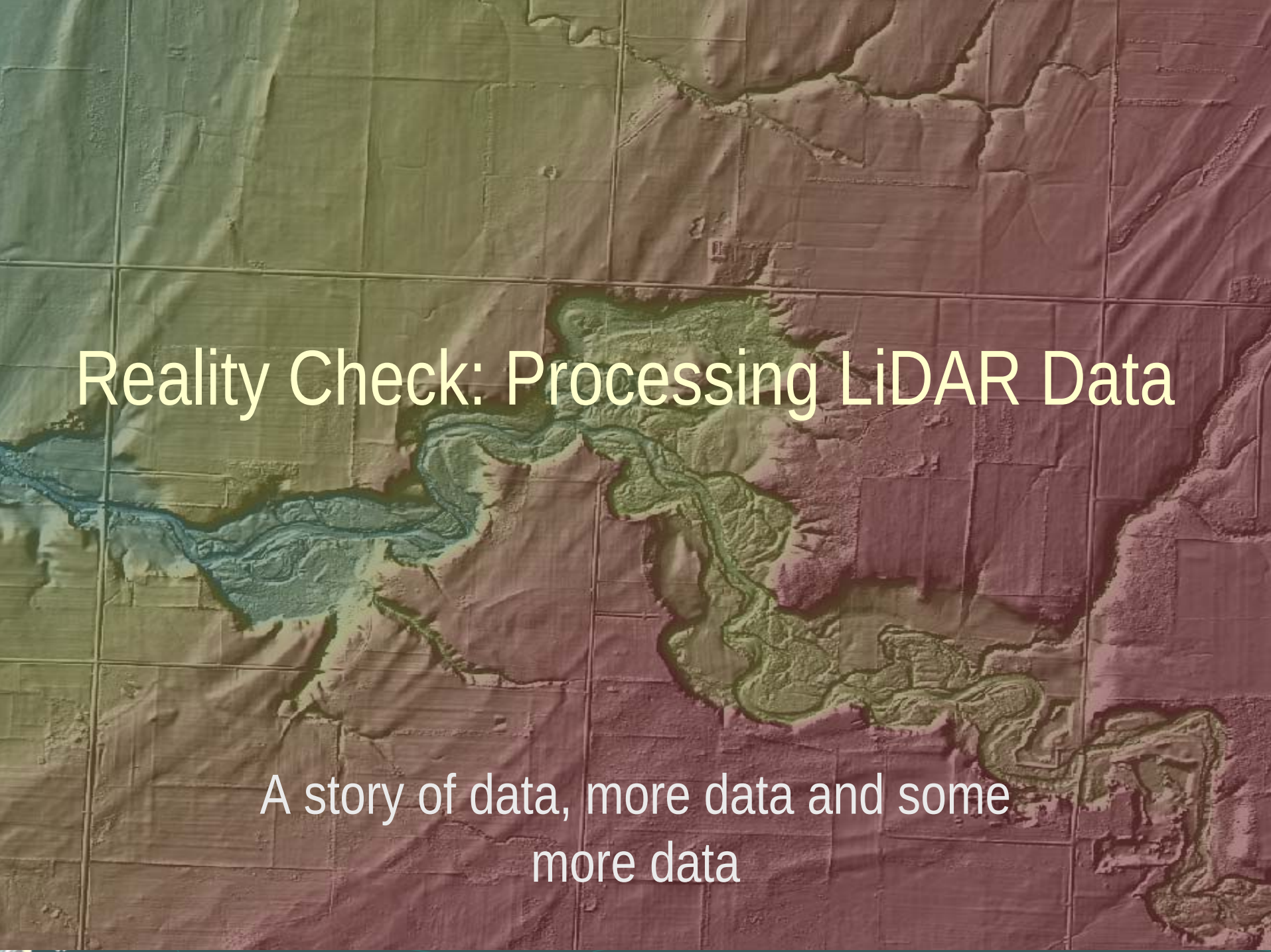
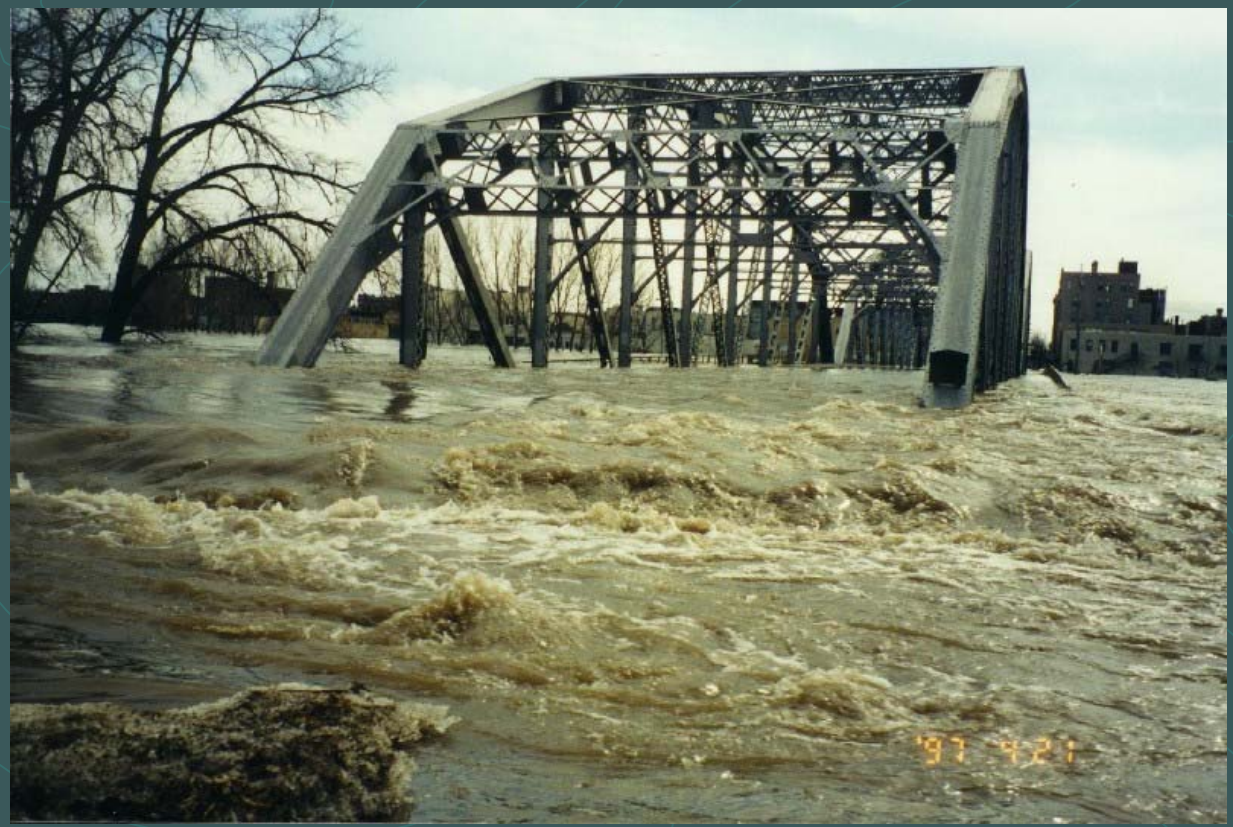


Reality Check: Processing LiDAR Data

A story of data, more data and some more data

Red River of the North

Red River of the North



Red River of the North

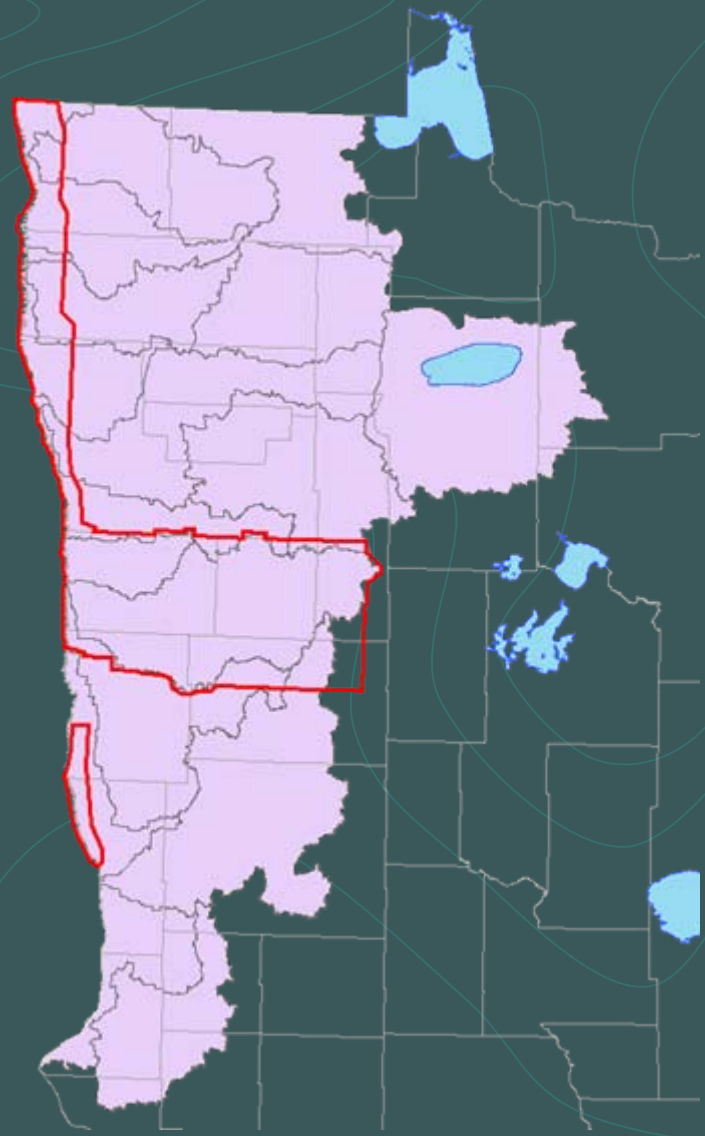
Red River of the North

Introduction and Background

- FEMA Grant to DNR in 2006
  - Create a high resolution Digital Elevation Model for Floodplain Mapping in the Red River Valley
- Partnered with
  - Clay County
  - Mn/DOT
  - Norman County
  - White Earth Reservation
  - Wild Rice Watershed District

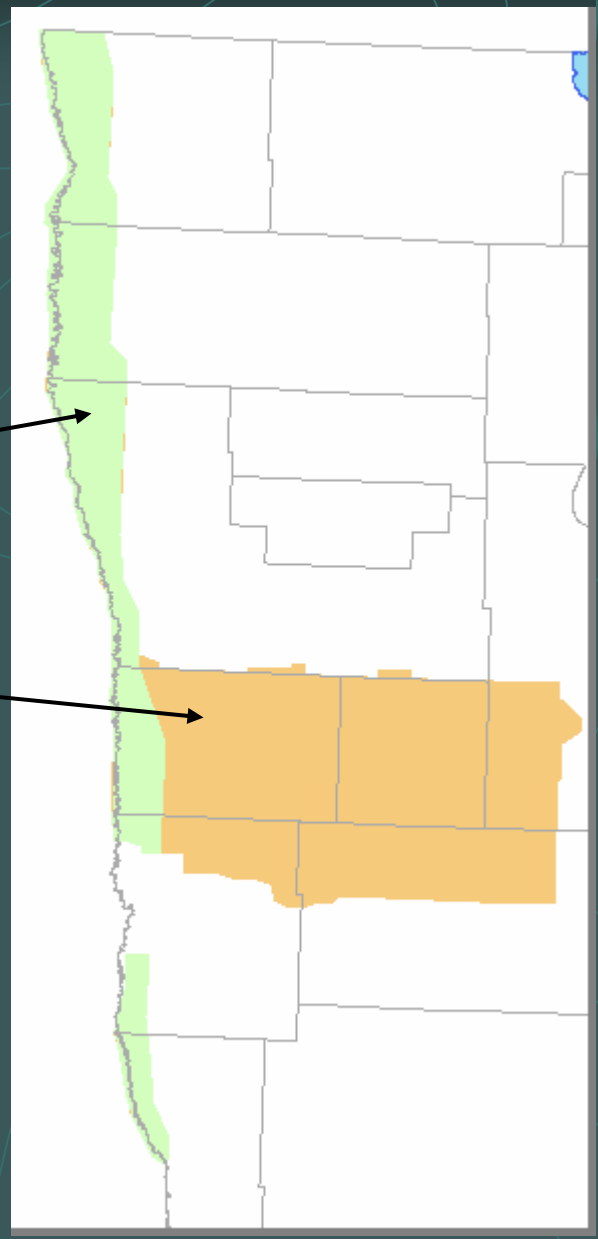
Background

- Red River Watershed
  - 17,700 Square Miles (Minnesota only)
- LiDAR Collect Area (red outline)
  - 3663 Square Miles



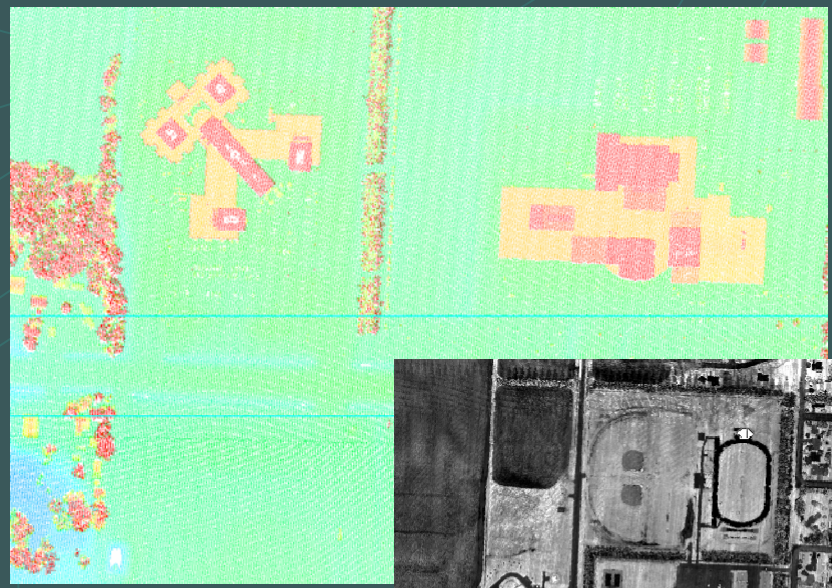
Background

- Data Specifications
  - Vertical Accuracy
    - 12 cm RMSE
      - Capabable of supporting 1.2’ contour generation
    - 15 cm RMSE
      - Capable of supporting 1.7’ contour generation
  - Horizontal Accuracy
    - 0.5 meters RMSE
  - 1 meter nominal point spacing



Background

- Data to be delivered
  - All LiDAR Points
  - Bare Earth Points
  - Bare Earth Grid
  - Building Points
  - Vegetation Points
  - Intensity Imagery
  - Edge of water break lines
    - Used to enforce flat water areas….



Delivery Formats…

- LAS – ASPRS LiDAR Exchange Format
  - Binary, Open standard, not vendor specific
  - Stores a variety of point information
    - Number of returns
    - Return Number
    - Intensity
    - X,Y, Z values
    - Scan Direction
    - Classification
    - Scan Angle Rank
    - GPS Time

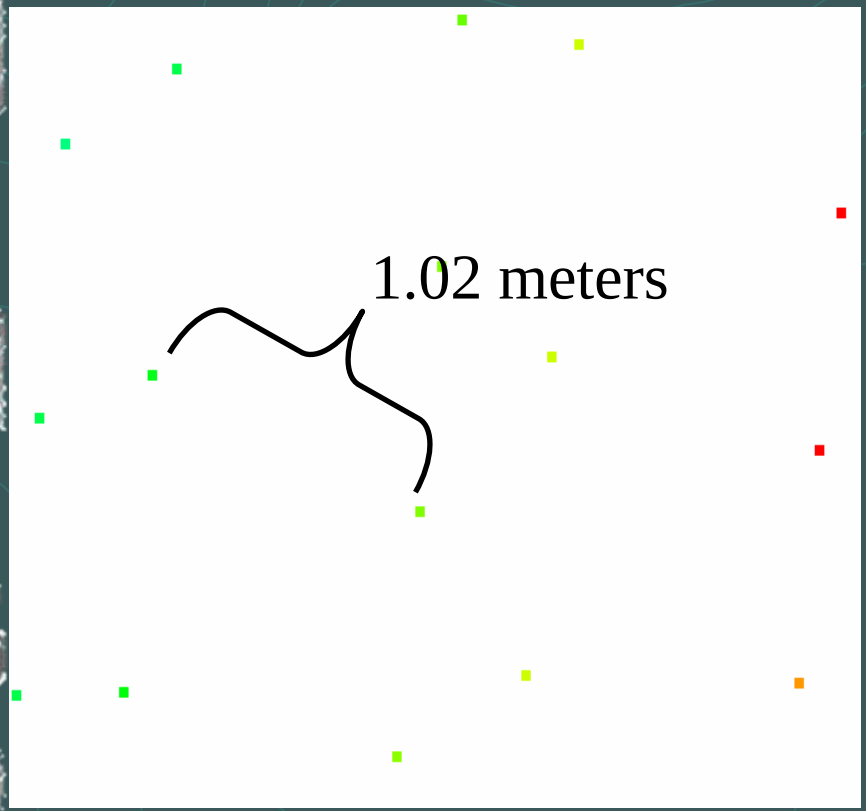
Delivery Formats

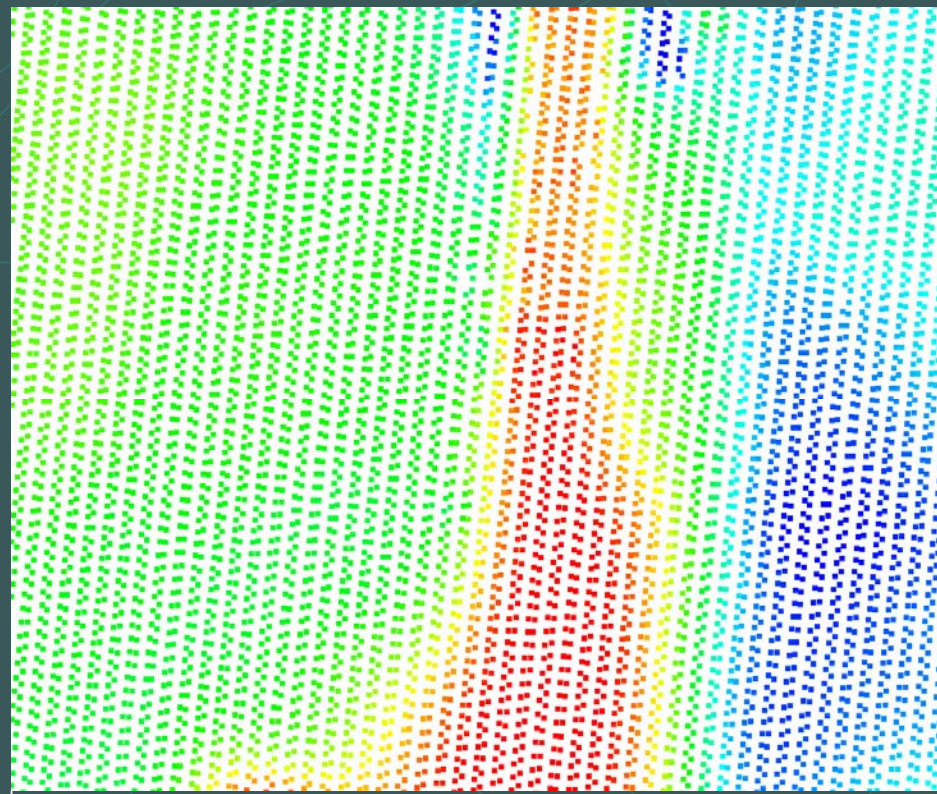
- ASCII Comma-delimeted
  - Very generic format
  - Digested by most any software
  - Limited amount of point information available
    - x, y, z
  - Large because no compression
- Raster Grid
  - 1 meter resolution created from bare earth points
  - Generic and portable binary format
  - Integer format, centimeter Z-Values

Working with LiDAR Data

- LiDAR datasets tend to be very large
  - LAS Format
    - All Returns – 7 million points, 100 mb / square mile
    - Bare Earth – 3 million points, 45 mb / square mile
  - ASCII Format
    - All Points – 4 million points, 75 mb / square mile
    - Bare Earth – 3 million points, 73 mb / square mile
  - Grid Format
    - 2.8 mb / square mile in integer format
    - 11.2 mb / square mile in floating point format

Data volume = high density





Now for some math….

- 1 sq mile = 296mb
- 3663 sq miles = 1,084,248 mb
  - Just over 1 gb worth of data for the project area!
- Implications?
  - Lot's of horsepower, er hertz-power
  - Lot's of disk space
  - Lot's of staff-time to copy, handle and process data
  - Lot's of network capability for Web based delivery

Accuracy

- LiDAR has the capacity to collect very high accuracy data
  - Depends on the flight height and the mission parameters
  - Increasing accuracy = Increasing Costs!
- Limitation is the positional accuracy of the airborne GPS system

Accuracy

- Validated the project data deliverables for a pilot project area of 100 square miles
- Twenty-four control points captured by Mn/DOT survey crews
- Accuracy proved to be very good.
- Two sites were removed from the assessment
  - One was in a swamp
    - wet in spring, dry during survey
  - One was just outside the study area

Accuracy Assessment

Control Point Report

Red River Pilot Lidar Area Deliver #1
All Units are in Meters

--------- Report Summary ---------

Error Mean:	-0.090
Error Range:	[-0.276,0.00
Skew:	-0.300
RMSE(z):	0.134
NMAS/VMAS	
Accuracy(z) (90% CI):	±0.221
ASPRS/NSSDA	
Accuracy(z) (95% CI):	±0.263

ding, ding ding ding

22 control points included in summary out of 24
- 2 control points turned off
- 0 control points returned no-data

Surface Method: Triangulation (TIN)

--------- Control Points ---------

	Name	Control X	Control Y	Control Z	Surface Z	Error
	spot-l3b brush	247649.278	5243508.614	300.735	300.902	-0.167
	spot-l2t crop	248877.386	5244221.049	307.471	307.536	-0.065
	spot-l4f forested	241986.286	5243569.440	284.572	284.743	-0.171
	spot-l3b brush	240204.134	5242216.589	281.397	281.561	-0.164
Turned off	spot-l1o field	250312.683	5240113.769	309.783	277.872	31.911
	spot-l4f forested	247154.135	5241882.511	299.652	299.734	-0.082
	spot-l4f forested	235280.195	5242704.533	275.427	275.703	-0.276
	spot-l1o field	233671.253	5242706.007	274.032	274.010	0.022
	spot-l3b field	233158.438	5244735.381	273.837	273.862	-0.025
	spot-l5u parking lot	234227.364	5244244.504	275.889	275.875	0.014
	spot-l5u parking lot	235408.681	5243998.172	277.154	277.177	-0.023
	spot-l2t field	238671.083	5243870.540	279.611	279.645	-0.034
	spot-l5u playground	234538.698	5231253.871	276.704	276.779	-0.075
	spot-l1o field	233267.838	5233423.815	274.680	274.702	-0.022
	spot-l1o field	238318.659	5236869.925	279.881	279.913	-0.032
	spot-l3b fence line	240198.447	5237329.335	281.839	281.916	-0.077
	spot-l2t field	241551.004	5235698.076	284.701	284.662	0.039
Turned off	spot-l4f swamp	243619.789	5235563.922	298.511	298.889	-0.378
	spot-l5u yard	245170.210	5224233.781	319.714	319.794	-0.080
	spot-l3b field	248513.920	5224107.912	337.122	337.347	-0.225
	spot-l2t field	248018.791	5224924.490	331.105	331.351	-0.246
	spot-l1ot field	244802.959	5225176.423	311.382	311.637	-0.255
	spot-l4f edge of woods	244943.115	5229085.531	310.758	310.664	0.094
	spot-l2t field	245199.428	5233666.809	311.128	311.250	-0.122

Report produced by LP360, QCoherent Software, LLC

13.4 cm * 1.96 = 26 cm at the 95% confidence level

Assumptions:

- Normal Distribution
- Average of zero

LiDAR Derived Products

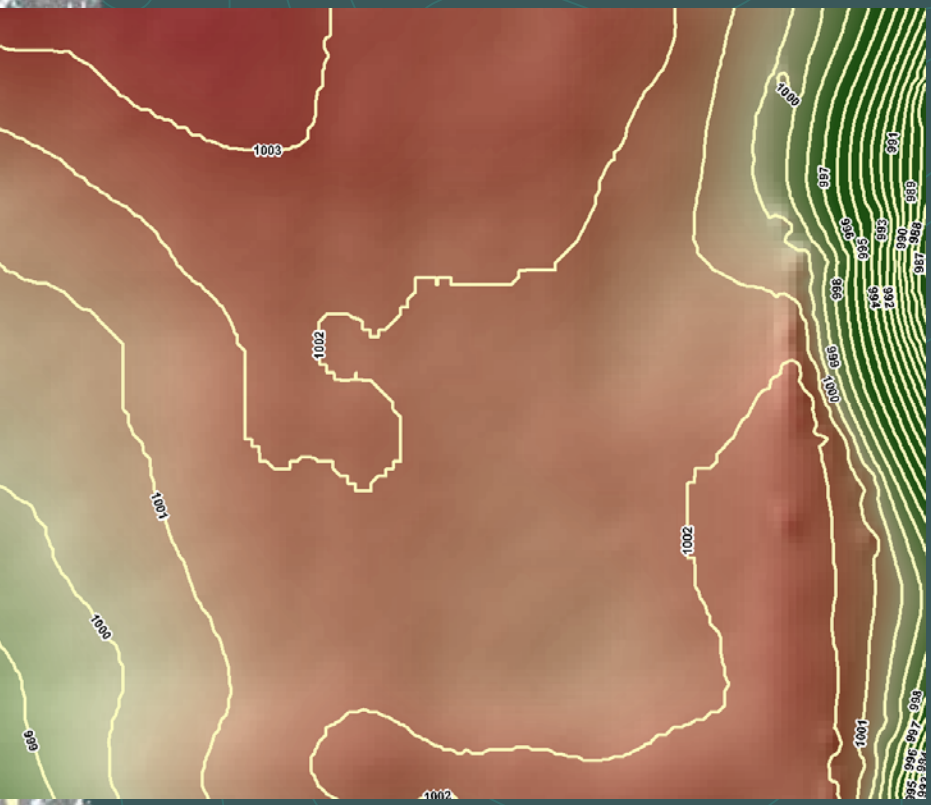
- What Data Do People Use?
  - Primary use products
    - Contours
    - Raster Digital Elevation Model
  - Most users don't bother with the raw LiDAR data
    - Not a lot of tools available but this list is growing
    - ArcGIS extensions are now available to read LAS format LiDAR data
  - Derived products from raw LiDAR is a growing research field

Creating Contours

- Contours are typically created from a raster DEM
- Contours don’t always look visually appealing
  - Jagged lines that may wrap on themselves
- Smoothing the DEM can help
  - 3x3 averaging filter works well
  - Makes the interpolation routine work harder
- Commonly called Neighborhood analysis

Creating Contours….

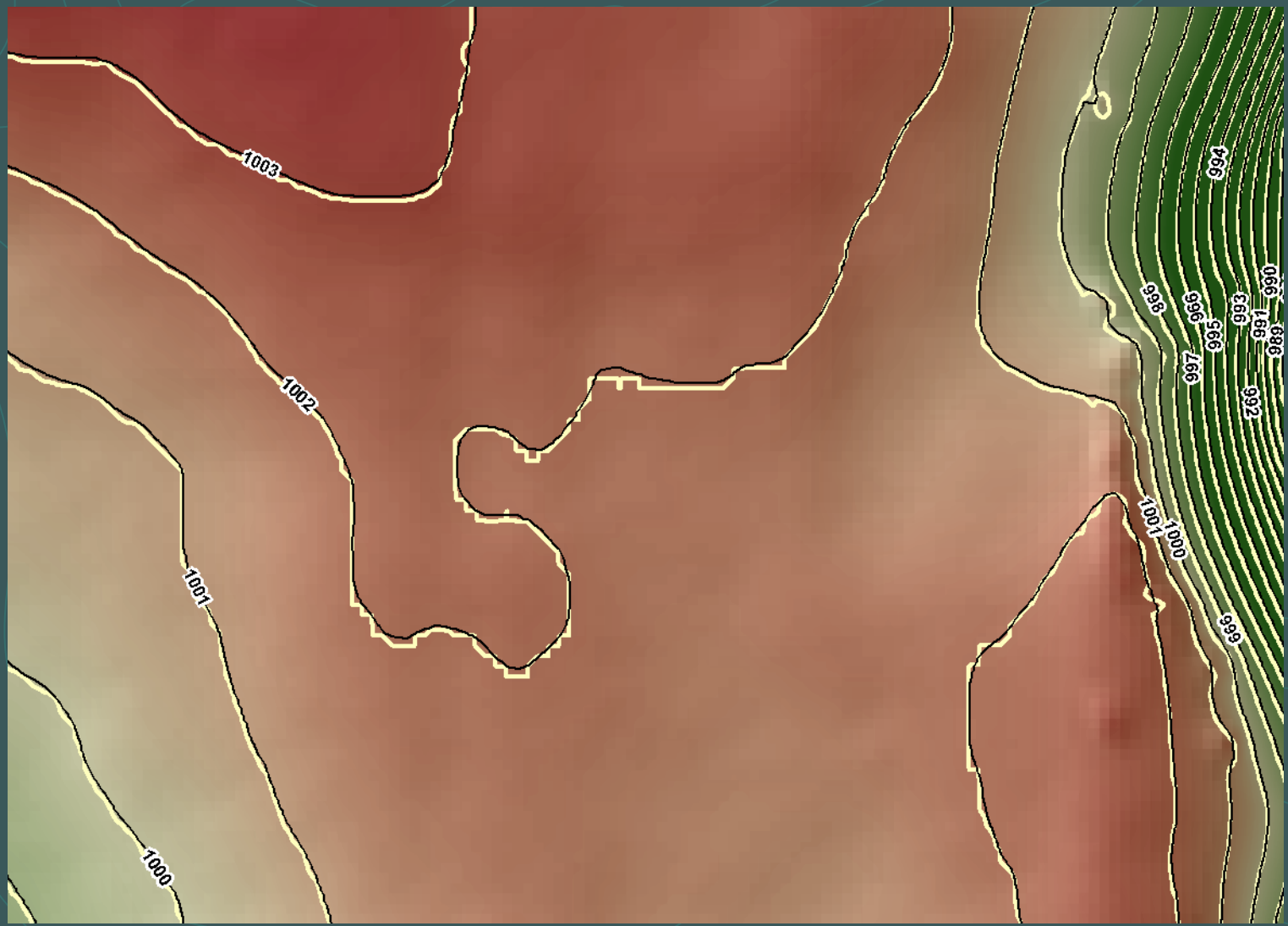
Non-filtered DEM



Filtered DEM

1’ contours on shaded relief

Contours.....


1003
1002
1001
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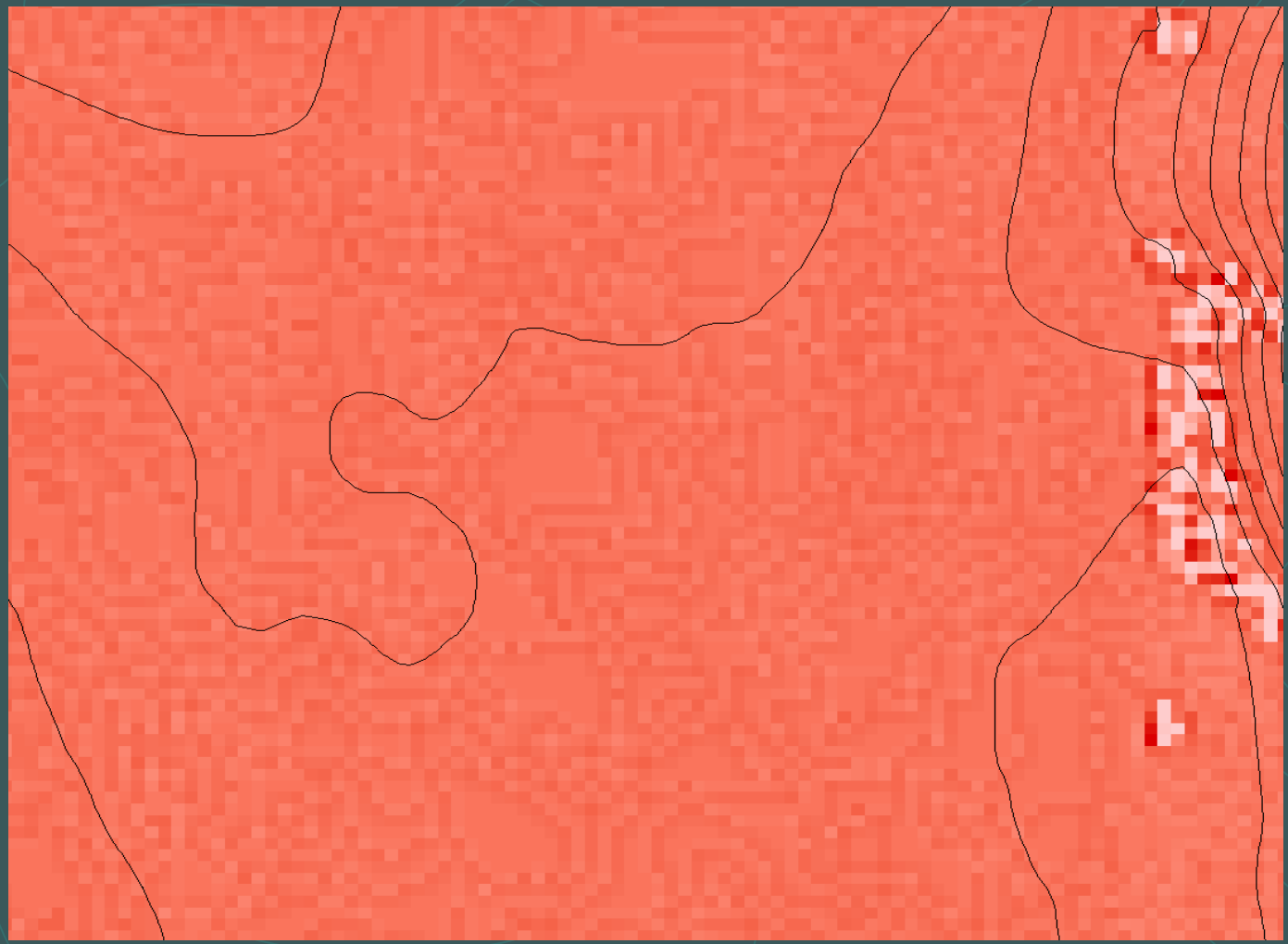
988

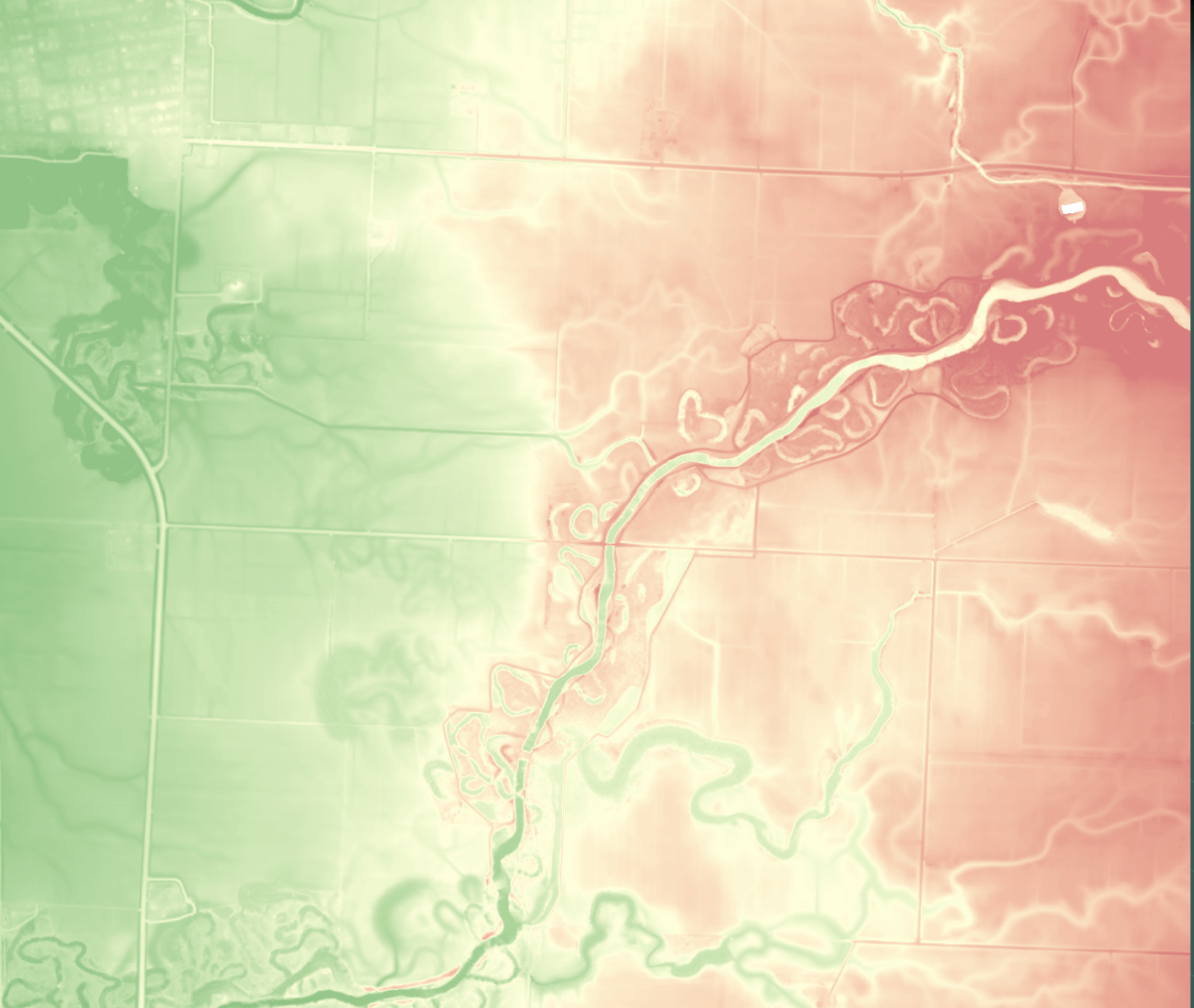
Contours…..

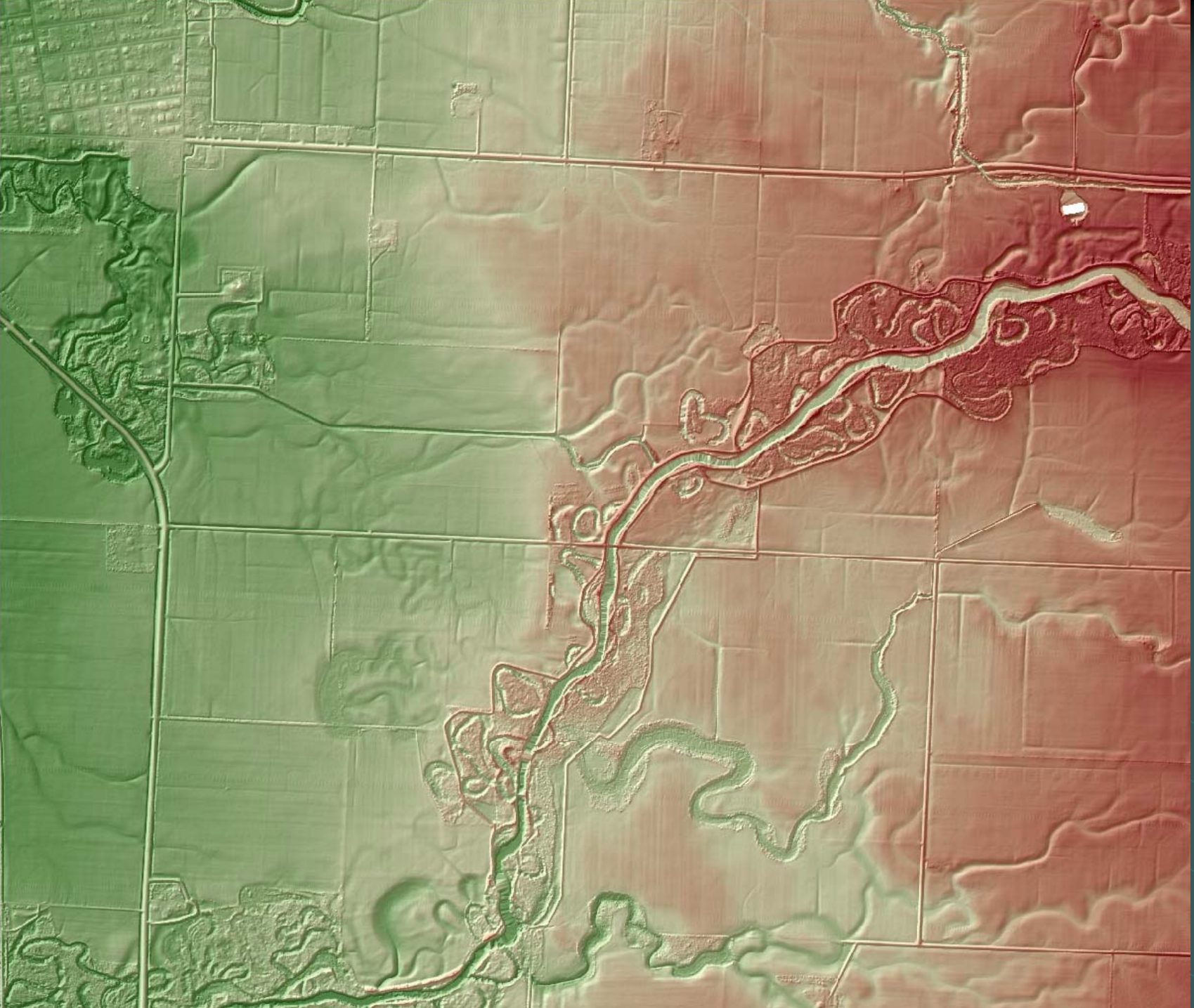


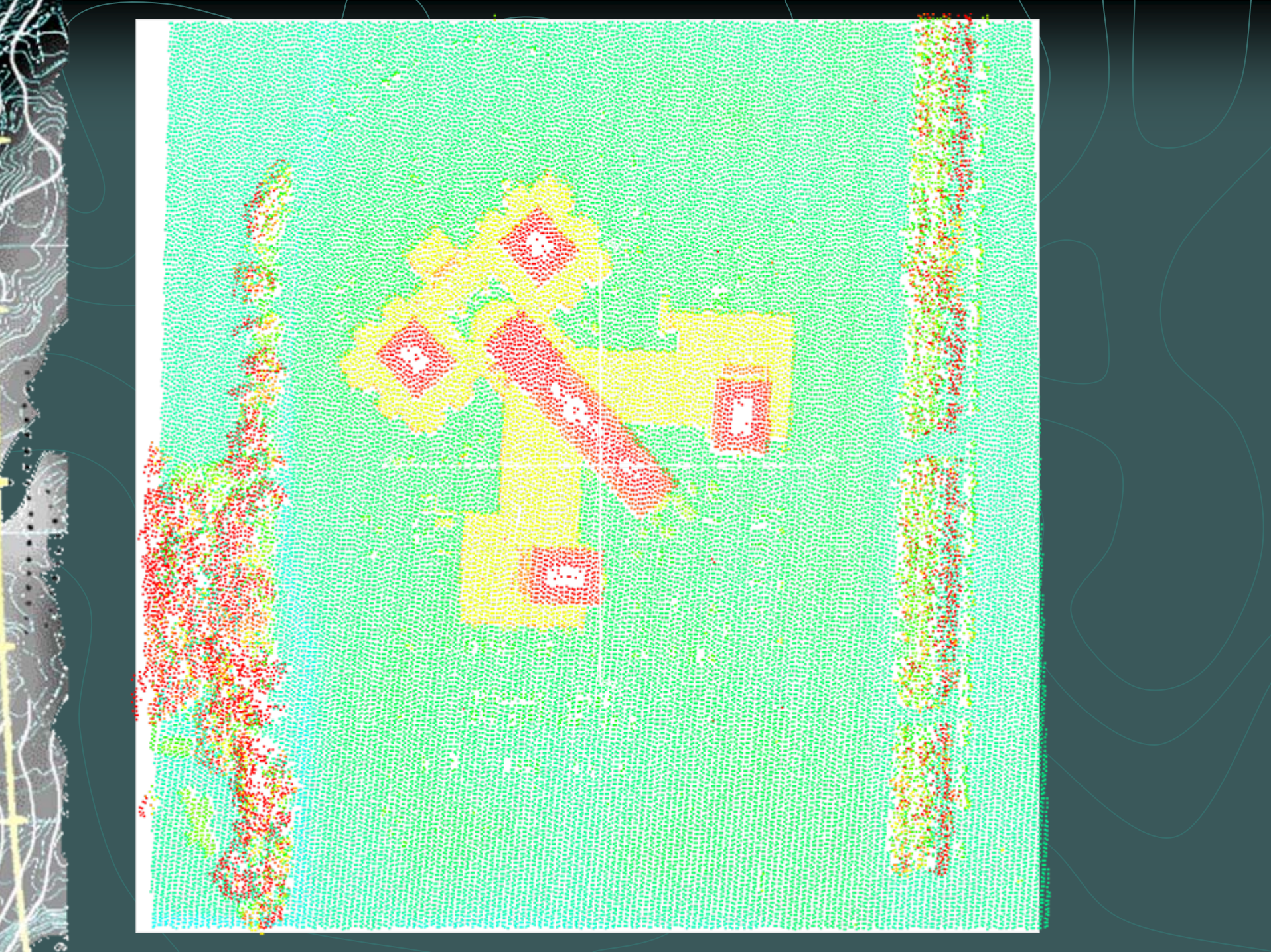
Difference surface of Original – Smoothed DEM
Maximum Difference 0.9 feet

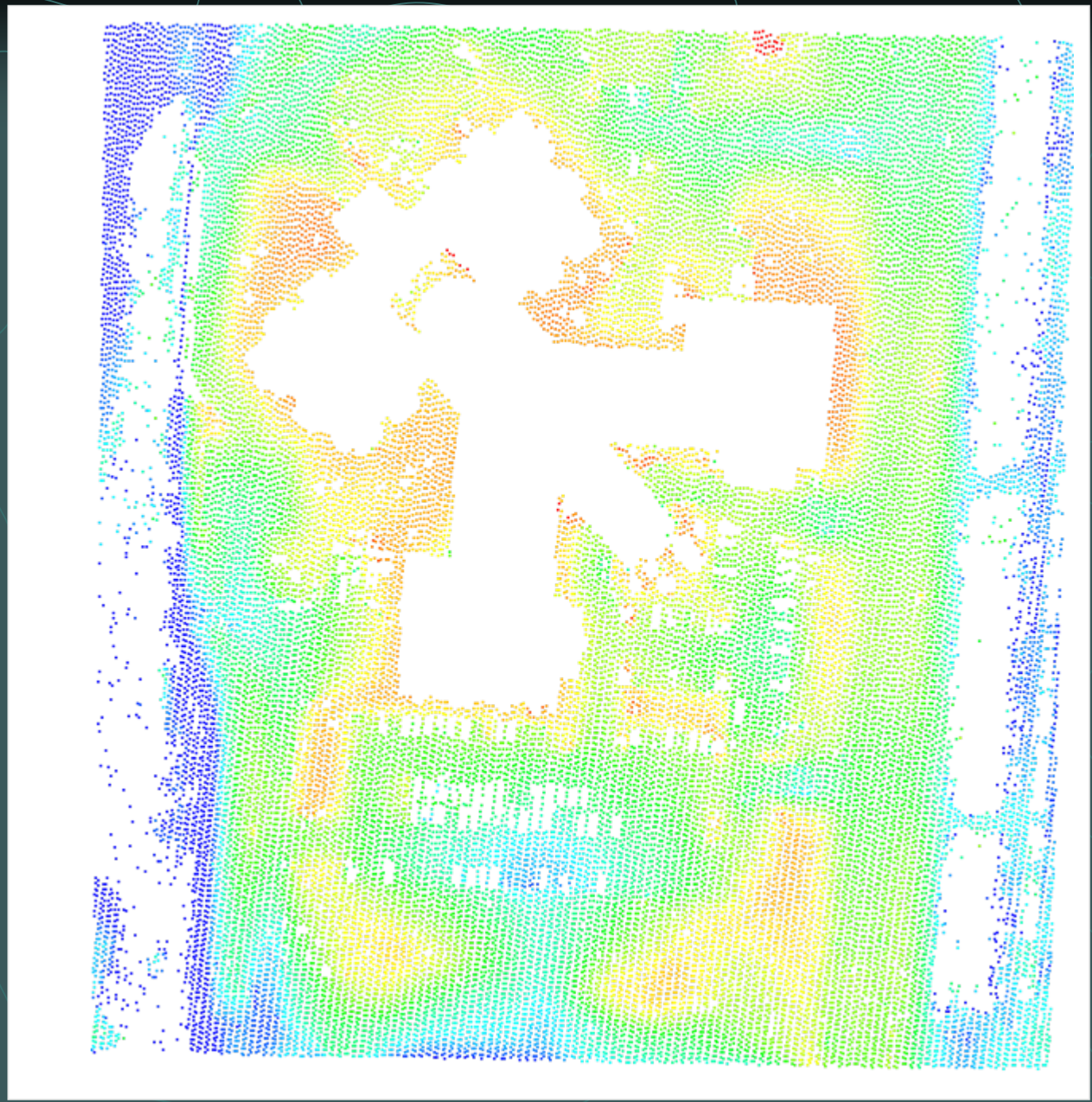
Visualization

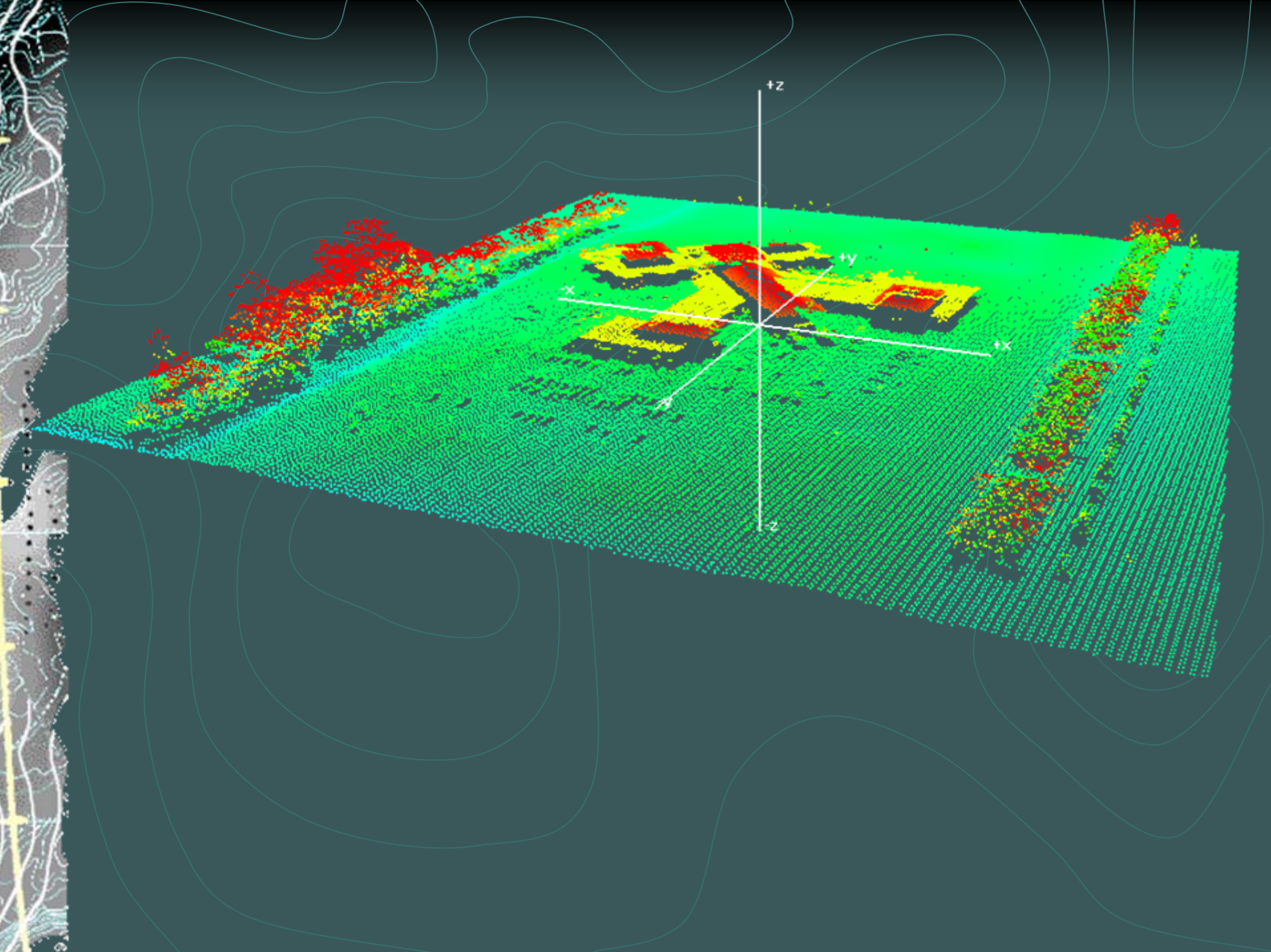
- Lidar data can be visualized a number of ways
  - Shaded Relief images can reveal very subtle relief
    - Especially with high detail data
    - Helpful for data validation and looking for anomalies and errors in the data
  - 3-Dimensional viewing
  - Cross-sections
  - Contour generation

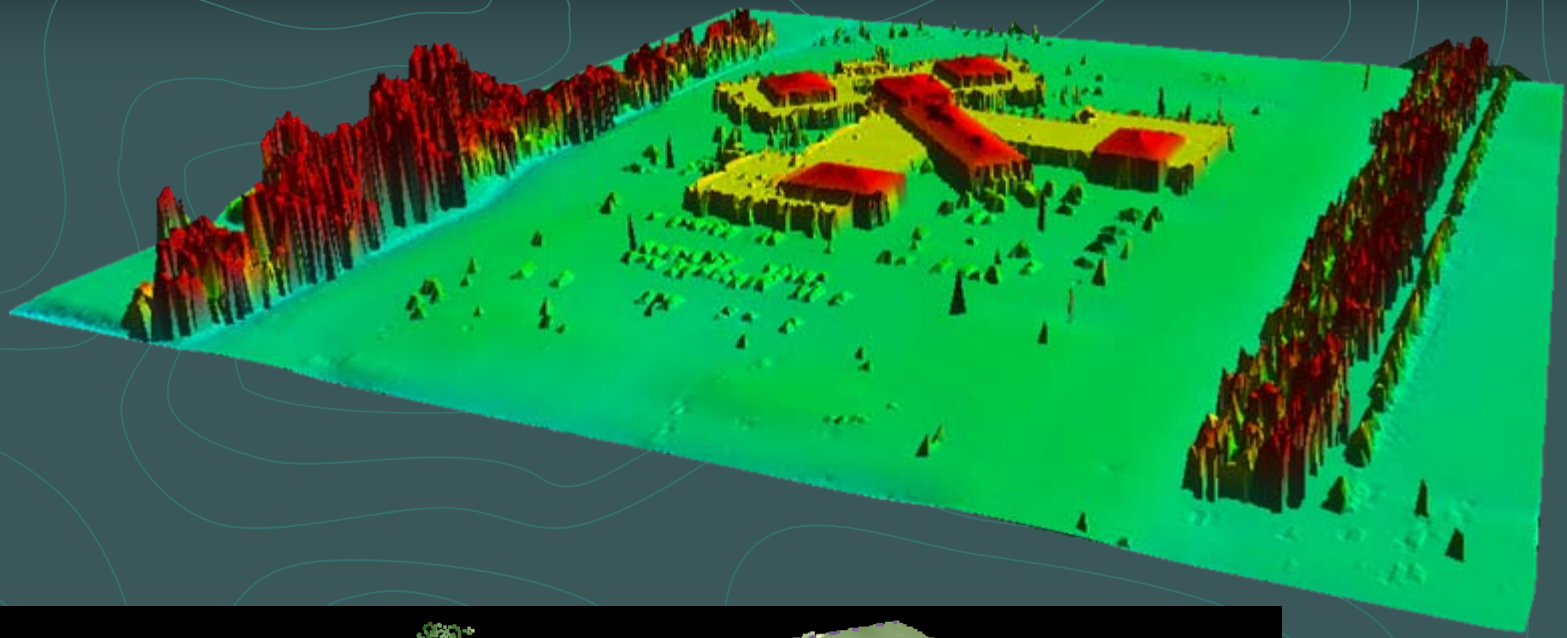


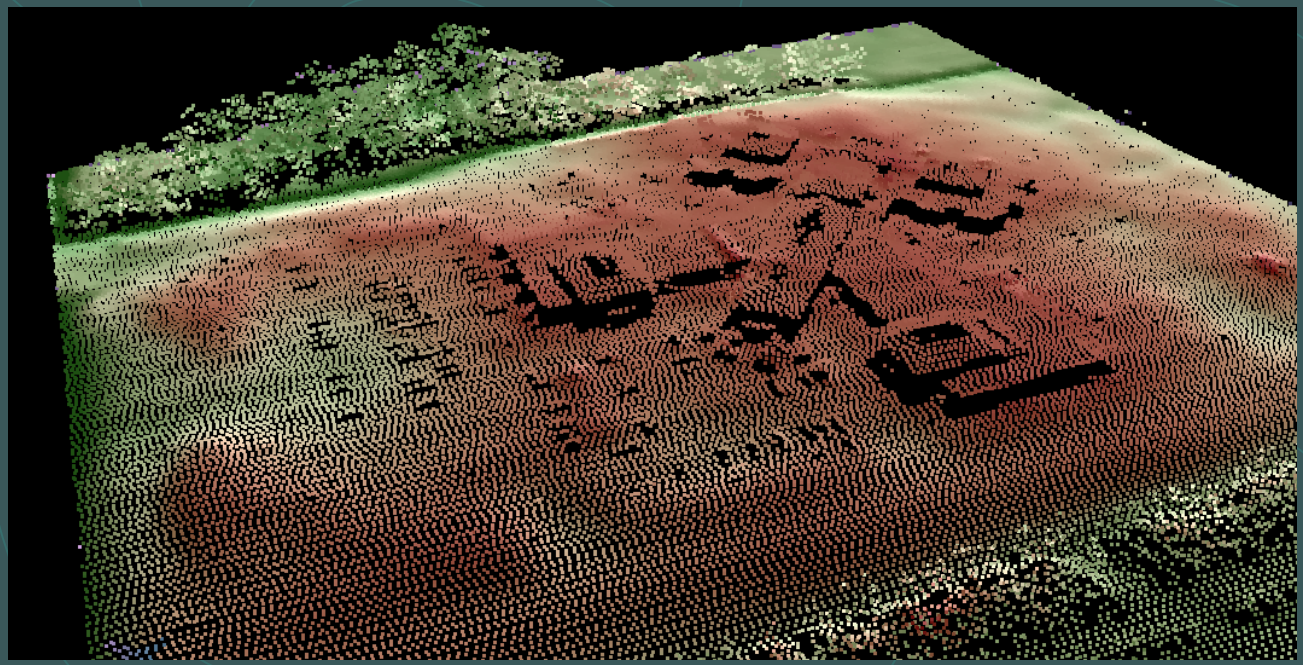


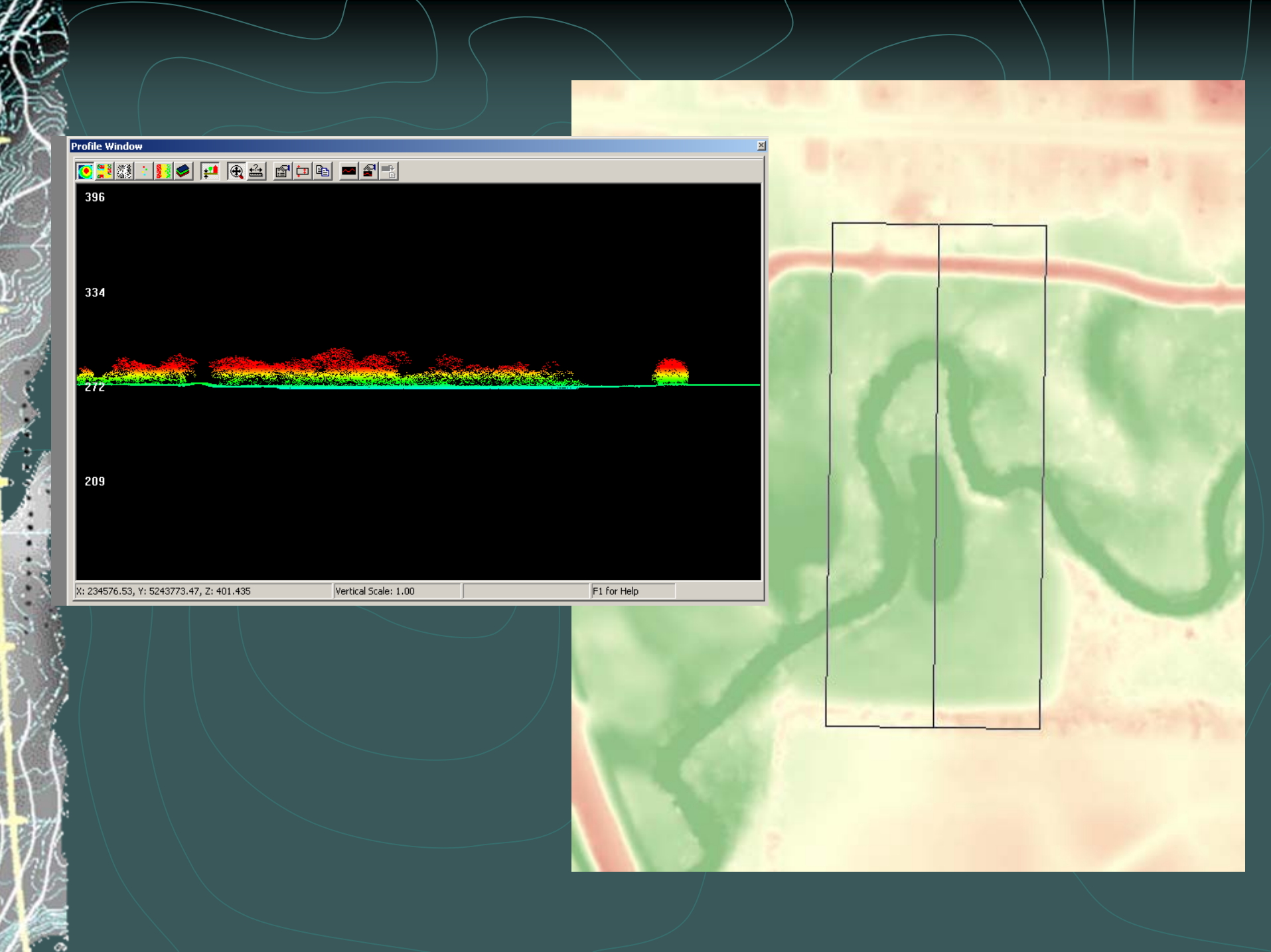





+z
+y
-x
+x
-z

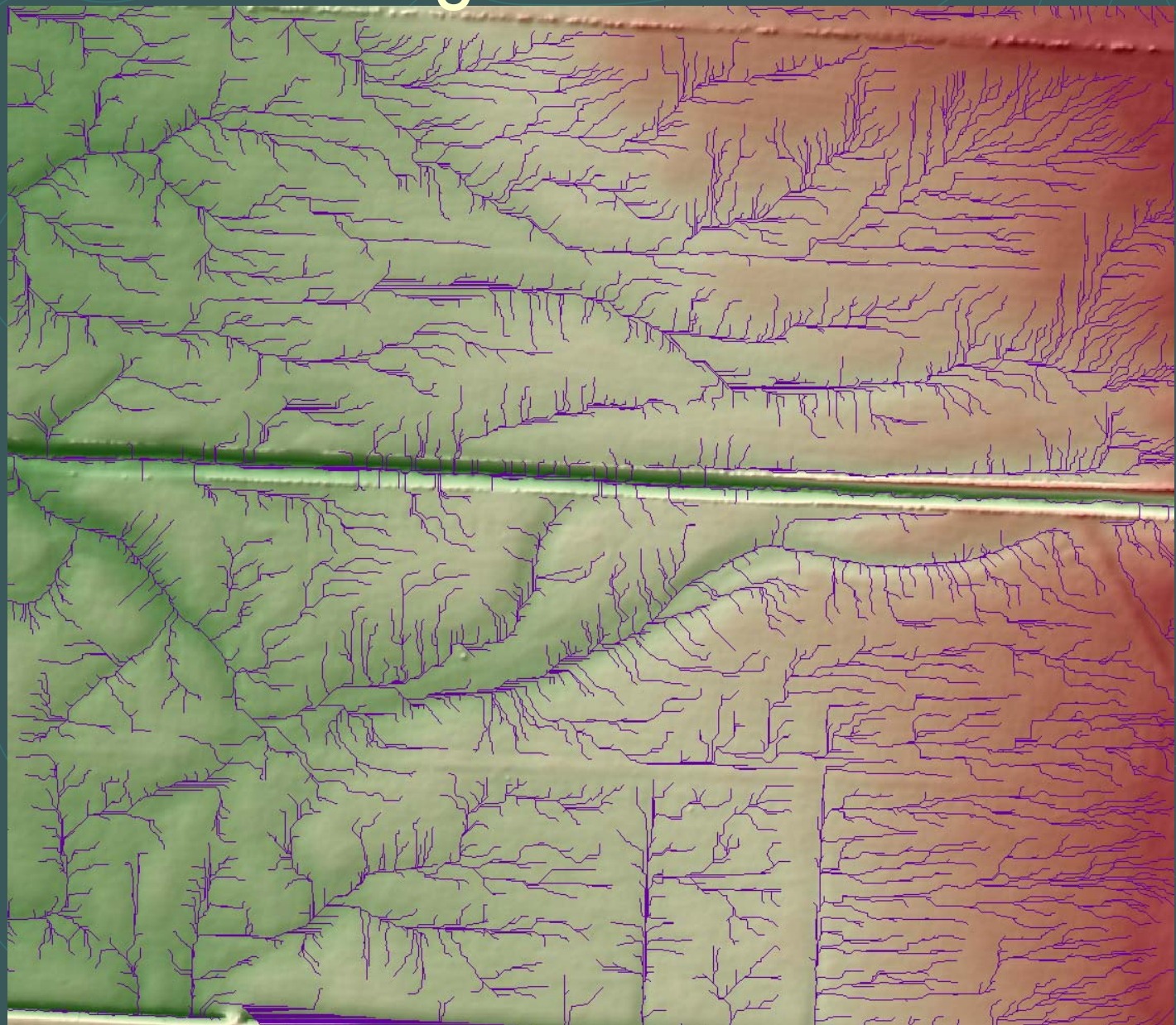





Profile Window
396
334
272
209
X: 234576.53, Y: 5243773.47, Z: 401.435
Vertical Scale: 1.00
F1 for Help

Intensity……

Terrain Modeling…..



Lessons Learned

- Use a Tiling Scheme of Your Choice
  - PLS Section boundaries work well
- Validate the data using for a small pilot area
  - Saves you and the vendor time if there are problems
- Do an independent accuracy assessment!
  - You might be surprised at what you find
- Smoothed DEMs generate smooth contours