

# *LIDAR*



## **VERMONT SOCIETY** *of* **LAND SURVEYORS**

J. Thaddeus "Thadd" Eldredge

*ELDREDGE SURVEYING & ENGINEERING, LLC*

1038 Main Street, Chatham, MA 02633

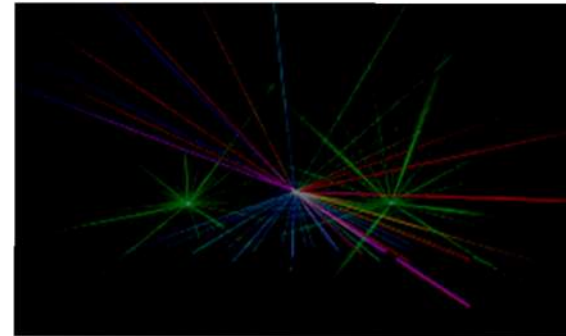
[www.ese-llc.com](http://www.ese-llc.com)

***J. THADDEUS “THADD”  
ELDREDGE***

- BA in Theoretical Mathematics, Colby College
- PLS Certificate from Wentworth Institute of Technology
- PLS 46471, MA
- Soil Evaluator, MA
- Certified Floodplain Manager, USA
- Has a fancy pants name; goes by Thadd.
- I will try to not put you to sleep.

# *WHAT IS LIDAR?*

- Laser Radar
- Light Detection and Ranging
  - Scanning

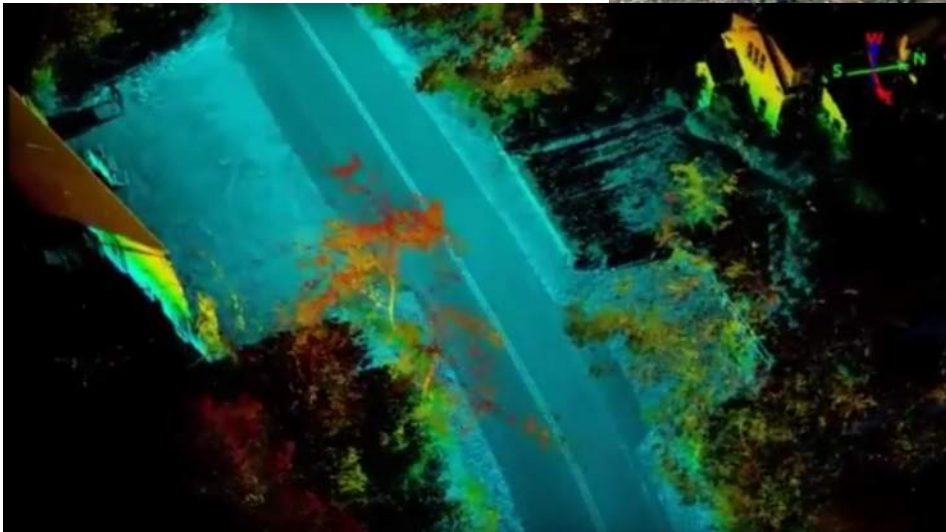


Lidar (also written LIDAR, **LiDAR** or LADAR) is a remote sensing technology that measures distance by **illuminating a target with a laser and analyzing the reflected light**. Although thought by some to be an acronym of Light Detection And Ranging,[1] the term lidar was actually created as a portmanteau of "light" and "radar".

[2][3] Lidar is popularly used as a technology to make high-resolution maps, with applications in geomatics, archaeology, geography, geology, geomorphology, seismology, forestry, remote sensing, atmospheric physics, airborne laser swath mapping (ALSM), laser altimetry, and contour mapping. (wikipedia) **SURVEYING!!!**

# ***WHO IS USING LIDAR?***

- Aerial
- Static
- Mobile



Oyster Bay Lane  
Sullivan  
Stream Analysis

Video Sources:

2014 NOAA Aerial LiDAR "Post-Sandy"

***ELDREDGE SURVEYING & ENGINEERING, LLC***

1038 Main Street, Chatham, MA 02633

[www.es-e-llc.com](http://www.es-e-llc.com)

# *POINT CLOUD FORMATS*

Rapidlasso - \*.las and \*.laz  
ASTM – \*.e57  
Text - \*.xyz and \*.pts

**There are more.**

E57 is being developed by a committee within the American Society for Testing and Materials. It may one day be the universal standard for imagery and scan data.

Text formats are valid and you can make your own point clouds!

X,Y,Z

X,Y,Z

X,Y,Z



I like the LAS and LAZ formats the best. LAZ is the most compact format. **The Vermont LiDAR all seems to be in LAS format.**

<https://rapidlasso.com/>

- Downloadable tools with a rough GUI. Some are open license and others require licensing.
- Downloadable toolboxes for:
  - ARC
  - QGIS

# ***SURVEY POINTS V. POINT CLOUD***

- Surveyed Points (smart)
- Few
- Specific targets – That point is along that edge of pavement and that one is at the building corner.
- Described – Even when the descriptor is cryptic, there is still something there.
- Scanned Points (dumb)
- Many
- Unspecific targets – That point is on an object and I don't know if it is at the edge of the pavement or right at the building corner.
- Undescribed - That point is on an object and when I look at the 2000 points around it plus the imagery, I see a bush.

# ATTRIBUTES

THESE ARE MORE THAN JUST POINTS

Point Query

Model: Job313664\_2013\_2014\_usgs\_post\_sandy\_ma\_nh\_ri

<u>Model Info</u>		<u>Source File Info</u>	
X:	1,066,735.22 ft	File:	Job313664_2013_2014_usgs_post_sandy_ma_nh_ri.las
Y:	2,720,692.32 ft	Folder:	C:\Users\Thadd\AppData\Local\Temp\QTTempFilesFolder\TMP65B9.tmp\
Z:	76.57 ft	X:	1,066,735.220 ft
Intensity:	248	Y:	2,720,692.320 ft
		Z:	76.575 foot
		Intensity:	247
		Return Number:	1
		Number Returns:	1
		Scan Direction:	1
		Line Edge:	0
		Classification:	18
		Classification (8-Bit):	18
		Scan Angle:	12.7559 deg
		User Data:	0
		Point Source ID:	1,251
		Withheld:	0
		Synthetic:	0
		Keypoint:	0
		Time:	80,836,473.4150913 sec (RAW)

Create Marker Here    Do It!    Copy to Clipboard    Help    Close

Classifications (Right-Click to Change Color/Name)

Code	Description
<input type="checkbox"/>	0 Created, never classified
<input type="checkbox"/>	1 Unclassified
<input checked="" type="checkbox"/>	2 Ground
<input type="checkbox"/>	3 Low Vegetation
<input type="checkbox"/>	4 Medium Vegetation
<input type="checkbox"/>	5 High Vegetation
<input type="checkbox"/>	6 Building
<input type="checkbox"/>	7 Low Point (Noise)
<input type="checkbox"/>	8 Model Key-point (mass point)
<input type="checkbox"/>	9 Water
<input type="checkbox"/>	10 Railroad
<input type="checkbox"/>	11 Road
<input type="checkbox"/>	12 Overlap
<input type="checkbox"/>	13 Wire - Guard (Shield)
<input type="checkbox"/>	14 Wire - Conductor (Phase)
<input type="checkbox"/>	15 Transmission Tower
<input type="checkbox"/>	16 Wire-structure Connector
<input type="checkbox"/>	17 Bridge
<input type="checkbox"/>	18 High Point (Noise)
<input type="checkbox"/>	19 Reserved for ASPRS Definition

Enable All    Disable All

Return Types to Display

Return Type
<input checked="" type="checkbox"/> Unknown
<input checked="" type="checkbox"/> First
<input checked="" type="checkbox"/> Second
<input checked="" type="checkbox"/> Last
<input checked="" type="checkbox"/> Single
<input checked="" type="checkbox"/> First-of-Many

Restore Default Settings



# ***SOFTWARE***

<http://www.ese-llc.com/lidar> - This is a dumping ground webpage for links to LiDAR software.

## Software you may have:

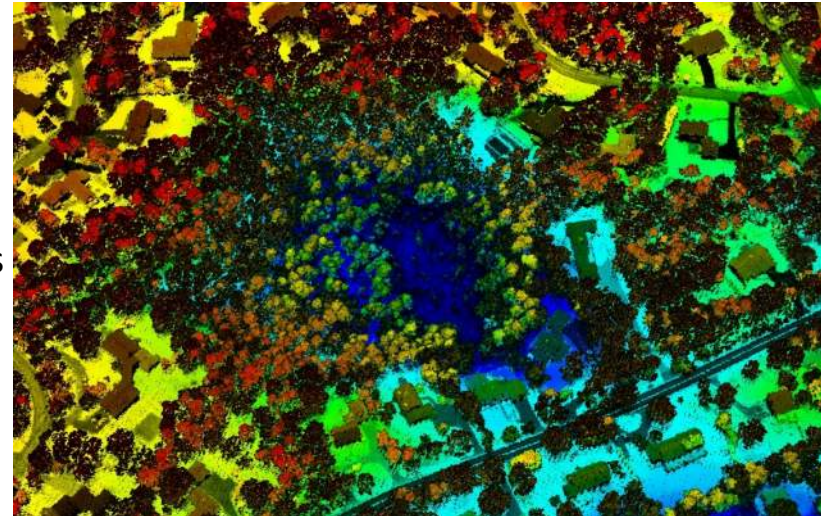
**ESRI ARC** 10.1 or greater  
AutoDesk **Civil3d**  
AutoDesk **ReCap**  
**QGIS**

## Free Software:

**Fugro Viewer** – Great for surface visualization. Will export points and lines to SHP files.  
**Quick Terrain Viewer** – Great for viewing. Measurement and listing of points available.  
**LasTools** – A tool for manipulating, converting or otherwise using clouds.  
**Fusion** – US Forest Service tool for Trees  
**MeshLab** – Will create 3d models from clouds  
**Cloud Compare** – It will compare two clouds and more.  
**PointCloudViz** – Viewer  
**SceneLT** – View clouds

## Marketed Software:

**Global Mapper** – Great for all LiDAR types, best value  
**Carlson Point Cloud** – Great for a surveyor using Carlson to get into clouds  
**TopoDOT** – If you have MicroStation, it is an excellent product  
**Quick Terrain Modeler** – Excellent tools for the toolbox.  
**Faro Scene** – Stitches scans and extracts some data.  
And More... (These are the ones that we have in the office)



Tilipi Run  
Guillard  
Coastal Bank

Video Sources:

2014 NOAA Aerial LiDAR "Post-Sandy"

***ELDREDGE SURVEYING & ENGINEERING, LLC***

1038 Main Street, Chatham, MA 02633

[www.es-e-llc.com](http://www.es-e-llc.com)

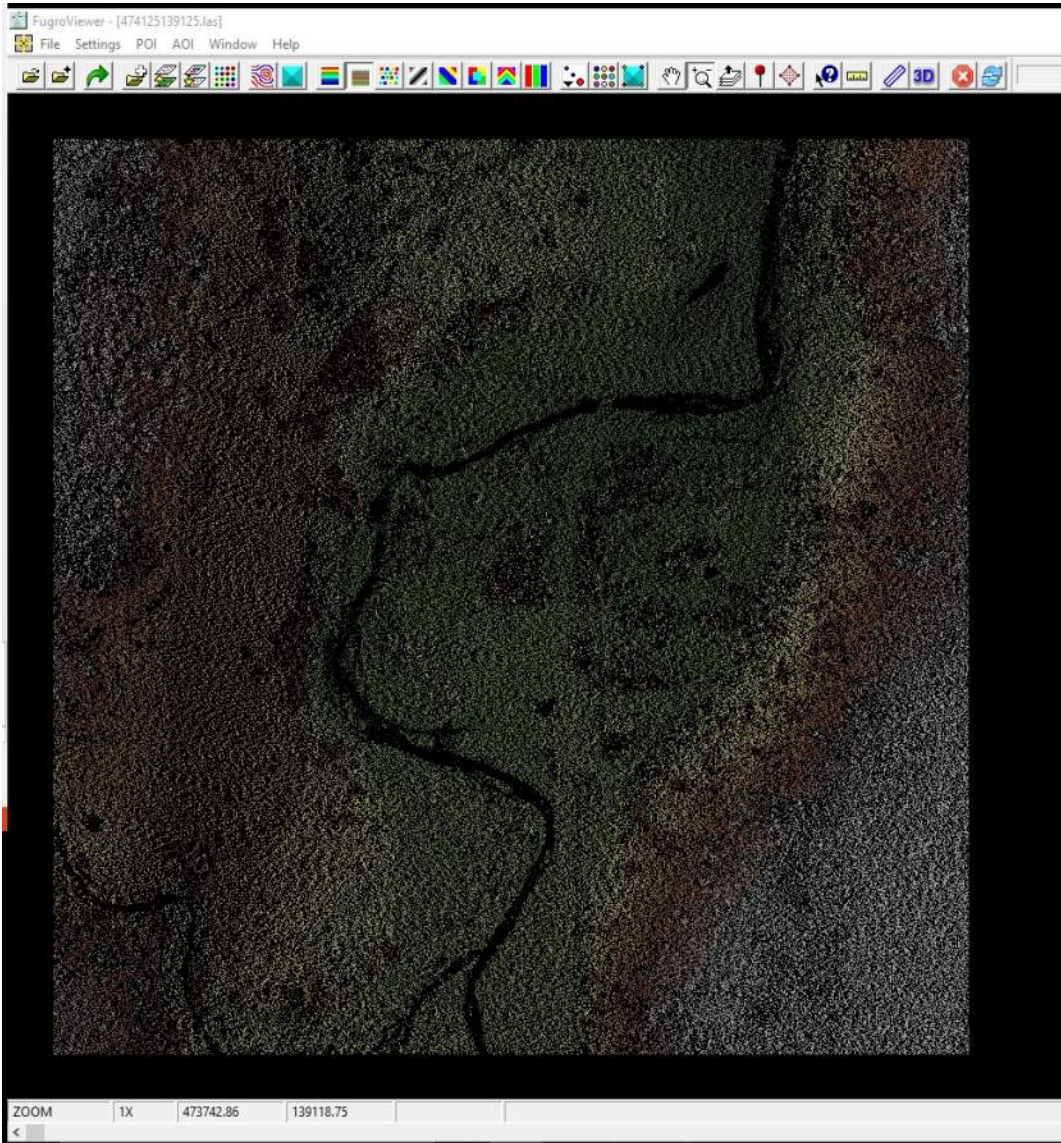
# *FUGRO VIEWER*

FUGROVIEWER

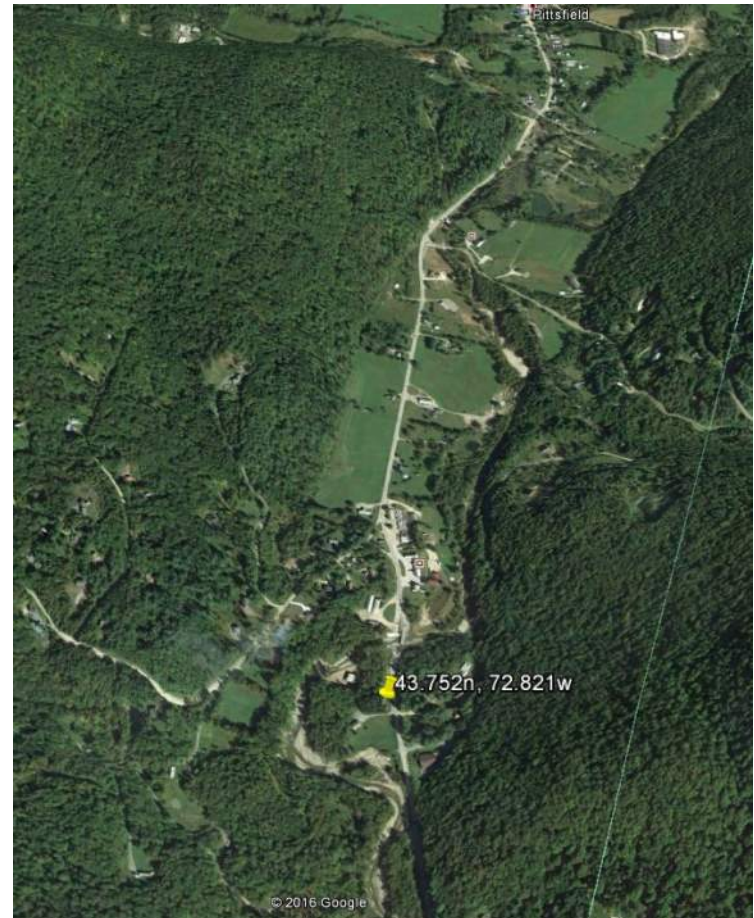


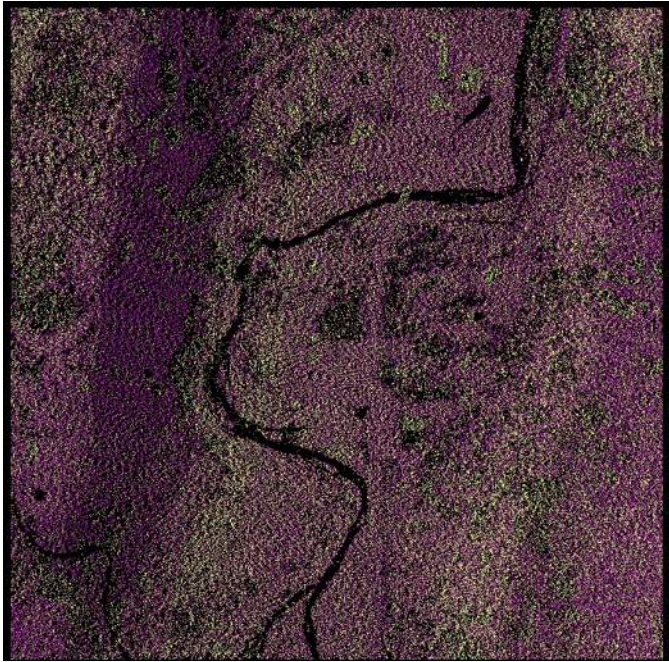
View your data. Analyze your data. Communicate your data.

[www.fugrogeospatial.com](http://www.fugrogeospatial.com)



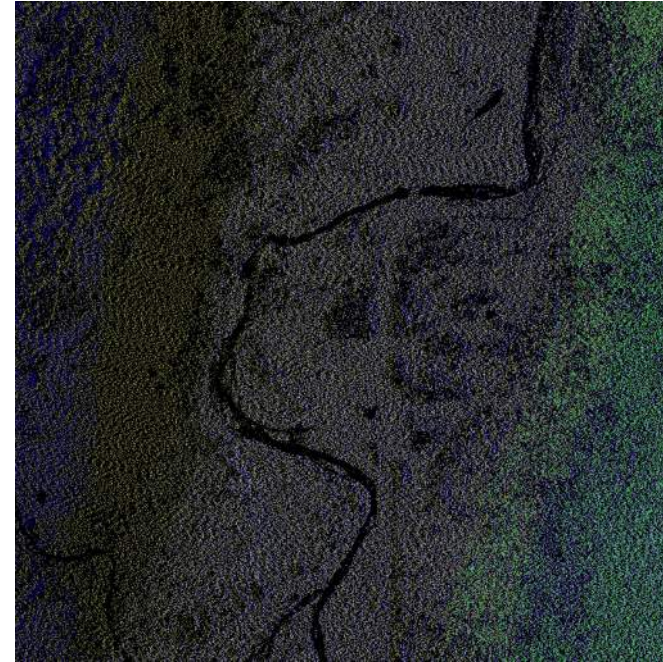
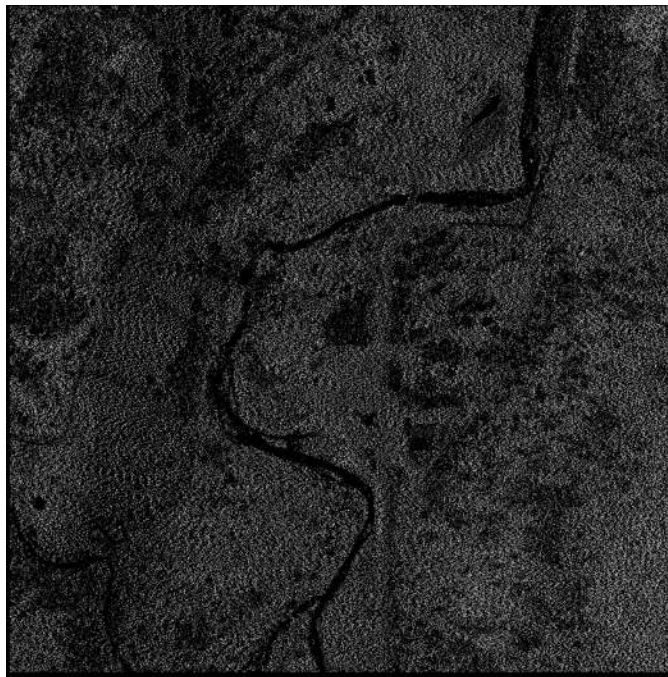
Just an example from Pittsfield, VT.  
Heights are visualized by color.





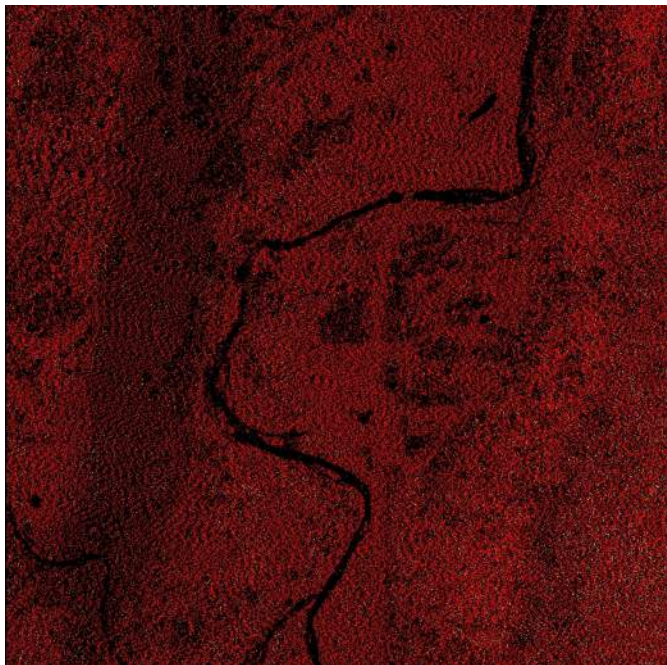
Colored by Classification

Colored by Intensity

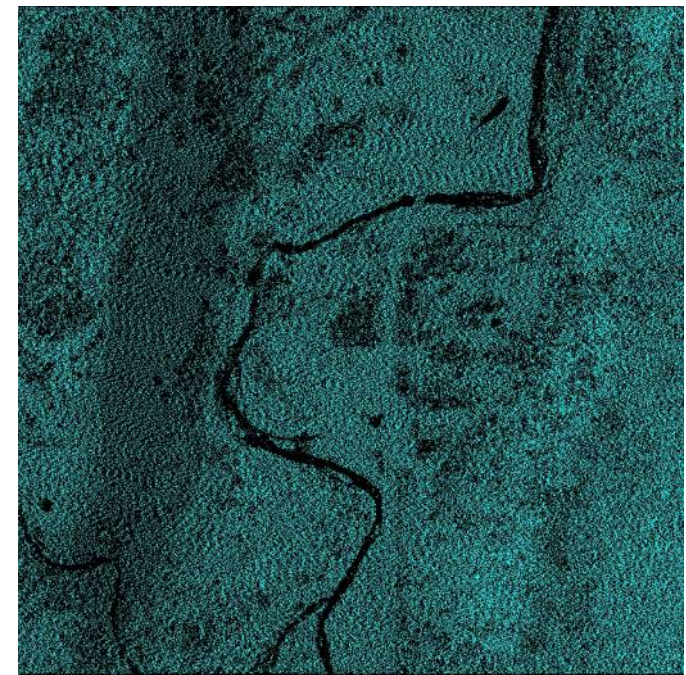


Colored by Source ID  
(Flightline)

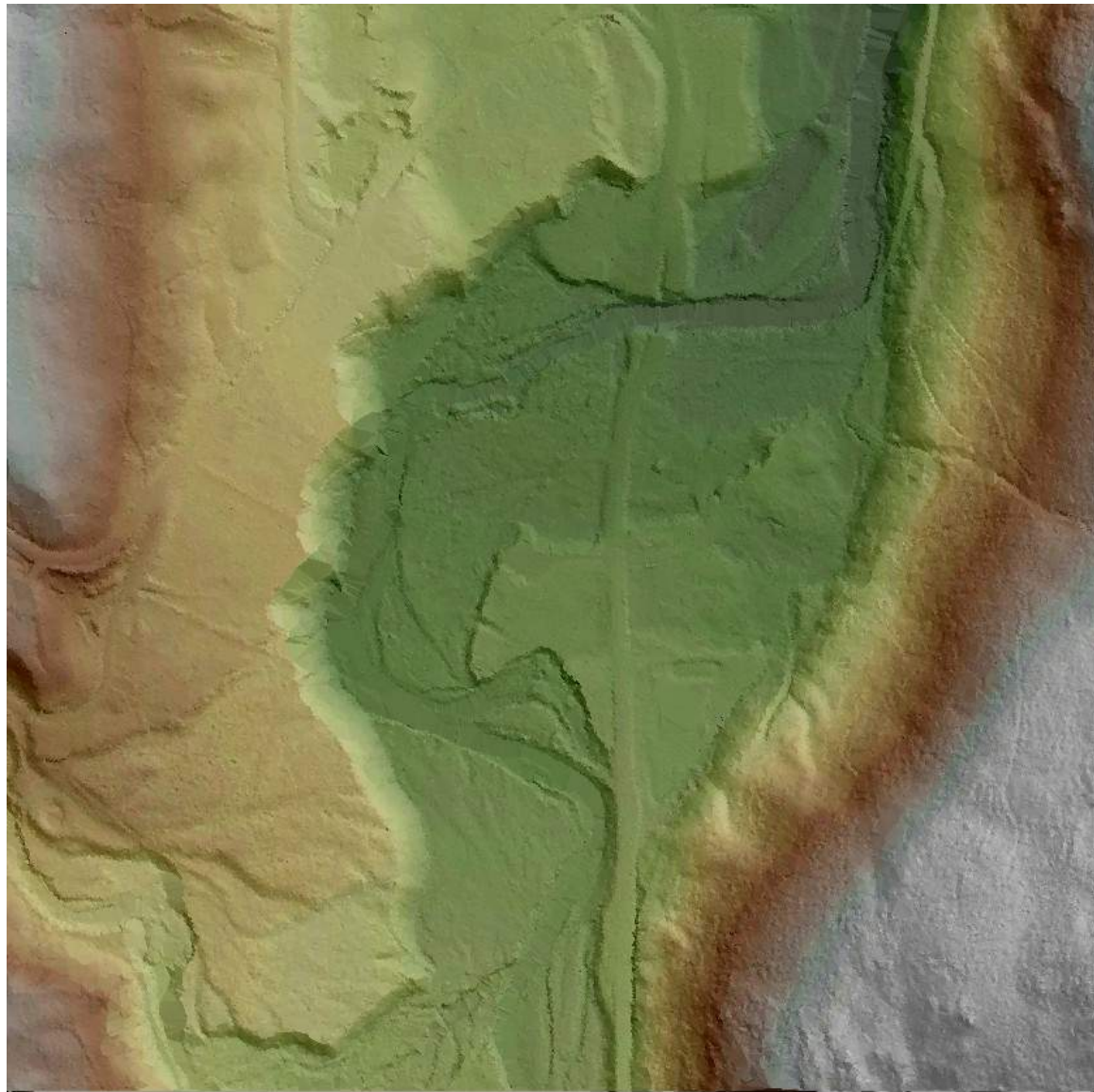
Colored by Return



Colored by Imagery



Colored by File (You need 2 files to see it.)



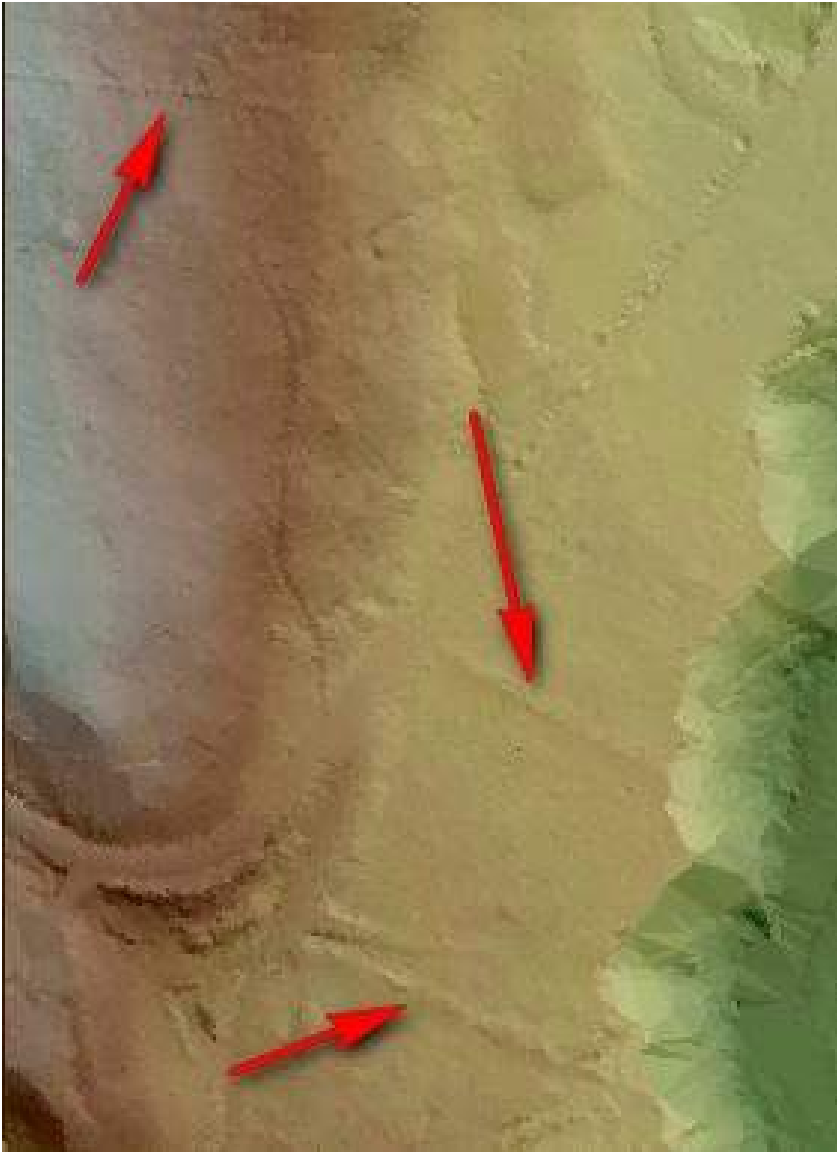
With a few clicks, you can create a solid surface model from the previously classified ground points. Take a moment and pick out some features:

River & Escarped Embankment

Roads & Driveways

Trails & Paths

Potential Stone Walls

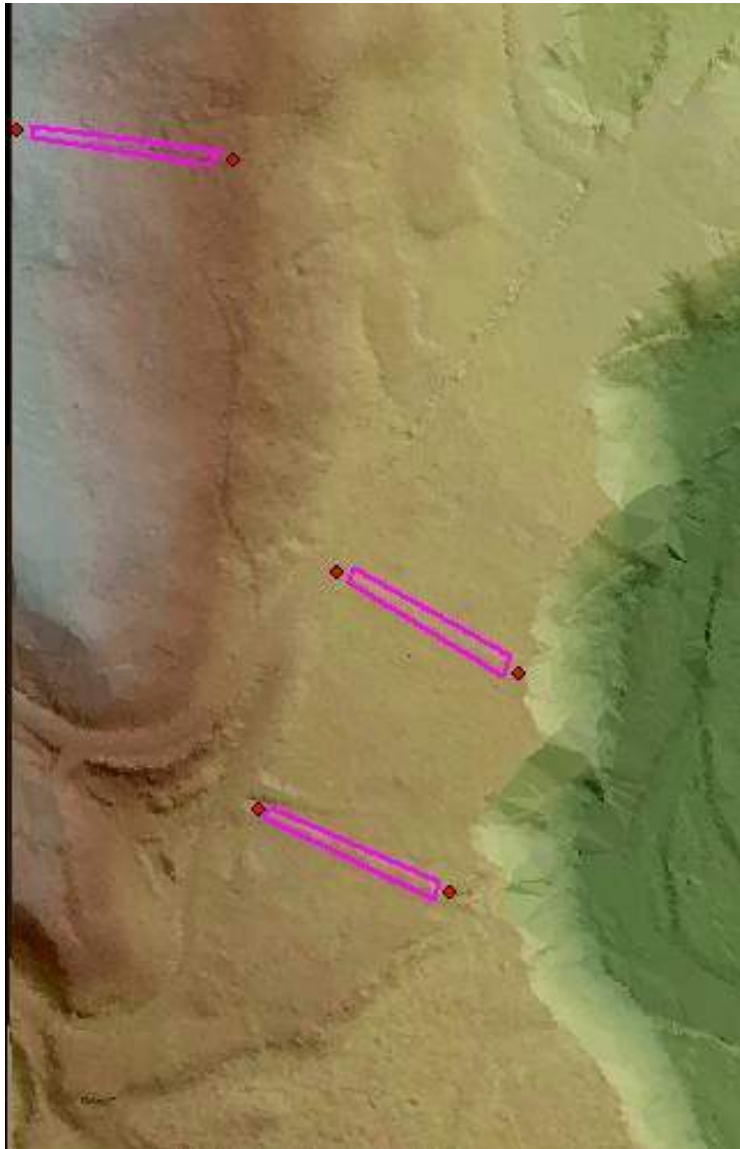


The two potential walls adjacent to the field could very well be there. These could be picked out from aerial photography. If the one to the north is a stone wall, one would be hard pressed to find it in the aerials.

We have recovered dozens of ancient boundaries with the aerial lidar surface models. We have used these models to rough in deeds and prepare for the ground surveys to locate features on the ground.



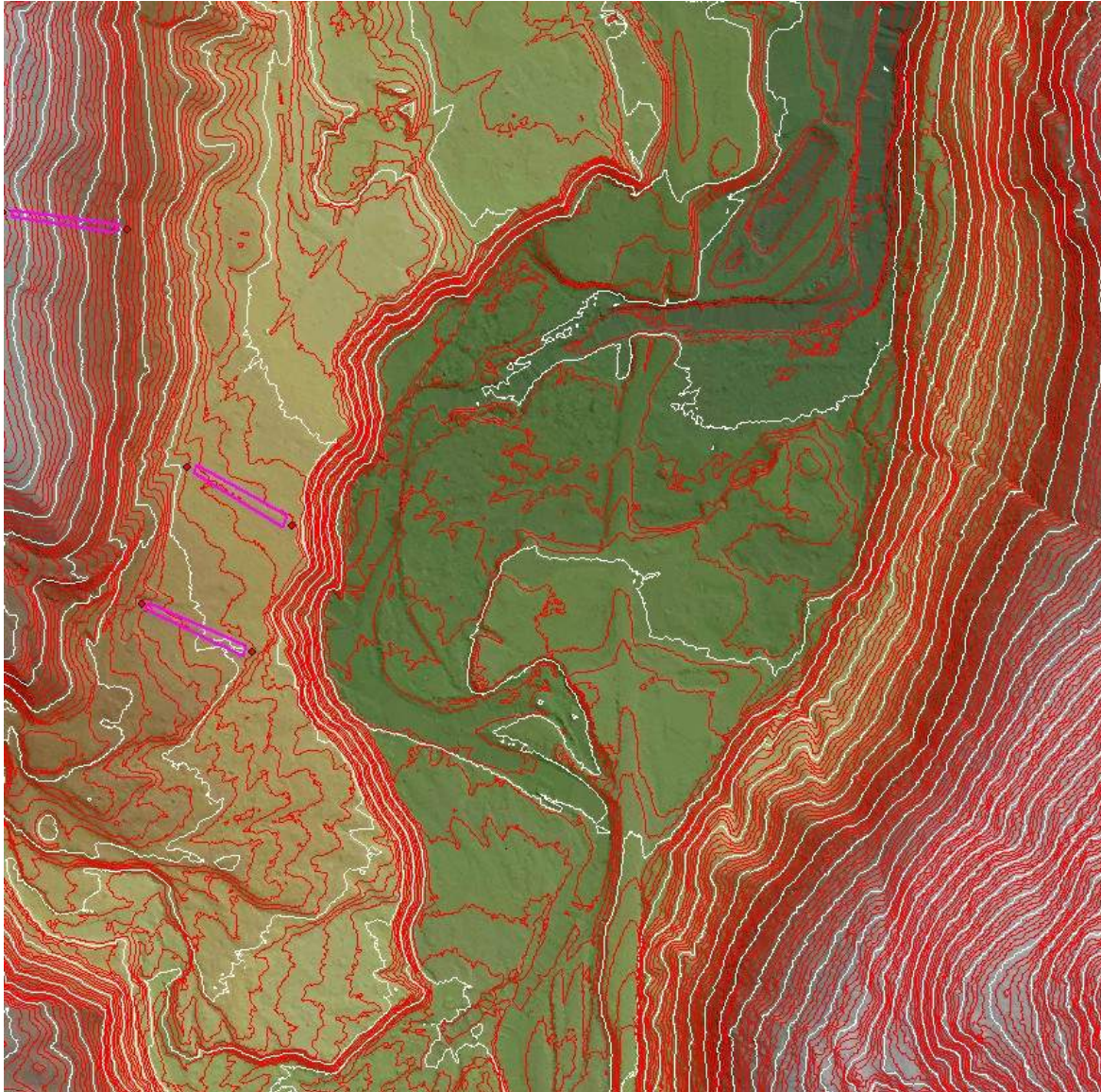




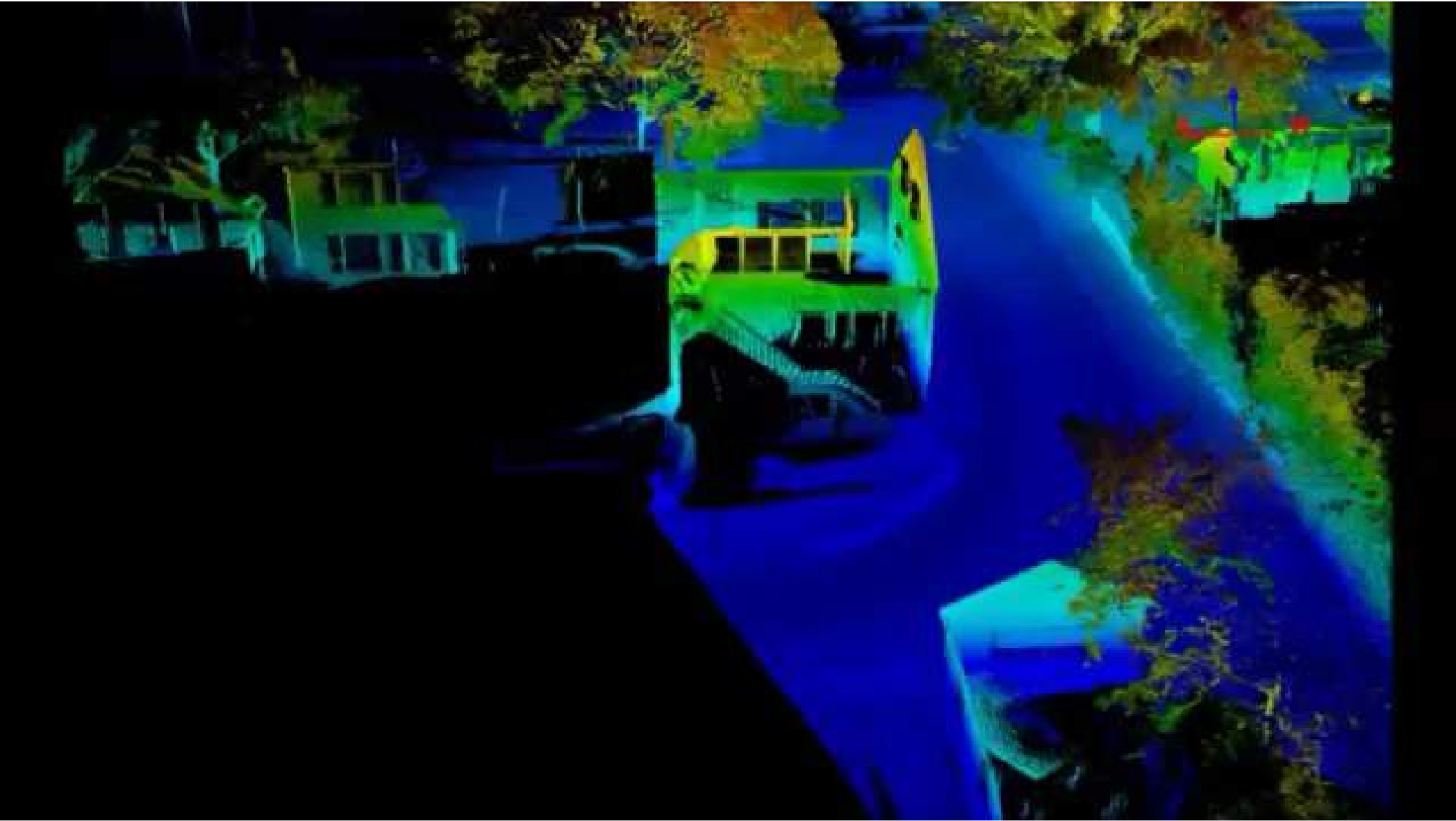
Fugro allows you to create POI and AOI: Points of Interest and Areas of Interest. These can be exported to Shape Files, then used accordingly.

Please note that there are other items in the surface that can look like walls, paths, streams and other features. This can be a great starting point. It can help point those boots on the ground but cannot replace them.



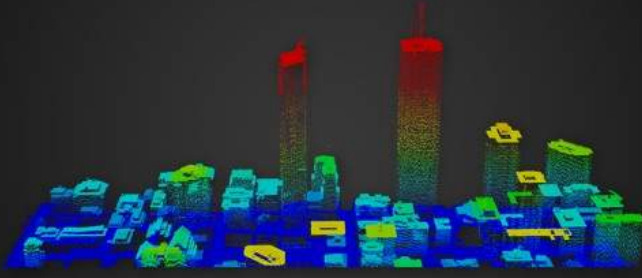


Fugro will allow you to show the contours from the surface, but you cannot export them. There are image overlay options as well, go have some fun.



# Quick Terrain Reader<sup>8</sup>

Free companion software to Quick Terrain Modeler



Please visit [www.appliedimagery.com](http://www.appliedimagery.com) for Quick Terrain Modeler upgrade information.

©2003 Johns Hopkins University Applied Physics Laboratory. All Rights Reserved.

APPLIED IMAGERY

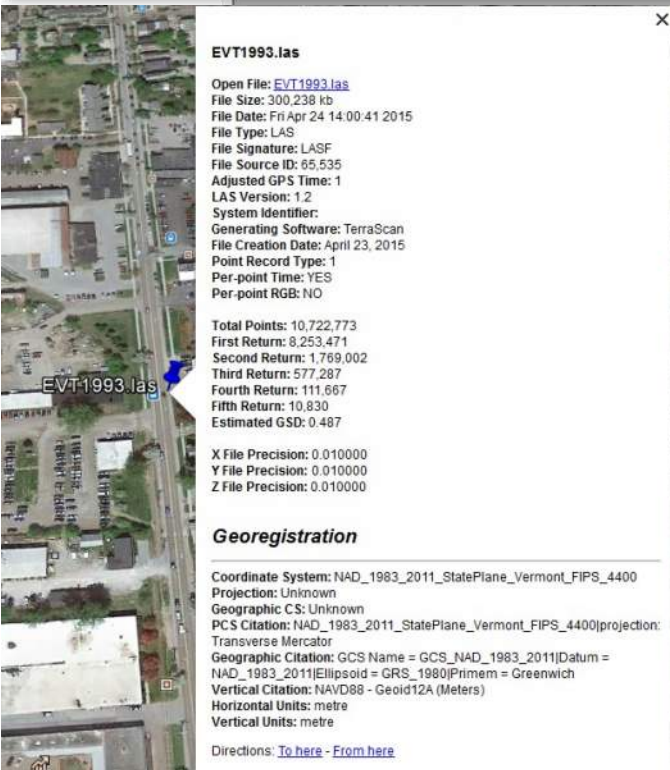
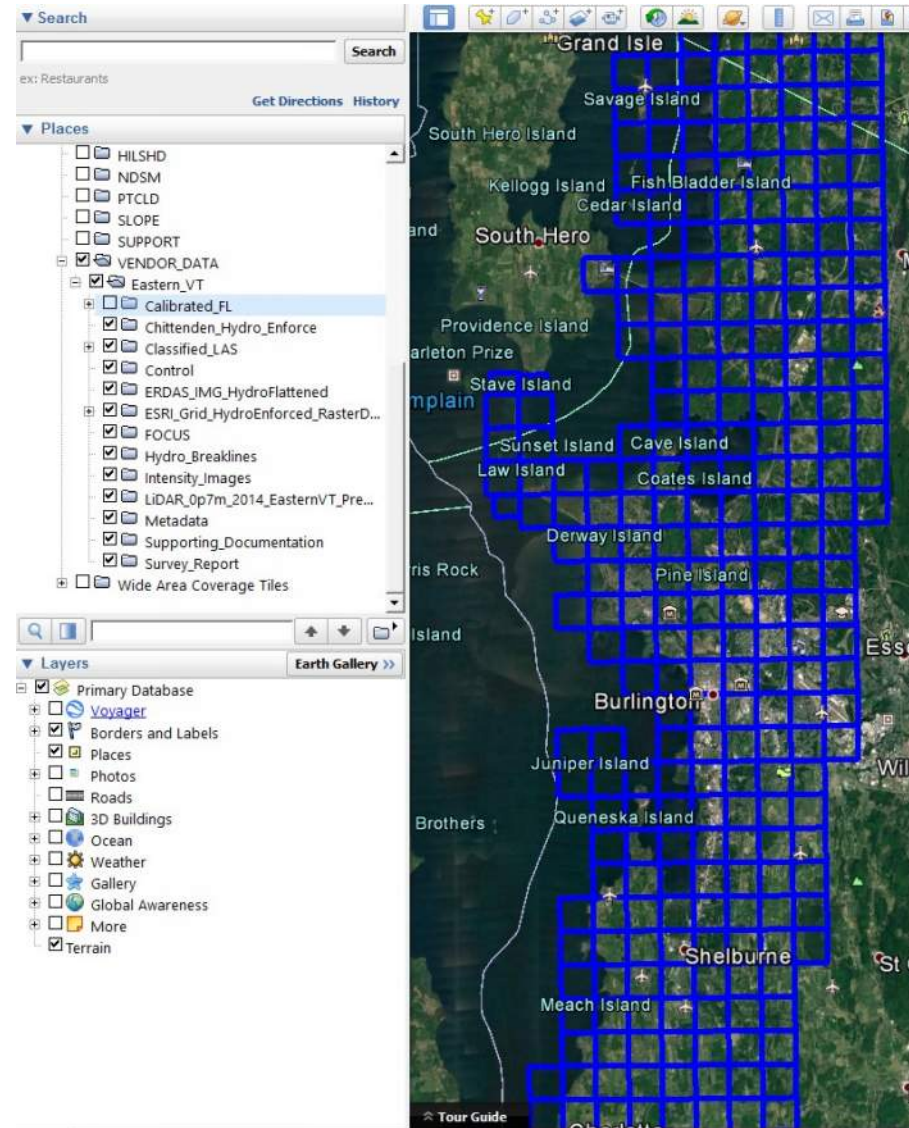
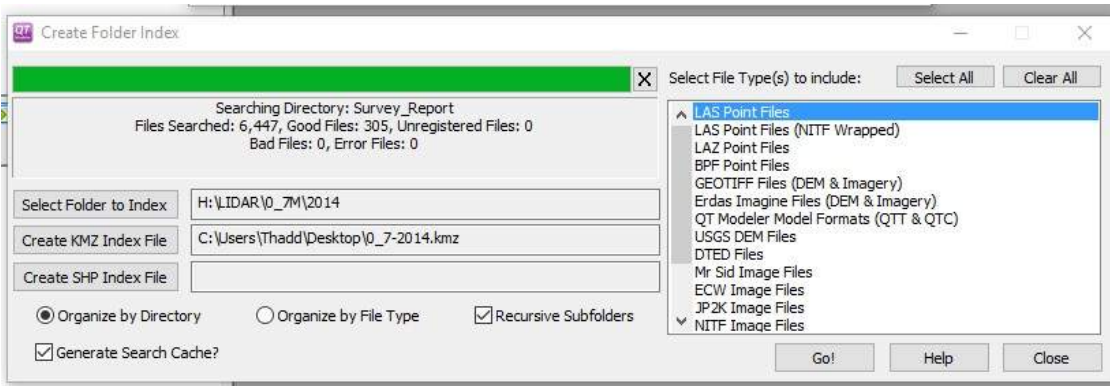
*THE READER HAS SOME  
GREAT QUALITIES, BUT  
THE MODELER HAS SO  
MANY MORE.*

# Quick Terrain Modeler<sup>8</sup>

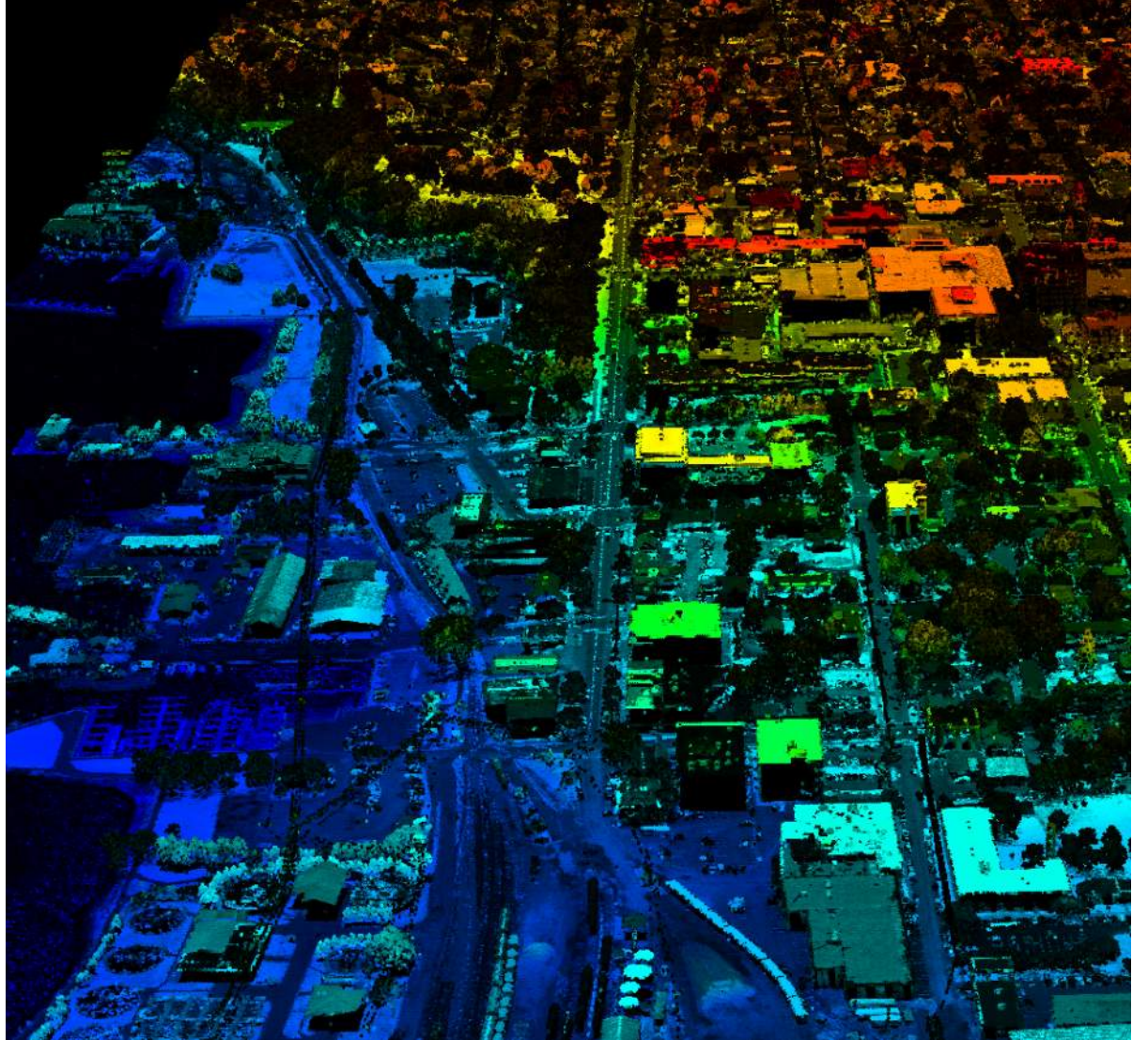
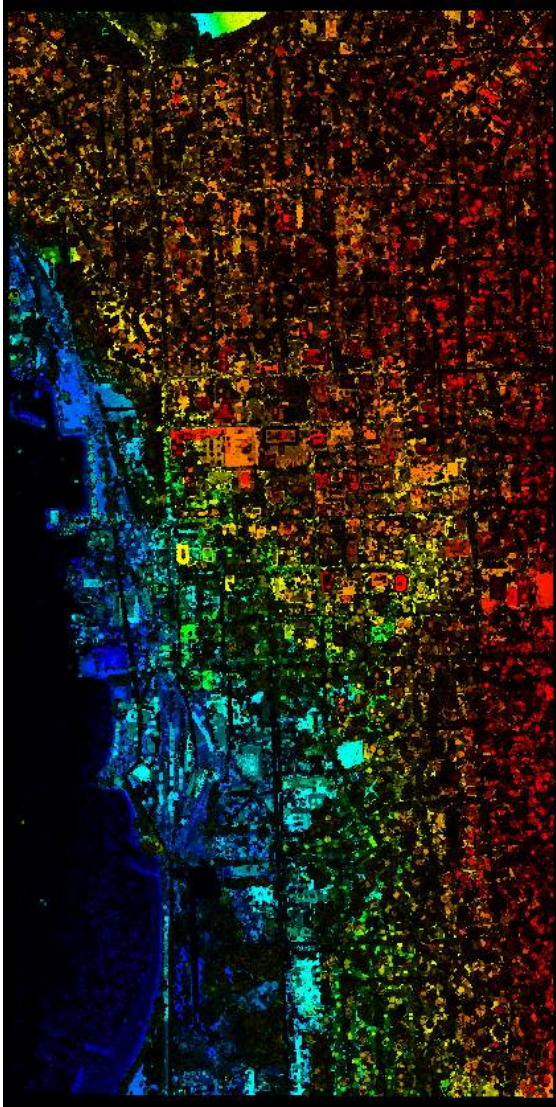
APPLIED IMAGERY

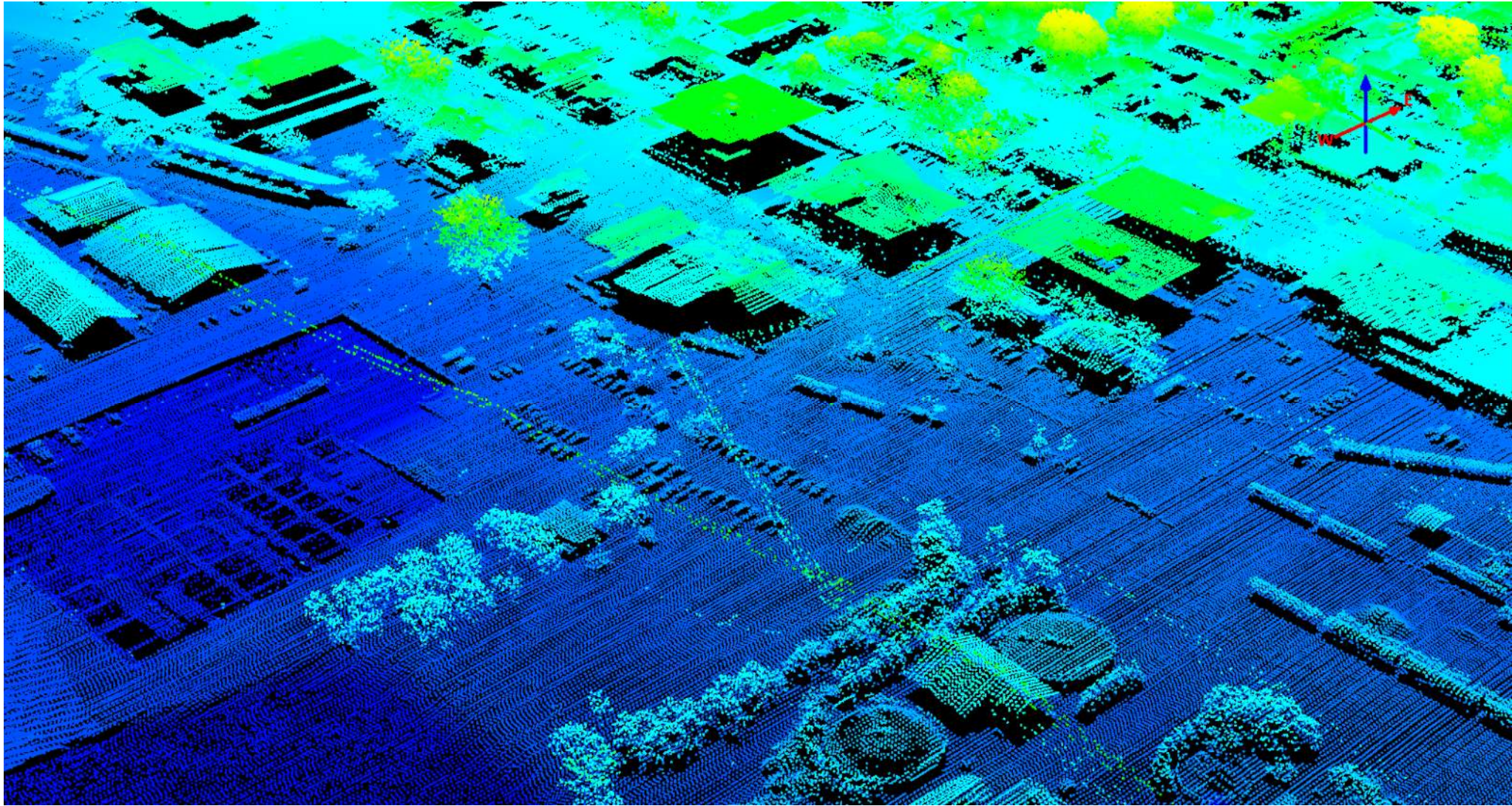


©2003 Johns Hopkins University Applied Physics Laboratory. All Rights Reserved.

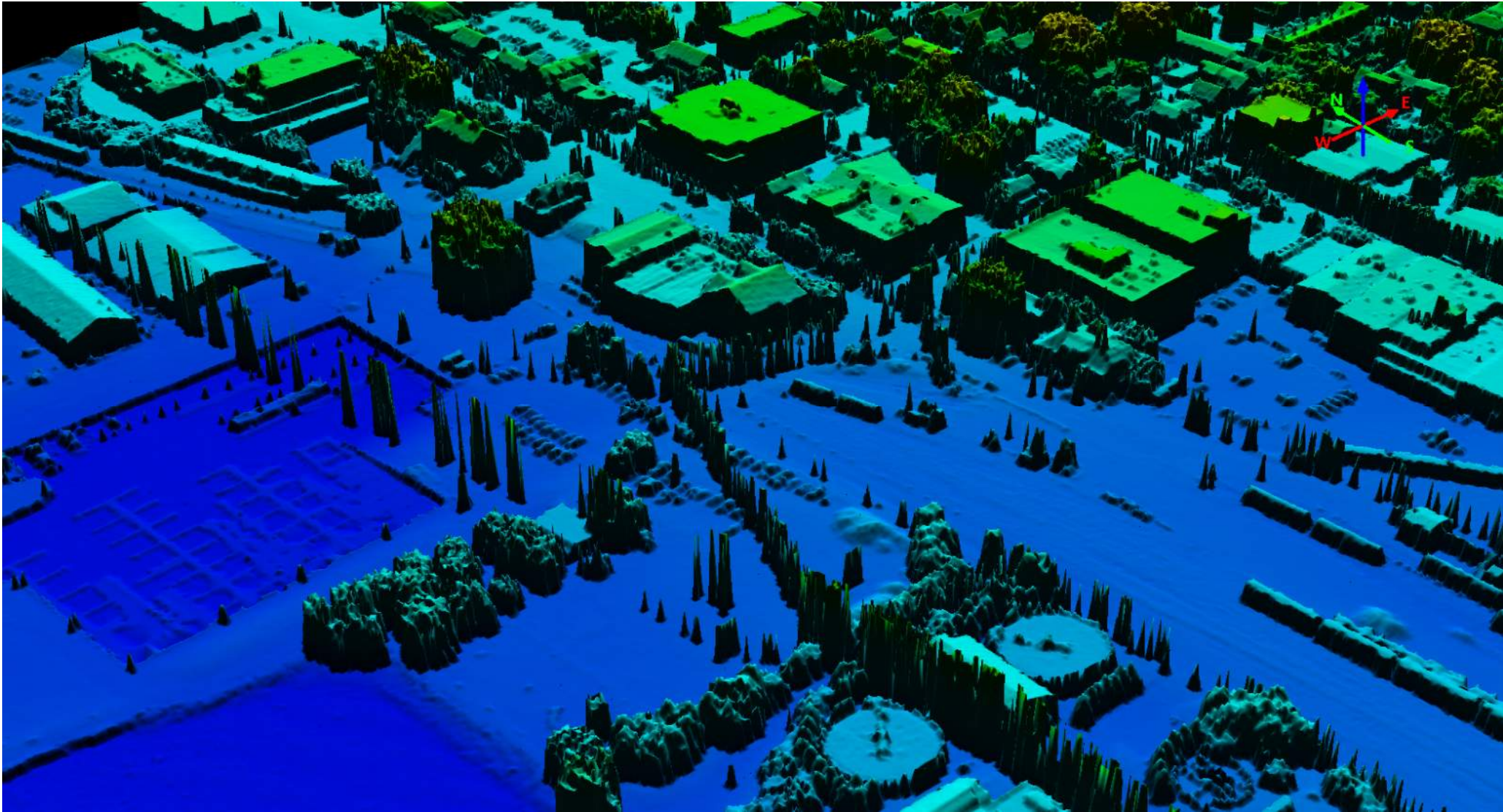


Took a directory, made an index to KMZ. Found an interesting area in Google Earth. Listed the tiles and all kinds of information comes out.





An oblique view.



Created a surface with all the points.



← → ↻ <https://earthexplorer.usgs.gov>

Apps ★ Bookmarks CAPE COD LIDAR COMPUTER NOAA: Data Access FEMA Flood Map Ser Free Music Archive: S Massachusetts Law all Town Records of Barn Radio Garden

**USGS**  
science for a changing world

**EarthExplorer** Page Expires In 1:59:24

Home 1 New System Message Save Criteria Load Favorite Manage Criteria Item Basket (0) spledeus Feedback Help

Search Criteria Data Sets Additional Criteria Results

### 1. Enter Search Criteria

To narrow your search area: type in an address or place name, enter coordinates or click the map to define your search area (for advanced map tools, view the [help documentation](#)), and/or choose a date range.

Address/Place Path/Row Feature Circle

Show Clear

Coordinates Predefined Area Shapefile KML

Degree/Minute/Second Decimal

1. Lat: 44° 29' 00" N, Lon: 073° 14' 01" W	✖
2. Lat: 44° 29' 02" N, Lon: 073° 12' 24" W	✖
3. Lat: 44° 28' 05" N, Lon: 073° 12' 15" W	✖
4. Lat: 44° 28' 04" N, Lon: 073° 13' 59" W	✖

Use Map Add Coordinate Clear Coordinates

Date Range Result Options

Search from: mm/dd/yyyy to: mm/dd/yyyy

Search months: (all)

Data Sets > Additional Criteria > Results >

### Search Criteria Summary (Show)

Map Satellite (44° 28' 04" N, 073° 14' 18" W) Options Overlays

Google

Map data © 2016 Google Imagery © 2016, Cnes/Spot Image, DigitalGlobe, USDA Farm Service Agency 200 m

The up-to-date Google map is not for purchase or for download; it is to be used as a guide for reference and search purposes only.

USGS Earth Explorer (write that one down and google it or <https://earthexplorer.usgs.gov>)

EE EarthExplorer x Thaddeus

https://earthexplorer.usgs.gov

USGS science for a changing world

EarthExplorer Page Expires In 1:59:04

Home 1 New System Message Save Criteria Load Favorite Manage Criteria Item Basket (0) spledeus Feedback Help

Search Criteria Data Sets Additional Criteria Results

### 4. Search Results

If you selected more than one data set to search, use the dropdown to see the search results for each specific data set.

Show Result Controls

Data Set [Click here to export your results](#)

High Resolution Orthoimagery

1		Entity ID:3188416_VT102920130423 Acquisition Date:22-APR-13 State:VT
2		Entity ID:3189901_VT92920130423 Acquisition Date:22-APR-13 State:VT
3		Entity ID:3189901_VT92920130423 Acquisition Date:22-APR-13 State:VT
4		Entity ID:3189887_VT82920130422 Acquisition Date:22-APR-13 State:VT
5		Entity ID:3189402_VT93020130423 Acquisition Date:22-APR-13 State:VT
6		Entity ID:3189902_VT93120130423 Acquisition Date:22-APR-13 State:VT

[View Item Basket](#) [Submit Standing Request](#)

### Search Criteria Summary (Show)

Map Satellite

(44° 28' 51" N, 073° 14' 08" W) Options Overlays

Google

Map data ©2015 Google Imagery ©2016, Cnet, Spot Image, DigitalGlobe, USDA Farm Service Agency 200 m

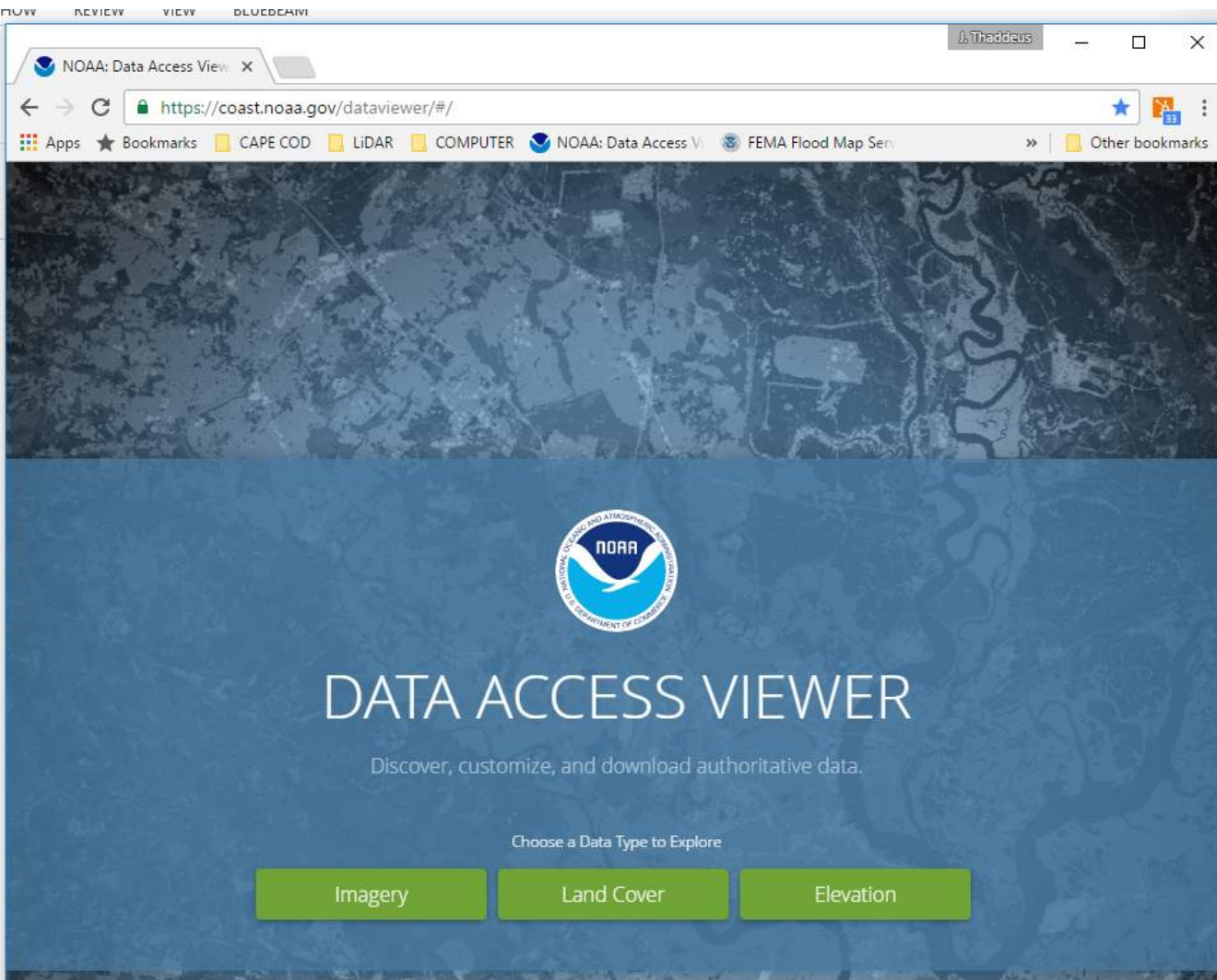
The up-to-date Google map is not for purchase or for download; it is to be used as a guide for reference and search purposes only.

3189402\_VT93020...zip 12.8 MB

3189901\_VT92920...zip 25.0 MB

Show all

Downloaded some 2013 High Resolution Orthoimagery.



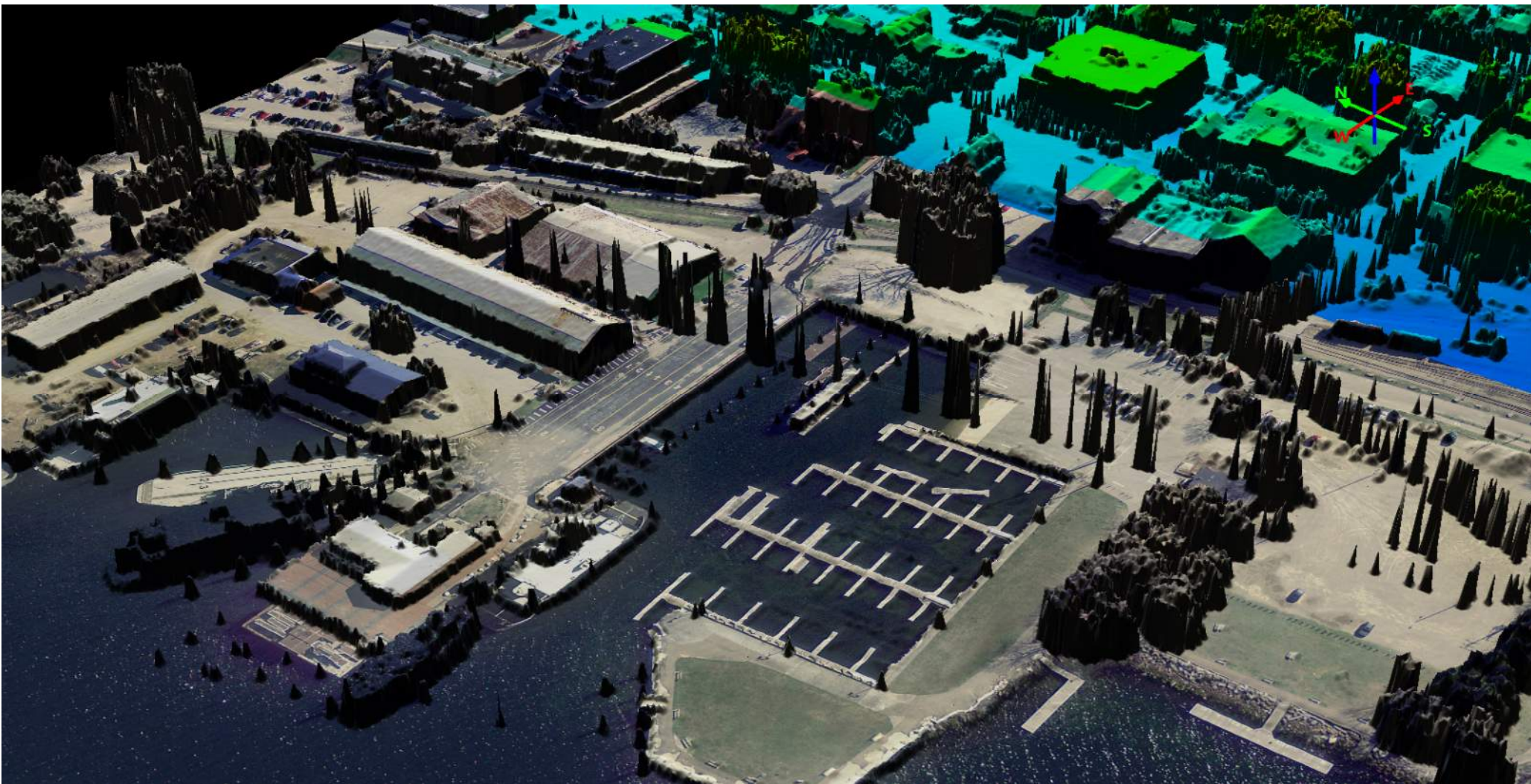
Elevation  
(On some  
borders)

Imagery (A little)

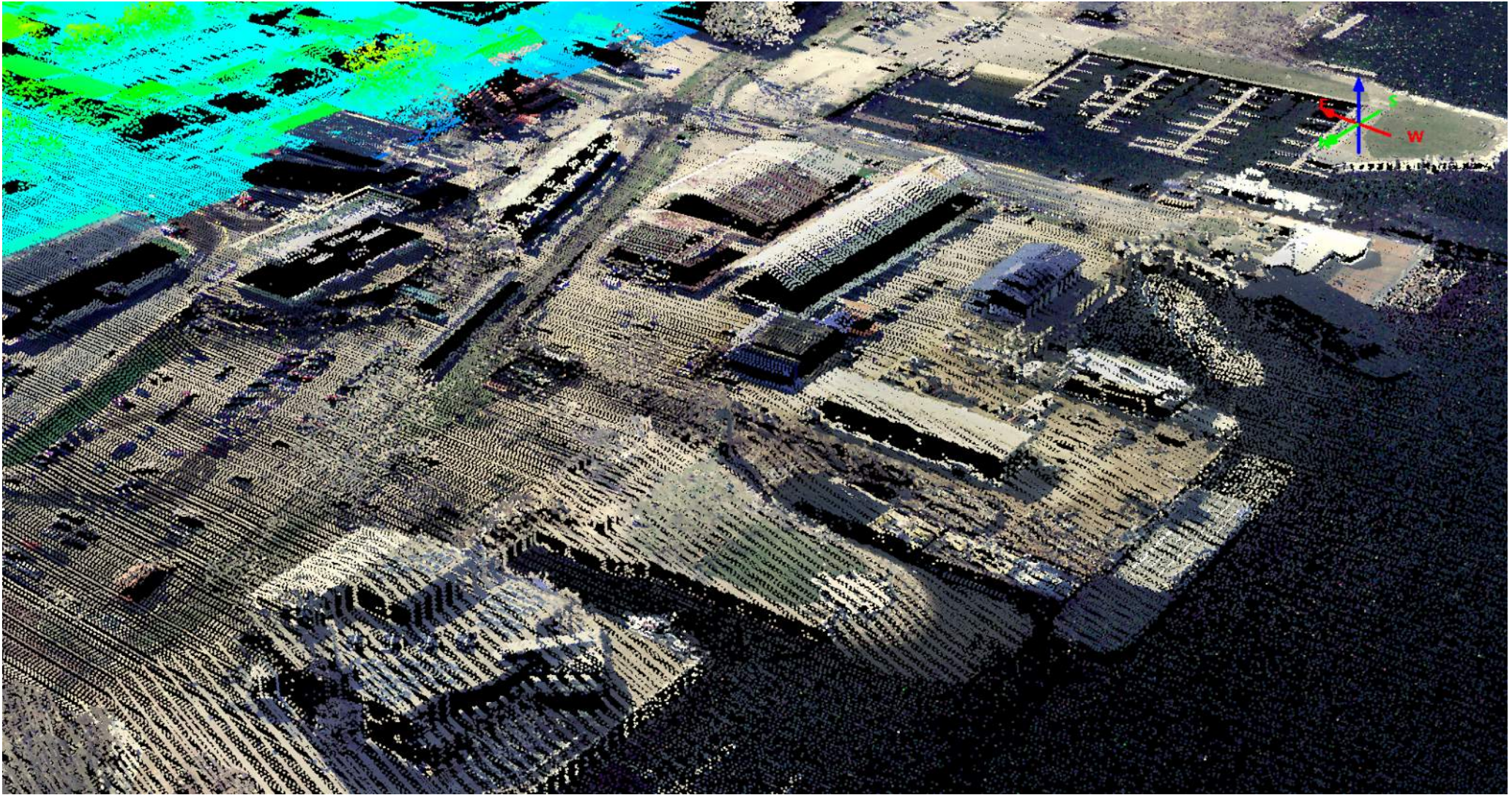
<https://Coast.noaa.gov/dataviewer/#/>

The USGS Earth Explorer delivers tiles on mostly in UTM Meters.

The NOAA viewer allows you to take random areas and converts them to any system you'd like.



This makes for a great 3d visualization of the scene.  
Some spikes are from noise, others are along the power lines.



The points remain colorized.

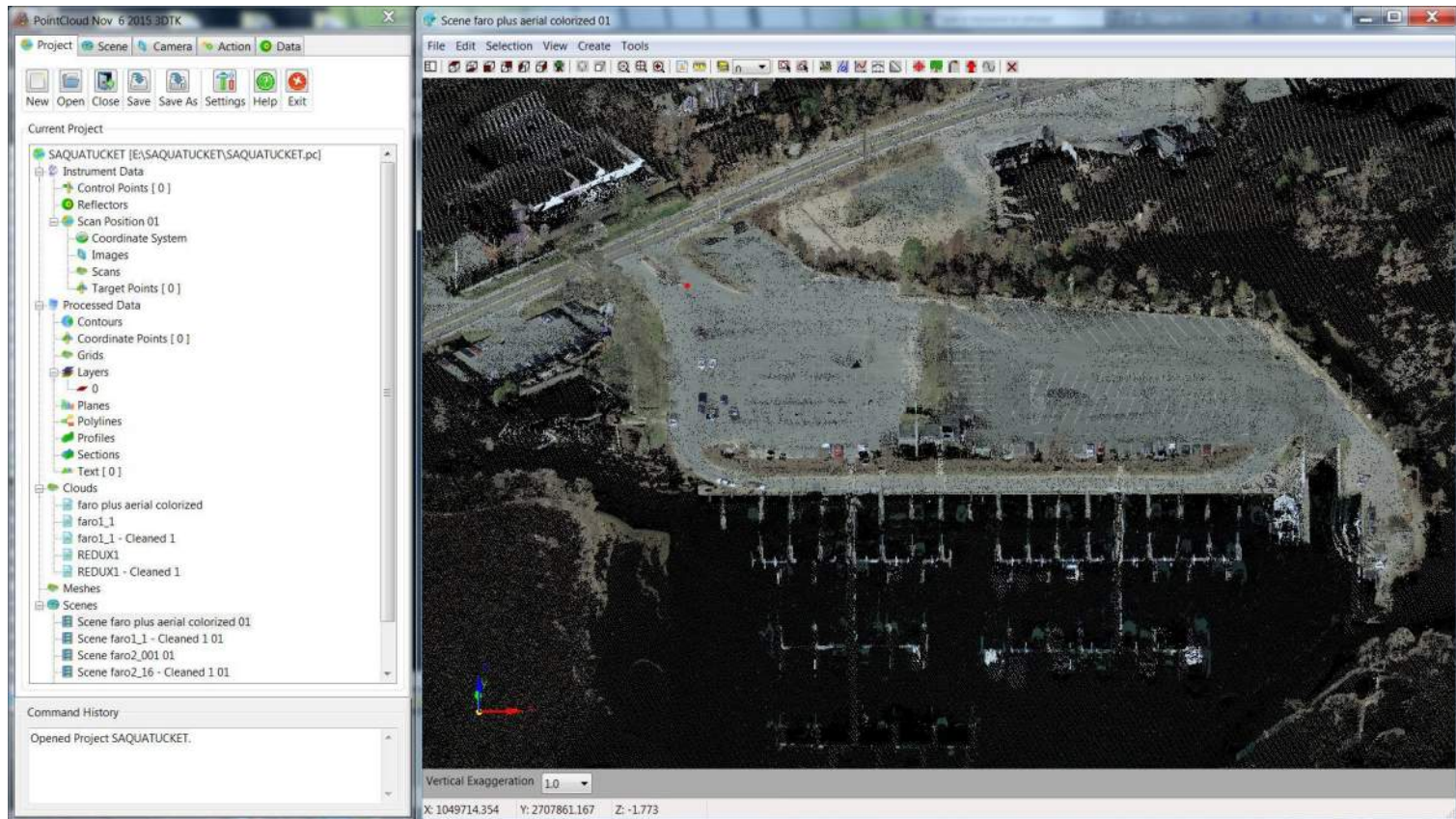


# *CARLSON POINT CLOUD*

Carlson PC is built on the Carlson methodology.  
It runs through CAD or IntelliCAD in its own  
window and menu.

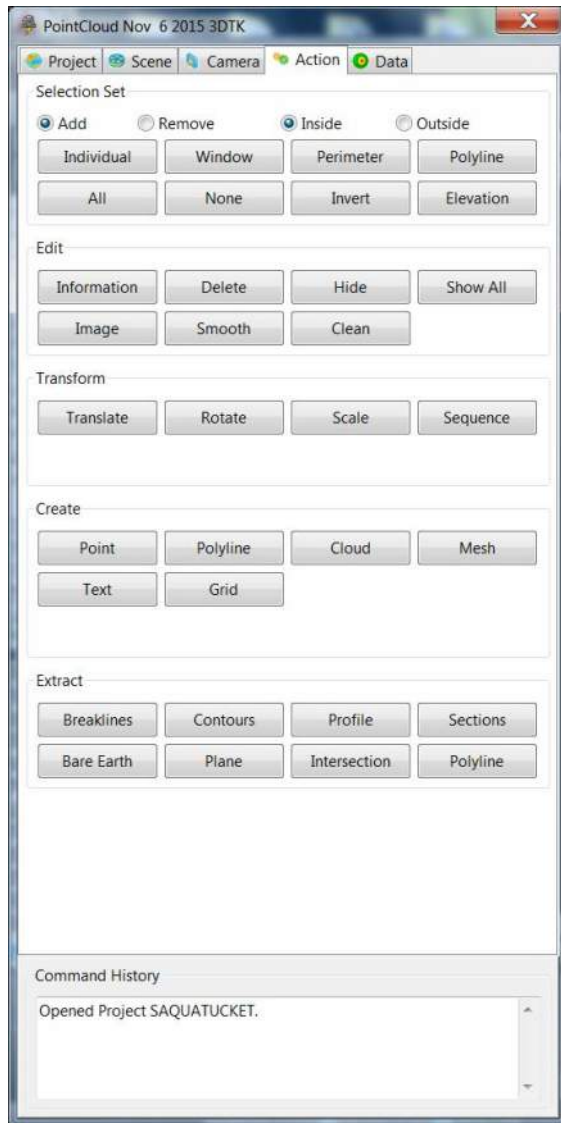
I chose this program because of their excellent  
support for their other products. They have not  
failed that support with this module.





Beautiful Saquatucket Harbor, Harwichport, MA. There is noise from the water. This was colorized from 2014 Aerial Imagery (3" pixel) and it was scanned (Mobile, FARO) in the early Fall, 2015. The outlying areas are based on 2014 Aerial LiDAR. The point cloud module runs outside or alongside AutoCAD or IntelliCAD.





## Action

**Selection** – 8 tools to select point with 2 pairs of radios.

**Edit** – Hide, show, list and colorize the clouds. Smooth evens out meshes (think TINs) and Clean reduces points from a cloud (some get a little dense)

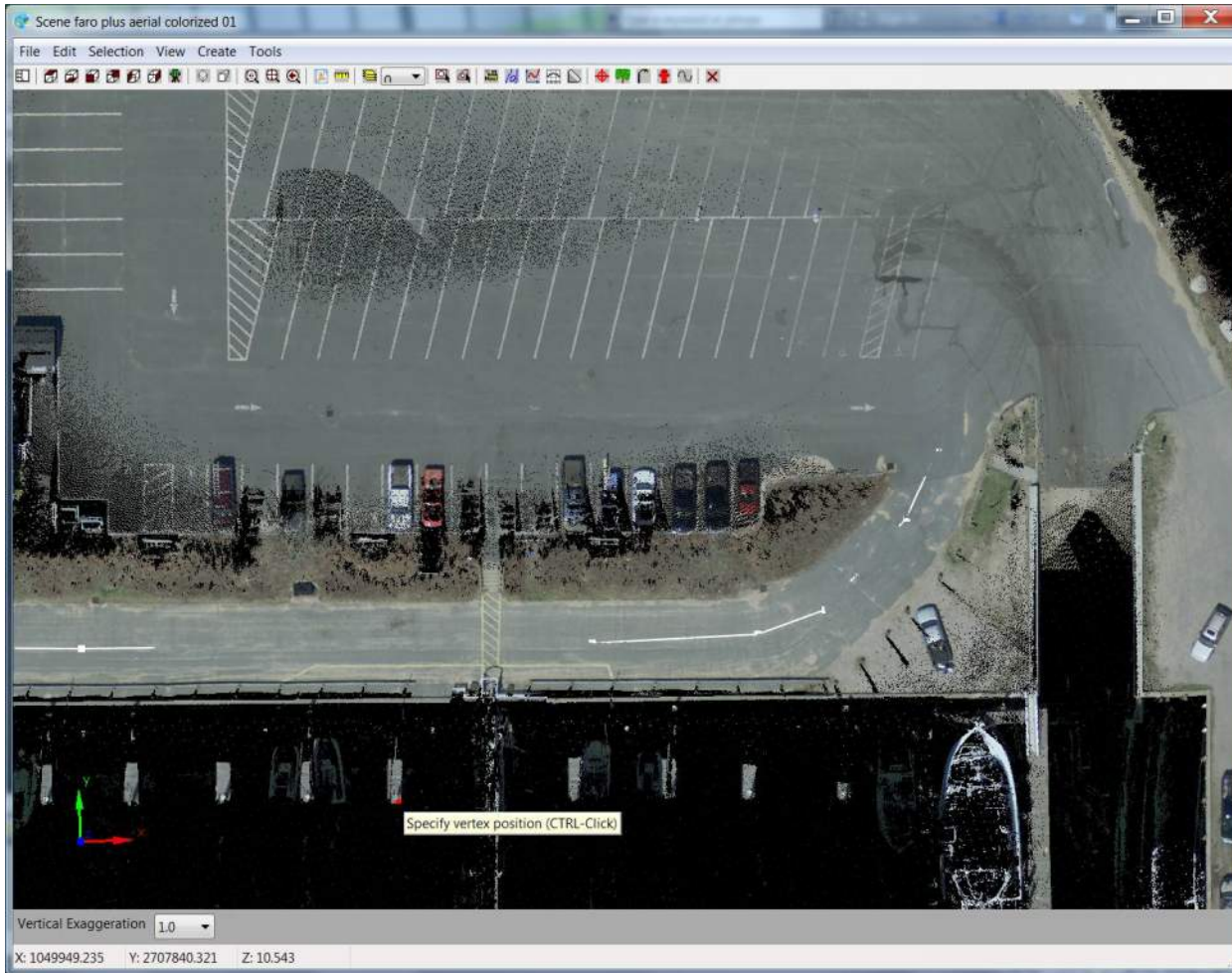
**Transform** – The transform functions will move the clouds.

## Create -

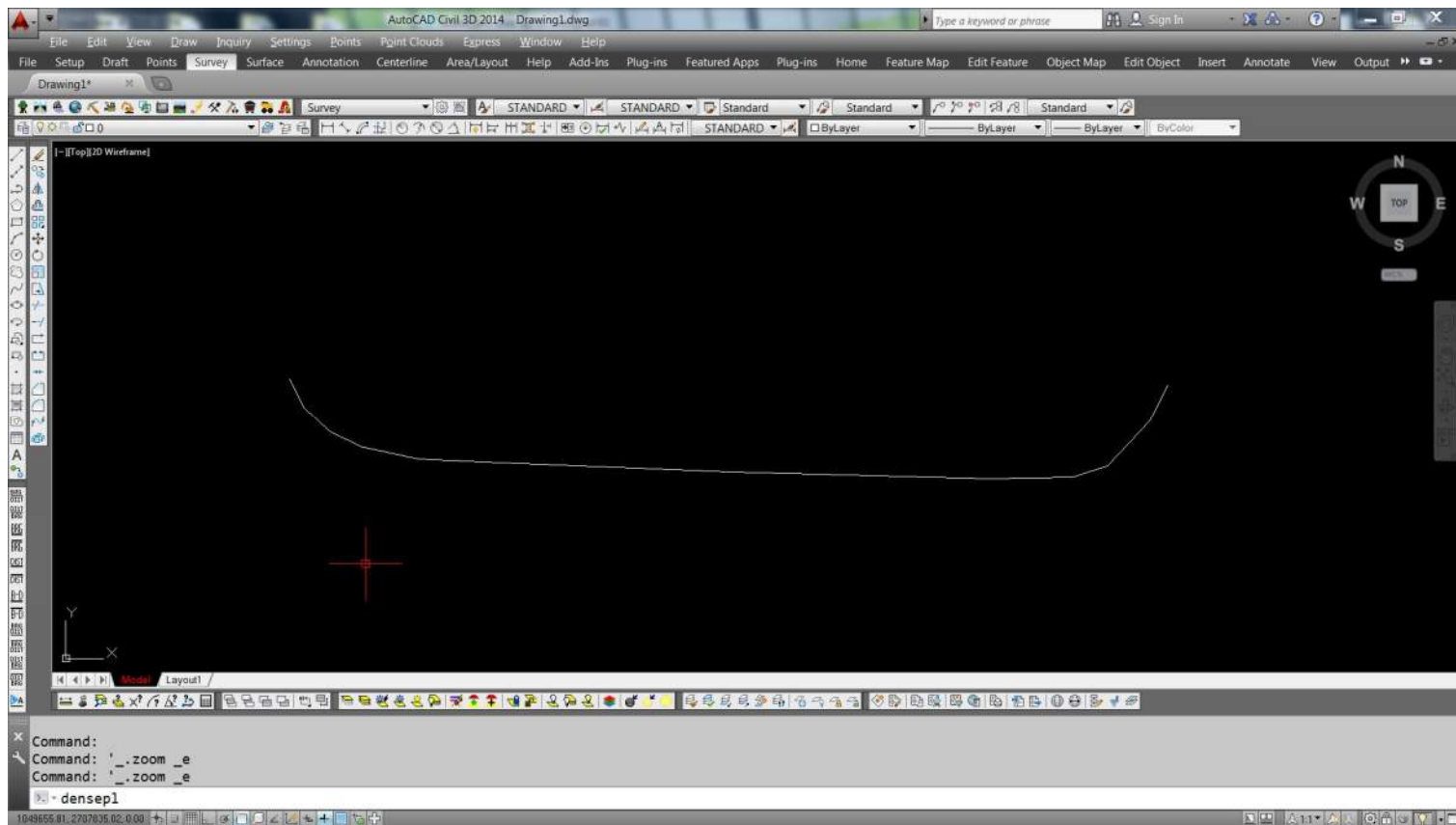
- Point – points with your F2F codes
- Polyline – simple 3-d polylines
- Cloud – Select an area and create a neww (smaller) cloud
- Mesh – A surface
- Text – Text
- Grid – Grid

## Extract -

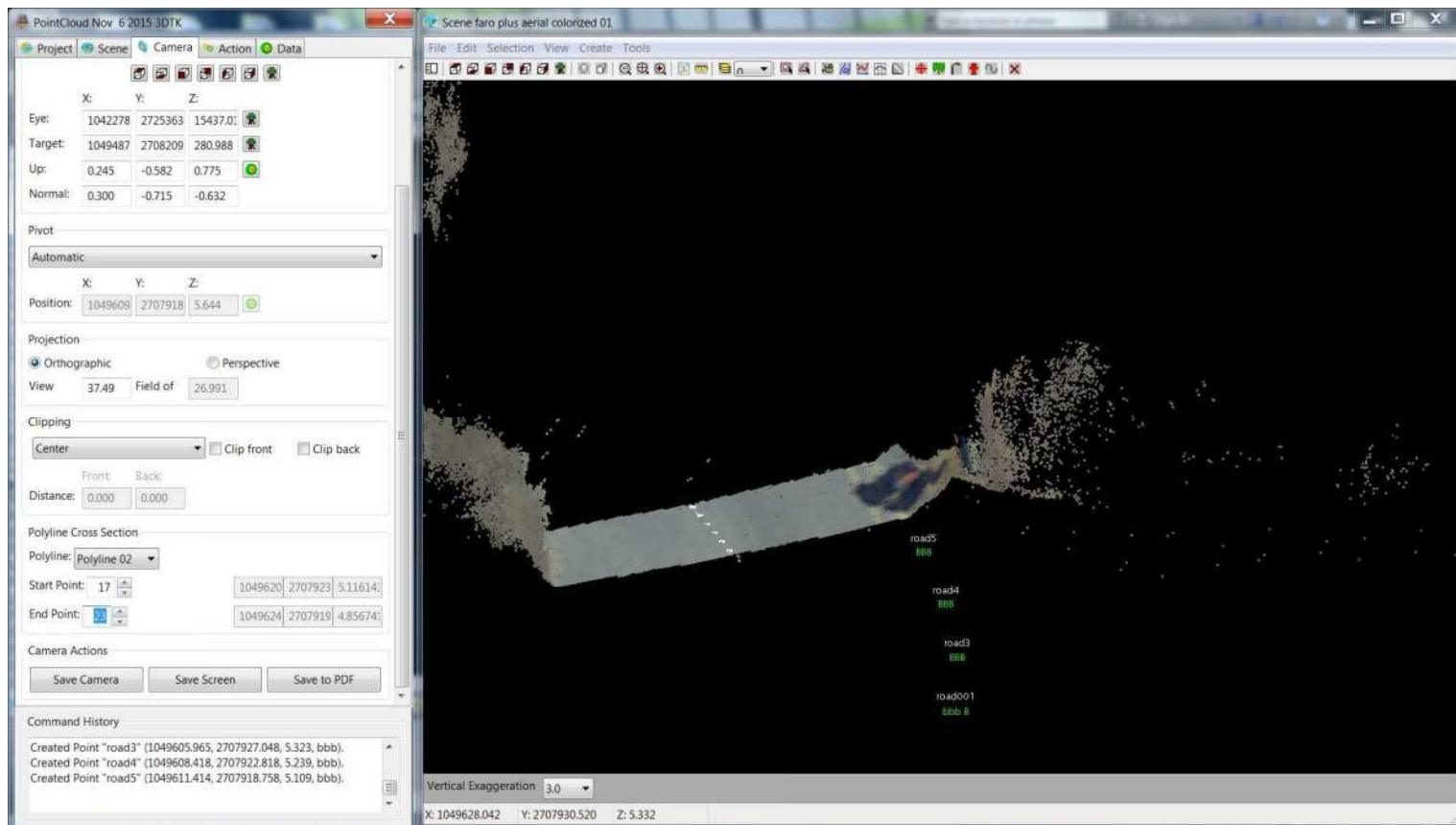
- Breaklines – from a mesh
- Contours – from a mesh
- Profile & Section – need a CL file in Carlson
- Bare Earth – Creates a new cloud with the ground only
- Plane – flat plane
- Intersections – Intersects two planes
- Polyline – Automatic extraction based on Intensity



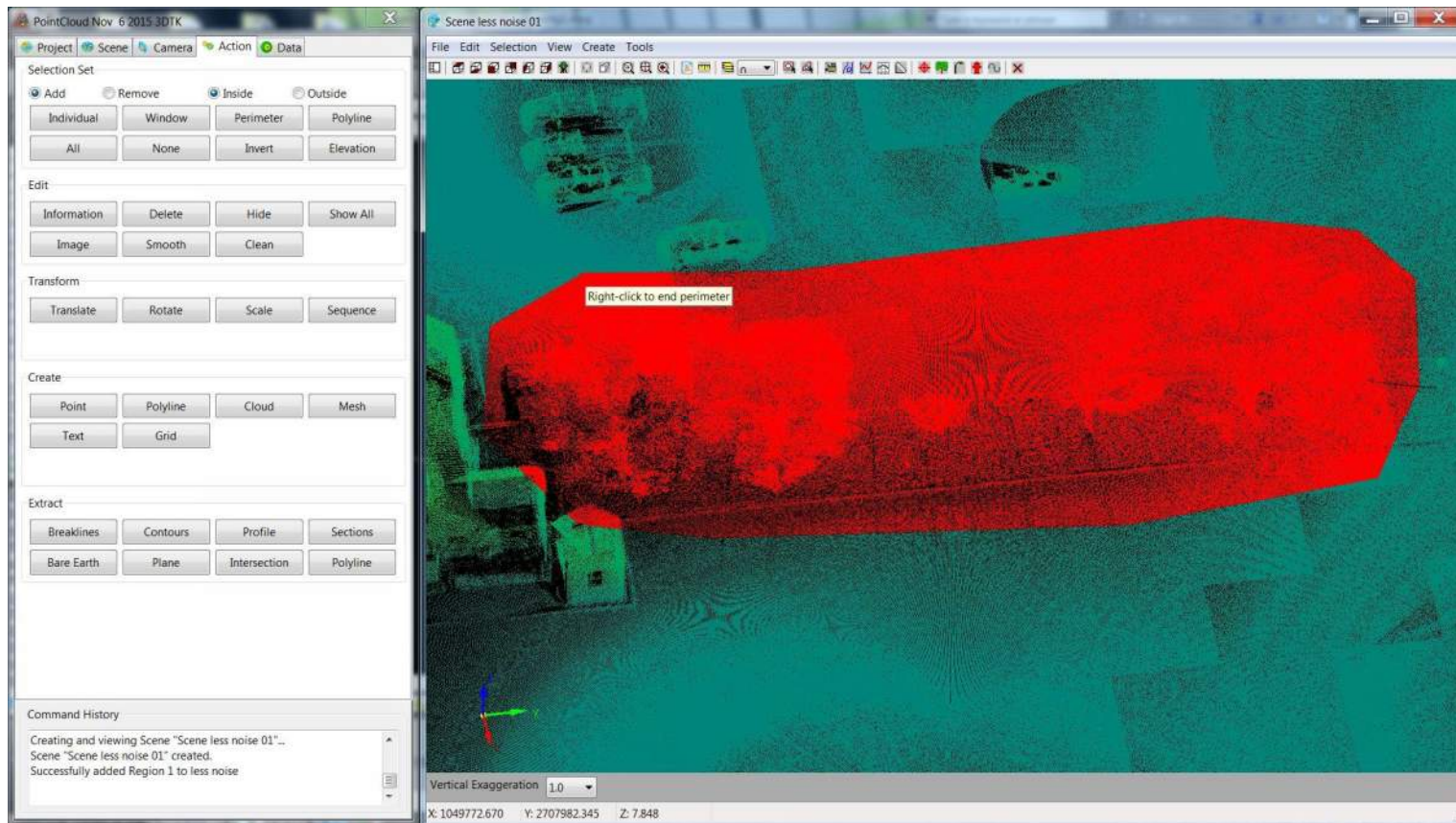
A polyline was created along the centerline of the drive. At this vantage, it appears to be above and below the cloud.



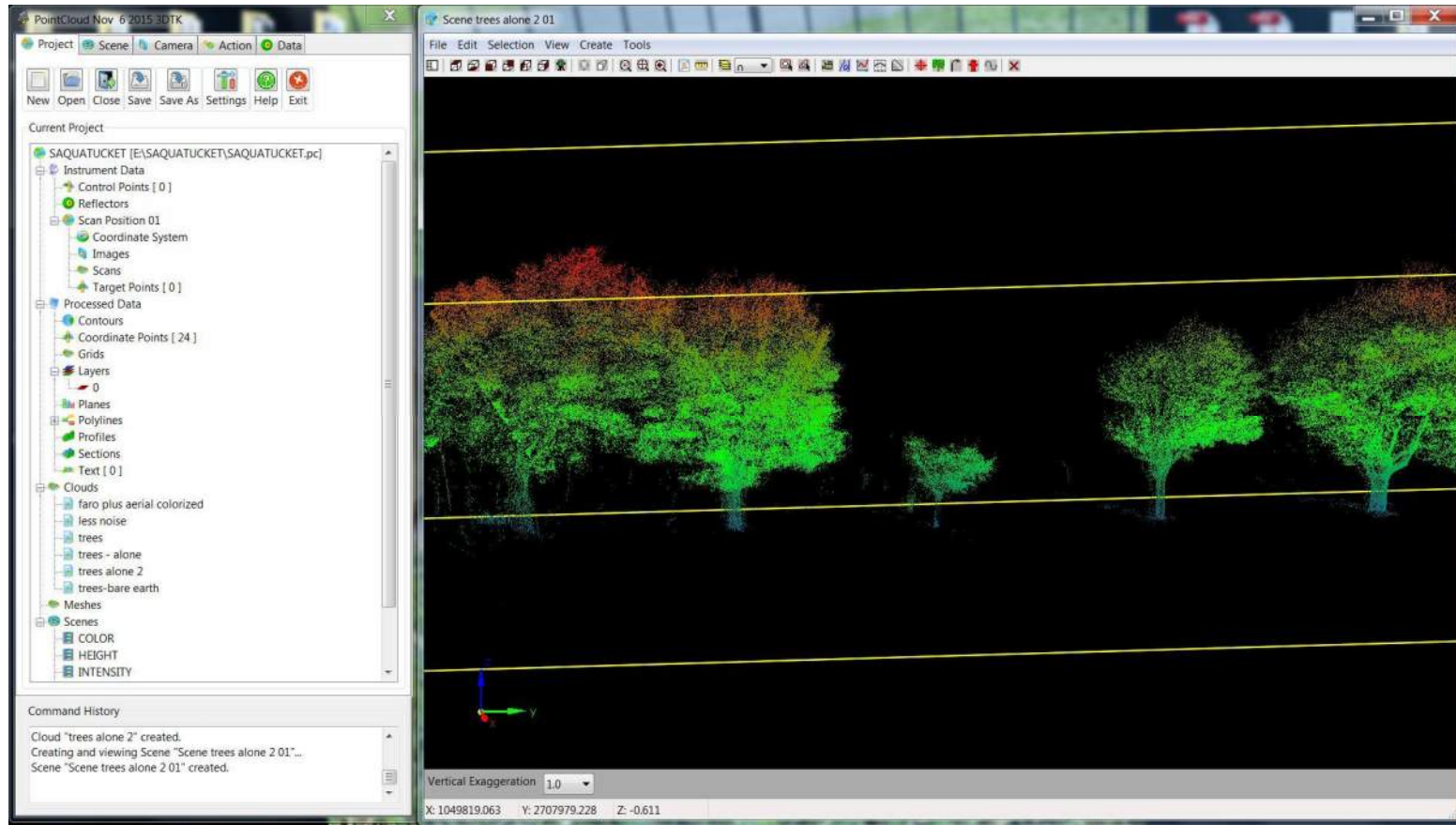
The polyline can be quickly drawn into the open CAD session. The same goes for points and Field 2 Finish can be executed directly from the Point Cloud module. The objects in a CAD drawing can be imported into the Point Cloud session.



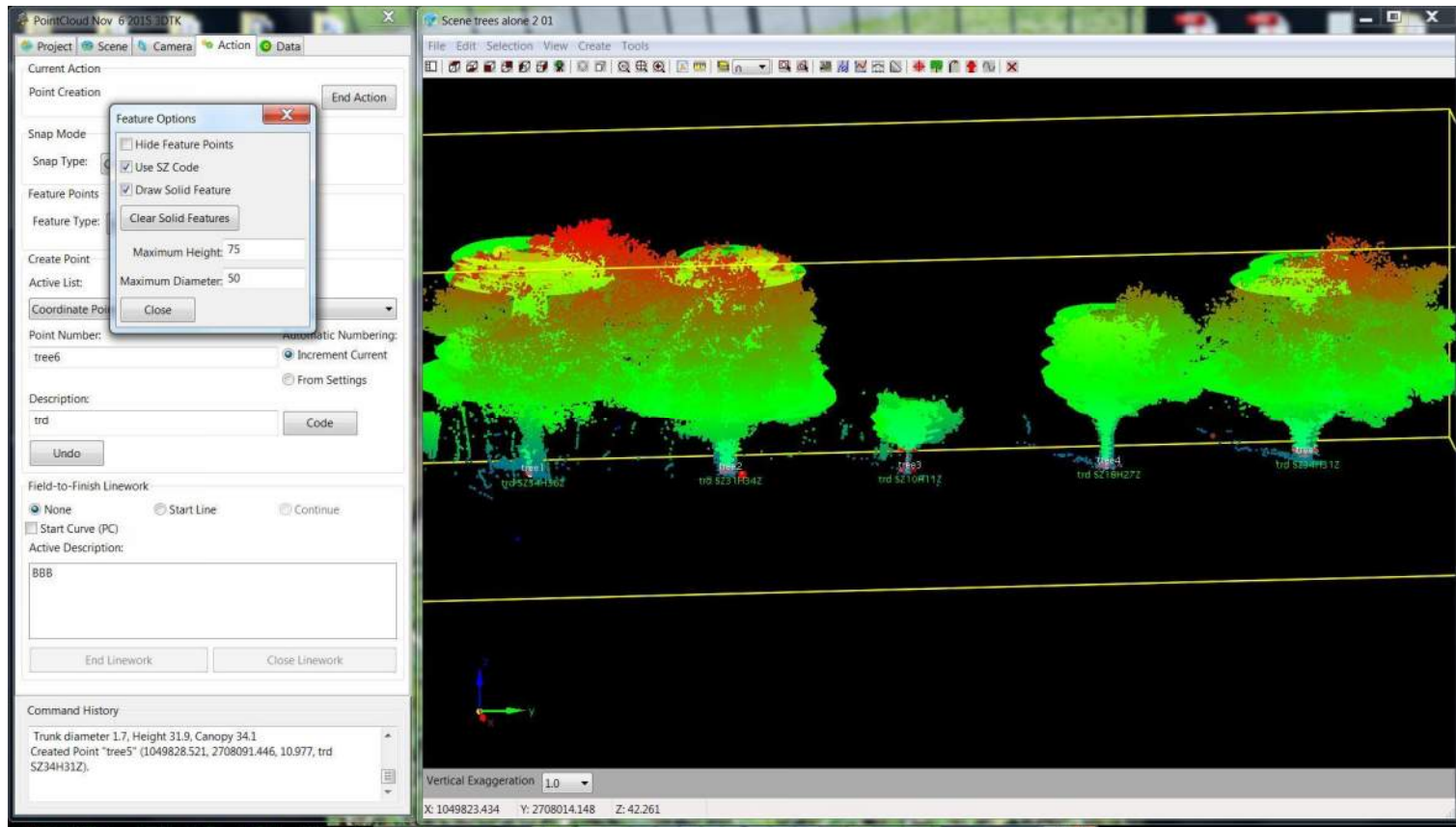
The polyline can be used to show a slice of the cloud. The points shown here are along the flow line at the base of a Cape Cod Berm. The cloud has been vertically exaggerated by 3.



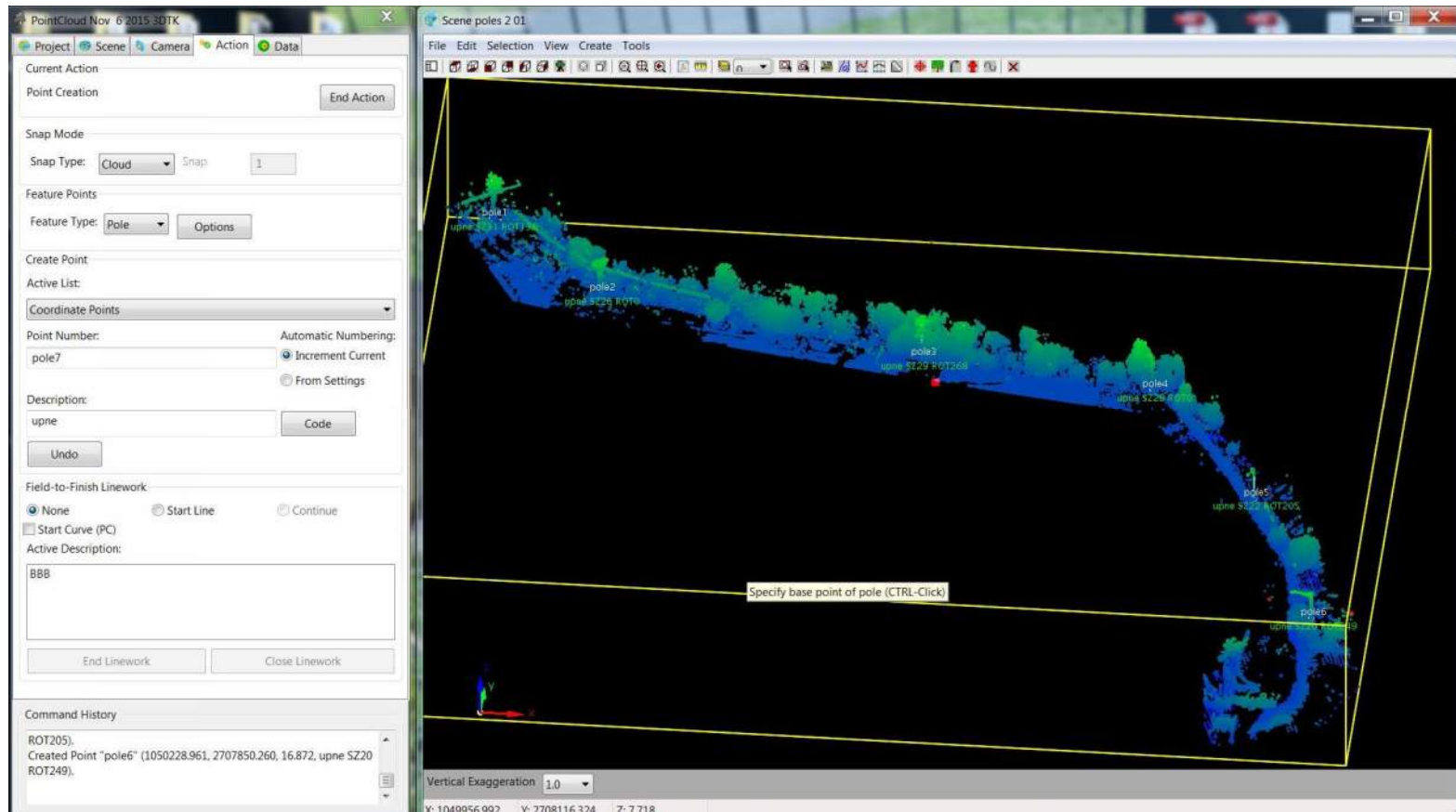
The cloud is being viewed by height. The red is a selection set to be isolated.



Some additional isolation and resetting the range for height coloration shows the trees.

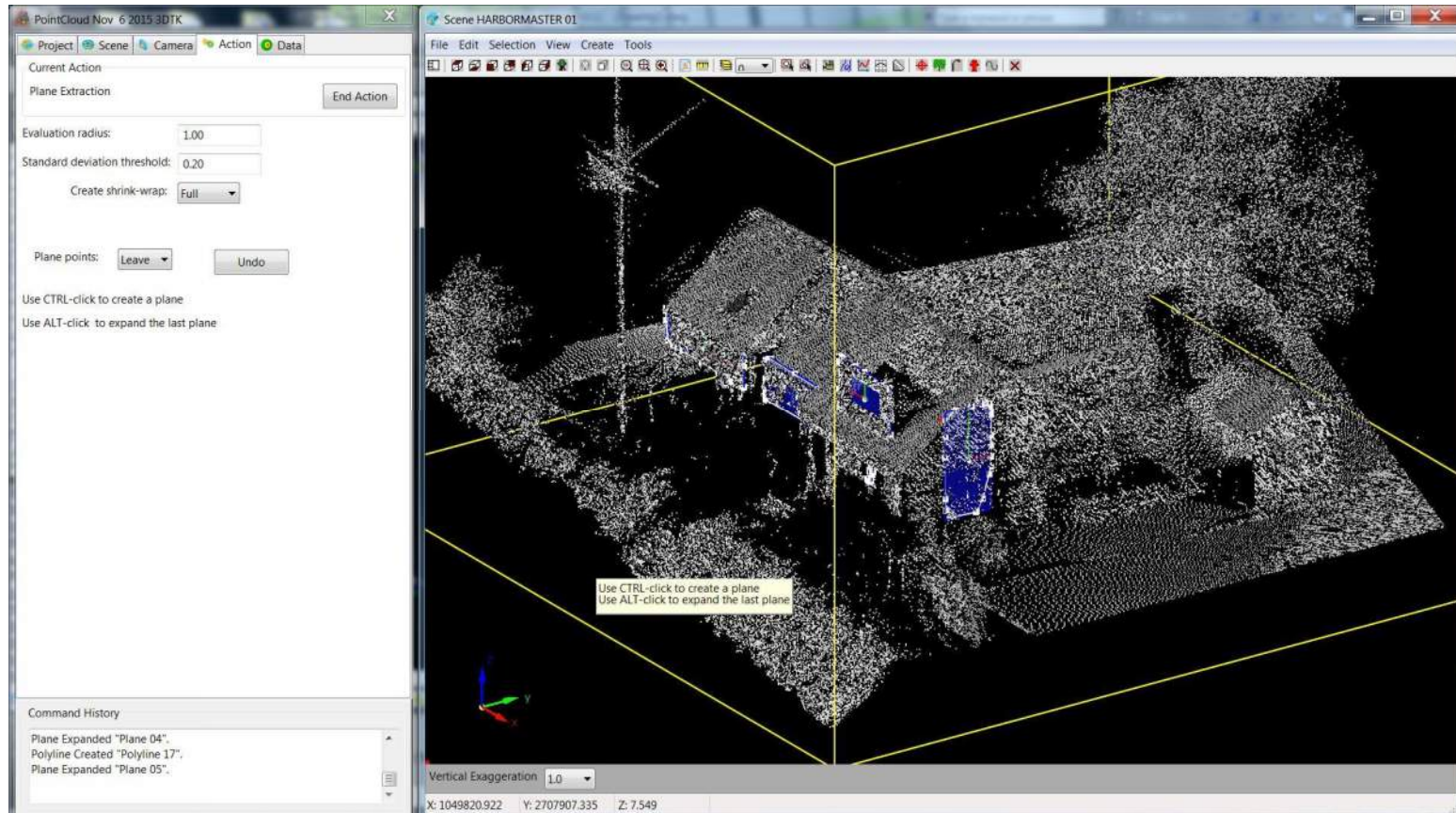


The software has tree extraction functions that work best with isolated trees. It will provide a coded descriptor with caliper, height and spread.

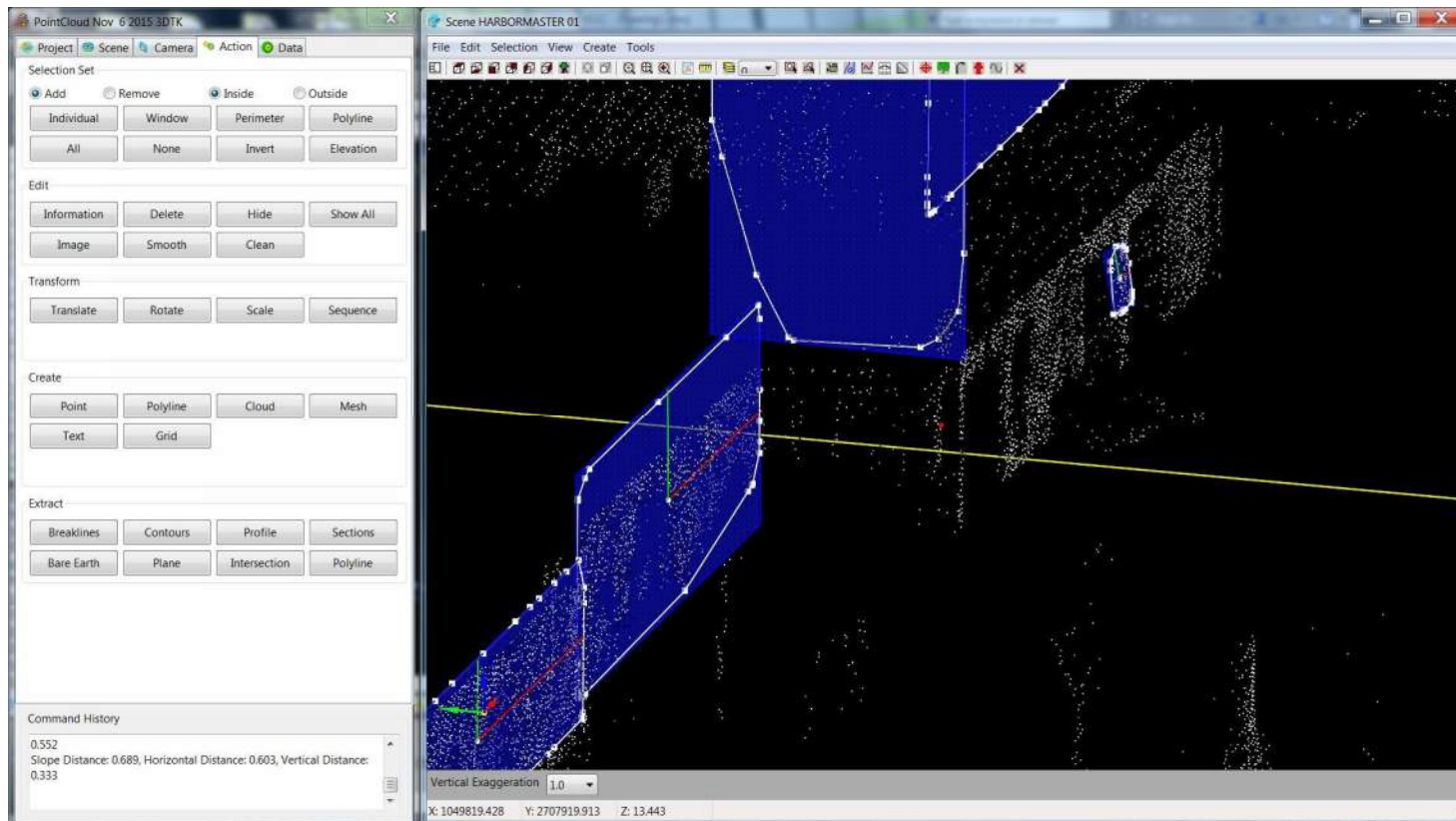


Isolating another part of the cloud allows for the quick extraction of the utility poles. The lines show up and the height above a road can be determined.

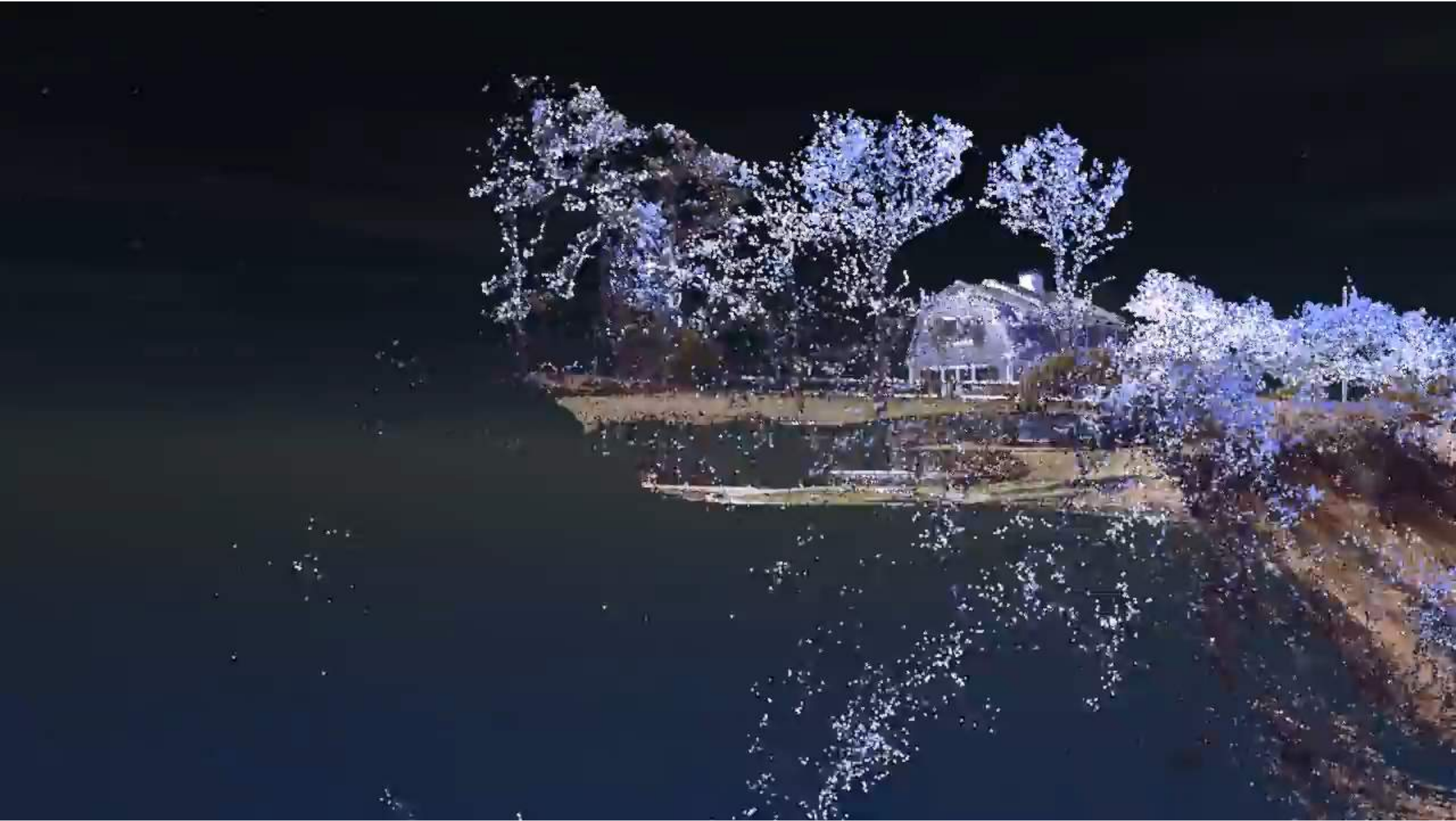




If you can see this building, then good. The blue patches are planes extracted from visible sides. These can be intersected to form corners. The can also be imported into 3d CAD.



The other side of the building.



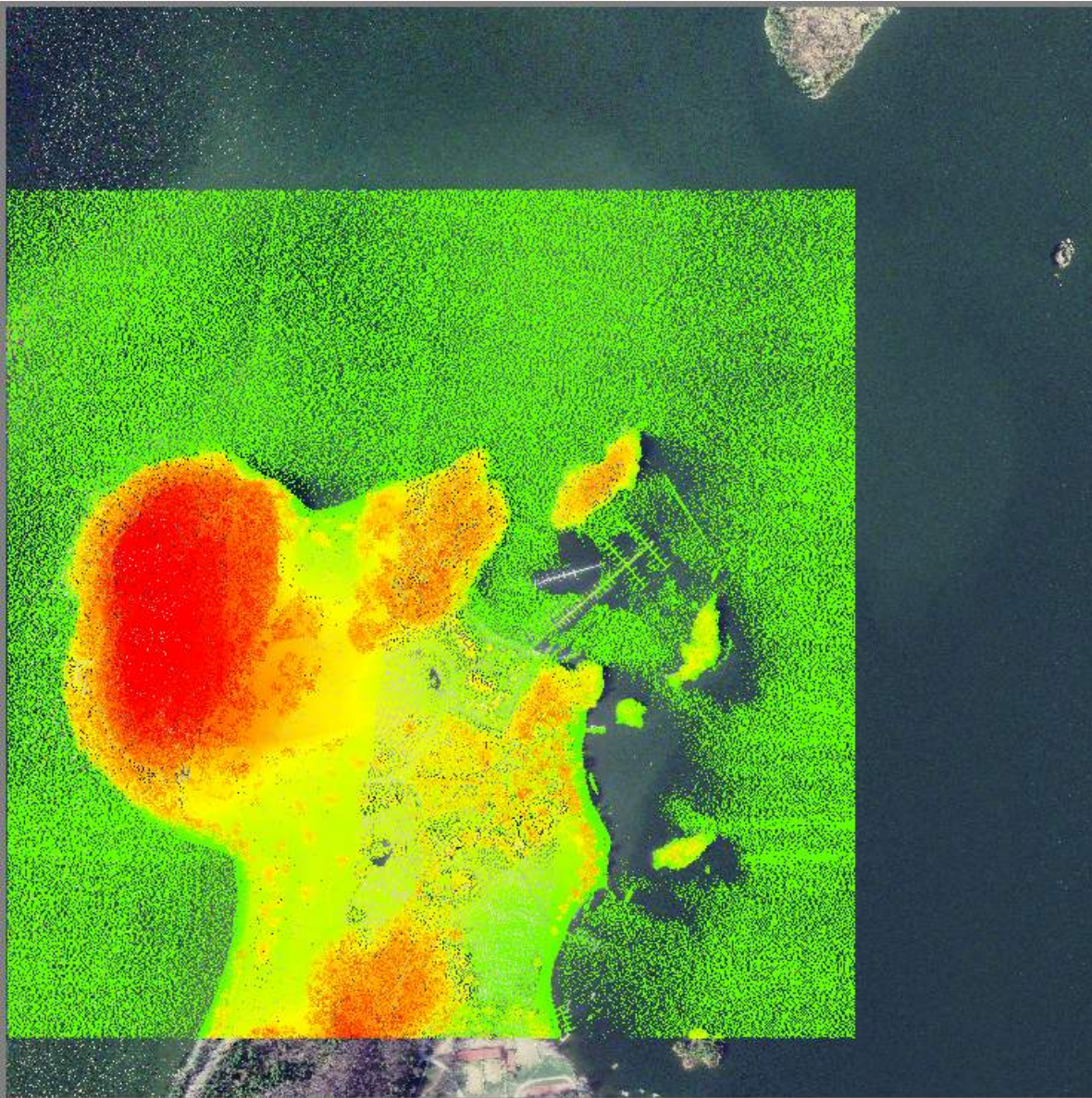


# Global Mapper

-  **Open Your Own Data Files**  
(Menu Command: File->Open Data File)
-  **Download Free Maps/Imagery from Online Sources**  
(Menu Command: File->Download Online Imagery/Topo Maps)
-  **Display Settings/Projection**  
(Menu Command: Tools->Configuration)
- Load Sample Data**

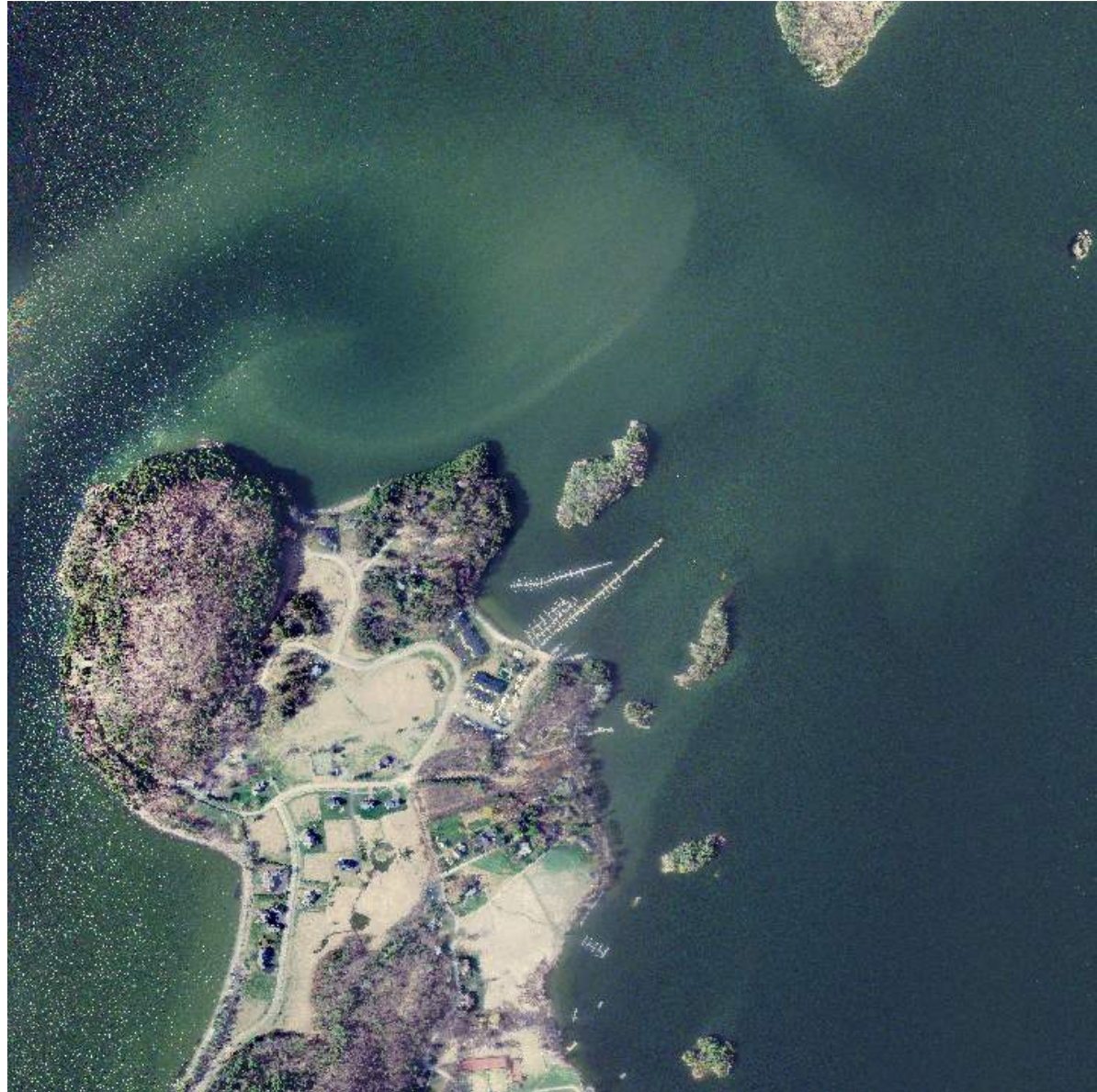


Colchester, VT



USGS Earth Explorer does have some high resolution orthoimagery.

The cloud is still there, it has been colorized based on the imagery.





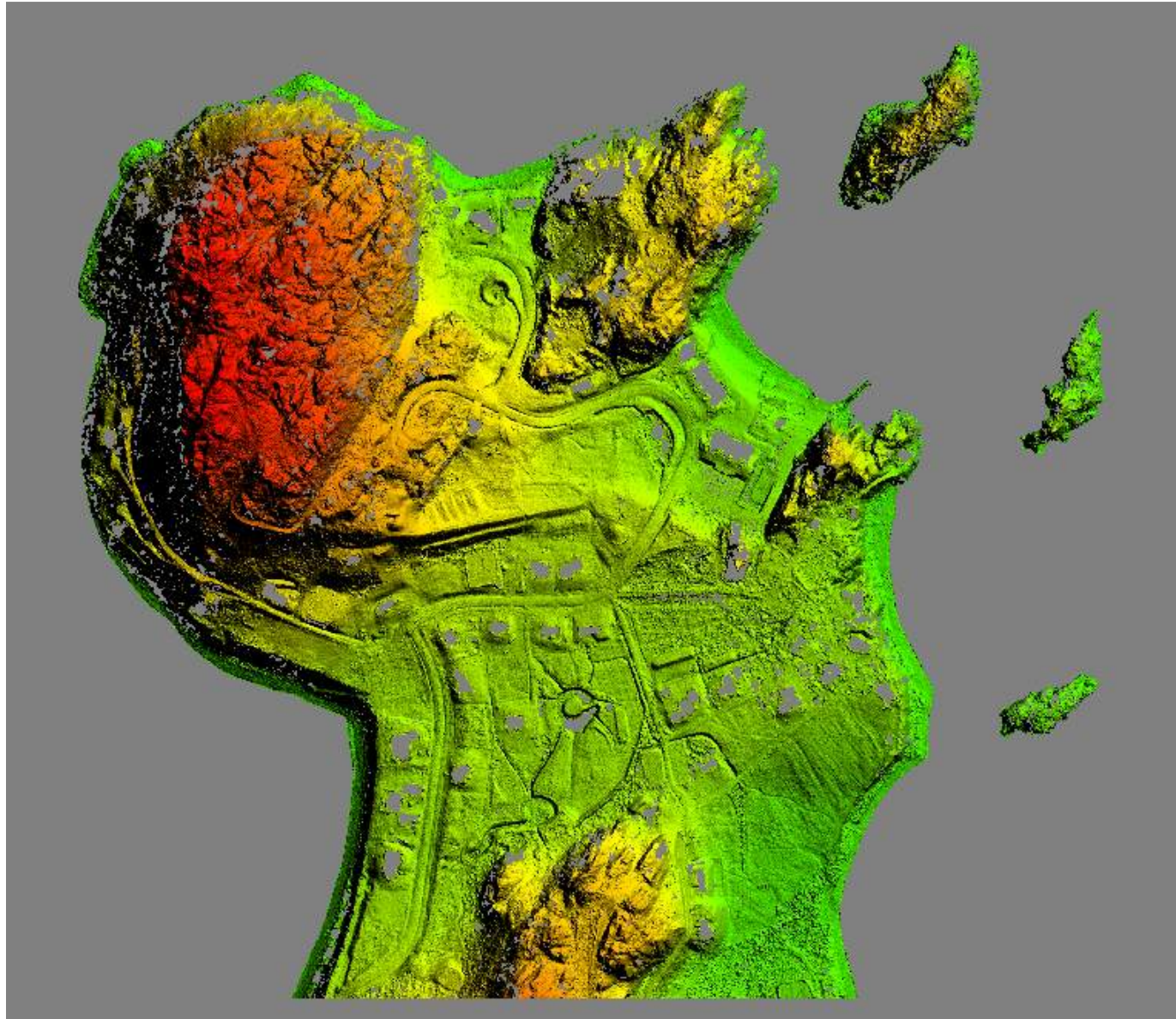
This is just colorized cloud.

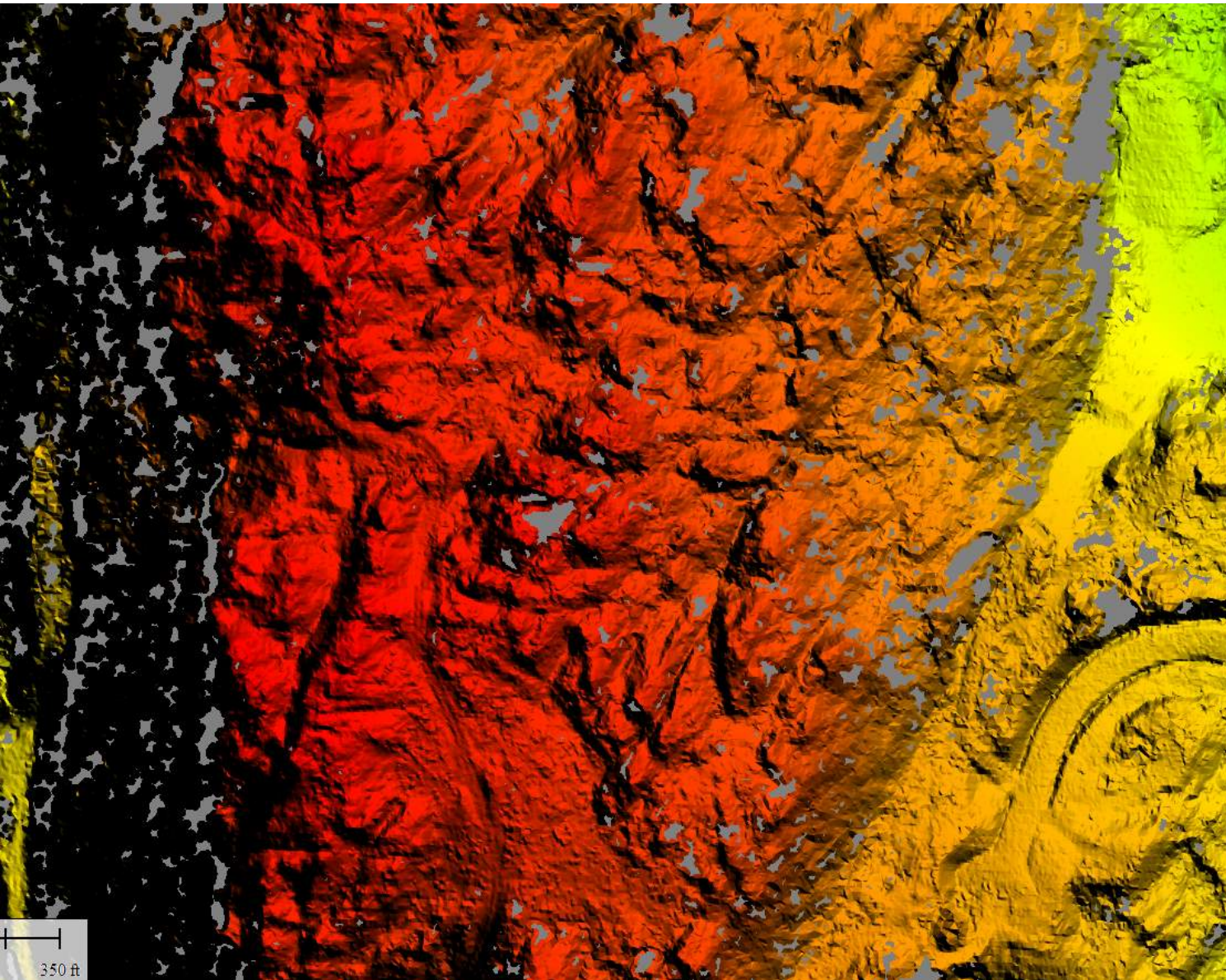




Just the ground points.

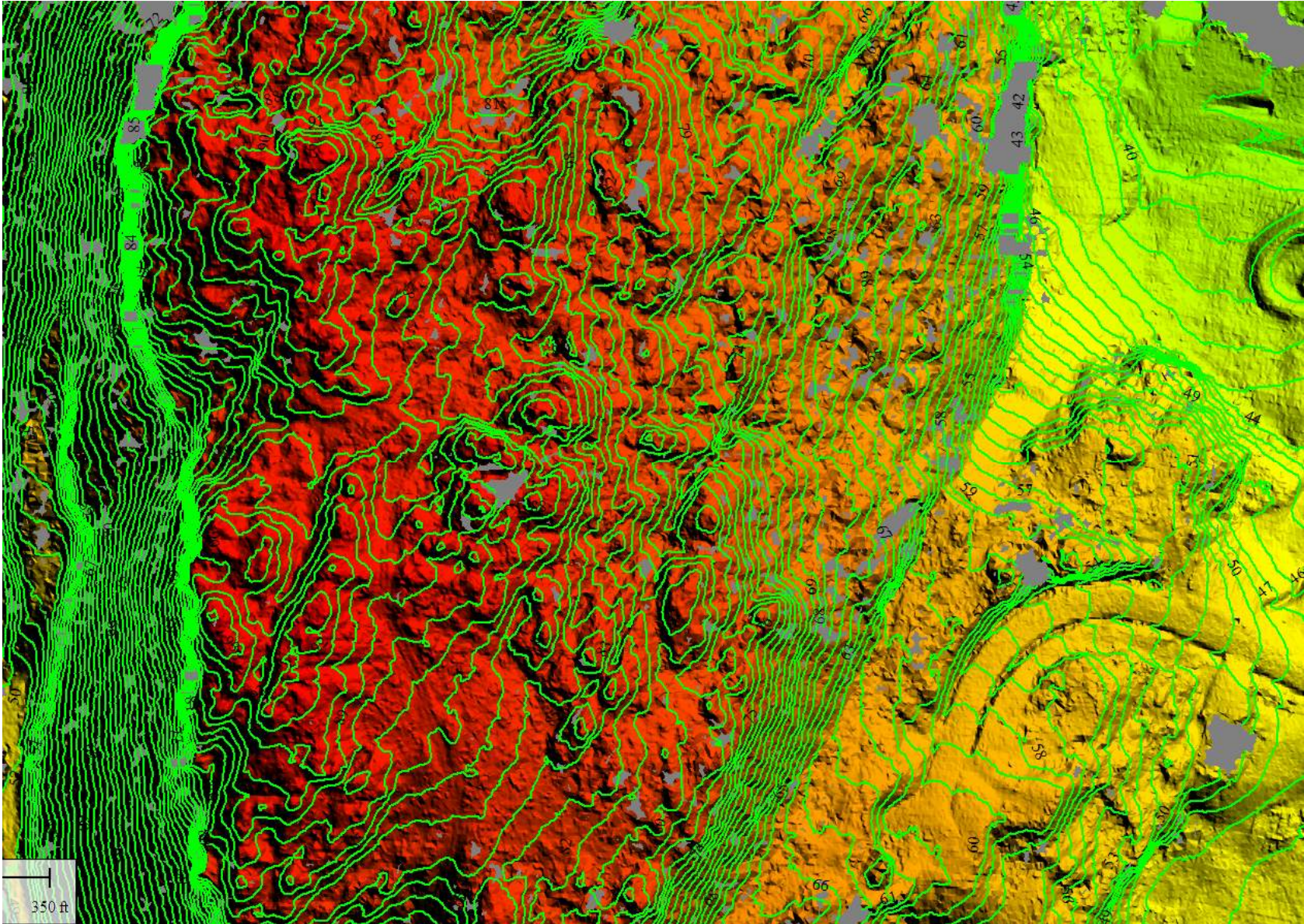
A surface model. This is very similar to the Fugro surface model.



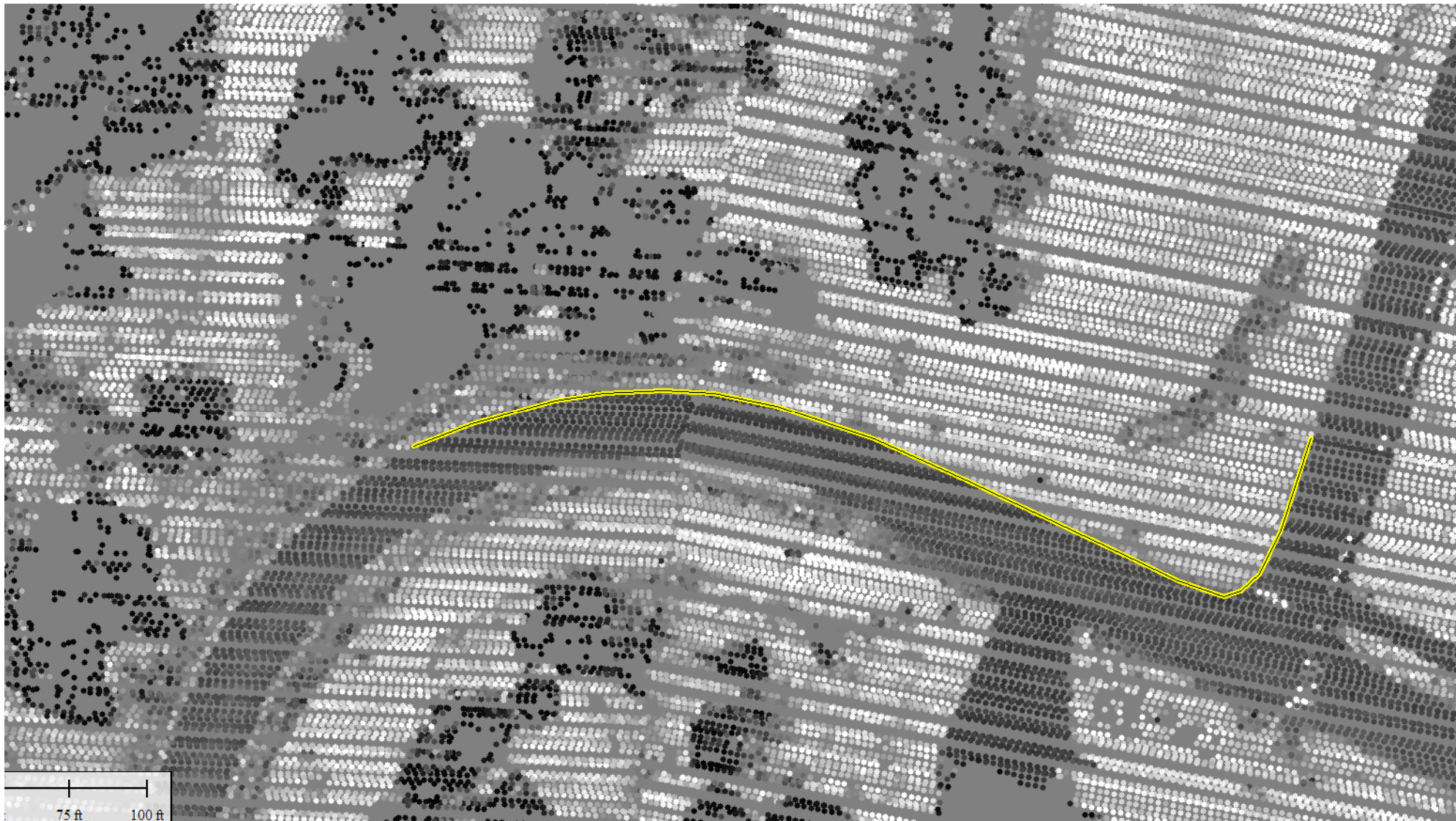


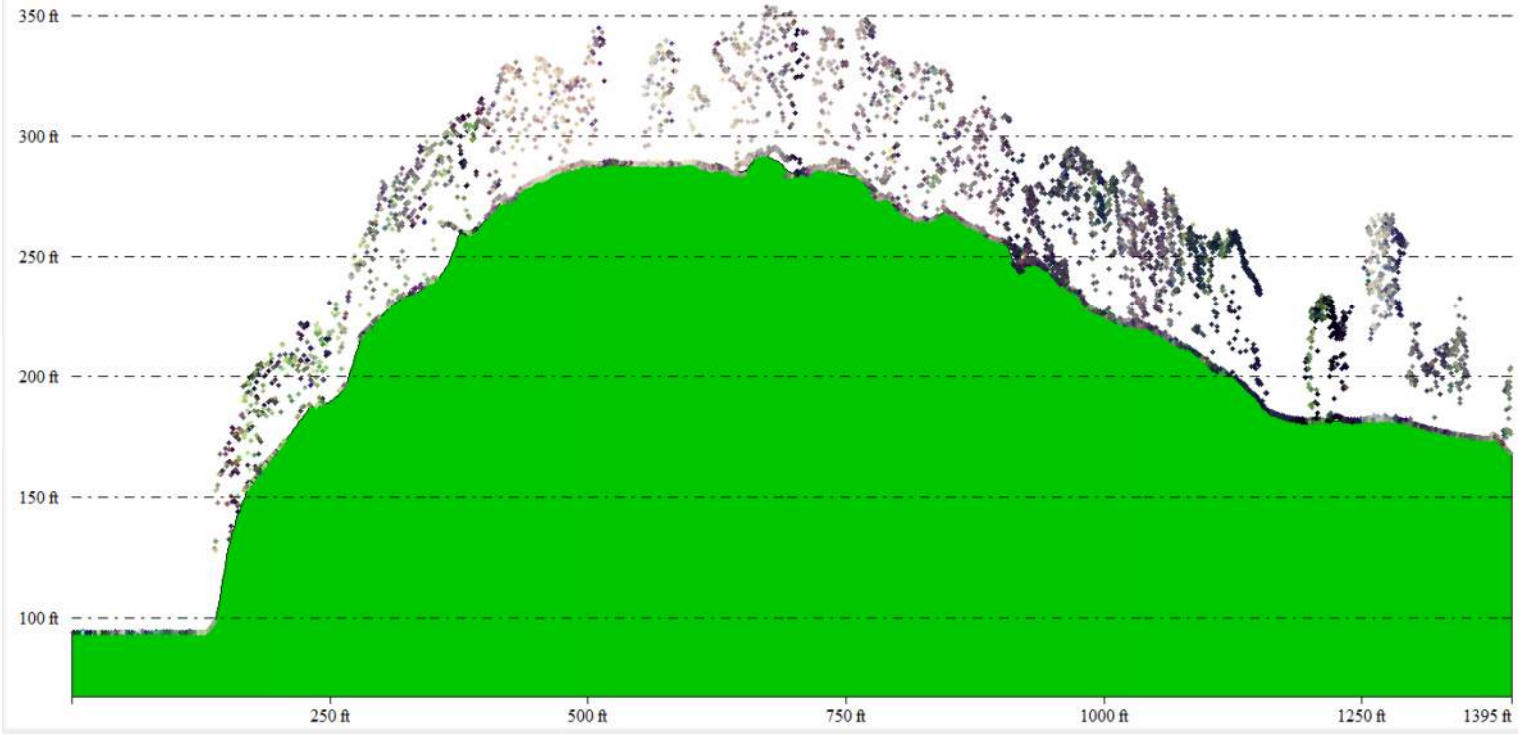
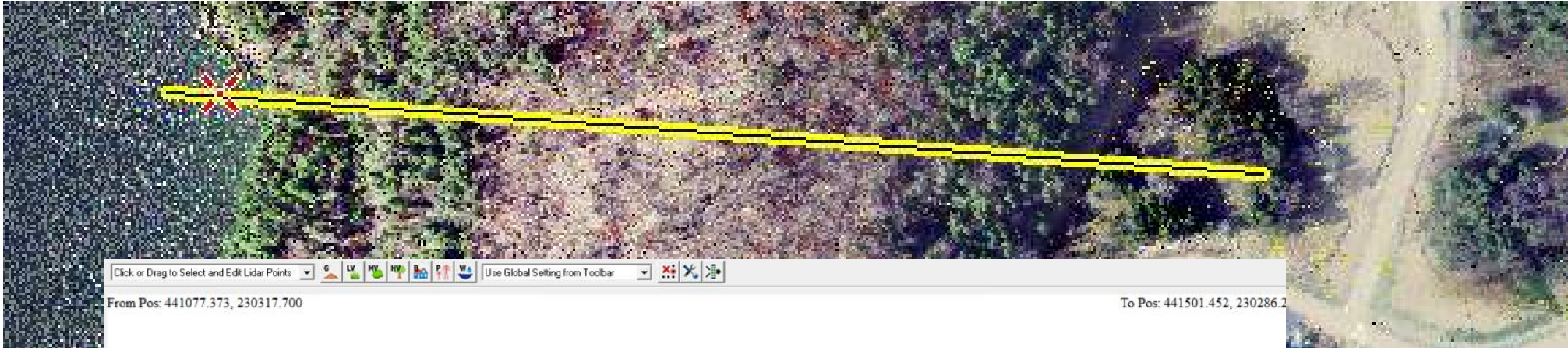
It looks like some trails and some geology atop this rock.

Contours can be created and exported to CAD or SHP. Surface models can be exported.



Linework can be determined and extracted (Digitized)





Quick Plan and Profile Views

Automatic Classification of Ground Points

Select Unclassified Point Cloud(s) to Find Likely Ground Points In

EVT1488.las

Only Classify Lidar Points Selected in Digitizer Tool

Base Bin Size to Check for Curvature Deviations:  Meters

Minimum Height Departure from Local Mean for Non-Ground Point

Specify the minimum height above the local average minimum elevation that a point has to be in order to be considered a non-ground point. Larger values require greater vertical deviation from local averages to make a point non-ground.

meters

Removal of Likely Non-Ground (i.e. Building/Vegetation) Points

The following parameters control the automatic remove of likely non-ground (i.e. building) points using a morphological filter. Use larger slope and height delta in areas with high relief and/or large buildings (skyscrapers).

Maximum Height Delta:  meters (use larger values for high relief/tall buildings)

Expected Terrain Slope:  degrees (use larger for steep terrain)

Reset Existing Ground Points to Unclassified at Start

Specify Bounds... Filter Points... Restore Defaults OK Cancel

Now we can get into the real fun: Classification Tools based on mathematical models of the world in point format. Pull out the ground, vegetation and buildings. Results can be verified and adjusted as needed. Once classified, there are some features that can be extracted.

Automatic Classification of Building/Vegetation Lidar Points

Select Unclassified Point Cloud(s) to Find Likely Building/Ground Points

EVT1488.las

Only Classify Lidar Points Selected in Digitizer Tool

Base Bin Size to Check for Planar Points:  Meters

ADVANCED: Threshold Values

The following parameters control how close to a calculated local best-fit plane that points need to be in order to be considered a potential building or a likely vegetation area. Use values larger than the expected error in the elevations):

Minimum Height Above Ground:  meters

Maximum Co-Planar Distance:  meters

Minimum Vegetation Distance:  meters

Max Co-Planar Angle Difference:  degrees

Reset Existing Non-Ground Points to Unclassified at Start

Specify Bounds... Filter Points by Elev/Class/etc... Restore Defaults OK Cancel

Lidar Feature Extraction Settings

Select Point Cloud(s) to Extract Features From

EVT1488.las

Only Extract from Lidar Points Selected in Digitizer Tool

Resolution to Extract at:  Point Spacings

Building Outline Extraction Settings

Extract 3D Building Outlines

Create Separate 3D Areas for Different Roof Pieces if Possible (i.e. Very High Detail)

Max Co-Planar Angle Difference:  degrees

Max Distance From Adjacent Plane:  meters

Create Side Wall Areas Extending to Ground

ADVANCED - Simplification Multiplier for Smoothing Buildings:

Tree Extraction Settings

Extract Tree Points

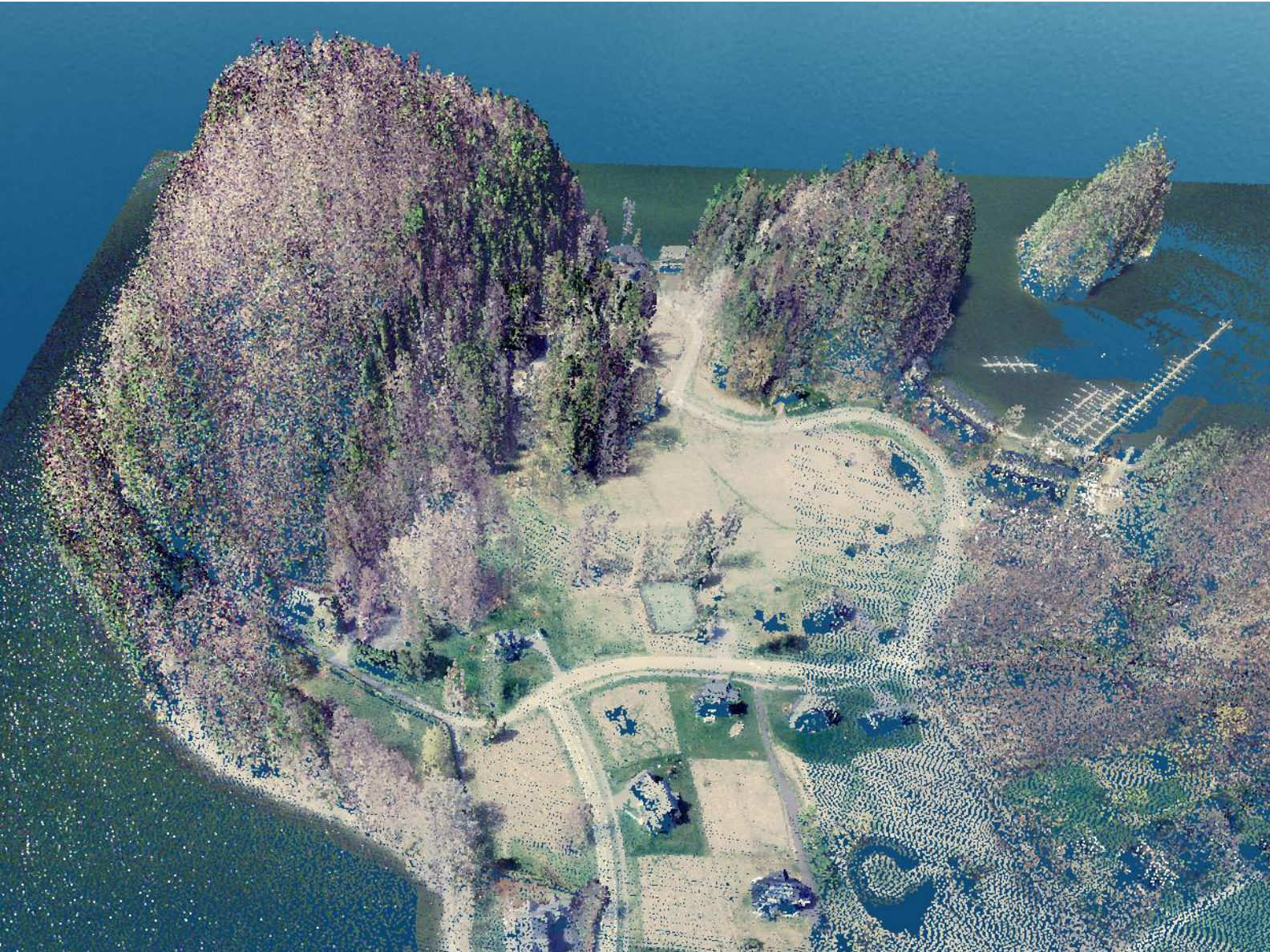
Minimum Tree Height:  meters

Minimum Tree Spread:  meters

Maximum Tree Spread:  meters

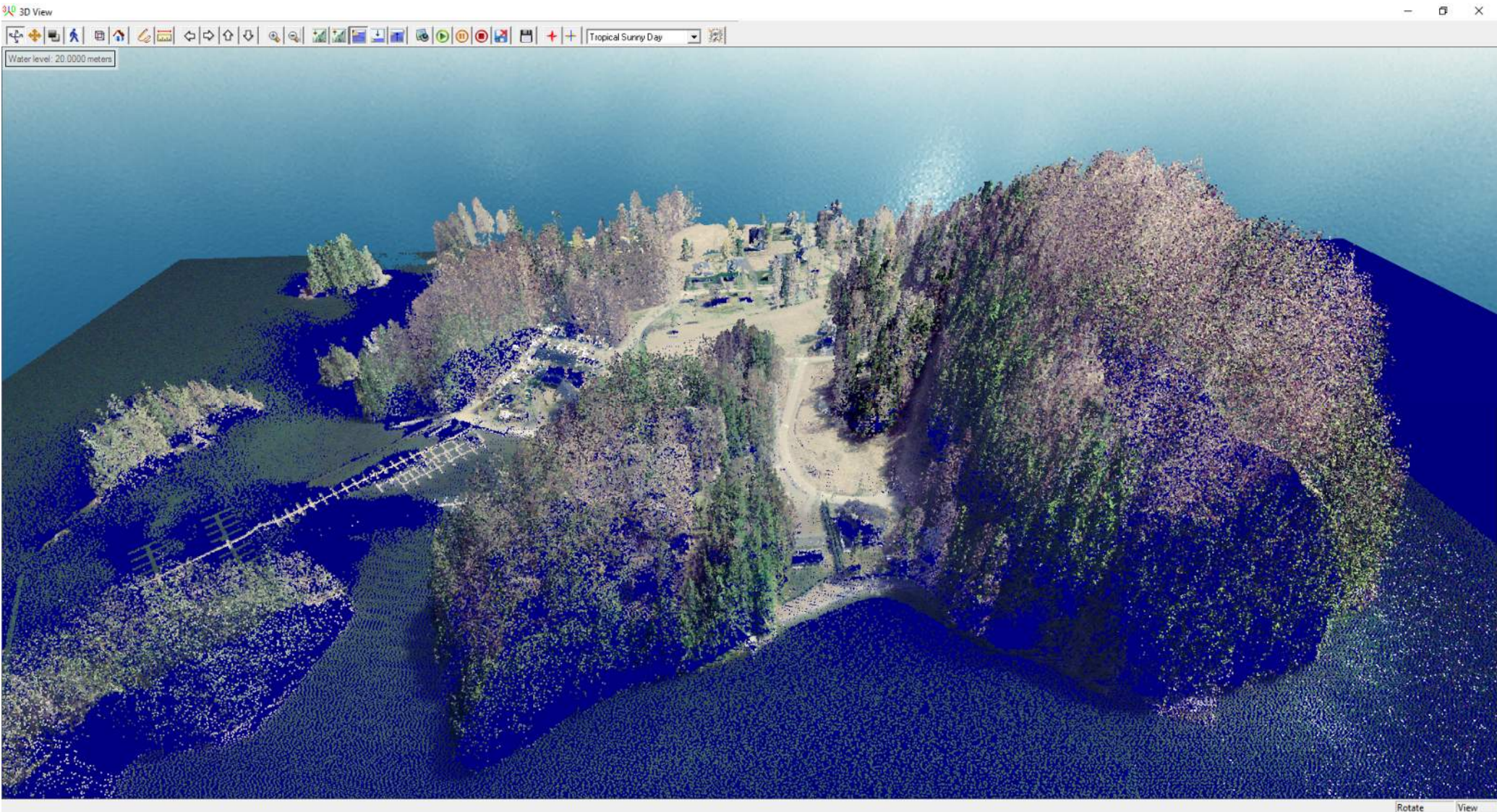
Create Approximate Tree Coverage Polygons

Specify Bounds... Filter Points... Restore Defaults OK Cancel

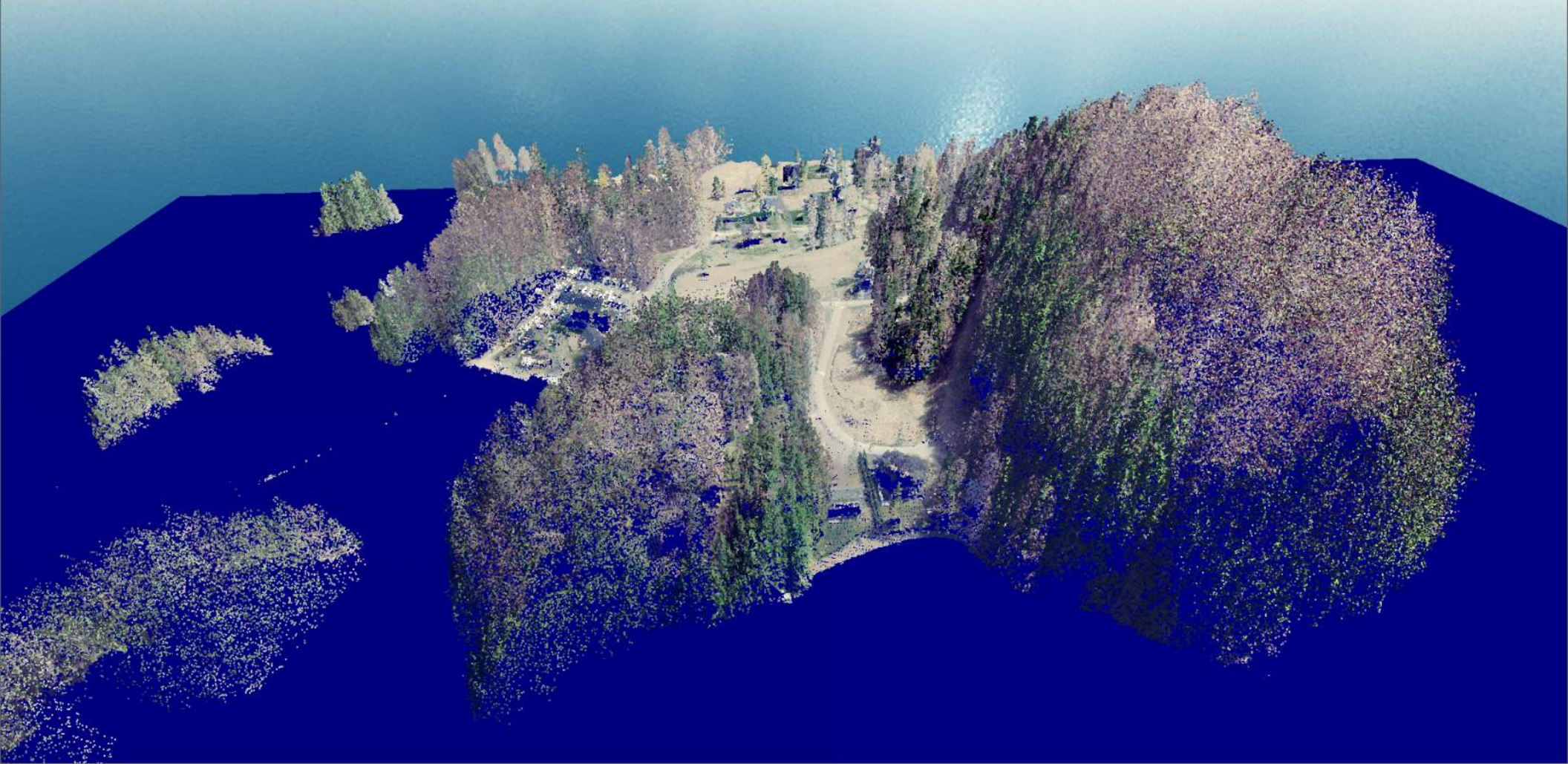


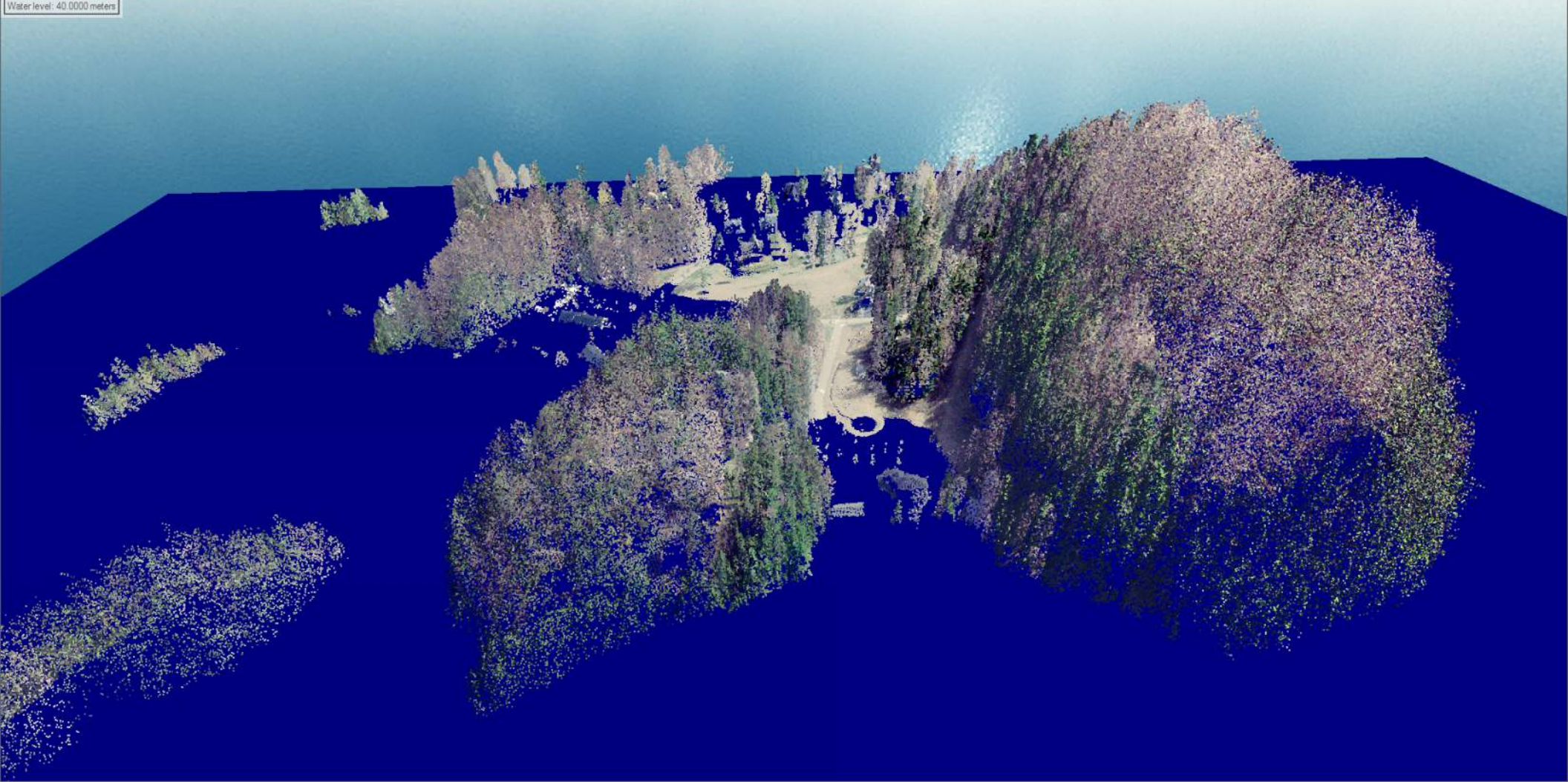
All the previous work was completed in 2d from above. There is also a 3d viewer.

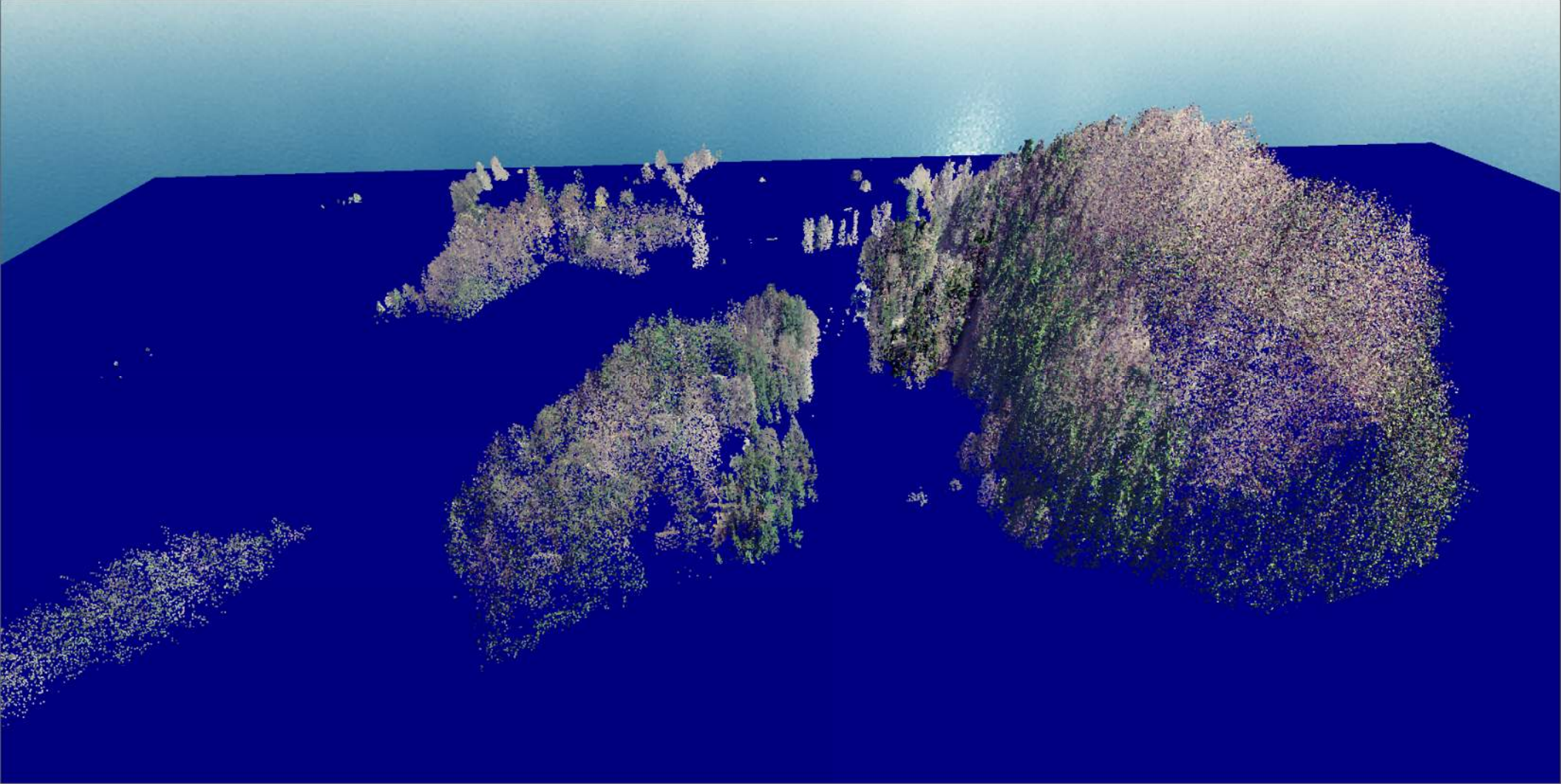




Flood visualization. (Not well advanced for large area flood analysis)







# *LIDAR*



## **VERMONT SOCIETY** *of* **LAND SURVEYORS**

J. Thaddeus "Thadd" Eldredge

*ELDREDGE SURVEYING & ENGINEERING, LLC*

1038 Main Street, Chatham, MA 02633

[www.ese-llc.com](http://www.ese-llc.com)