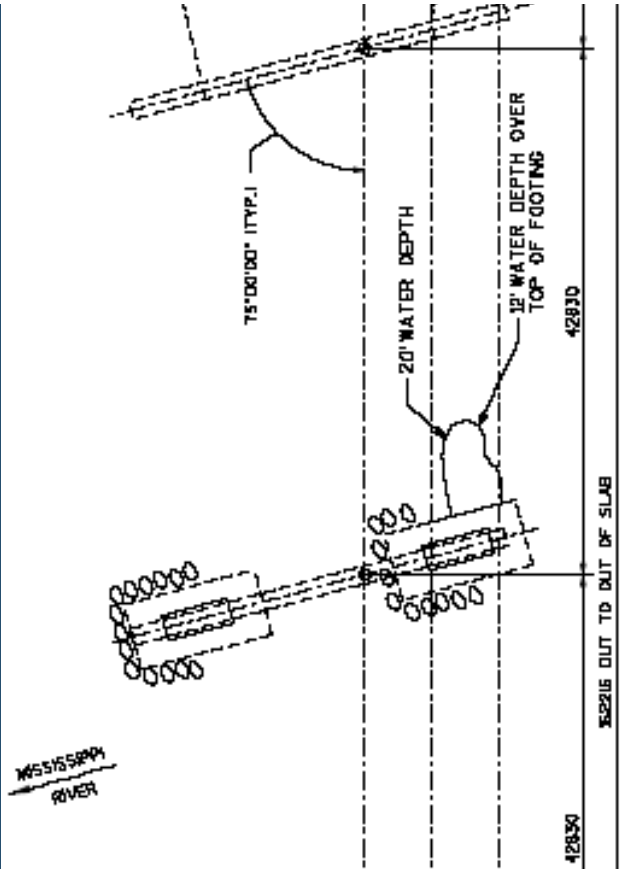
Pier Scour

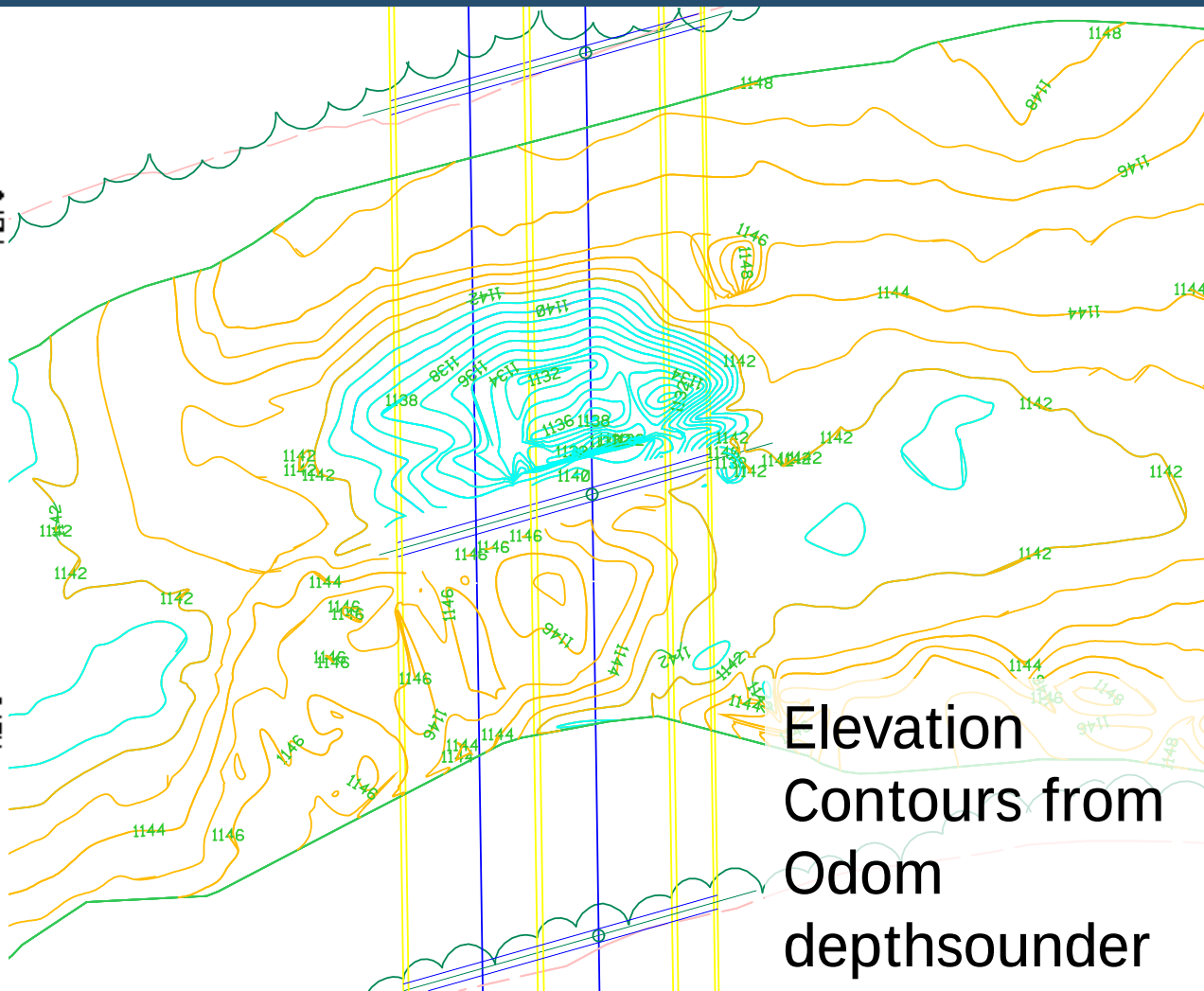
- Obstructions can cause scour
- Mapping defines extent of repairs

Scour Hole from pier

Bridge 18004 MN 371 Brainerd

Underwater Inspection Detail



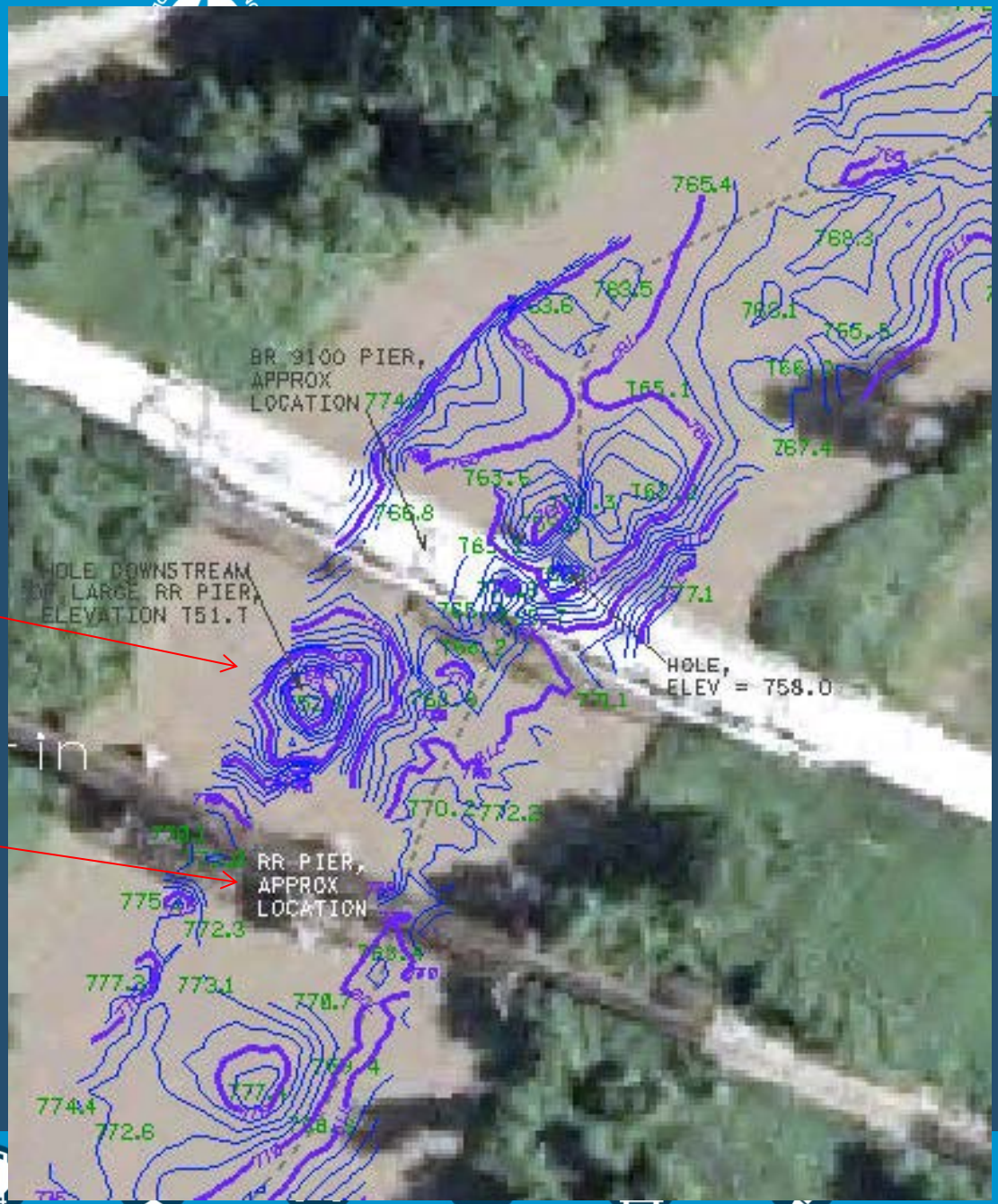


Elevation Contours from Odom depthsounder

Oslo MN – Massive RR pier

Bridge 9100 at
MN Hwy 1 and Red River
Oslo

Scour hole downstream of RR pier



Low water reveals more stuff behind RR pier

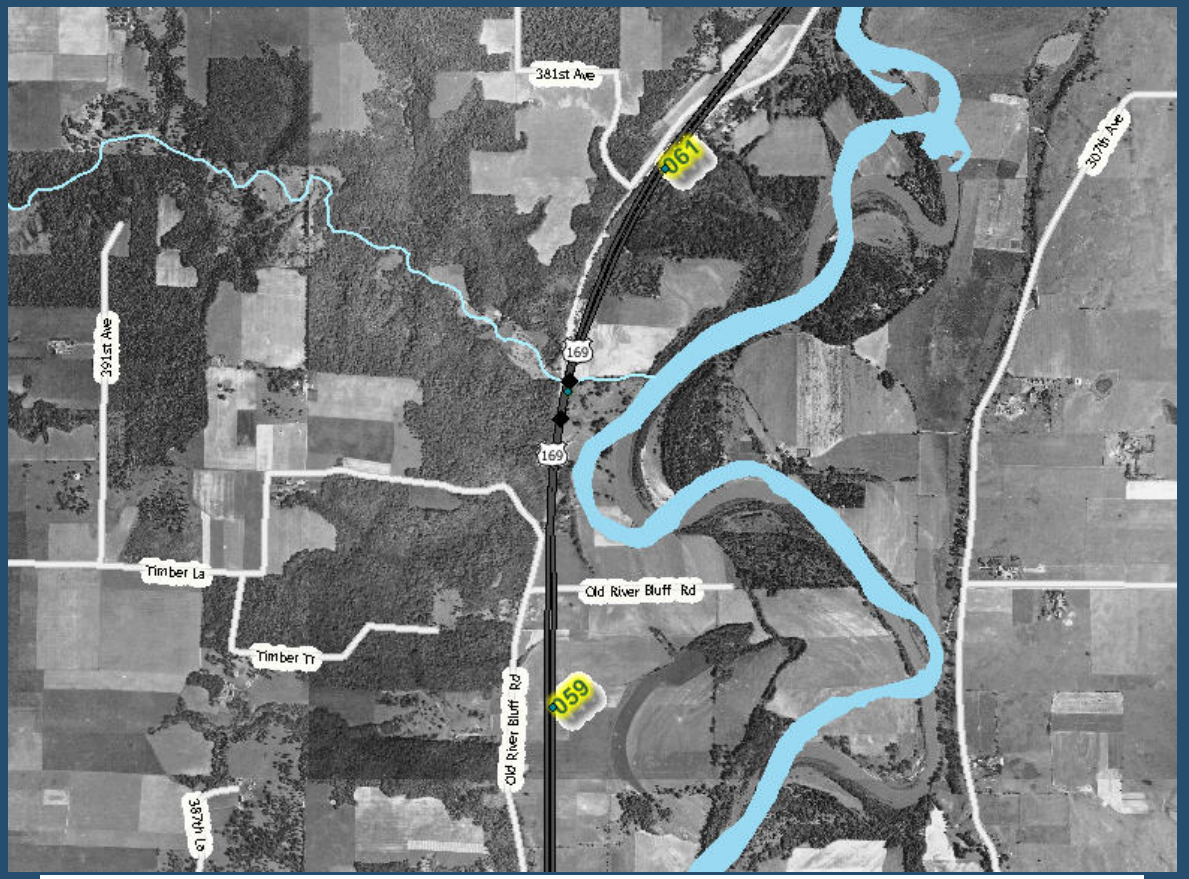
- Lateral Migration

- The Minnesota meanders like crazy
- 1930's highway was far from river

➢ **Ref. Pt. 60**

USDA-ASCS 1936-1939 Aerial

By 2008 river had neared the highway

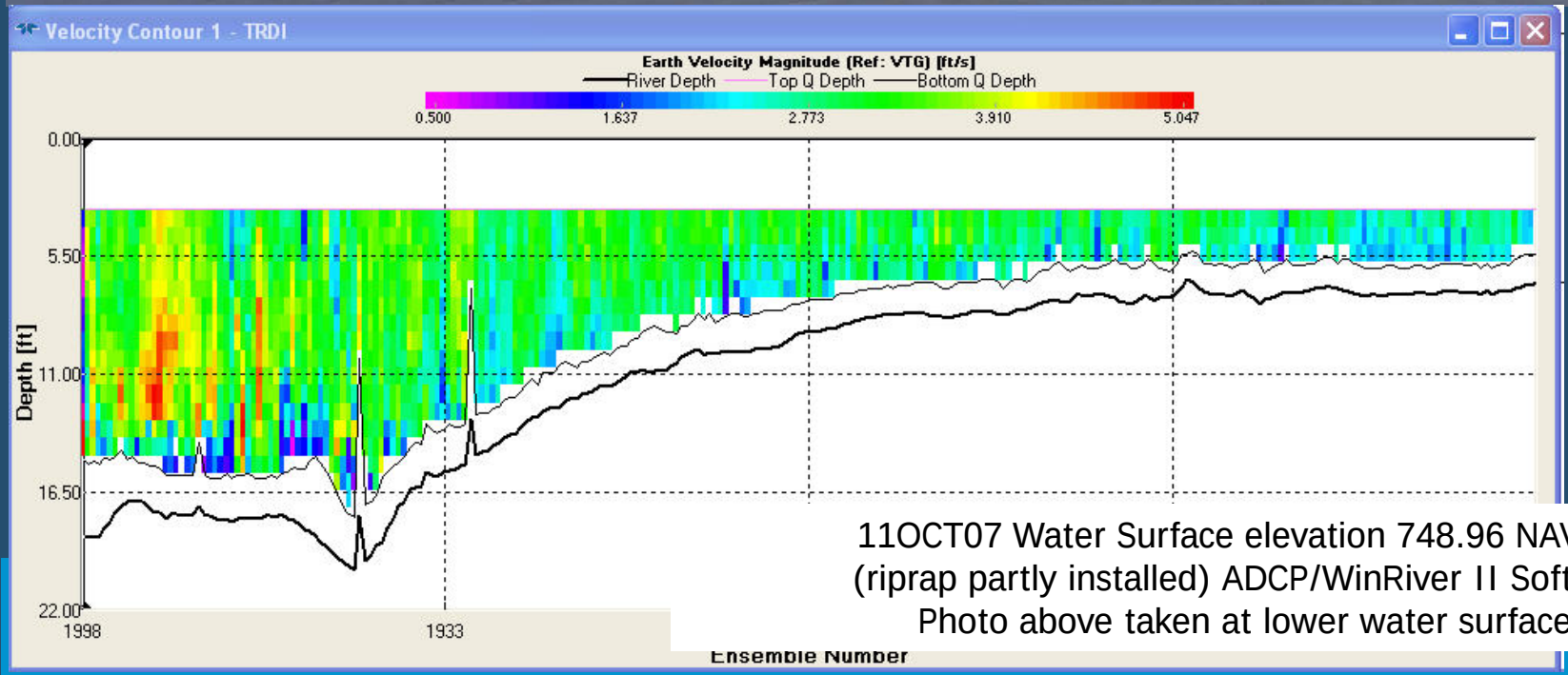


2008 river and highway on USDA-ASCS 1936-1939 Aerial

Highway embankment collapses

MN River US 169 R.P. 60 Scour Repair

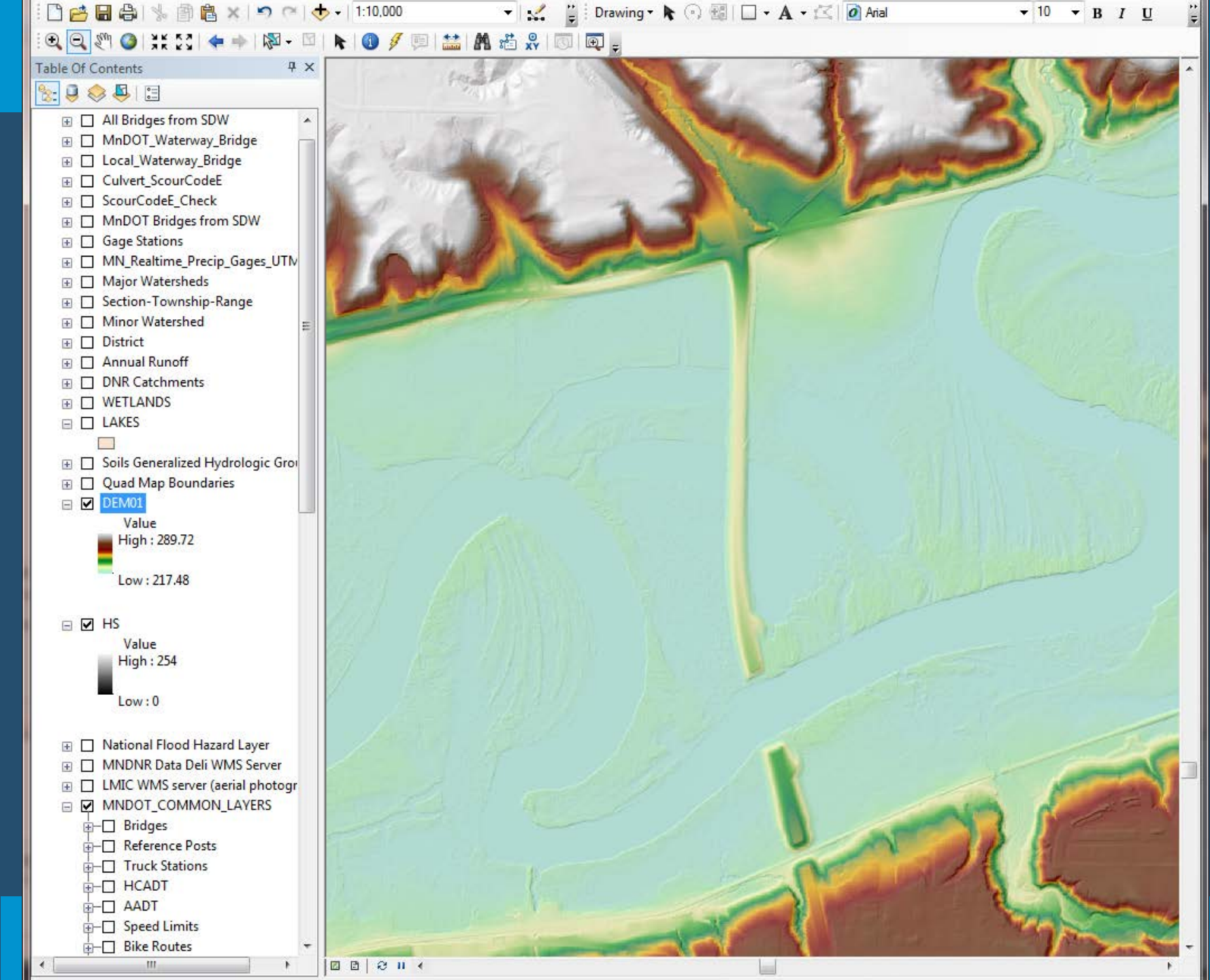
Water velocities 5 fps near cut bank (left)



11OCT07 Water Surface elevation 748.96 NAVD88 (riprap partly installed) ADCP/WinRiver II Software
Photo above taken at lower water surface.

Riprap to preserve highway

Contraction Scour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Drawing
Arial
10
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All Bridges from SDW
MnDOT_Waterway_Bridge
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Quad Map Boundaries
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High : 254
Low : 0
National Flood Hazard Layer
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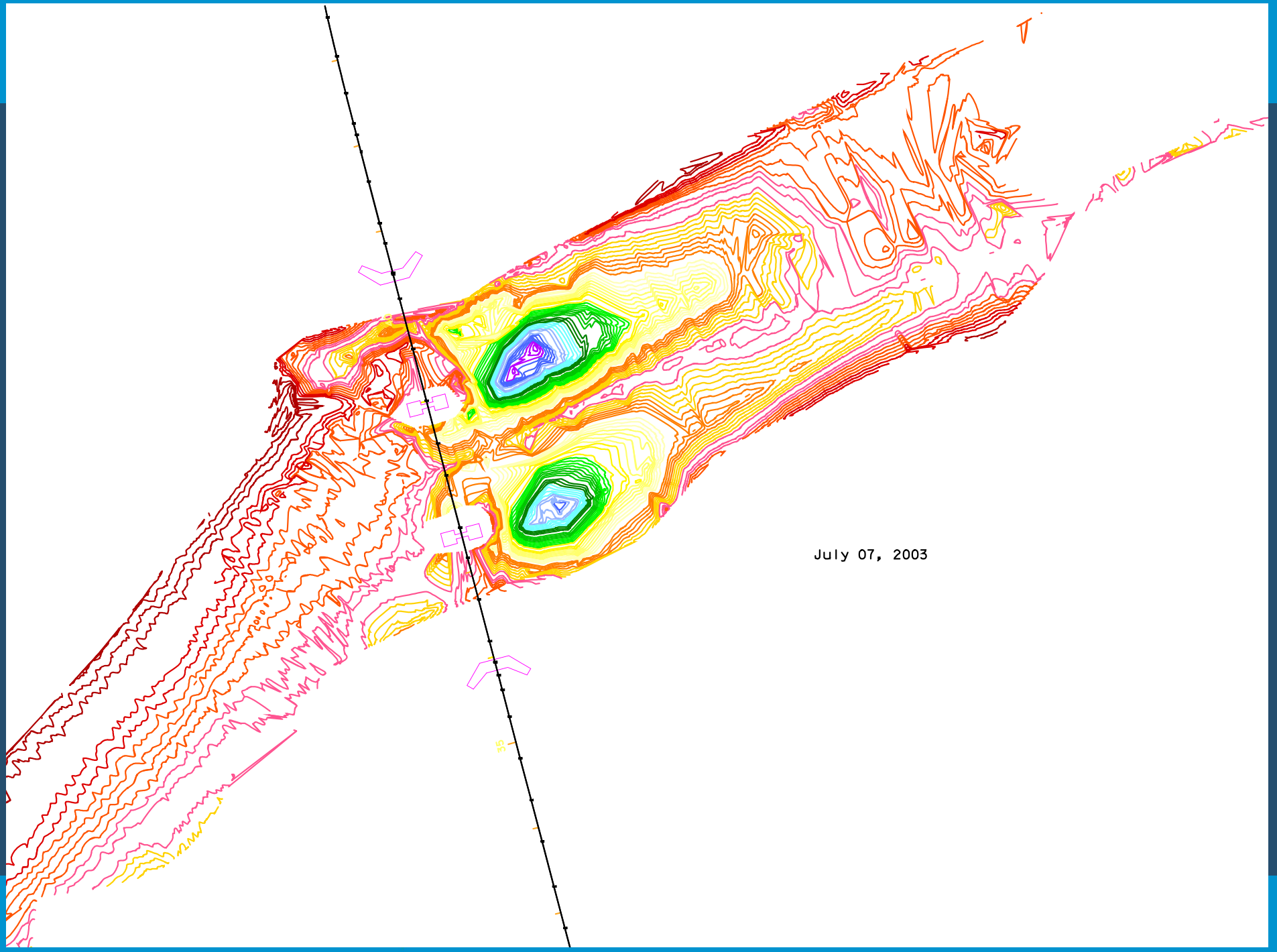
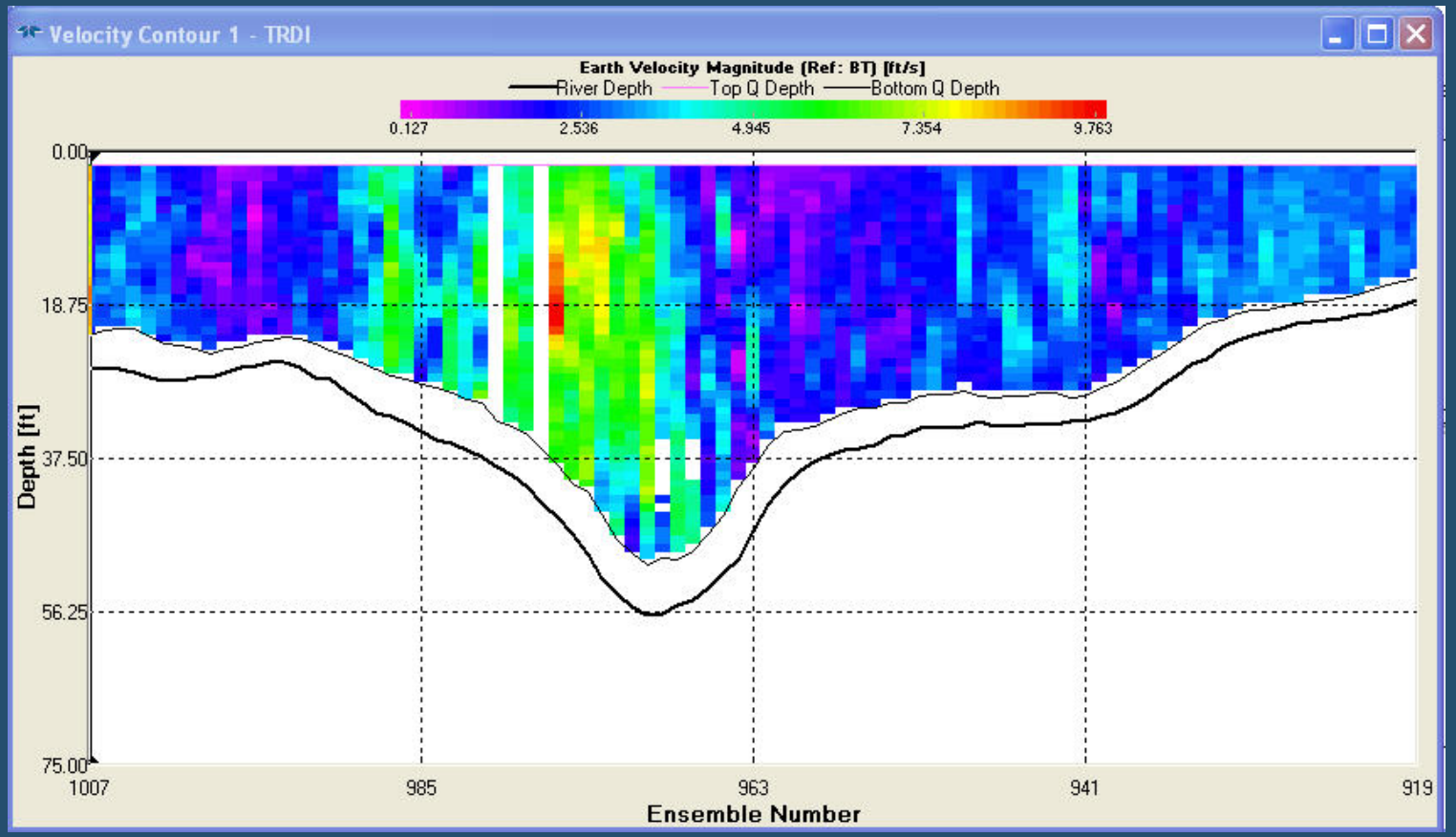
HCADT
AADT
Speed Limits
Bike Routes


July 07, 2003

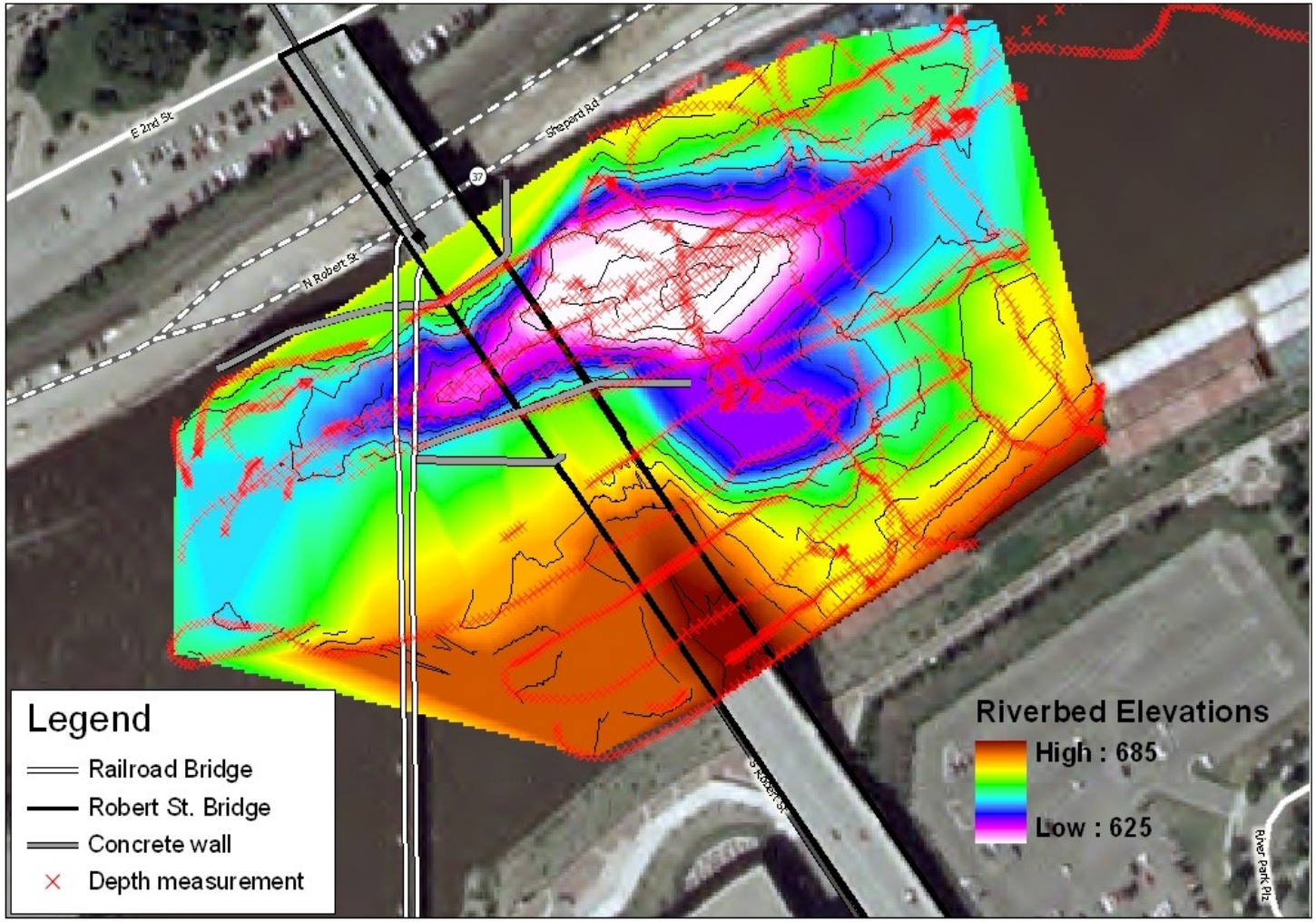
St. Paul Historic Robert Street Bridge
Mississippi River, St. Paul

- April 1, 2010 Flood was receding
- Crib wall channels flow from RR to Robert Street

WinRiver II Software
Measure and process flow velocities

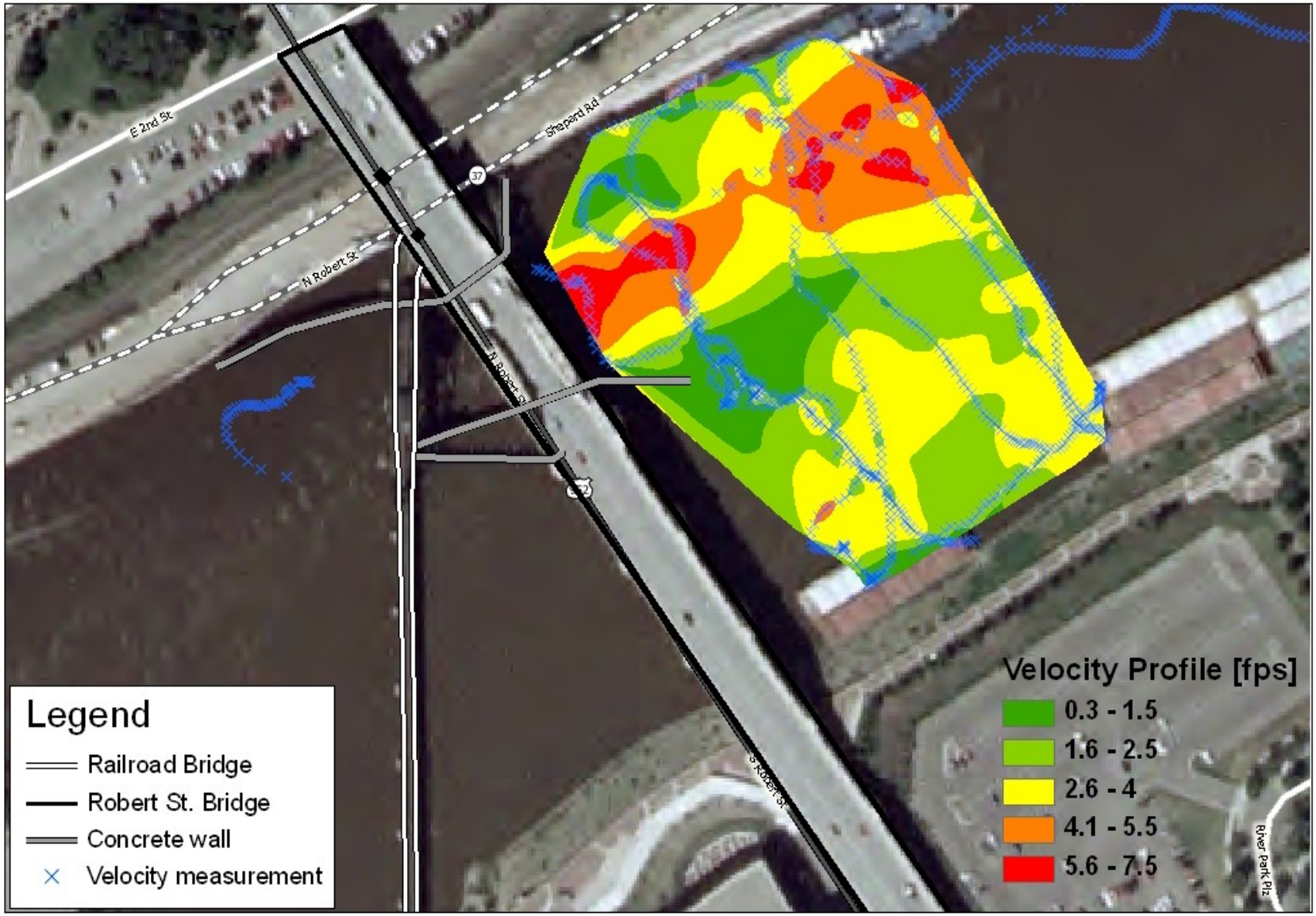


Depths show scour downstream of Bridge



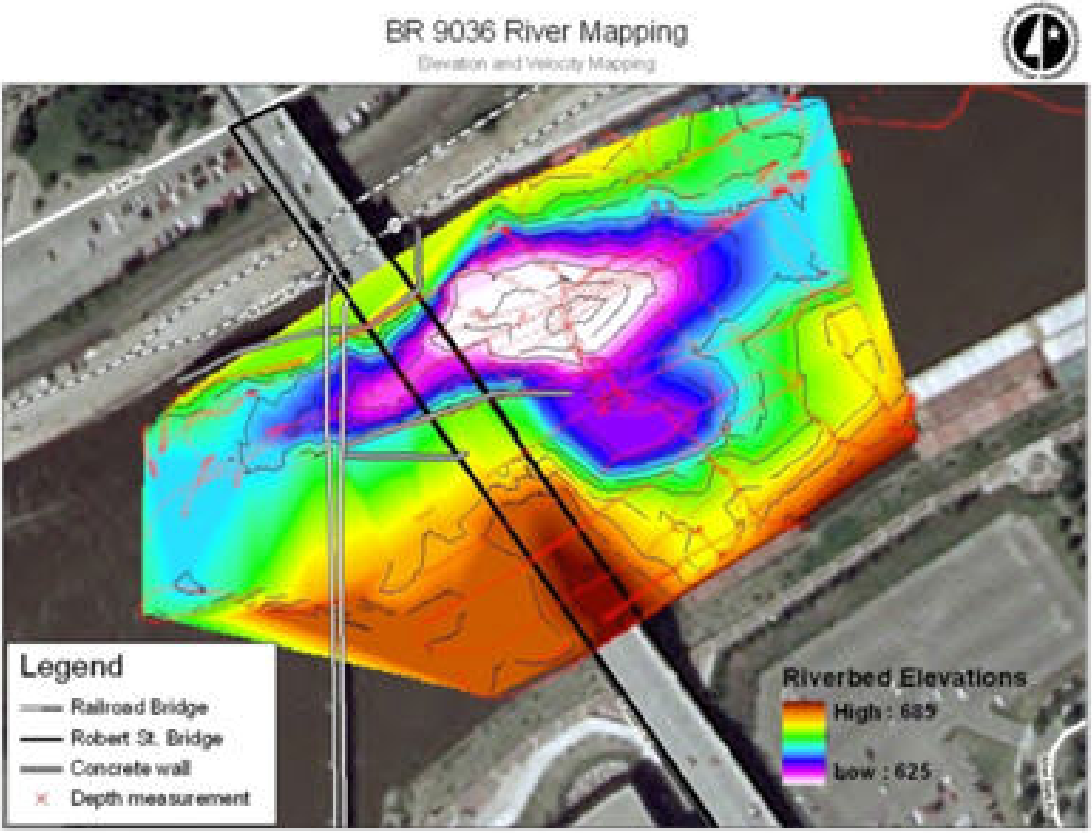
- Scour to 30 feet below the normal riverbed
- Area of a football field!

Flow velocities illustrate constriction from cribbing

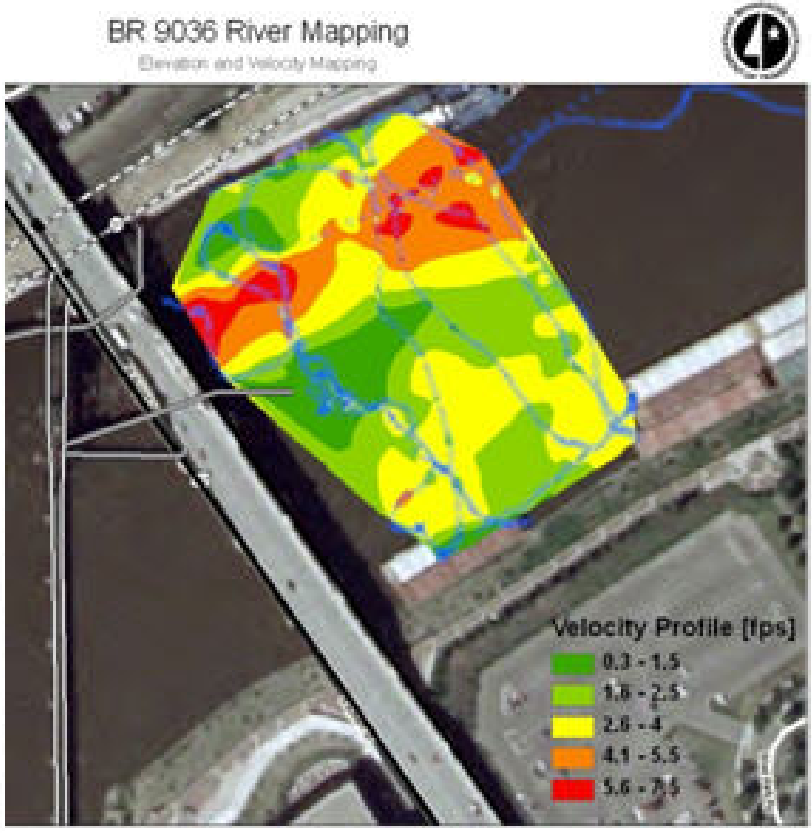


Depth and Velocity Correlation

Hydrotrac Depths



ADCP Velocities
(GPS location was lost under bridge)

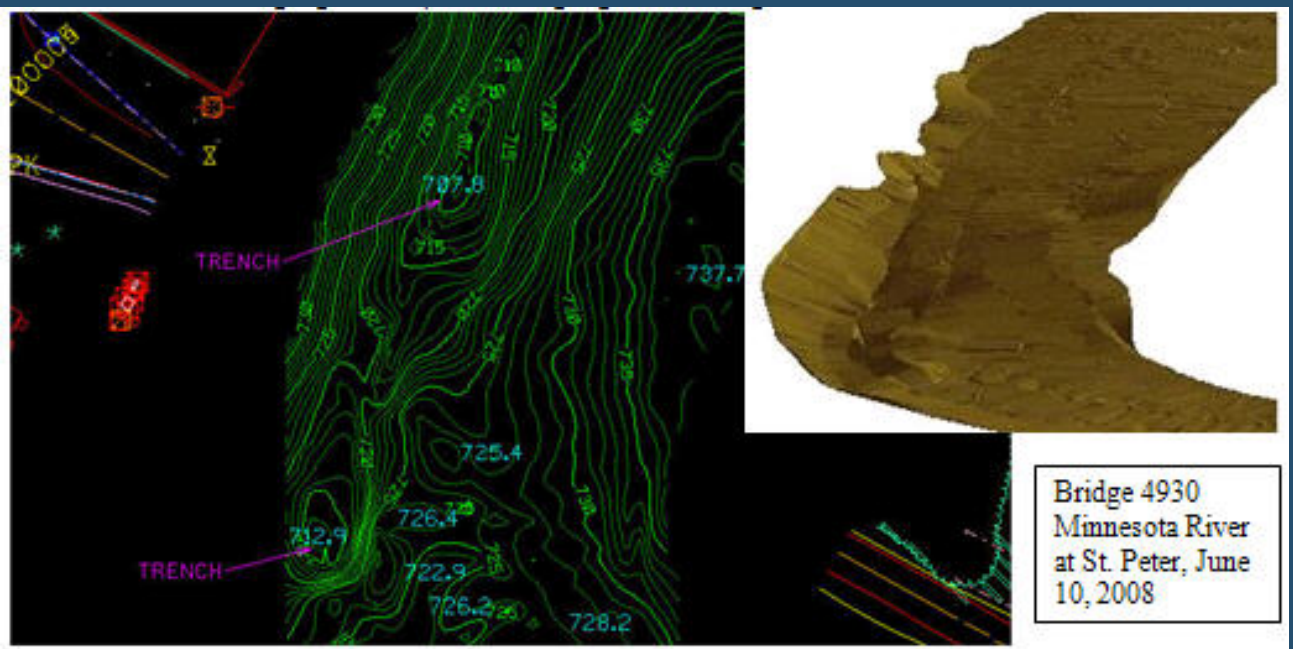


Pre-design Mapping for Hydraulic Modeling

Bathymetry is most important!

- Backbone of the hydraulic model
- Physical characteristics
  - XYZ data
  - Soil properties
  - Land cover (trees, grass, developed, etc)

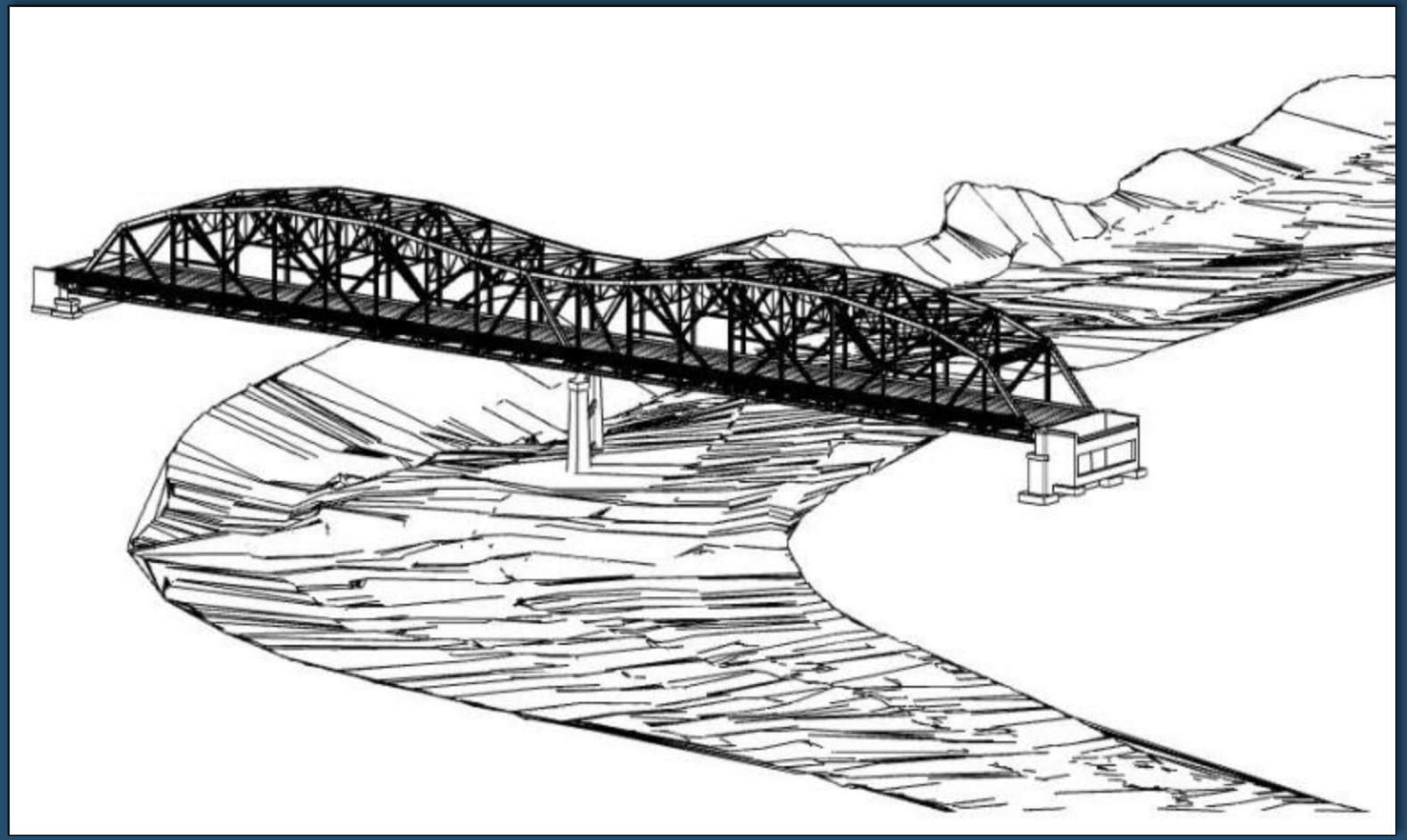
Mapping for design
Elevation Contours and 3D Rendering



Bridge 4930
Minnesota River
at St. Peter, June
10, 2008

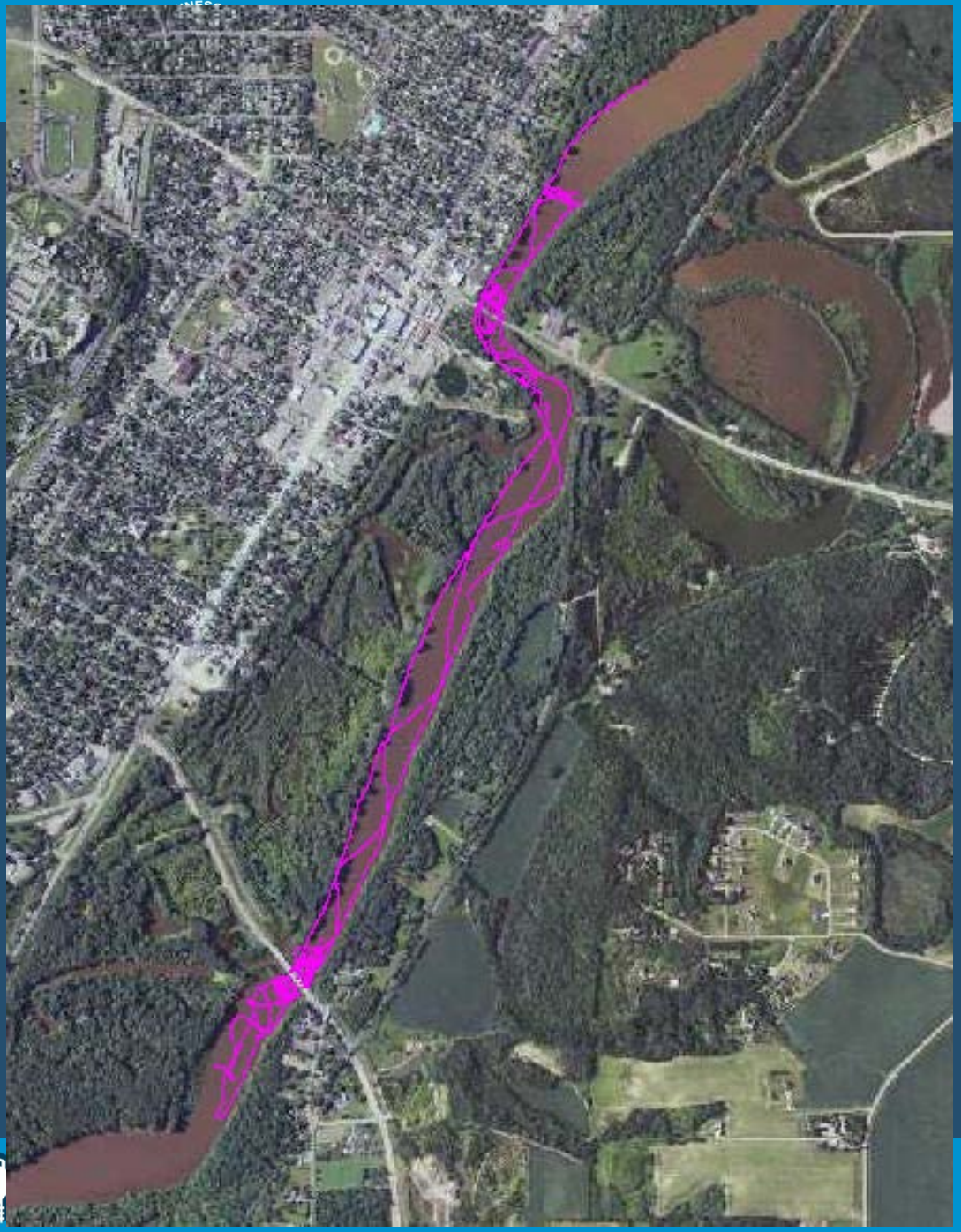
Contours and 3d rendered isometric view, at Bridge 4930, St. Peter, from Microstation file Br4930_10JUN08_cn.dgn (note: 3d image scale is smaller than contours scale).

Surveys Bridge Lidar with river map

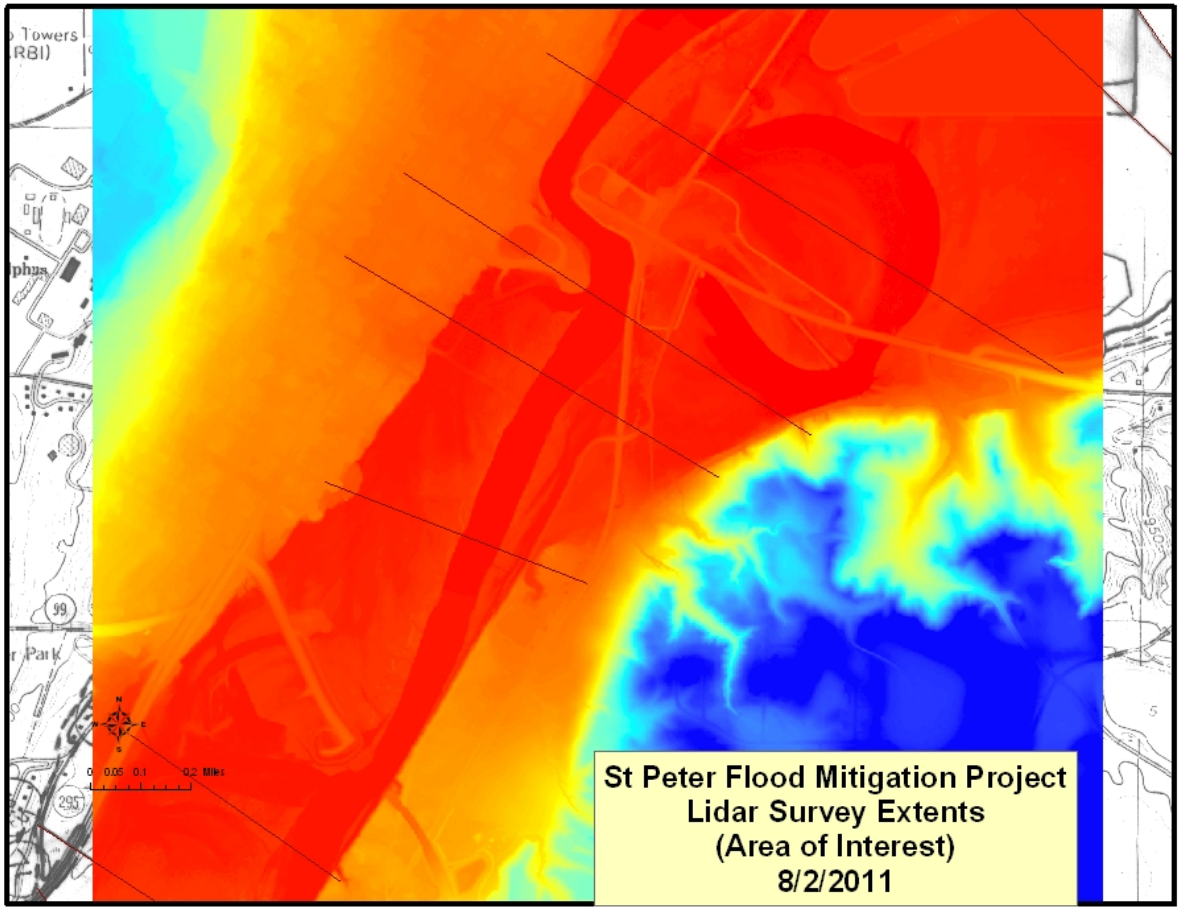


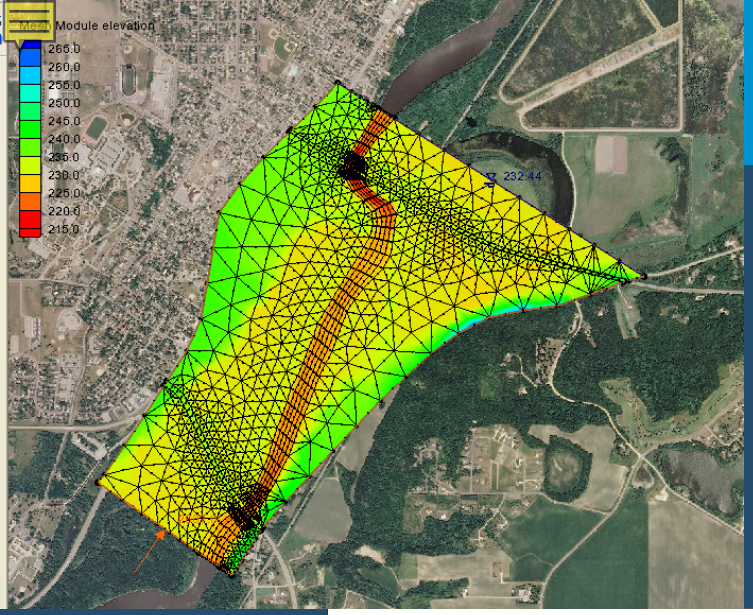
Up-ended floating tree damages historic bridge 4930 MN 99

MN River Mapping for Flow Model St. Peter

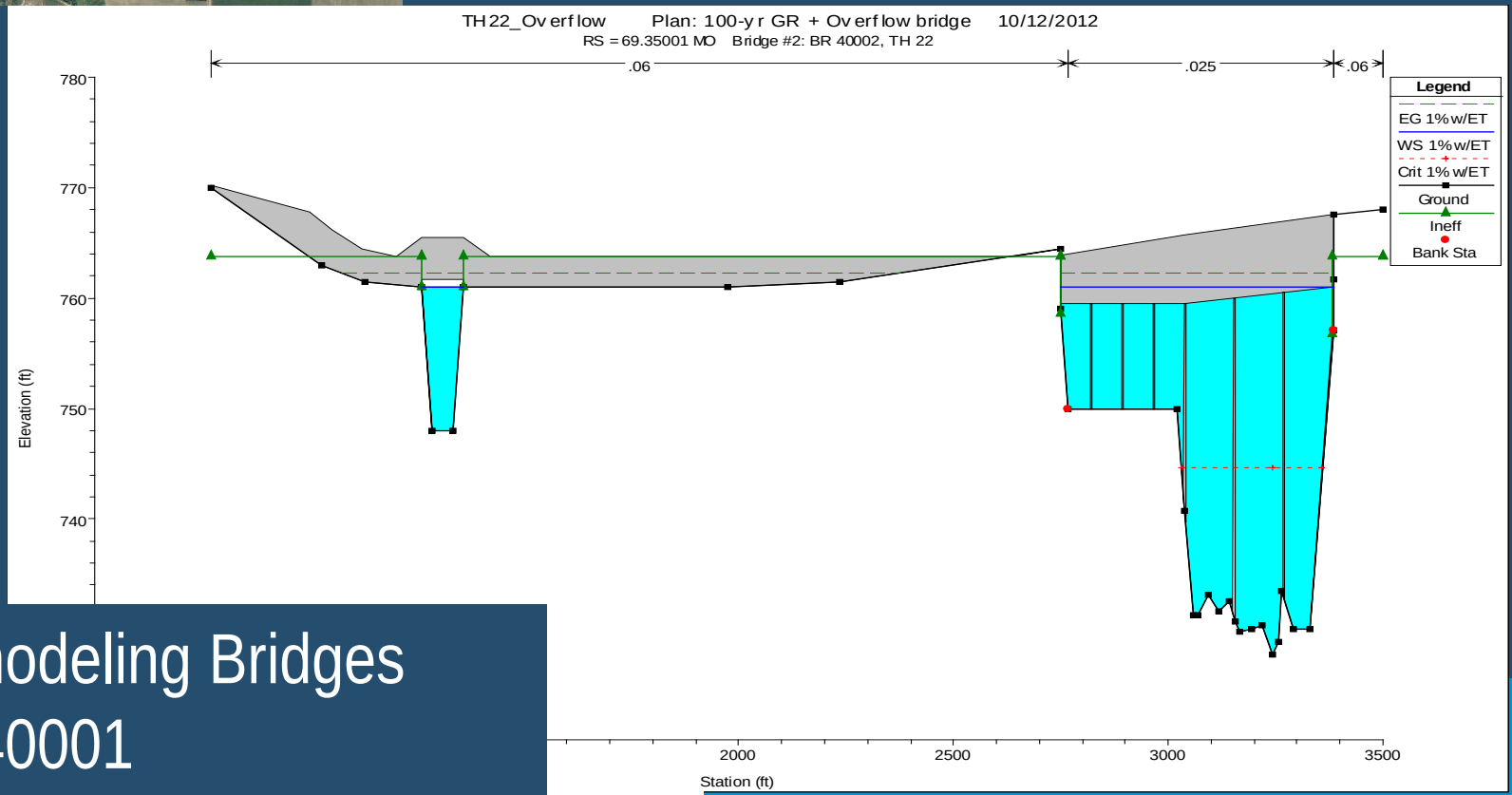


Lidar Data at St Peter





Pre-design Mapping for Waterway Modeling



St. Peter modeling Bridges 4930 and 40001

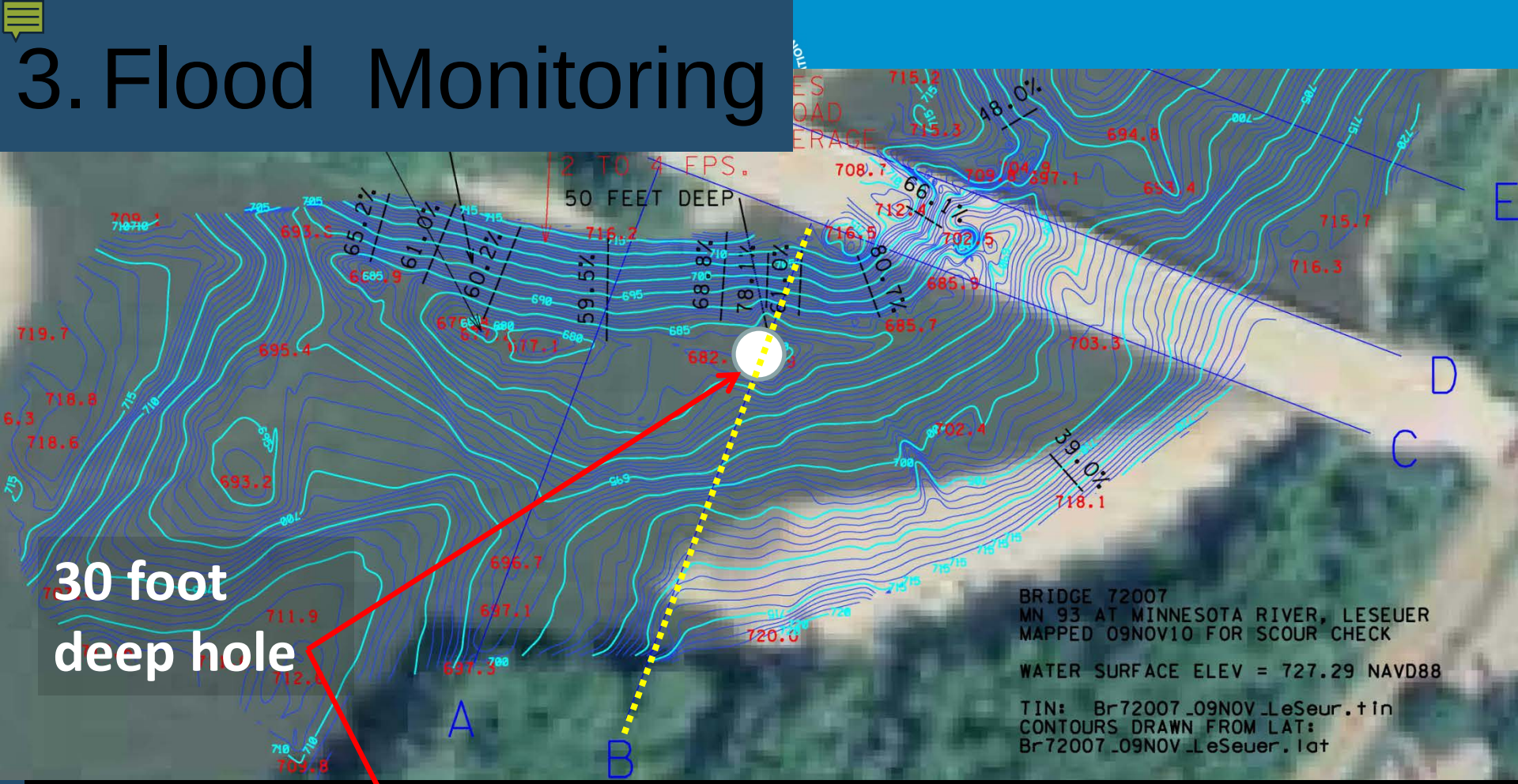
Monitoring Bridges for Scour during and after Floods

Ref. Pt. 76

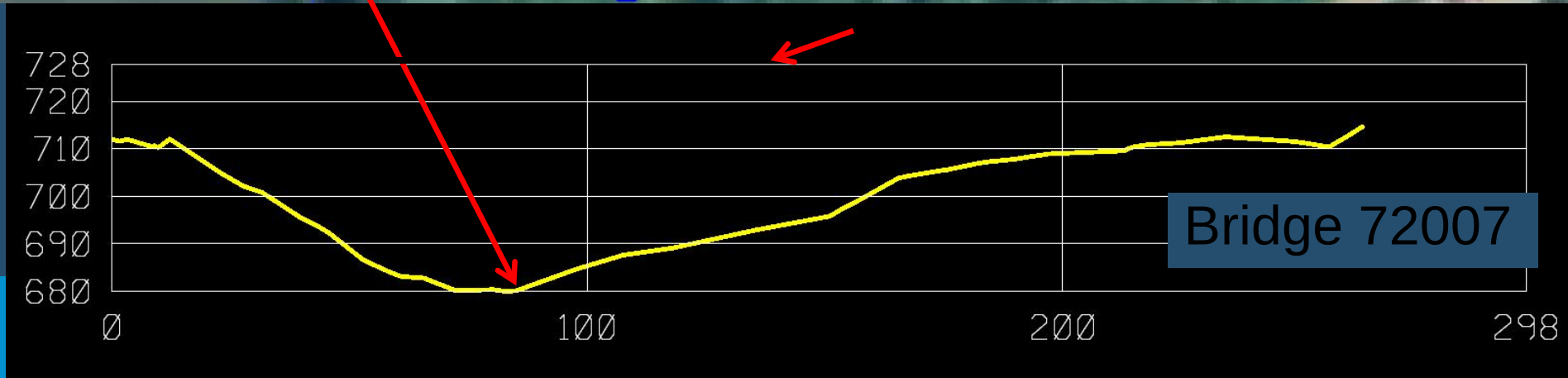
MN 93 Le Sueur

River channel aims at abutment

3. Flood Monitoring

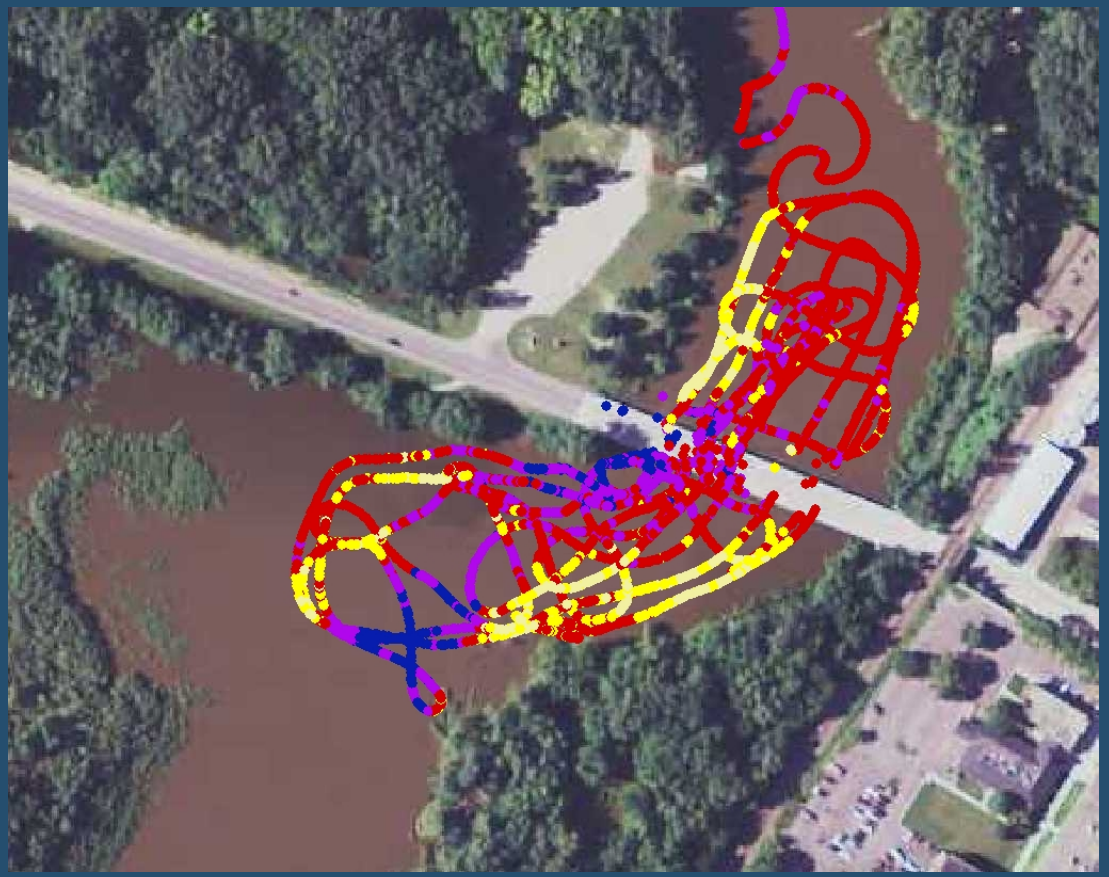


30 foot deep hole

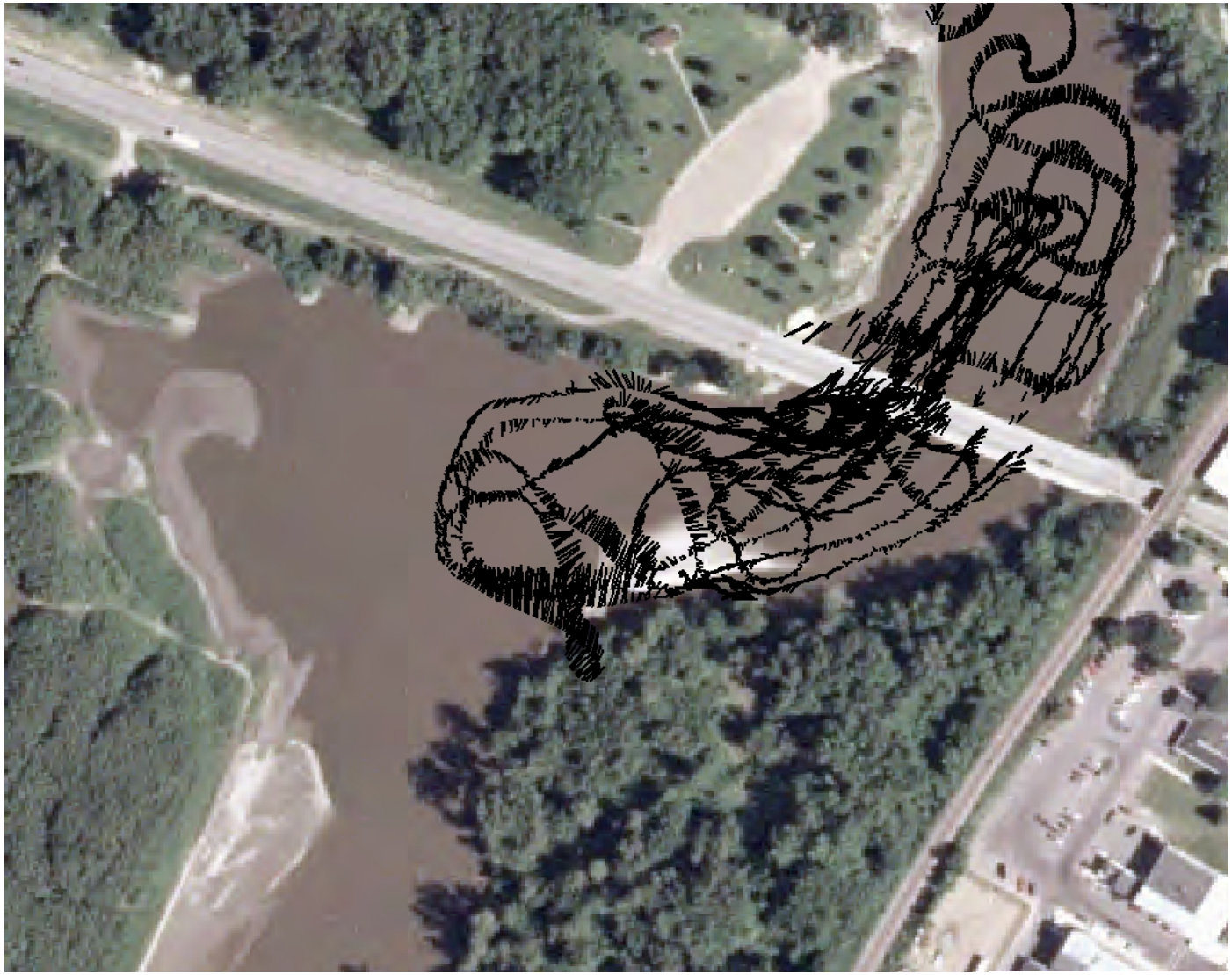


Ref. Pt. 76

4 fps velocities at abutment, ADCP data



ADCP flow vectors show direction of flow



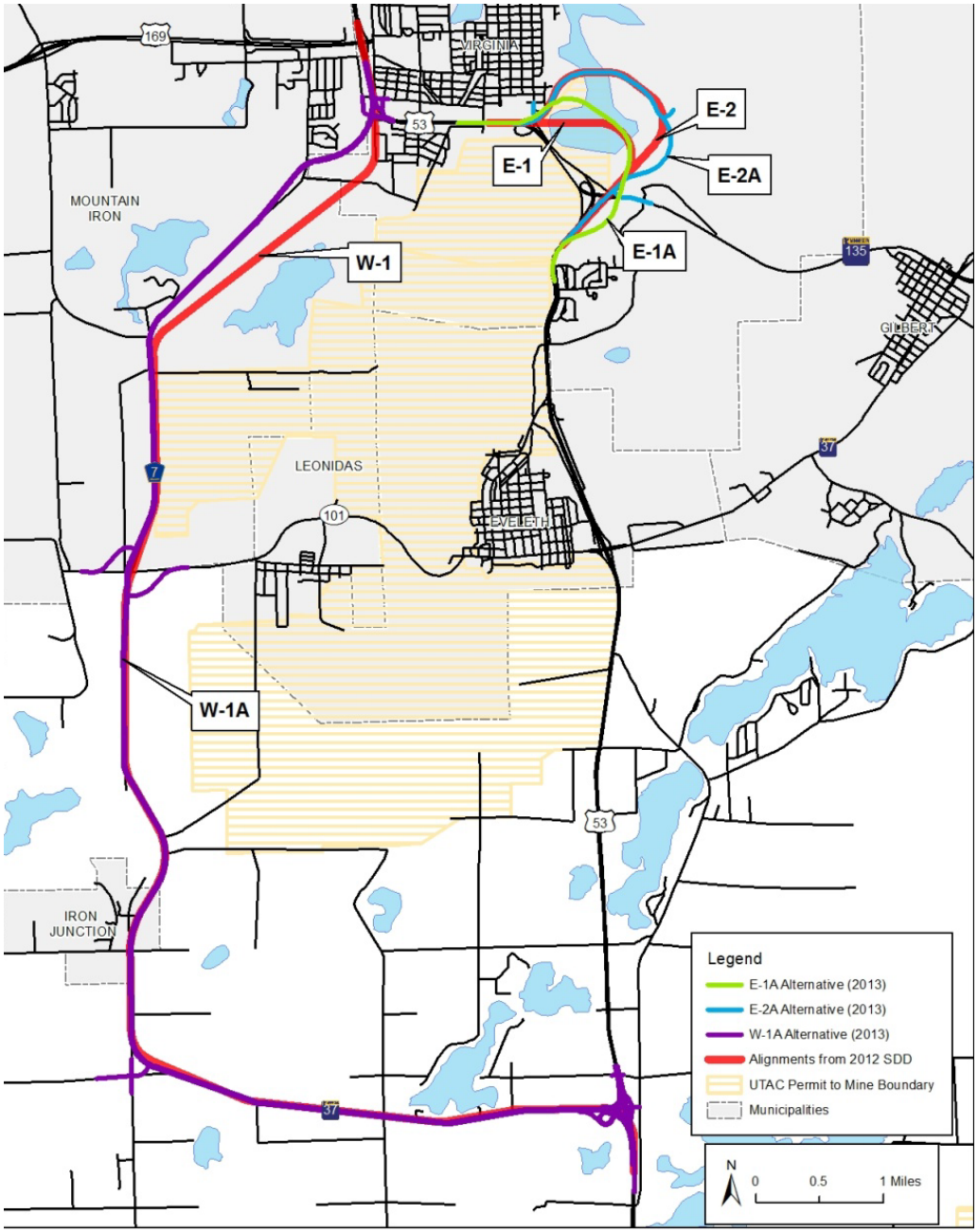
Bridge 72007

Iron Mine Bathymetry

Mapping the Rochleau Mine Pit

Mining Companies say *"Move it!"*

- Mining companies own parts of US 53
- MnDOT has R/W easement
- $400 **Million** Value of ore under current US53
- United Taconite and RGGS want **to mine it**
- MnDOT must move US 53 by Spring 2017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VIRGINIA
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E-1
E-2A
MOUNTAIN
IRON
W-1
E-1A
135
GILBERT
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7
LEONIDAS
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EVELETH
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53
IRON
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37
Legend
E-1A Alternative (2013)
E-2A Alternative (2013)
W-1A Alternative (2013)
Alignments from 2012 SDD
UTAC Permit to Mine Boundary
Municipalities
N
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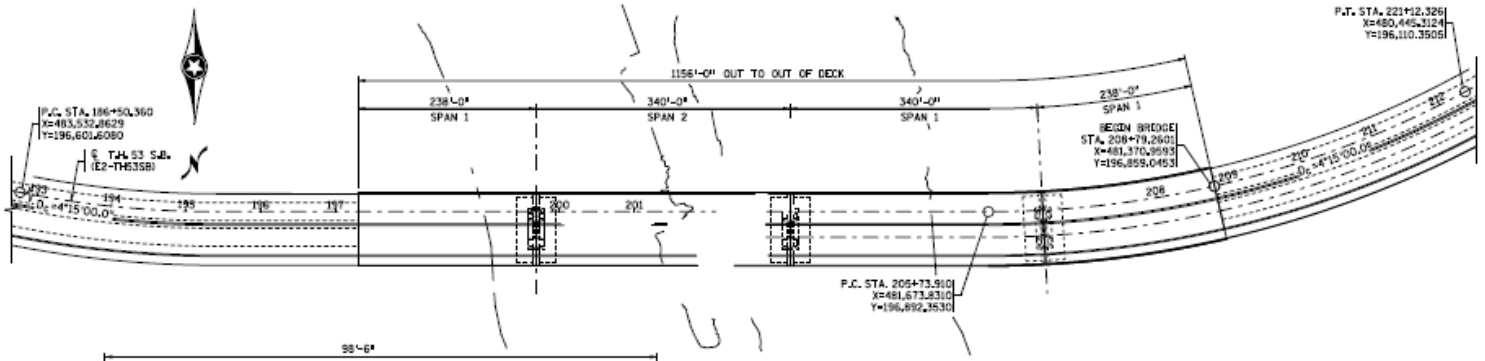
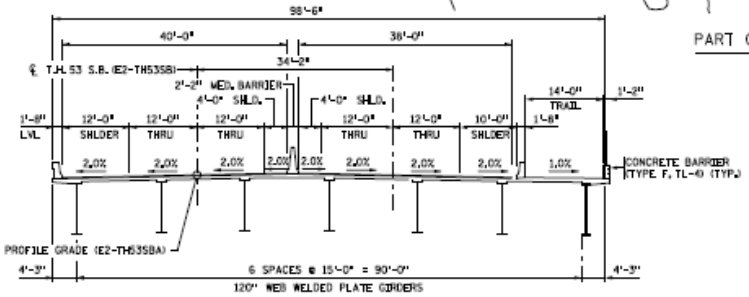
0.5
1 Miles



PART GENERAL PLAN



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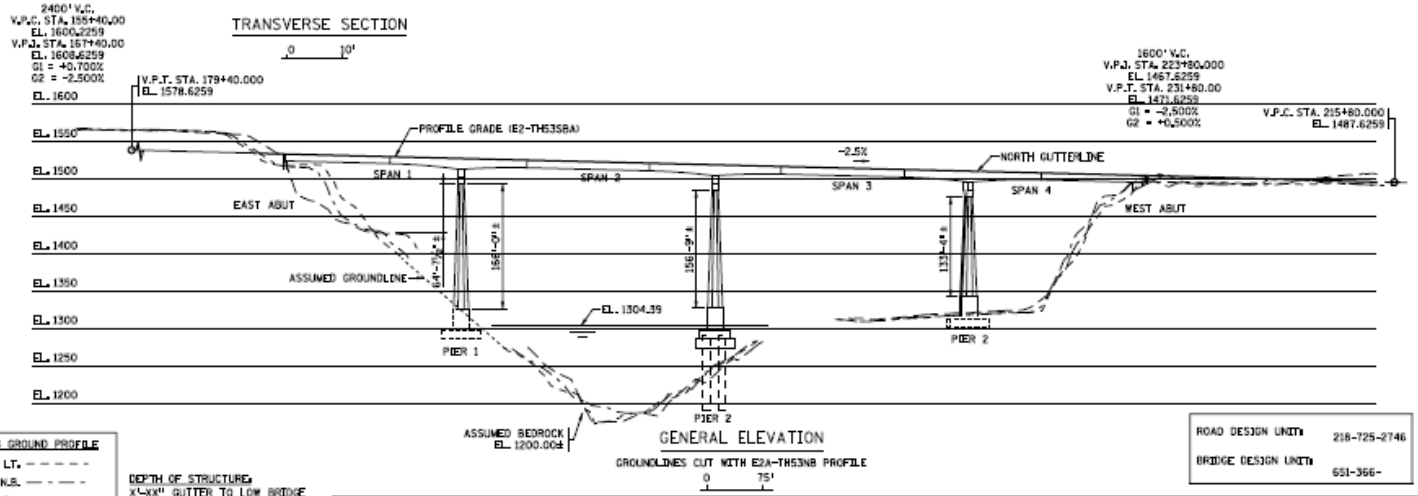


GENERAL ELEVATION

GROUNDLINES CUT WITH E2A-TH53NB PROFILE

0 75'

EXISTING GROUND PROFILE
64' LT. - - - - -
℄ T.H. 53 N.B. — — —
30' RT. — — —

DEPTH OF STRUCTURE:
X'-XX" GUTTER TO LOW BRIDGE
XXX STEEL X± LONES

ROAD DESIGN UNIT: 218-725-2746
BRIDGE DESIGN UNIT: 651-366-

DESIGN DATA

2012 AND CURRENT INTERIM AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

LOAD AND RESISTANCE FACTOR DESIGN METHOD
HL93 LIVE LOAD

DEAD LOAD INCLUDES 20 PSF ALLOWANCE FOR FUTURE WEARING COURSE MODIFICATIONS

MATERIAL DESIGN PROPERTIES:
REINFORCED CONCRETE:
f'c = 4 KSI n = 8
fy = 60 KSI REINFORCEMENT

STRUCTURAL STEEL:
fy = 50ksi STRUCTURAL STEEL

DESIGN SPEED:
OVER = MPH UNDER = MPH

APPROXIMATE DECK AREA 36,700 SQ FT

20XX PROJECTED TRAFFIC VOLUMES

ROADWAY OVER	ROADWAY UNDER
A.D.T.	
D.H.V.	
A.D.T.T.	

PROPOSED TYPE OF STRUCTURE

DECK:
HAUNCHED WELDED STEEL GIRDERS
CONTINUOUS SPANS
SEPARATE CONCRETE OVERLAY
ALL BARS EPOXY COATED

SUBSTRUCTURE:
PARAPET TYPE ABUTMENTS SUPPORTED ON XX" C.I.P. PILES
PIERS SUPPORTED ON XX" C.I.P. PILES

AESTHETICS:
LEVEL X

MINNESOTA
DEPARTMENT OF TRANSPORTATION

PRELIMINARY PLAN
BRIDGE NO. 69XXX

T.H. 53 REALIGNMENT OVER WATER
E2 OPTION

SECS. 18, 19 & 20 TWP. 58 N. R. 18 W.

CITY: VIRGINIA ST. LOUIS CO.

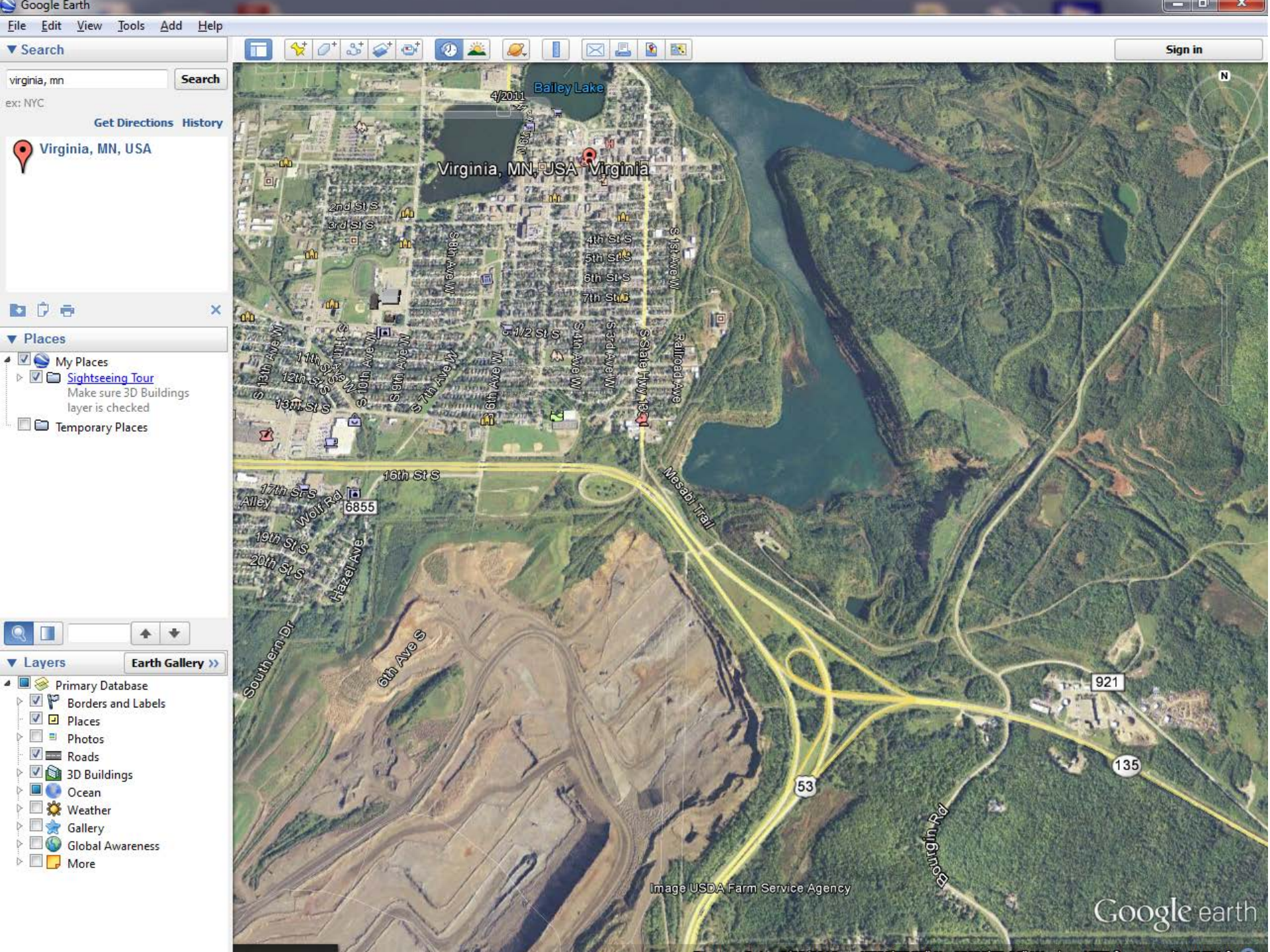
DATE: _____

NOT FINAL

STATE BRIDGE ENGINEER

JOB NO. T17662 MINNESOTA PROJECT NO. - STATE PROJECT NO. 6918-69 (T.H. 53=) SHEET NO. 1 OF SHEETS

DTP | CAG


Google Earth
File Edit View Tools Add Help
Search
virginia, mn
Search
ex: NYC
Get Directions History
Virginia, MN, USA
Sign in
Places
My Places
Sightseeing Tour
Make sure 3D Buildings layer is checked
Temporary Places
Layers
Earth Gallery
Primary Database
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
Bailey Lake
Virginia, MN, USA
Virginia
2nd St S
3rd St S
4th St S
5th St S
6th St S
7th St S
5 1/2 St S
8th Ave W
6th Ave W
5th Ave W
4th Ave W
3rd Ave W
S State Hwy 169
Railroad Ave
Mesabi Trail
16th St S
17th St S
Alley
Wolf Rd
6855
19th St S
20th St S
Hazel Ave
Southern Dr
6th Ave S
921
135
53
Bourgin Rd
Image USDA Farm Service Agency
Google earth

Rouchleau Pit - 2003

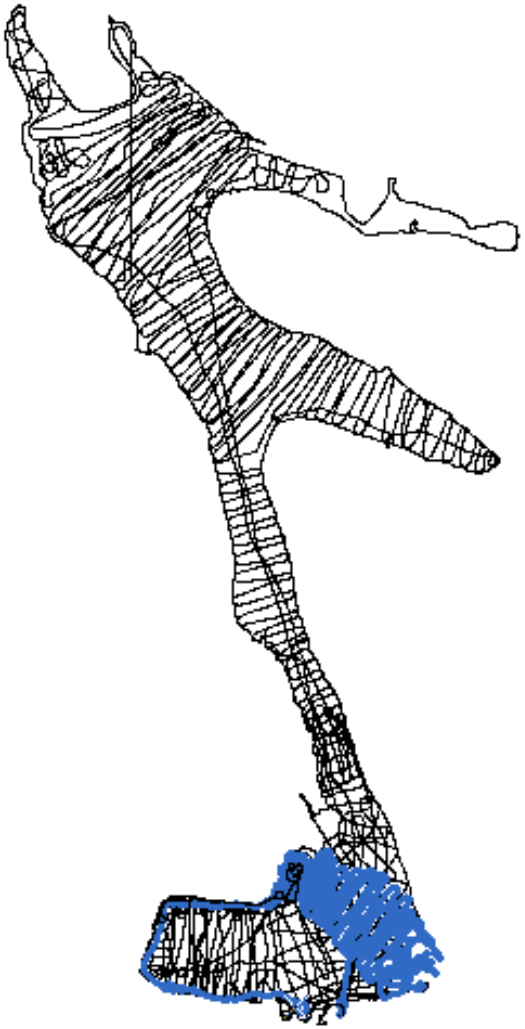
Bathymetric mapping July 29 - 31

Rochleau Mine Pit

- 1.9 miles long
- Average width about 1000 feet
- Perimeter 7.5 miles
- Water surface to cliff top about 200 feet
- Max water depth 325 feet
- Sheer underwater cliffs require tight XY location

Two GPS units:

1. VRS XY NMEA for depth map
2. Terrasync for navigation



New GPS unit in 2013!

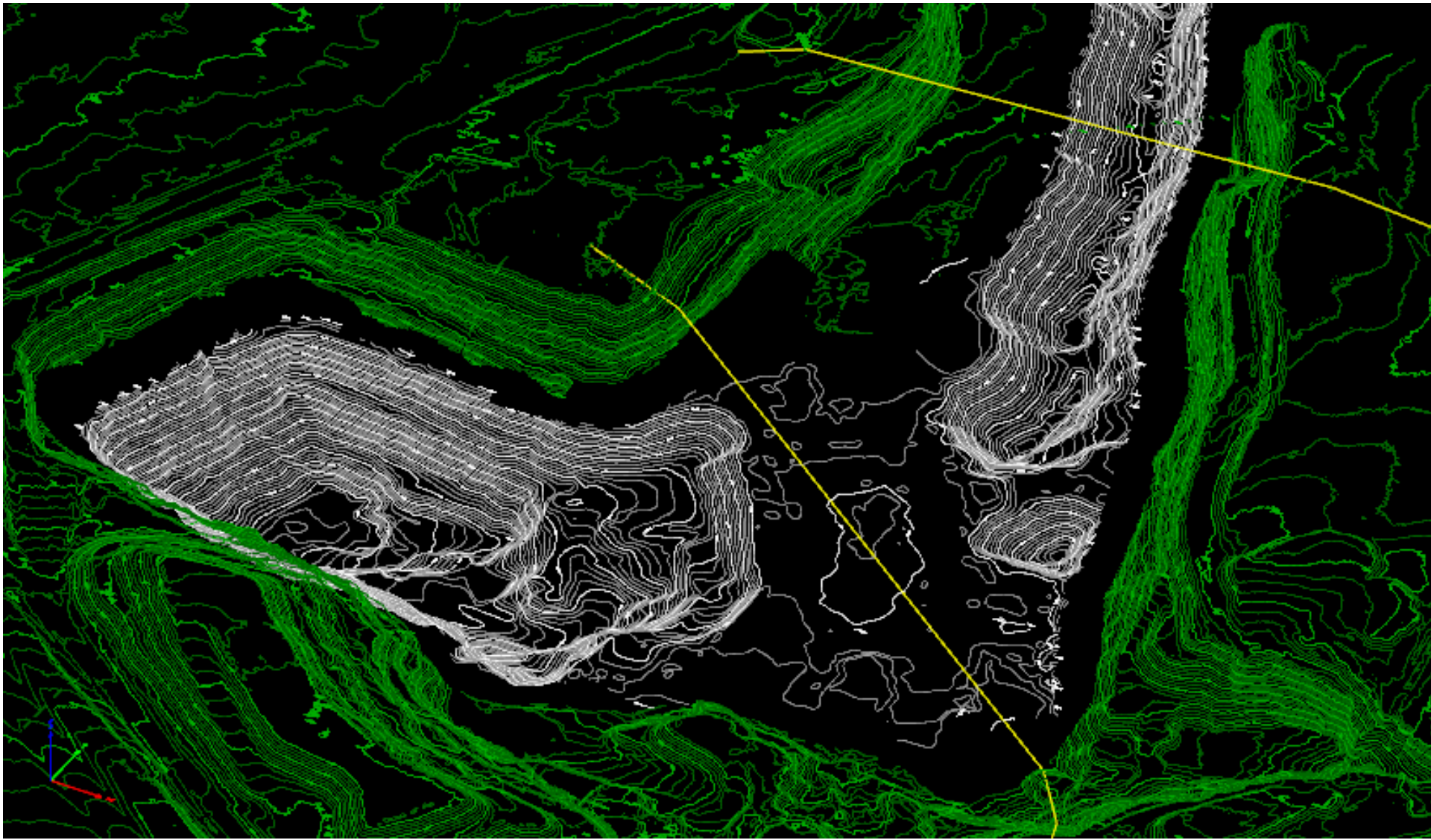
GLONASS and VRS GPS

- 10 cm XY accuracy
- Narrow canyon with sheer cliffs challenges GPS
- GLONASS Russian satellites – new GPS technology
- Sprint wireless MIFI hotspot
- VRS for GPS real-time correction from MnCORS
- Not Z – measured water surface from benchmark

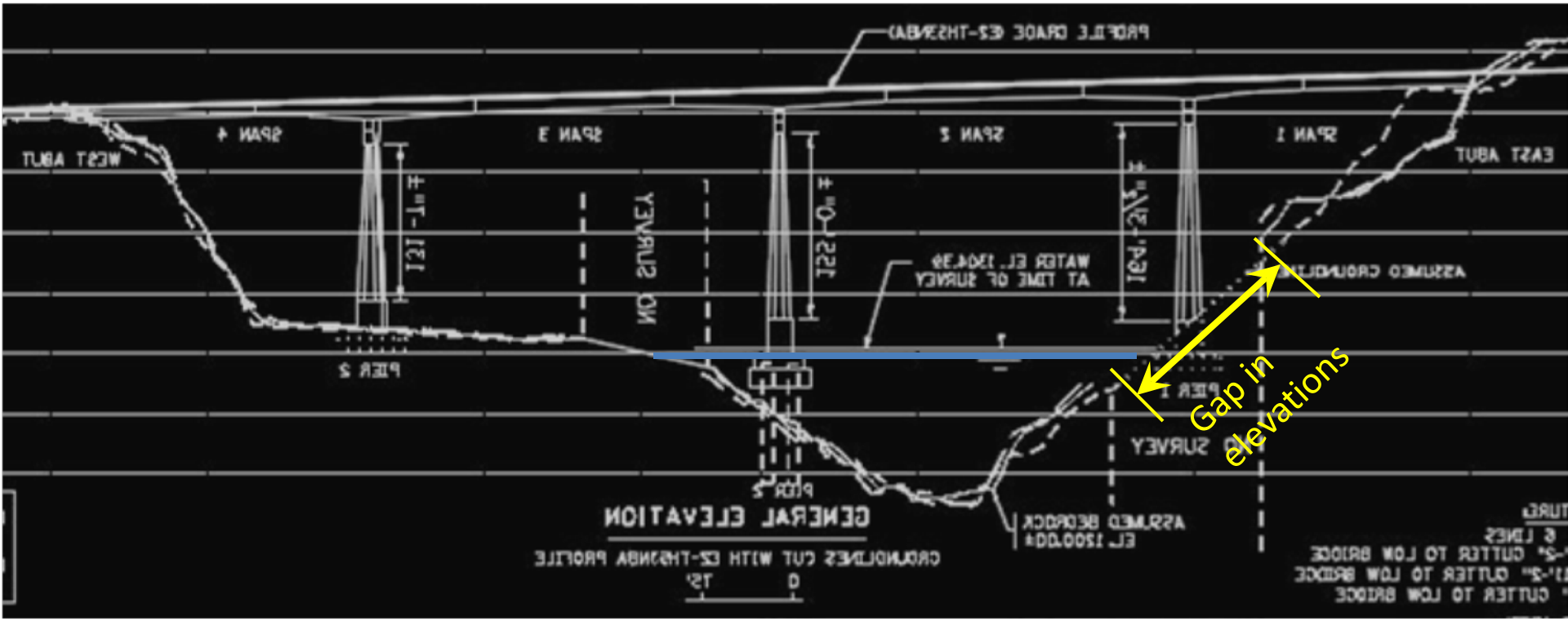
Rochleau Mine Pit Mapped for New Highway Crossing

10’ contours

Upland and underwater contours on 3D oblique view

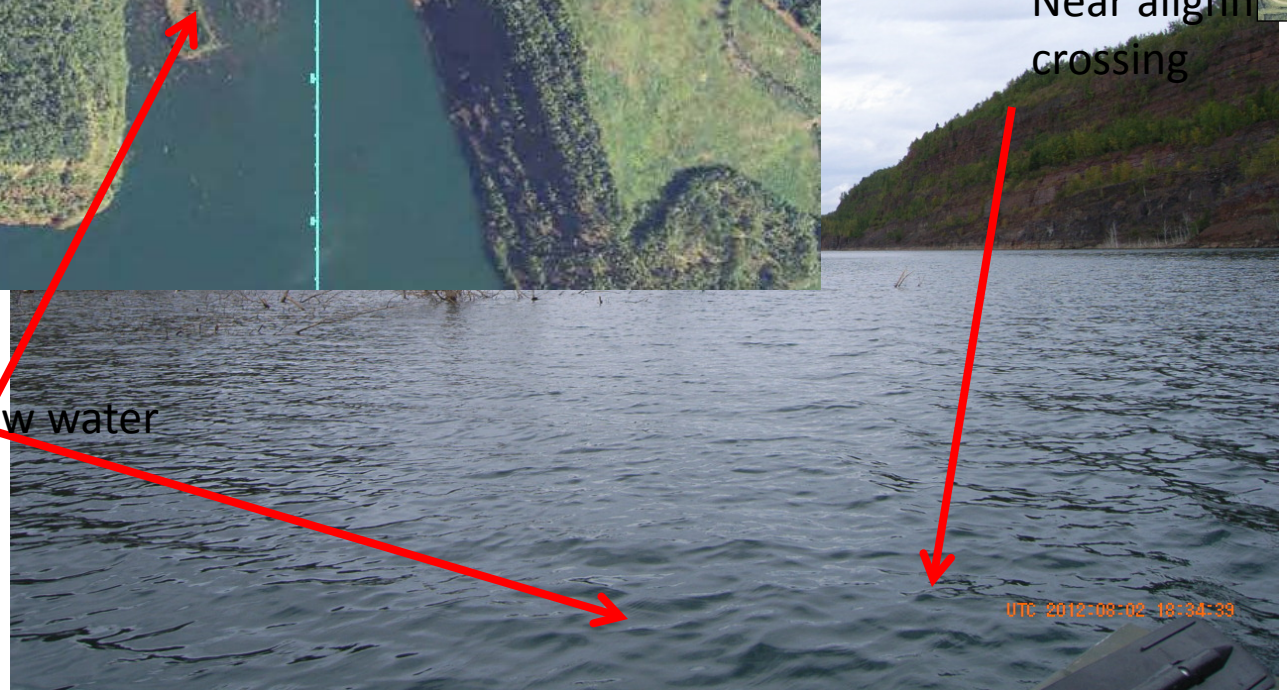


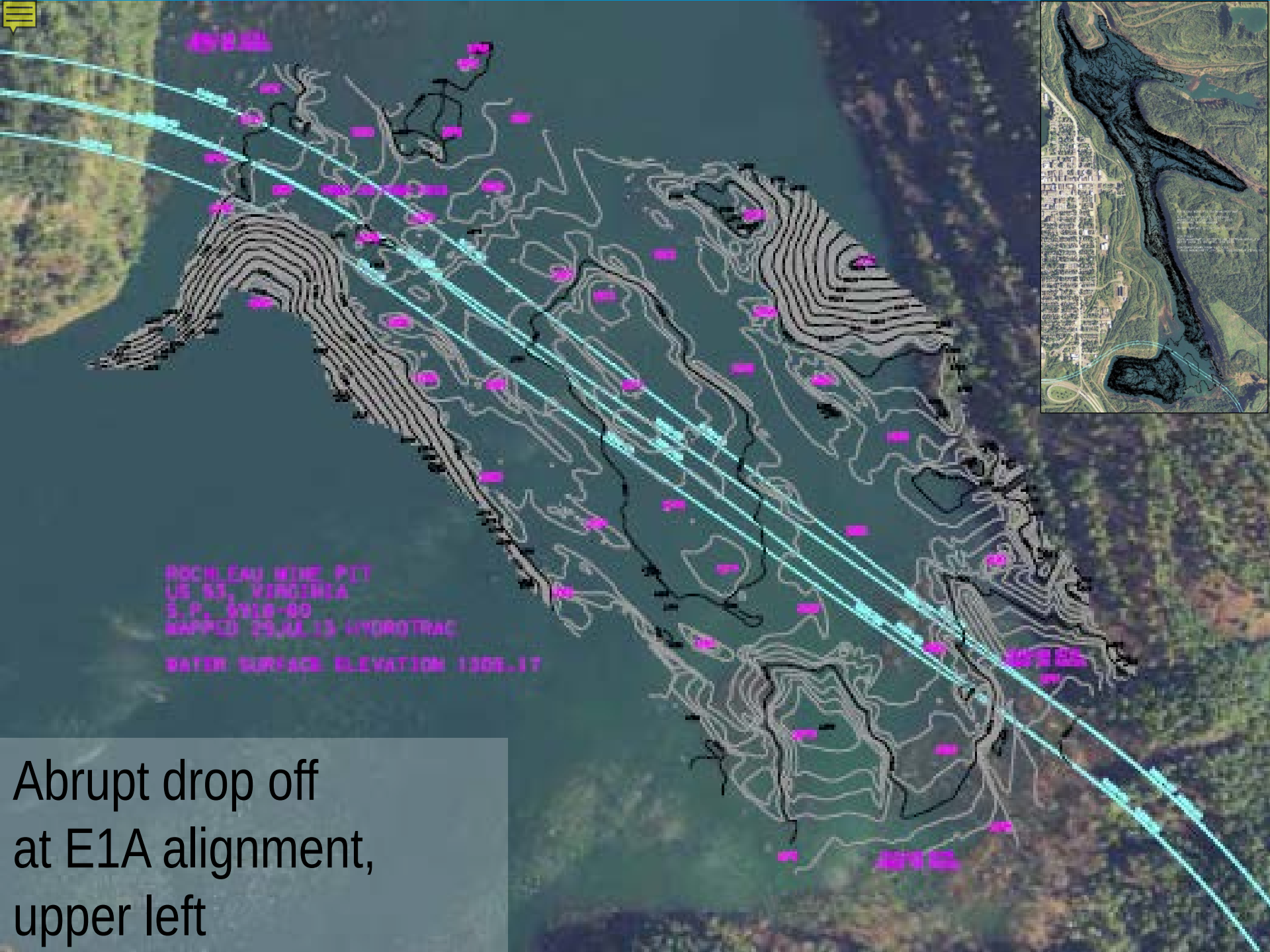
Cliffs are too steep, so Lidar elevations missing near waterline



E2 bridge flies 200 feet above 120’ deep water

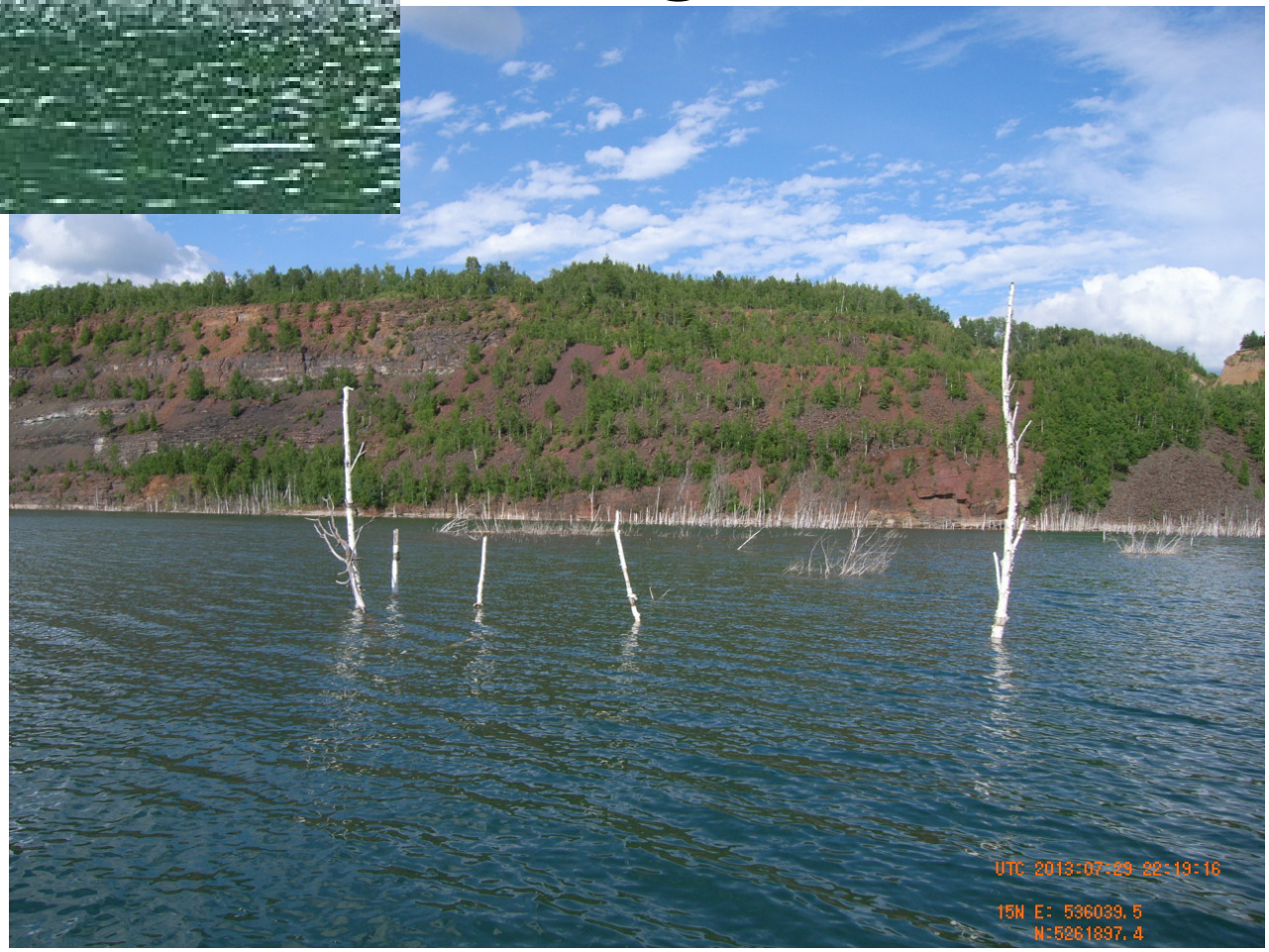
E2 alignment
broad ledge and deep trench





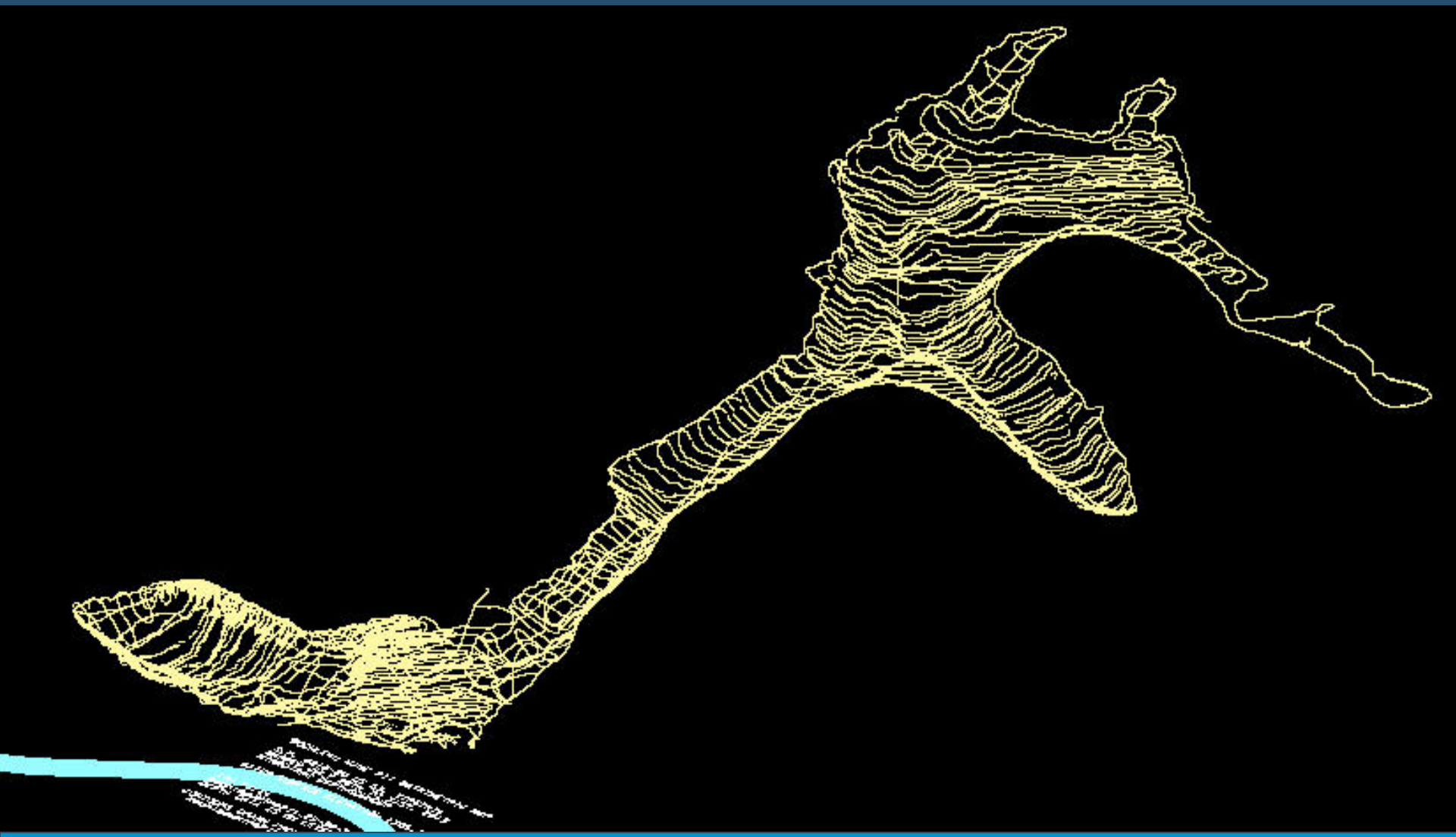
Abrupt drop off
at E1A alignment,
upper left

Submerged Trees and Power Poles Alignment E1A



False depths from underwater debris

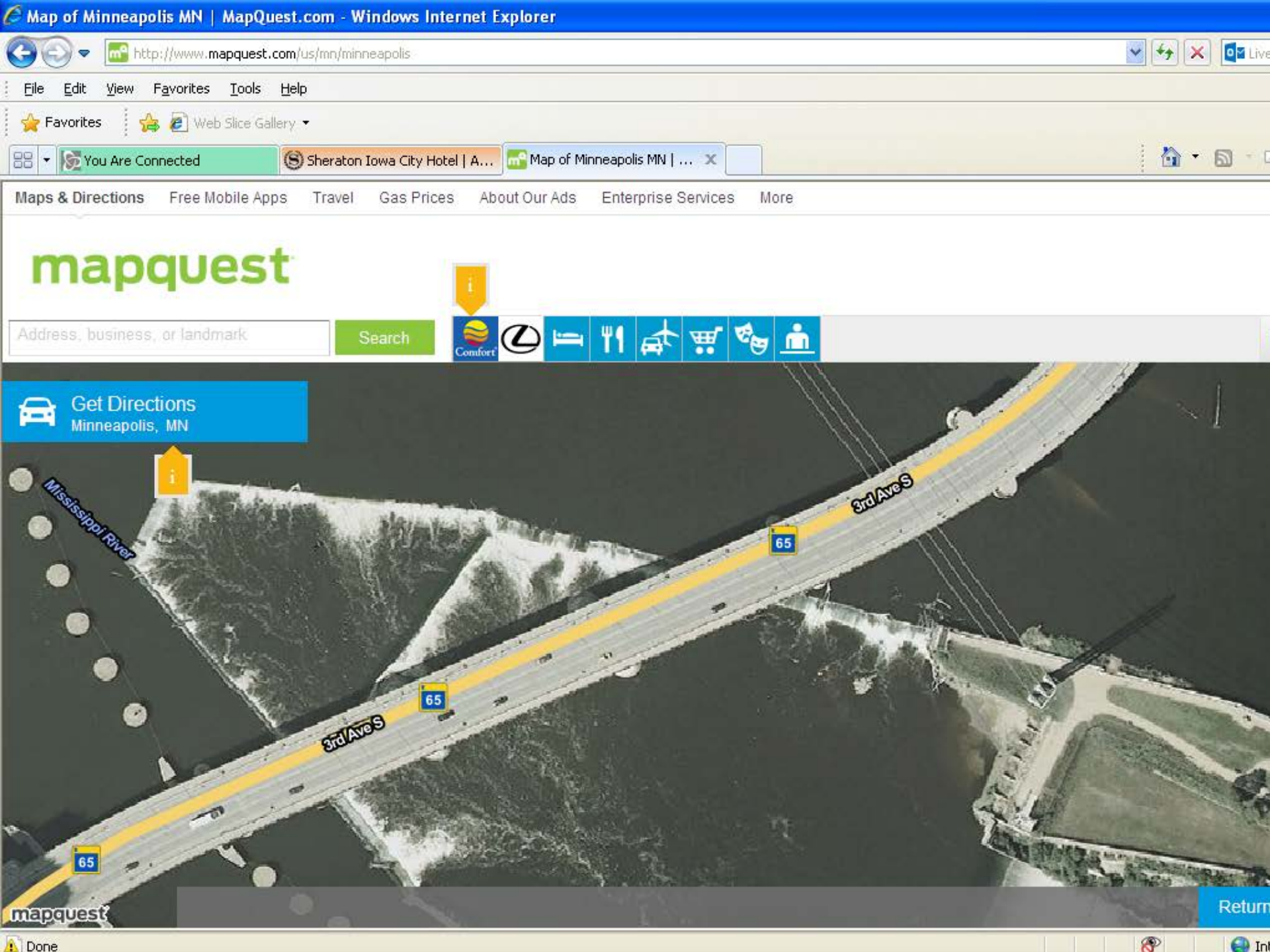
Spot elevations in Microstation 3D



“Mine View in the Sky”

will disappear

- What’s next for us!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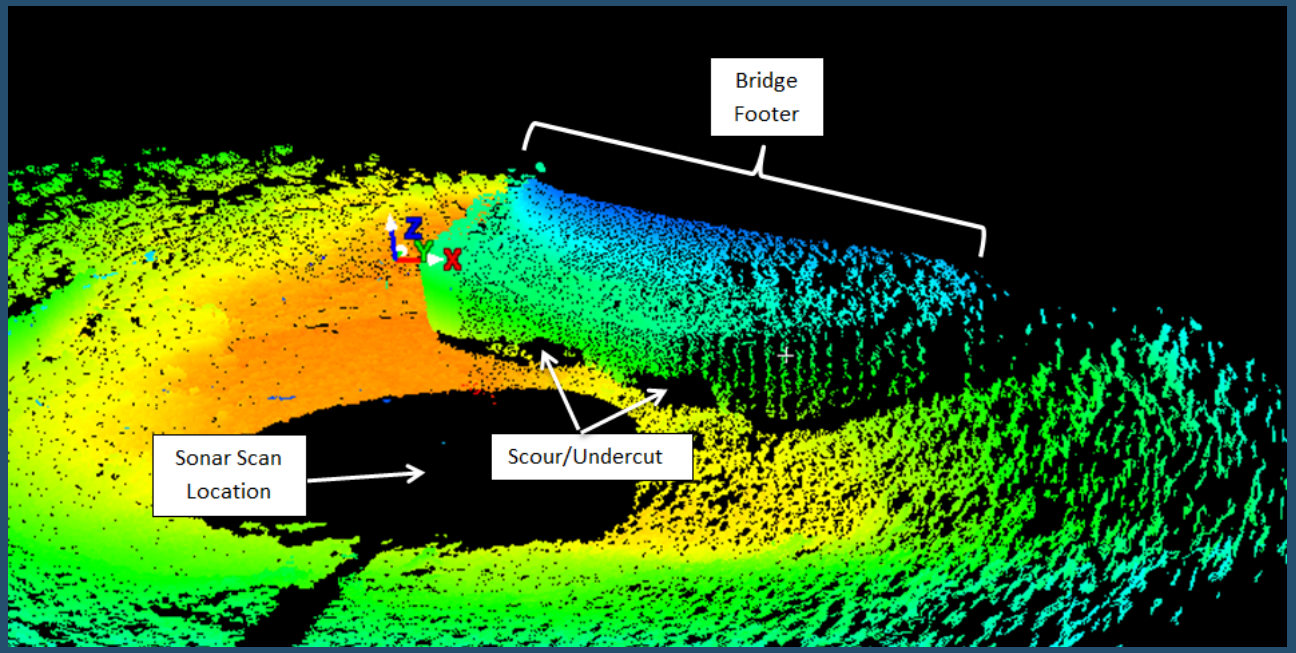
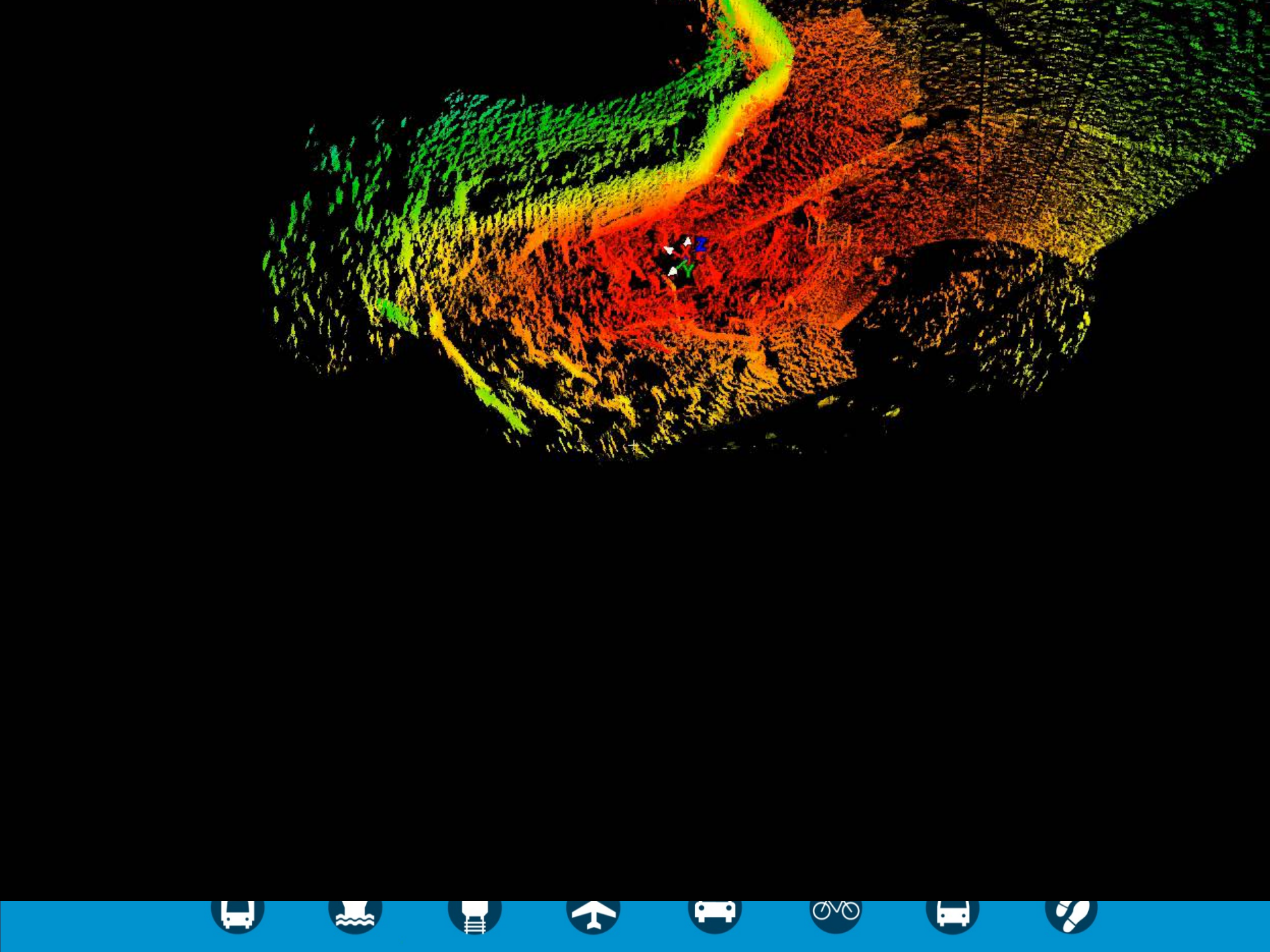
BV5000 3D System




Z
Y

Questions?