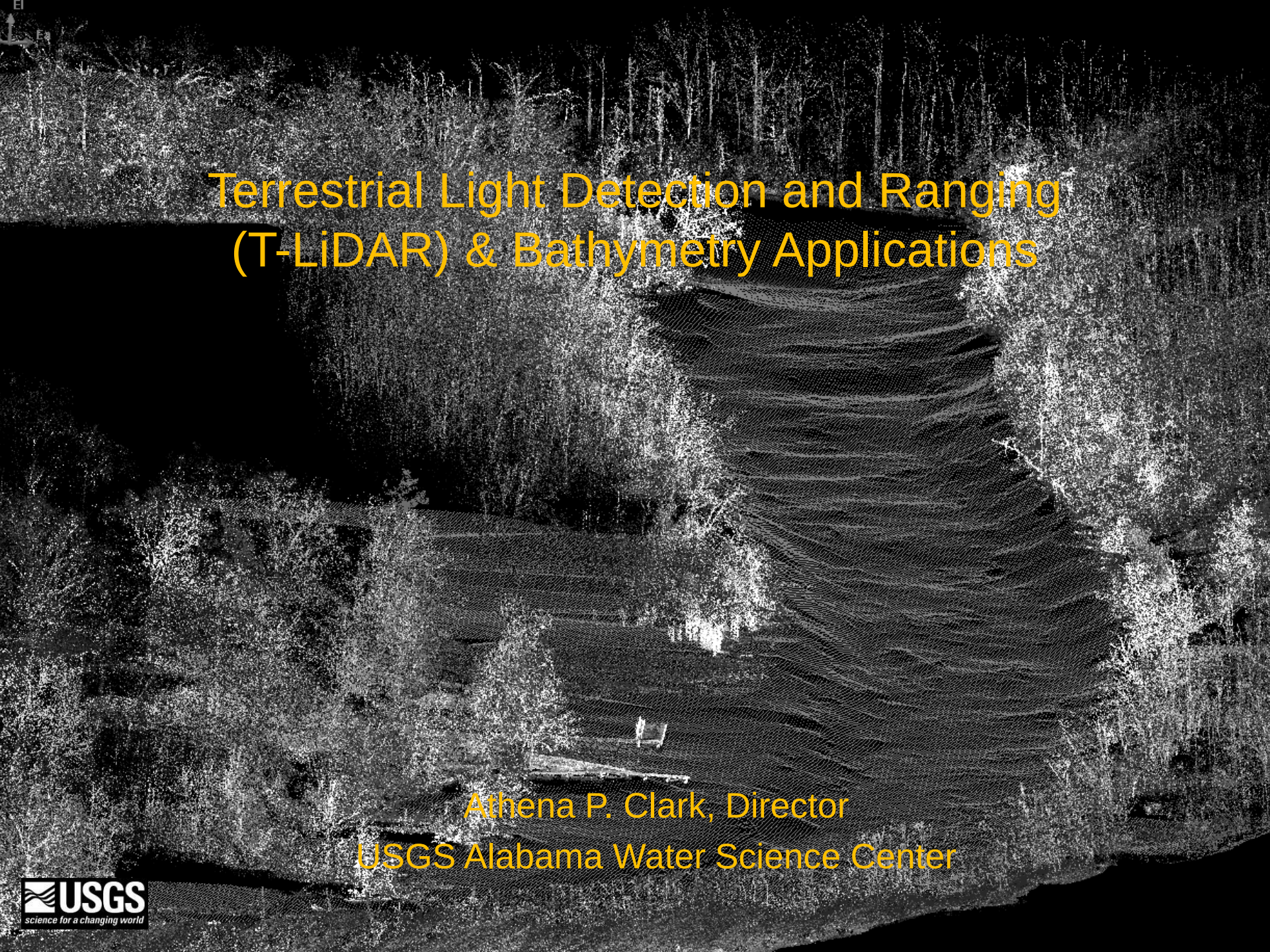

Terrestrial Light Detection and Ranging (T-LiDAR) & Bathymetry Applications

Athena P. Clark, Director
USGS Alabama Water Science Center

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science for a changing world

The applications of T-LiDAR are numerous and will change how some *Science* will be done. (G. Bawden, USGS)

- fault and fracture mapping
- paleo-seismology
- post seismic displacement field
- landslide hazards
- debris flow hazards
- fire science
- glacier science
- dam safety
- dam failure assessment
- surface water hydrology
- fluvial geomorphology
- snow pack depth
- snow fall density
- structural engineering
- material volume
- mine collapse
- reservoir volume
- biomass volume
- levee stability
- avalanche
- habitat
- land surface processes
- beach erosion
- dune migration
- crop health
- land subsidence
- co seismic offsets
- fault and fracture mapping
- geologic mapping
- trench mapping
- volume calculations
- mass calculations
- endangered species mapping
- low tide bathymetry
- surface water elevation
- flood measurements,
- ice flow measurements,
- ???

Why use Terrestrial (Ground-Based) LiDAR?

- Data typically more accurate than airborne LiDAR
- Higher point density can yield higher resolution Digital Elevation Models (DEMs)
- More cost-effective over small areas
- Requires less time for planning
- Horizontal field of view is useful for mapping vertically-oriented features such as cliffs, dunes, levees, etc.
- Can be combined with airborne LiDAR to provide a comprehensive 3-D view of landscape features

Several laser scanners available

Terrestrial or Ground-based LiDAR

Optech ILRIS-HD-ER-MC
Range 80% Reflectivity = 1700 m
Minimum Range = 3 m
Laser Repetition Rate = 10,000 Hz
Raw Range Accuracy (AVG) = 3-4 mm @ 100 m
Maximum Sample Density = 1.3 mm @ 100 m

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laser scanner

position and orientation system

Mobile Mapping

Streambank Erosion
Coosa River, AL

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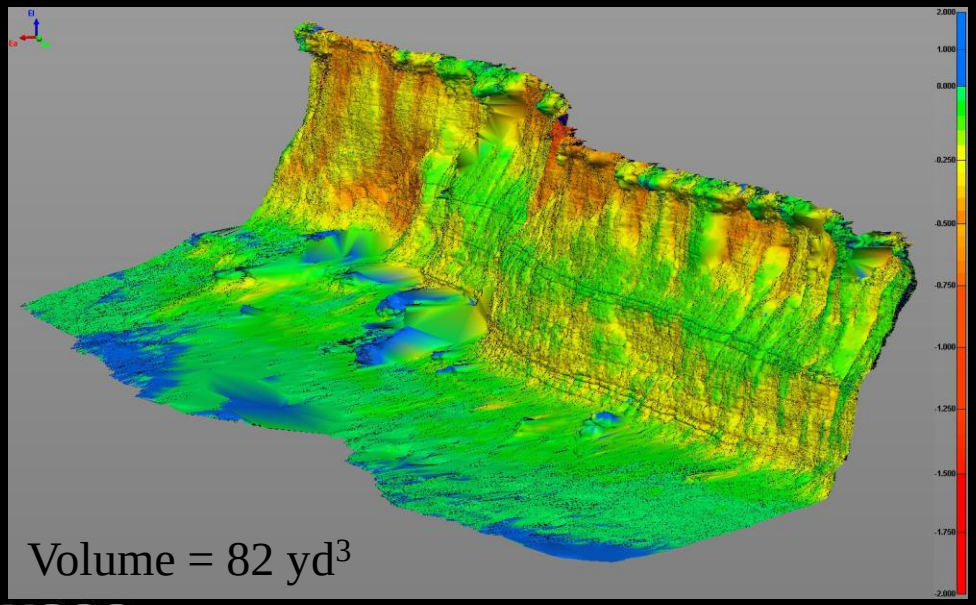
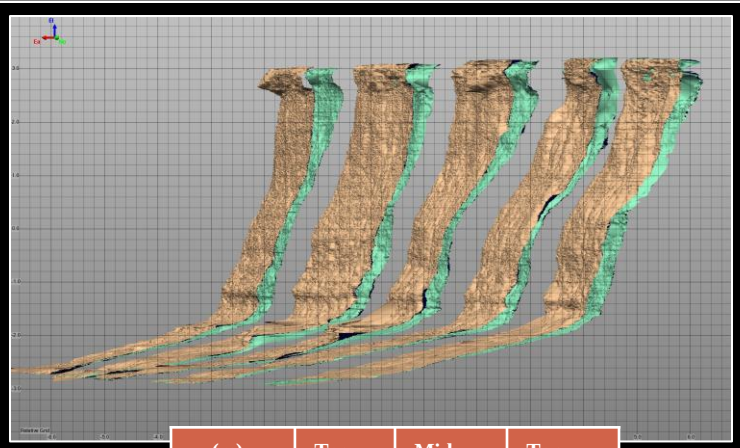
Streambank Erosion
Coosa River, AL





(m)	Toe	Mid	Top
Max	0.34	0.35	0.58
Min	0.25	0.10	0.37
Average	0.30	0.19	0.44

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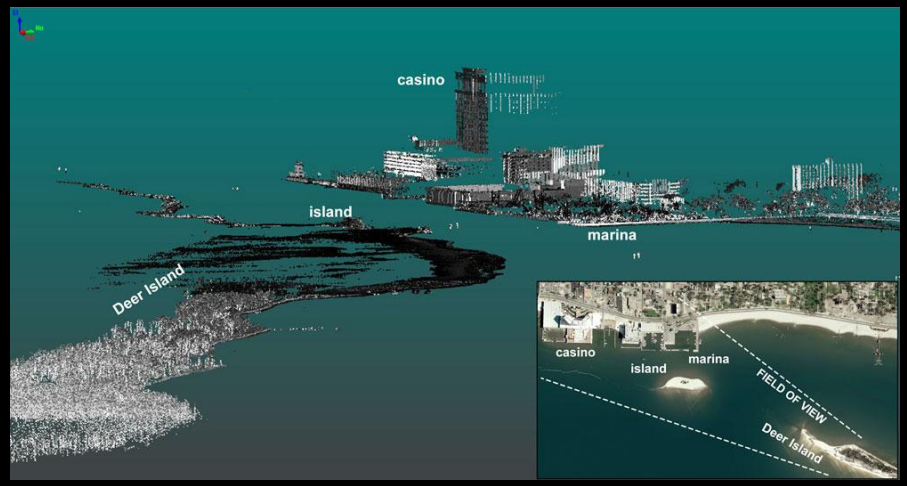
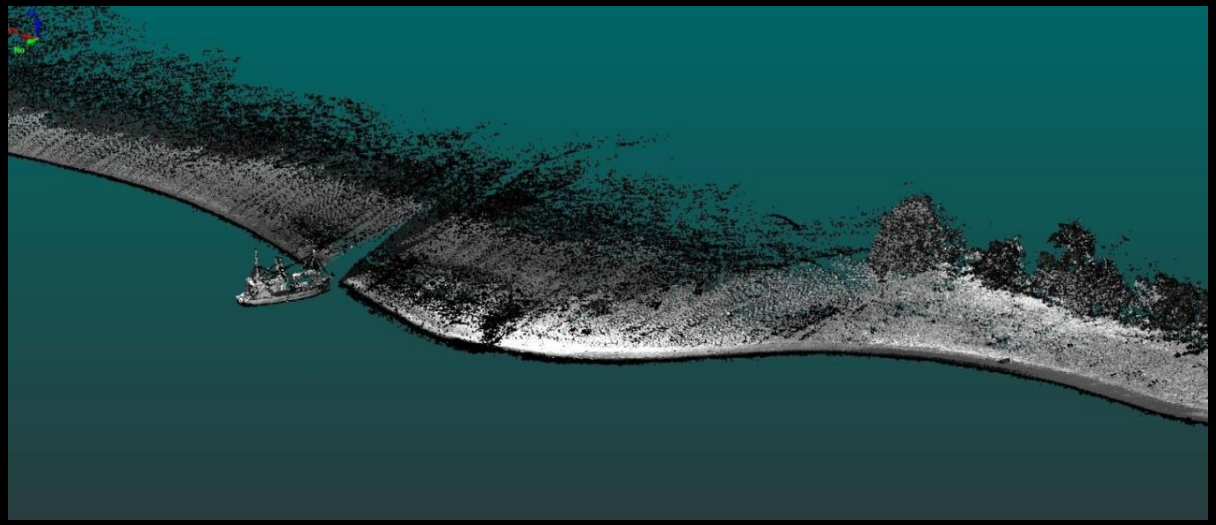
Barrier Island
Biloxi - Deer Island, MS





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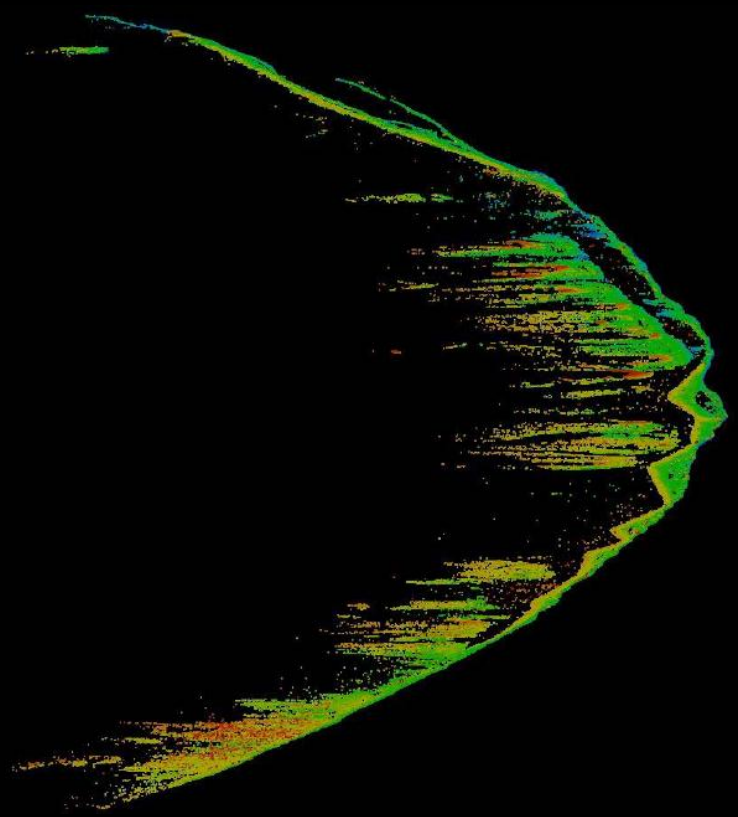
Barrier Island (T-LiDAR, boat)
Chandeleur Island, LA



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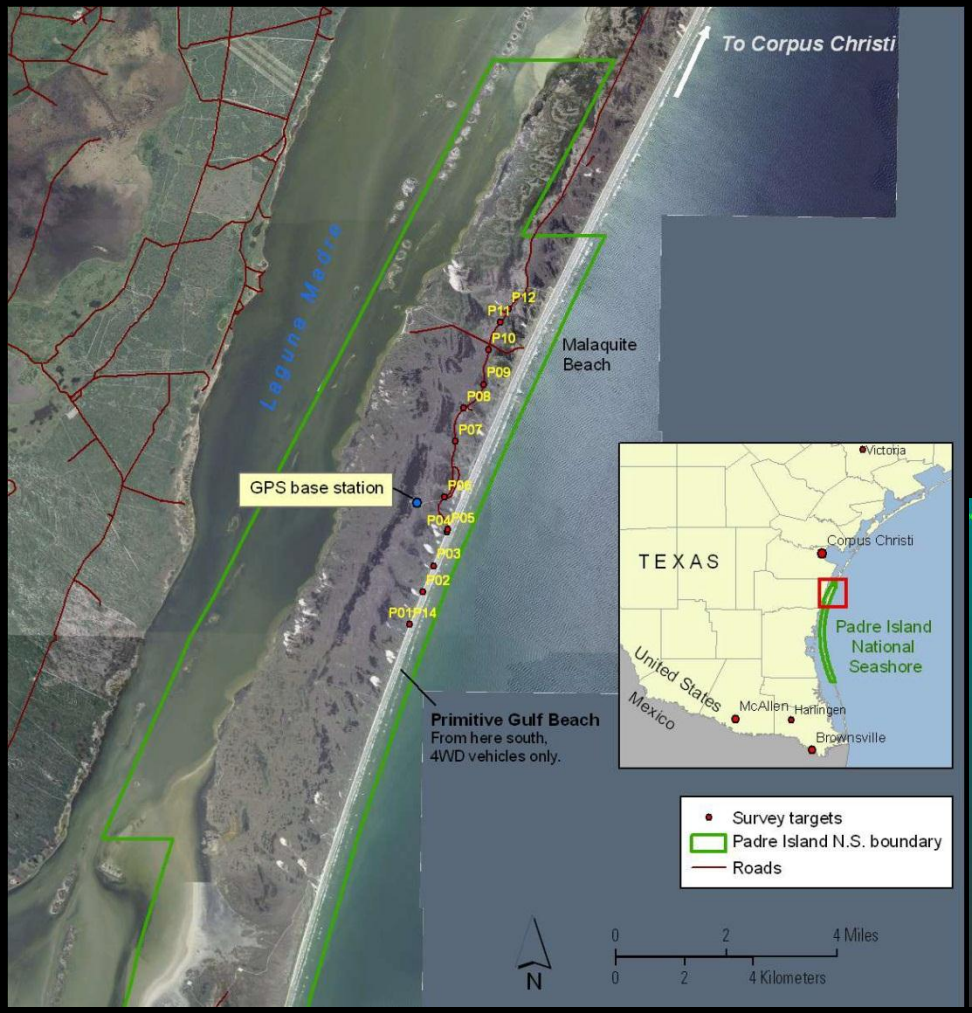
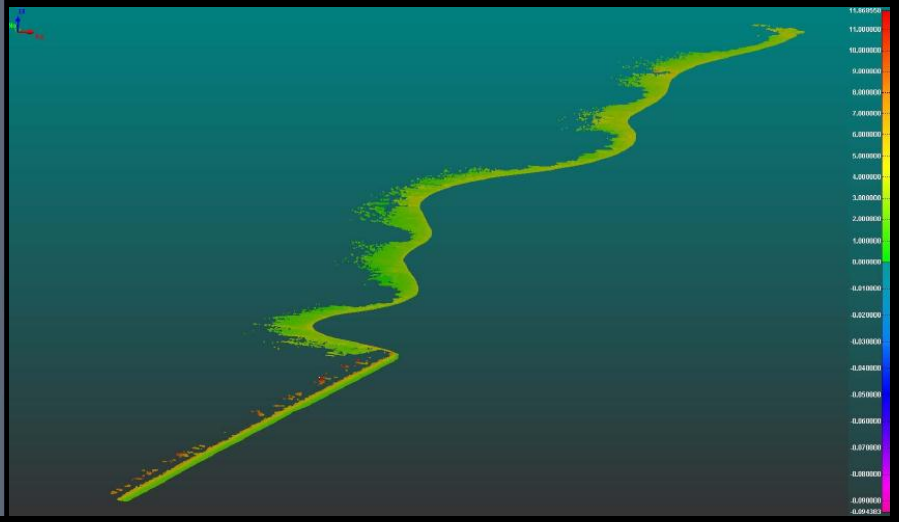
Land Subsidence
Padre Island, TX





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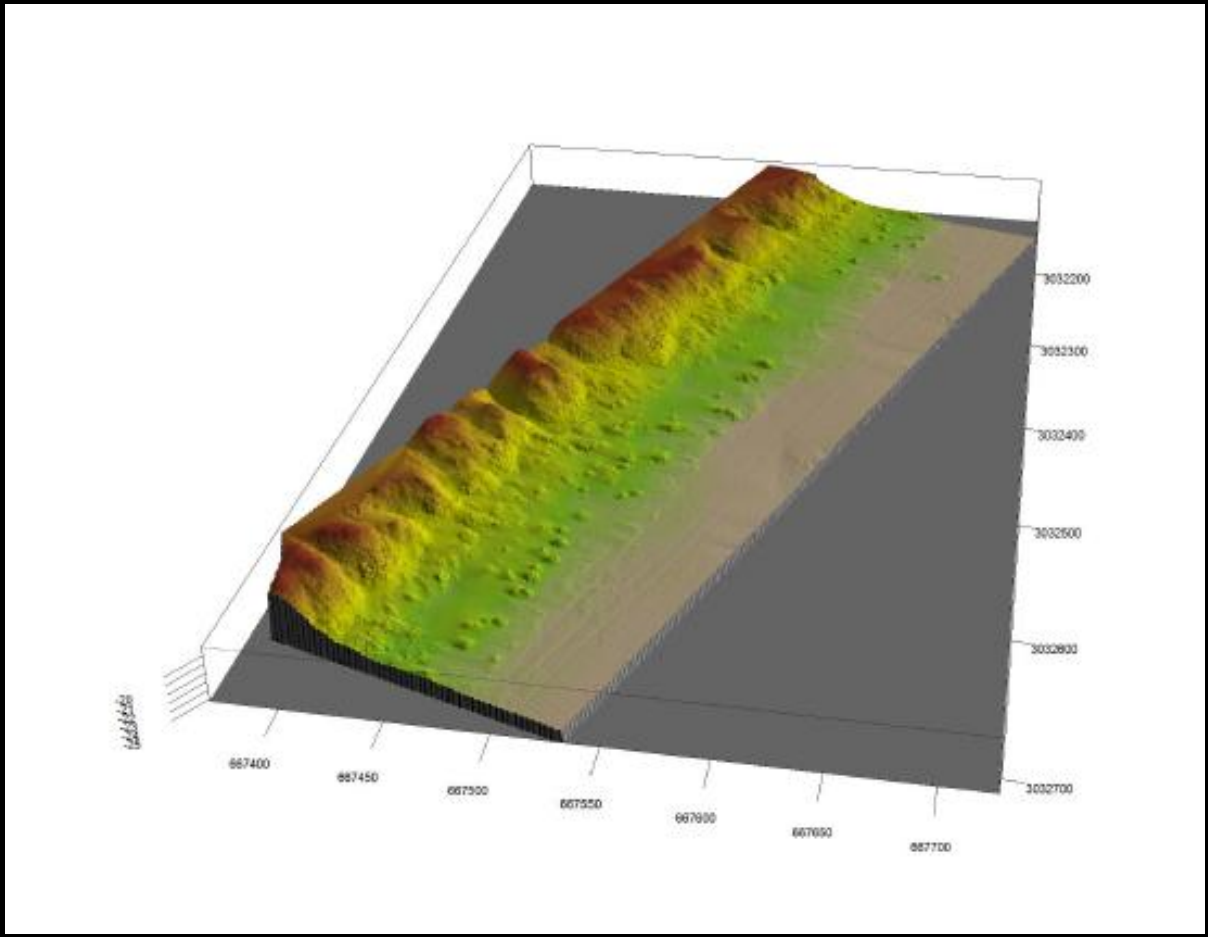
Land Subsidence
Padre Island, TX



Digital Elevation Model (DEM) of a section of beach and dunes, grided at 0.2 m resolution

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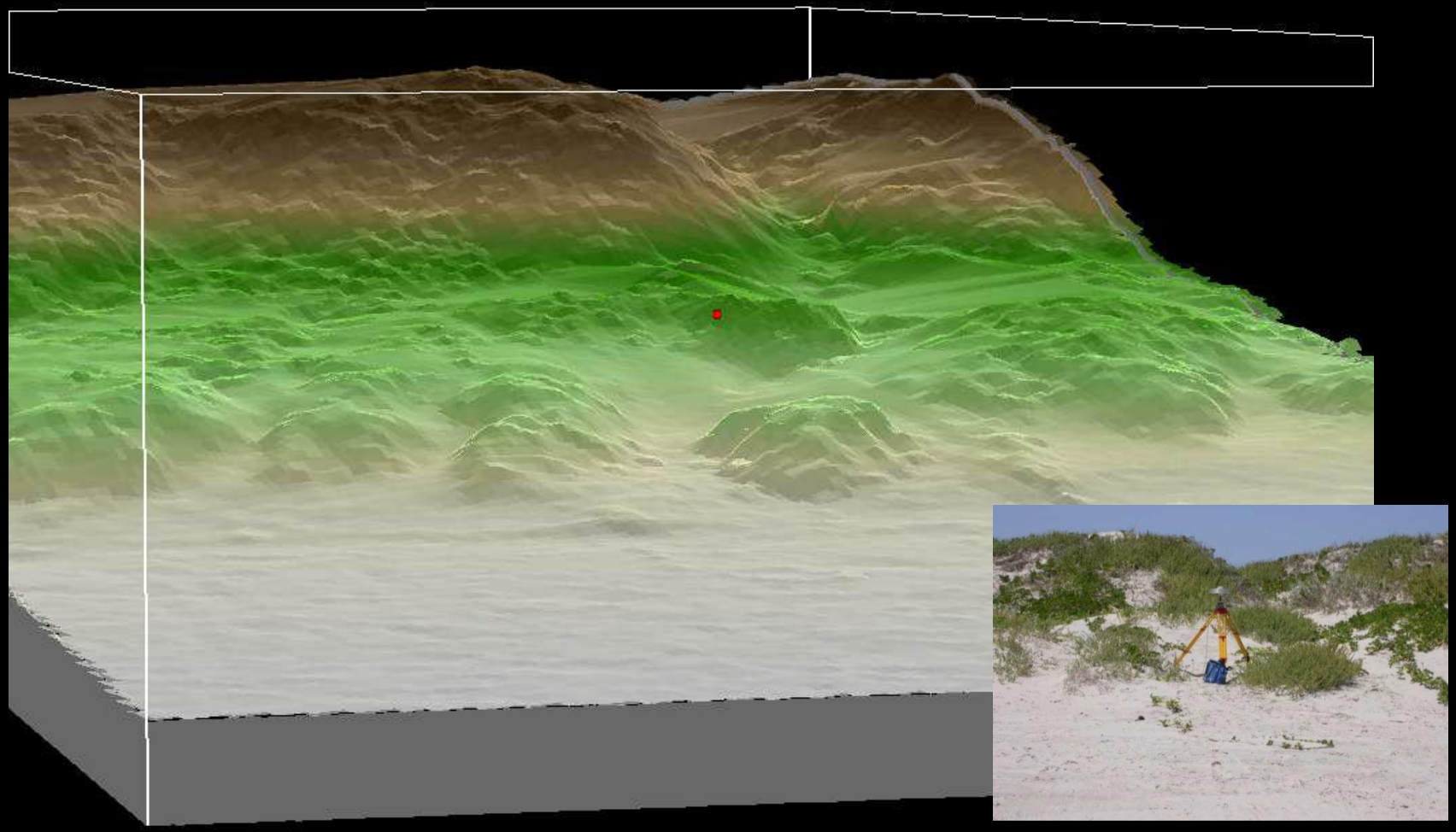
Land Subsidence
Padre Island. TX



Digital Elevation Model (DEM) of a section of beach and dunes, grided at 0.1 m resolution

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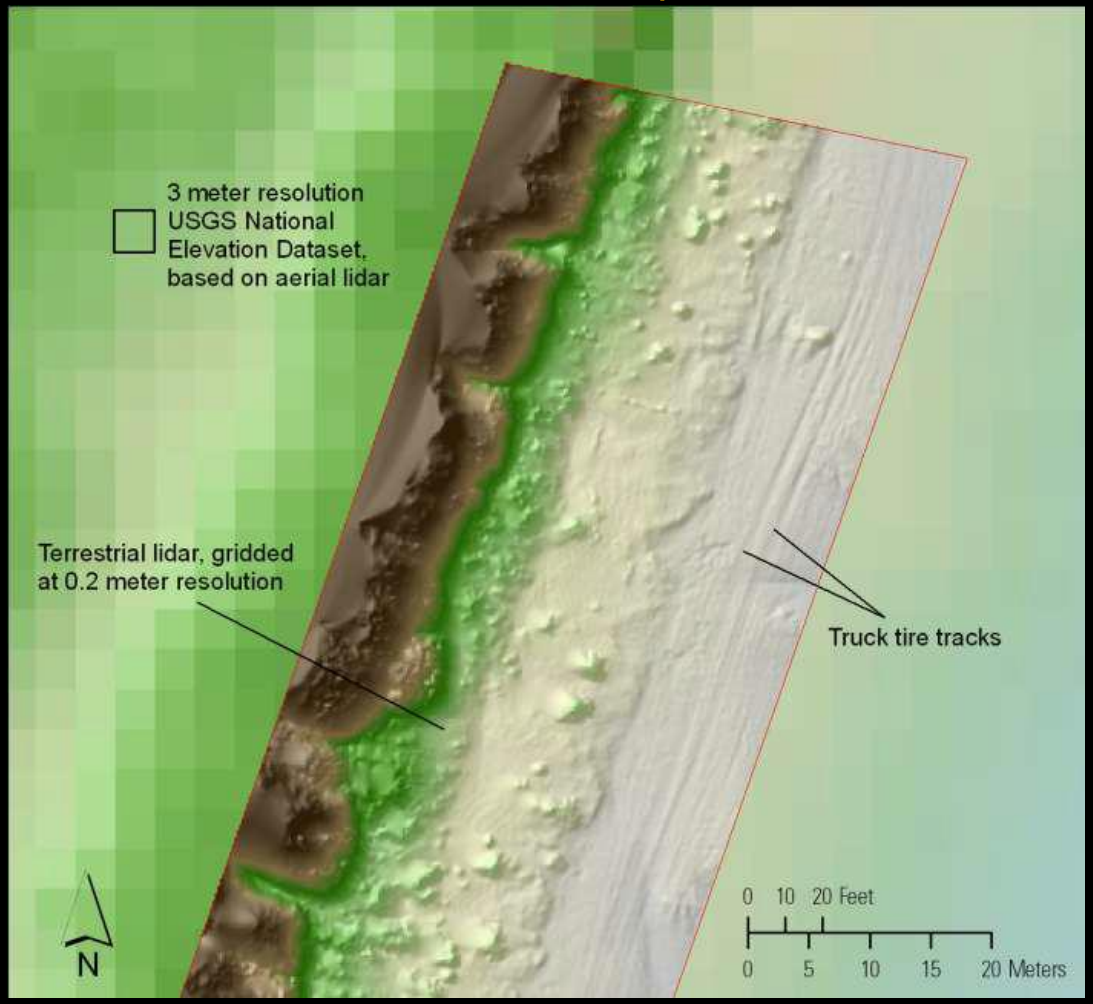
Land Subsidence
Padre Island, TX



Comparison of a 3-m resolution aerial LiDAR-based DEM to a 0.2 m resolution terrestrial LiDAR-based DEM

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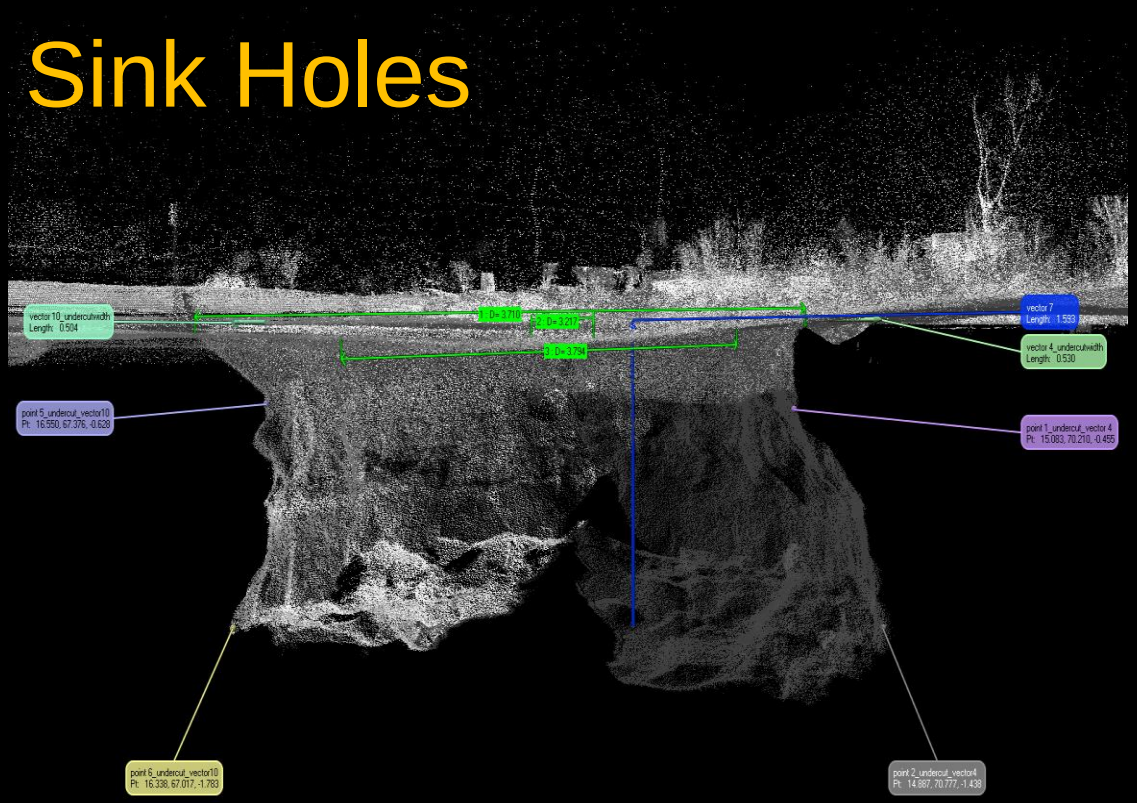
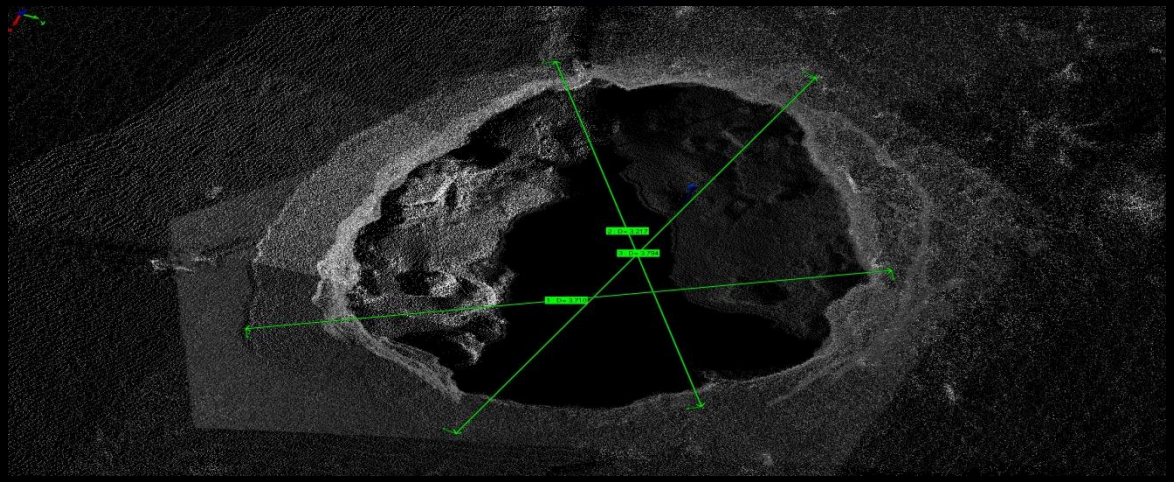
Sink Holes





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Gerald Bawden, USGS

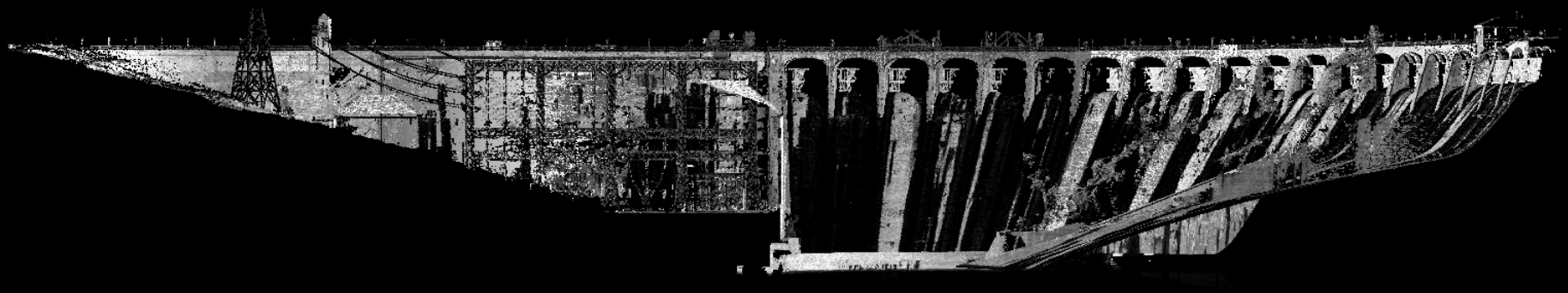
Dam Safety

USGS
science for a changing world

Dam Safety

USGS
science for a changing world

Dam Safety



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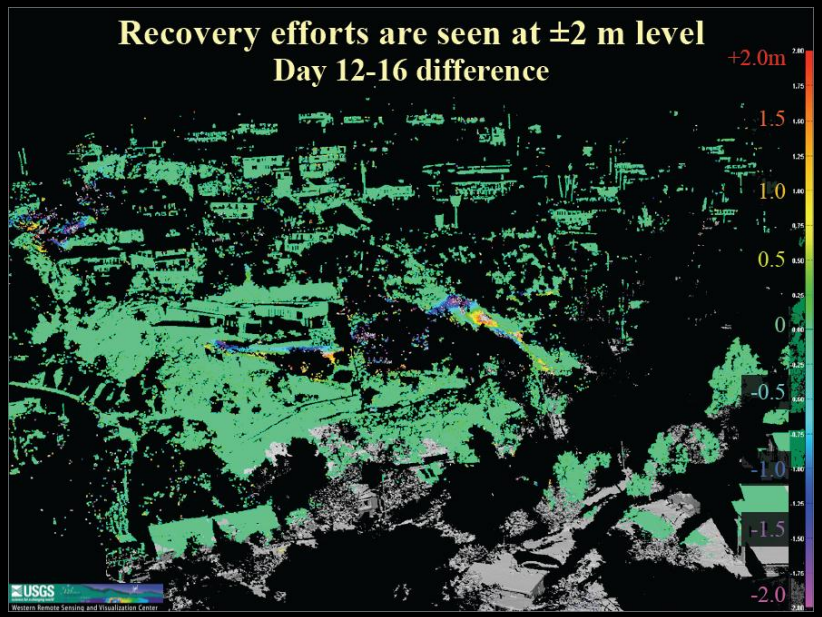
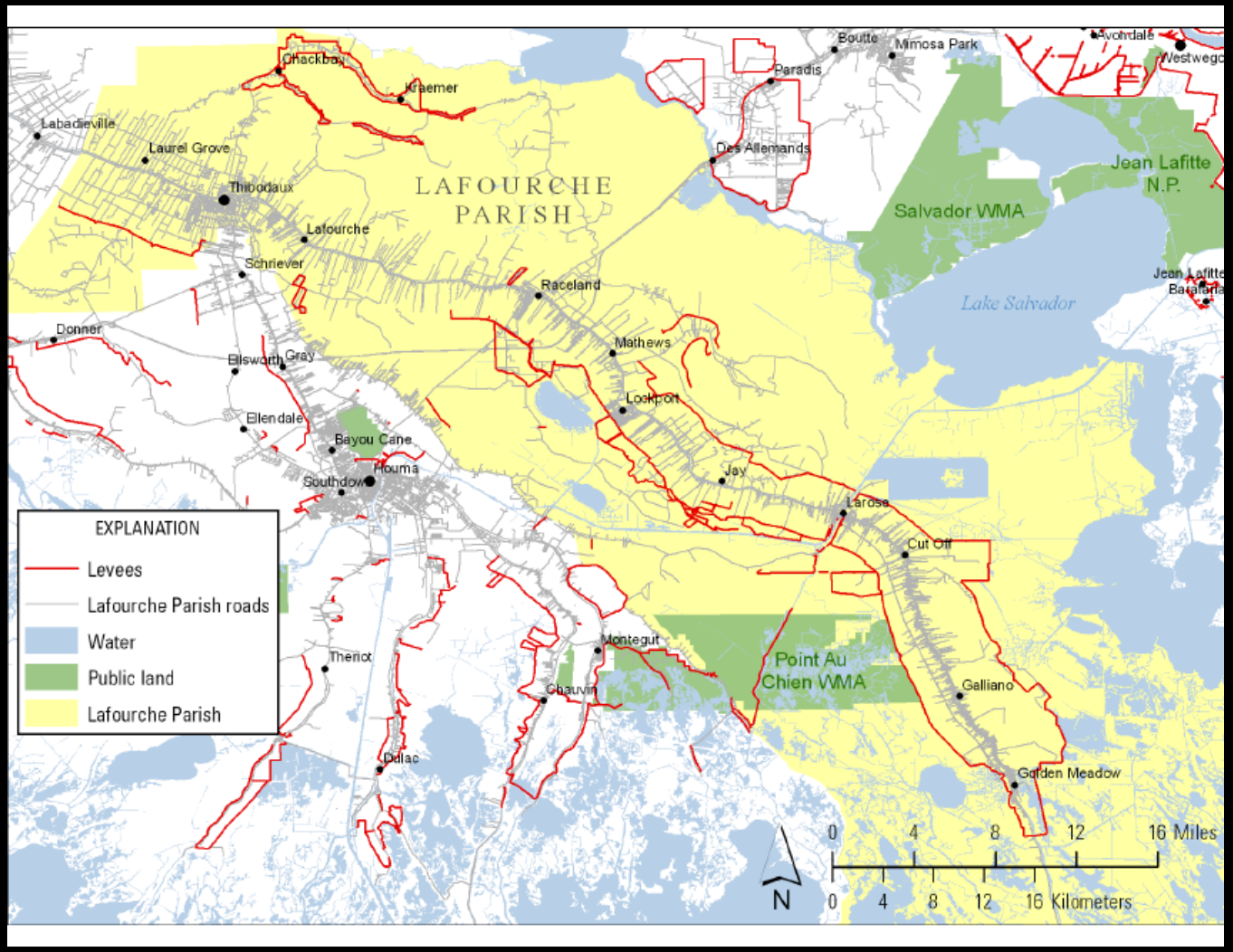
Landslide

Blue Bird Canyon Landslide
Laguna Beach CA - June 1, 2005
USGS
Western Remote Sensing and Visualization Center

>7.5 million points scanned at this location
Days 12,13,16, & 21 after the landslide
USGS
Western Remote Sensing and Visualization Center


Recovery efforts are seen at ±2 m level
Day 12-16 difference
+2.0m
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
USGS
Western Remote Sensing and Visualization Center

Levee mapping & analysis
LaFourche Parish, LA



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Levee mapping & analysis
LaFourche Parish, LA

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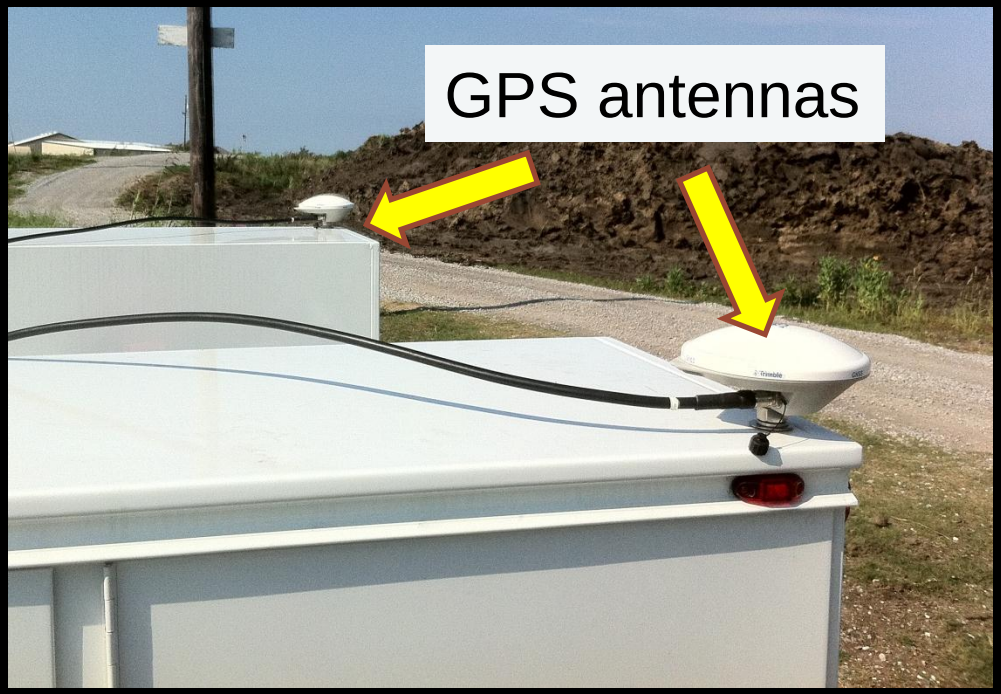
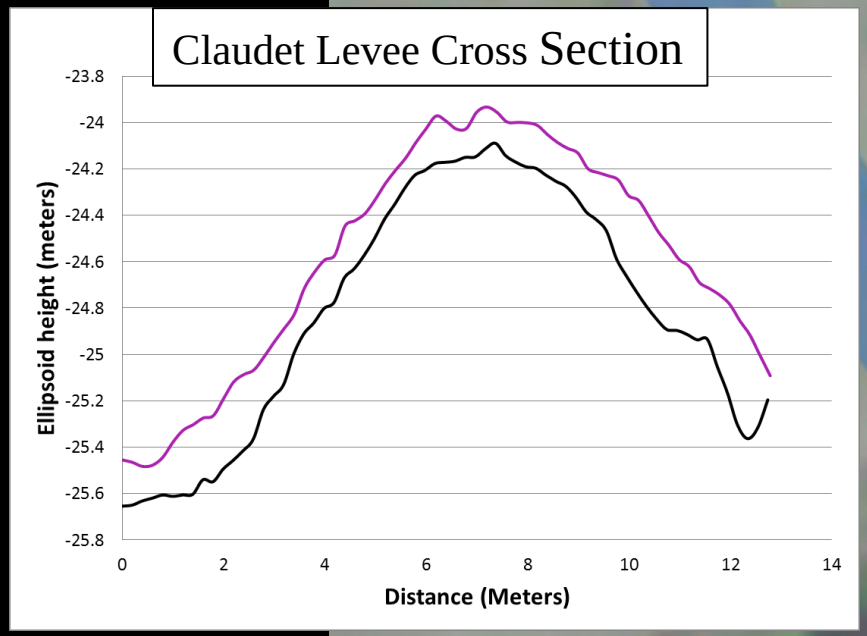
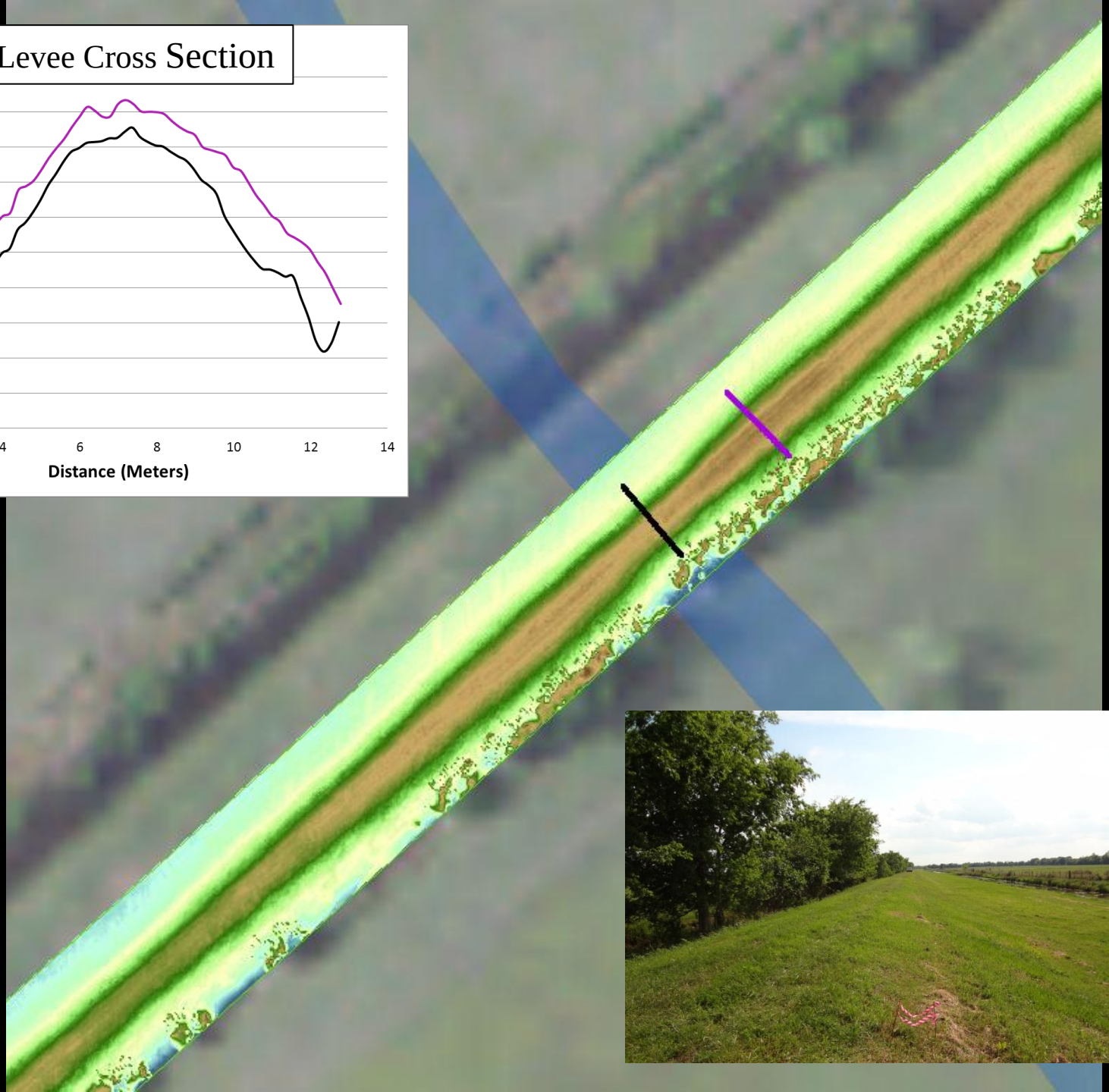


Position and Orientation System computer

40 meters
3x
800 meters
Lockport
Al Robichaux
Pump Station
Walds Levee
Claudet Levee
Romy Dr
Mar Dr
Hyland Dr
Comeaux Dr
2nd St
11th St
USGS
science for a changing world





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Accuracy Assessment

Vertical target in the field of view of laser scanner.

Horizontal target in the field of view of laser scanner.

Target coordinates established independently. (Rapid-static GPS survey w/30 minute observations at each target)

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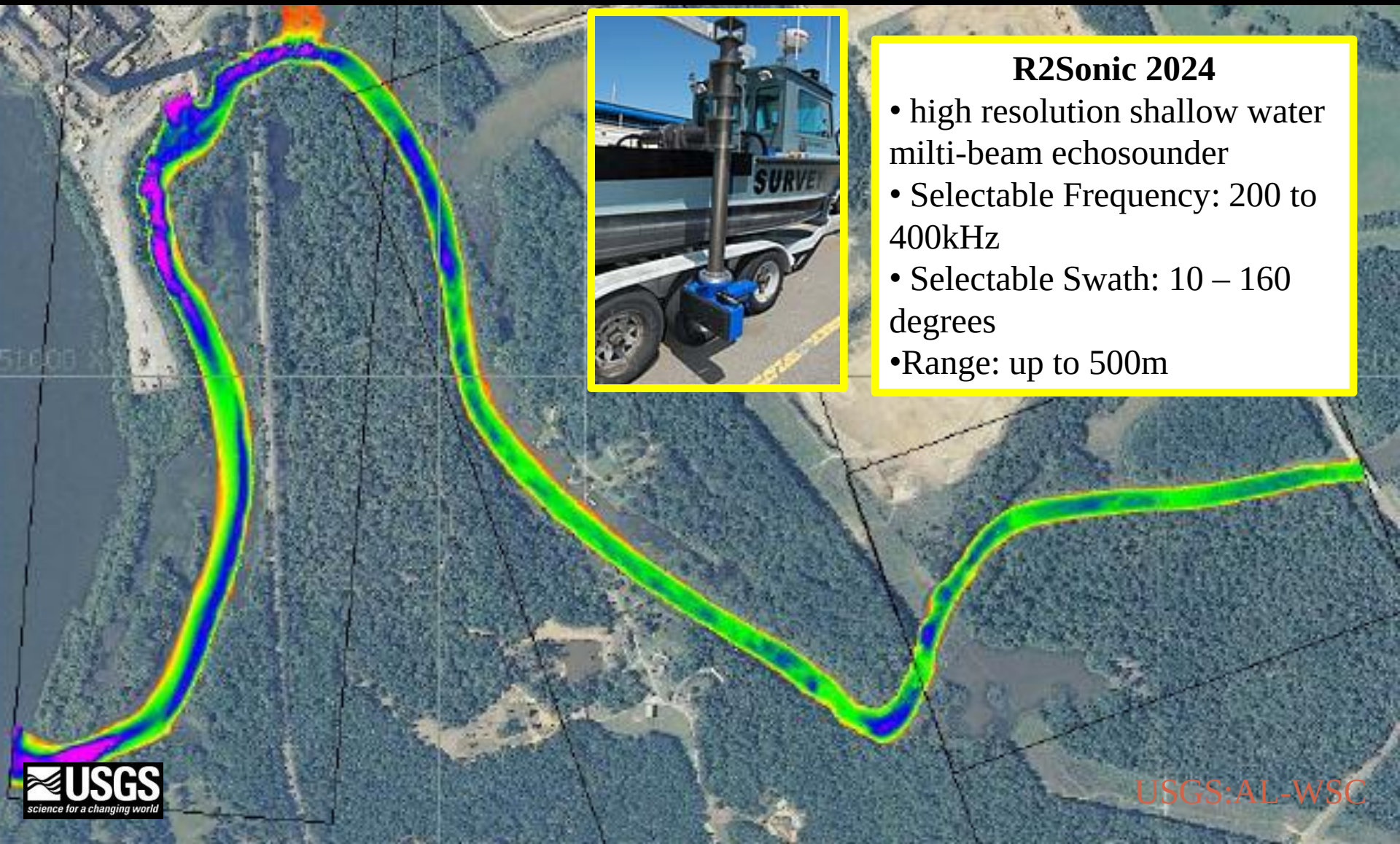
Accuracy Assessment

ID	Horizontal Diff. (meters)	Vertical Diff. (meters)
LL02	not fully visible in scans	
LL03	0.032	0.020
LL04	0.043	-0.031
LL05	0.056	0.043
LL06	0.048	0.044
LL07	not fully visible in scans	
LL08	0.038	-0.020
LL09	not fully visible in scans	
LL10	0.041	0.037
LL11	0.027	0.063
RMSE	0.042	0.039

USGS

Bathymetry
Alabama – Yellow Leaf Creek



R2Sonic 2024

- high resolution shallow water milti-beam echosounder
- Selectable Frequency: 200 to 400kHz
- Selectable Swath: 10 – 160 degrees
- Range: up to 500m

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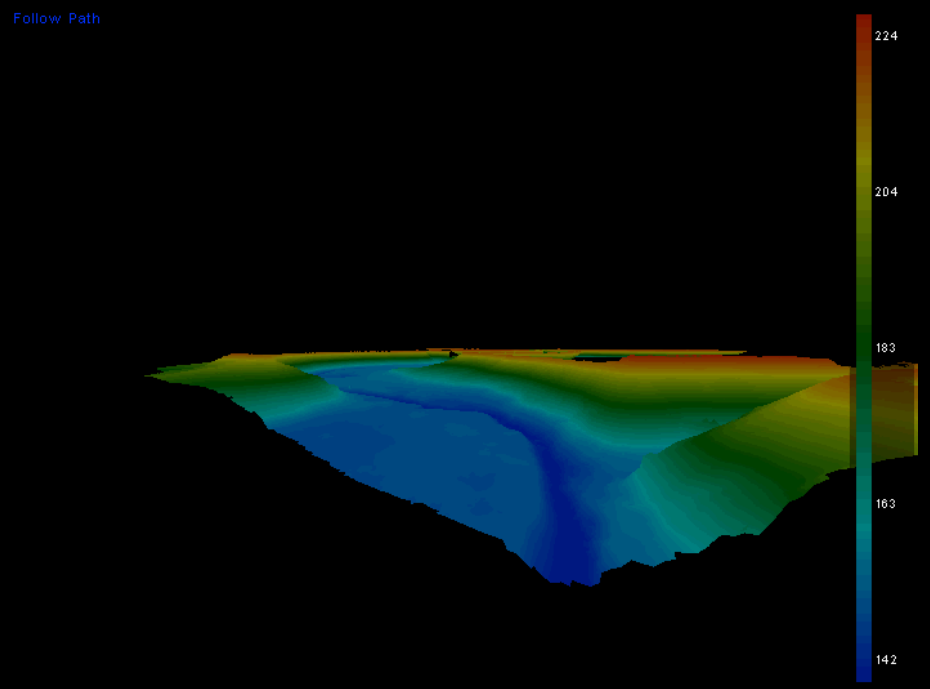
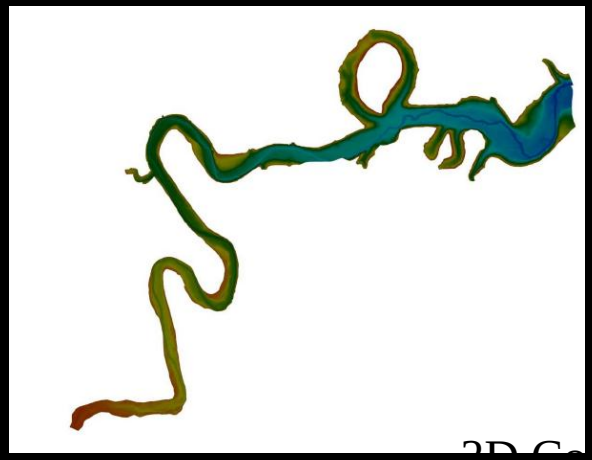
USGS:AL-WSC

Bathymetry
Alabama – Carroll Creek





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laser scanner

position and orientation system

multi-beam echosounder

Mobile Mapping

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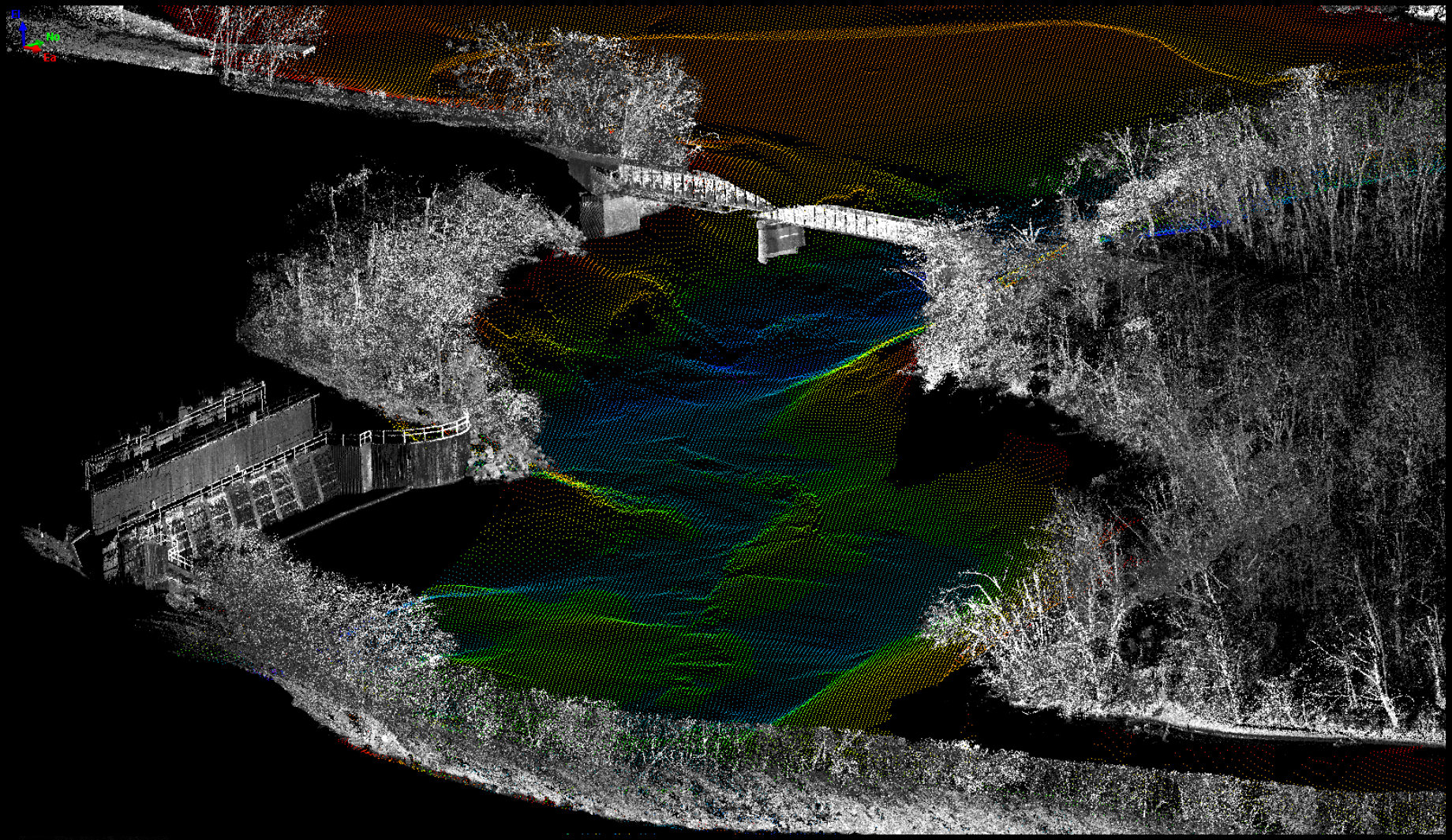
Seamless 3D Model (above & below water surface)
Yellowleaf Creek, AL



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Seamless 3D Model (above & below water surface)
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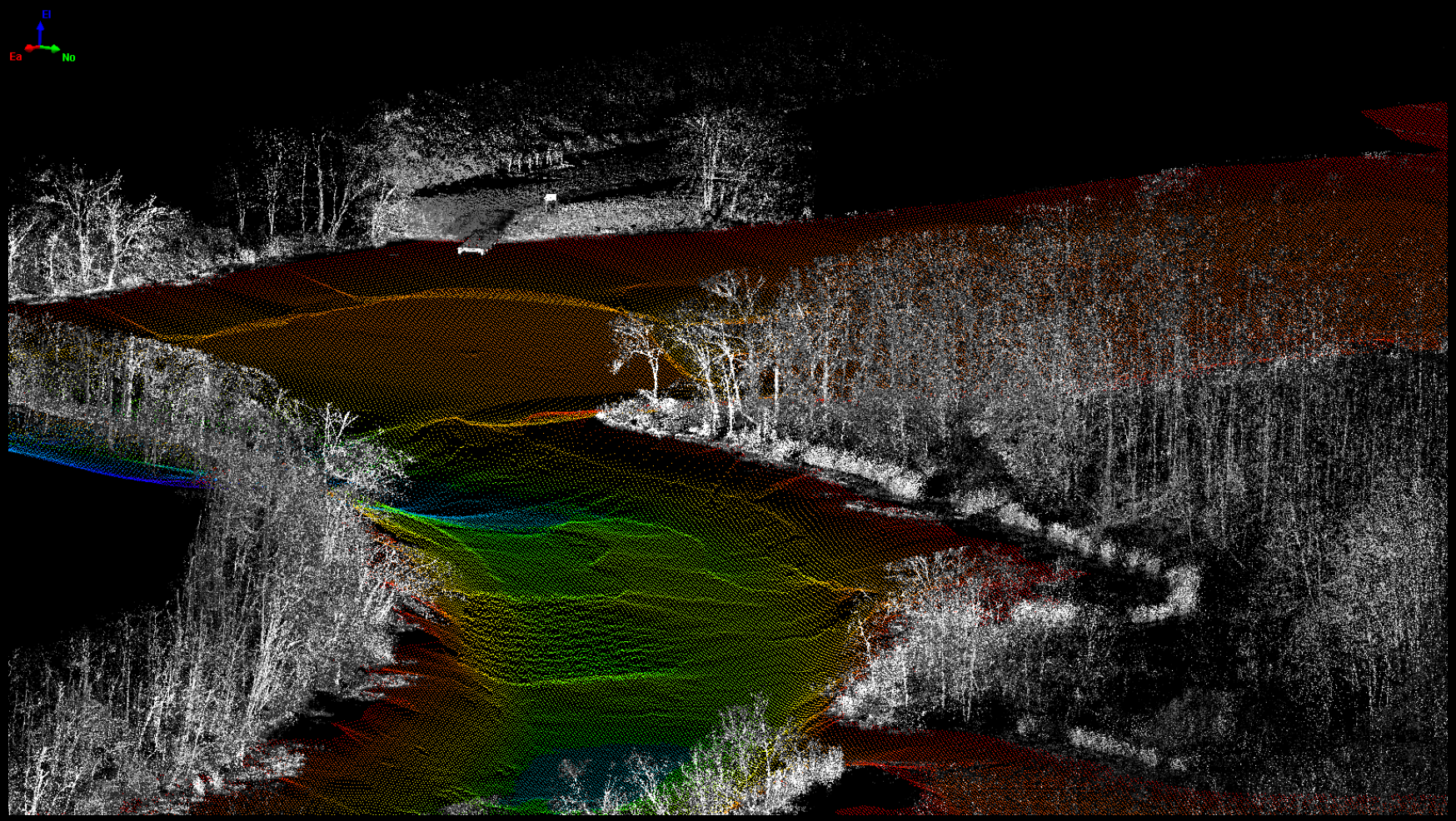

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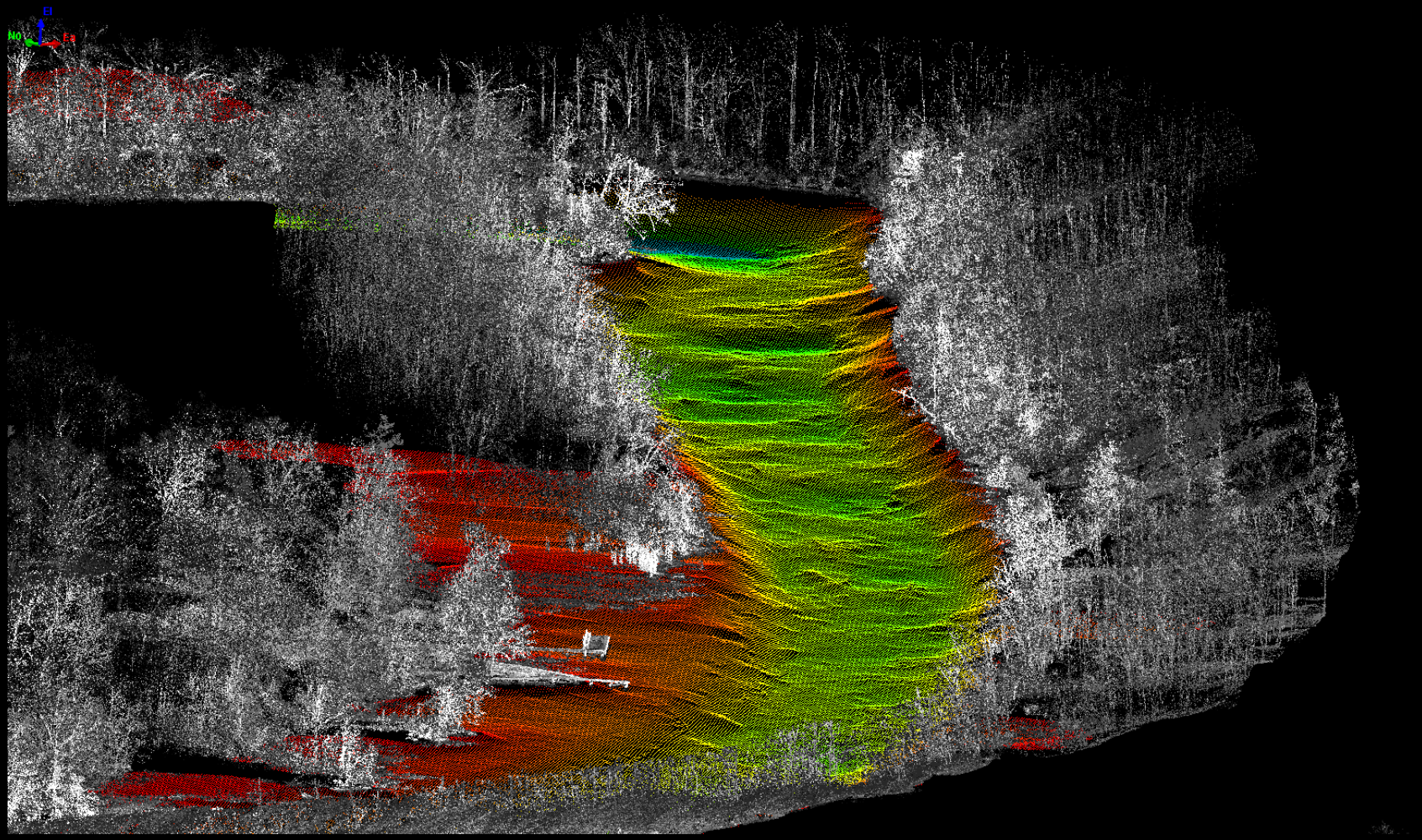
Seamless 3D Model (above & below water surface)
Yellowleaf Creek, AL



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Dam Safety Demonstration Project

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- Datasets were collected
  - T-LiDAR - tripod
  - T-LiDAR - truck
  - T-LiDAR - boat
  - Multibeam - Sonar

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MERCURY
USGS
science for a changing world

Horizontal – NAD83
Vertical – NAVD88
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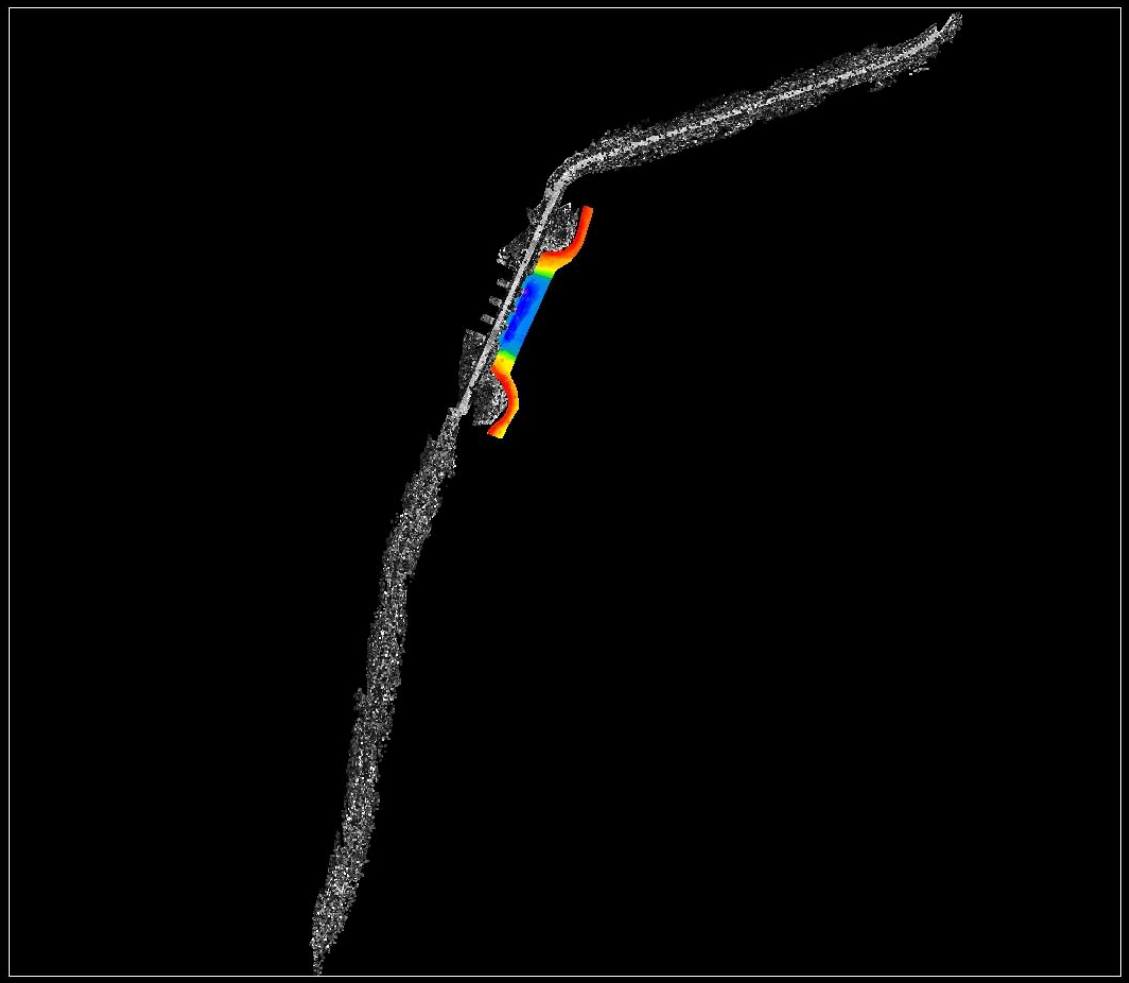
Plan View



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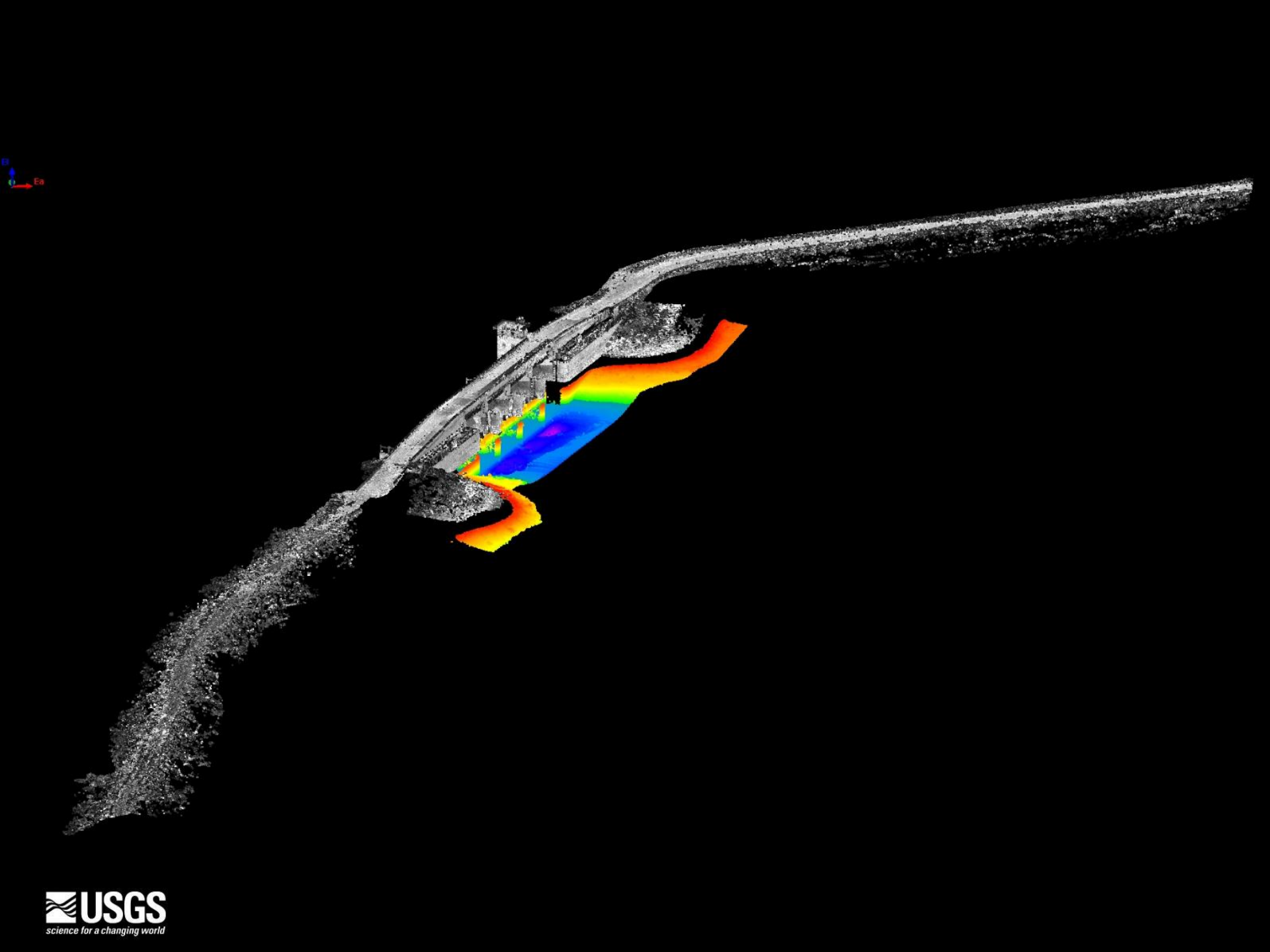
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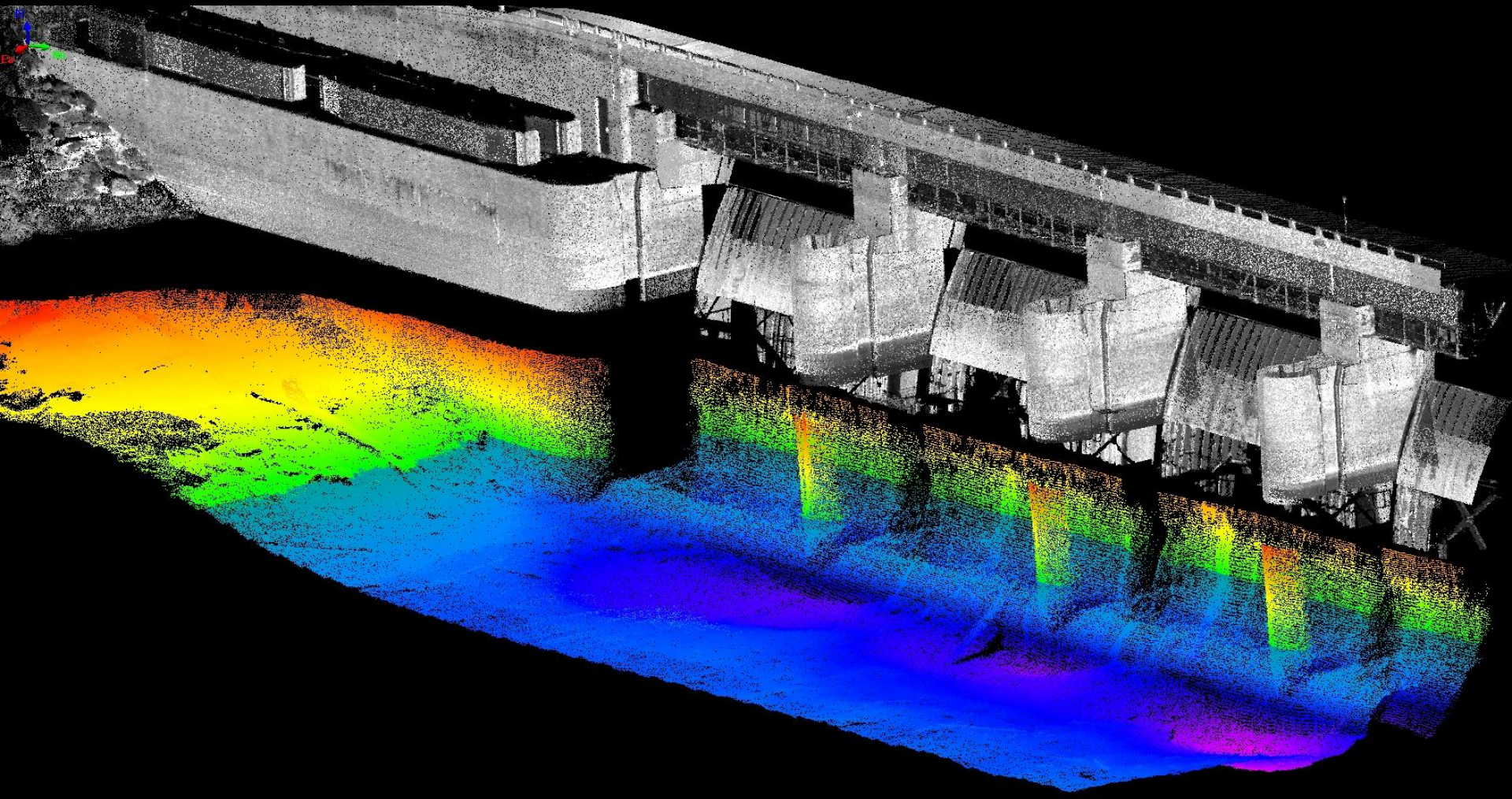

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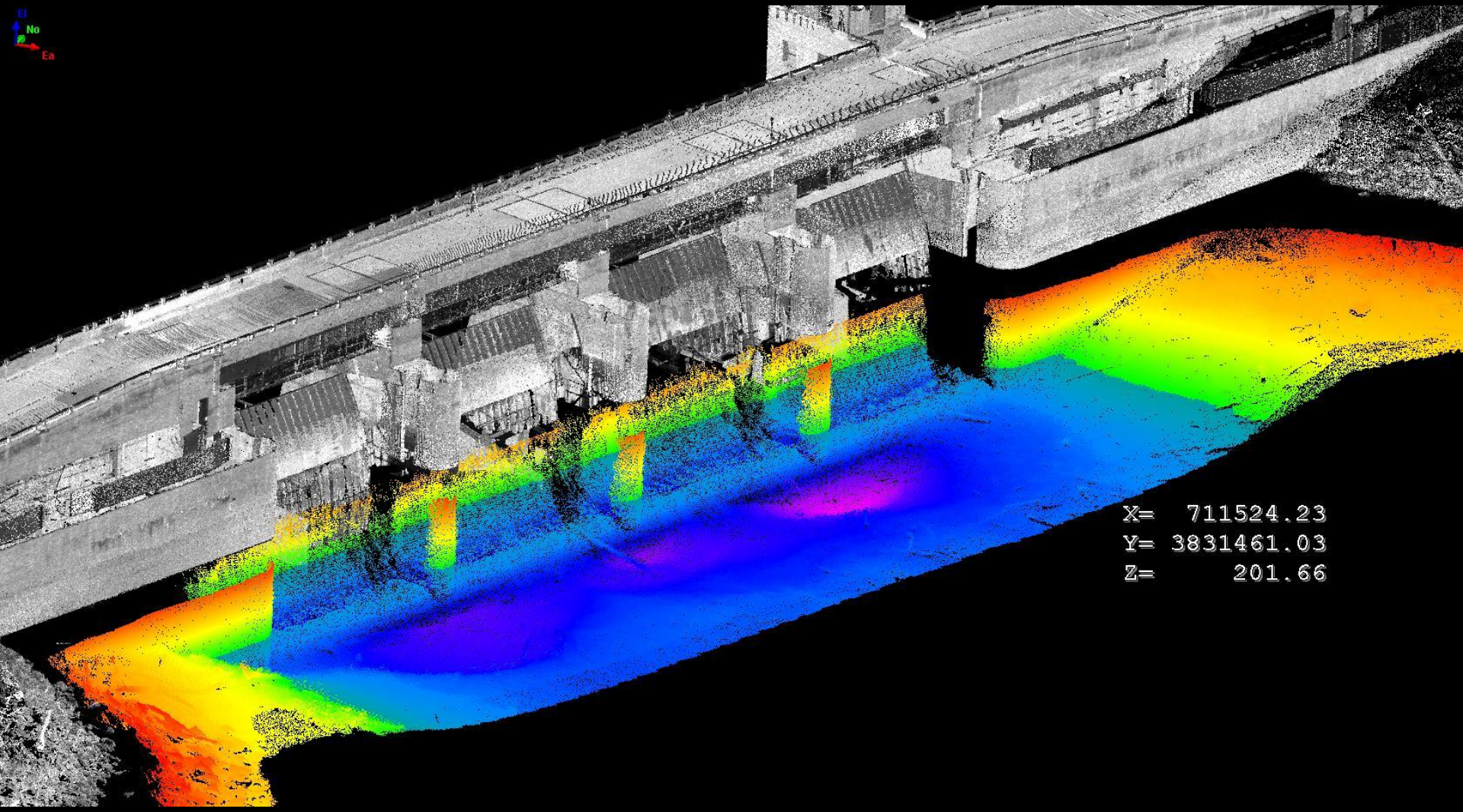

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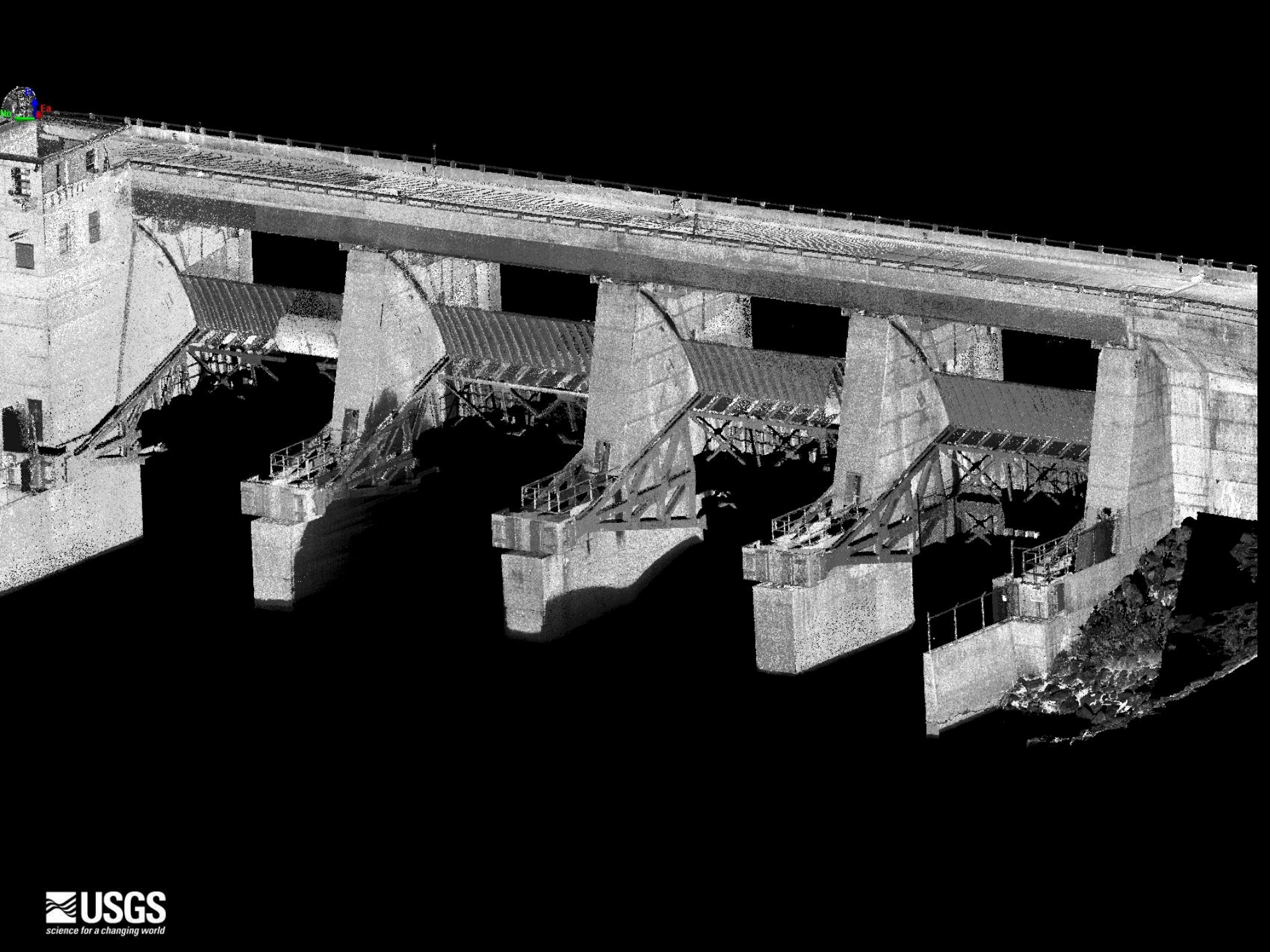

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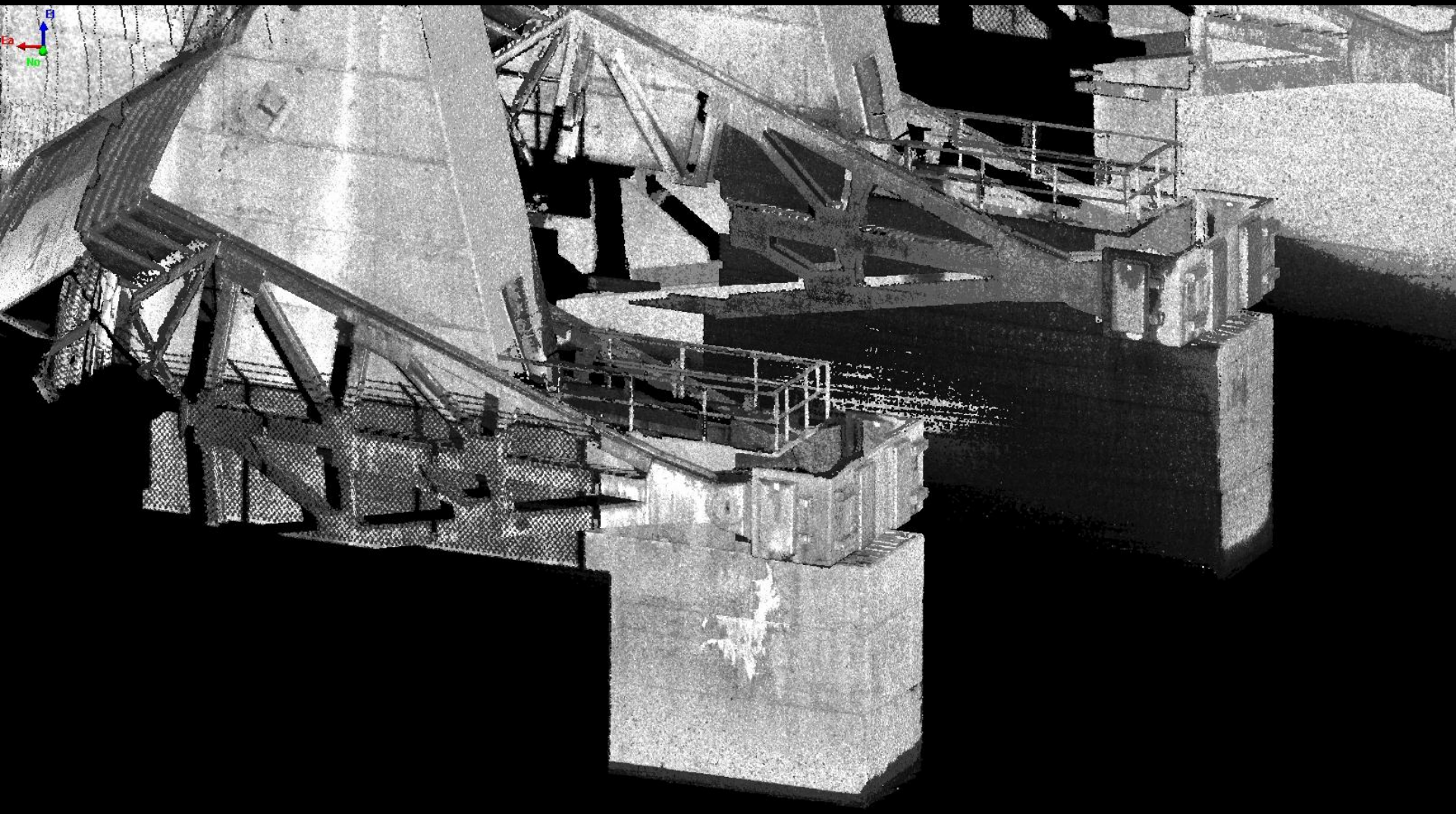
Target from previous LiDAR scan



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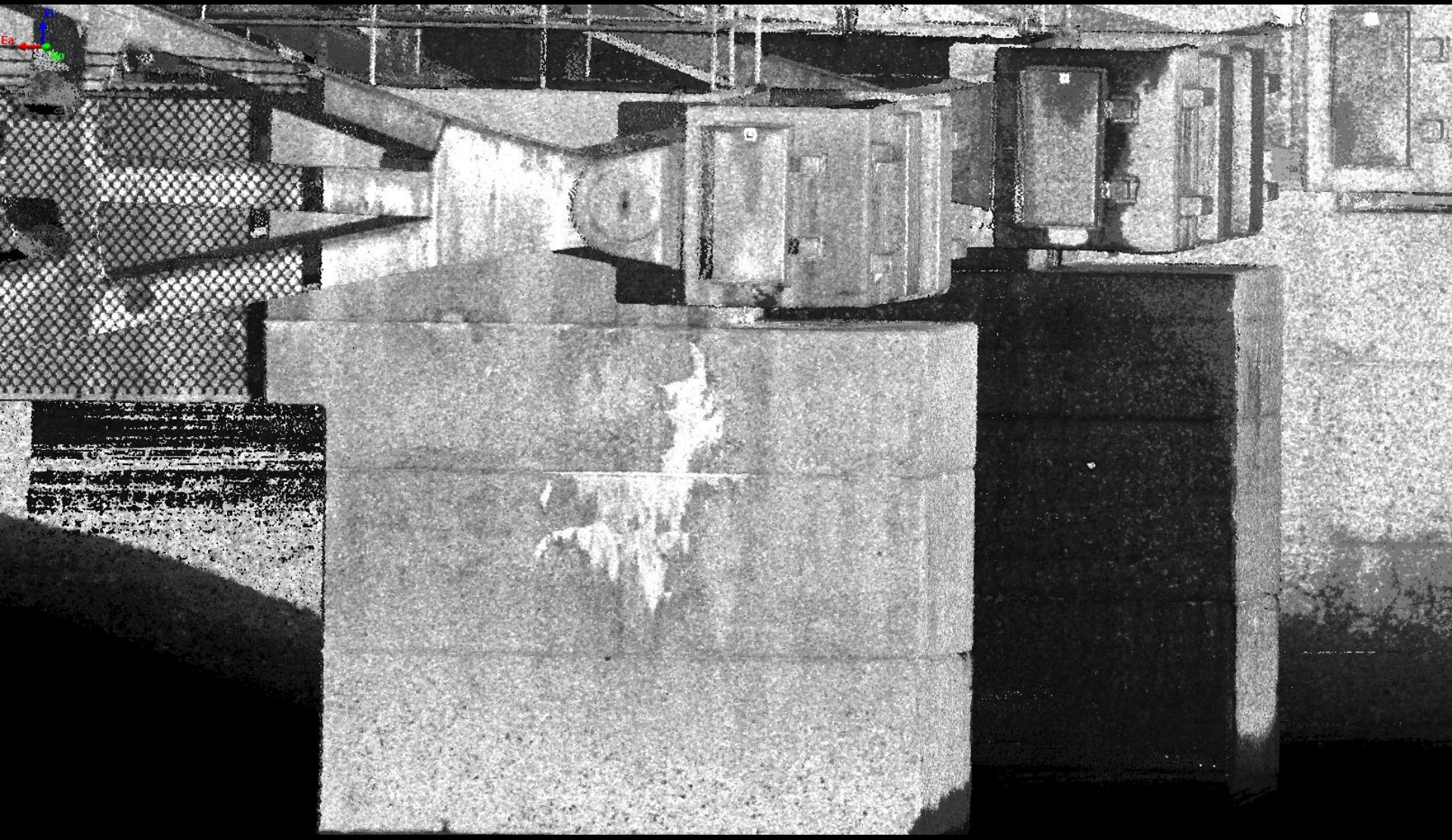

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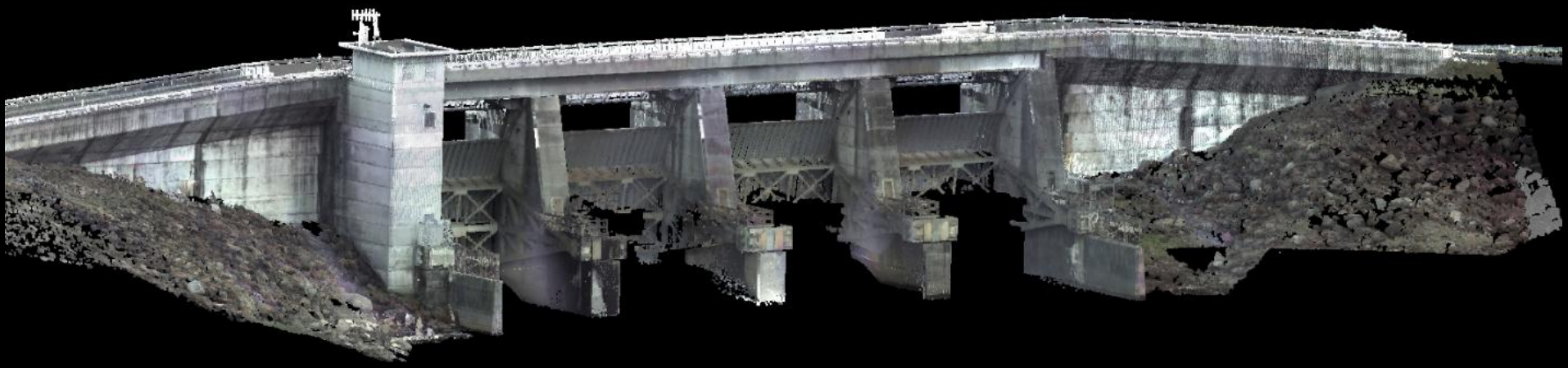
Previous Scan



Previous Scan

Change Detection Analysis
Scan 1 – Scan 2

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Change Detection Analysis
Scan 1 – Scan 2

USGS
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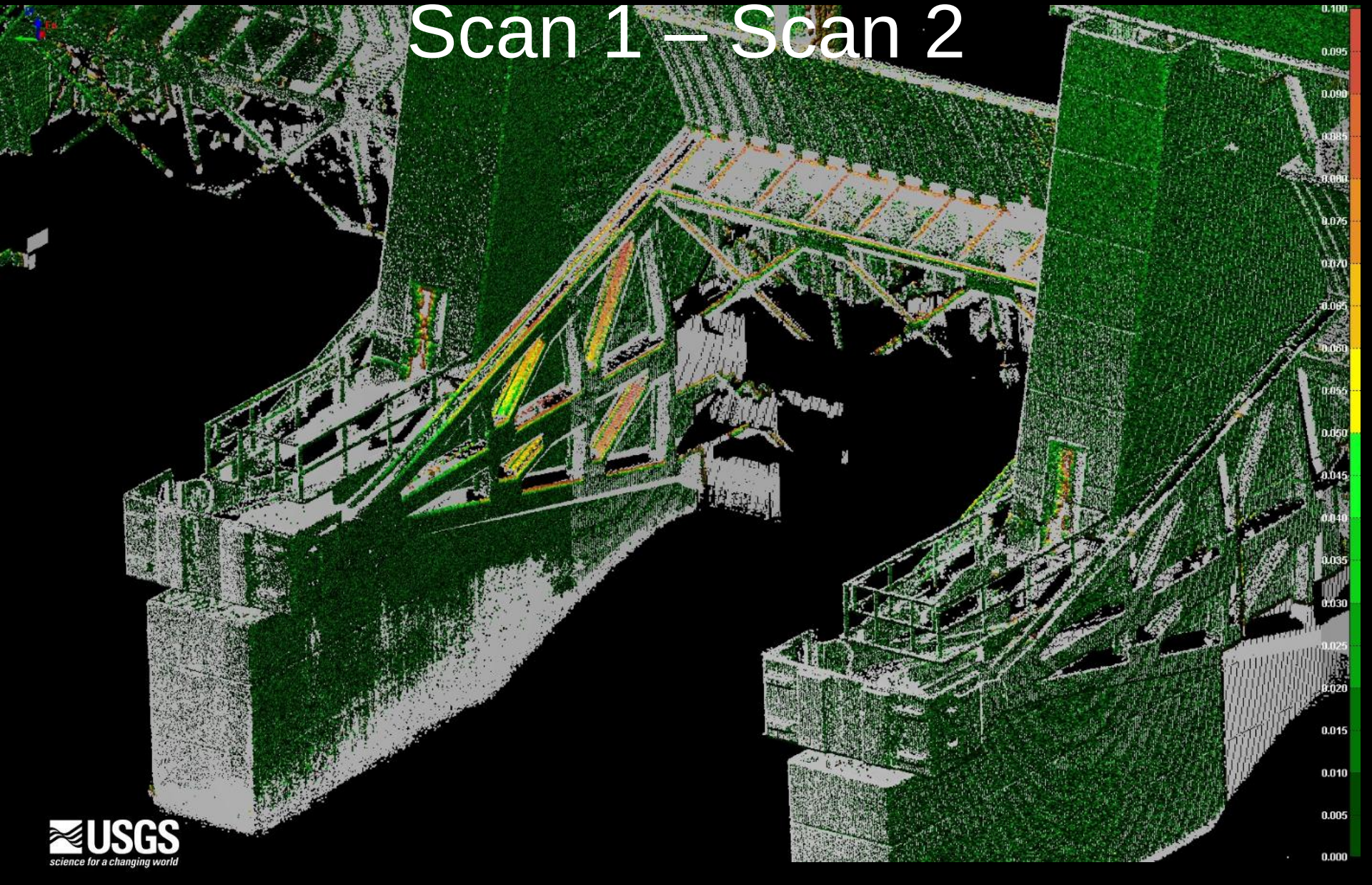
Change Detection Analysis

Scan 1 – Scan 2



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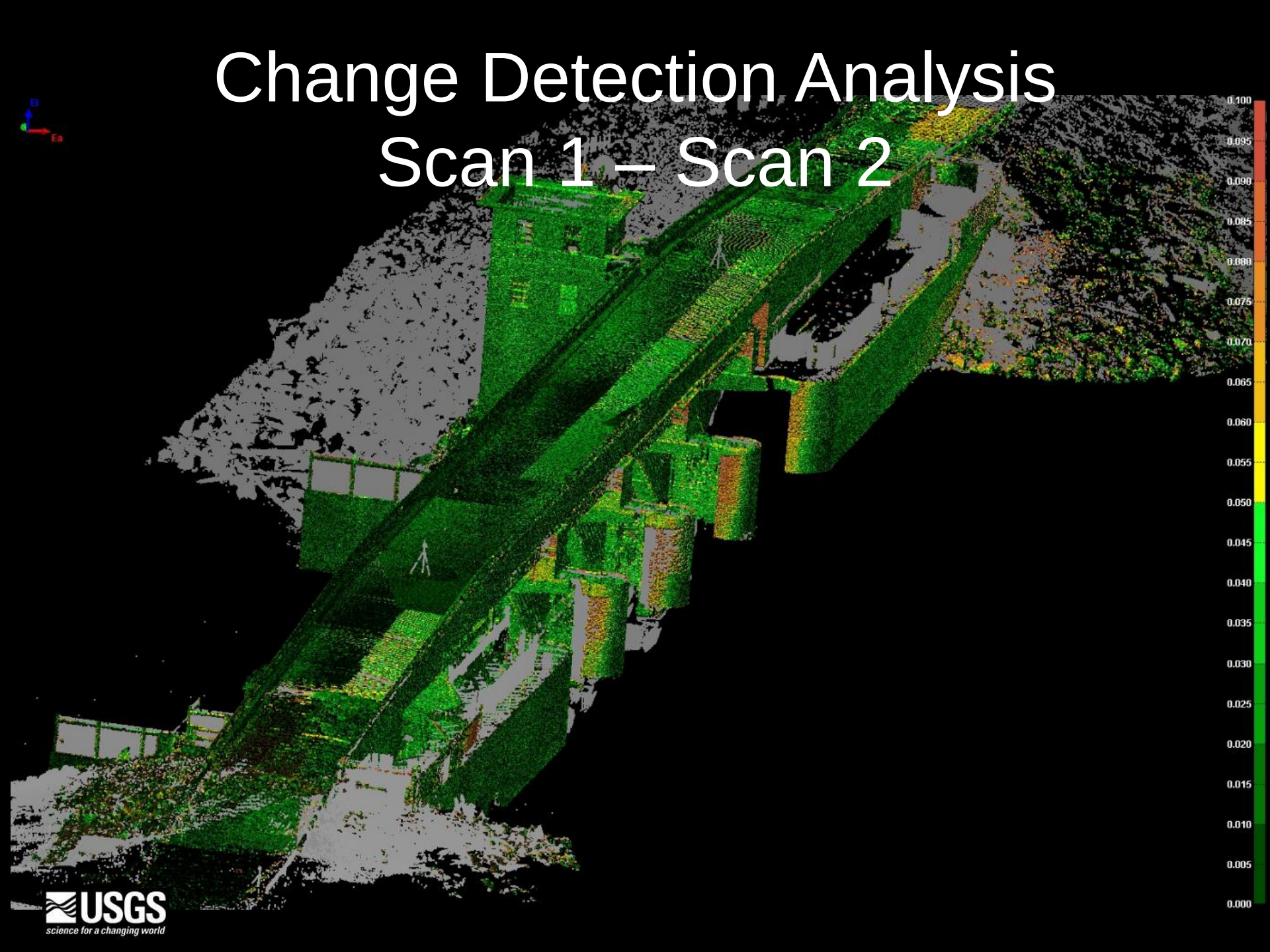
Change Detection Analysis
Scan 1 – Scan 2



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Hurricane Isaac
Tangipahoa Dam

Toby Minear, CA-WSC

USGS
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Hurricane Isaac
Tangipahoa Dam

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Hurricane Isaac
Tangipahoa Dam

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Hurricane Isaac
Tangipahoa Dam

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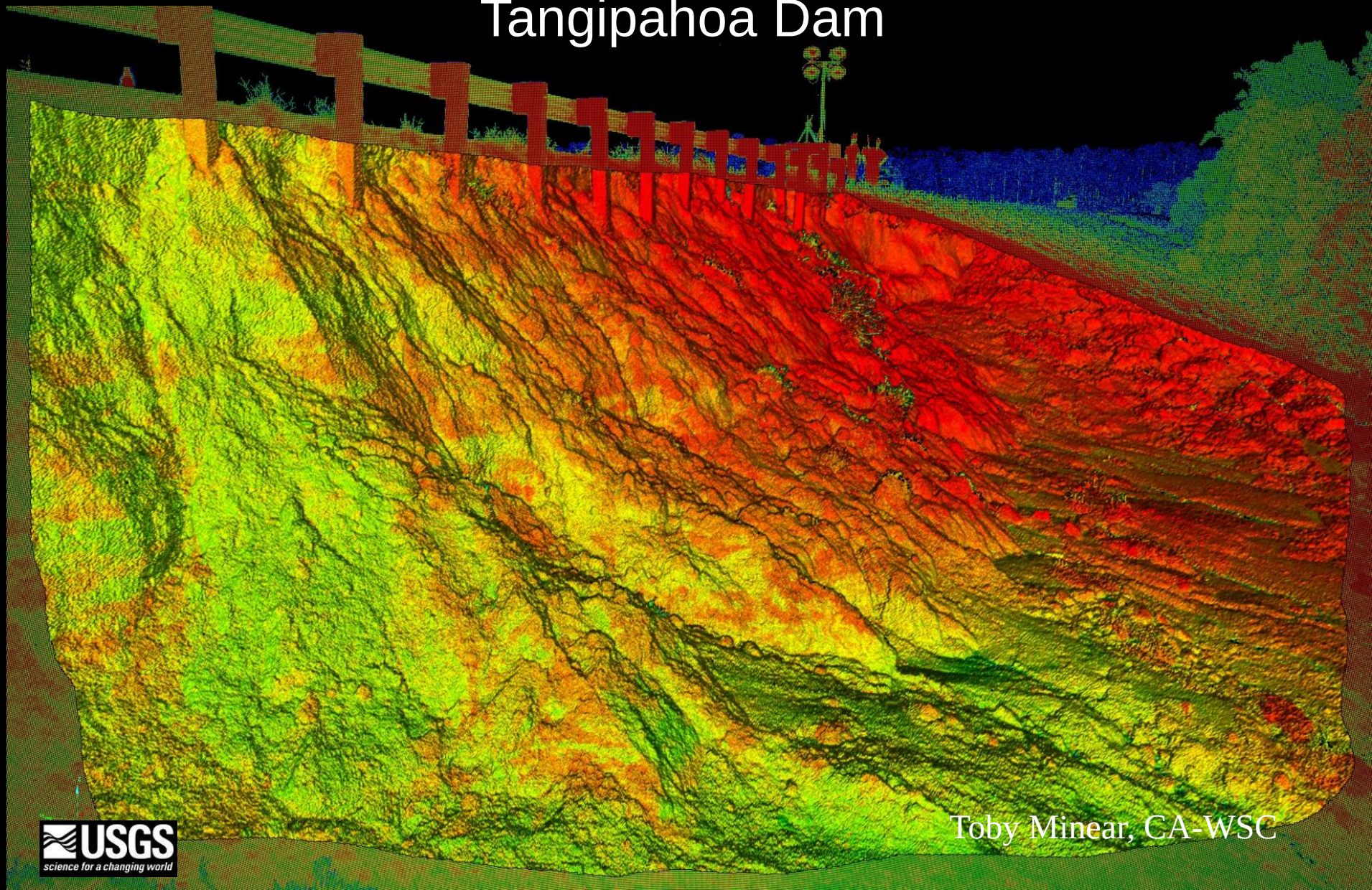
Hurricane Isaac
Tangipahoa Dam



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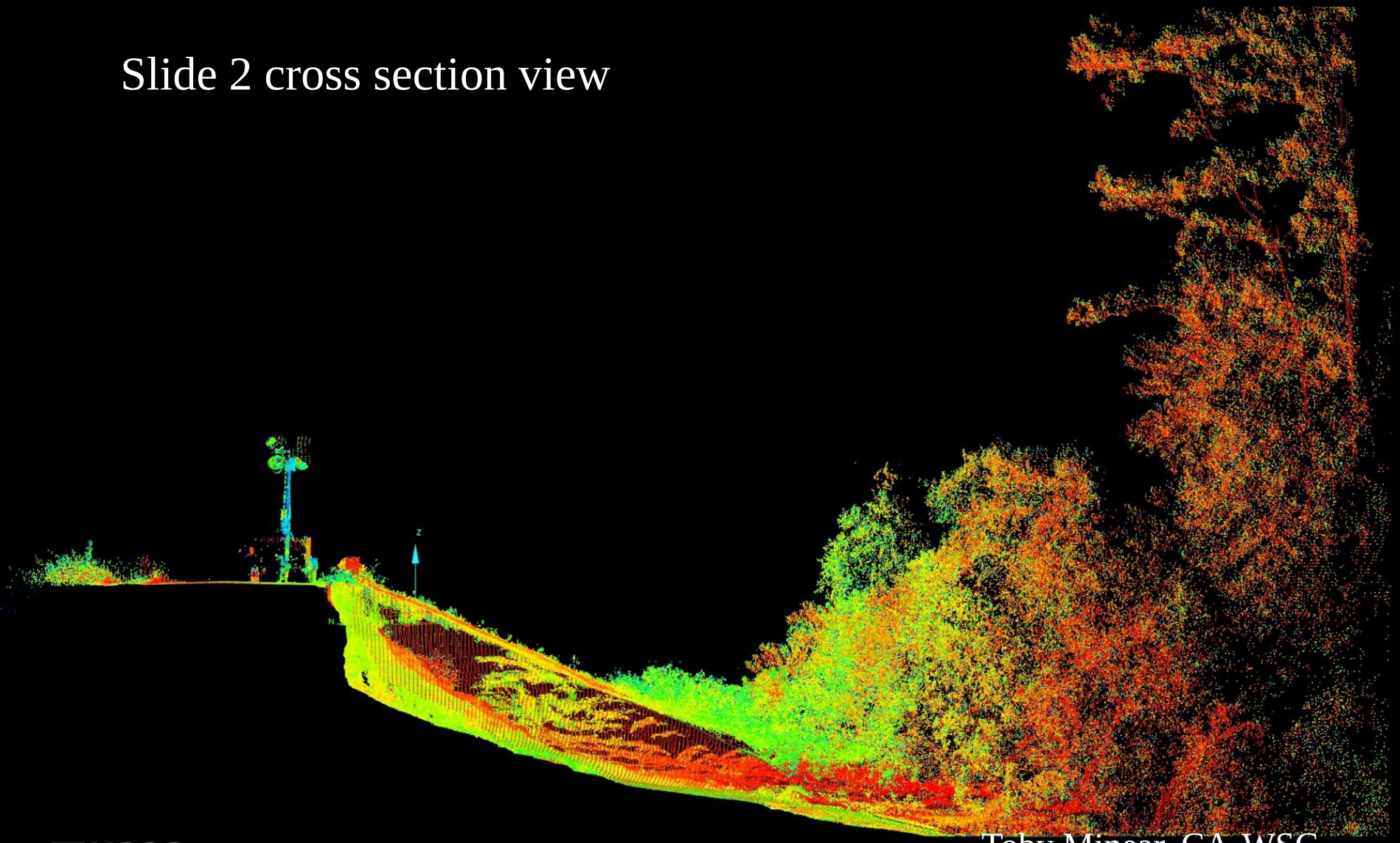
Tangipahoa Dam

Slide 2 cross section view



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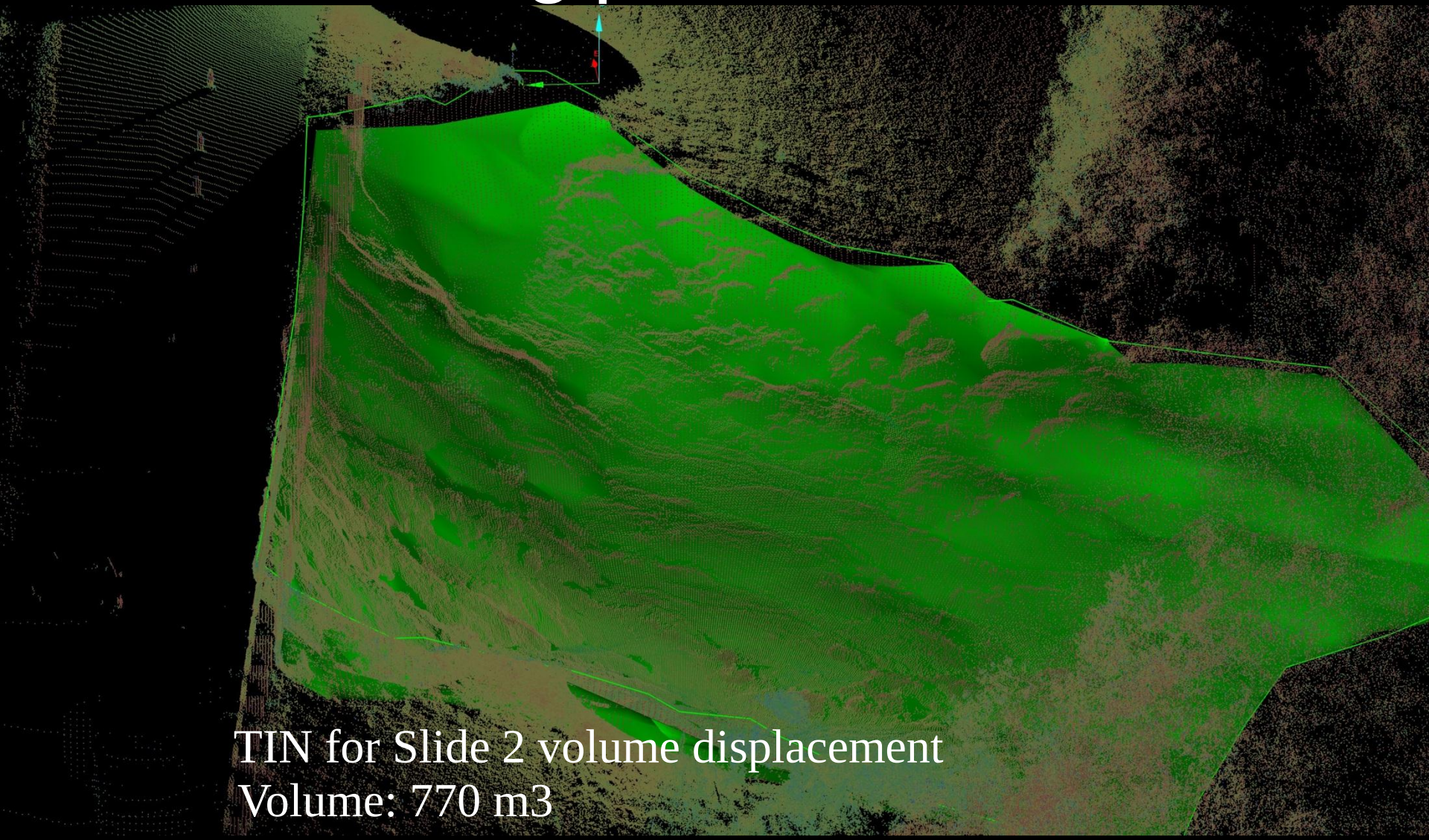
Tangipahoa Dam



TIN for Slide 2 volume displacement
Volume: 770 m3

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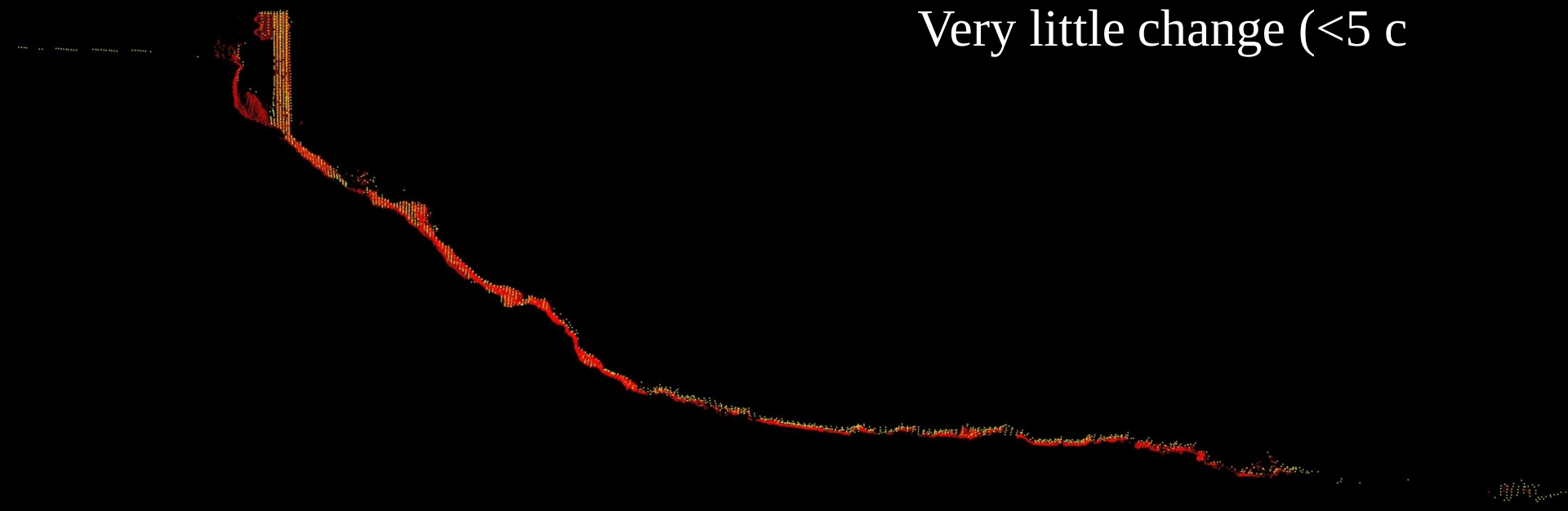
Tangipahoa Dam

Timelapse comparison:
Yellow = Sept 1, 2012
Red = Sept 3, 2012
Very little change (<5 c



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Hurricane Isaac, 2012
T-LiDAR Data Collection
Dauphin Island, AL
Venetian Isles, LA

USGS Alabama Water Science Center
Dustin Kimbrow

Athena Clark

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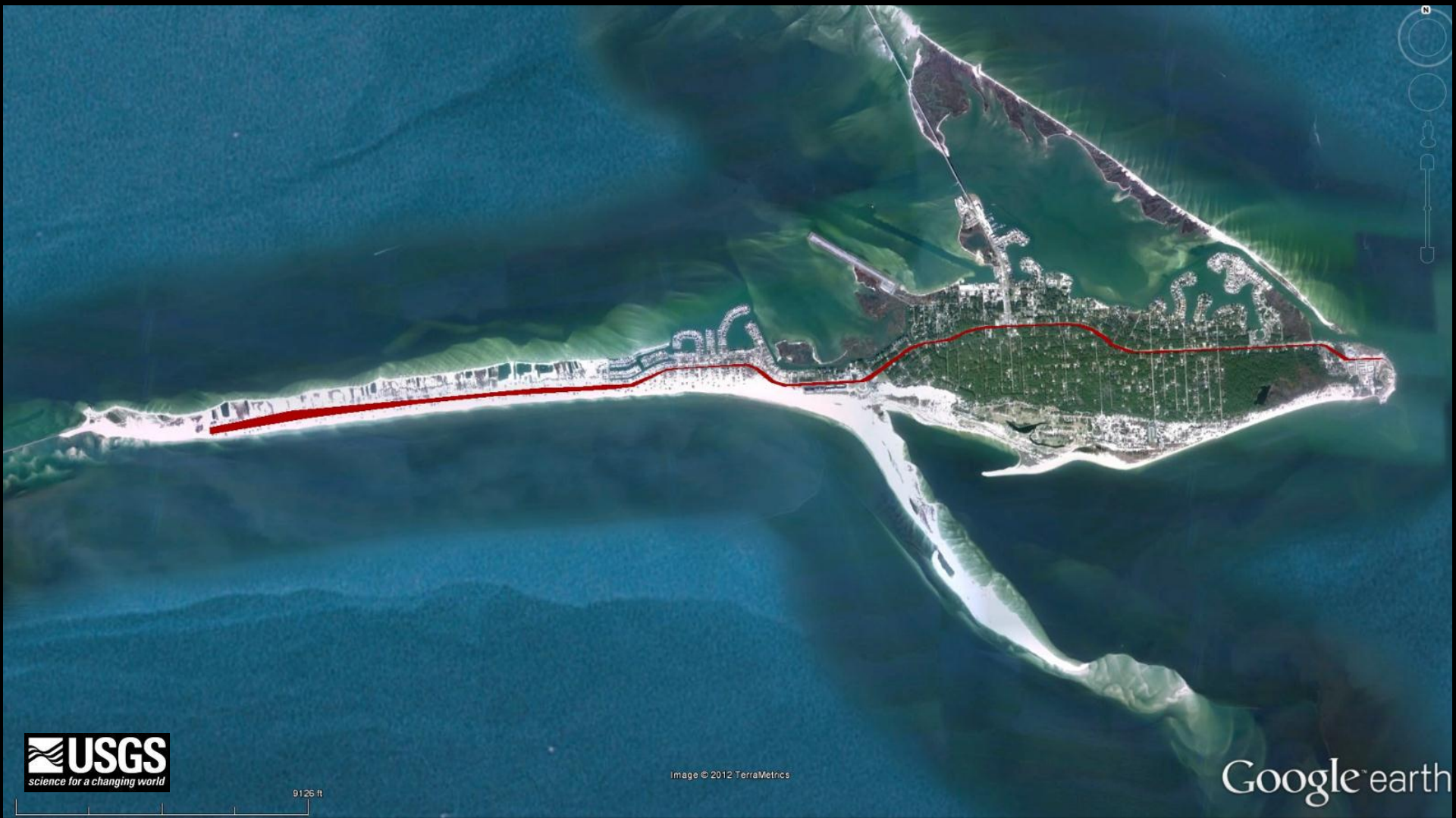
Dauphin Island, AL
Aerial Extent – Bienville Blvd



Dauphin Island, AL

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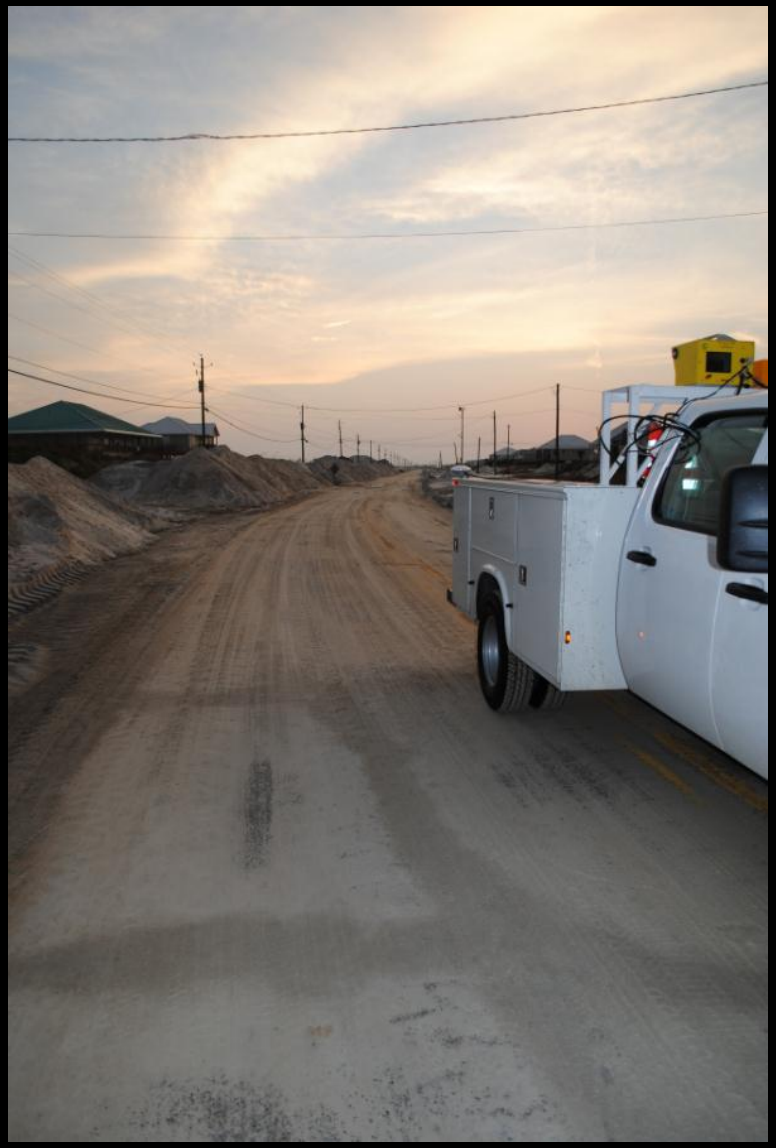
Dauphin Island, AL



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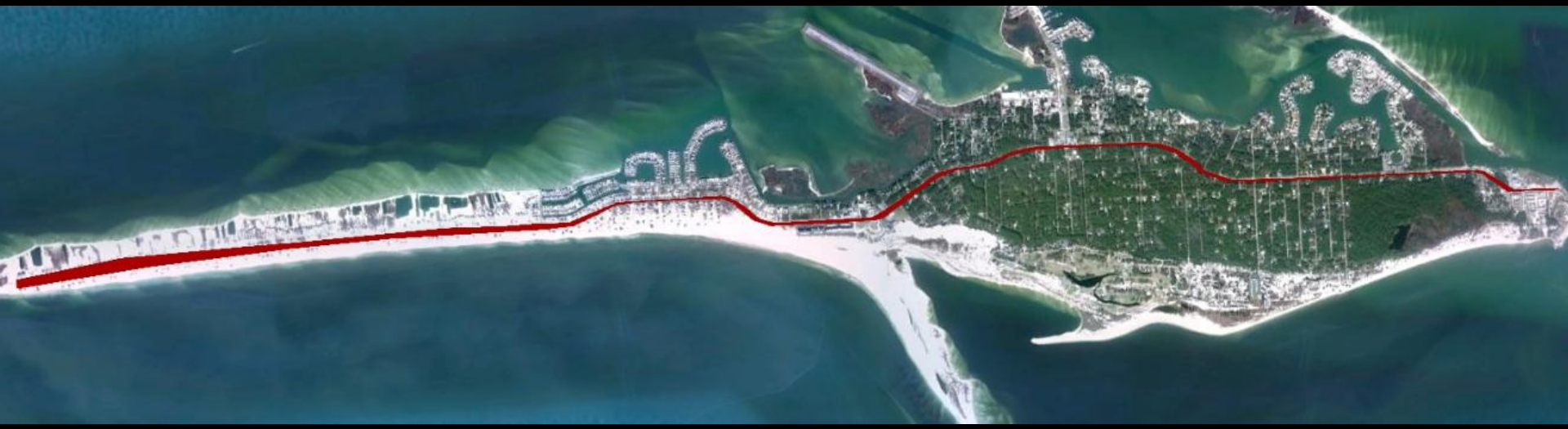
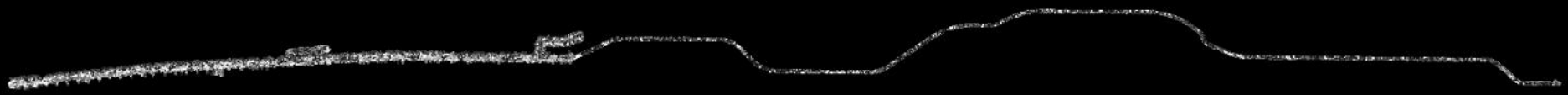
Dauphin Island, AL
Aerial Extent





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Dauphin Island, AL
Bienville Blvd - oblique

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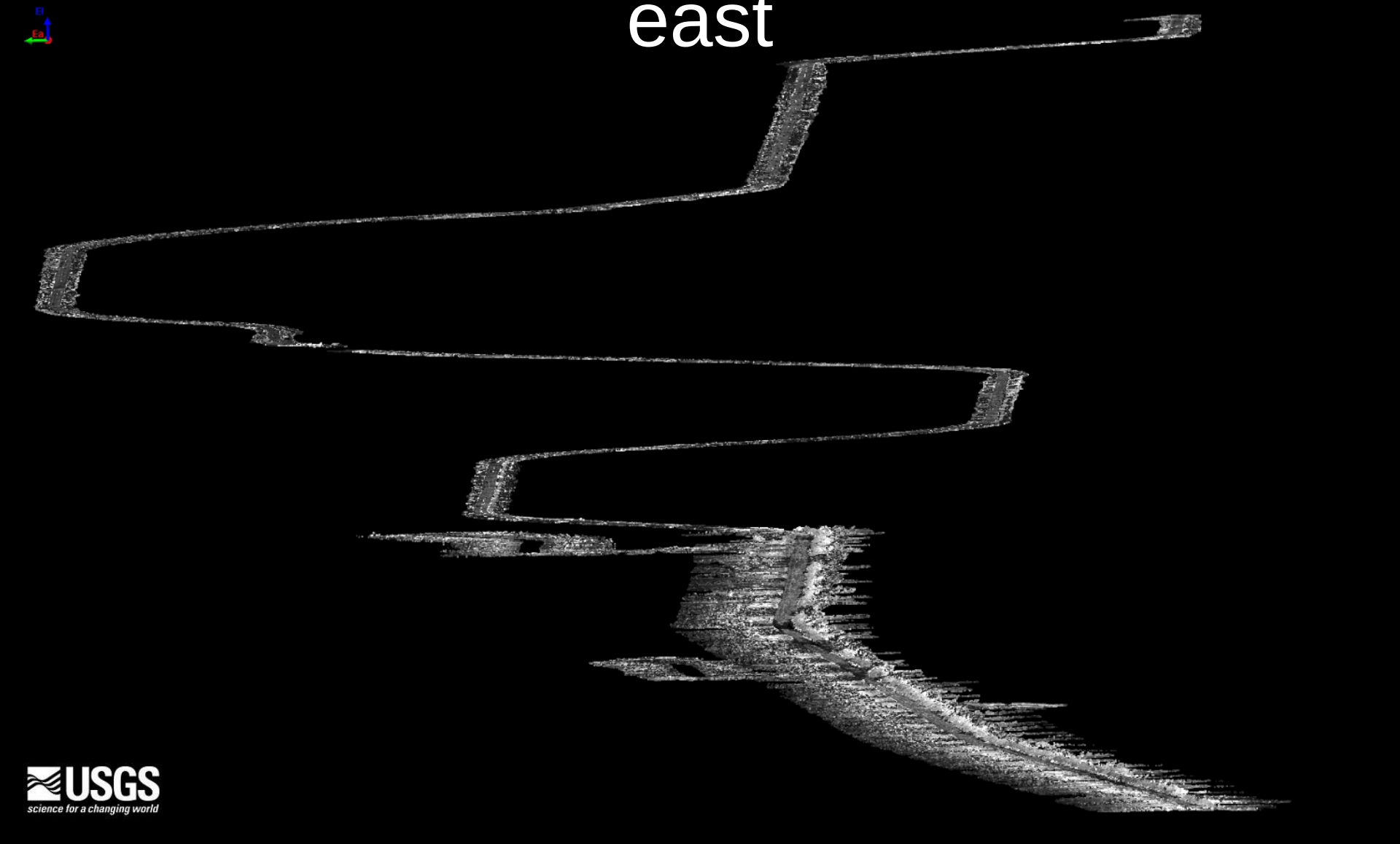
Dauphin Island, AL
Bienville Blvd – oblique, looking east



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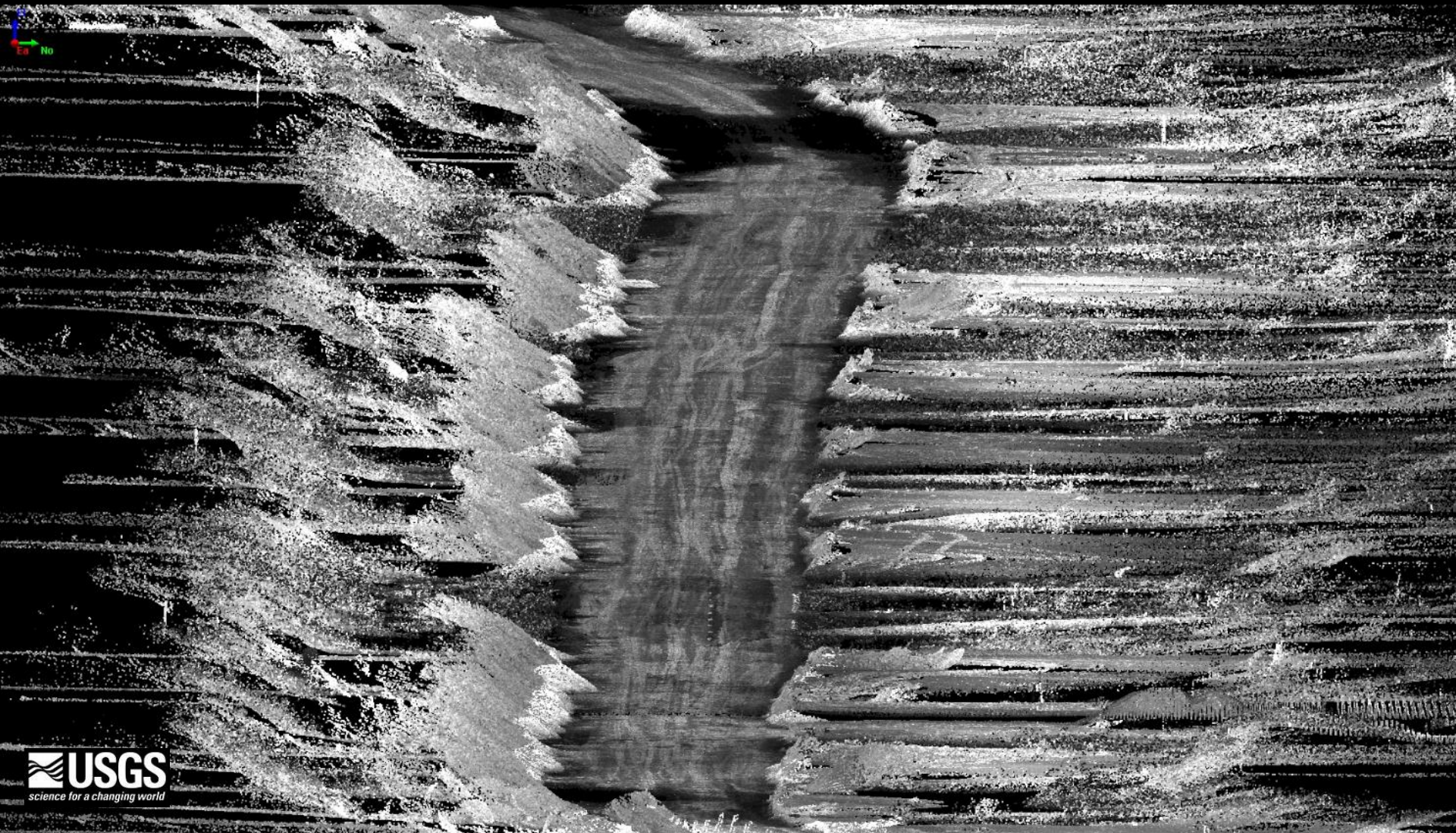
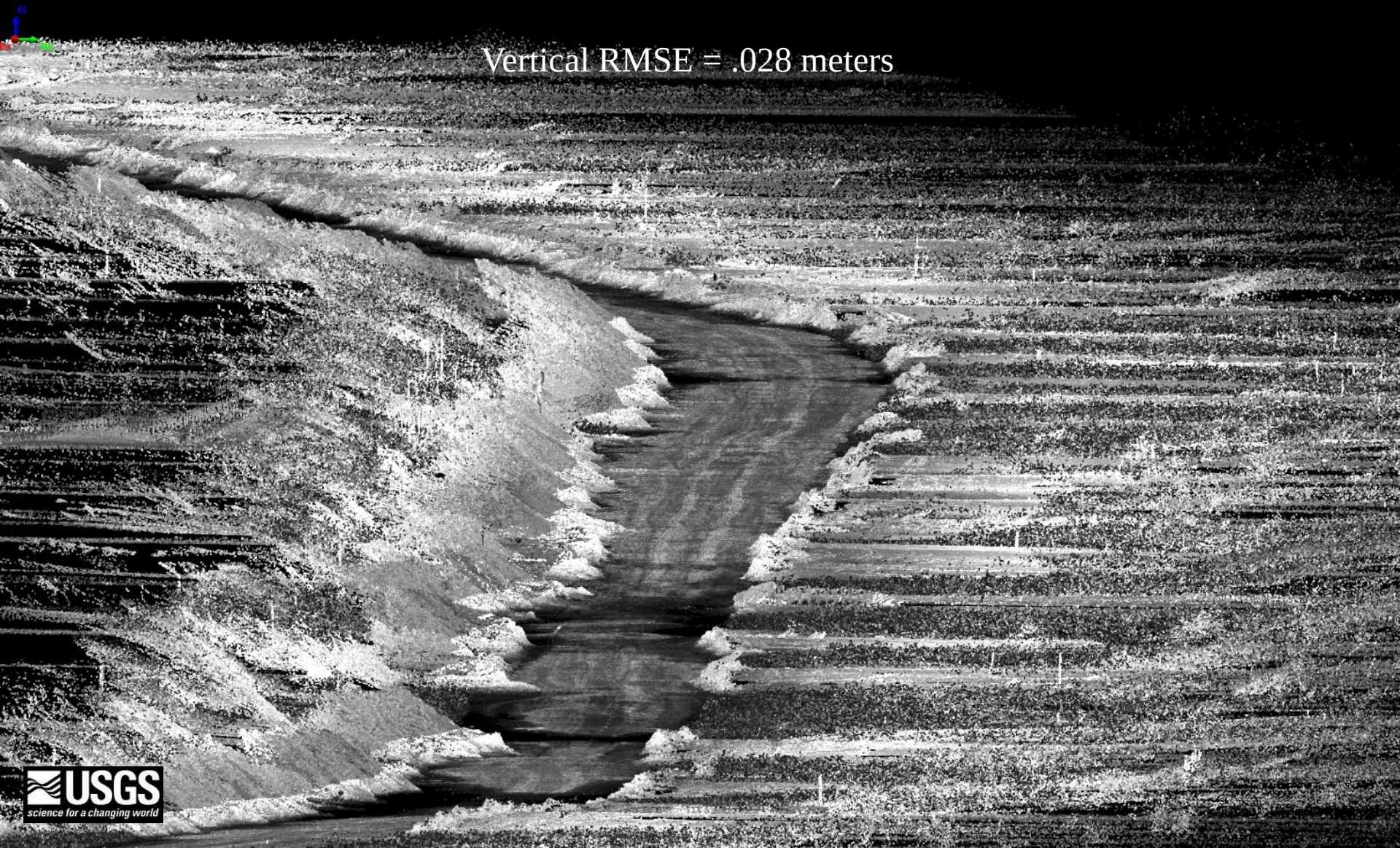
Dauphin Island, AL

Bienville Blvd - with sand berms on each side

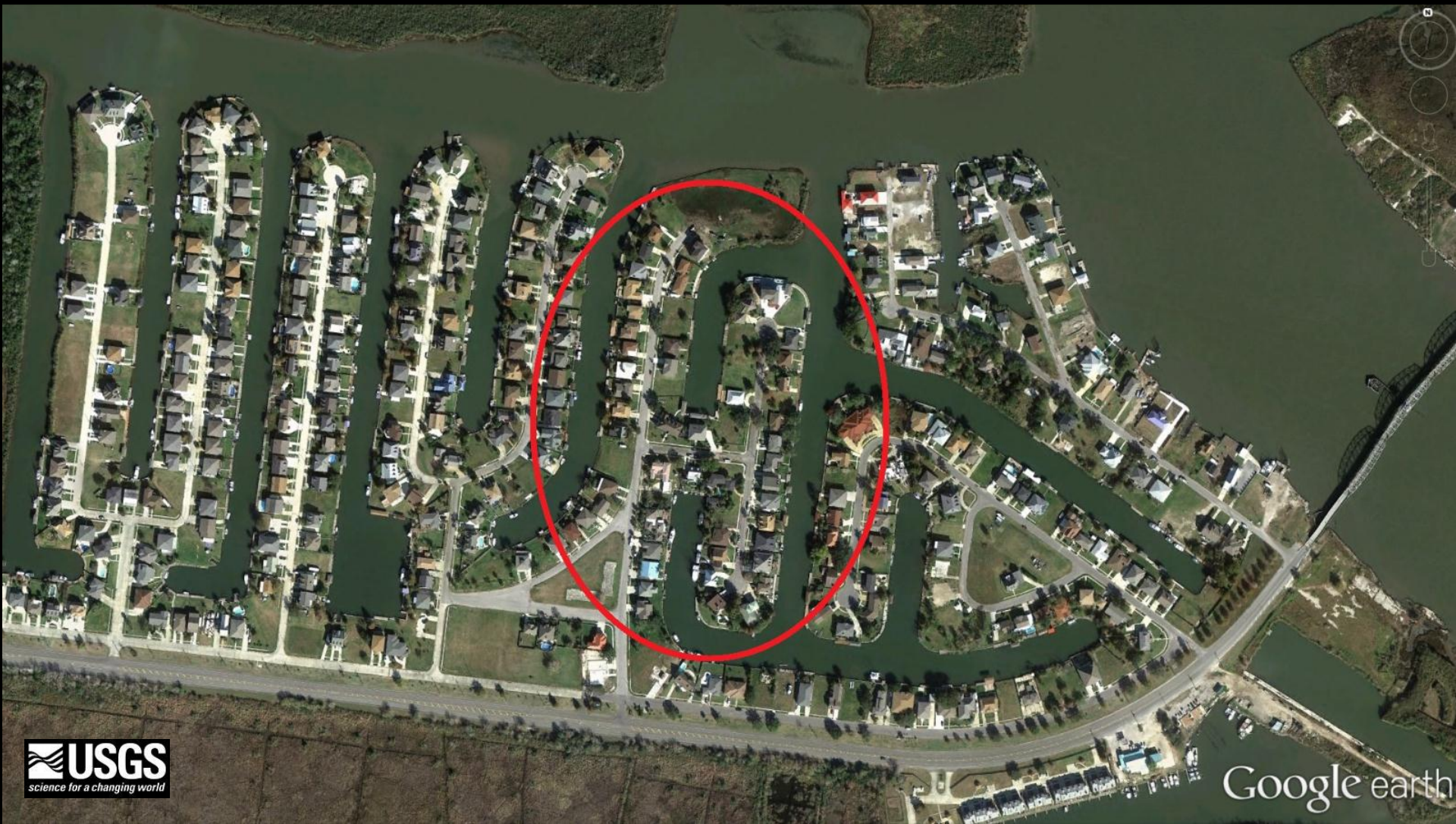


Dauphin Island, AL

Bienville Blvd - with sand berms on each side



Venetian Isles, LA
Aerial Extent



Venetian Isles, LA

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Venetian Isles, LA
fence, high water mark (duct tape)

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Venetian Isles, LA
high water mark (coordinates)

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Venetian Isles, LA
high water mark (coordinates)

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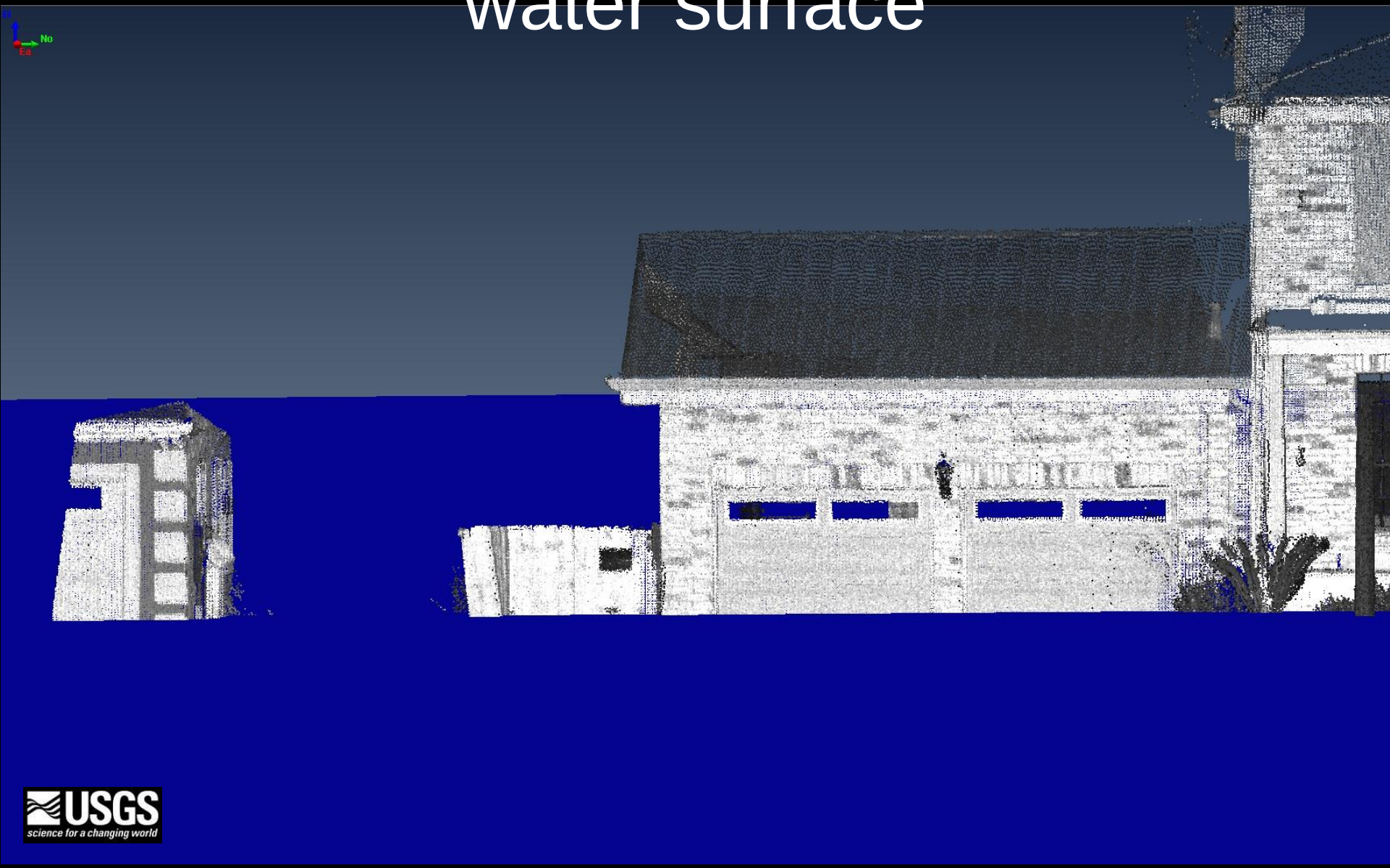
Venetian Isles, LA water surface



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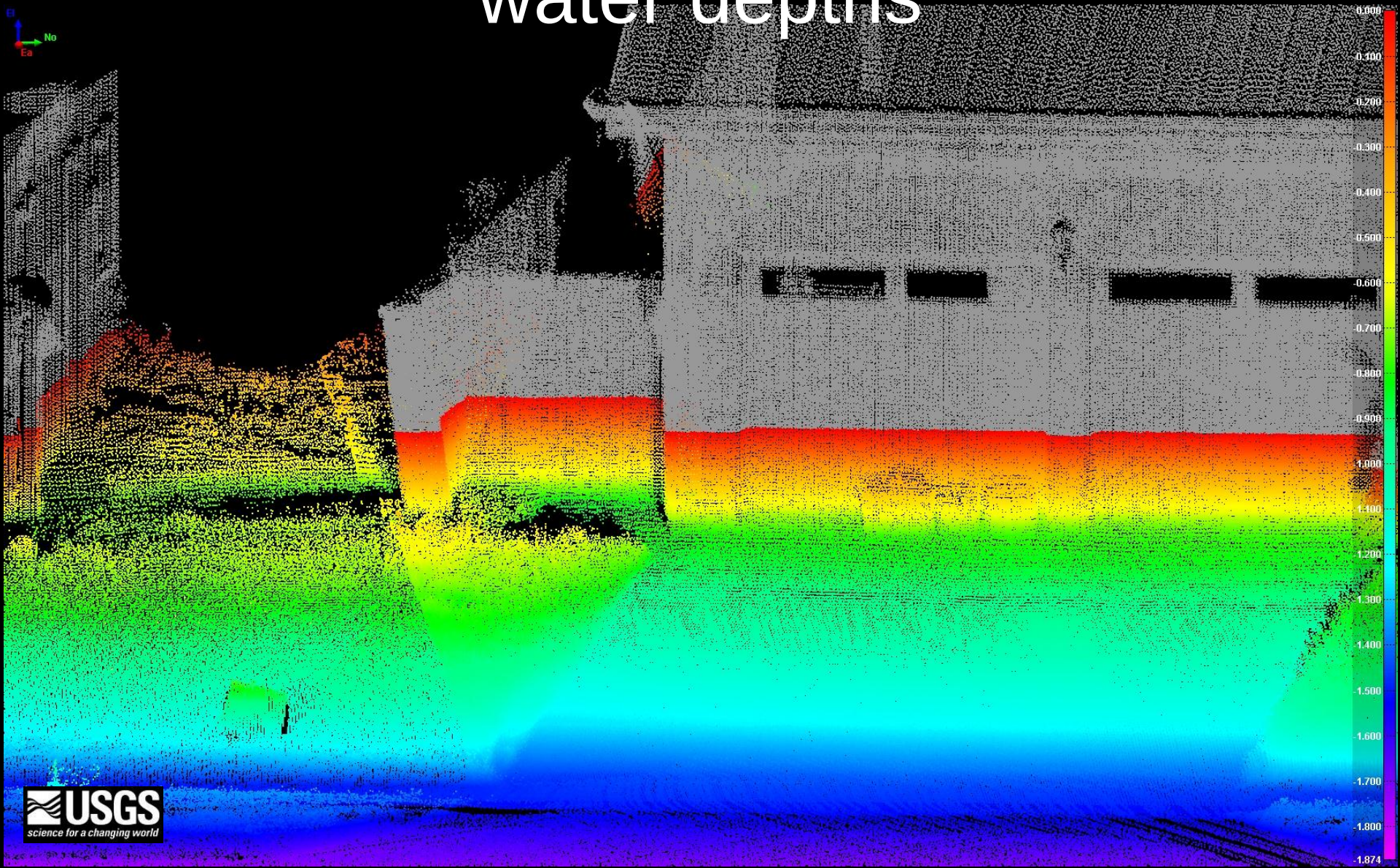
Venetian Isles, LA water depths



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Venetian Isles, LA

Clean-up house

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Venetian Isles, LA
Clean-up house

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Venetian Isles, LA
high water mark (coordinates)

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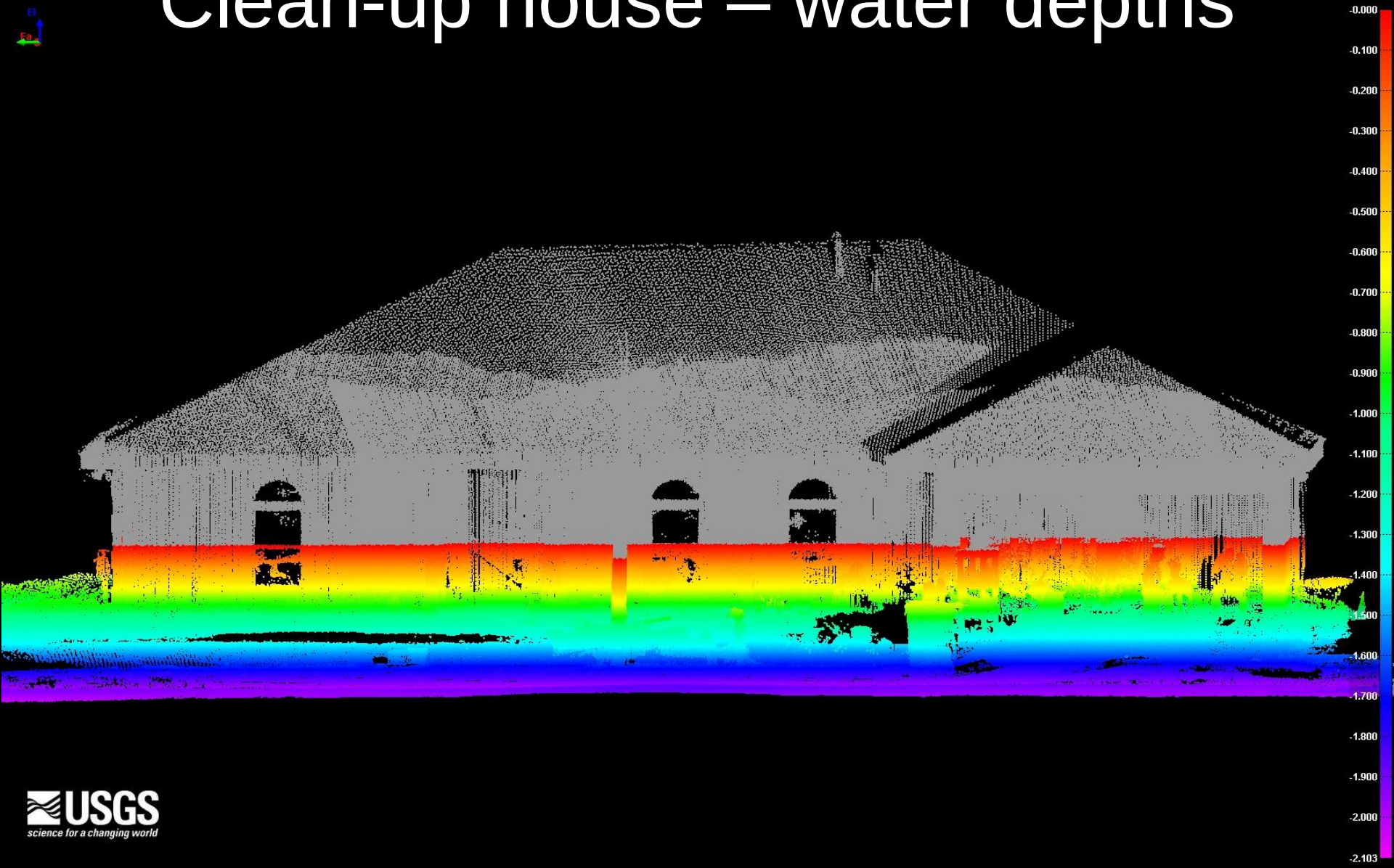
Venetian Isles, LA
Clean-up house – water depths



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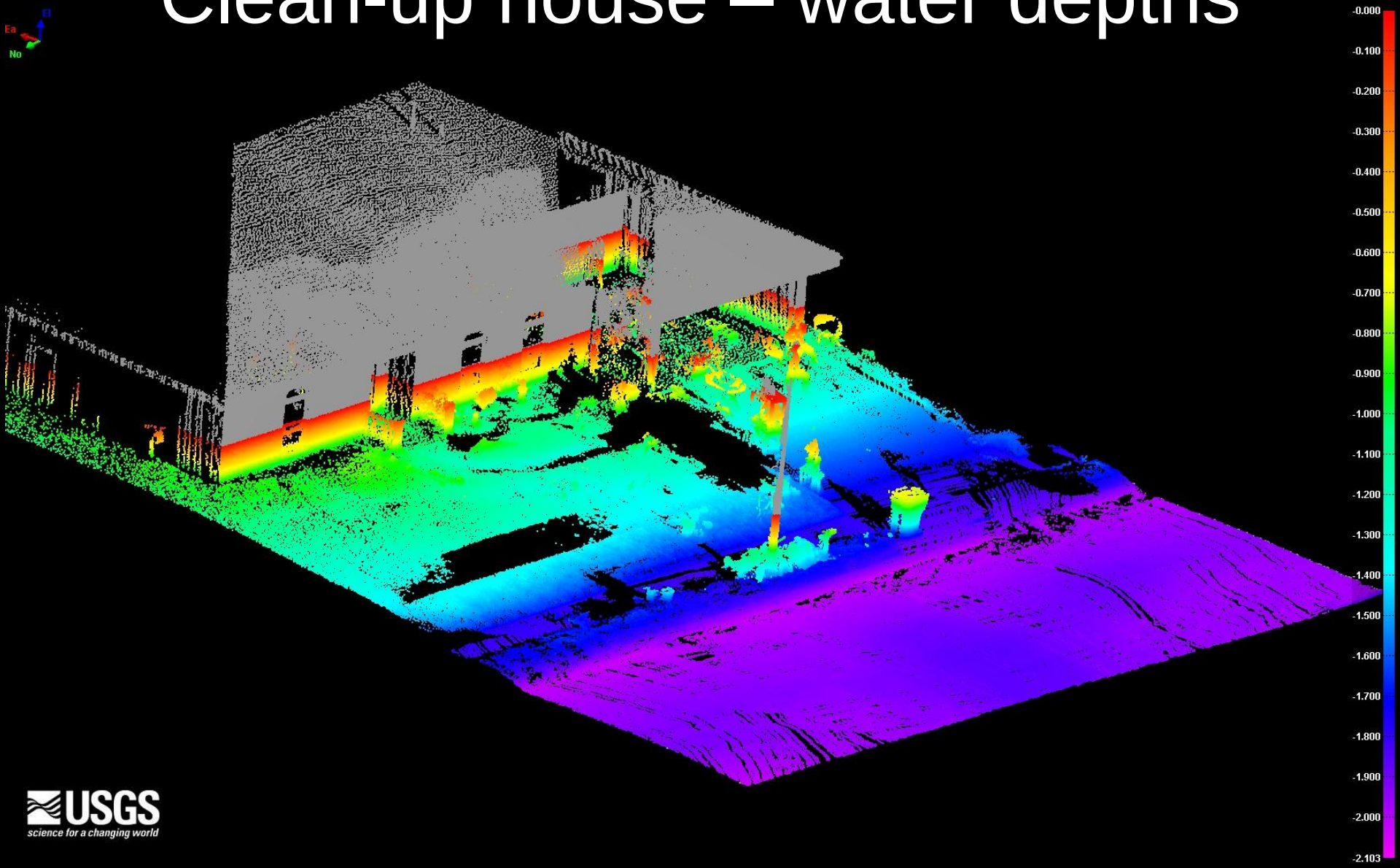
Venetian Isles, LA
Clean-up house – water depths



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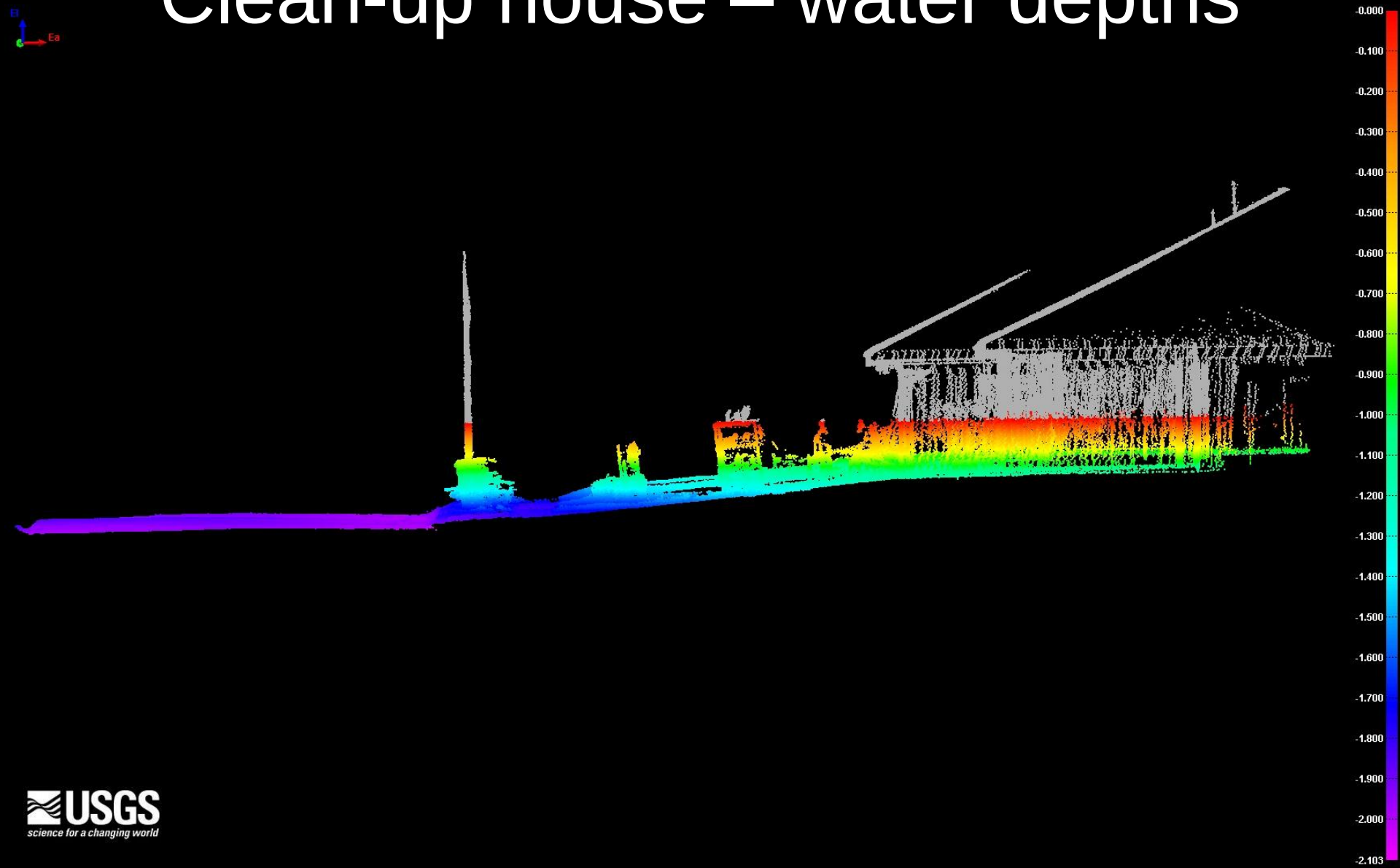
Venetian Isles, LA
Clean-up house – water depths



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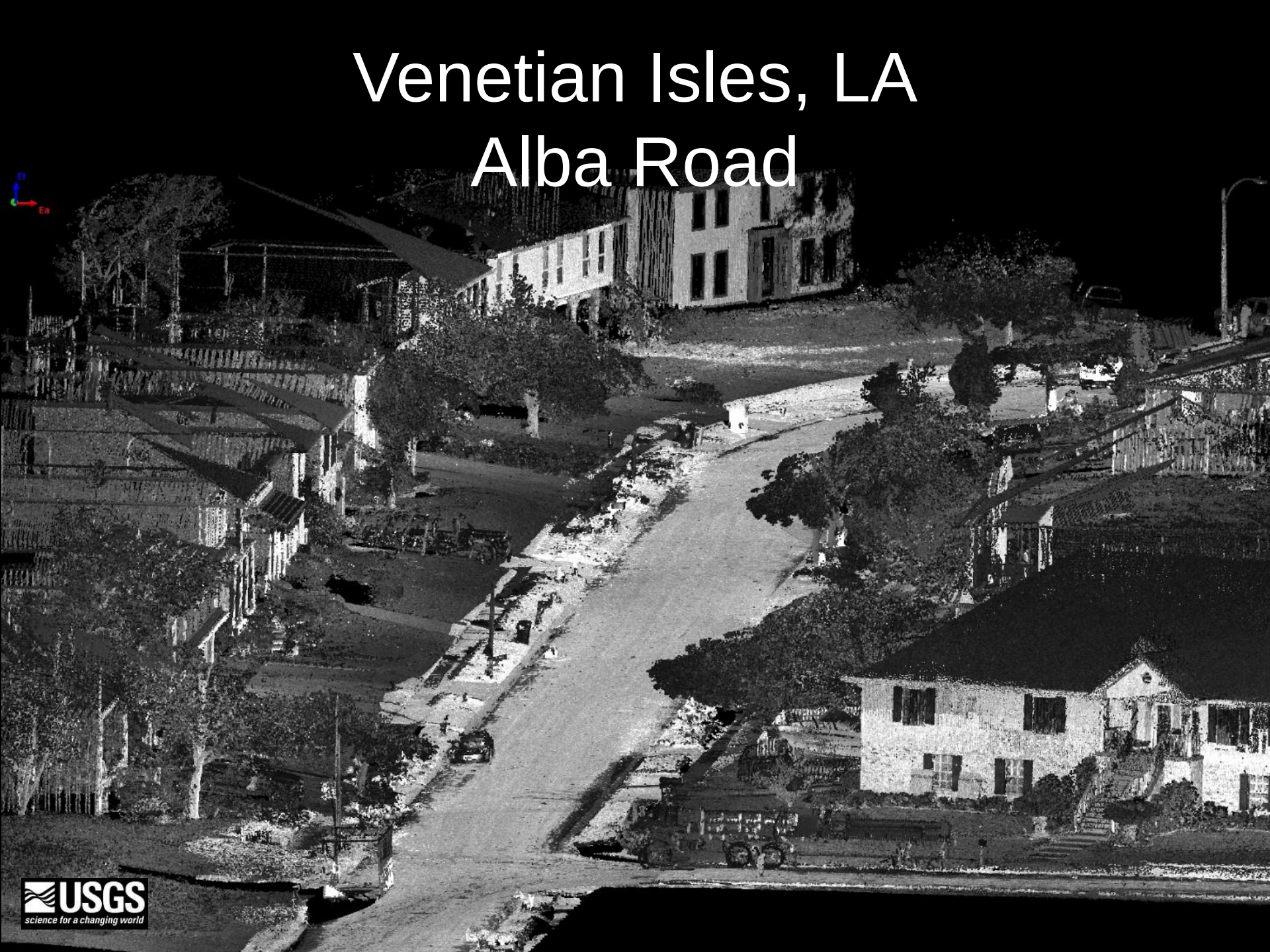
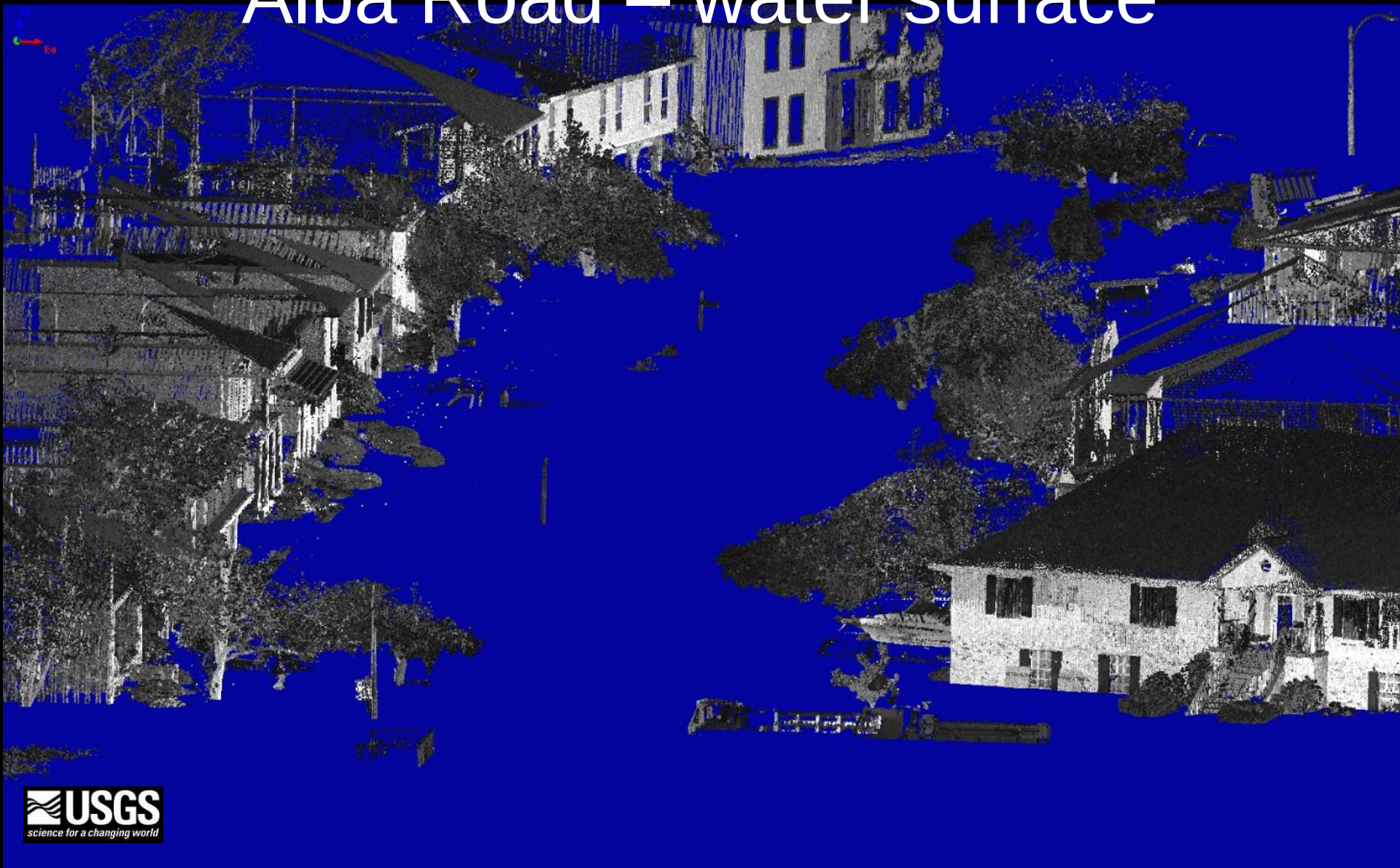
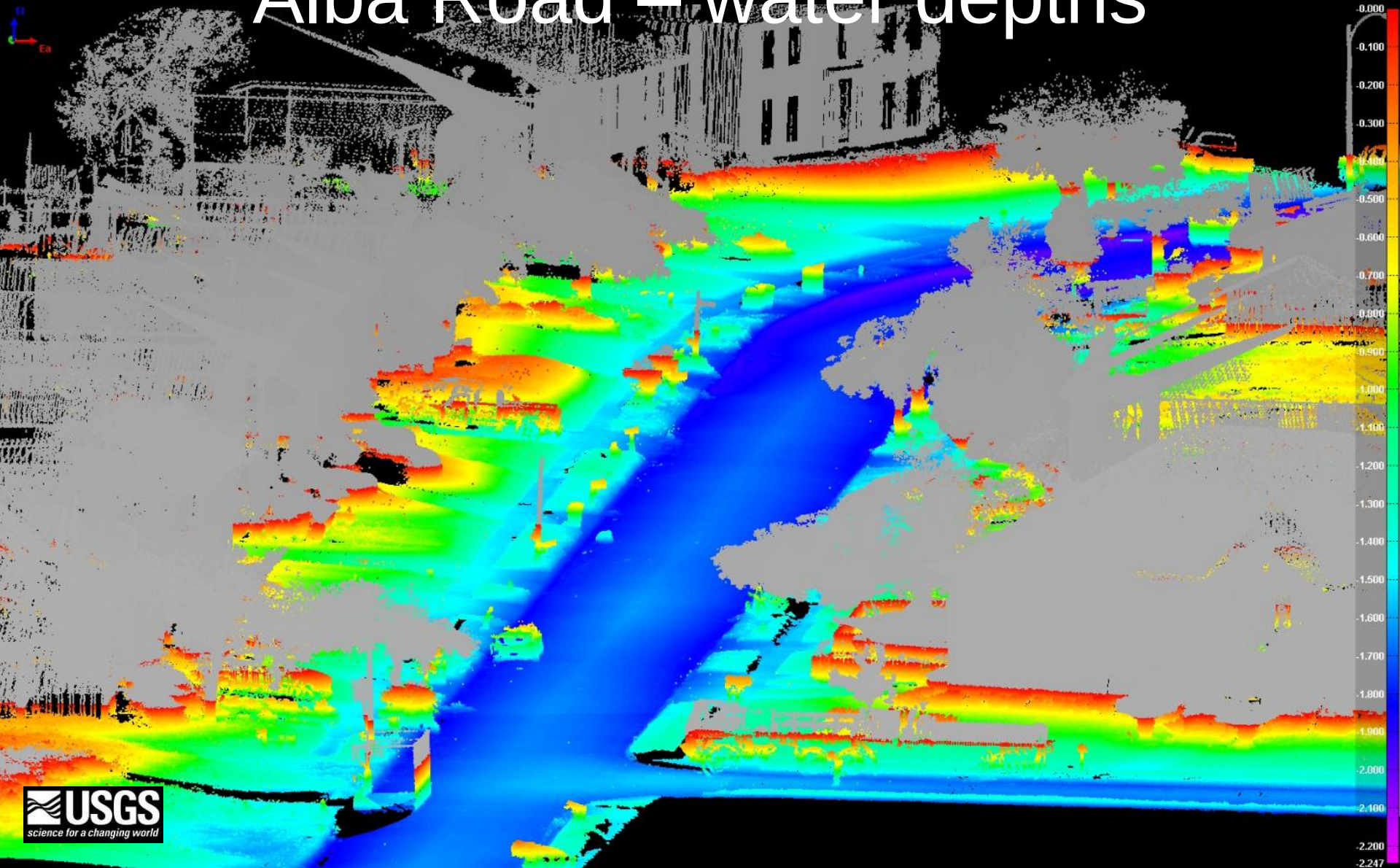
Venetian Isles, LA
Alba Road



Venetian Isles, LA
Alba Road – water surface



Venetian Isles, LA
Alba Road – water depths



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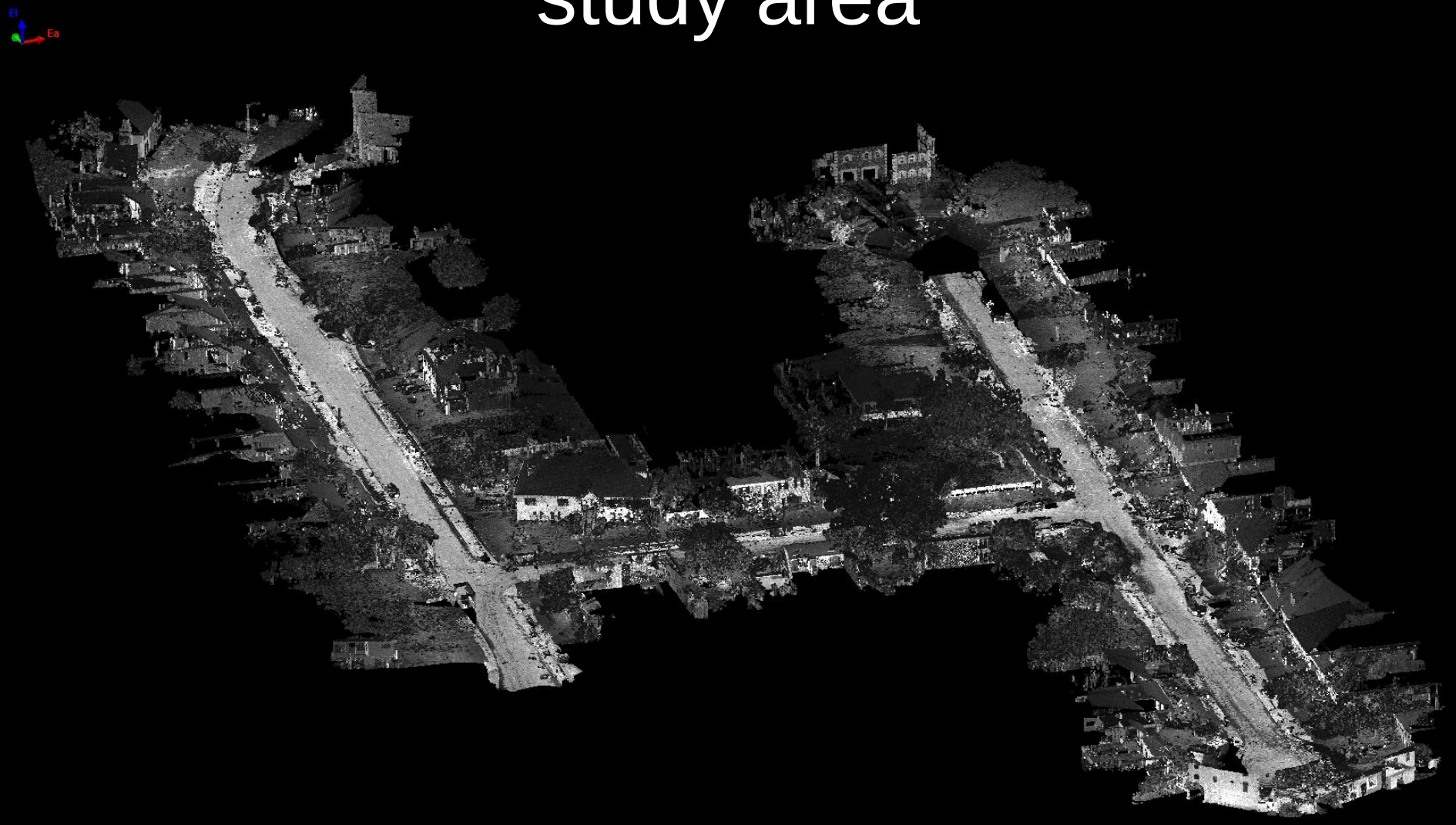
Venetian Isles, LA study area



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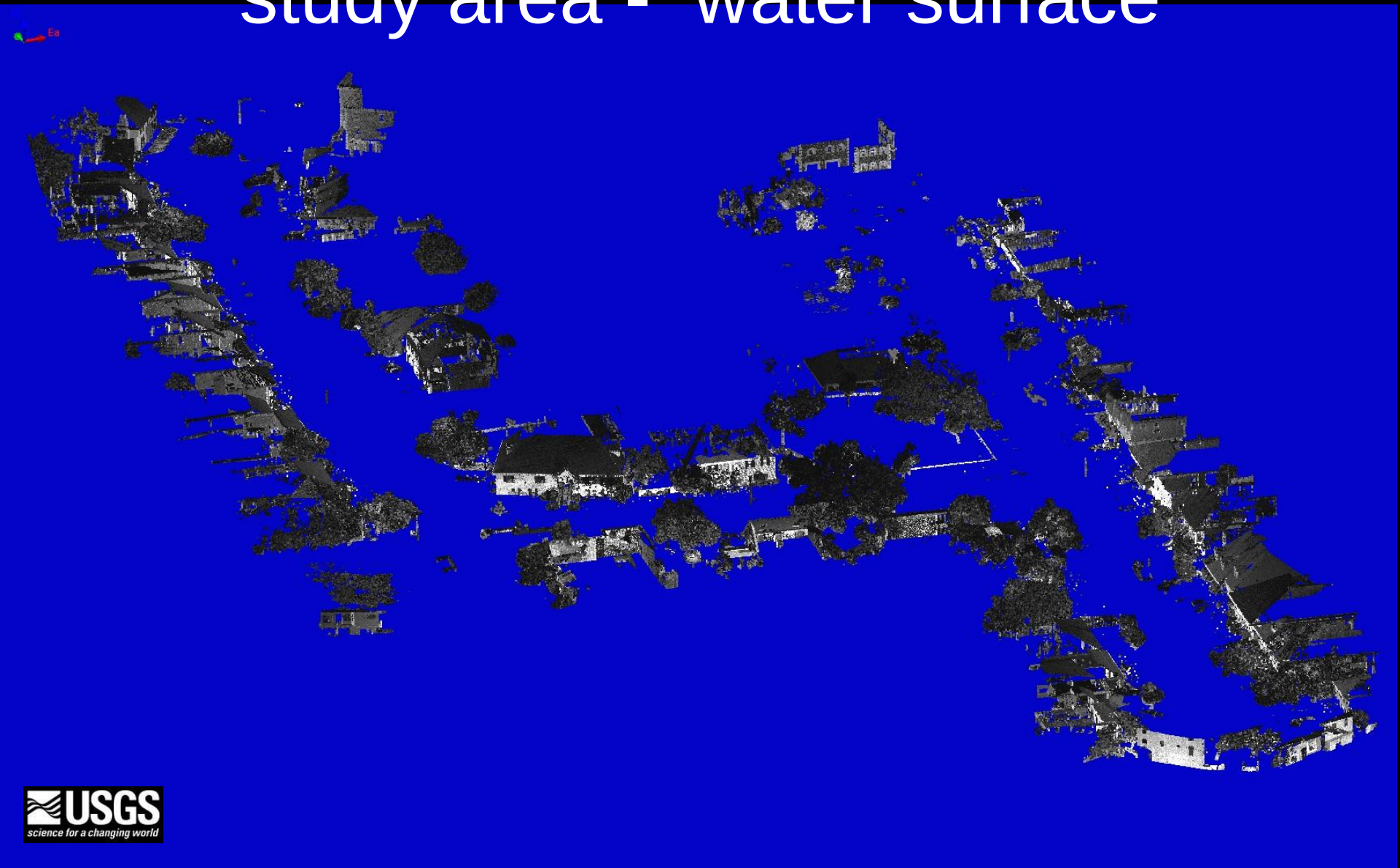
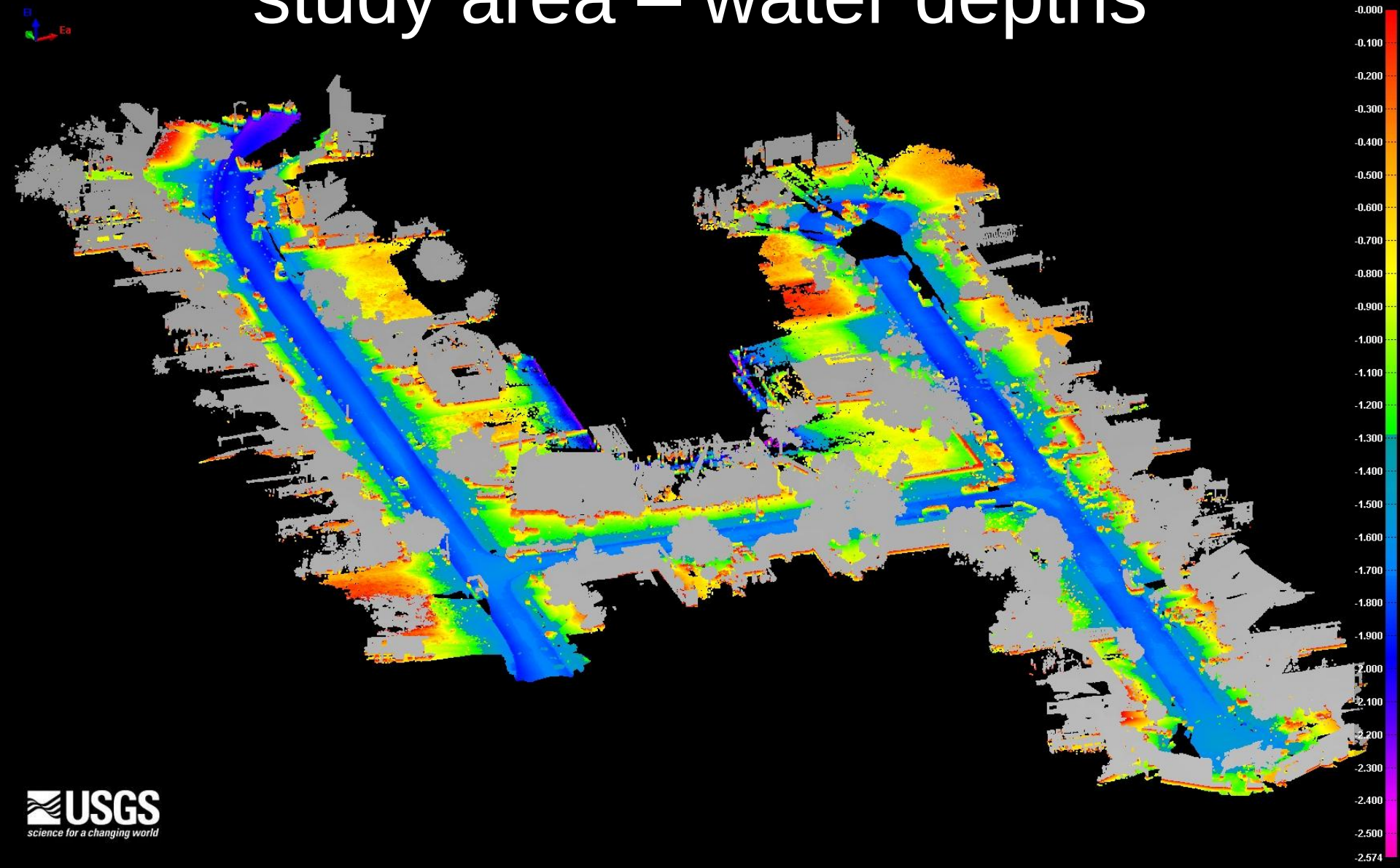
Venetian Isles, LA
study area - water surface



Venetian Isles, LA study area – water depths



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Questions?

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