Multibeam Hydrographic Technology Used to map Channel Bathymetry On the Colorado River In the Grand Canyon

by

F. Mark Gonzales, Survey Coordinator, GCMRC

USGS science for a changing world

Introduction:

In 1993 the GCES survey department began to development a hydrographic mapping program to facilitate all monitoring efforts requiring sub-aqueous measurements. Hydrographic data collection methods were designed to develop monitoring products such as:

*** Topographic maps,**

*** Digital Terrain Models (DTM)**

*** Triangulated Irregular Network models (TIN)**

*** Aquatic habitat models**

*** Sediment aggregation and degradation**

*** Hydrologic stage discharge modeling**

*** Cross-section analysis**

Purpose:

Hydrographic technology is used in the Grand Canyon primarily to measure changes in the river channel. The primary changes that occur are due to the movement of sediment.

These changes are monitored by hydro-acoustic measurements that are accurately positioned over the course of the river channel.

Survey Process for Accurate Positioning of Multibeam Data

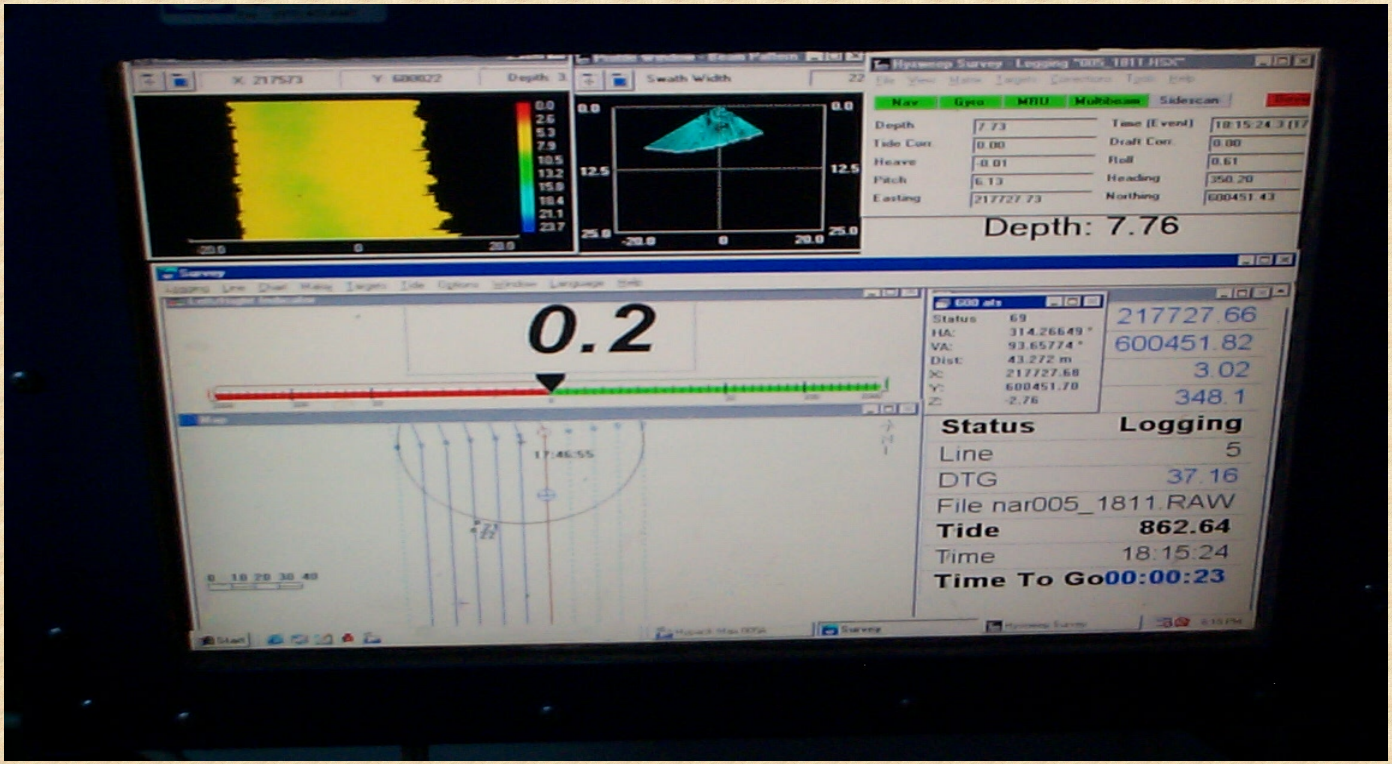
GPS Rim Control Network

GPS and Conventional Ground Control Measurements at the River

Robotic Tracking on Ground Control for Hydrographic Positioning

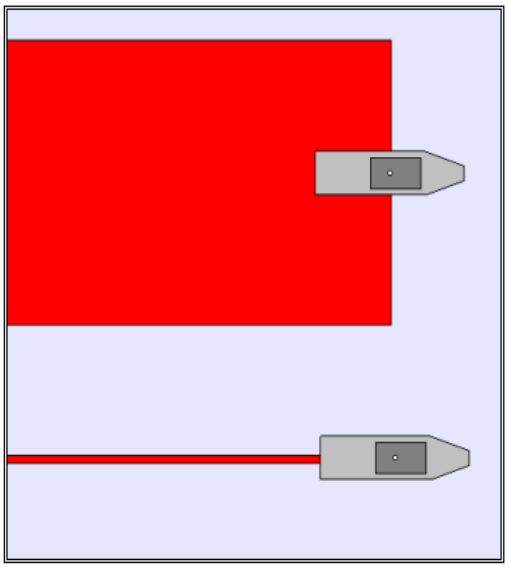
Hydrographic Surveying

Multibeam Data Collection



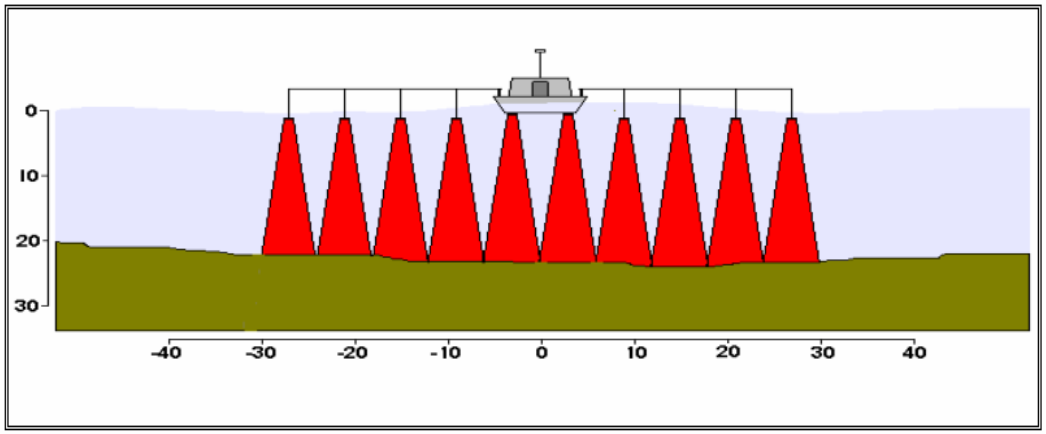
Hydrographic Methods

Survey Coverage



- Multibeam surveys a 2-dimensional area
- Single beam surveys a 1-D line directly under the boat.

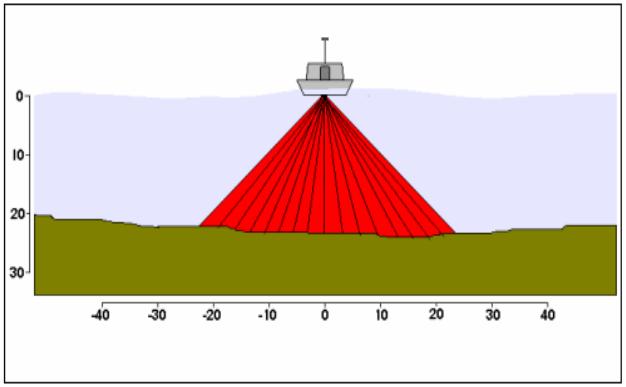
Multiple Transducer Systems

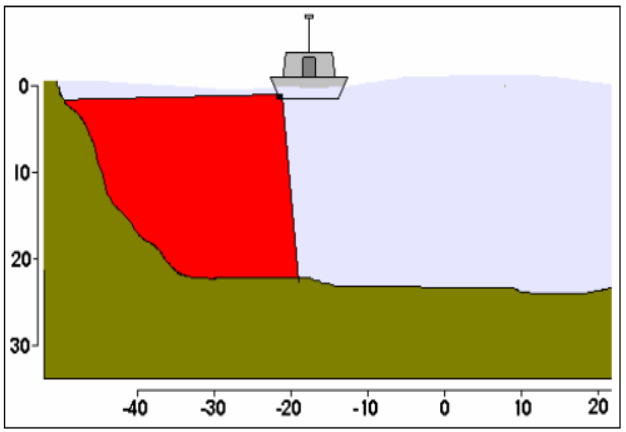


- No change in coverage with water depth.
- Vertical sounding beams.
- Simple in theory and operation.

Multibeam Systems

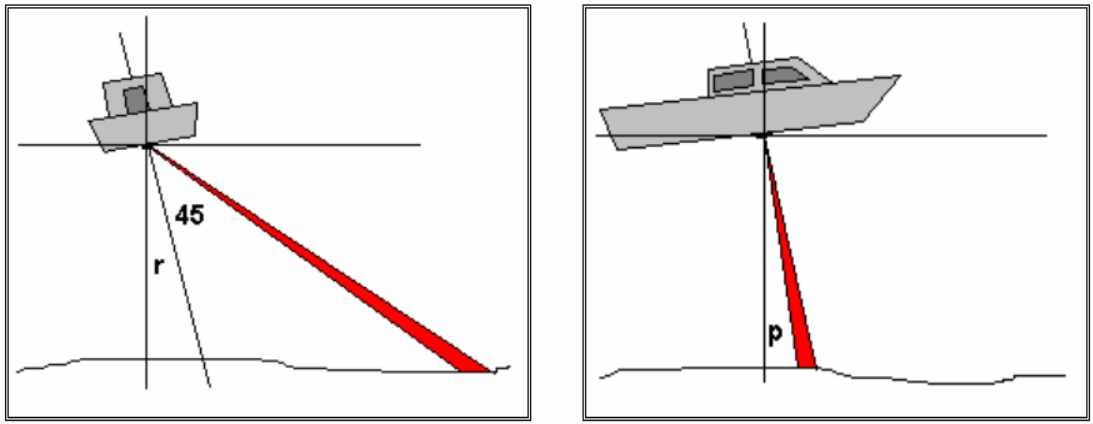
- Increasing coverage with water depth.
- Rough water operation.
- Mounting options – vertical or rotated.





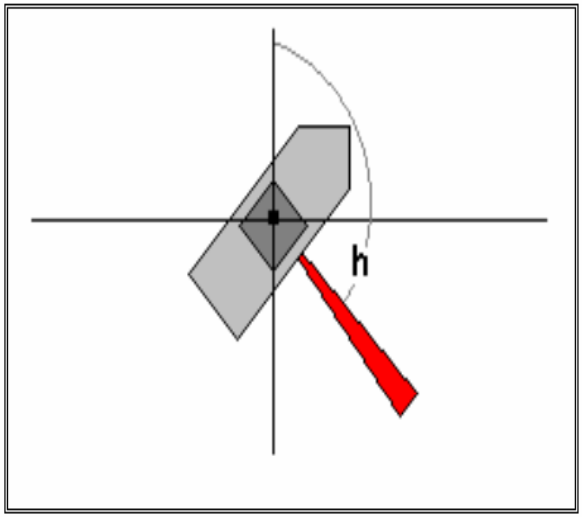
Multibeam Motion Compensation

Beam Geometry



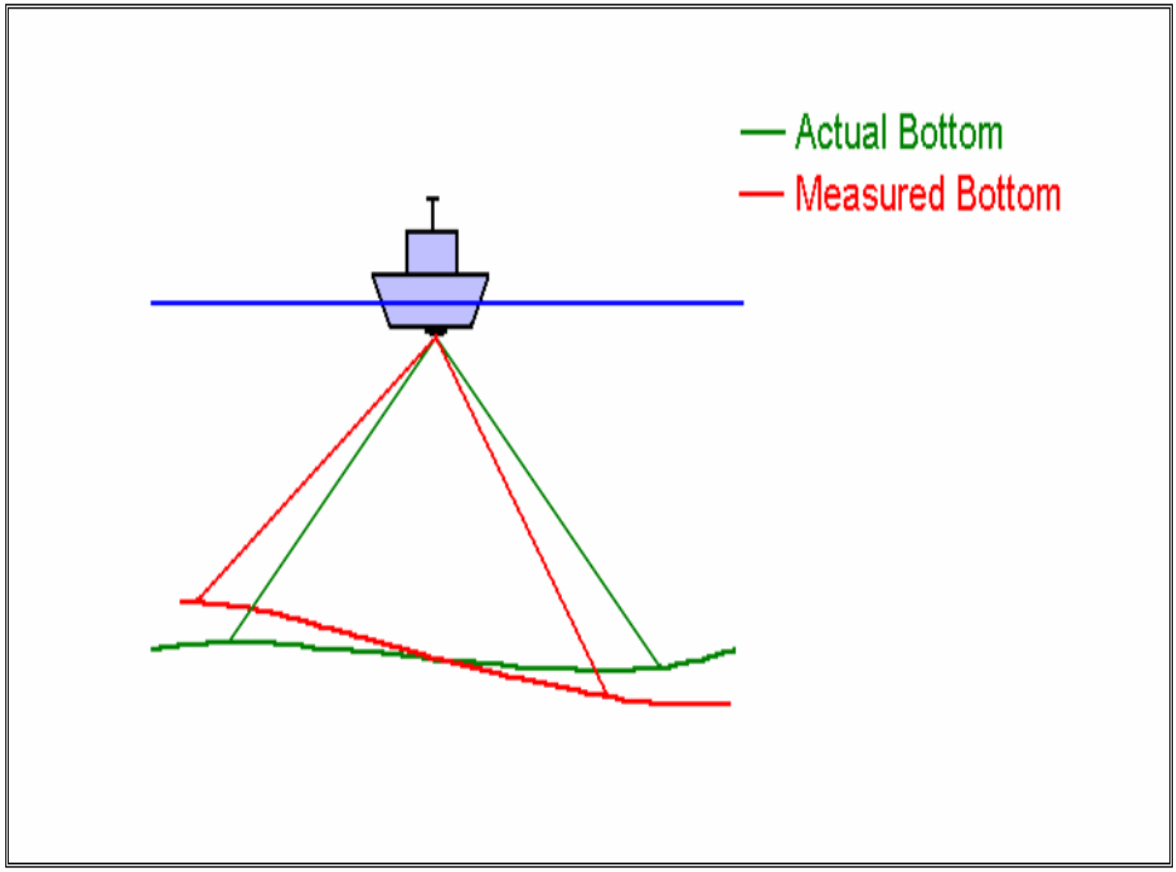
- Boat rotations due to roll and pitch must be compensated.
- Roll and pitch are measured by a Heave Compensator (MRU, VRU).

Beam Geometry (cont.)

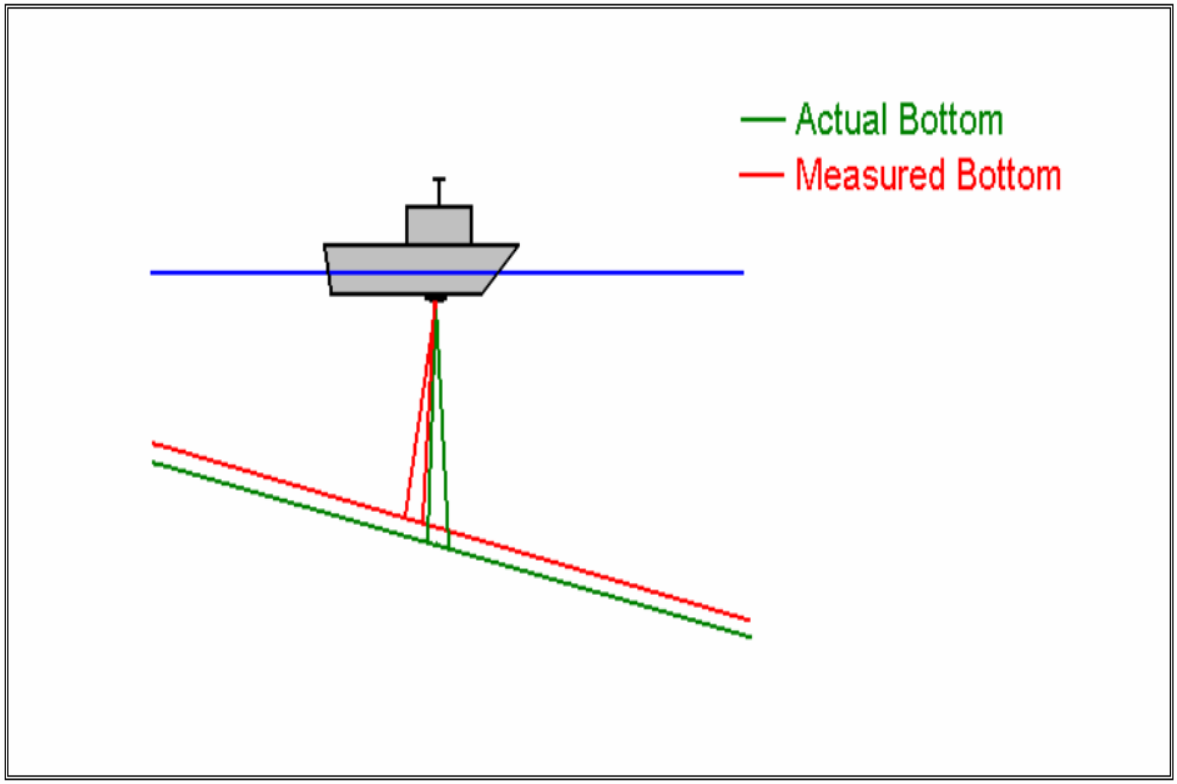


- Boat heading must be considered
- Heading measured by Gyro, Compass or GPS antenna array.

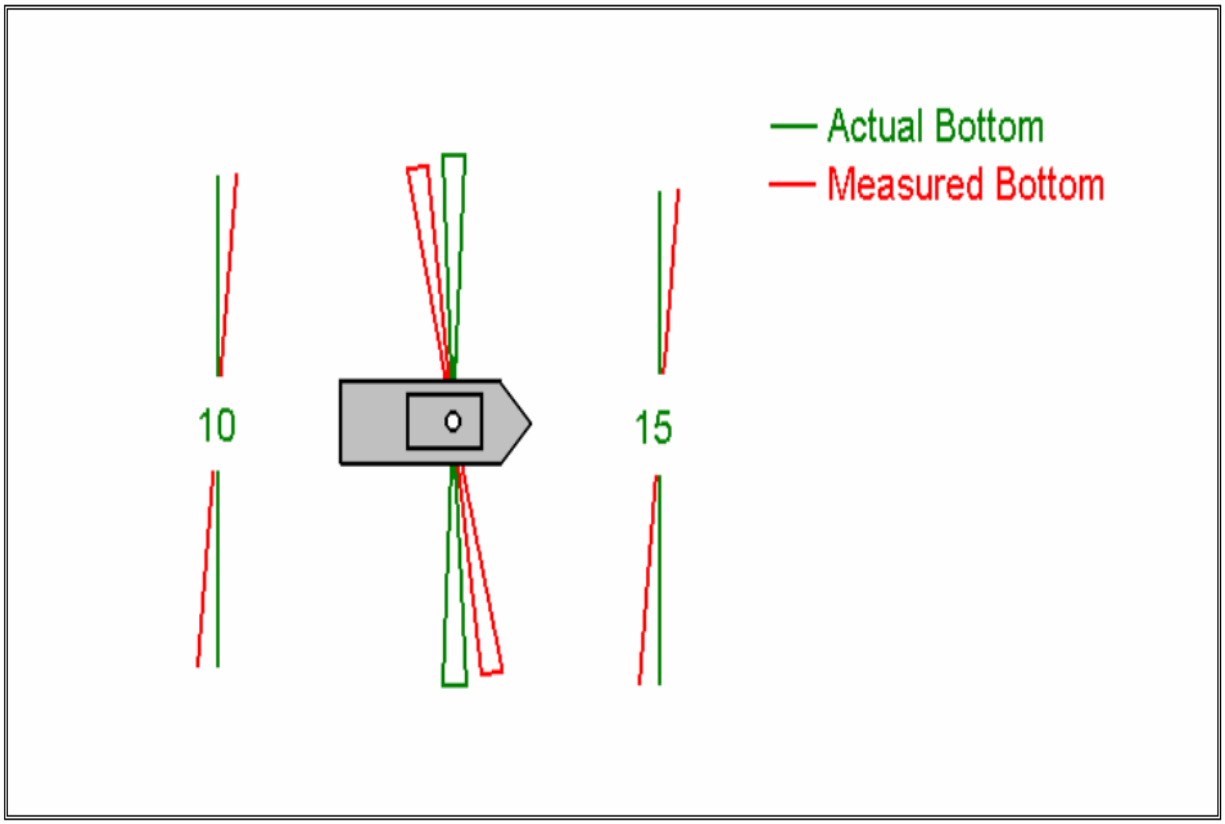
Roll Misalignment



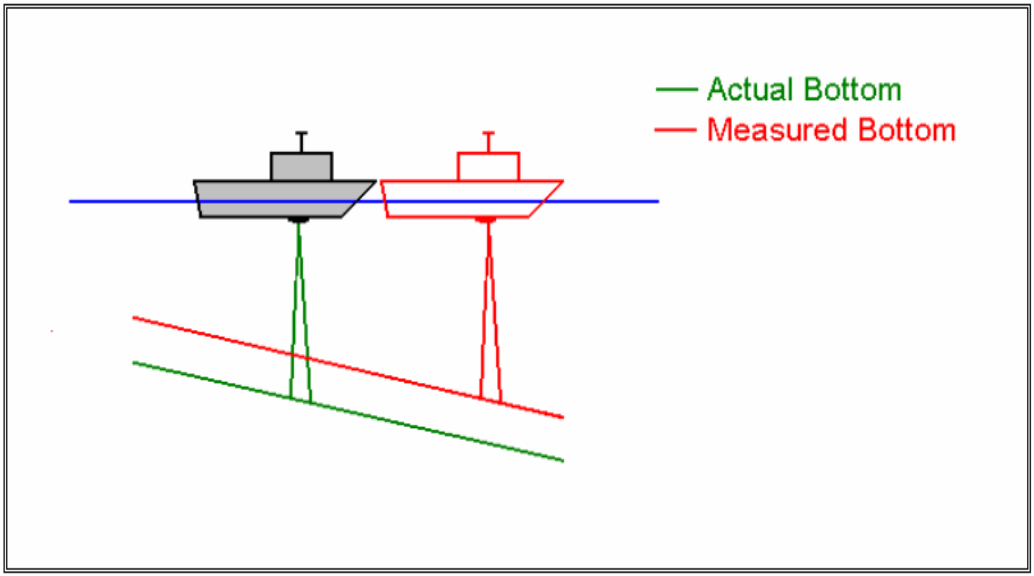
Pitch Misalignment



Yaw Misalignment



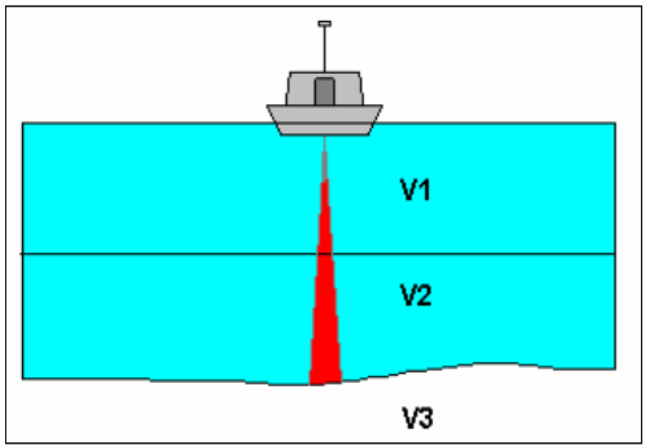
Position Latency



- Latency is the delay time between position fix and MB transmission. When latency isn't correct, the boat isn't where you think it is.

Acoustics - Simple

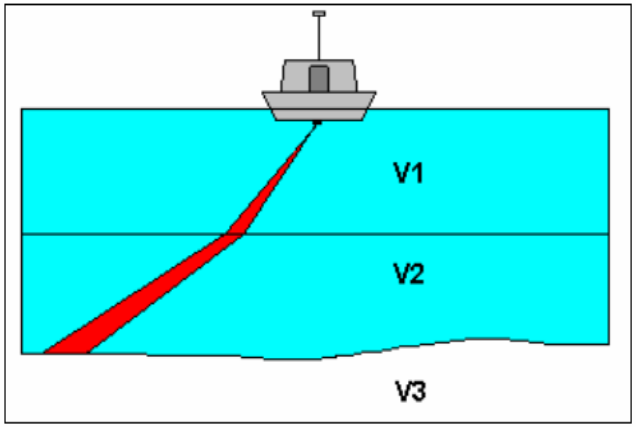
Vertical Beam



- No change in direction at velocity change.
- Average sound velocity is sufficient.

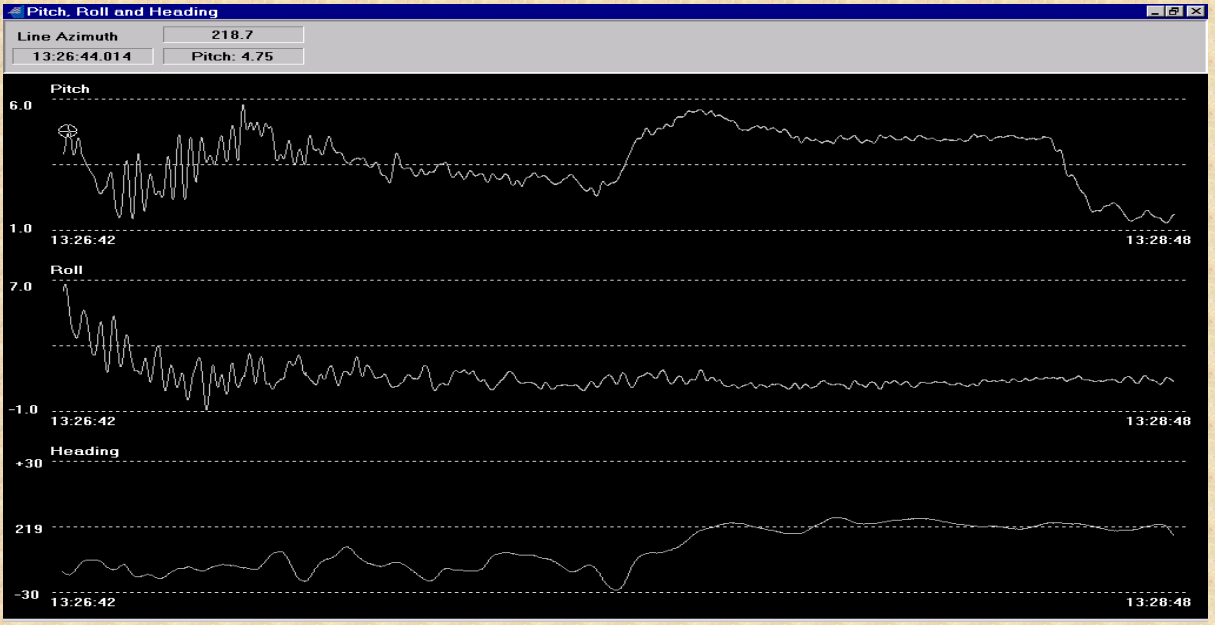
Acoustics – Not so simple

Slanted beam

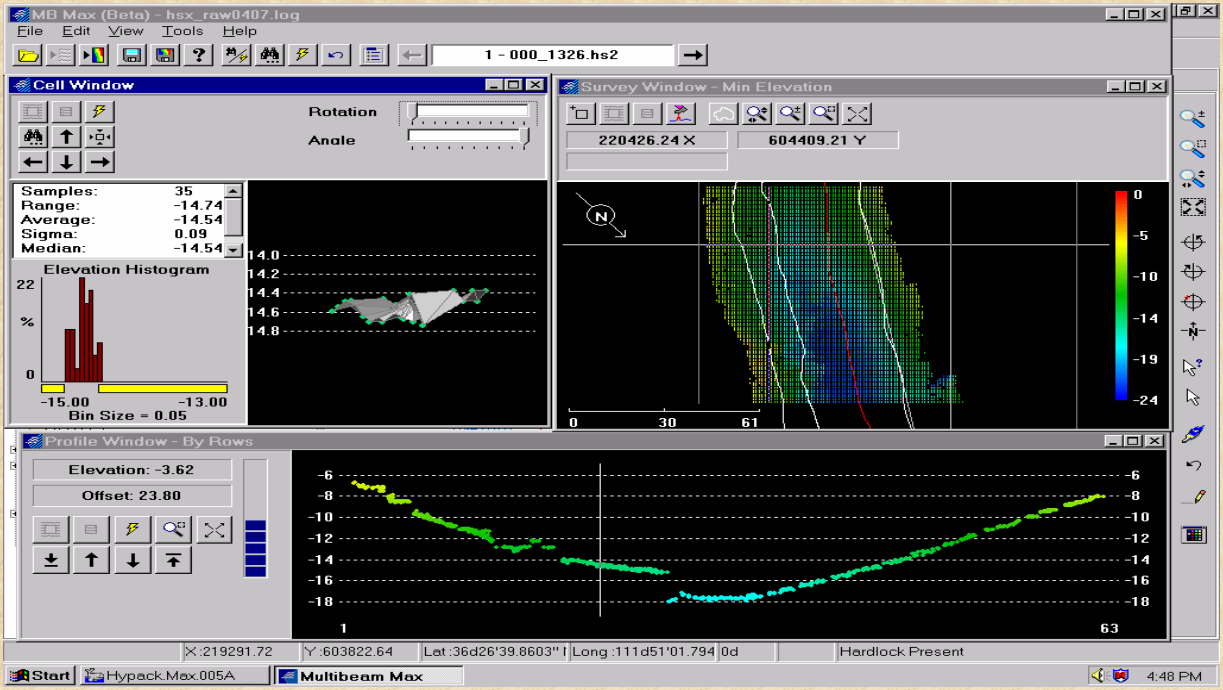


- Refraction (ray bending) at SV change.
- Requires sound velocity profile.
- Look for “Smiley Faces” (refraction errors).

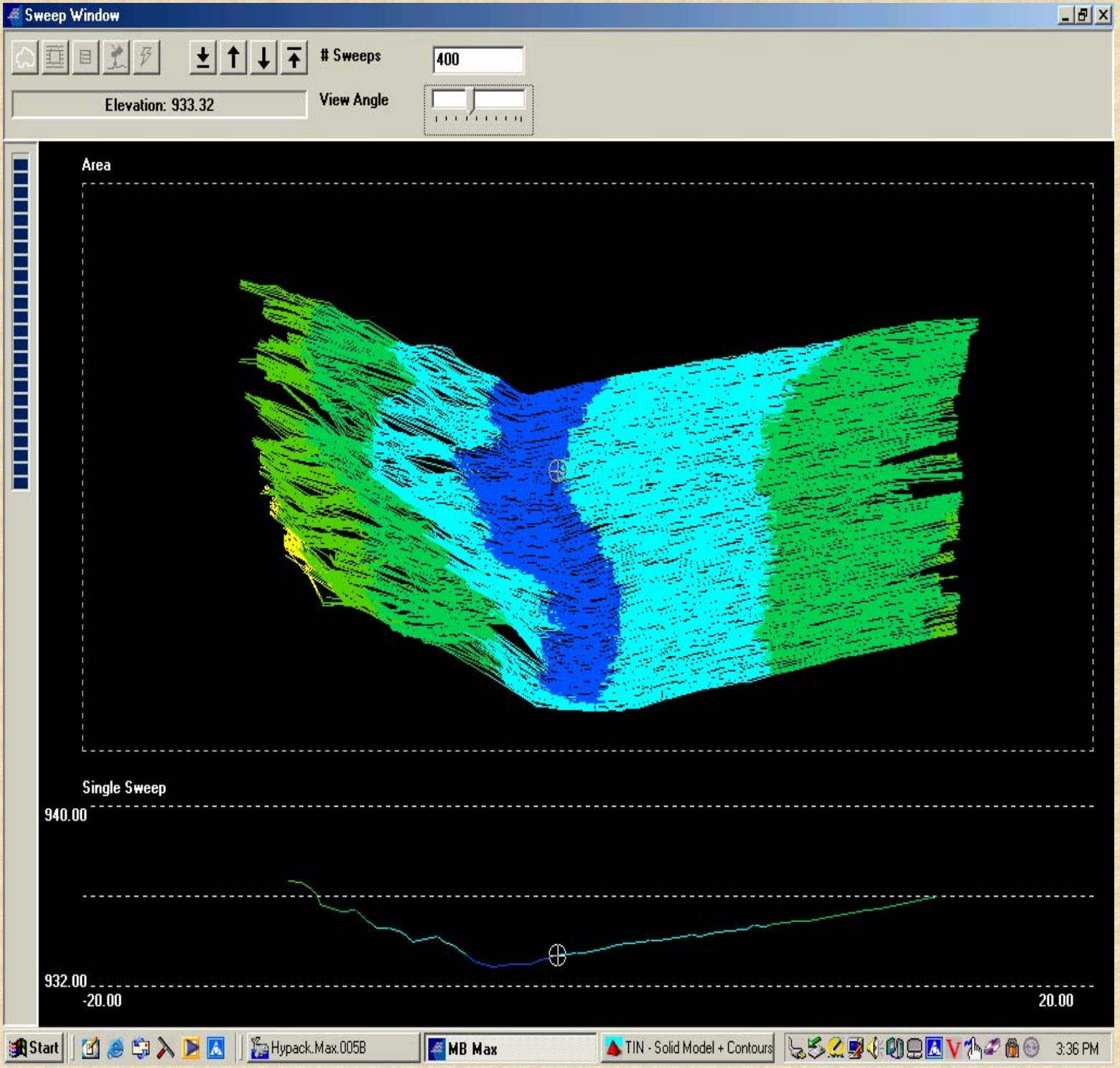
Processing Multibeam Data

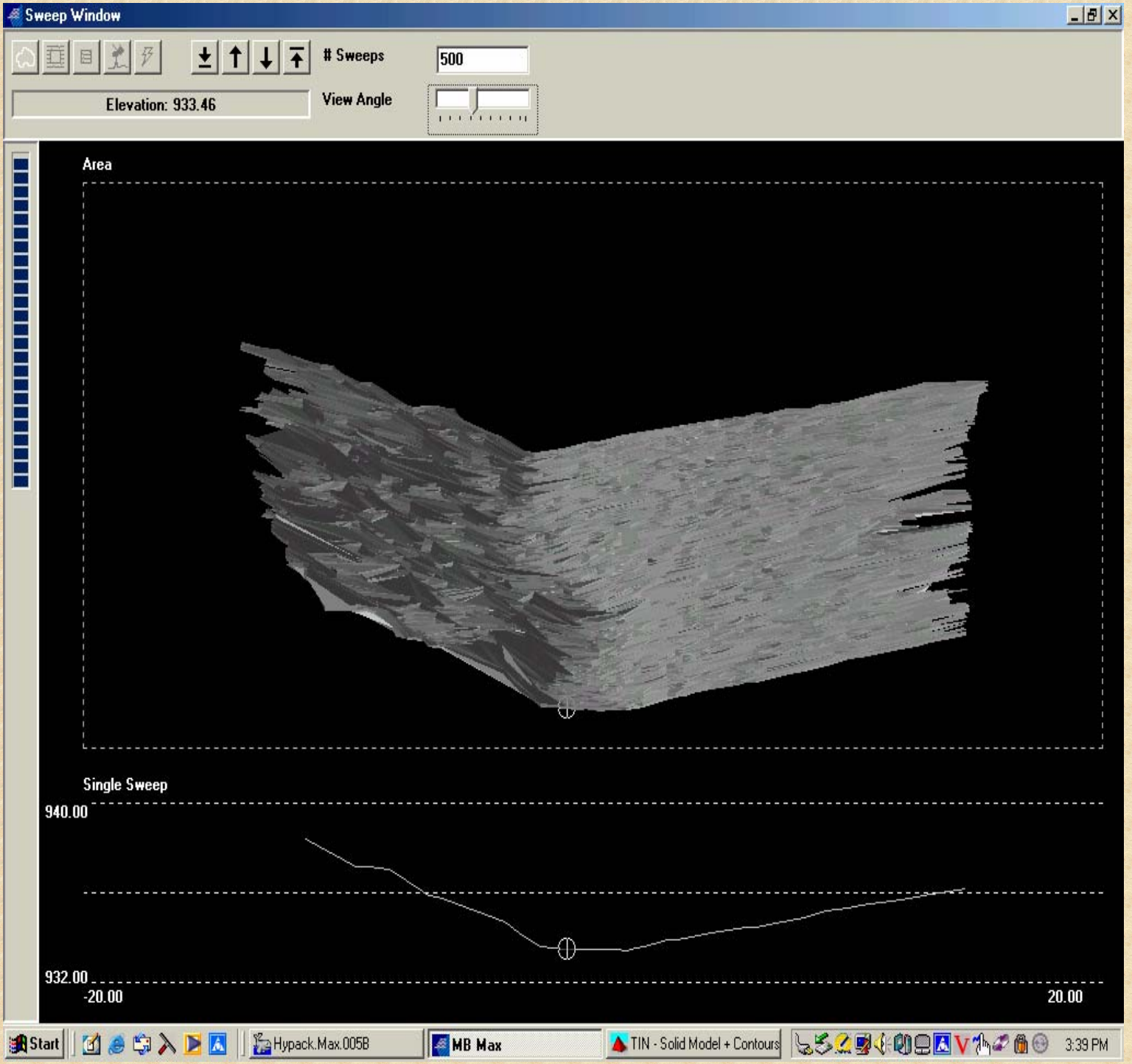


Motion Compensation Corrections

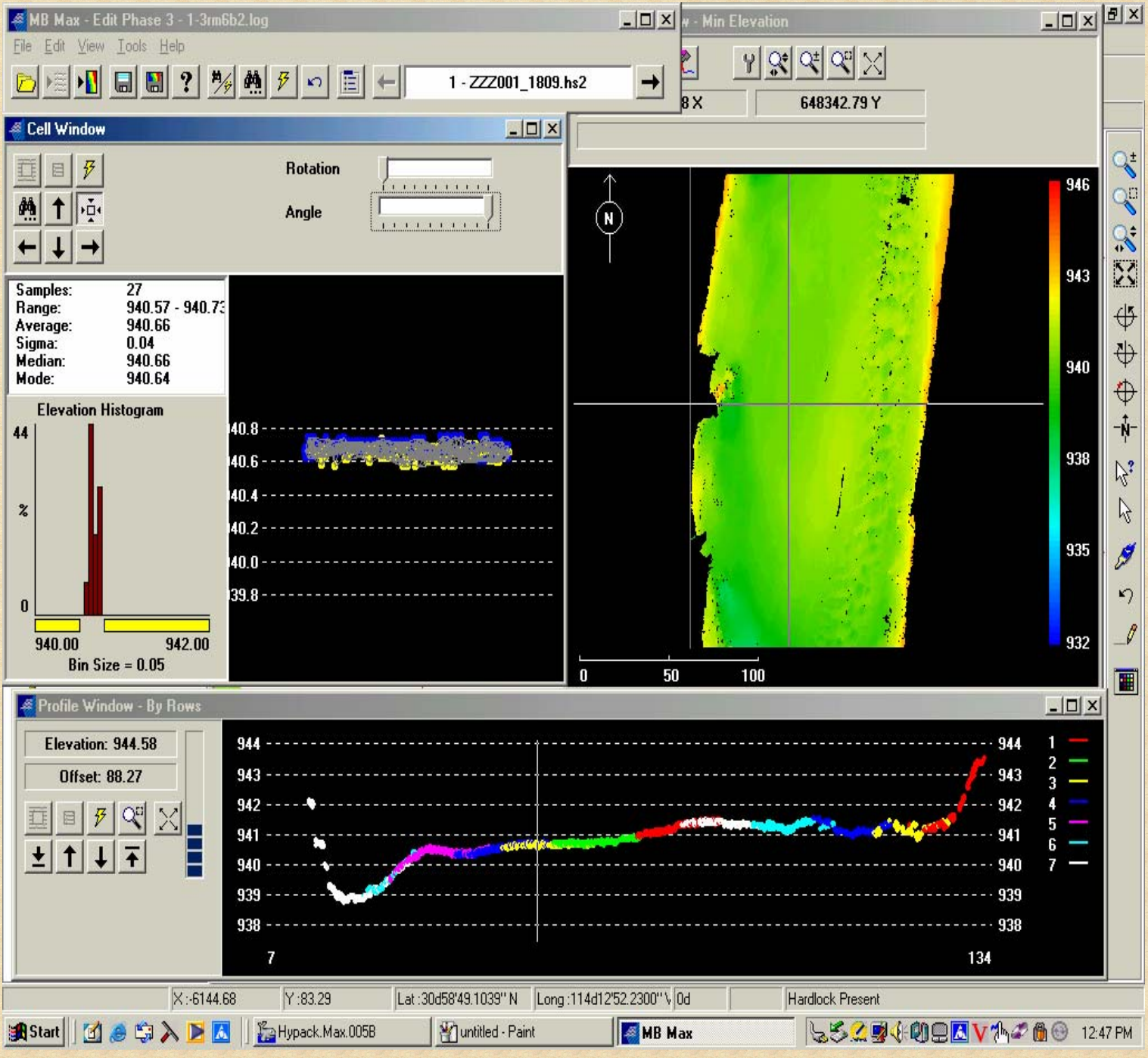


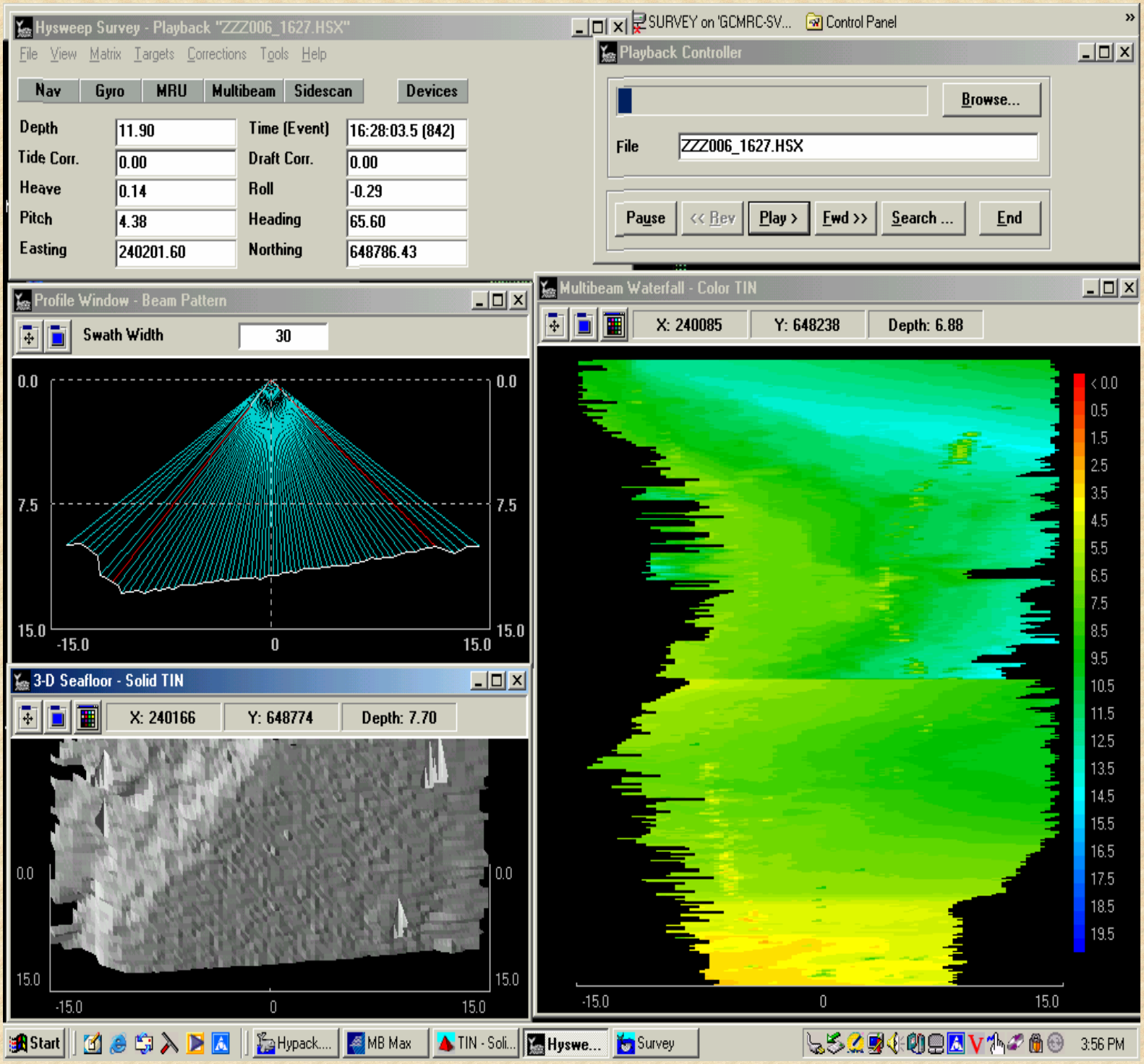
Editing, Processing, and Statistical Analysis of Multibeam Data

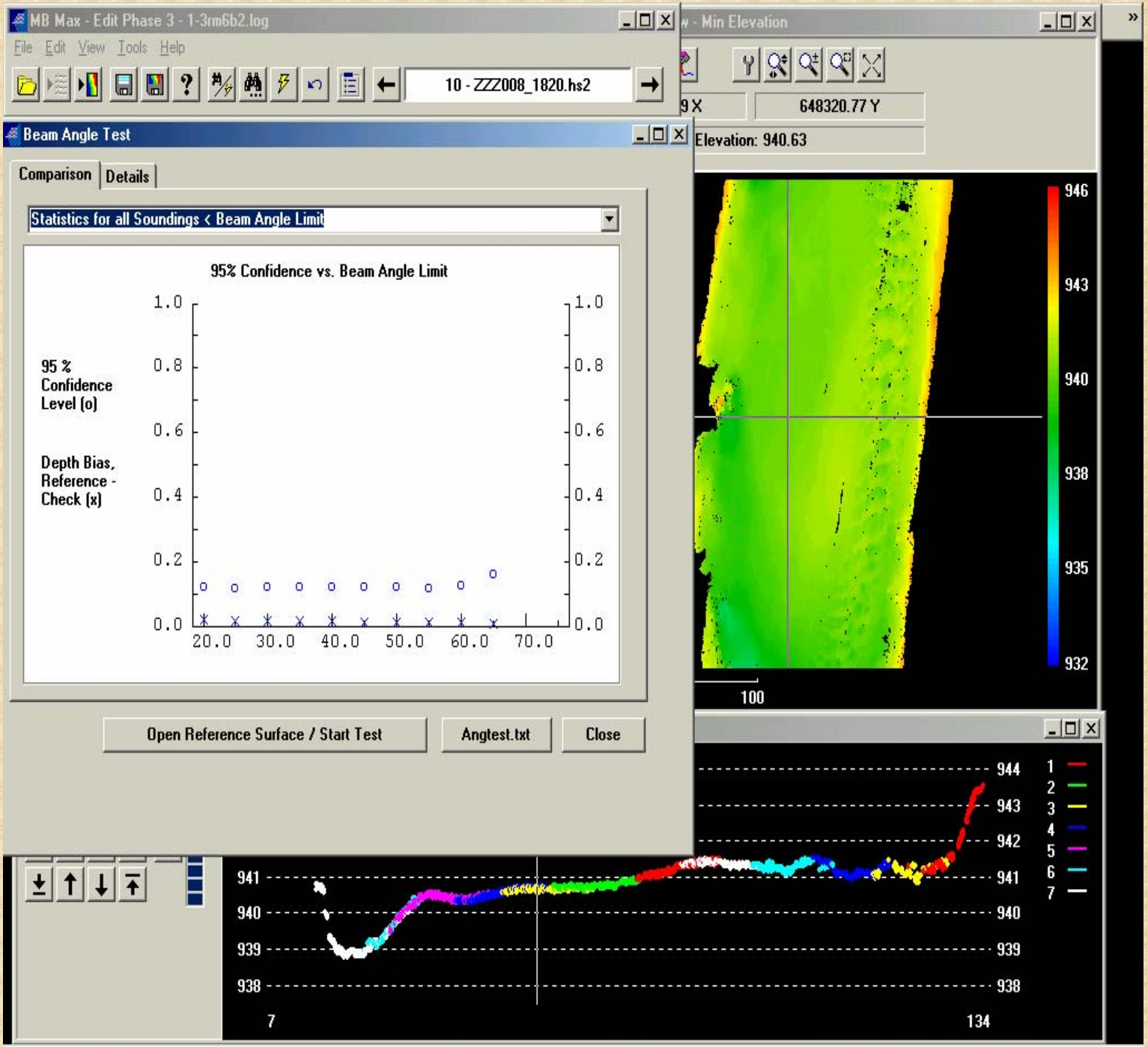

Sweep Window
Sweeps
400
Elevation: 933.32
View Angle
Area
Single Sweep
940.00
932.00
-20.00
20.00
Start
Hypack.Max.005B
MB Max
TIN - Solid Model + Contours
3:36 PM

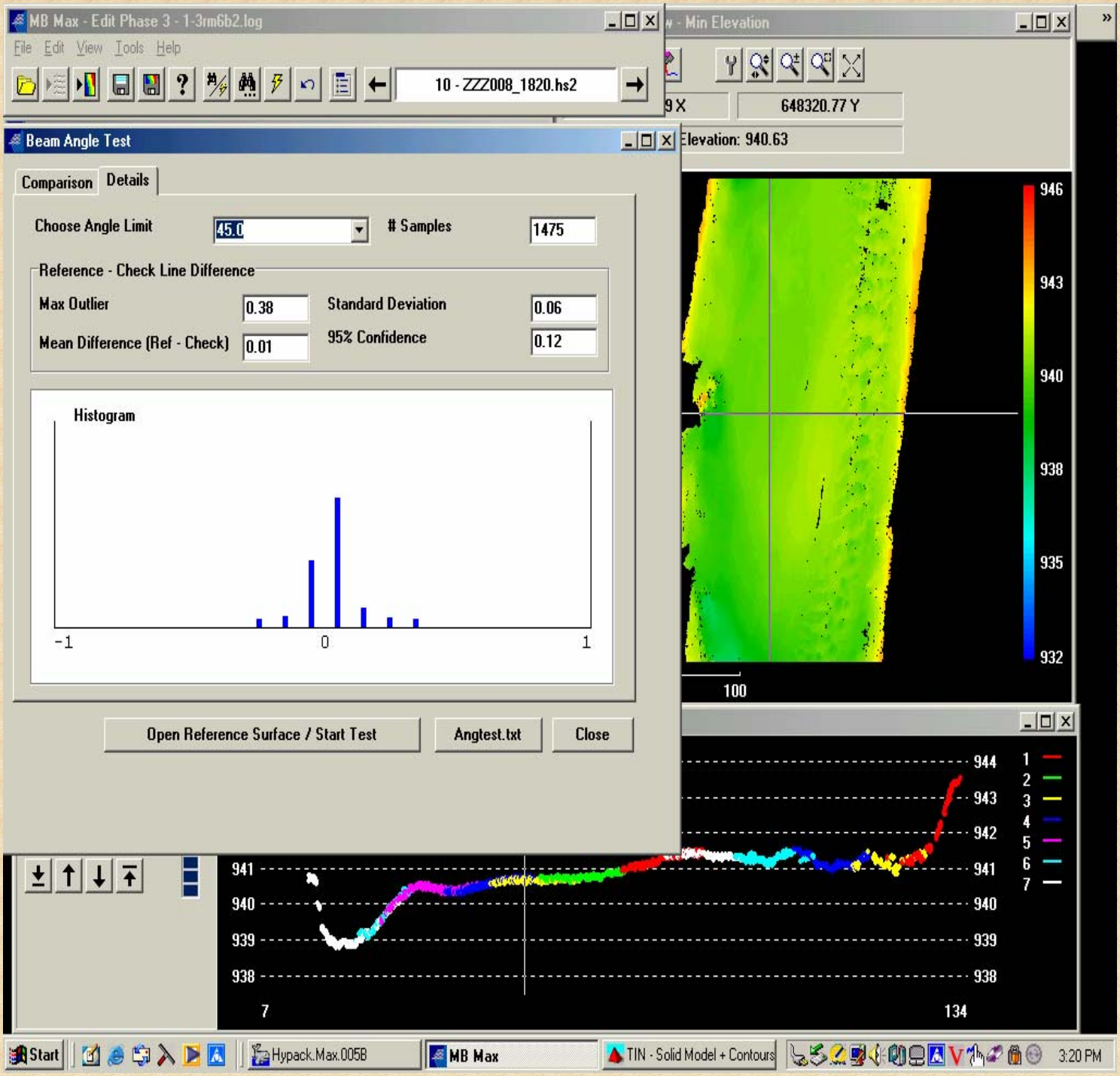

Sweep Window
Sweeps
500
Elevation: 933.46
View Angle
Area
Single Sweep
940.00
932.00
-20.00
20.00
Start
Hypack.Max.005B
MB Max
TIN - Solid Model + Contours
3:39 PM

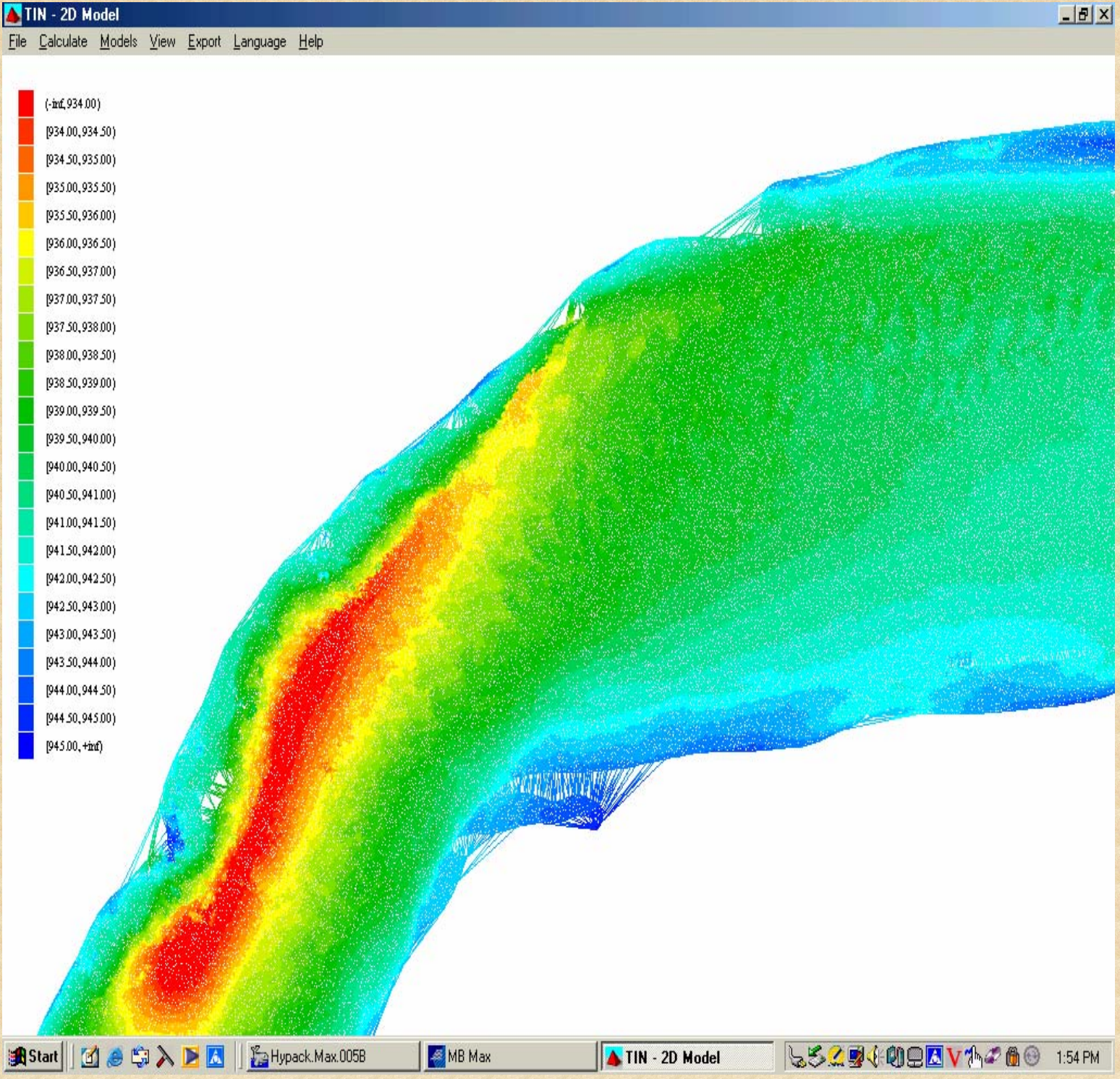

MB Max - Edit Phase 3 - 1-3rm6b2.log
File Edit View Tools Help
10 - ZZZ008_1820.hs2
and Draft Corrections
Static Draft
0.00
Cell Window
Pitch, Roll and Heading
Line Azimuth
226.4
18:21:06.926
Roll: 0.35
18:21:06.982
Tide: 945.76
Pitch
6.0
1.0
18:20:18
18:22:42
Roll
3.0
-7.0
18:20:18
18:22:42
Heading
+120
226
-120
18:20:18
18:22:42
Tide Correction
946.0
945.0
18:20:18
18:22:42
Draft Correction
1.0
Bin Size = 0.05
0
Profile Window - By Rows
Elevation: 937.03
Offset: 16.00
944
943
942
941
940
939
938
7
134
1
2
3
4
5
6
7
Start
Hypack.Max.005B
MB Max
TIN - Solid Model + Contours
2:56 PM


MB Max - Edit Phase 3 - 1-3rm6b2.log
File Edit View Tools Help
1 - ZZZ001_1809.hs2
Min Elevation
8 X
648342.79 Y
Cell Window
Rotation
Angle
Samples: 27
Range: 940.57 - 940.73
Average: 940.66
Sigma: 0.04
Median: 940.66
Mode: 940.64
Elevation Histogram
44
%
0
940.00
942.00
Bin Size = 0.05
940.8
940.6
940.4
940.2
940.0
939.8
N
946
943
940
938
935
932
0
50
100
Profile Window - By Rows
Elevation: 944.58
Offset: 88.27
944
943
942
941
940
939
938
7
134
1
2
3
4
5
6
7
X:-6144.68
Y:83.29
Lat:30d58'49.1039" N
Long:114d12'52.2300" W
0d
Hardlock Present
Start
Hypack.Max.005B
untitled - Paint
MB Max
12:47 PM


Hysweep Survey - Playback "ZZZ006_1627.HSX"
File View Matrix Targets Corrections Tools Help
Nav Gyro MRU Multibeam Sidescan Devices
Depth 11.90
Time (Event) 16:28:03.5 (842)
Tide Corr. 0.00
Draft Corr. 0.00
Heave 0.14
Roll -0.29
Pitch 4.38
Heading 65.60
Easting 240201.60
Northing 648786.43
SURVEY on 'GCMRC-SV...
Control Panel
Playback Controller
Browse...
File ZZZ006_1627.HSX
Pause << Rev Play > Fwd >> Search ... End
Profile Window - Beam Pattern
Swath Width 30
0.0
7.5
15.0
-15.0
0
15.0
3-D Seafloor - Solid TIN
X: 240166
Y: 648774
Depth: 7.70
Multibeam Waterfall - Color TIN
X: 240085
Y: 648238
Depth: 6.88
< 0.0
0.5
1.5
2.5
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
13.5
14.5
15.5
16.5
17.5
18.5
19.5
Start
Hypack....
MB Max
TIN - Soli...
Hyswe...
Survey
3:56 PM


MB Max - Edit Phase 3 - 1-3rm6b2.log
File Edit View Tools Help
10 - ZZZ008_1820.hs2
Min Elevation
9 X
648320.77 Y
Elevation: 940.63
Beam Angle Test
Comparison
Details
Statistics for all Soundings < Beam Angle Limit
95% Confidence vs. Beam Angle Limit
95 % Confidence Level (o)
Depth Bias, Reference - Check (x)
1.0
0.8
0.6
0.4
0.2
0.0
20.0
30.0
40.0
50.0
60.0
70.0
946
943
940
938
935
932
100
Open Reference Surface / Start Test
Angtest.txt
Close
944
943
942
941
940
939
938
7
134
1
2
3
4
5
6
7
Start
Hypack.Max.005B
MB Max
TIN - Solid Model + Contours
3:22 PM


MB Max - Edit Phase 3 - 1-3rm6b2.log
File Edit View Tools Help
10 - ZZZ008_1820.hs2
Min Elevation
9 X
648320.77 Y
Elevation: 940.63
Beam Angle Test
Comparison
Details
Choose Angle Limit
45.0
Samples
1475
Reference - Check Line Difference
Max Outlier
0.38
Standard Deviation
0.06
Mean Difference (Ref - Check)
0.01
95% Confidence
0.12
Histogram
-1
0
1
946
943
940
938
935
932
100
Open Reference Surface / Start Test
Angtest.txt
Close
944
943
942
941
940
939
938
7
134
1
2
3
4
5
6
7
Start
Hypack.Max.005B
MB Max
TIN - Solid Model + Contours
3:20 PM


TIN - 2D Model
File Calculate Models View Export Language Help
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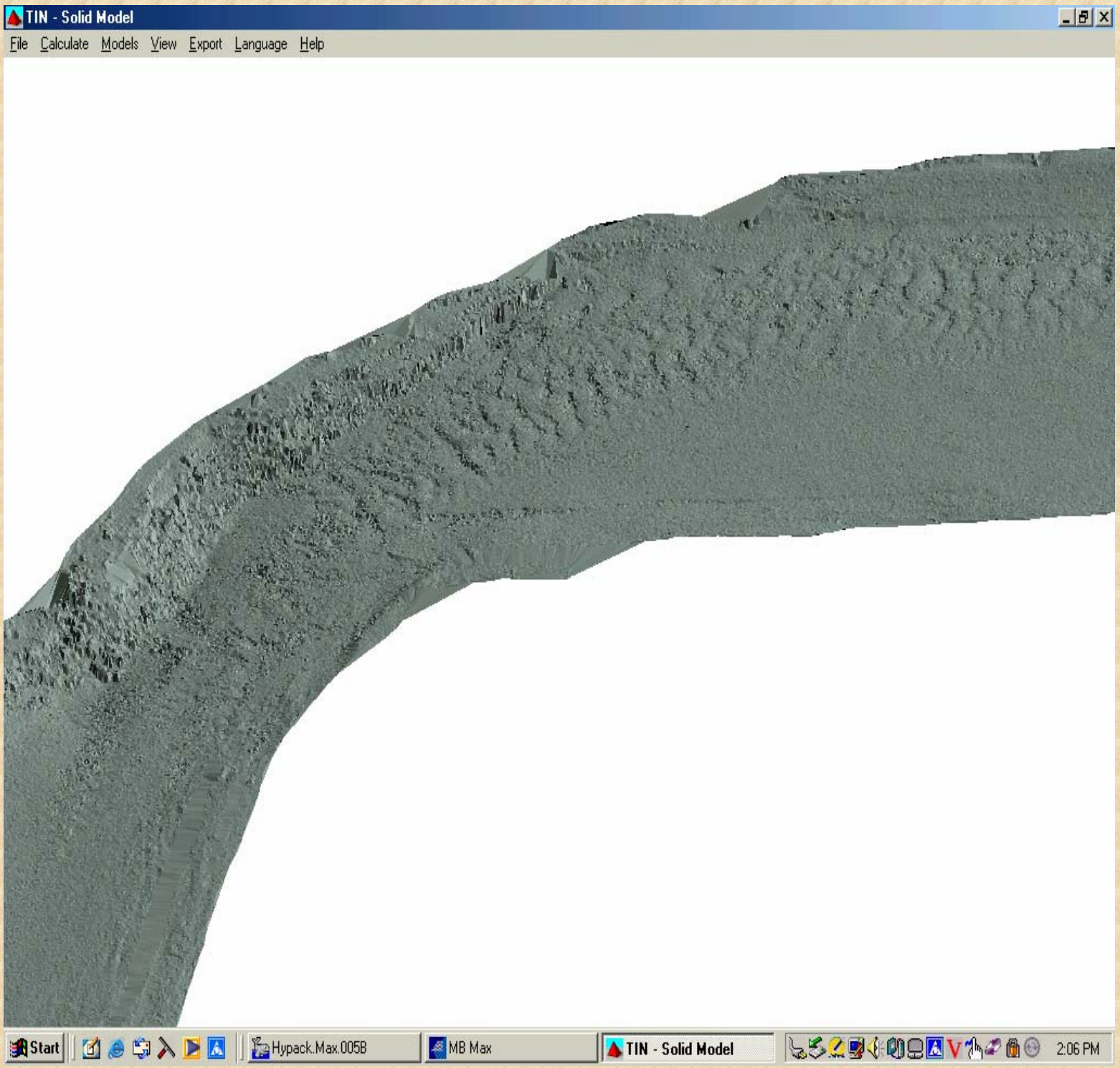
MB Max
TIN - 2D Model
1:54 PM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File Calculate Models View Export Language Help
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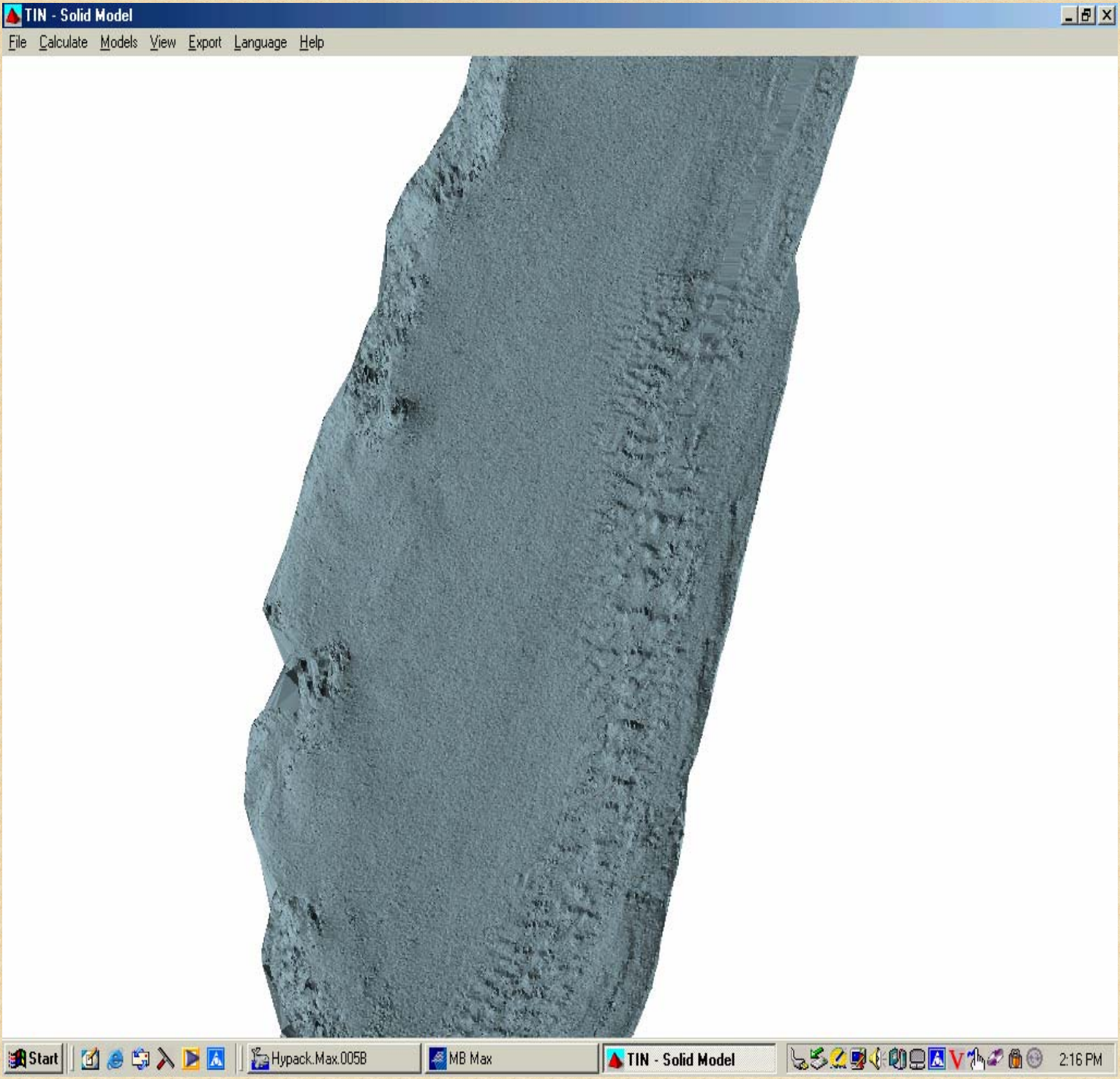
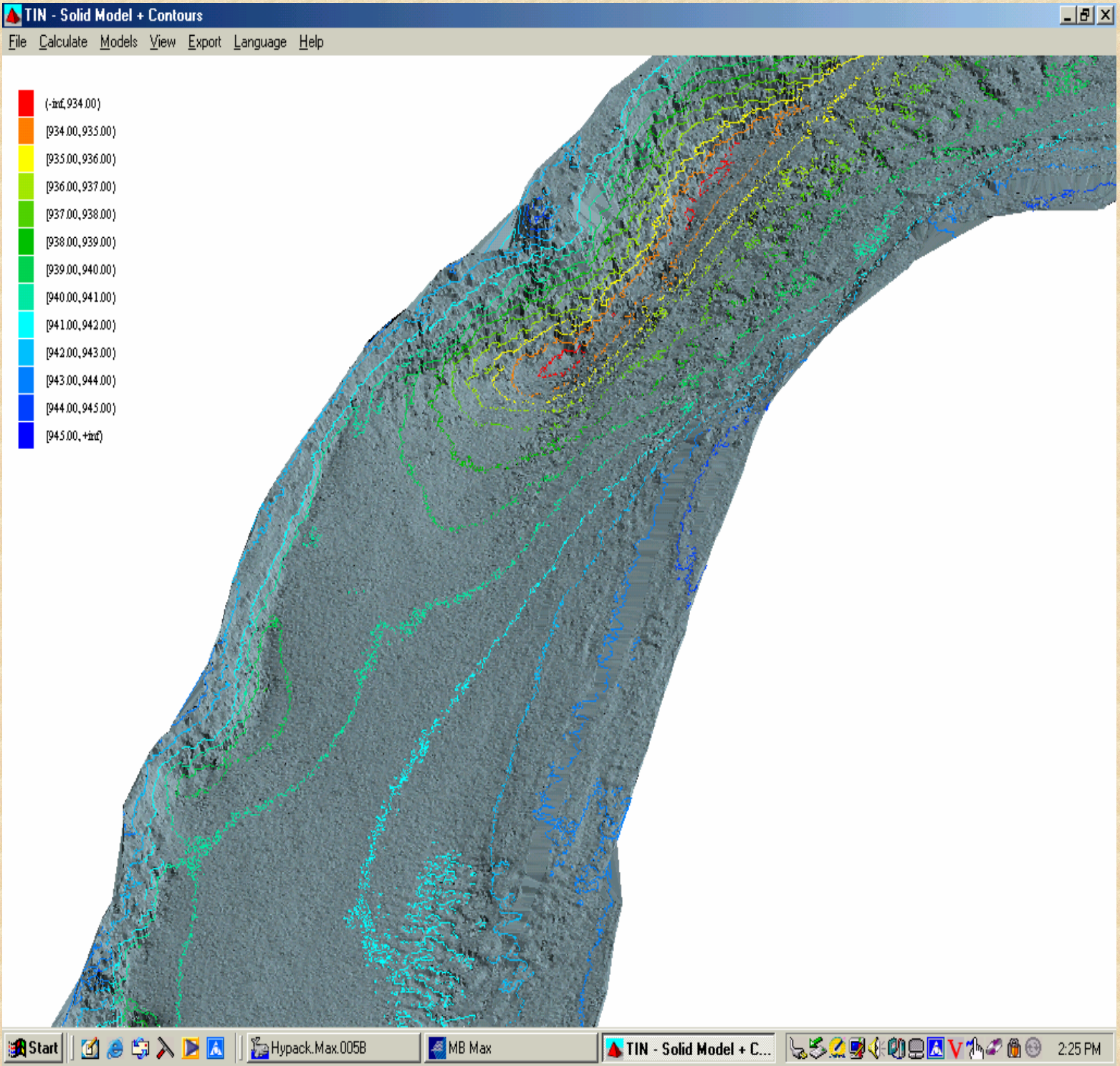
MB Max
TIN - Solid Model
2:06 PM


TIN - Solid Model
File Calculate Models View Export Language Help
Start
Hypack.Max.005B
MB Max
TIN - Solid Model
2:16 PM


TIN - Solid Model + Contours
File Calculate Models View Export Language Help
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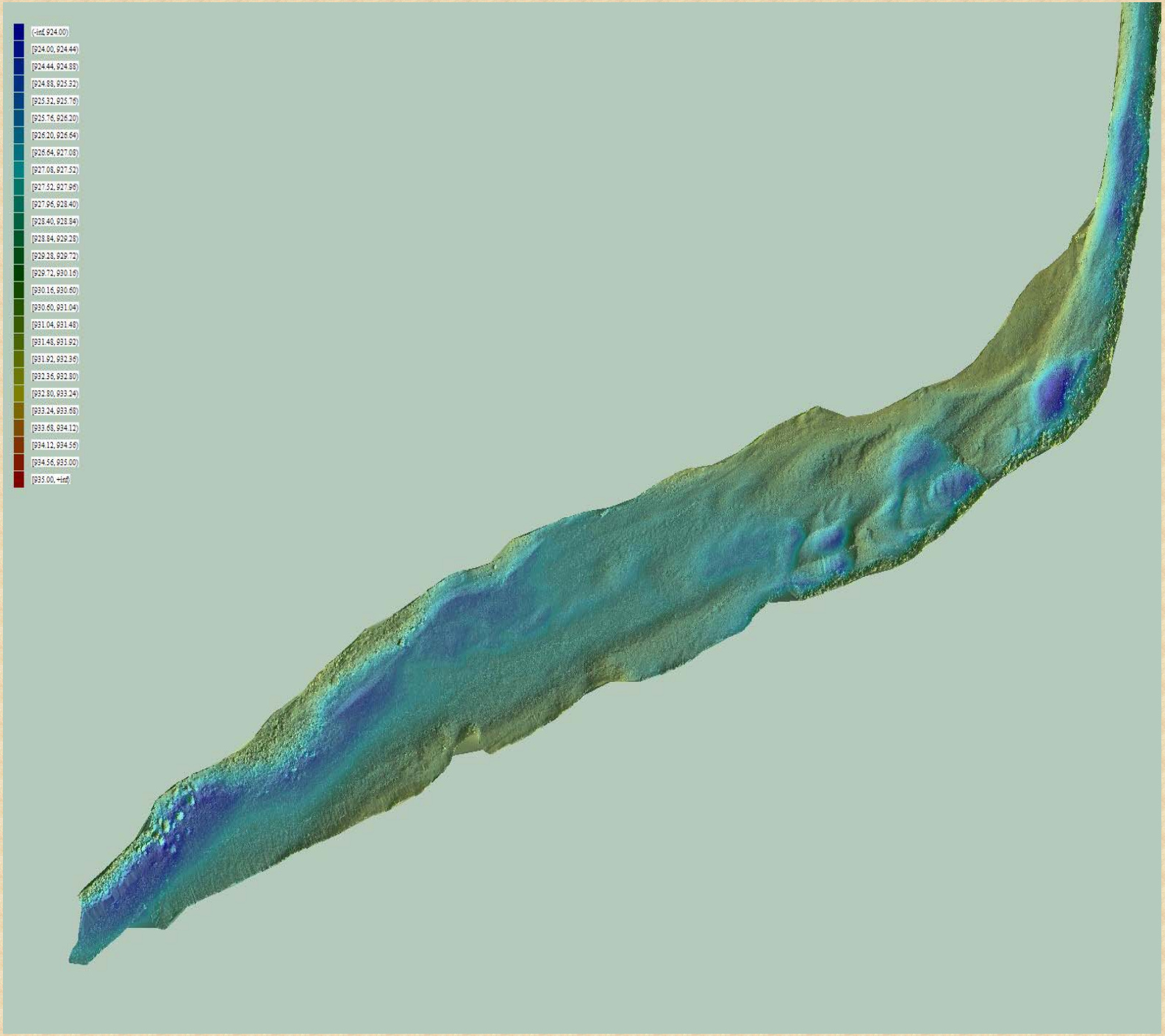
MB Max
TIN - Solid Model + C...
2:25 PM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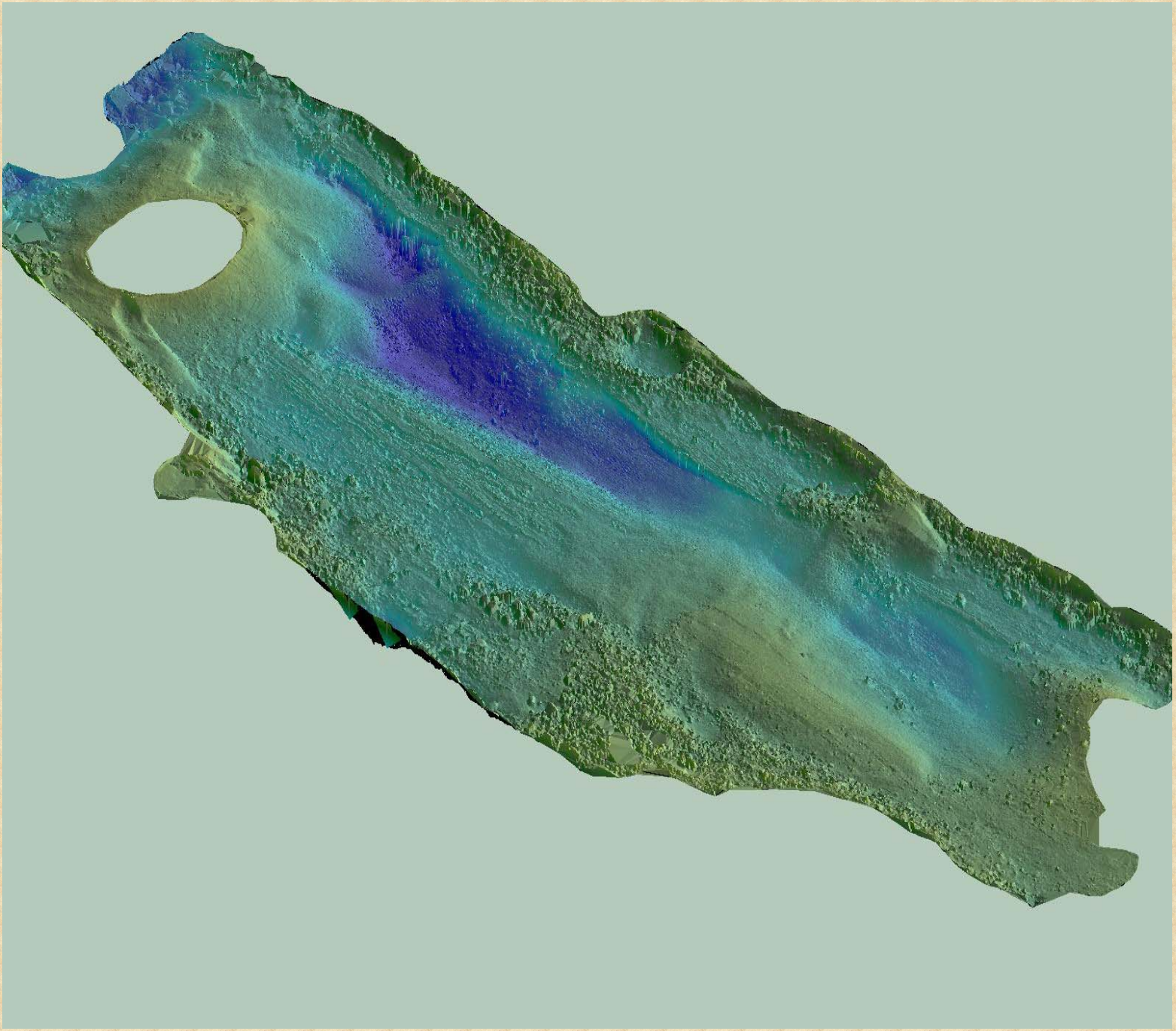
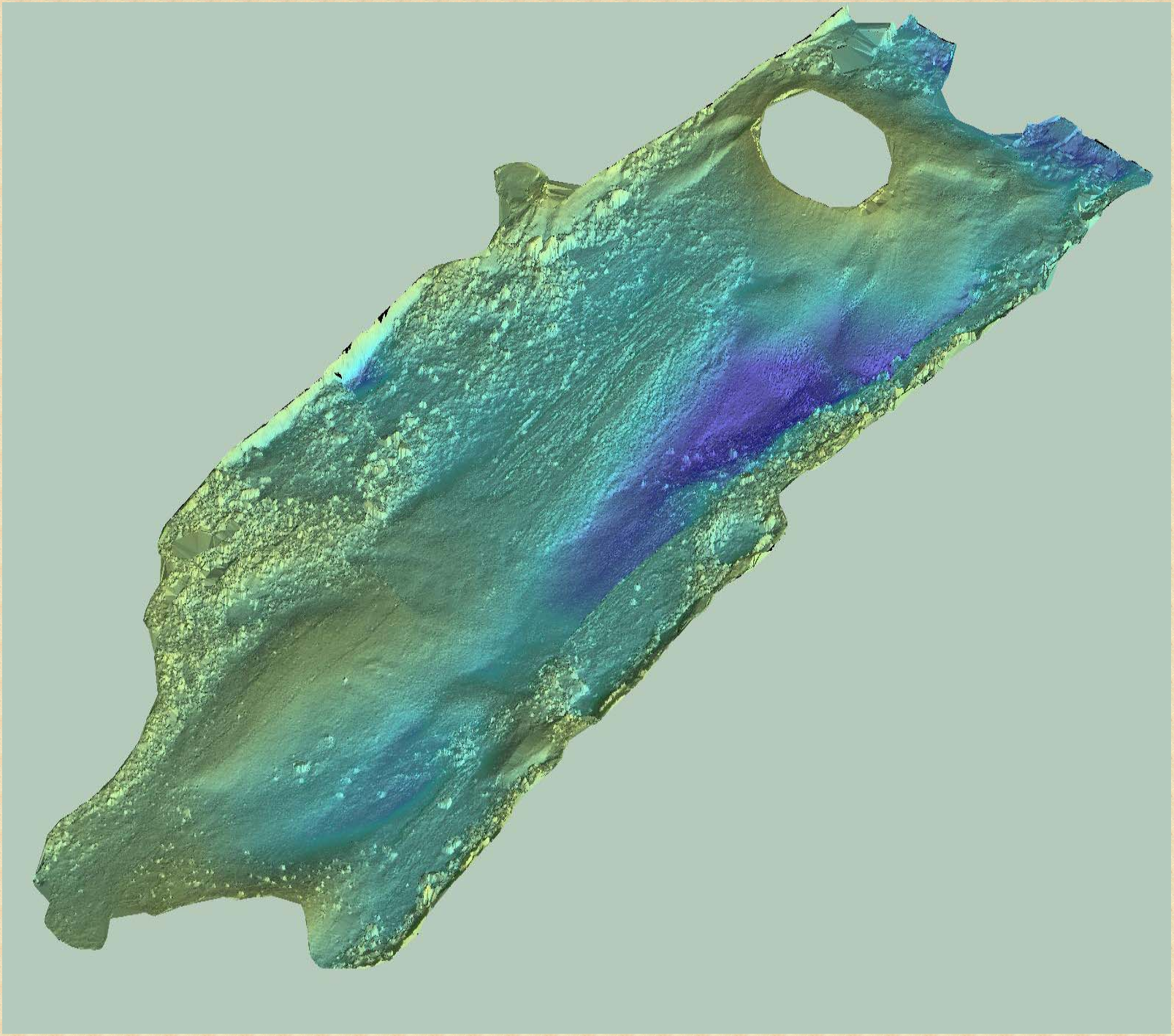
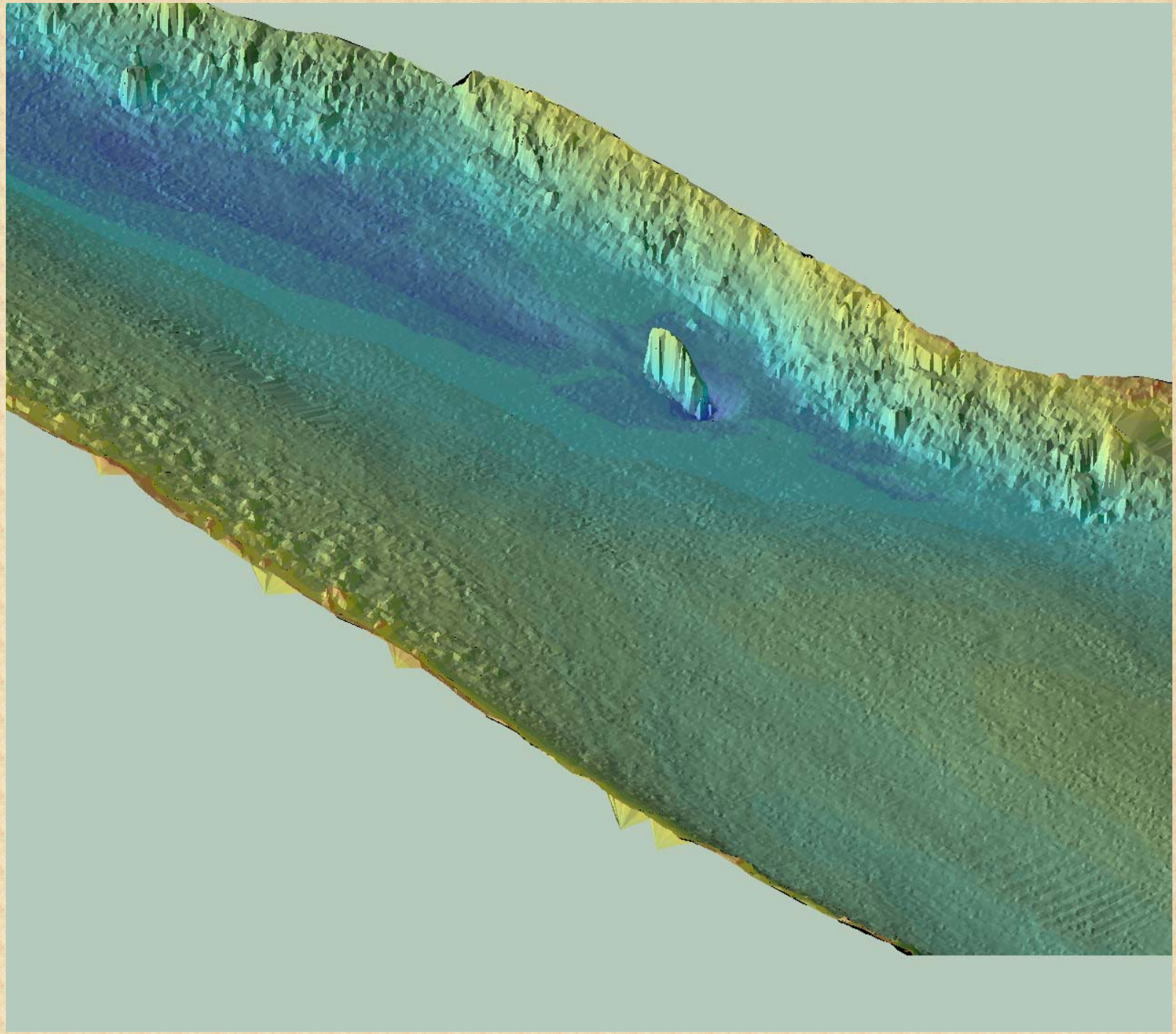
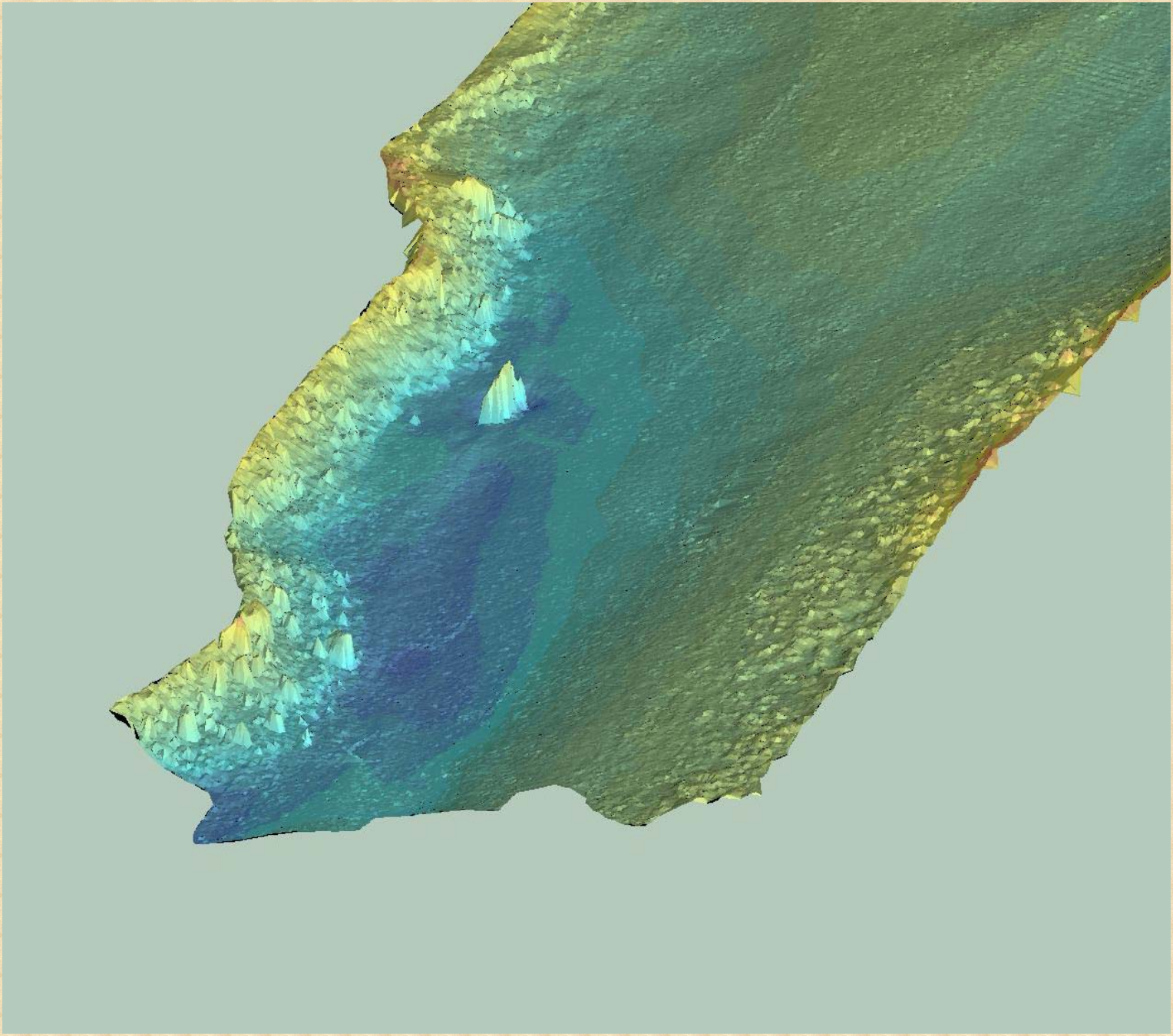
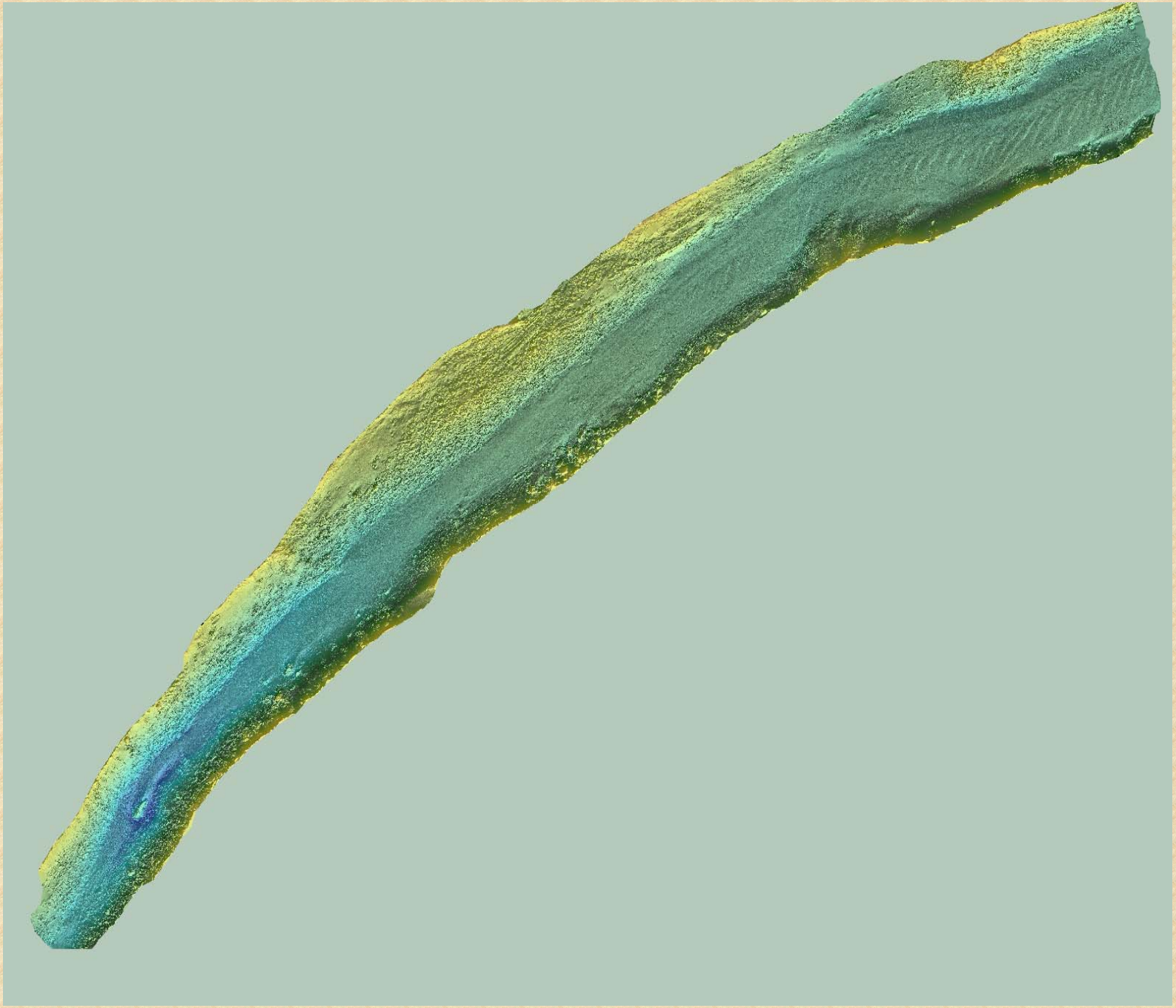
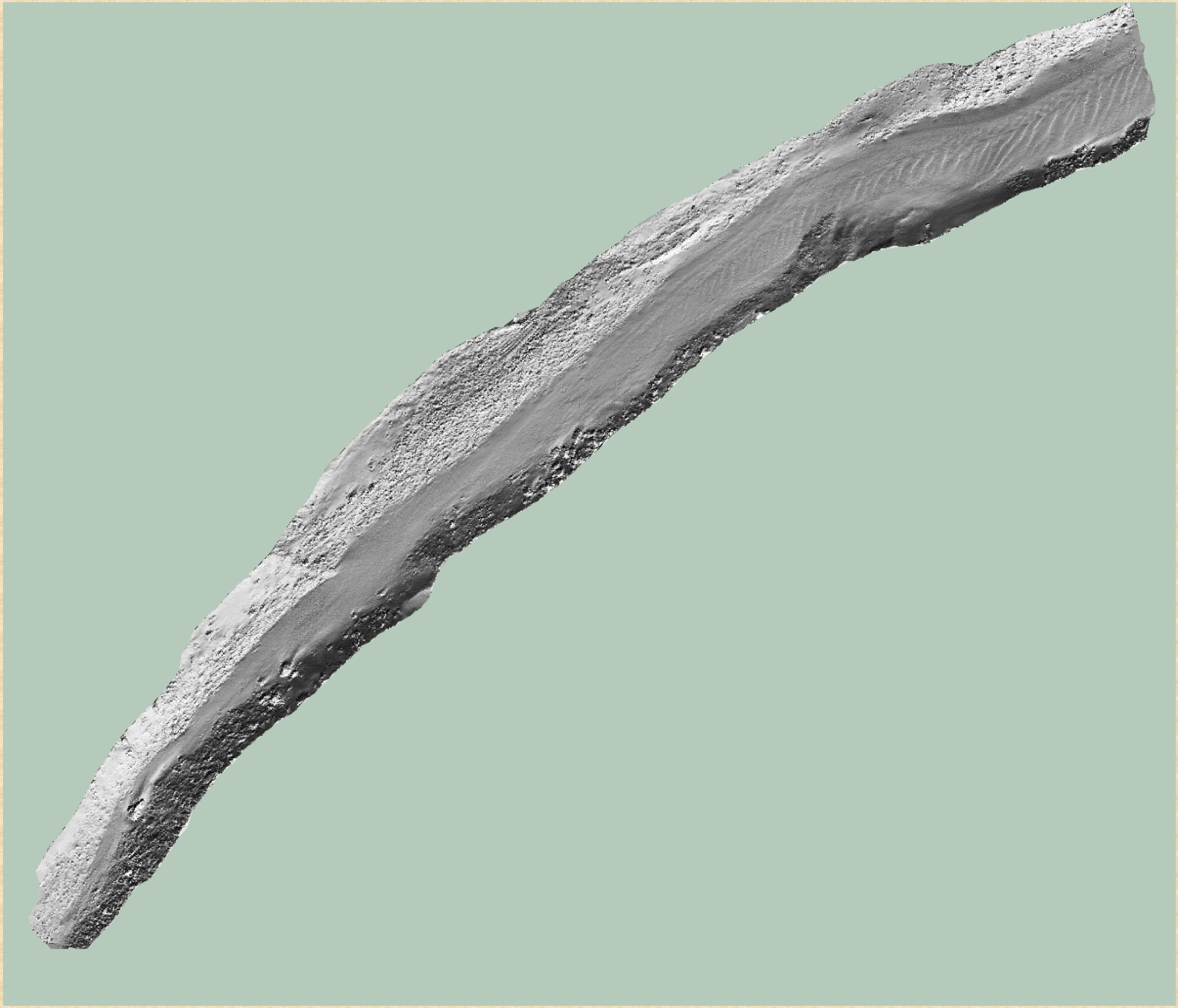


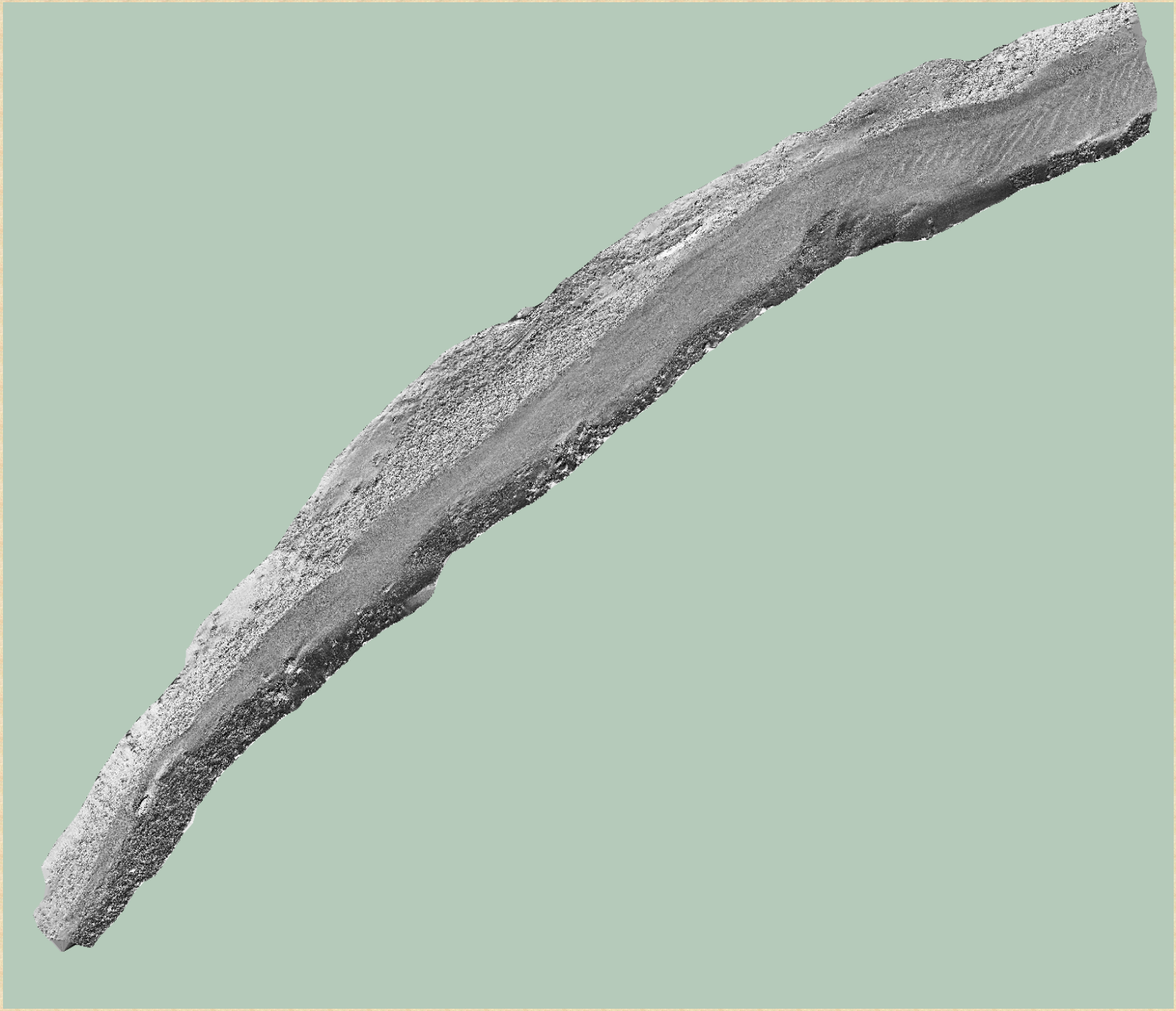


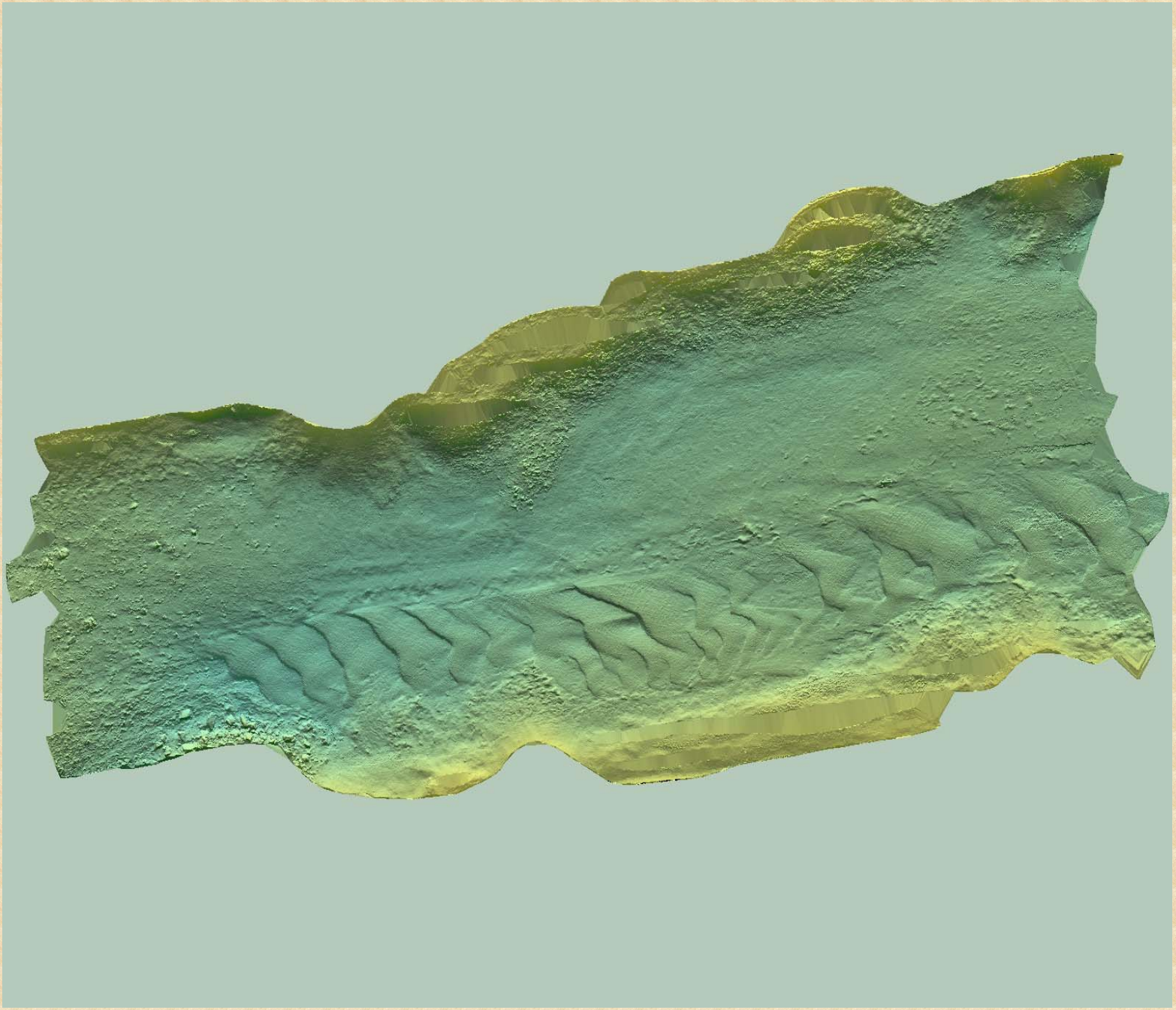


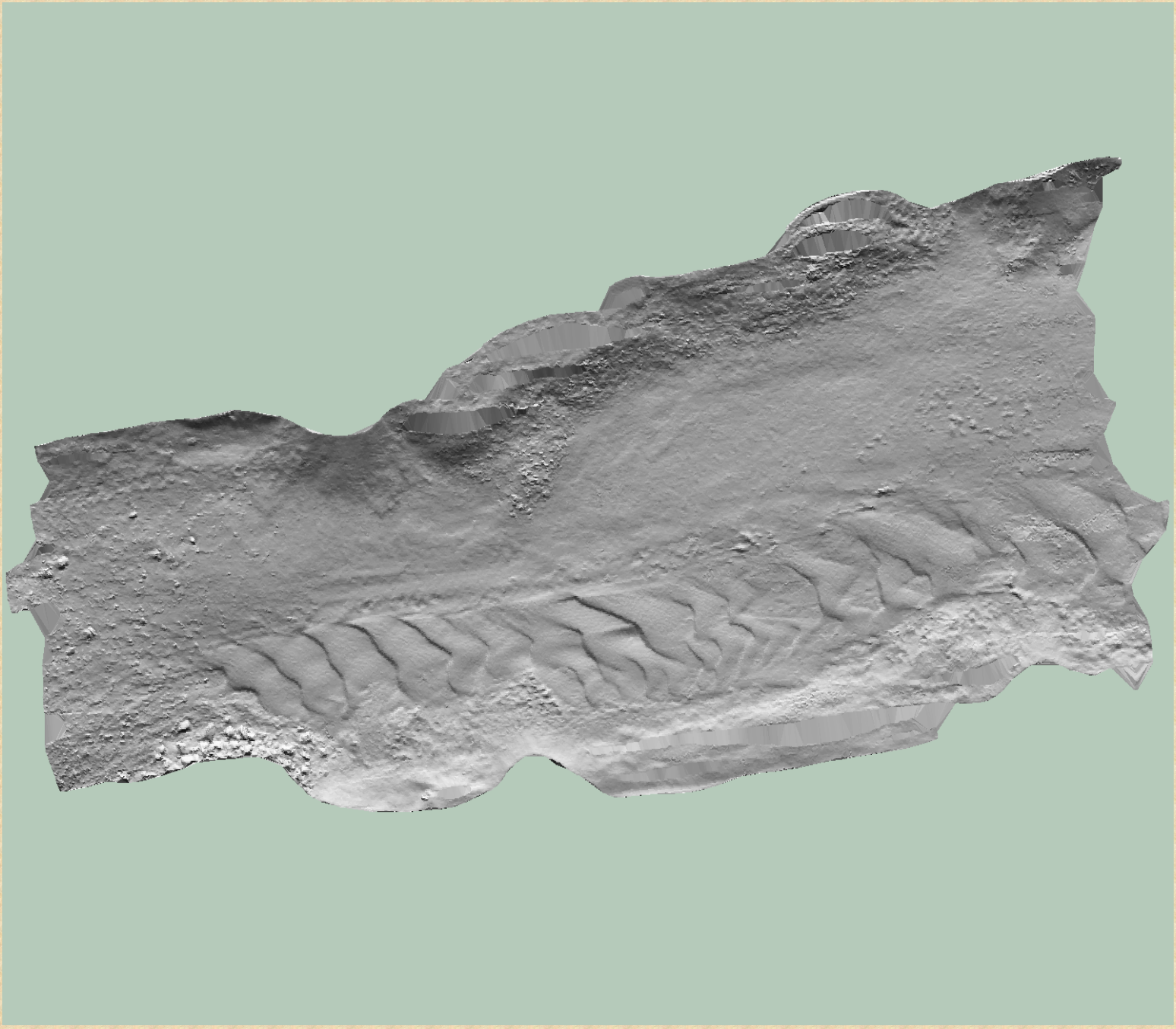


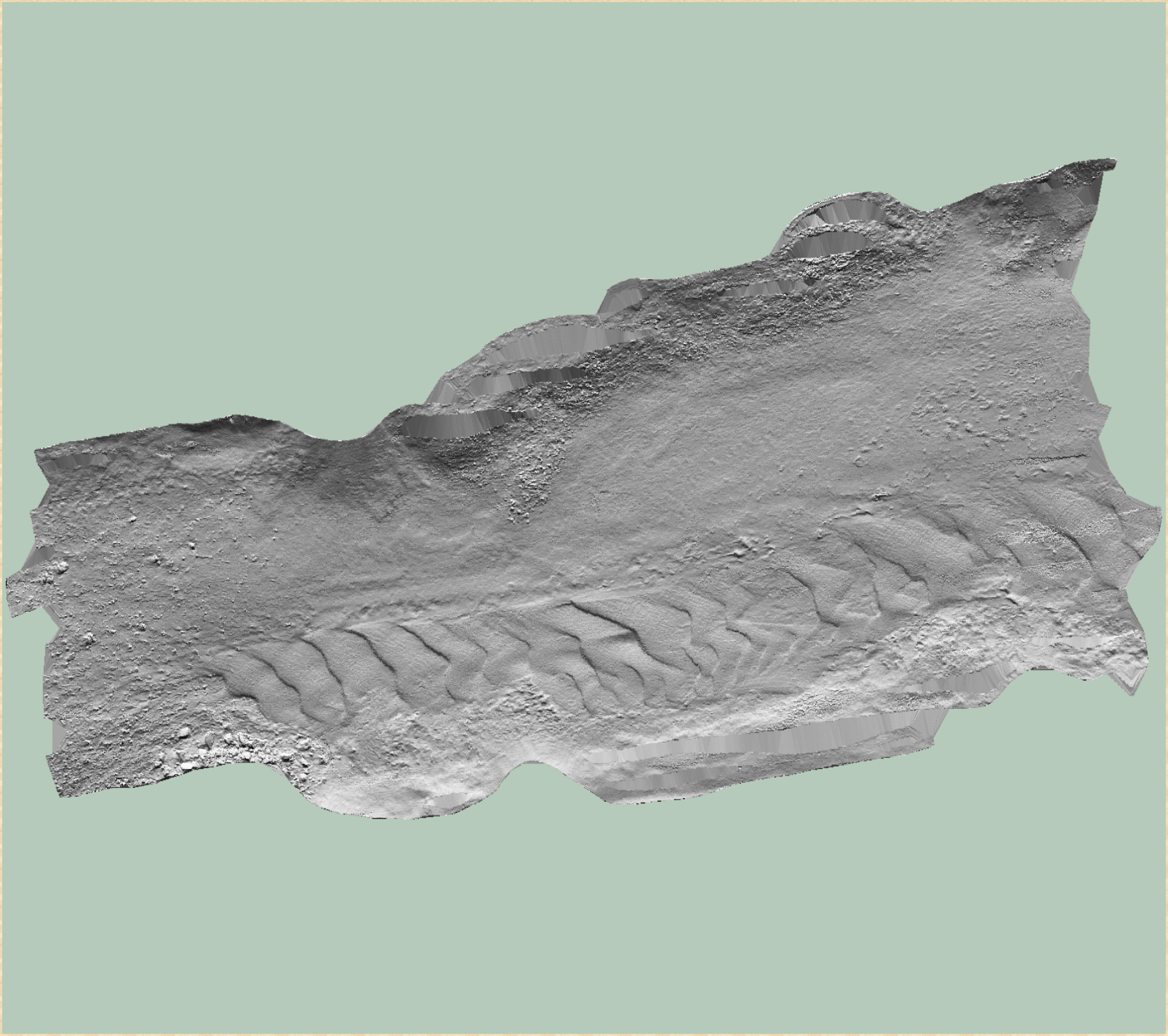


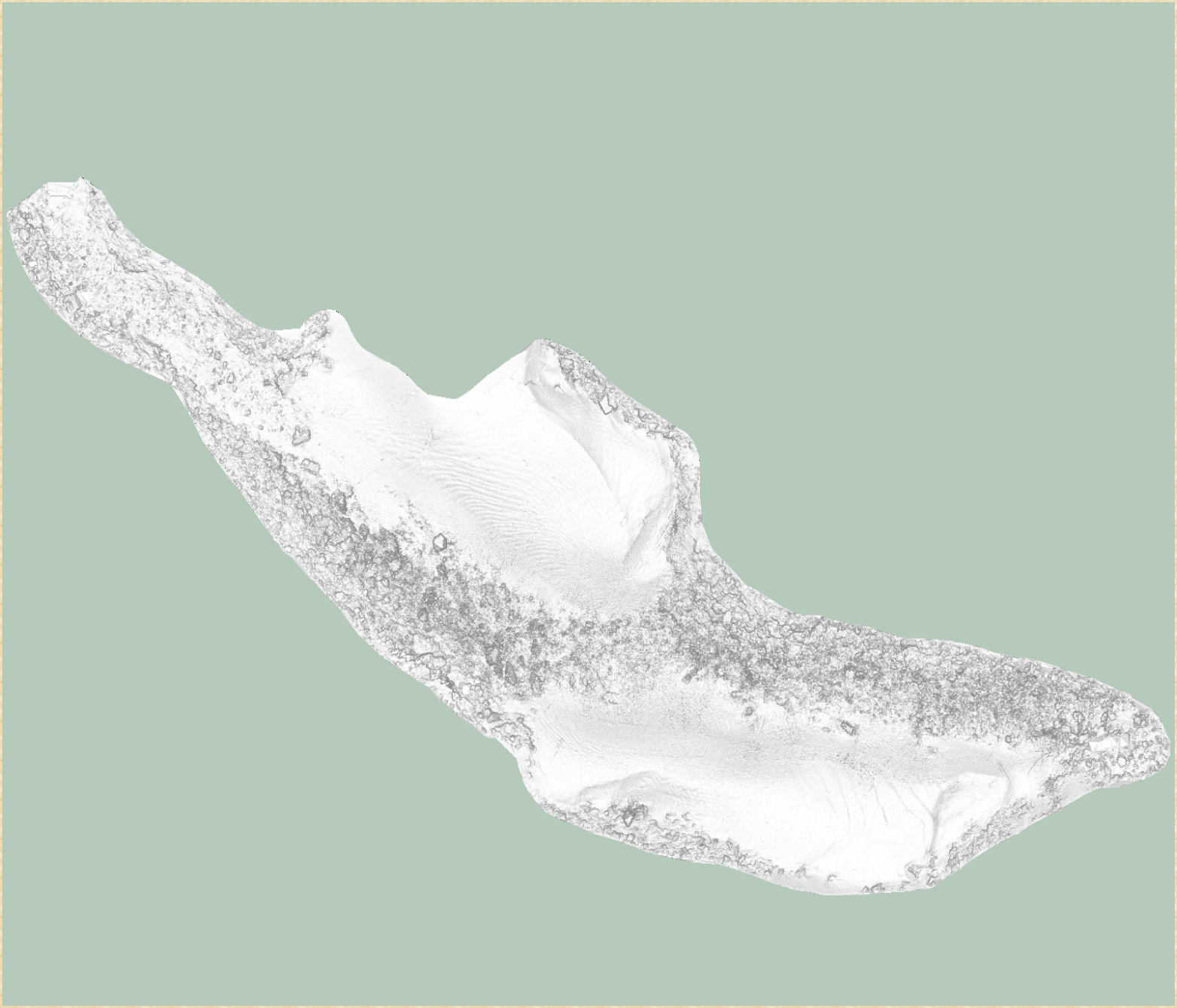


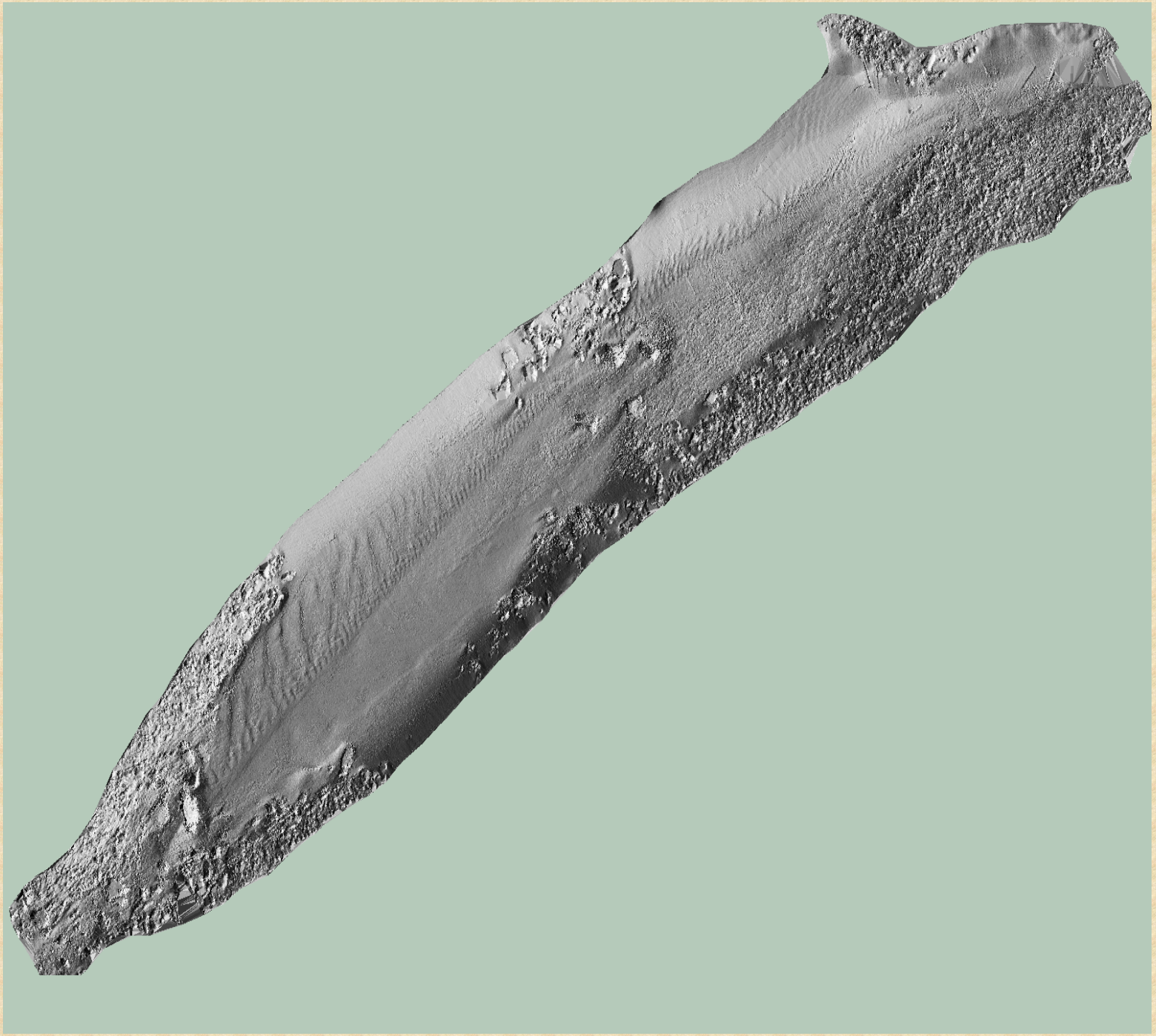


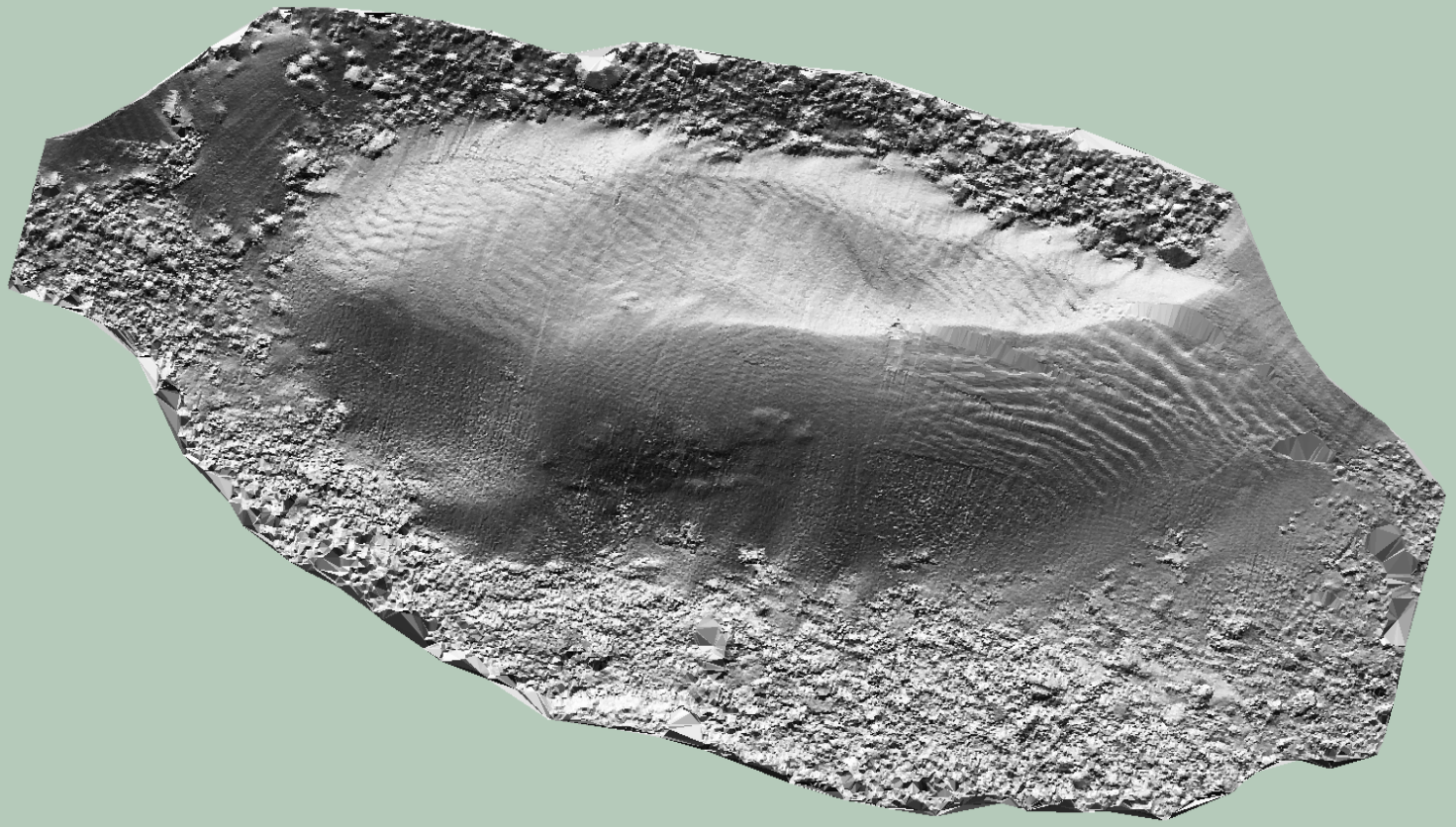


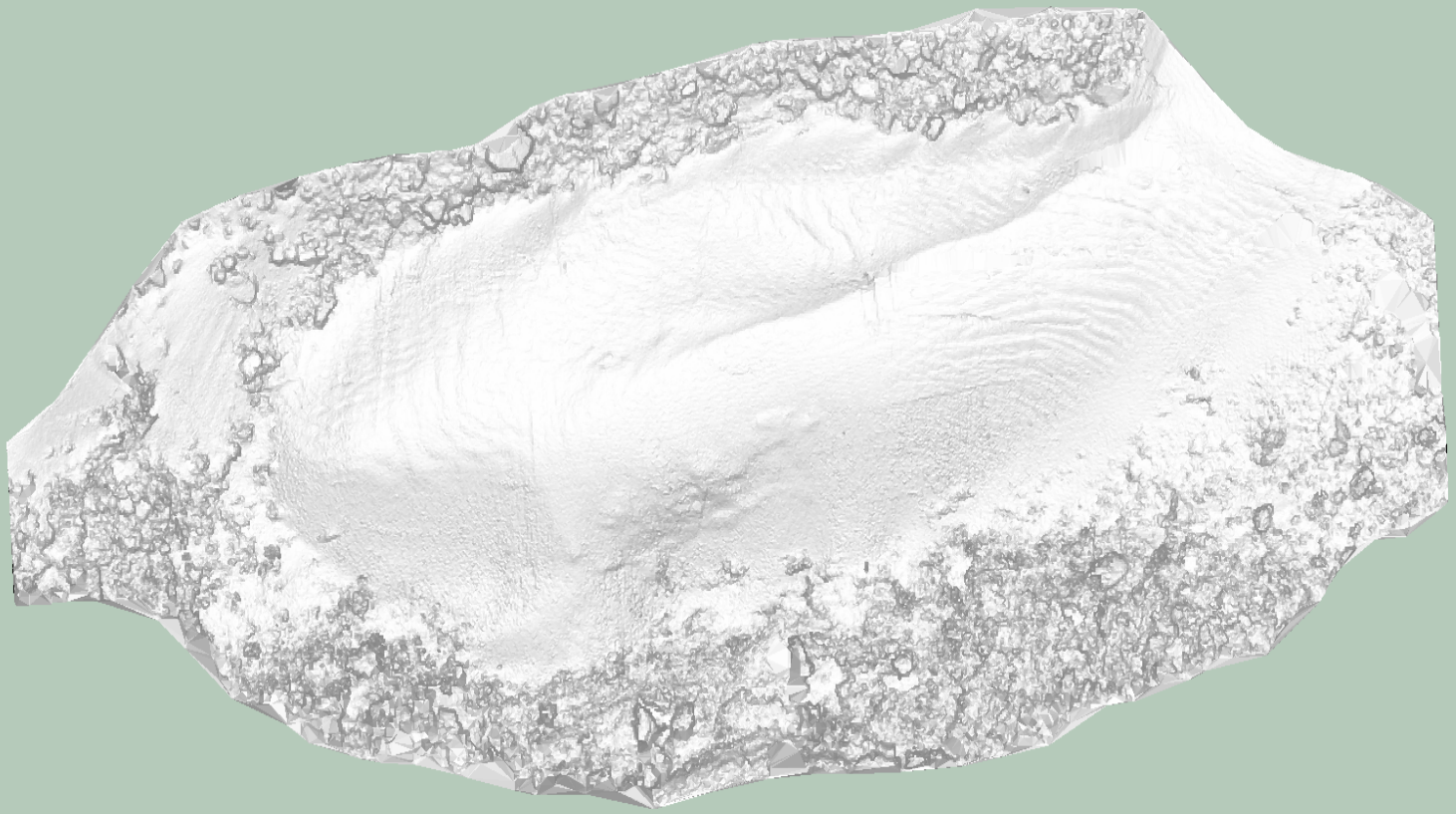






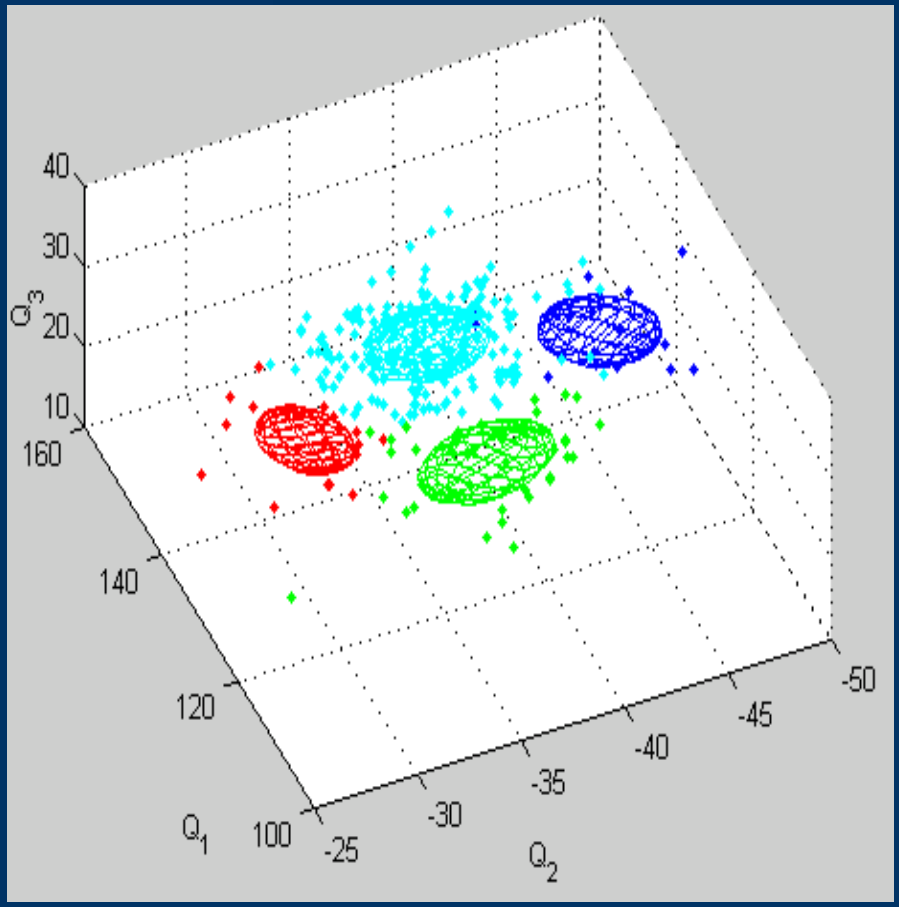






Multibeam Seabed Classification

- Load line-by-line
- Mask bad data
- Condition data
- Rectangle Creation
- Feature Generation
- Data Optimization
- Cluster and Cataloguing
- Mapping



Multibeam
Seabed
Classification

QTC MultiView™

Five acoustic classes overlaid on sun-illuminated bathymetry.

EM8125 Survey
Colorado River
28 April 2002