An Application for Topo-Bathymetric LiDAR on the Springs Coast of Florida

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and

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Discussion Outline

Introduction/Motivation

Pilot Project/Study Site

Data Processing

Accuracy Results

Future Work

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Introduction

Because soluble limestone of the upper Floridan Aquifer occur close to the surface and are not covered by confining sands, the northern portion of the SWFWMD has developed into a karst landscape, characterized by sink holes, sinking streams, underground caverns, and springs,

The King's Bay Springs (aka Crystal River Springs) group is the second largest springs system in Florida and composed of numerous springs distributed over a large area; the largest are: Black, Tarpon Hole, Idiots Delight, and Hunter's Springs,

The King's Bay Springs discharge approximately 567 MGD into King's Bay, the headwaters of the Crystal River,

Groundwater discharging at the King's Bay Springs may be fresh (primarily on the eastern side) or brackish (primarily on the western side), depending on tides and water levels in the Floridan aquifer,

Material, both organic and inorganic, tends to accumulate in the underwater Karst terrain.

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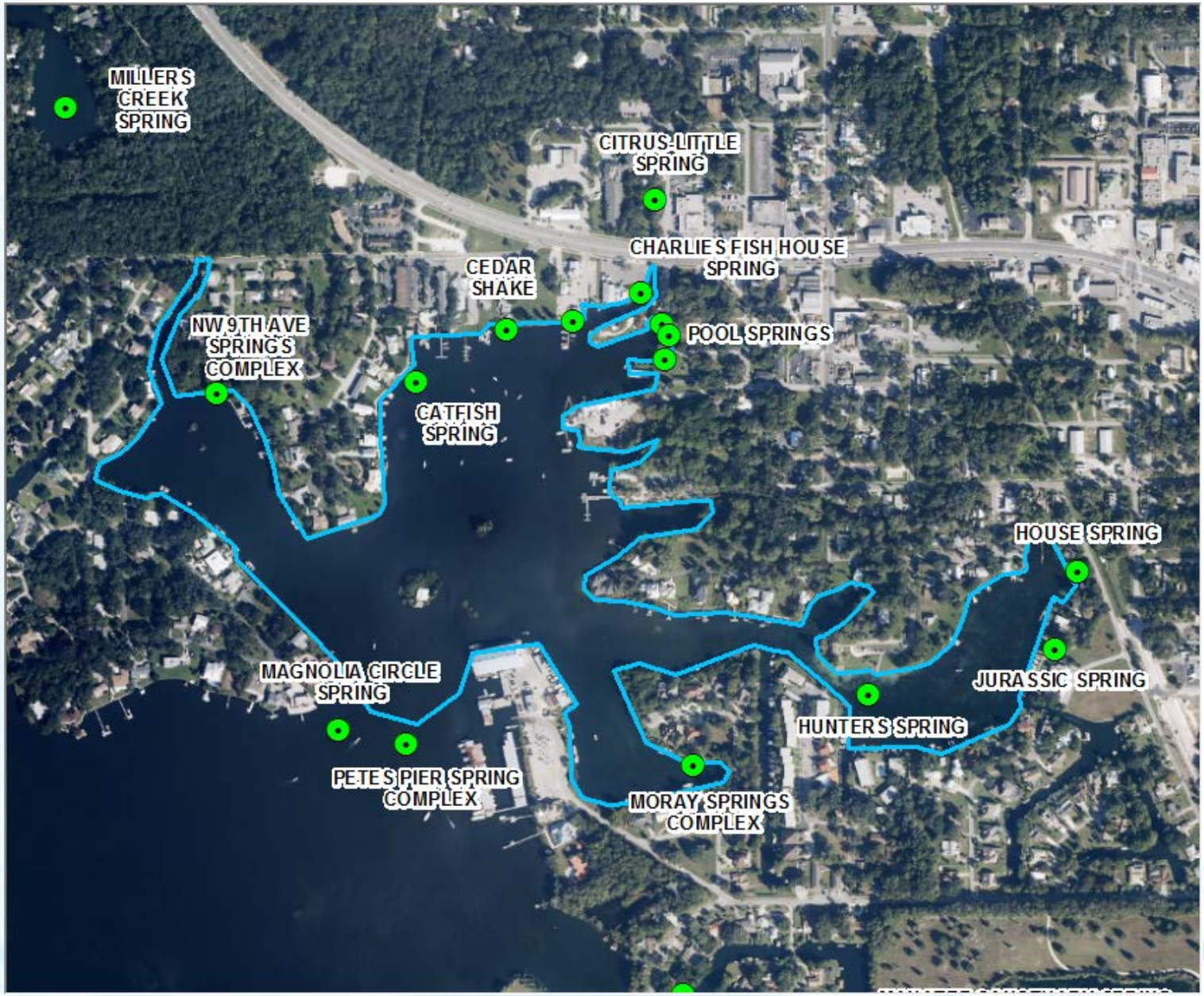
King's Bay Springs Complex, Citrus County, FL



King's Bay, Citrus County, FL

View from "Cracker's Restaurant" (Winter 2016)

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King's Bay, Citrus County, FL

King's Bay, Citrus County, FL

Near Hunter's Spring (Winter 2015)
137 Manatees (by my count)

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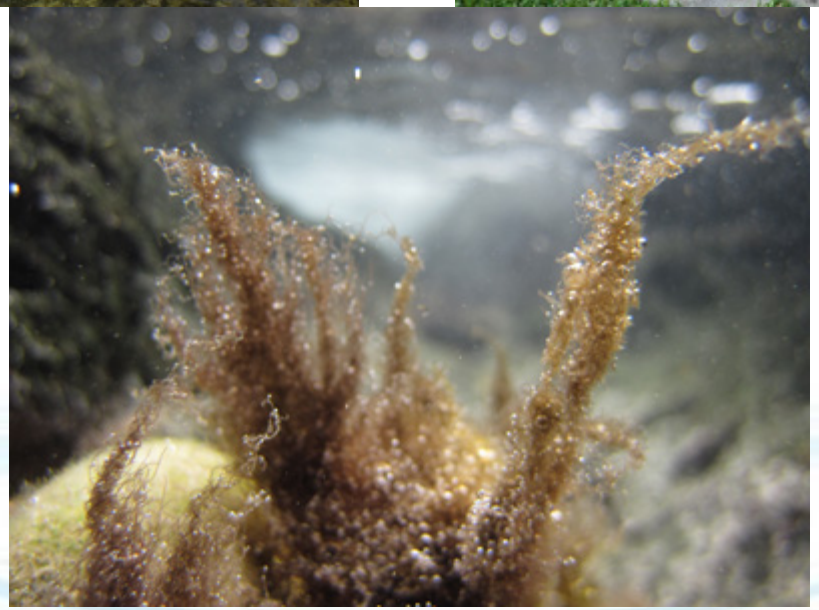
King's Bay, Citrus County, FL – *Lyngbya ssp.*



KINGS BAY RESTORATION PROJECT

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King's Bay, Citrus County, FL – *Lyngbya ssp.*

KINGS BAY RESTORATION PROJECT

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KINGS BAY RESTORATION PROJECT

So the questions are:

1- Where are the most critical areas for material removal?

2- How much material needs to be removed?

3- How do we monitor the success/failure of the project?

4- How much will it cost?

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CZMIL Coastal Zone Mapping and Imaging Lidar

Joint Airborne Lidar Bathymetry Technical Center of Expertise

Teledyne/Optech
Coastal Zone Mapping and Imaging LiDAR

Itres, Ltd.
CASI 1500H Hyperspectral Imaging System

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Images care of JALBTCX and Teledyne/Optech)

CZMIL (LiDAR) Specifications

- The LiDAR is a hybrid scanned-flash system employing a 10 KHz green laser and a circular scanner, with a large aperture receiver (0.20m) having multiple channels.
- A Photo-multiplier (PMT) segmented detector and multiple fields-of-view are used to measure topography and bathymetry.
- The measured laser returns are digitized at 1 GHz to produce the waveforms required for ranging measurements.
- The segmented detector approach enables discrimination of bottom and surface returns in very shallow water conditions without compromising performance in deep water.

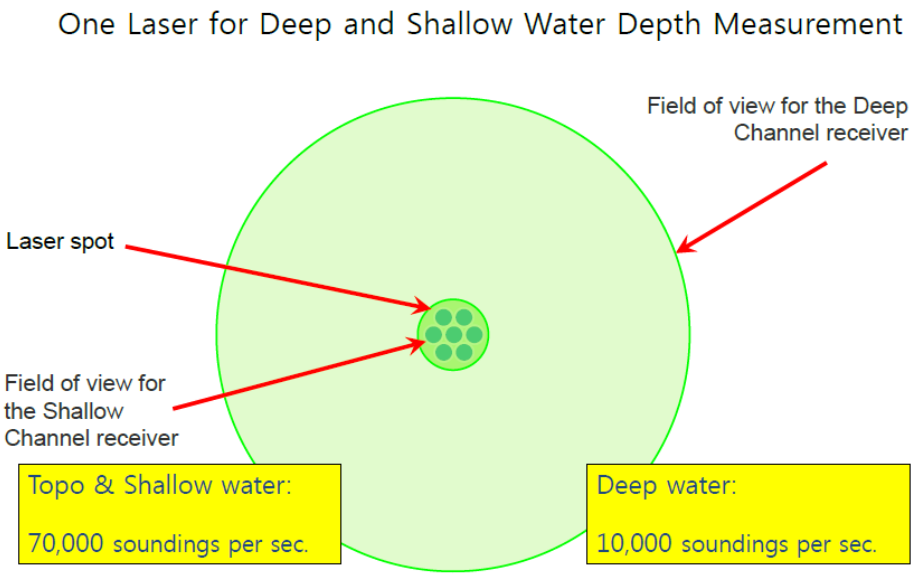

Image courtesy Teledyne-Optech

Shallow channels measurement rate	70 kHz
Shallow channels maximum depth	$2/K_d$ (bottom reflectivity > 15%)
Deep channel measurement rate	10 kHz
Deep channel maximum depth	$4.2/K_d$ (bottom reflectivity > 15%)

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CZMIL Unique Capabilities in Turbid waters

Key parameters for optically deep (turbid) waters and muddy seafloors

- Specific hardware design
  - High Laser Power
  - Short pulse length
  - Big aperture mirror
  - Fast response receiver

  } Higher valid point density

- Clear and smoothed waveforms
  - ABL Waveforms from shallow turbid water can be generated by well defined optical design, good receiver characterizations and noise reduction techniques
- Water Turbid Algorithm module to extract depth information from muddy bottoms

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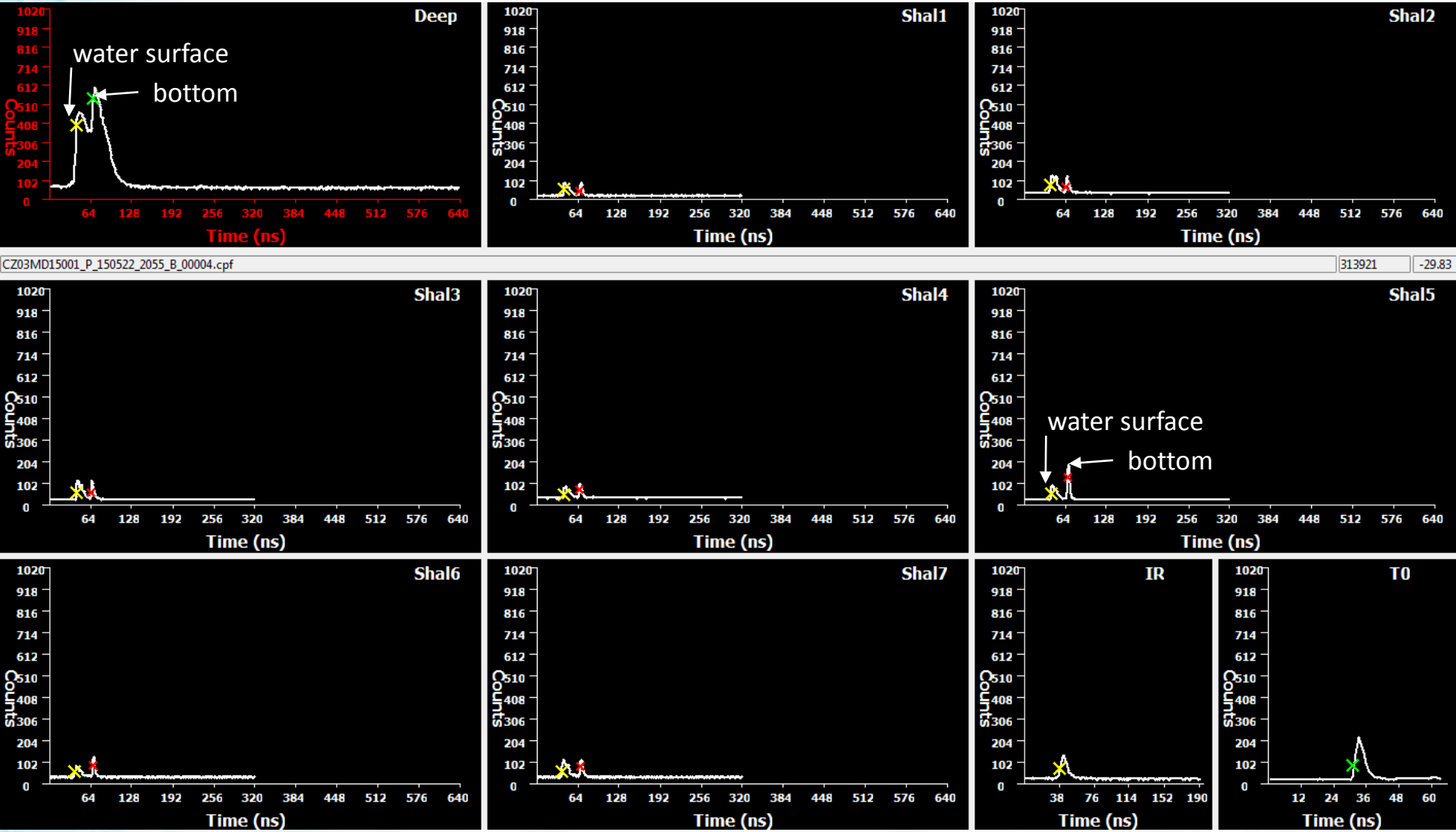
CZMIL Waveforms (Deep + 7 shallow channels)



Data visualized in PFM-ABE software

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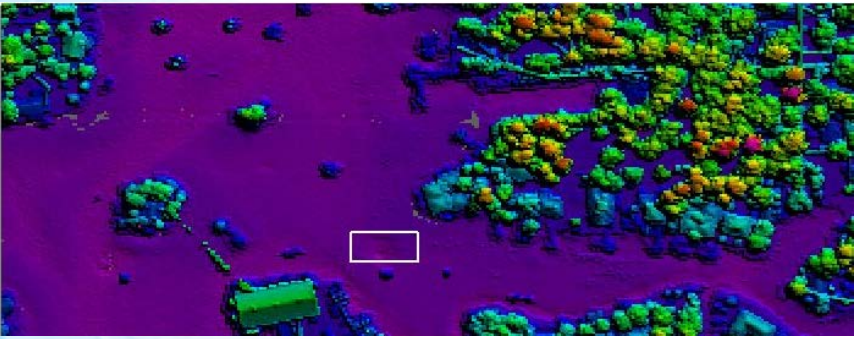
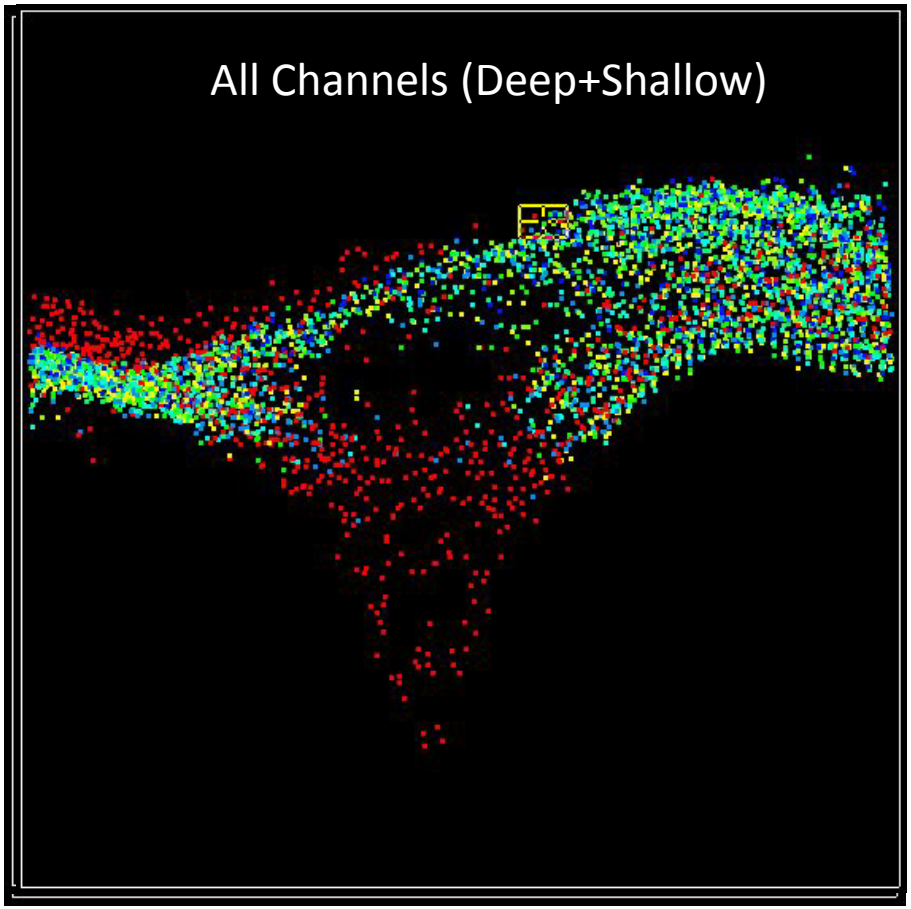
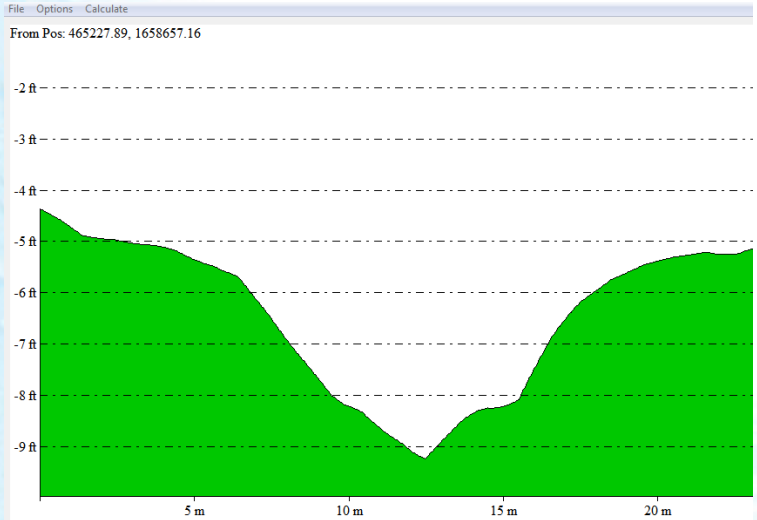
Why CZMIL Sensor for this study?





Deep + Shallow channels used to create bathymetric model



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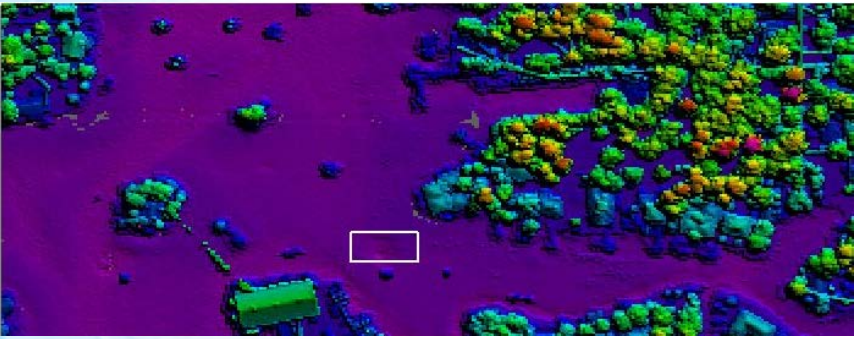

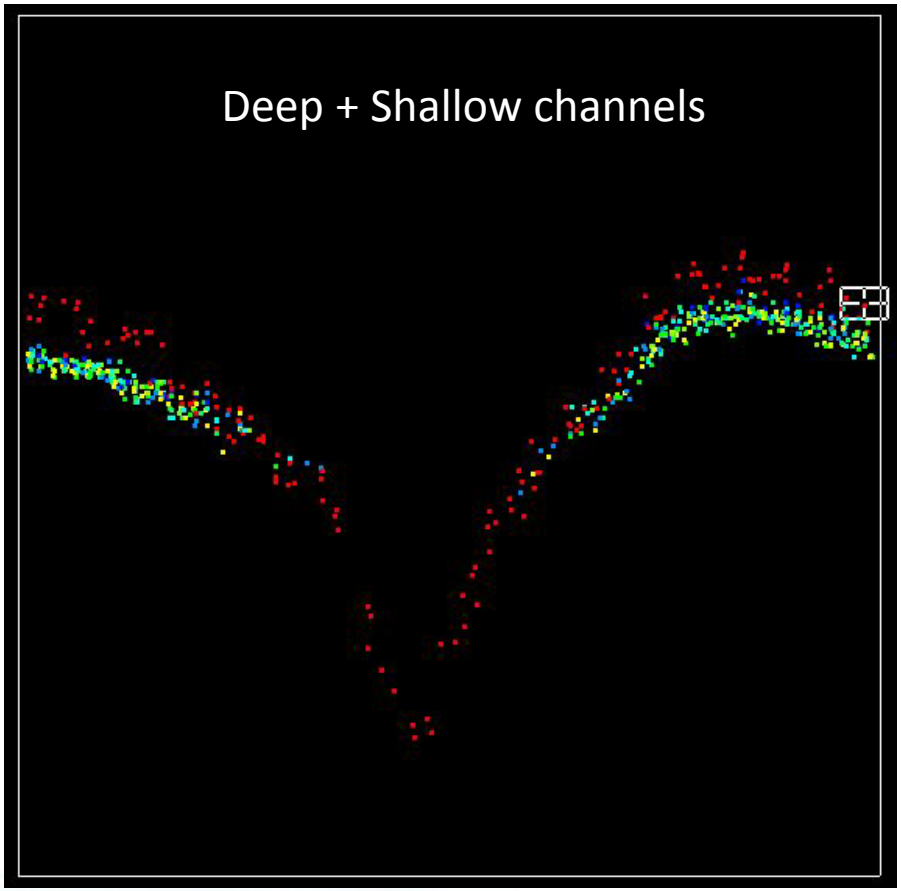

Deep + Shallow channels used to create bathymetric model

Slice = 3.50 m

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Processing Workflow

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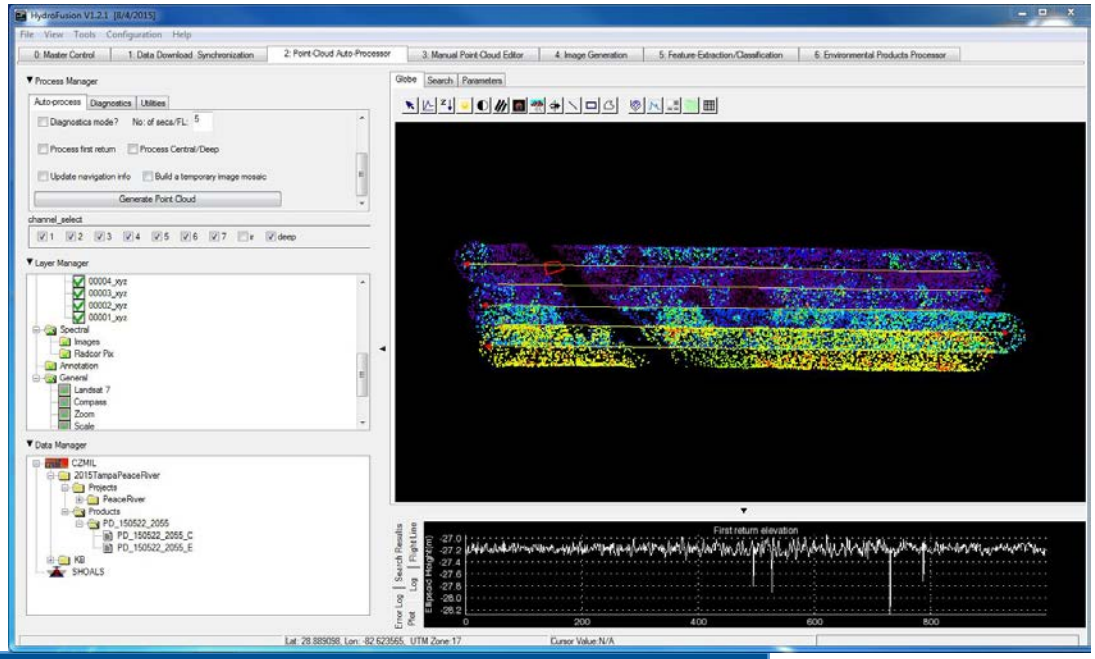
Data processed in Teledyne-Optech HydroFusion software and reviewed in PFM-ABE software.

3D hydrographic breakline was extracted from the LiDAR data to represent the land-water interface at the time of data collection.

Lidar data classification conducted in TerraSolid software



ASPRS (LAS v1.4) Lidar Classes used in this study	
Class	Description
2	Ground
40	Bathymetric Ground
41	Water Surface
42	Synthetic Water Surface
45	No bottom found
46	Top of Unconsolidated Material

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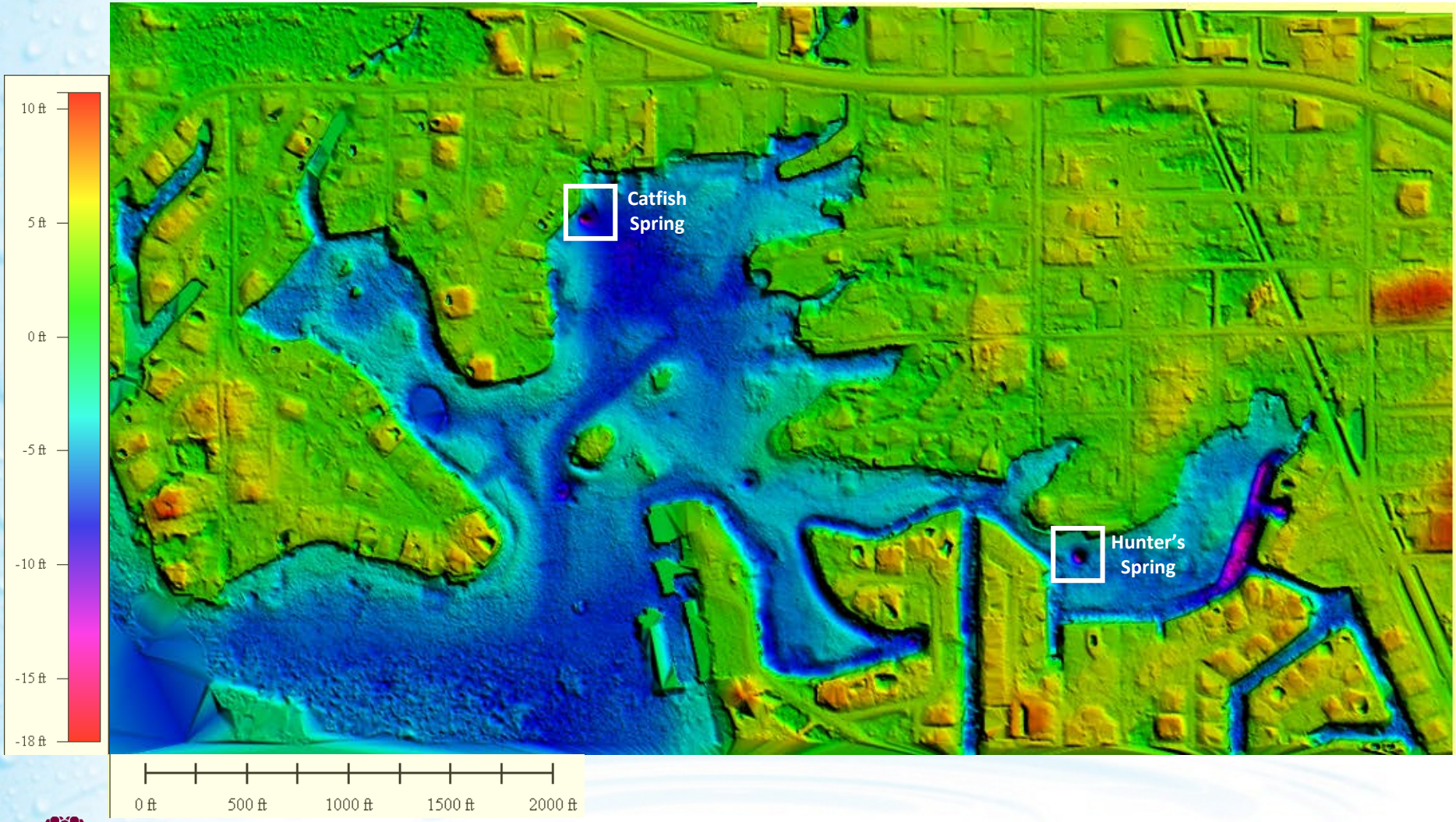
Seamless Topobathymetric Digital Elevation Model (Hard Bottom)



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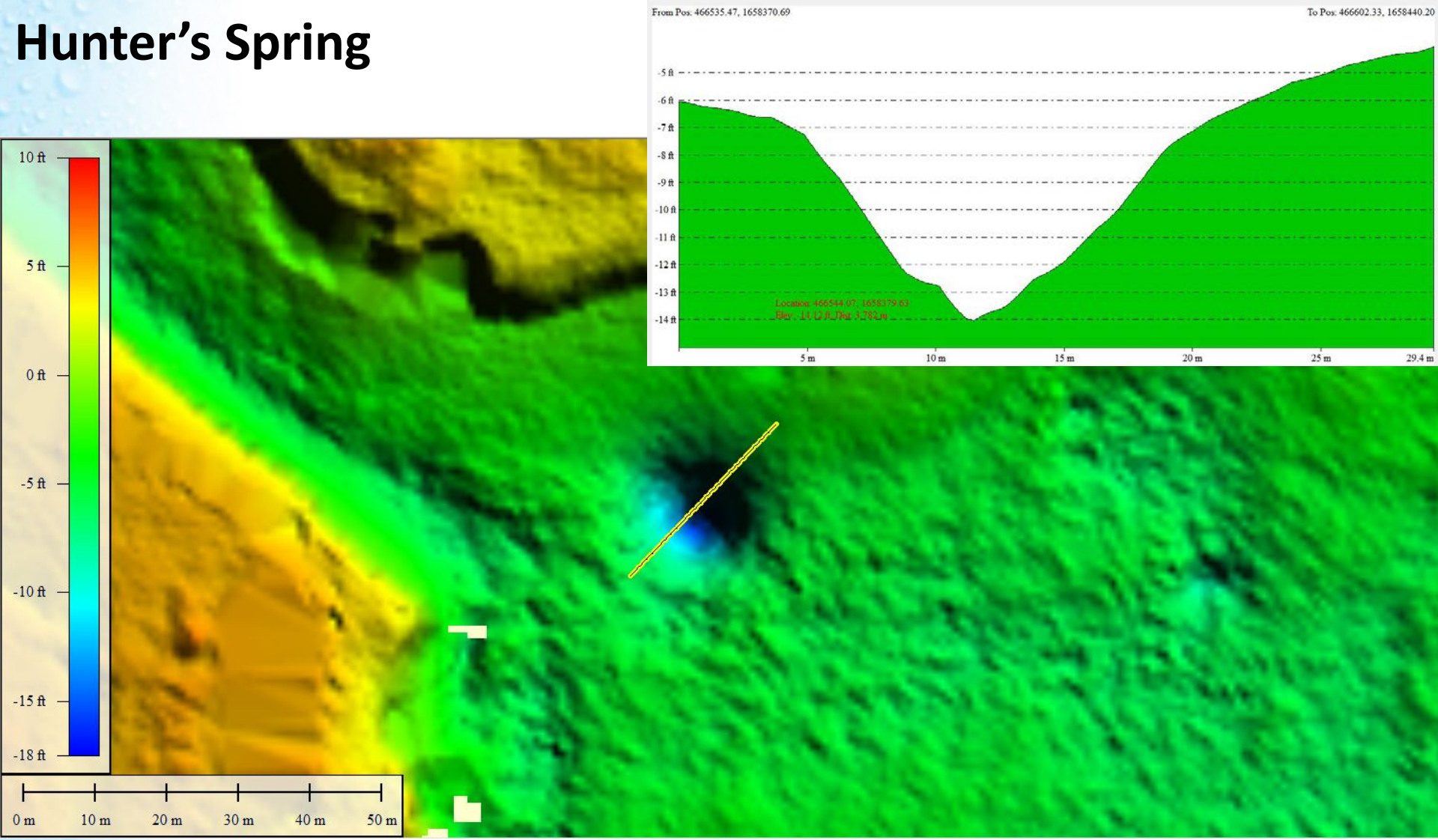
Hunter's Spring



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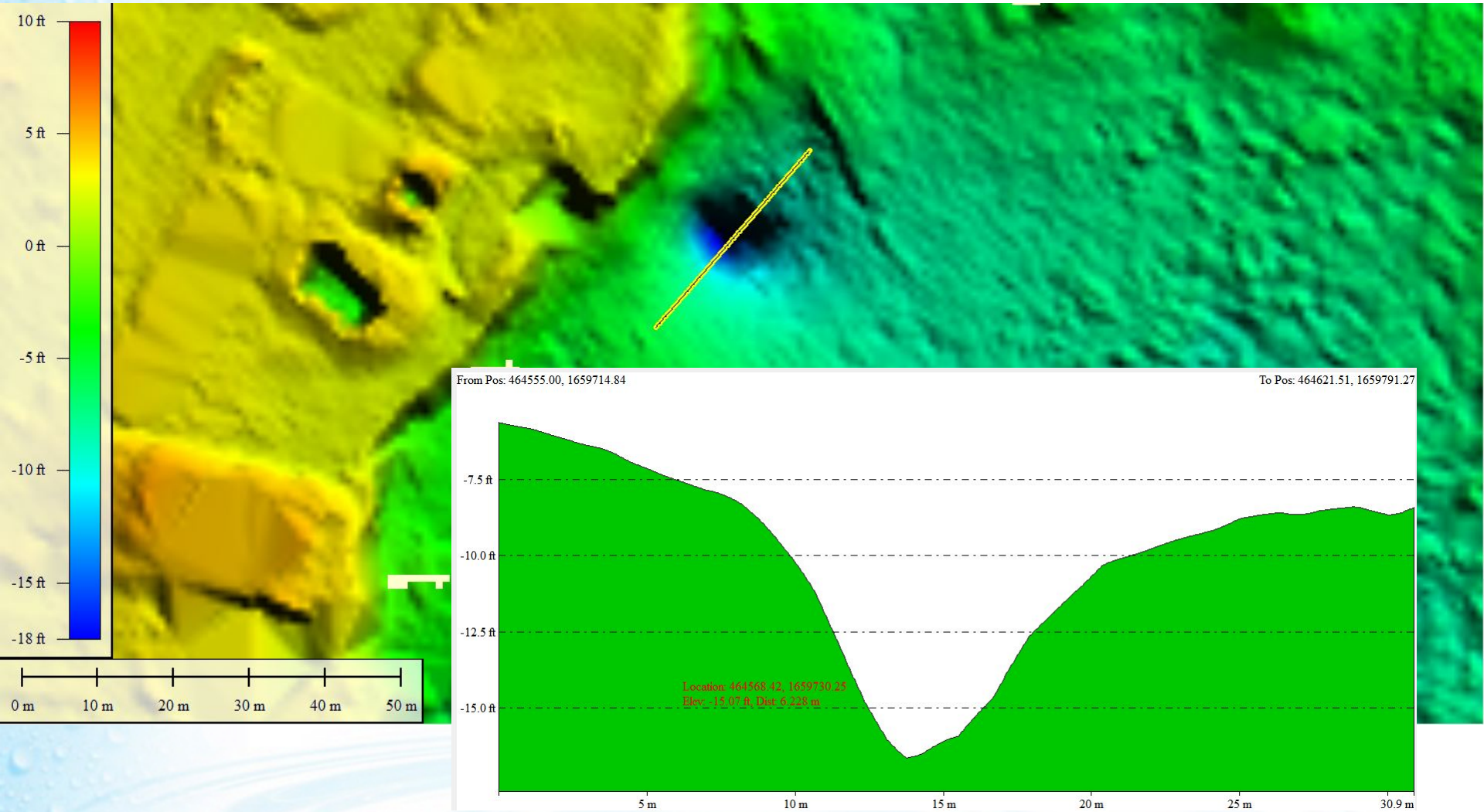
Catfish Spring



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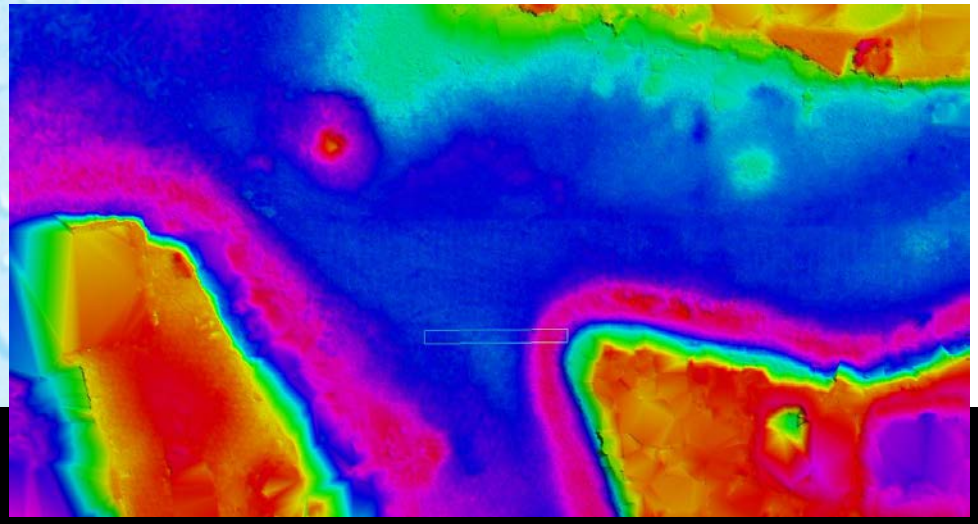
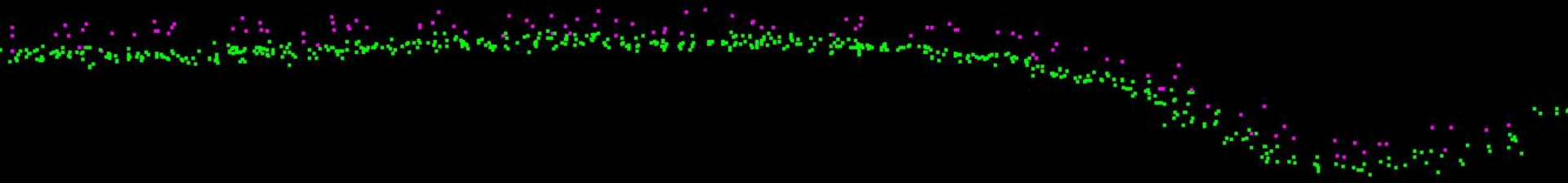
Can we determine the height of unconsolidated material?

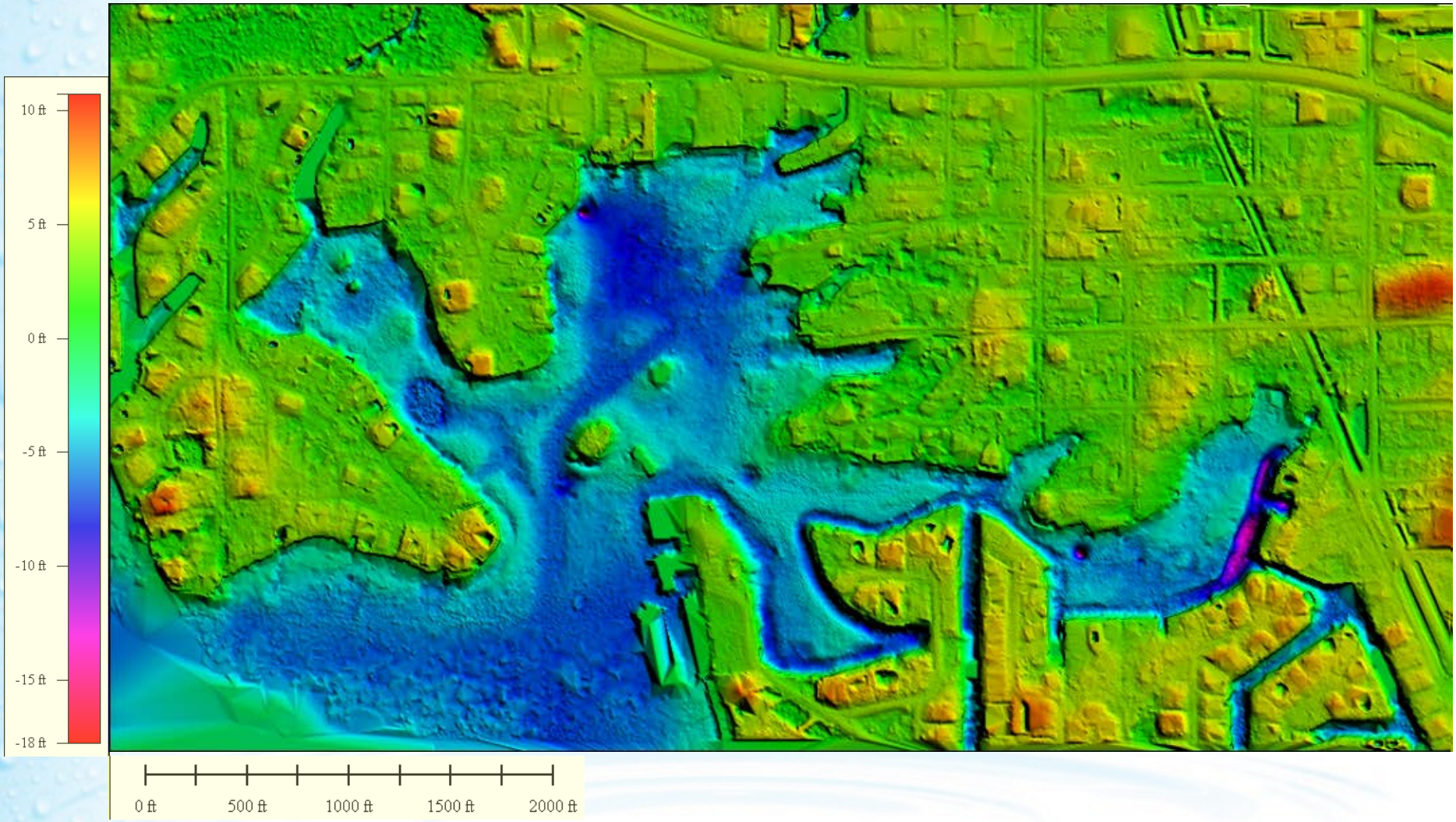


(LAS v1.4) Lidar Classes used in this study	
Class	*Description*
2	*Ground*
40	*Bathymetric Ground*
46	Top of Unconsolidated Material

Magenta points- Class 46
Green points – Class 40



Seamless Topobathymetric Digital Elevation Model (Hard Bottom → Top of LiDAR)



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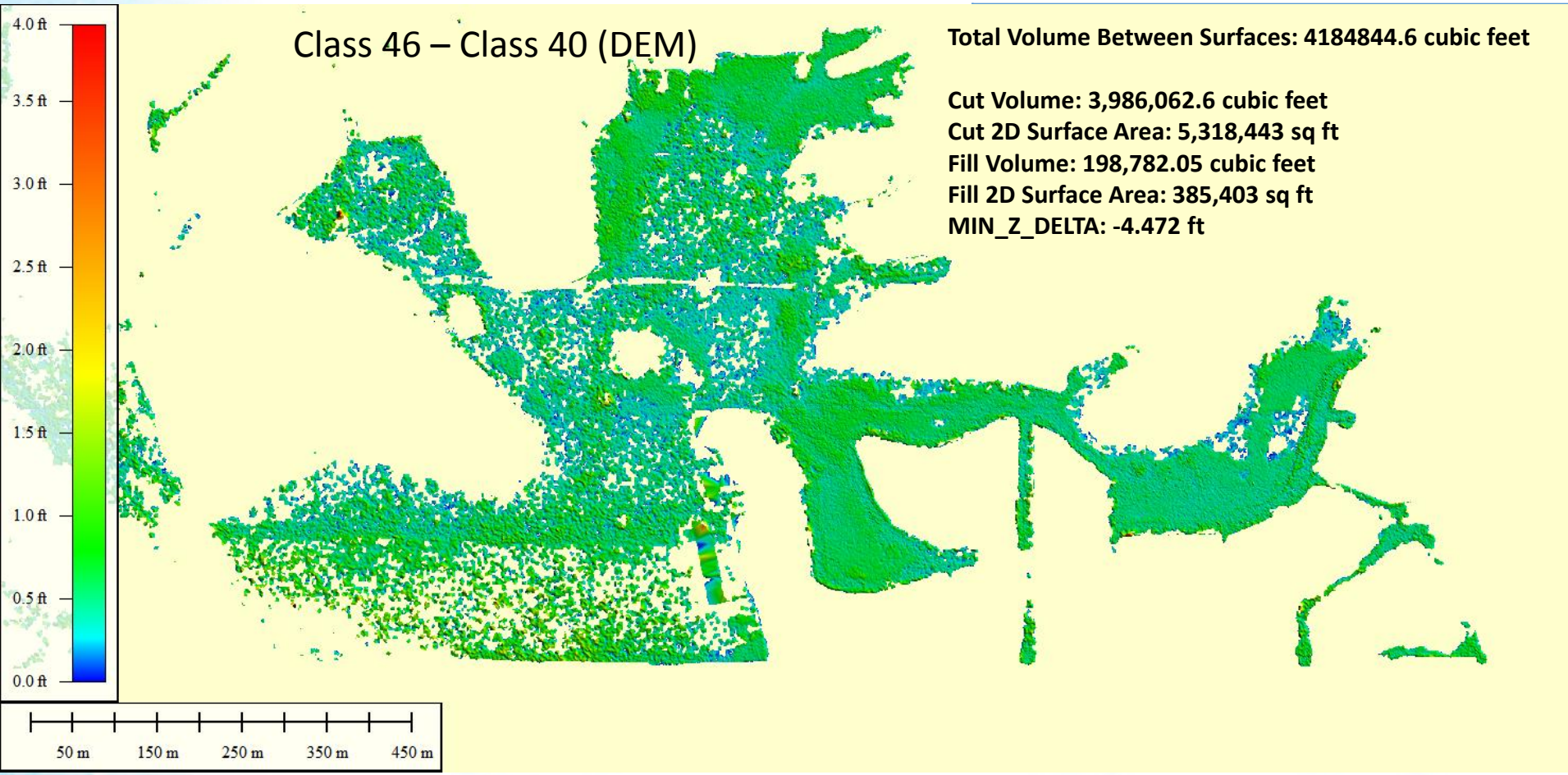
Can we determine the volume of unconsolidated material?

Dewberry processed the point cloud data to create Class 40 (bathymetric bottom) and Class 46 (top of unconsolidated material), and used the Esri Raster Calculator to subtract Class 46 from Class 40 to make a "Difference DEM" …

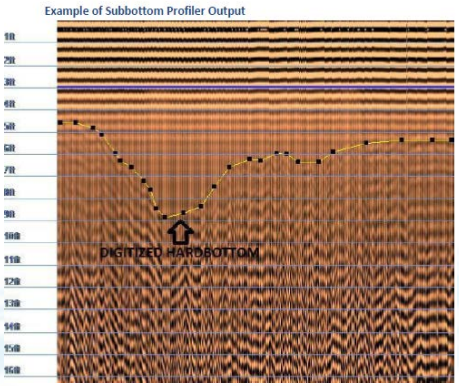


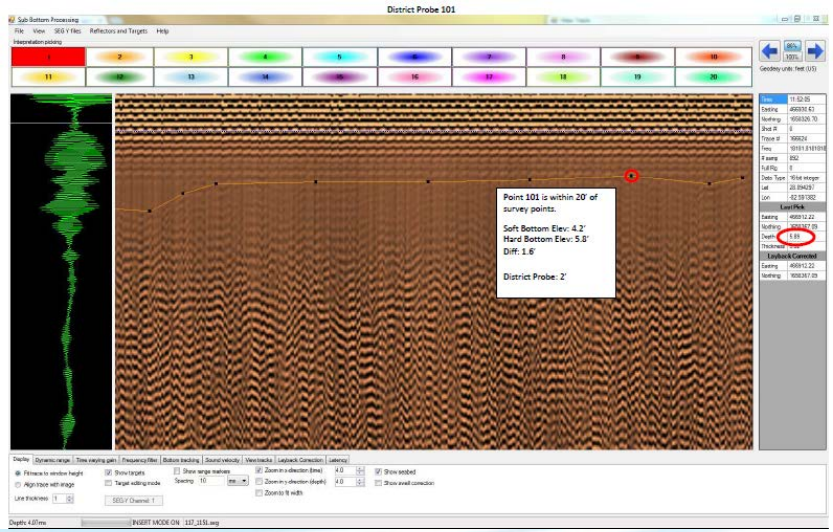
Dewberry® So… green (and yellow-green) areas show high accumulation

How Accurate is the CZMIL-derived Volume?

Odom MK III Single Beam Fathometer - 200 kHz
for top of "unconsolidated muck" layer

Ross 8510 Subbottom Profiler – 3.5 kHz
for hard bottom





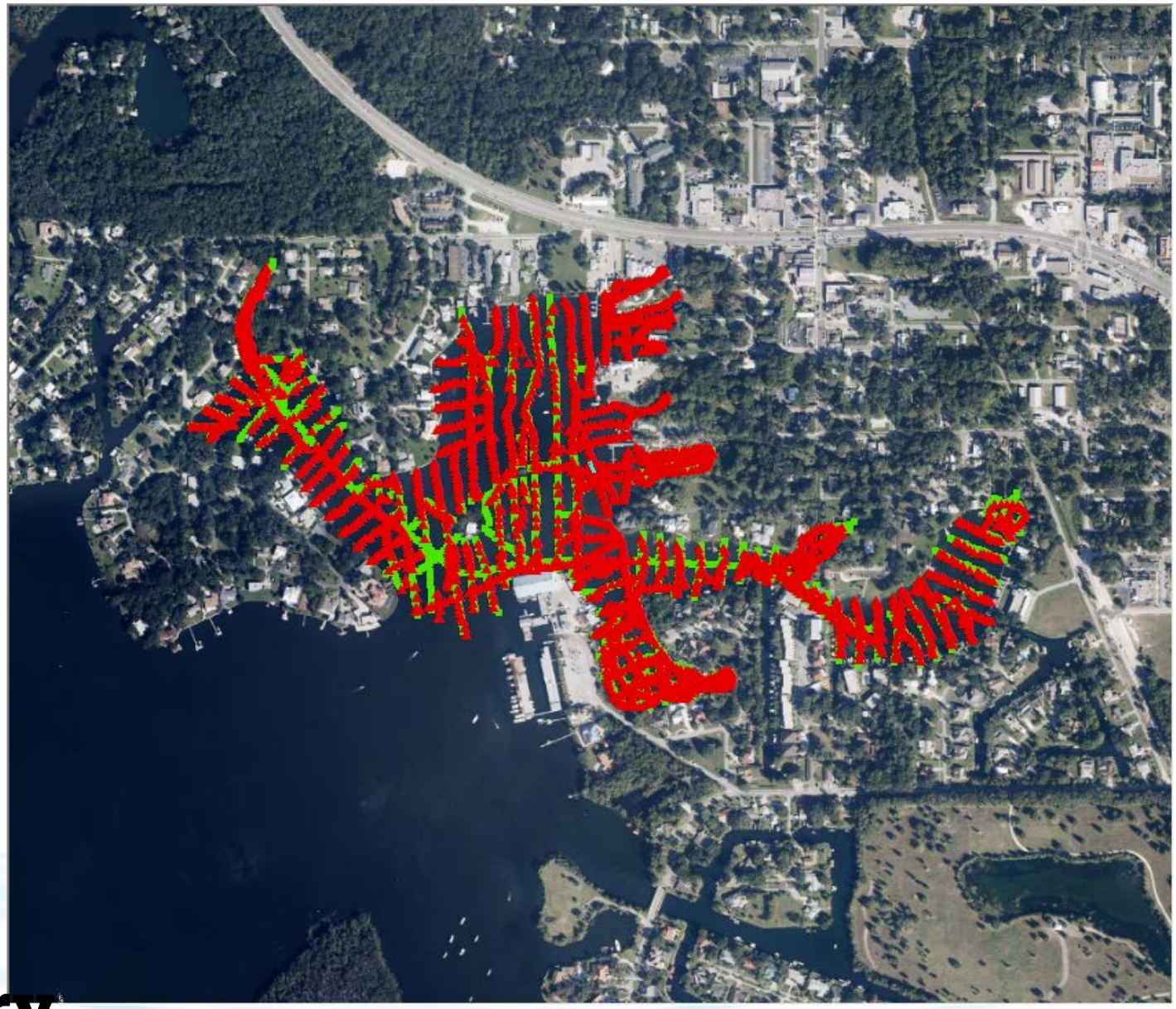
How Accurate is the CZMIL-derived Volume, con't?

Sonar Survey:
Cross-sections at 100' apart
20' sample interval

2788 Hard Bottom Points

1956 Soft Bottom Points

Same area contained 1,259,953 LiDAR Ranges



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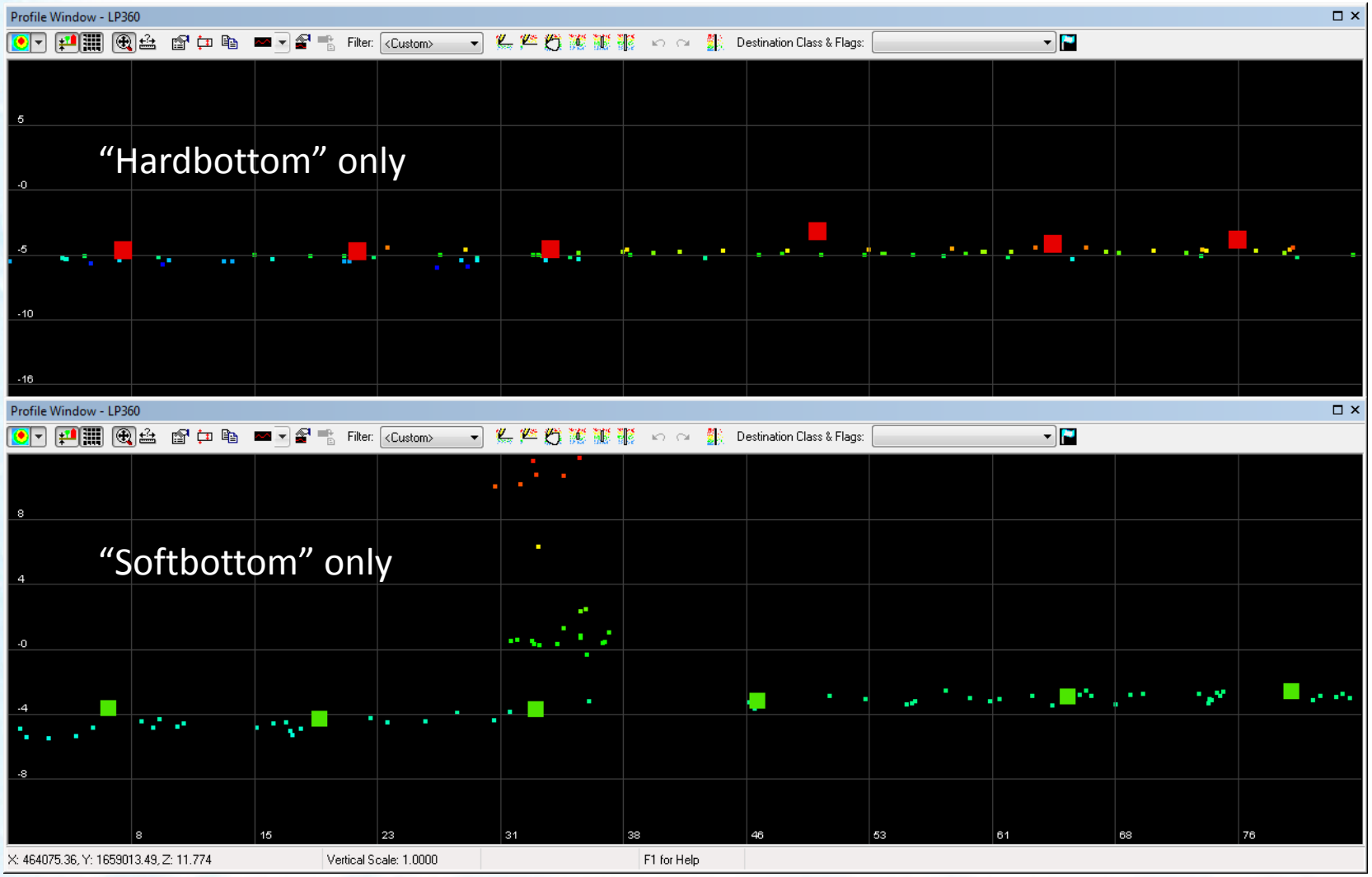
Comparison/Results – Accuracy Assessment



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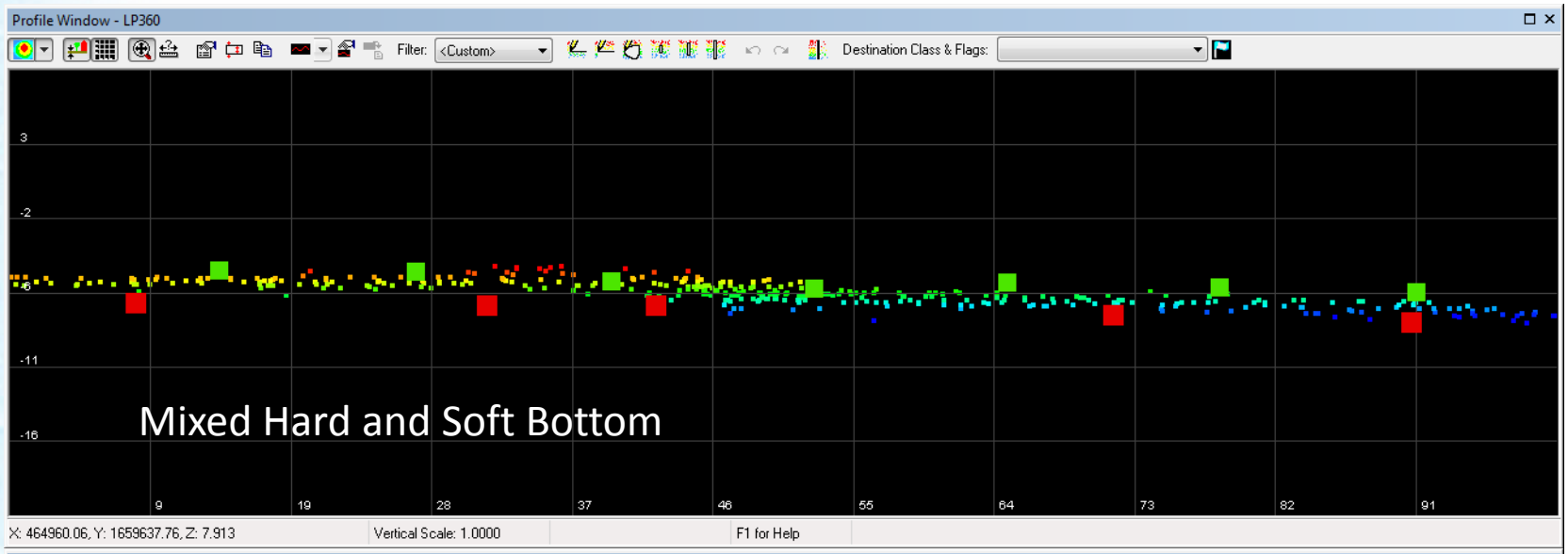
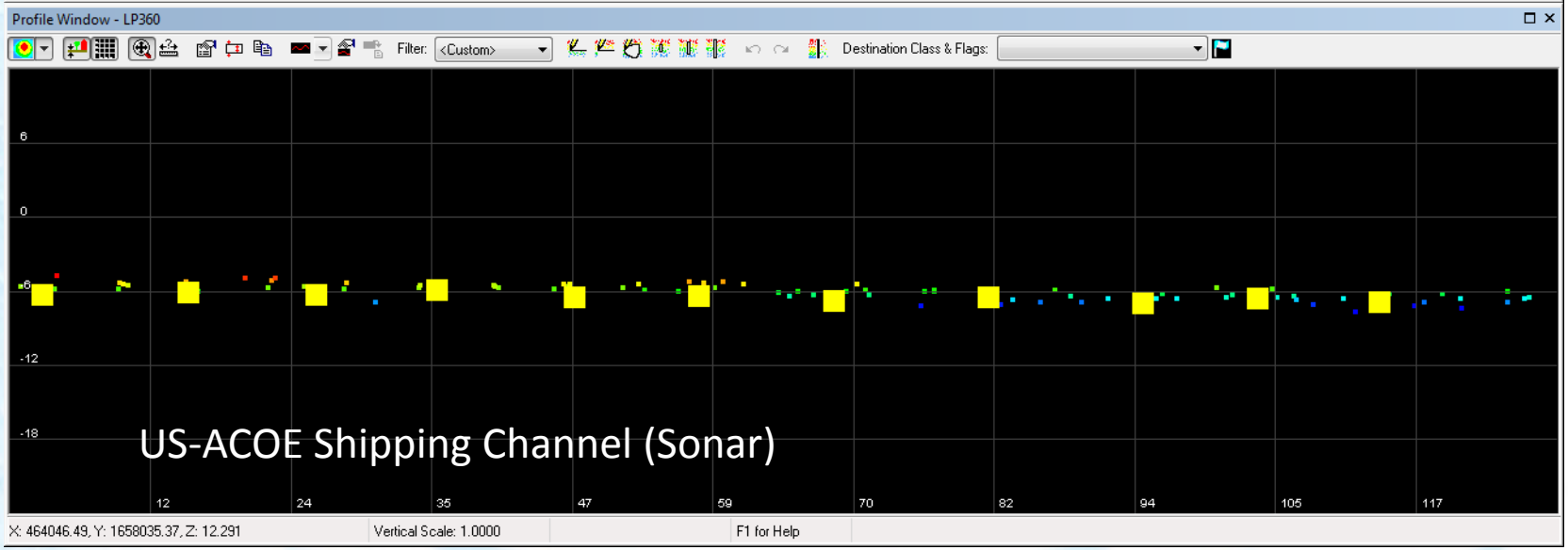
Comparison/Results – Accuracy Assessment





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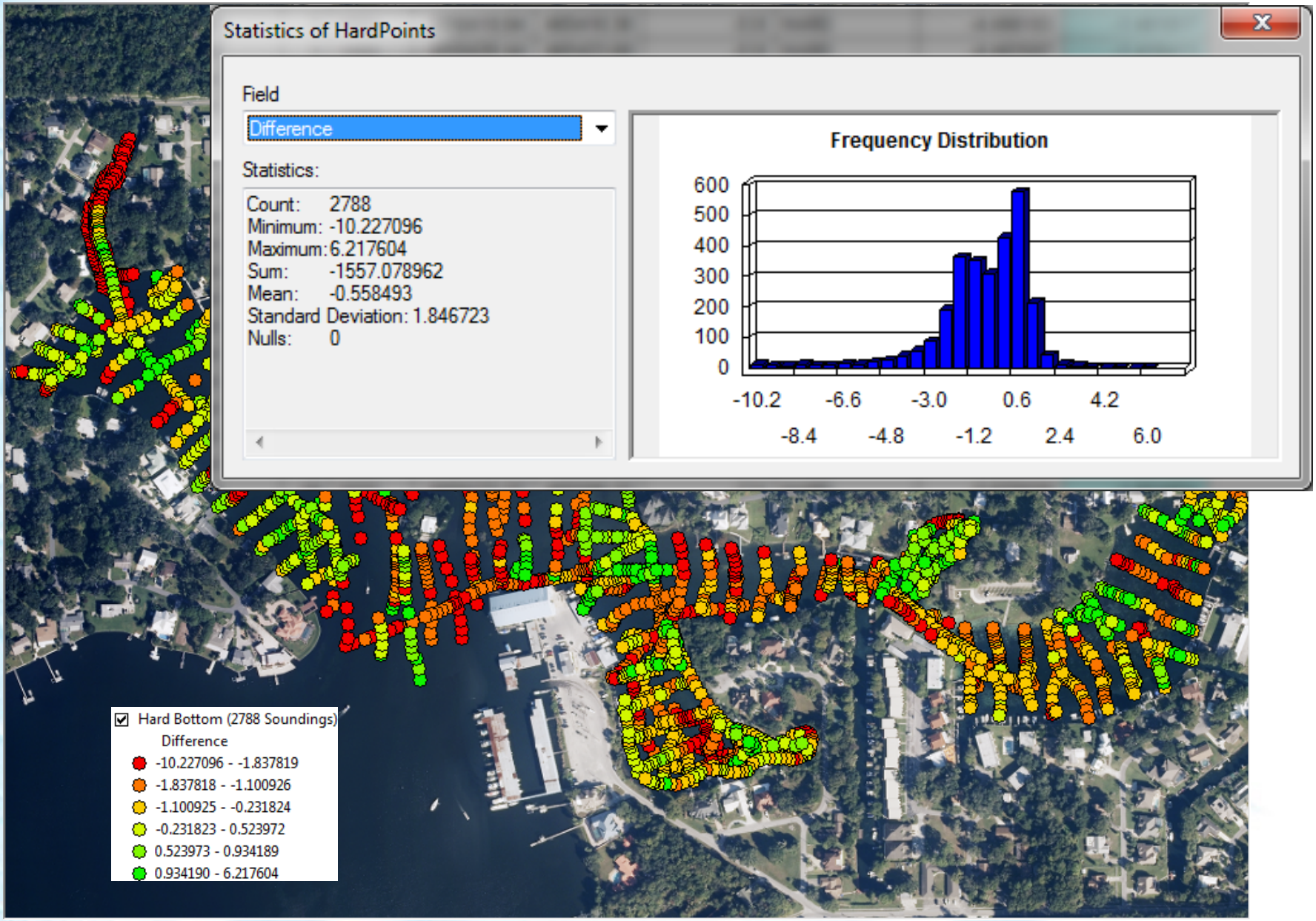
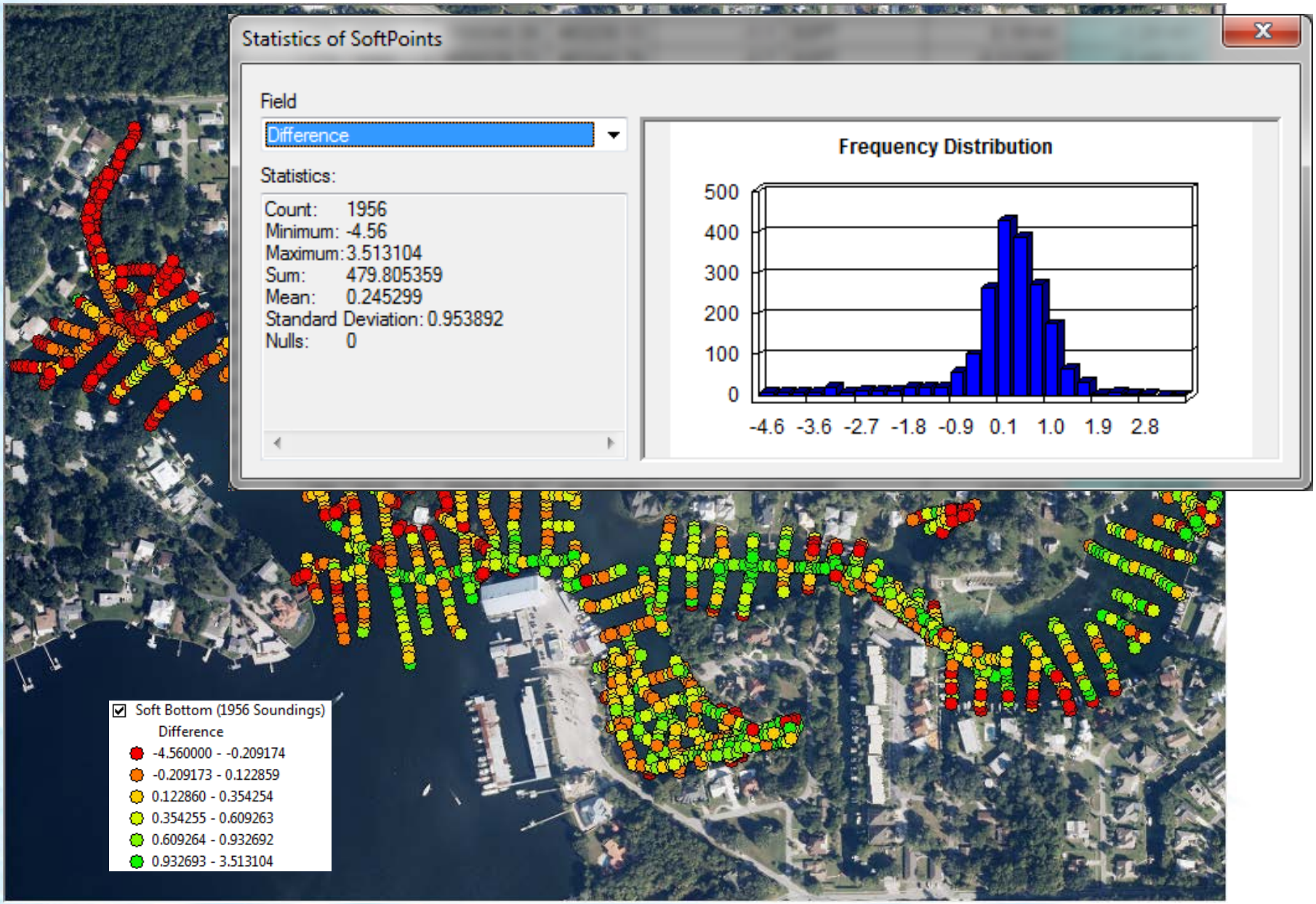
Comparison/Results – Accuracy Assessment – Hard Bottom



Comparison/Results – Accuracy Assessment – Soft Bottom

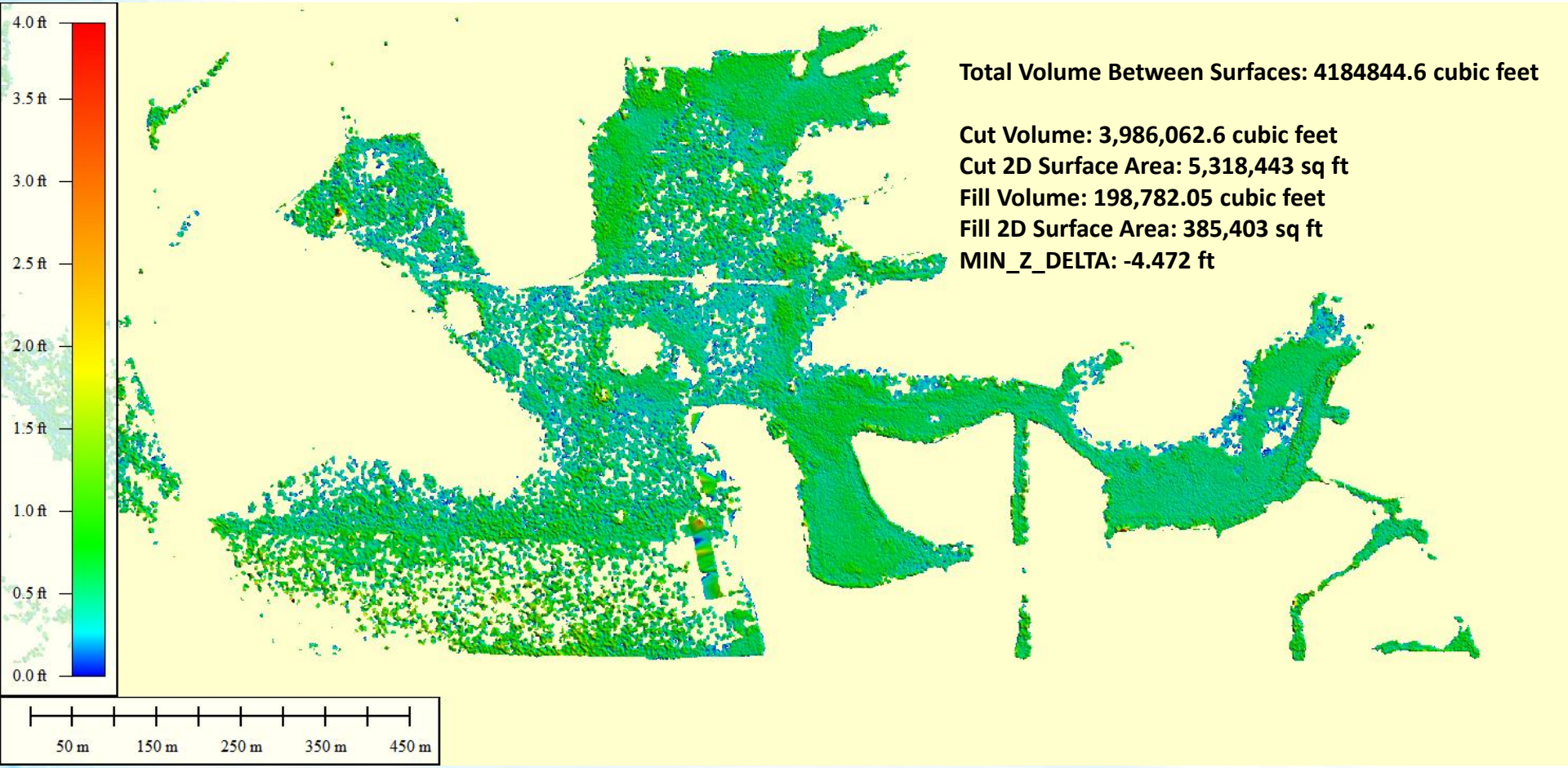


Comparison/Results – Accuracy Assessment – Summary

Control Source	# of Points	Mean Difference (ft)	RMSE	Error Range (ft)	Skew (ft)
JEA – HardBottom (all*)	2788	-0.43	1.66	-10.2 < x < +6.9	-1.22
JEA-HardBottom (select*)	**2573**	**-0.17**	**1.18**	**-2.9 < x < +2.9**	**-0.24**
JEA – Unconsolidated (all)	1956	+0.48	0.78	-3.2 < x < +3.8	+0.31
JEA – Unconsolidated (select)	**1880**	**-0.48**	**0.77**	**-1.9 < x < +3.8**	**+0.57**
USACE – Dredge Channel (all)	**147**	**-0.11**	**0.37**	**-1.1 < x < +1.0**	**-0.11**

* All = all available checkpoints; Select = obvious outliers removed

Can we determine the volume of unconsolidated material?



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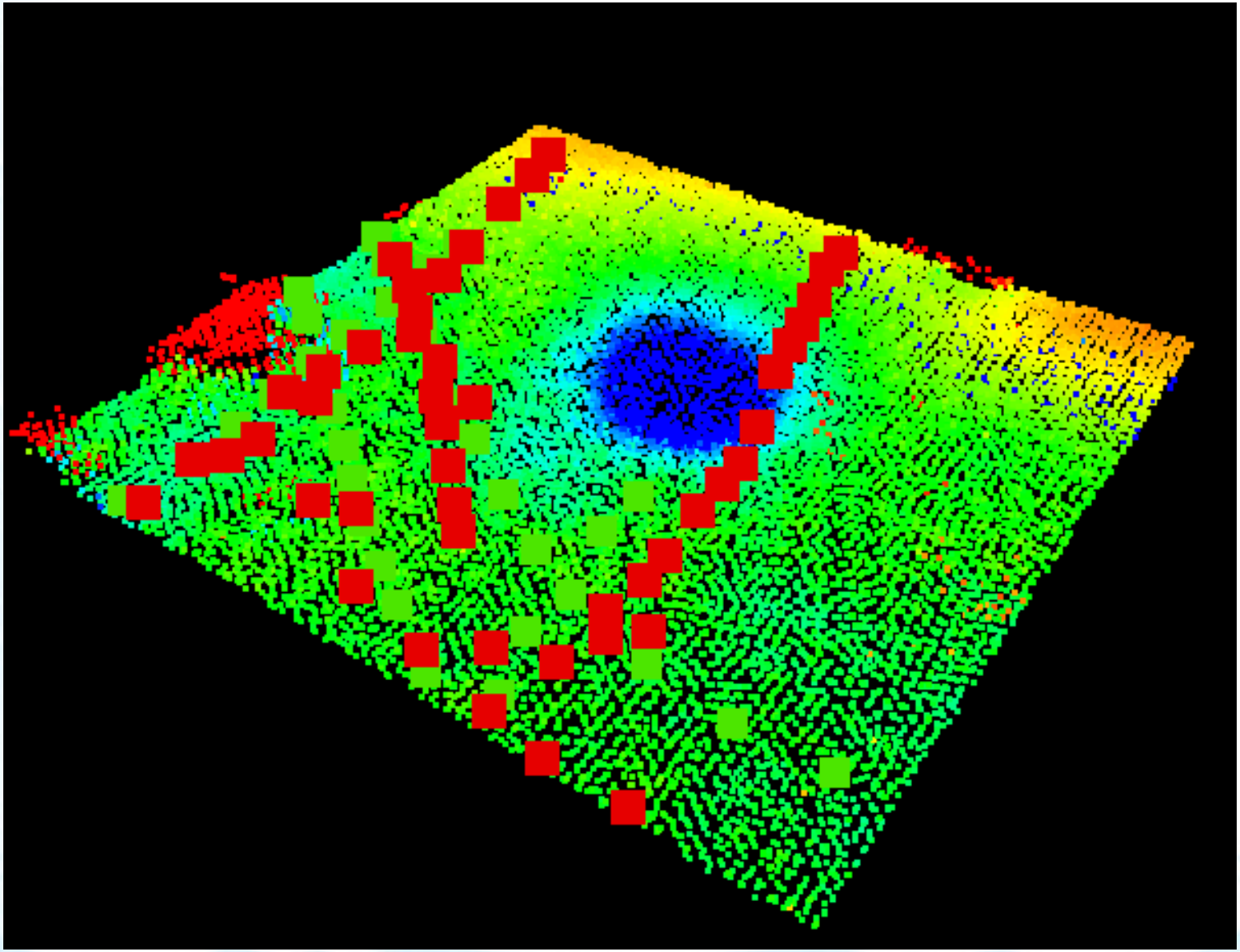
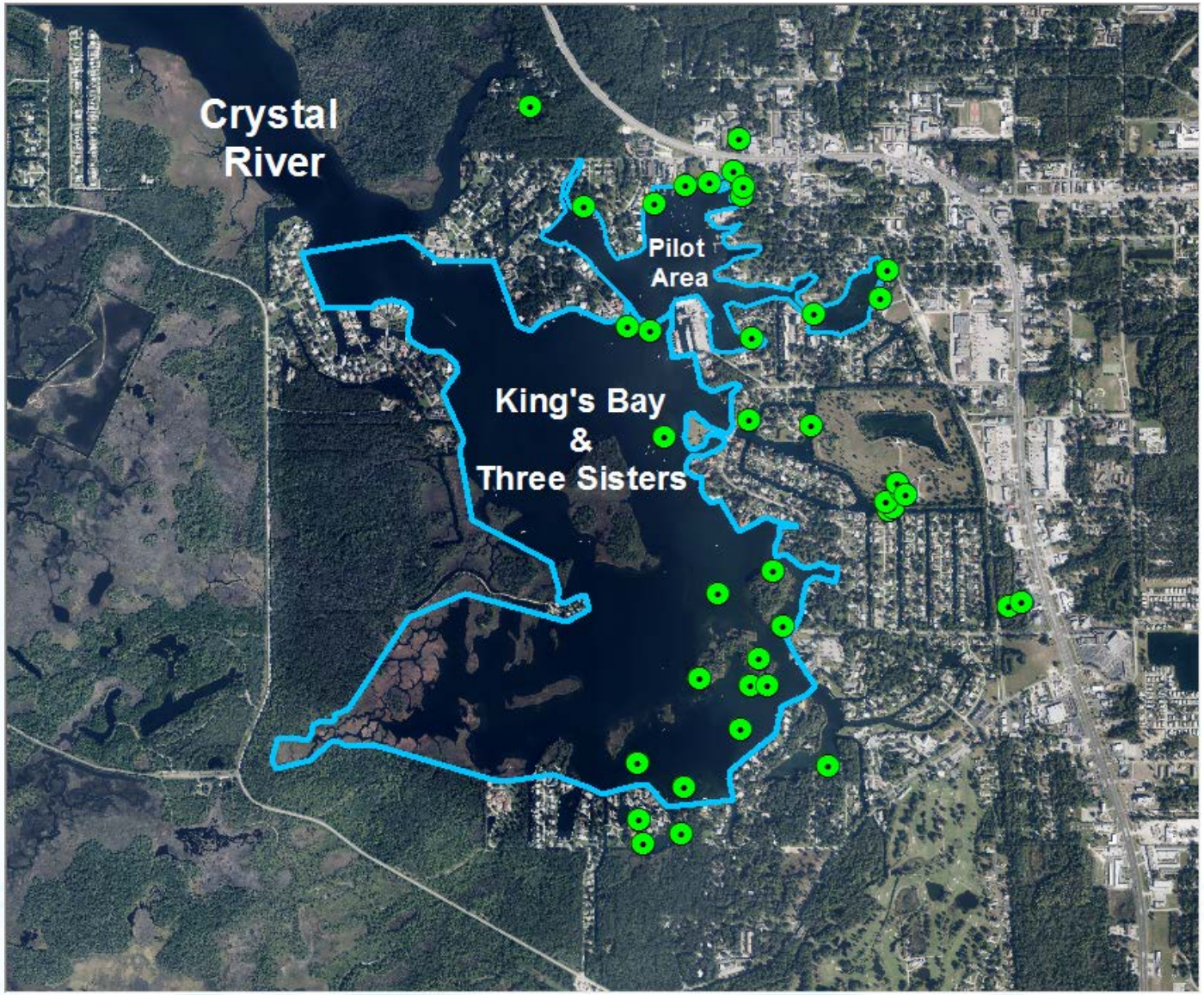
YES!

Need to review artifacts related to flight line overlaps.

Why LiDAR? Oops… Sonar missed Hunter's Spring!



Future for King's Bay



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Questions and Discussion

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