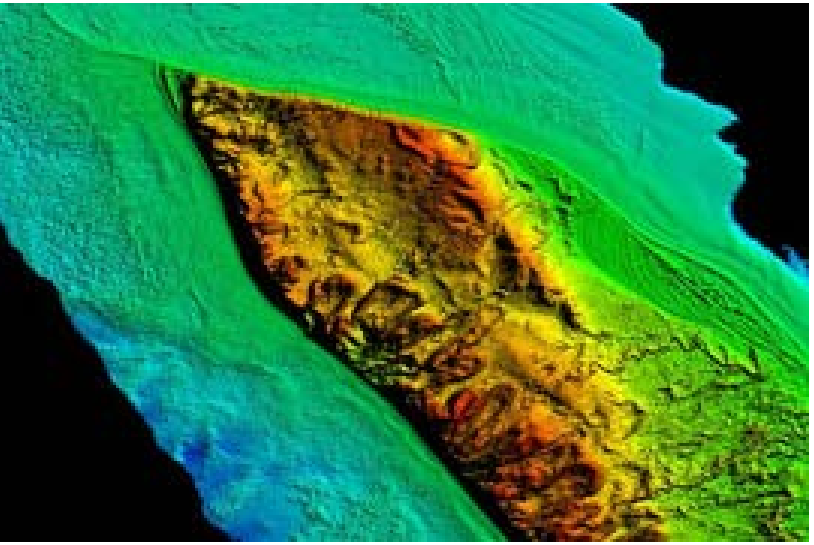
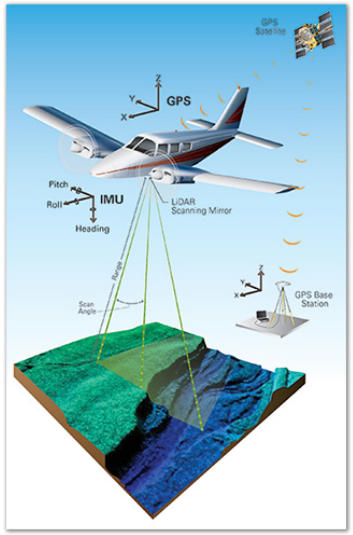
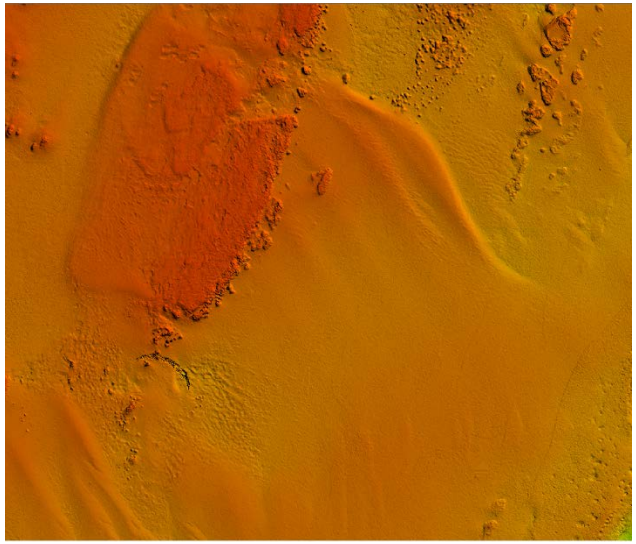
Dewberry





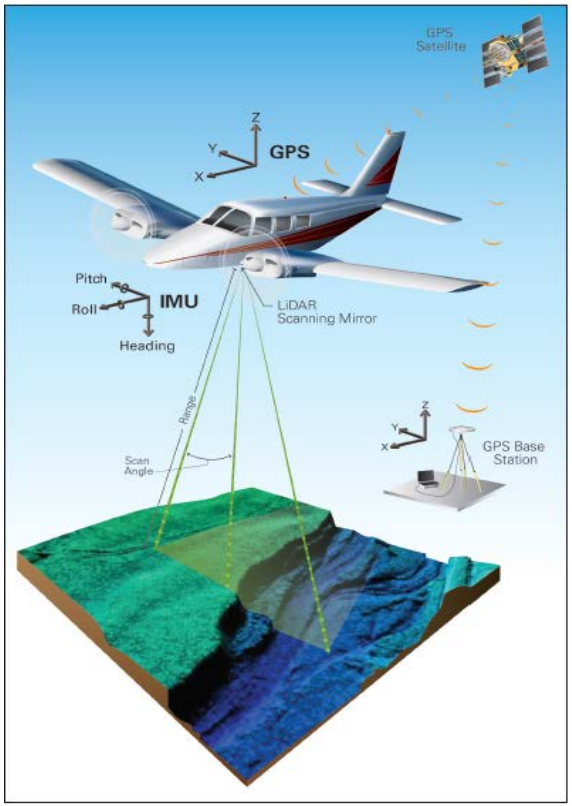


Recent Topobathymetric Lidar Surveys in various coastal, riverine, and lacustrine environments

Amar Nayegandhi, Dewberry

Airborne topobathymetric LiDAR

- Airborne remote sensing technique used to measure the height of the surface on land and underlying streams, rivers, lakes, bays, and shallow coastal waters in moderately clear water column conditions.
- The depth range of bathy LiDAR systems is primarily limited by
  - water clarity (turbidity)
  - bottom reflectivity
  - type of LiDAR system being used.
- Current bathy and topobathy LiDAR systems have depth performance of 1 to 3 times the Secchi depth.



Why topobathy LiDAR?

- Complements acoustic (multi-beam sonar) technology
- Airborne topobathy LiDAR is of high value in filling the “0 to 10 m” depth gap in coastal and riverine areas
- Rapid survey of shallow water areas that are difficult, dangerous, or impossible to get using water borne methods
- Ability to rapidly assess riverine and estuary environments: channel cross sections, biological habitat, riparian conditions

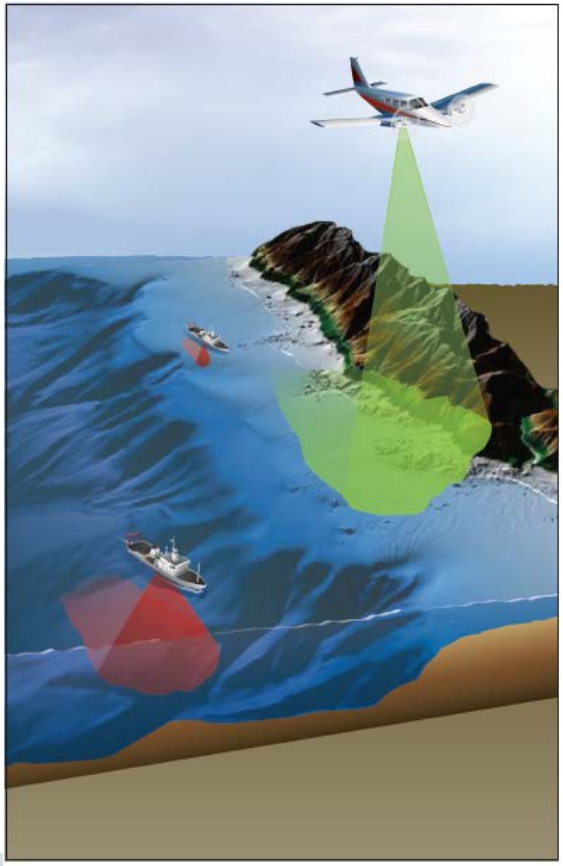
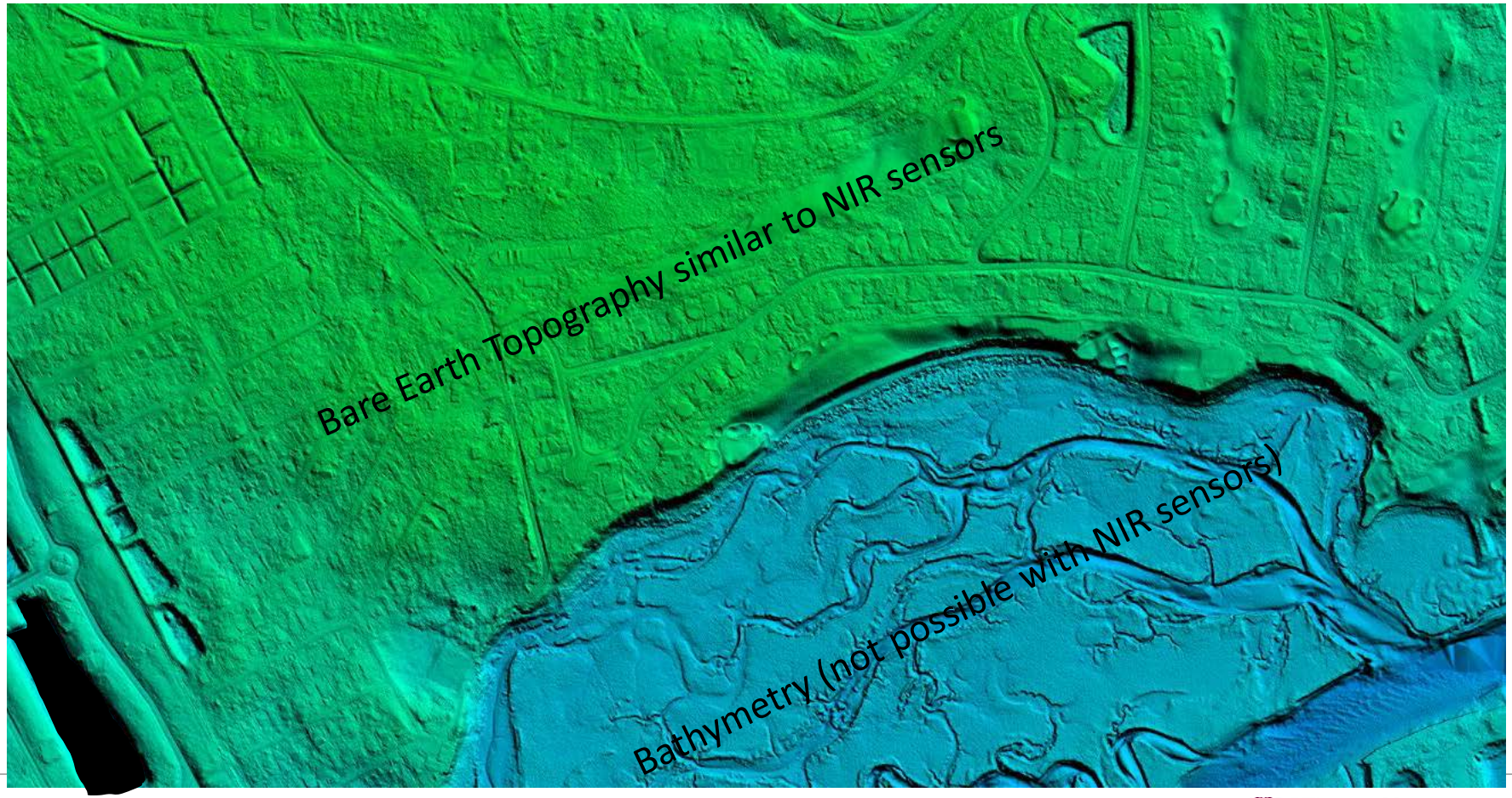
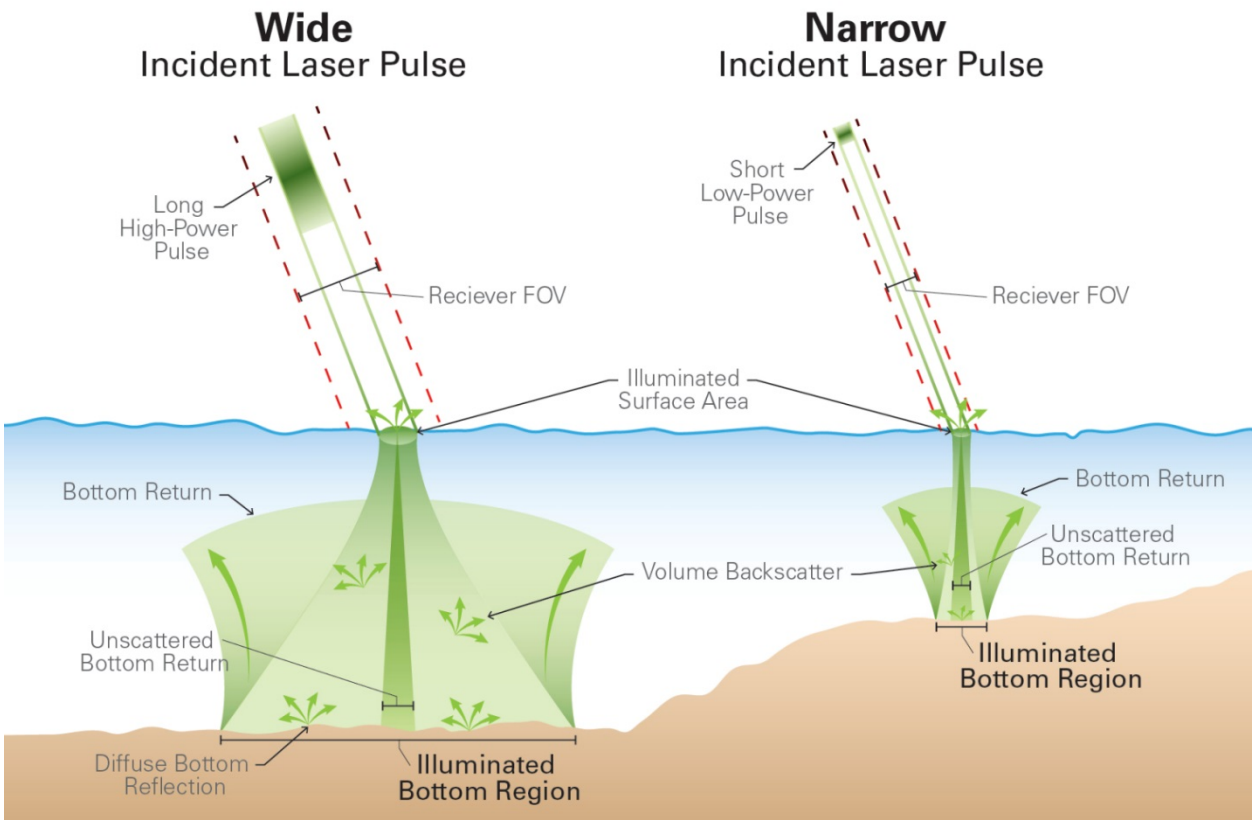


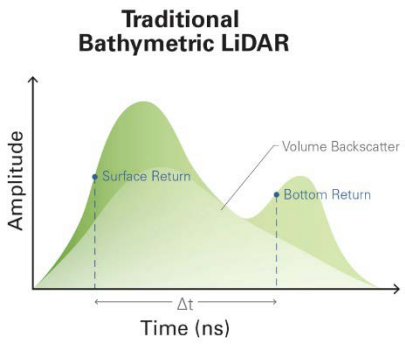
Image courtesy Watershed Sciences, Inc.

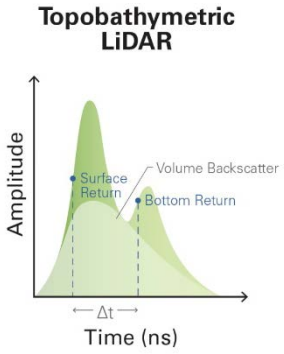
Seamless topobathy DEM



Bathymetric vs. Topobathymetric Lidar







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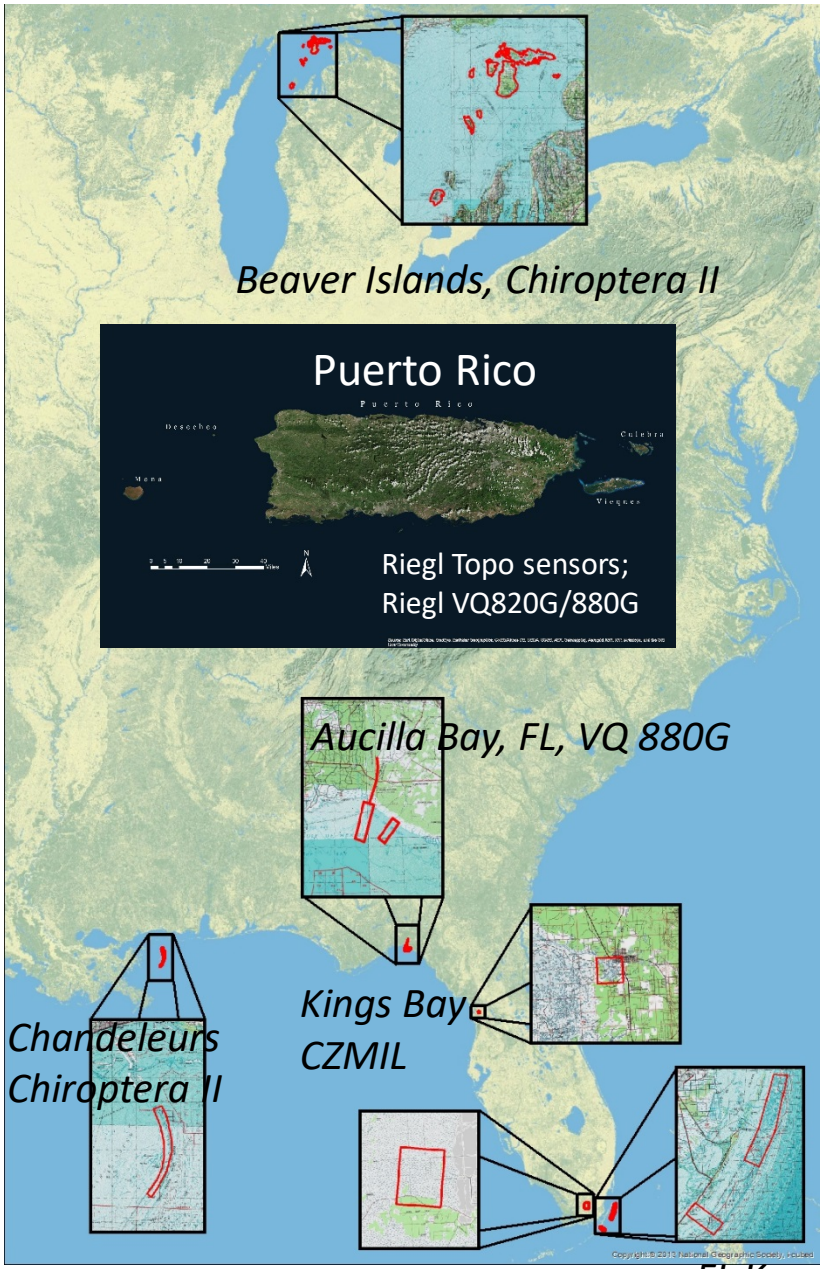
Airborne LiDAR Bathymetric Systems

- Traditional bathymetric systems
  - SHOALS / CHARTS (Optech)
  - LADS (Fugro LADS)
  - HawkEye III (AHAB)
  - CZMIL (Optech)
- Commercial topobathymetric systems
  - Riegl VQ-820G/880G
  - Optech Titan
  - Leica-AHAB Chiroptera
  - CZMIL (Optech)

*Not an exhaustive list



Dewberry's Sensor Selection Criteria

- Dewberry selects/recommends topobathy sensor technology based on a "horses for courses" approach.
- Sensor selection is based on project requirements, intended application, cost, and client recommendation.
- Sensor agnostic / vendor neutral approach
- Work with sensor manufacturers, data acquisition partners, and client to acquire data.
- Dewberry will work with government agencies who own topobathy lidar sensors to help process data from these sensors.
- Will lease sensor/aircraft or subcontract as needed.

Recent Topobathy Projects by Dewberry

Client	Project Location	Sensor Used	Data Acquisition	Application
SWFWMD	Kings Bay / Three Sisters Springs, FL	Optech CZMIL	April 2015	Florida Springs Initiative – protect and preserve natural springs
NOAA Office for Coastal Management	Beaver Islands Archipelago and South Manitou Island, Upper Lake Michigan	AHAB Chiroptera II	November 2015, completed May 2016	Sea Level Rise
USGS & NOAA NGS	Puerto Rico Topography and Topobathy	Riegl Q780i Riegl Q680i Riegl VQ820G	2014/15 (bathy) Jan – May 2016; Dec – Feb 2017 (topo) – 96% complete	Mapping the entire island, including surrounding islands, for USGS 3DEP program.
NOAA NGS	Puerto Rico	Riegl VQ880G	Winter 2015/16	NGS Shoreline Mapping Program
USGS / NPS	Everglades NP Pilot	Riegl VQ880G Optech Titan	April / May 2016	Pilot study to determine the most appropriate sensor technology to use for mapping the Everglades
Florida DEP, Aucilla Research Institute	Aucilla and Ecofina Bay/River	Riegl VQ880G	July 2016	Delineation of submerged river channels
USGS	Chandeleur Islands, Gulf of Mexico	AHAB Chiroptera II	June 2016	USGS Coastal Program research
USGS	Northern FL Reef Tract	AHAB Chiroptera II	June 2016	USGS Coastal Program research
USGS & NOAA (and USACE)	West coast El Nino project	Topo sensor – helicopter based	April-May 2016	Impact of El Nino to beach and cliff erosion along the US west coast
NOAA NGS	Martha's Vineyard and Nantucket	AHAB Chrioptera II	Oct – Nov 2017	NOAA's shoreline mapping program

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

Alvan Karlin, Ph.D., CMS, GISP
Southwest Florida Water Management District

and

Amar Nayegandhi, CP, CMS, GISP
Dewberry

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.

Dewberry®

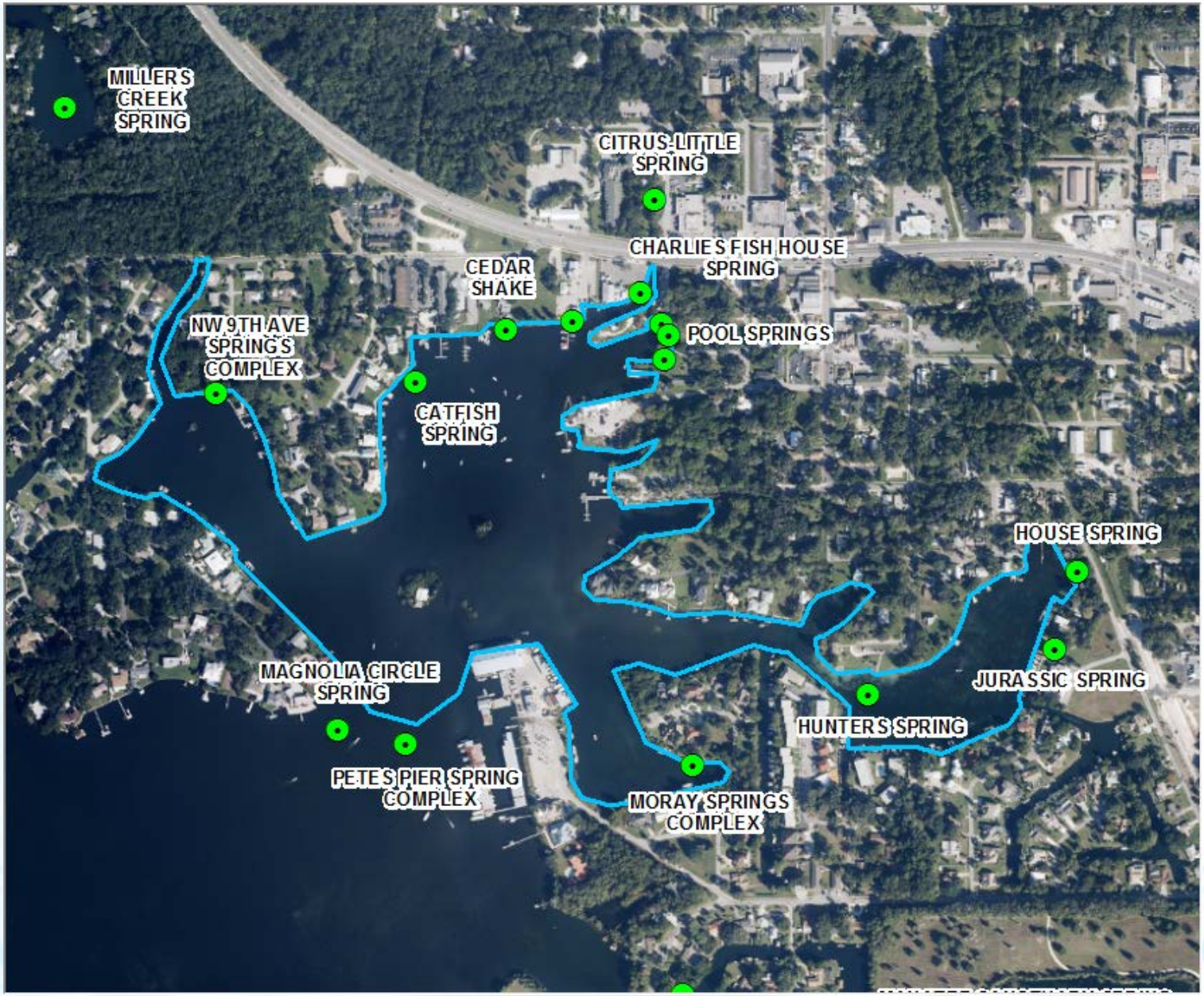
Southwest Florida Water Management District

King's Bay, Citrus County, FL

Near Hunter's Spring (Winter 2015)
137 Manatees

Dewberry®

King's Bay Springs Complex, Citrus County, FL

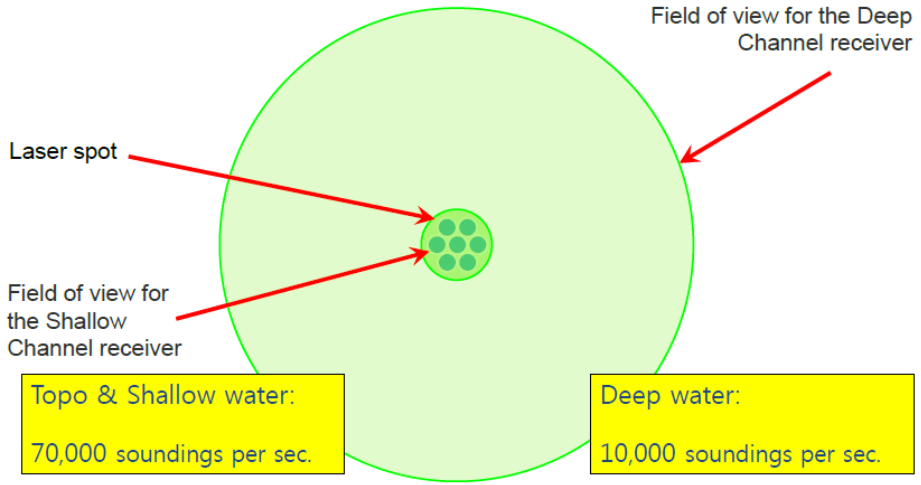


CZMIL Coastal Zone Mapping and Imaging Lidar

Joint Airborne Lidar Bathymetry Technical Center of Expertise

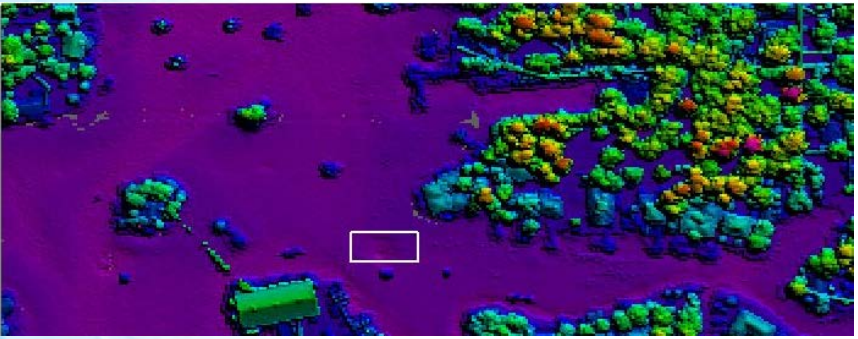
Teledyne/Optech
Coastal Zone Mapping and Imaging LiDAR

One Laser for Deep and Shallow Water Depth Measurement

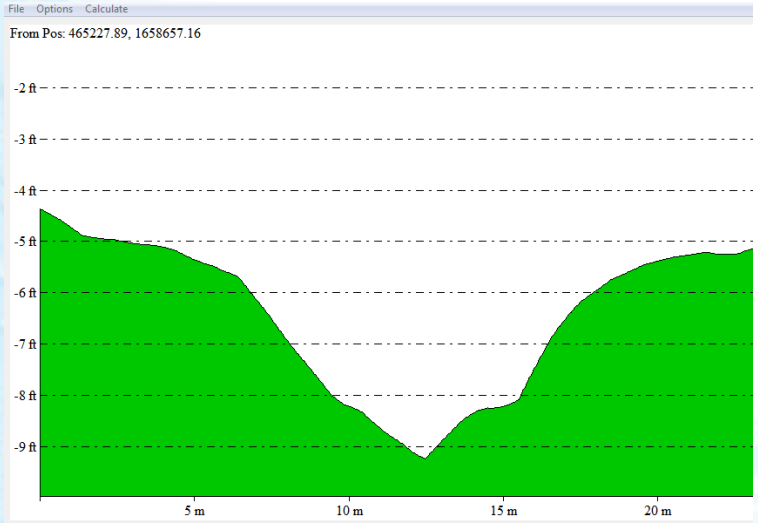


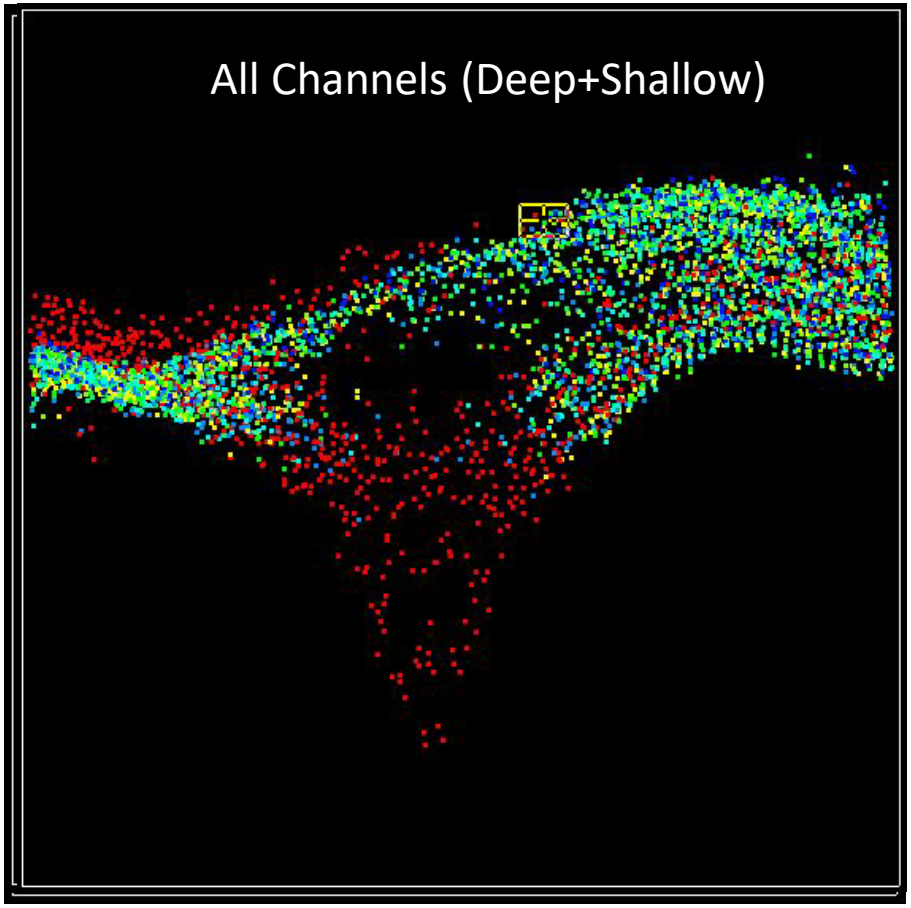
Images care of JALBTCX and Teledyne/Optech)

Why CZMIL Sensor for this study?

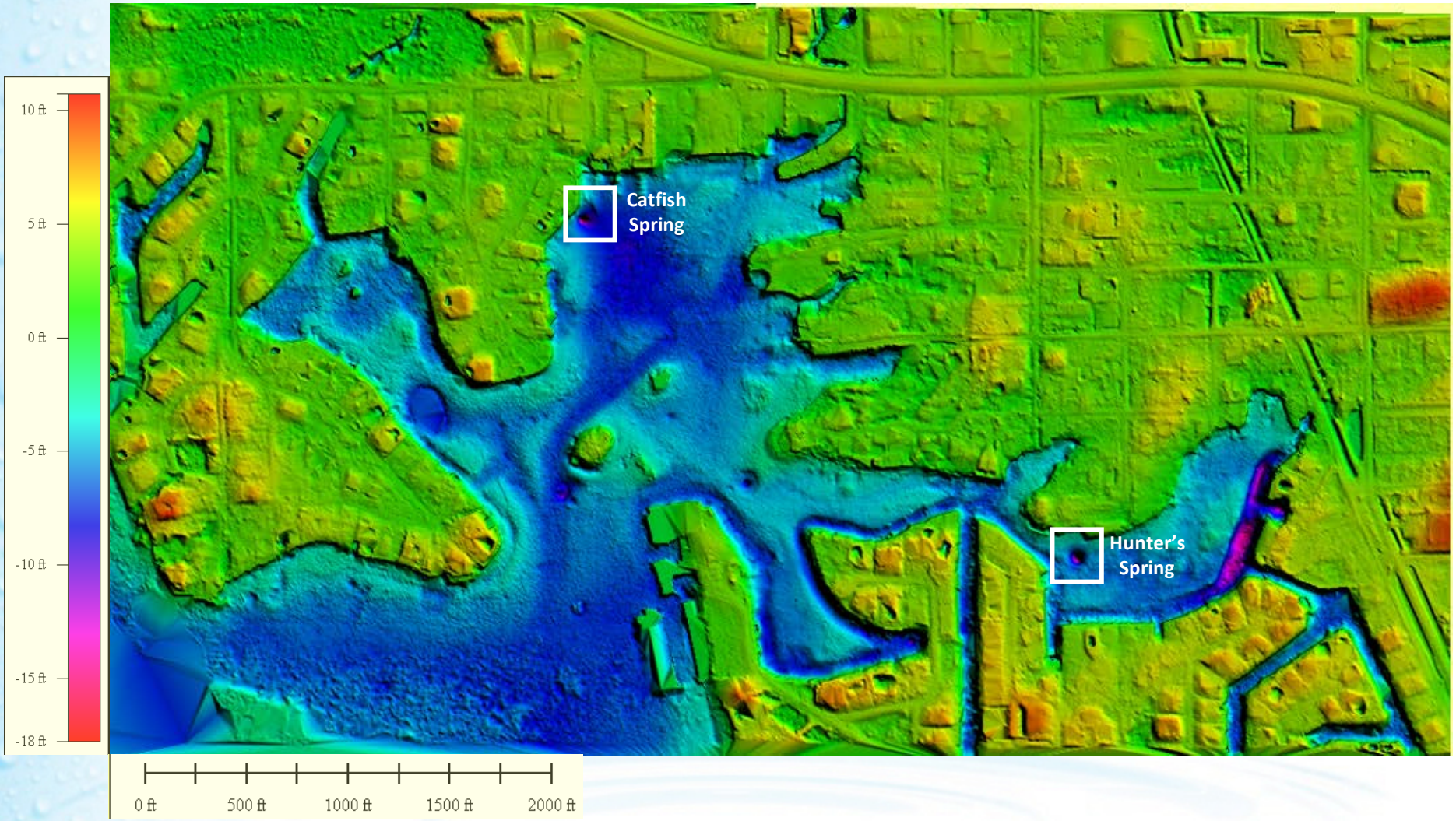


Deep + Shallow channels used to create bathymetric model

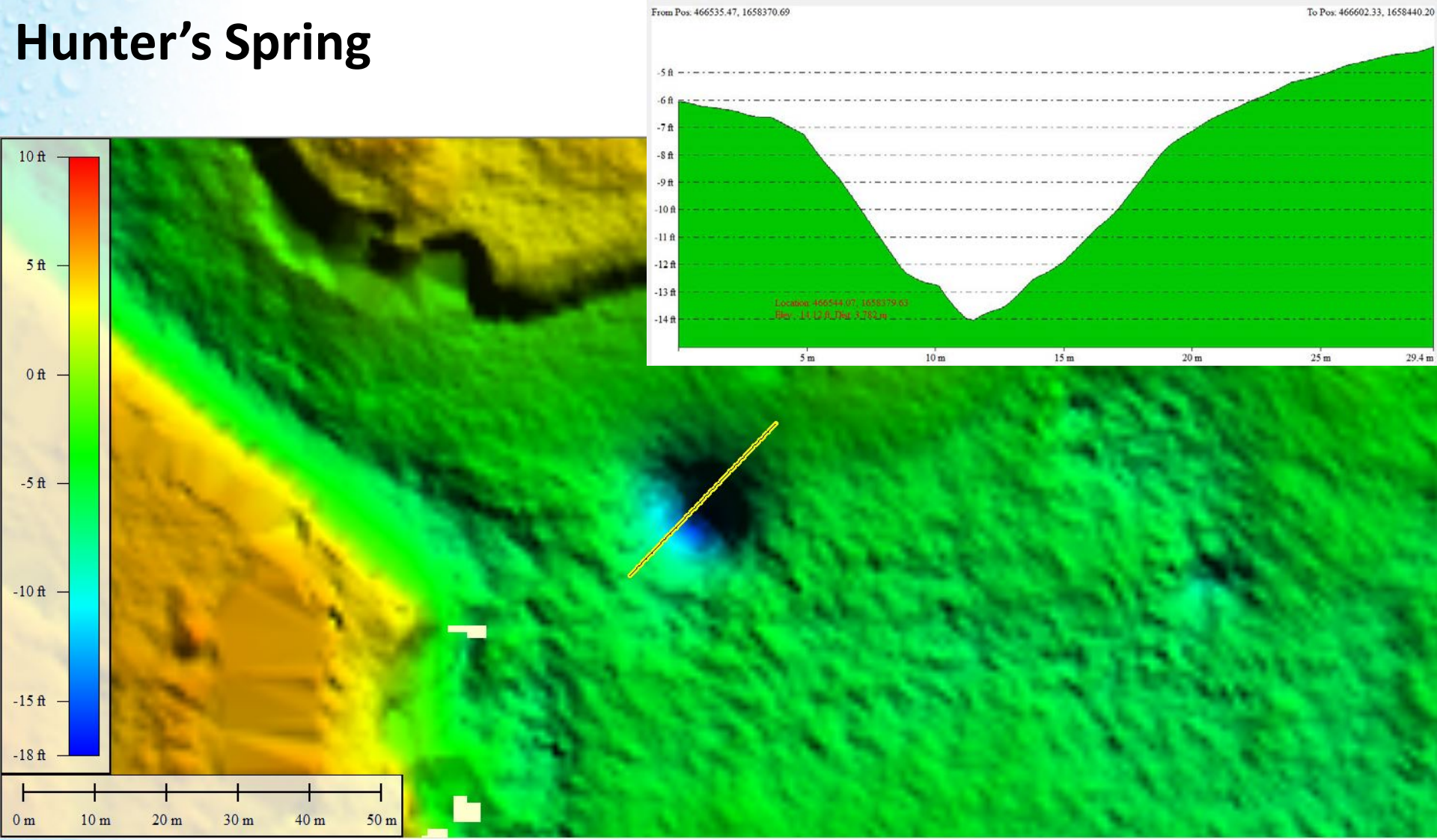




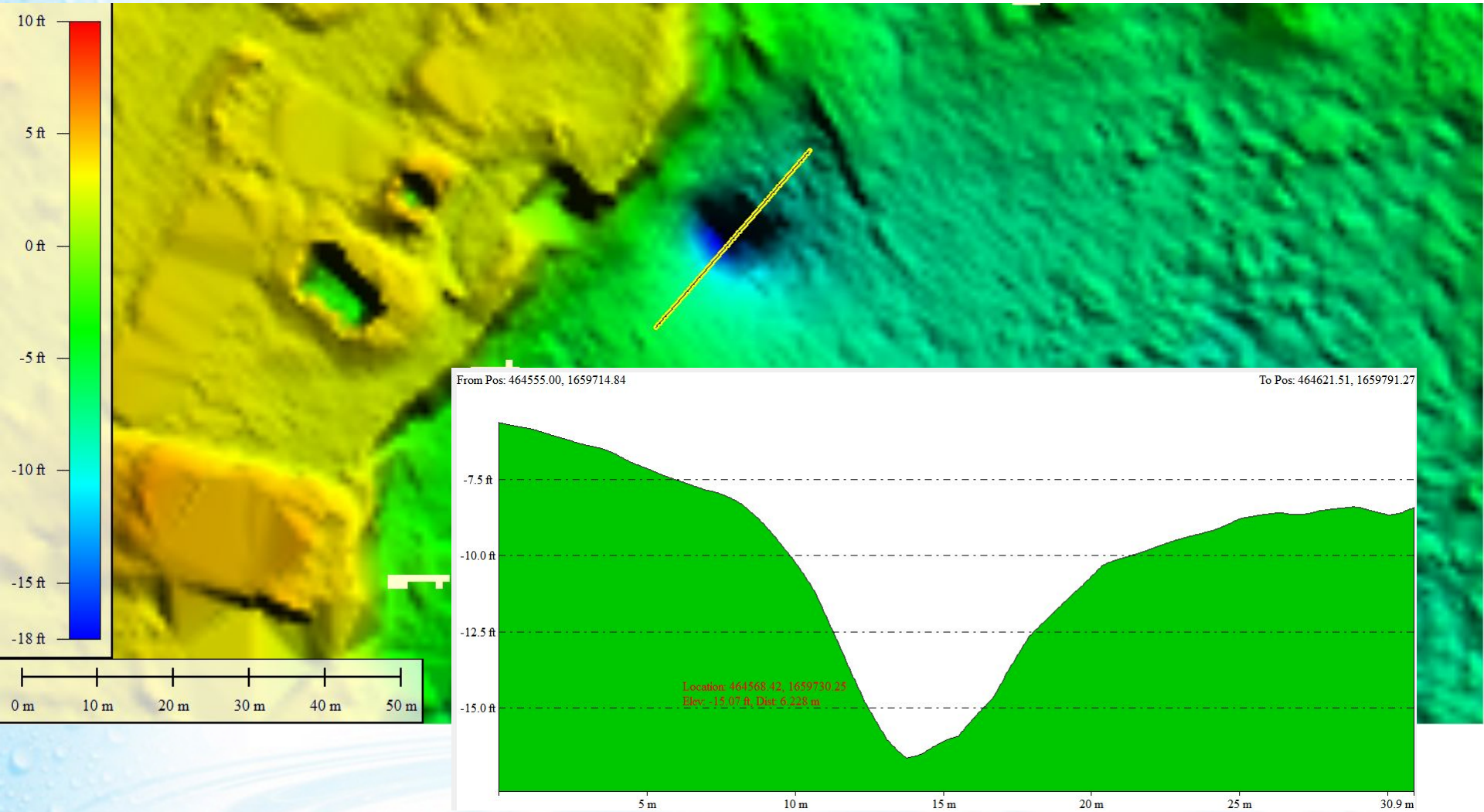
Seamless Topobathymetric Digital Elevation Model (Hard Bottom)



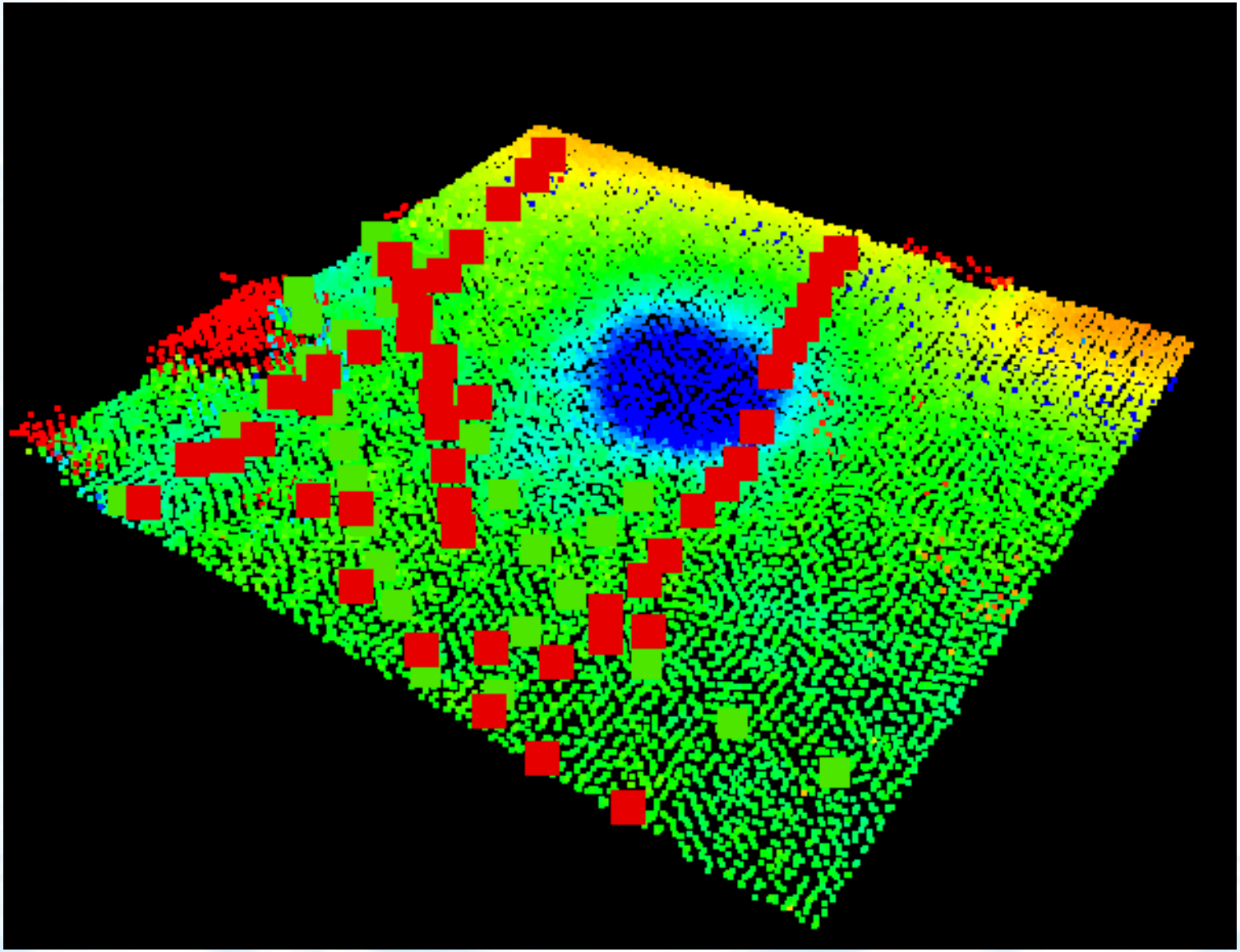
Hunter's Spring



Catfish Spring



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



Everglades National Park LiDAR Project

Dewberry

FL Everglades NP LiDAR Pilot 2016

USGS – NPS funding Partnership for lidar collection covering Everglades National park.

USGS asked Dewberry to fly lidar for the project.

Dewberry proposed a Pilot Study.

- Lidar sensors vary in their ability to collect data over a combination of dry land, wetland and open water.
- Due to the unique nature of the Everglades landscape, we wanted to test lidar sensor technology prior to full implementation of lidar collection for a large area of Everglades NP.

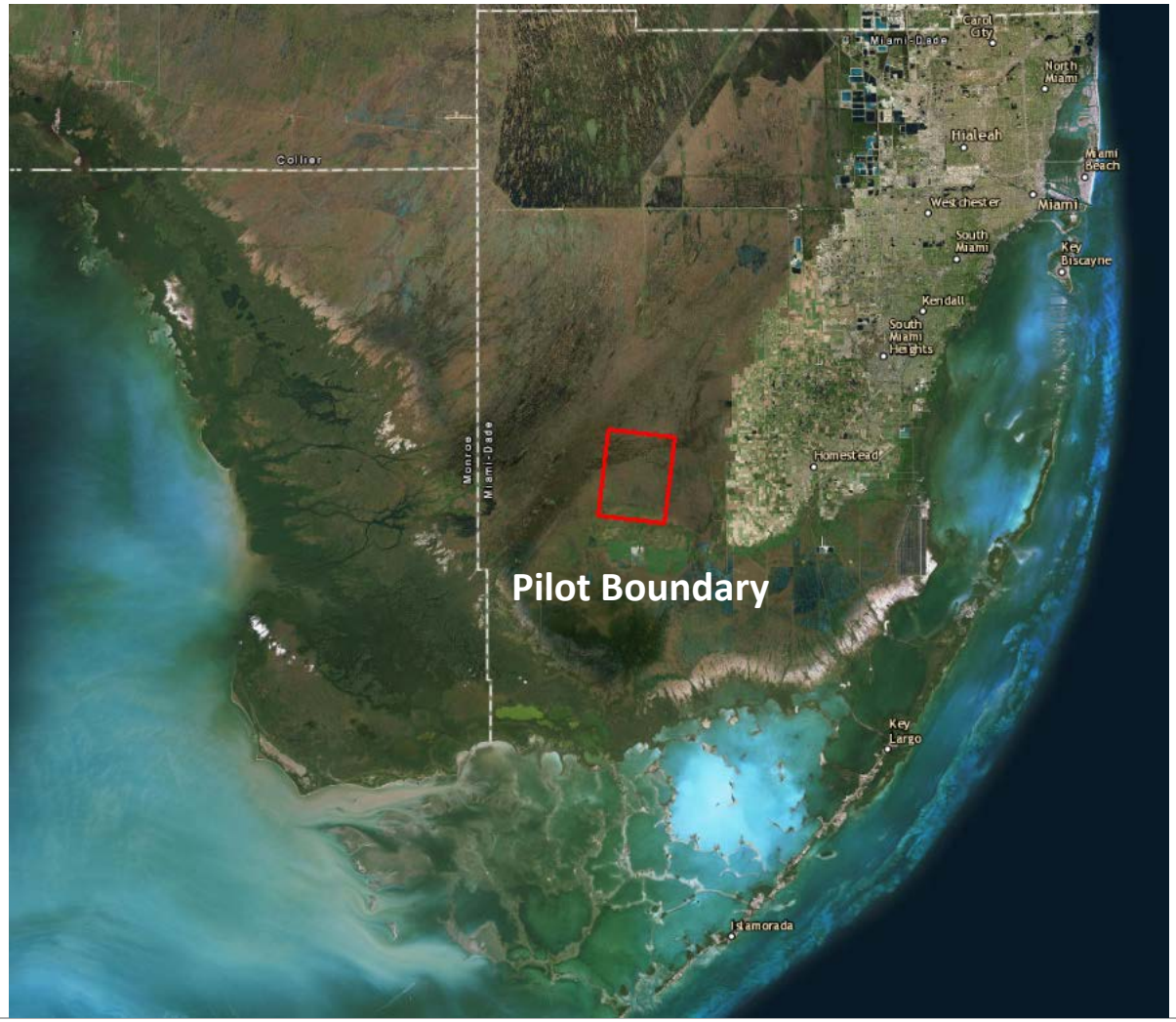
Elevation data resulting from lidar collection and processing will be used to support several scientific studies underway including a study to model marl prairie habitat for the Cape Sable Seaside Sparrow, an endangered non-migratory song bird residing solely in the Everglades.

Cape Sable Seaside Sparrow

Everglades NP LiDAR Pilot 2016

Coordination with NPS to determine a suitable footprint for the pilot project.

- 33 Square Miles



Everglades NP LiDAR Pilot 2016

TWO INDEPENDENT LIDAR ACQUISITIONS WERE COMPLETED

Lidar acquired by NOAA NGS on May 5, 2016.

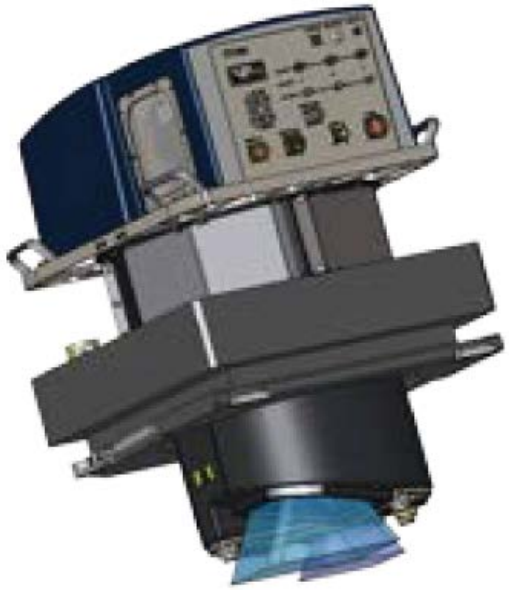
Riegl VQ-880-G lidar sensor

- Combined Topo-Bathymetric airborne laser scanning system
- Full waveform sensor
- Narrow-beam **green** laser
- Integrated **infrared** laser
- Altitude = 400 m AGL

Everglades NP LiDAR Pilot 2016

TWO INDEPENDENT LIDAR ACQUISITIONS WERE COMPLETED

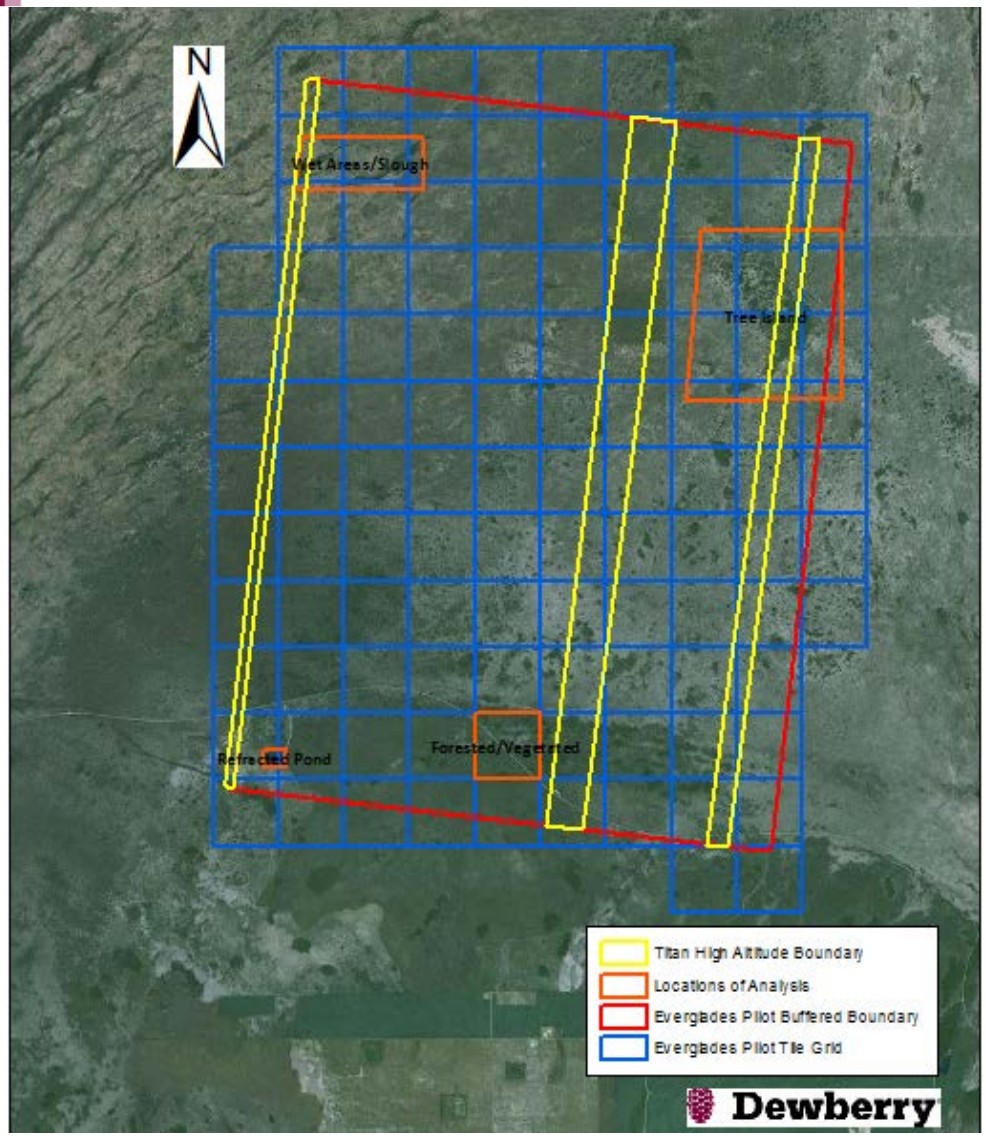
Lidar acquired June 15 -17, 2016.



Teledyne Optech Titan lidar sensor

- Combined Topo-Bathymetric airborne laser scanning system
- Three independent channels – one for each wavelength.
  - 532nm –visible (green)
  - 1064nm -NIR
  - 1550nm -IR
- Altitude 1: 400 m AGL
- Altitude 2: 1000 m AGL

Pilot Acquisition and Analysis – Testing to Model Different Habitats



MAP LEGEND

RED: Project Boundary

- Riegl and Titan LiDAR acquired at 400 m AGL

YELLOW: Titan high-altitude LiDAR acquired at 1000 m AGL

BLUE: Pilot project tile grid

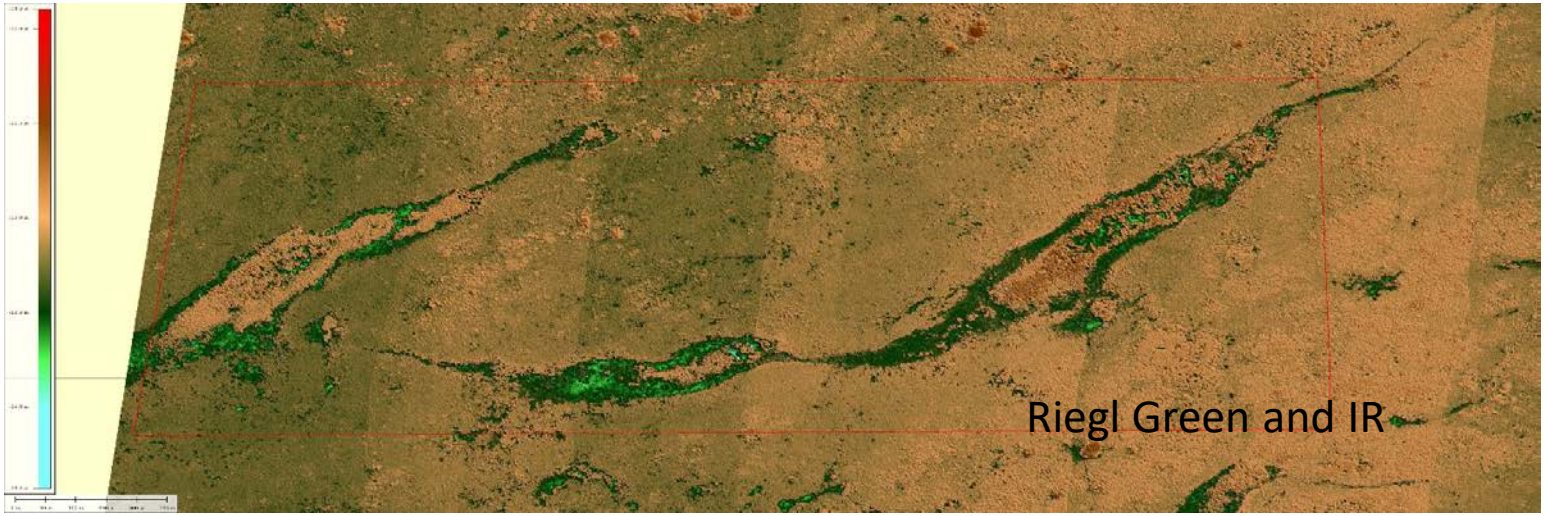
ORANGE:

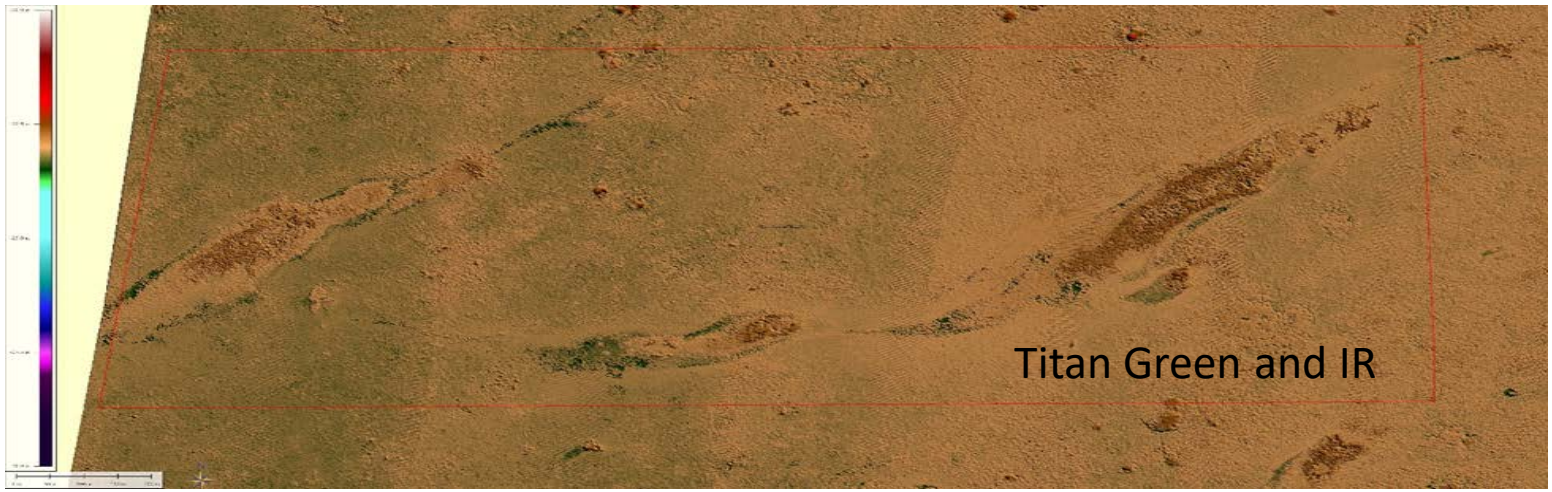
4 areas selected for detailed analysis based on the following land cover types:

- Forested
- Retention Pond (open water)
- Slough
- Tree Island

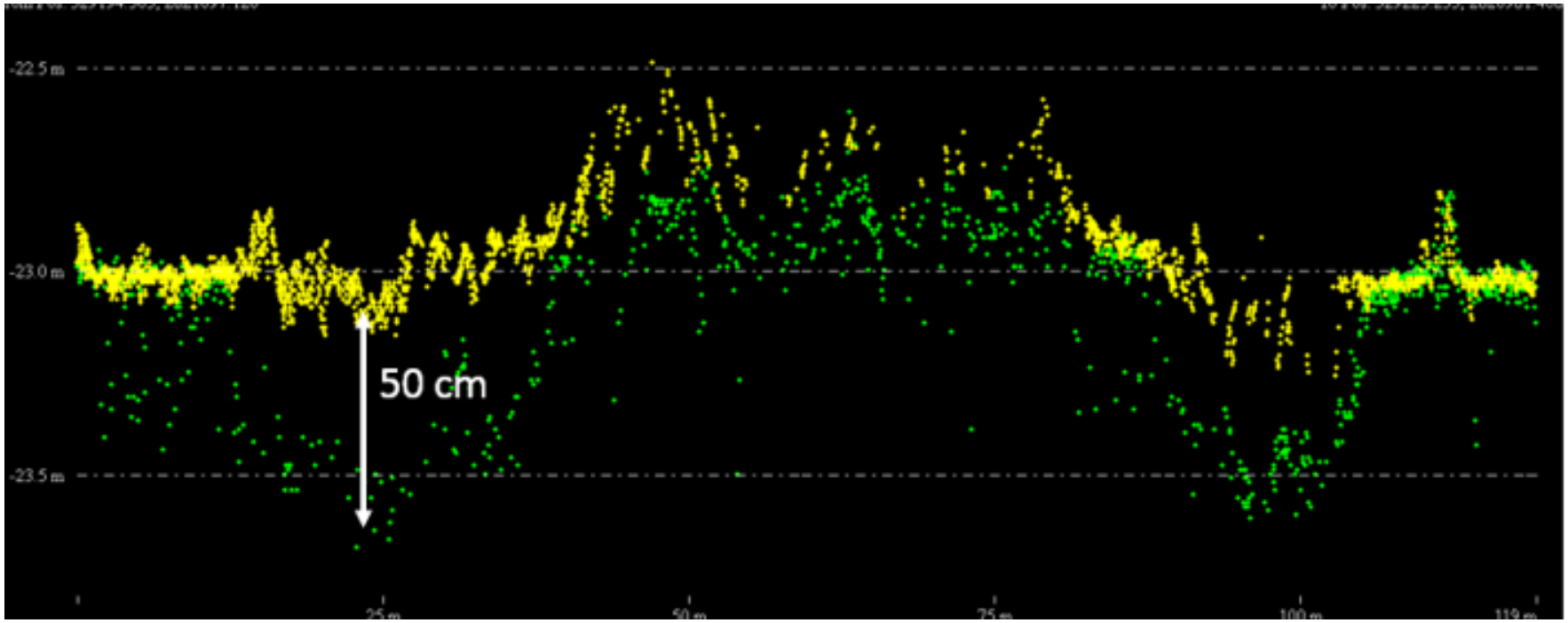
Shallow Slough

Sample DEMs produced from Riegl Green and IR data (top) and Titan Green and IR data (bottom) indicate the ability of the green wavelength data in the Riegl sensor to penetrate through the slough to produce submerged topography. The Titan Green data did not consistently penetrate through the water column to produce bottom returns.





Shallow Slough – Profiles



GREEN POINTS = Riegl Green

YELLOW Points = Titan Green

The Riegl green laser returns are consistently lower in areas that have water.

Pilot Project Conclusions

The modelling capabilities of the two sensors did exhibit significant differences in the shallow wet areas within Sloughs and within, and adjacent to, the Tree Islands.

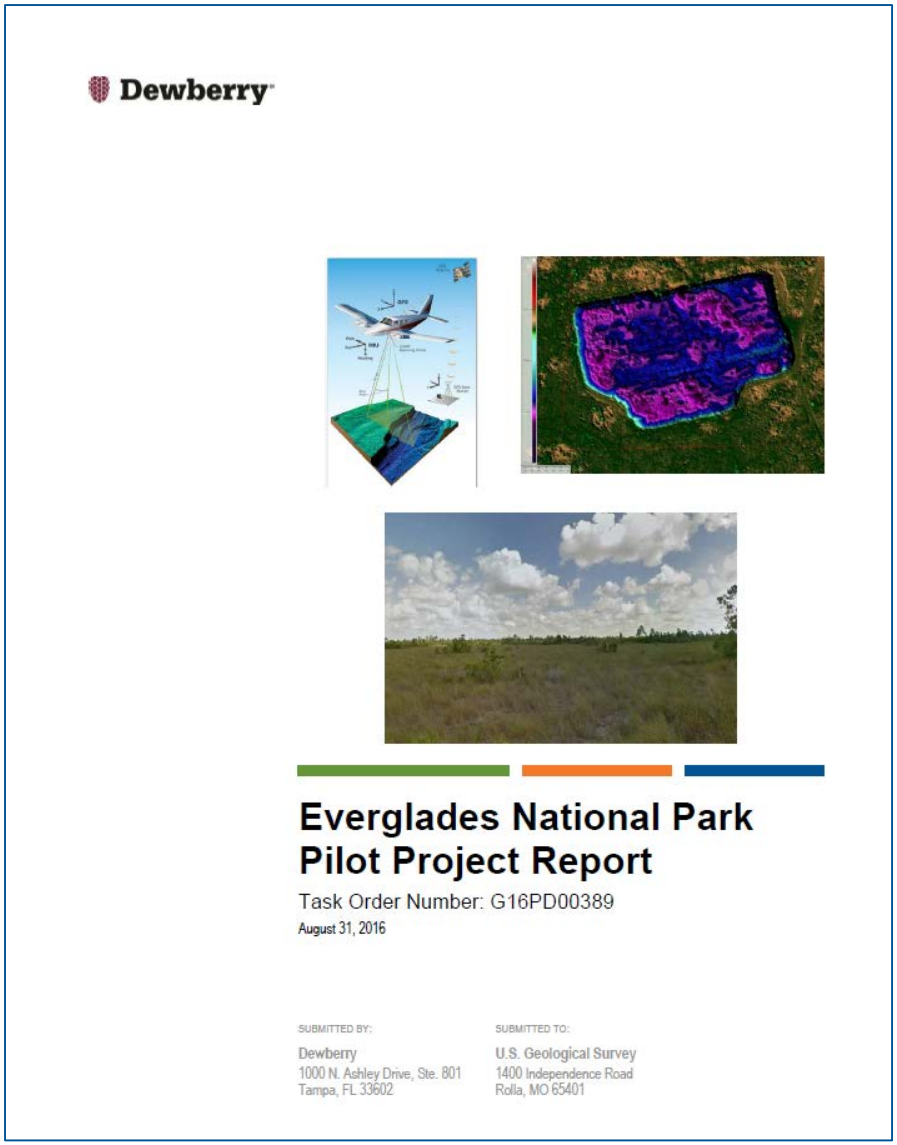
- The Riegl sensor was able to measure the shallow water depths (~50 cm – 1 m deep) more consistently than the Titan sensor.
- The Riegl sensor uses a short-pulse laser which enables improved depth performance in very shallow waters.

The ability to measure shallow water depths is a very important consideration for the Everglades National Park.

Pilot Project Report

The knowledge gained from the completion of the pilot project served to better scope the methodology to be used for the collection of LiDAR over a larger area of the Everglades National Park.

Dewberry's Pilot Project Report is available upon request.


Dewberry

Everglades National Park
Pilot Project Report

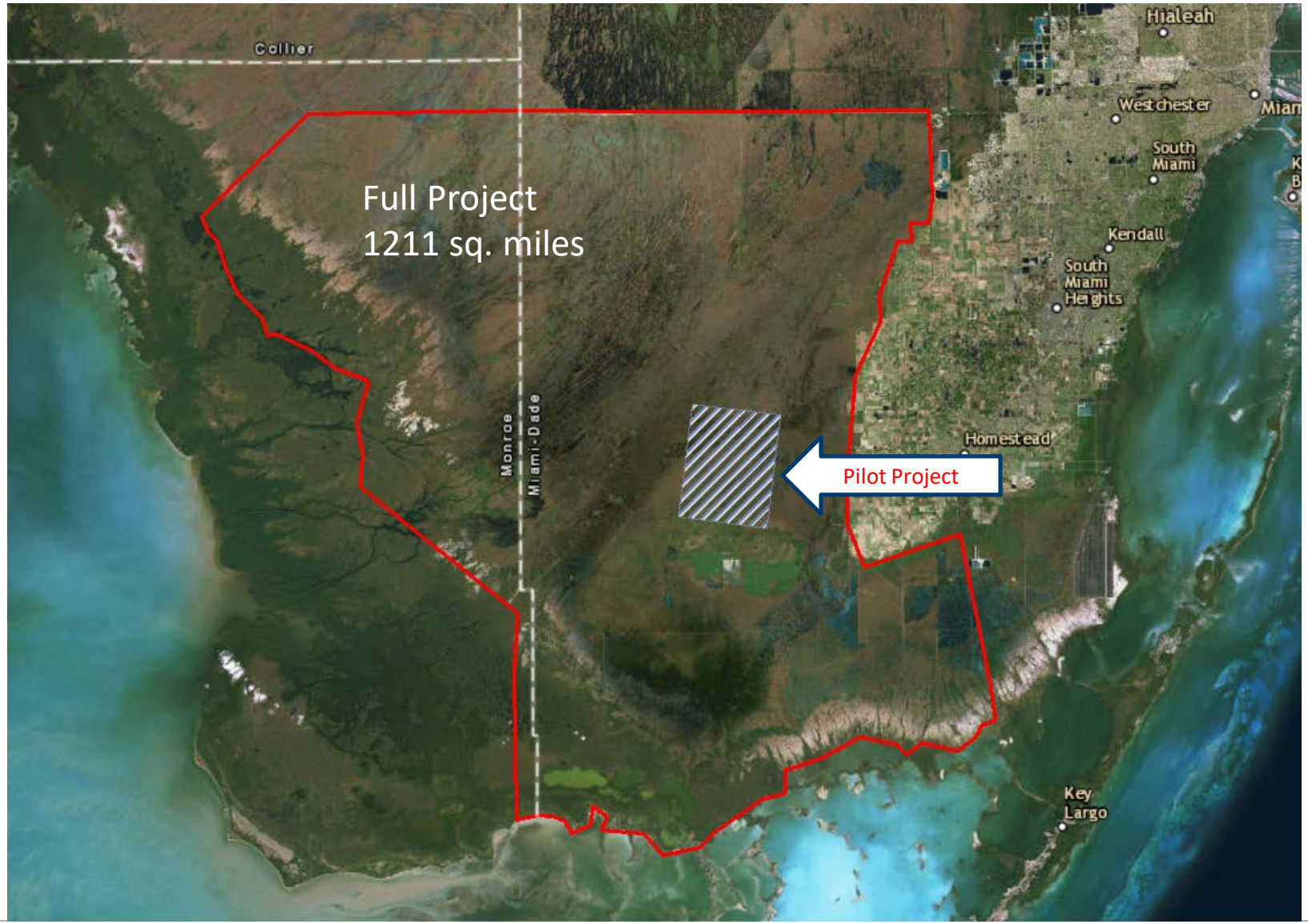
Task Order Number: G16PD00389

August 31, 2016

SUBMITTED BY:
Dewberry
1000 N. Ashley Drive, Ste. 801
Tampa, FL 33602

SUBMITTED TO:
U.S. Geological Survey
1400 Independence Road
Rolla, MO 65401

Everglades NP LiDAR Project



ENP Lidar - Full Project Acquisition Plan

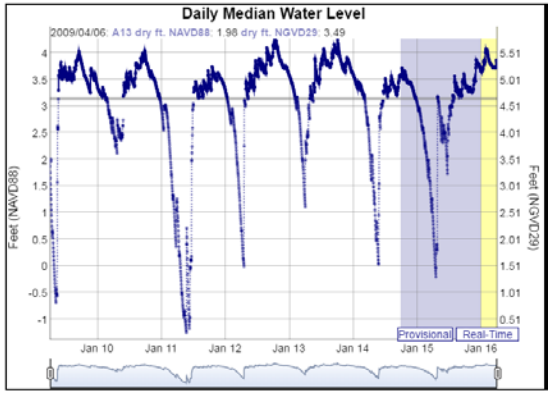
Planned Flying Height

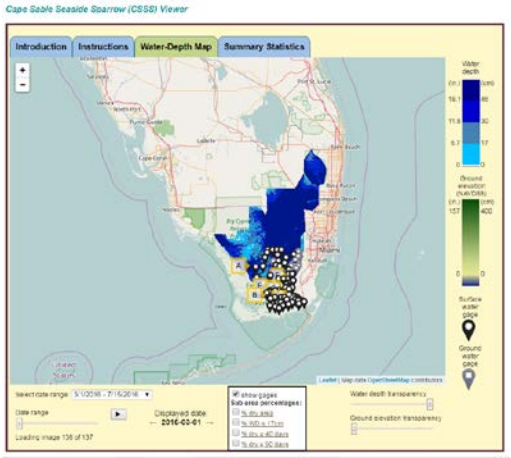
- ~600 m AGL

Planned Density

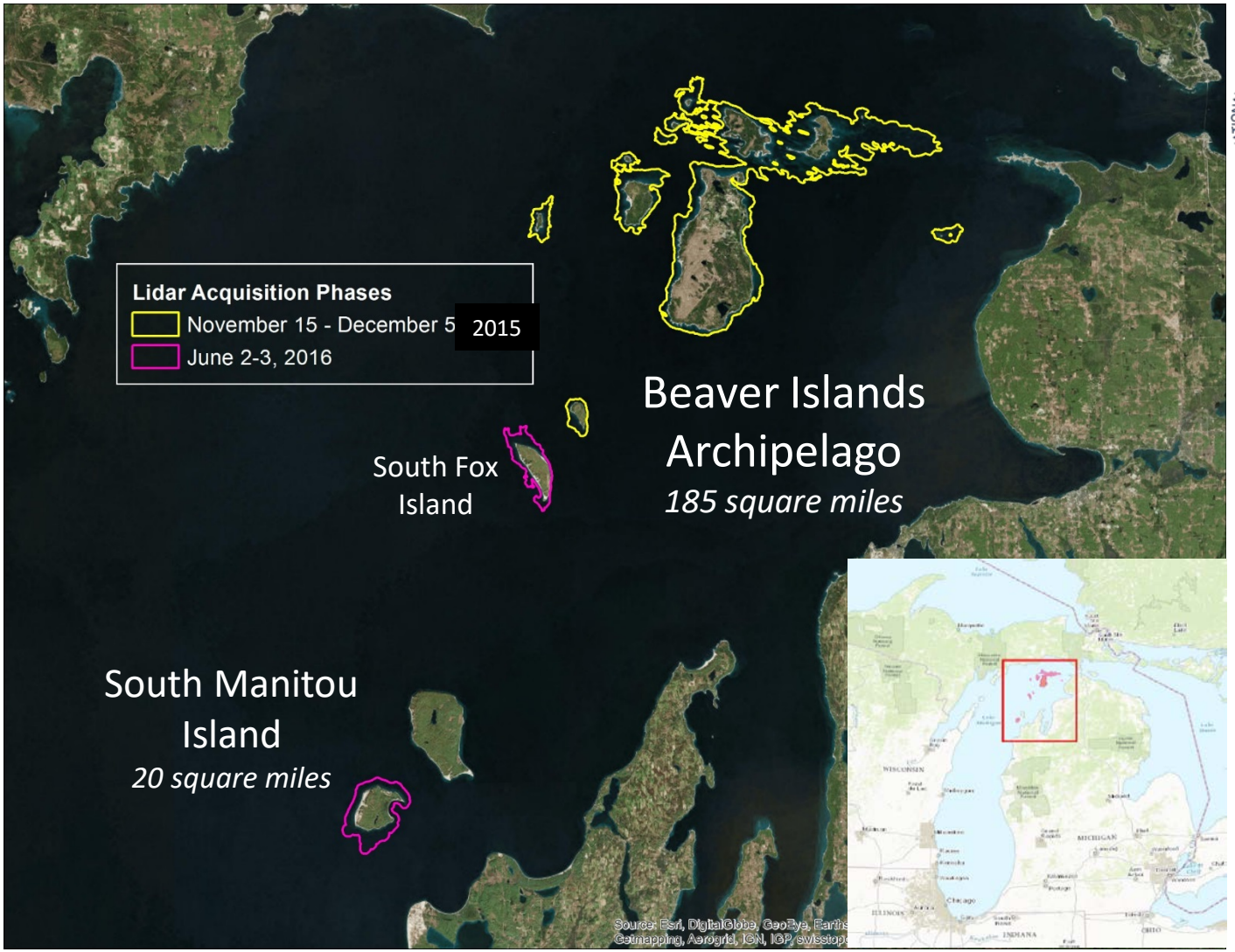
- IR wavelength = 6+ppsm
- Green wavelength = 8+ppsm

- **Timing**
  - Coordinate with NPS
  - Monitor real-time water level gages
  - Monitor ground conditions prior to mobilization
  - **Lidar Collection – March – May 2017**

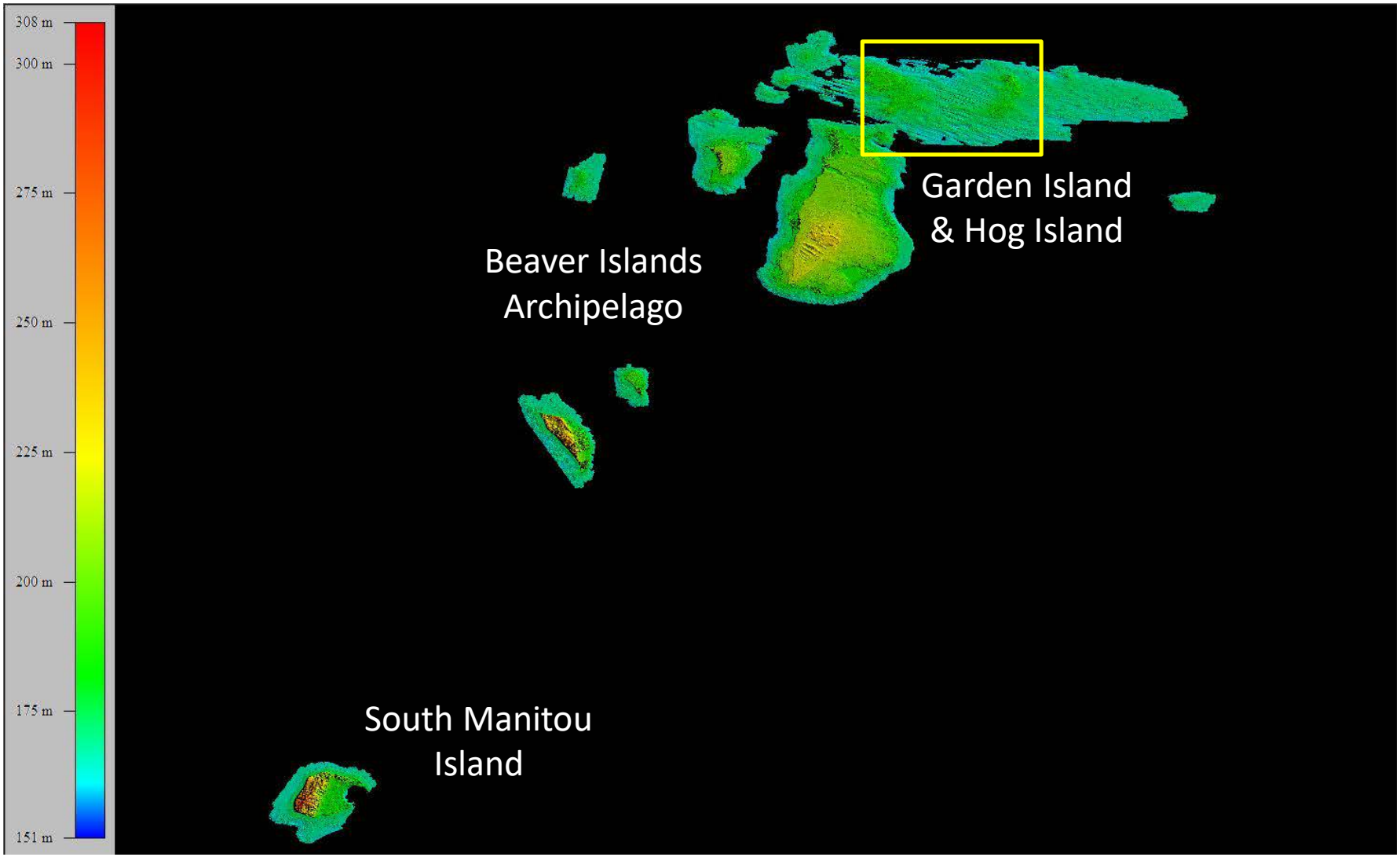




Beaver Islands Archipelago & South Manitou Island Topobathy Lidar Survey


Lidar Acquisition Phases
November 15 - December 5 2015
June 2-3, 2016
Beaver Islands Archipelago
185 square miles
South Fox Island
South Manitou Island
20 square miles
Source: Esri, DigitalGlobe, GeoEye, Earth
Getmapping, Aerogrid, IGN, IGP, swisstop
WISCONSIN
MICHIGAN
Chicago
ILLINOIS
INDIANA
OHIO

Northern Lake Michigan Topobathy Lidar



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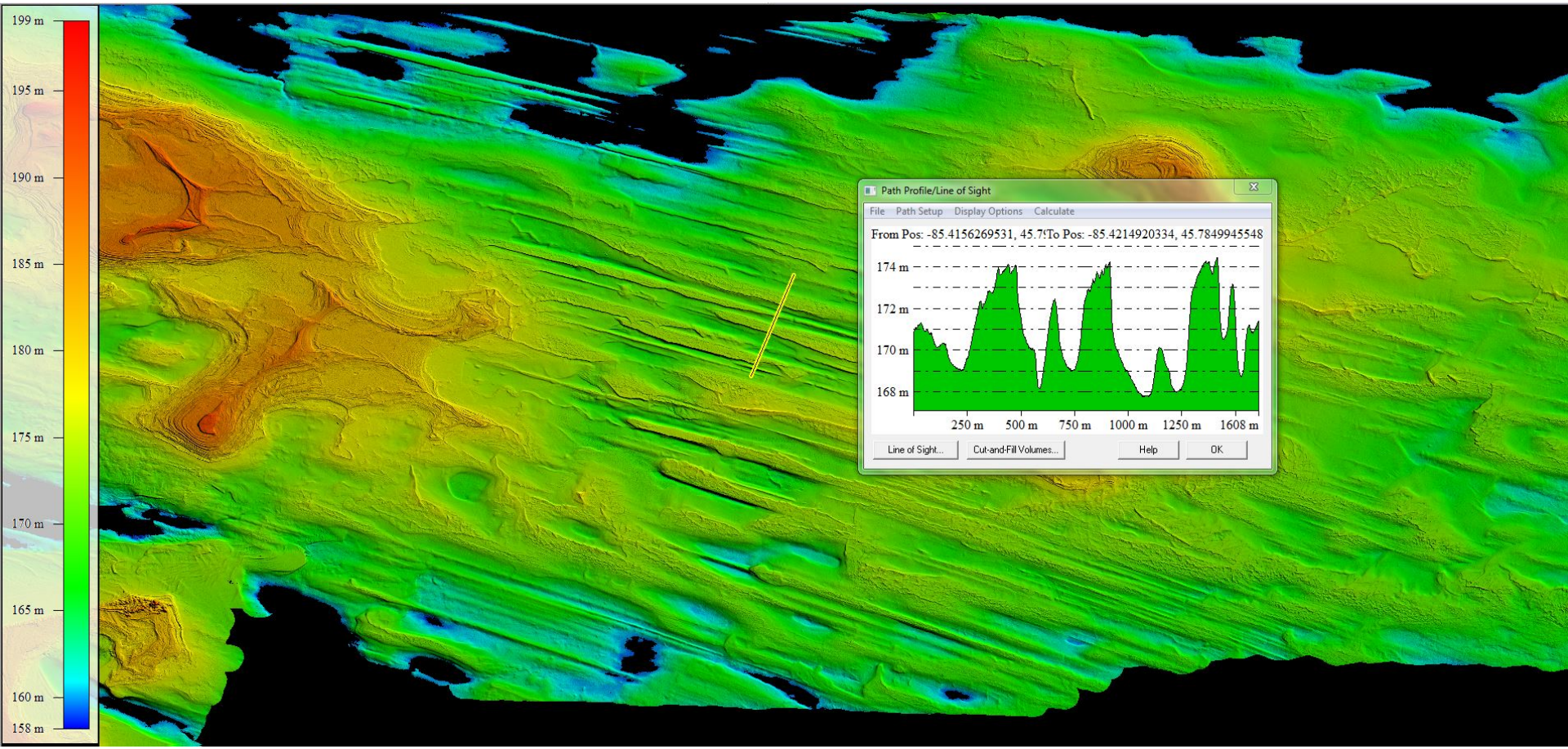
Garden and Hog Islands



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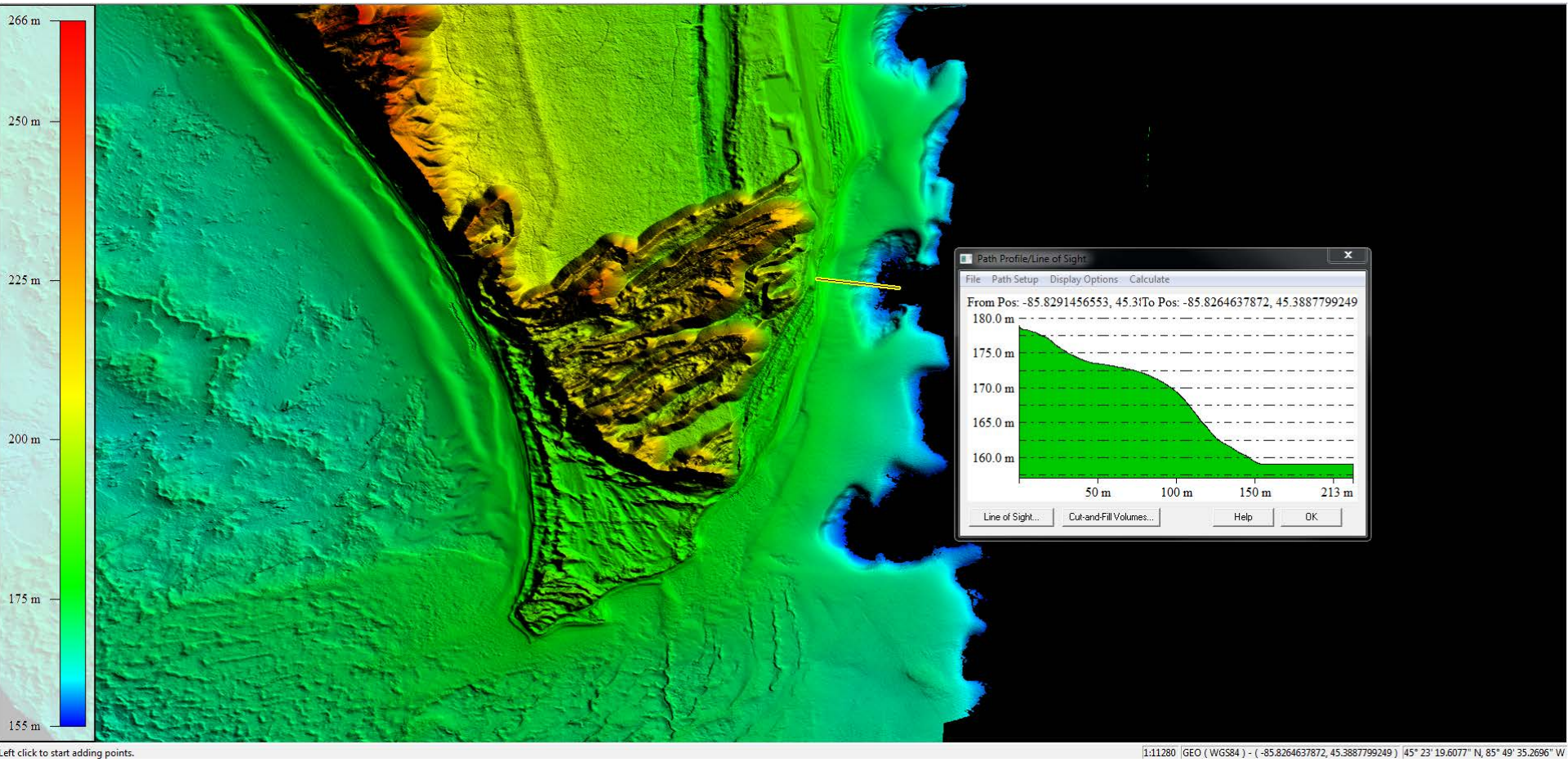
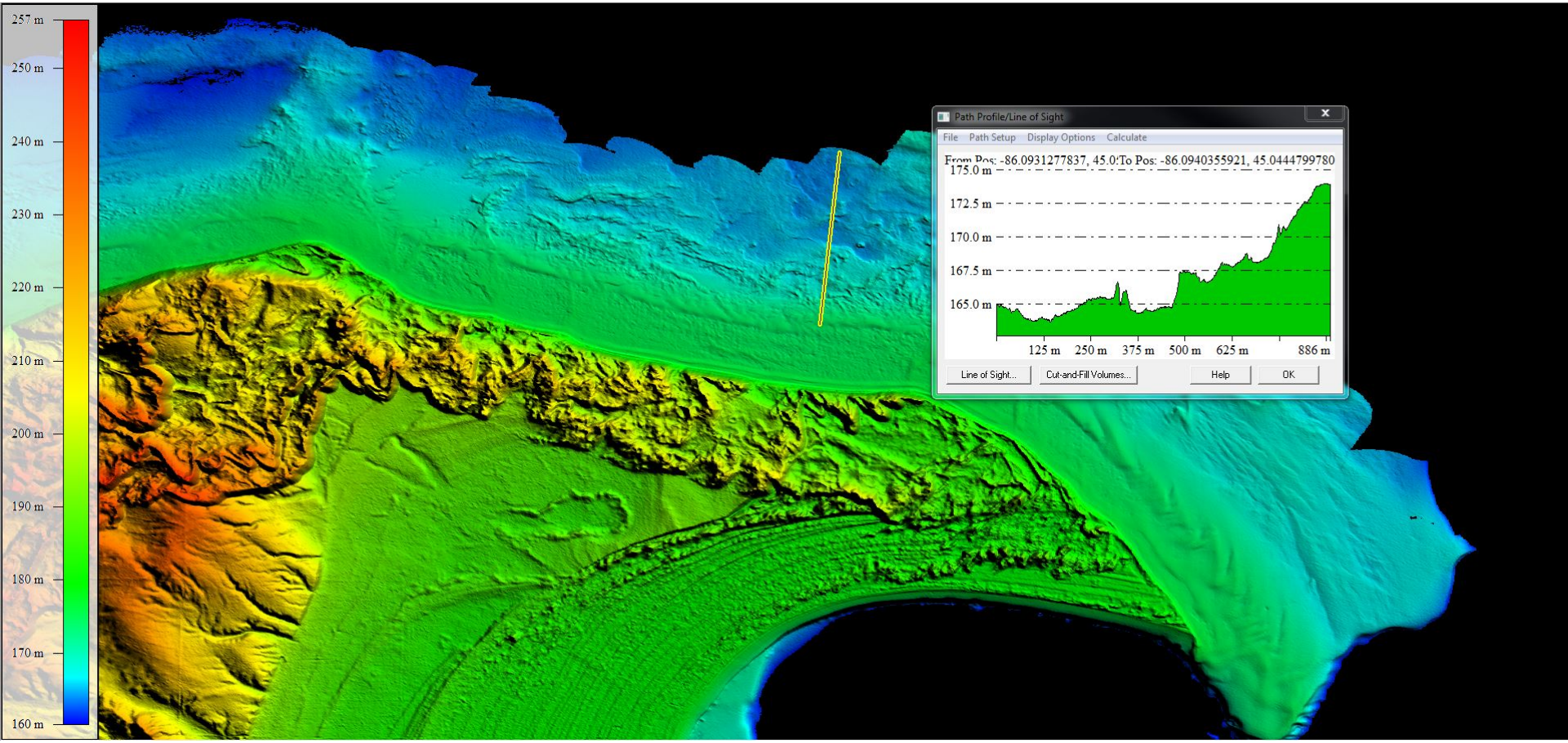
South Fox Island



South Manitou Island DEM



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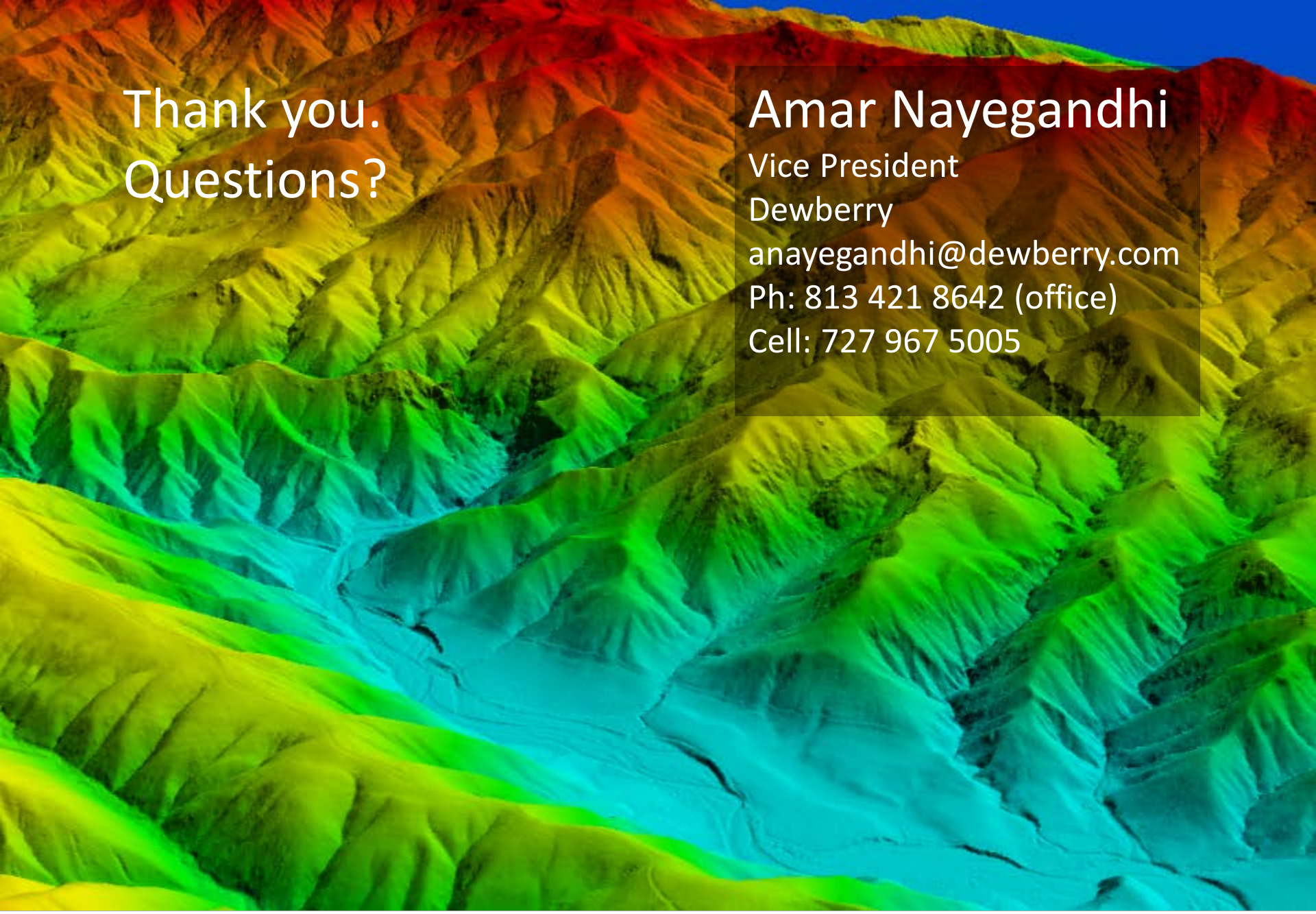

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