For this Postgres Database Engineer position, we want to get a feel for your abilities with open source GIS databases, raster analysis, and optionally, recommendations for automating the process for many datasets.

Please use the following technologies while working on this challenge:

* PostgreSQL database with PostGIS installed

A federal government client is developing a raster analytics platform for creating slope derivatives from LiDAR elevation data. They want to perform the analysis using PostGIS and store the results in Postgres.

**Requirements** (answers in-line, subordinated within outline):

1. Create a PostgreSQL database and install PostGIS on it (hint: [https://registry.hub.docker.com/r/postgis/postgis/](about:blank)).
   1. I chose the 64-bit Windows Interactive Installer by EDB, from <https://www.postgresql.org/download/windows/>
   2. Using this installed, I installed (on my local):
      1. PostgreSQL 15.5
         1. **SELECT** version(); -- PostgreSQL 15.5
      2. PostGIS 3.4.1
         1. CREATE EXTENSION postgis;
         2. SELECT PostGIS**\_Full\_Version**(); -- POSTGIS 3.4.1
      3. Miscellaneous Setups in PG
         1. CREATE EXTENSION postgis\_raster;
         2. CREATE EXTENSION pointcloud;
         3. CREATE EXTENSION pointcloud\_postgis;
         4. ALTER DATABASE postgres SET postgis.enable\_outdb\_rasters = true;
         5. ALTER DATABASE postgres SET postgis.gdal\_enabled\_drivers = 'ENABLE\_ALL';
   3. I am using, on my local, DBeaver Enterprise 23.3.0
2. Download LiDAR raster elevation data from [https://apps.nationalmap.gov/downloader/](about:blank) from a small area in the continental USA. Remember that you will be uploading this data to a GitHub repository later, so the data will need to be a reasonable size.
   1. I chose a small USGS Lidar Point Cloud, just east of Asheville, NC:
      1. USGS Lidar Point Cloud NC\_Phase5\_2018\_A18 LA\_37\_00964920\_
      2. Its download/reference URL:
         1. <https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/NC_Phase5_2018_A18/NC_Phase5_Buncombe_2017/LAZ/USGS_LPC_NC_Phase5_2018_A18_LA_37_00964920_.laz>
   2. After downloading, I extracted the LAS from LAZ via laszip.exe

Use an open-source tool to describe the characteristics of raster you downloaded.

* 1. I then used the following tools to investigate, peruse/view, and describe the raster above:
     1. [LAStools (lasinfo): integrated with QGIS 3.34.3 as plugin](#lasinfo_plugin_report)
     2. [LAStools (lasinfo): standalone / command-line](#LAStools_lasinfo_commandline_report)
     3. [pdal 2.6.0 command-line info metadata options](#pdal_2_6_0_info_metadata)
     4. [CloudCompare v2.13beta](#CloudCompare)
     5. QGIS 3.34.3 (various tools within Processing Toolbox)

1. Import the LiDAR elevation data into your PostGIS database. What is your justification for the tile size you used? (Answer: I tried auto, system chose 61x61 – so I used 128x128)
   1. I first created a target raster table, in PostgreSQL:  
      **CREATE** **TABLE** myrasters\_lidar(rid serial **PRIMARY** **KEY**, rast raster);
   2. I secondly used LAStools lasgrid (available directly from LAStools as lasgrid.exe, and within LAStools section of QGIS Processing Toolbox as lasgrid), to write the above laz file to a raster ASC file (by *elevation*).
   3. I thirdly used raster2pgsql.exe (from PostgreSQL installation folder structure) to affect the copy of rasters from local to the new raster table via the following syntax:
      1. raster2pgsql.exe -N -32767 -t auto -c -I -C -M -d C:\users\richard\downloads\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.asc public.myrasters\_lidar | psql -d postgres -h localhost -U postgres -p 5432
   4. I checked the resulting tile size (from auto), and found that the raster2pgsql.exe chose 61x61
   5. I then truncated the raster table, and used raster2pgsql.exe (from PostgreSQL installation folder structure) to affect the copy of rasters from local to the new raster table via the following syntax:
      1. raster2pgsql.exe -N -32767 -t 128x128 -c -I -C -M -d C:\users\richard\downloads\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.asc public.myrasters\_lidar | psql -d postgres -h localhost -U postgres -p 5432
   6. This 128x128 resulted in 400 records in the myrasters\_lidar table:  
      **SELECT** **count**(\*) **FROM** myrasters\_lidar; -- 400
   7. Also, as the dataset originated from USGS with an interesting custom CRS, I ***could*** use the following to set an SRID within the uploaded tables:
      1. **INSERT** **INTO** spatial\_ref\_sys (srid, proj4text)  
         **VALUES** (990000,  
          '+proj=lcc +lat\_0=33.75 +lon\_0=-79 +lat\_1=36.1666666666667 +lat\_2=34.3333333333333 +x\_0=609601.219202438 +y\_0=0 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=us-ft +vunits=us-ft +no\_defs');
      2. **SELECT** UpdateRasterSRID('myrasters\_lidar','rast',990000);
      3. **SELECT** **UpdateGeometrySRID**('my\_cents\_lidar','geom',990000);
2. If you wanted to reference the raster dataset in the database without having to load it in the database, what technique would you use? (Answer: Out-DB rasters stored in the cloud, via CrunchyBridge or similar: <https://www.crunchydata.com/blog/postgis-raster-and-crunchy-bridge>)
3. Use the PostGIS ST\_Slope() function to create a slope (in degrees) dataset from the elevation dataset.
   1. I used the following SQL (degrees is default):
      1. CREATE TABLE my\_slope\_lidar As  
          SELECT ST\_Slope(ST\_Union(rast), 1, '32BF') As slope  
          FROM myrasters\_lidar;
4. Use the PostGIS ST\_PixelAsCentroids() function to create a point dataset with the slope values.
   1. I used the following SQL:
      1. **CREATE** **TABLE** my\_cents\_lidar **As** **SELECT** a.geom, a.val, a.x, a.y  
          **FROM** (**SELECT** sp.\*   
          **FROM** my\_slope\_lidar,  
          **LATERAL** ST\_PixelAsCentroids(slope, 1) **As** sp) a;
5. Create a spatial index on the new slope *point* dataset.
   1. I used the following SQL:
      1. **CREATE** **INDEX** sidx\_my\_cents\_lidar\_geom   
          **ON** public.my\_cents\_lidar   
          **USING** gist (geom);
6. By selecting the pixels that have the minimum elevation from your elevation dataset, generate a table of polygon(s) from those pixels.
   1. I used the following SQL:
      1. **SELECT** ST\_SummaryStatsAgg(rast, 1, **TRUE**) **FROM** myrasters\_lidar; -- min: 0
      2. **CREATE** **TABLE** my\_poly\_lidar\_min\_val **As** **SELECT** val, geom  
          **FROM** (**SELECT** dp.\*  
          **FROM** myrasters\_lidar ml,   
          **LATERAL** ST\_DumpAsPolygons(rast) **As** dp) **As** foo  
          **WHERE** val = 0; -- min: 0

Bonus:

1. Recreate the new slope point dataset with the data organized on disk by the spatial index.

Questions:

1. Imagine that you must download and integrate 1,000 Lidar datasets; what techniques would you use to automate the process?
   1. First, analyze and catalog the targeted source datasets (origin site(s), URL folder and filename structure, date-identifying specifics (vintage(s), frequency/periodicity), available resolutions and formats, etc
   2. Decide if we are going to sole-source from the provider, or mirror-on-cloud or server (which one, how often, driven by what rules?)
   3. Benchmark file acquisition performances, decide acquisition frequency and model
   4. PoC the Out-DB connection(s) to same, methodology for initial acquisition and refresh, and project the required space/cost, and acquisition times/frequency
   5. Decide how stakeholders do – or do not – intend to request change-stacks (vintage comparisons of evolving source rasters – and if yes, decide how we are going to break up (h3, etc) the minimal dirtied grid pieces, store such as stacks, decide retention period and method
   6. If item “e” above is a yes, then UI of any associated solutions (including reporting) will have to avail and present same

Submitting your response

We understand that you probably have a lot going on, so make sure you negotiate enough time to do what you consider to be a good job. You will not be penalized for taking the time you need. Just keep in mind that we are continuing to screen candidates for the position you are applying for.

1. Create a private GitHub repository that will contain your code, including an export of the PostGIS database and elevation data you downloaded for the challenge. Please also include answers to the questions posed as part of the challenge. Share it with the GitHub user(s) from our team, giving those user(s) permission to at least read your repo.
   * Ventera Recruiting – ventera-recruiting
   * Heather Stanton – hstanton-ventera
2. Include a README.md that explains how to install (or deploy) and run (or access) your program.
3. Notify your technical recruiter that you have completed your challenge. Provide your repository URL and bundle (compressed).
4. No more changes can be committed/submitted after the deadline negotiated between you and your technical recruiter.

**lasinfo (240115) report for 'C:\Users\richard\Downloads\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.laz'**

reporting all LAS header entries:

file signature: 'LASF'

file source ID: 0

global\_encoding: 17

project ID GUID data 1-4: 00000000-0000-0000-0000-000000000000

version major.minor: 1.4

system identifier: 'IntelliEarth GmAPD Sensors #1-3'

generating software: 'ESP ANALYST'

file creation day/year: 57/2018

header size: 375

offset to point data: 377

number var. length records: 0

point data format: 6

point data record length: 30

number of point records: 0

number of points by return: 0 0 0 0 0

scale factor x y z: 0.01 0.01 0.01

offset x y z: 0 0 0

min x y z: 947500.01 690000.00 2188.53

max x y z: 950000.00 692500.00 2680.43

start of waveform data packet record: 0

start of first extended variable length record: 202780641

number of extended\_variable length records: 1

extended number of point records: 26814115

extended number of points by return: 26814115 0 0 0 0 0 0 0 0 0 0 0 0 0 0

extended variable length header record 1 of 1:

reserved 0

user ID 'LASF\_Projection'

record ID 2112

length after header 1396

description 'Georeference Info'

OGC COORDINATE SYSTEM WKT:

COMPD\_CS["NAD83(2011) / North Carolina (ftUS) + NAVD88 height - Geoid12B (ftUS)",

PROJCS["NAD83(2011) / North Carolina (ftUS)",

GEOGCS["NAD83(2011)",

DATUM["NAD83\_National\_Spatial\_Reference\_System\_2011",

SPHEROID["GRS 1980",6378137,298.257222101,

AUTHORITY["EPSG","7019"]],

AUTHORITY["EPSG","1116"]],

PRIMEM["Greenwich",0,

AUTHORITY["EPSG","8901"]],

UNIT["degree",0.0174532925199433,

AUTHORITY["EPSG","9122"]],

AUTHORITY["EPSG","6318"]],

PROJECTION["Lambert\_Conformal\_Conic\_2SP"],

PARAMETER["standard\_parallel\_1",36.16666666666666],

PARAMETER["standard\_parallel\_2",34.33333333333334],

PARAMETER["latitude\_of\_origin",33.75],

PARAMETER["central\_meridian",-79],

PARAMETER["false\_easting",2000000],

PARAMETER["false\_northing",0],

UNIT["US survey foot",0.3048006096012192,

AUTHORITY["EPSG","9003"]],

AXIS["X",EAST],

AXIS["Y",NORTH],

AUTHORITY["EPSG","6543"]],

VERT\_CS["NAVD88 height - Geoid12B (ftUS)",

VERT\_DATUM["North American Vertical Datum 1988",2005,

AUTHORITY["EPSG","5103"]],

UNIT["US survey foot",0.3048006096012192,

AUTHORITY["EPSG","9003"]],

AXIS["Up",UP],

AUTHORITY["EPSG","6360"]]]

the header is followed by 2 user-defined bytes

LASzip compression (version 3.4r3 c3 50000): POINT14 3

reporting minimum and maximum for all LAS point record entries ...

X 94750001 95000000

Y 69000000 69250000

Z 218853 268043

intensity 0 48316

return\_number 1 1

number\_of\_returns 1 1

edge\_of\_flight\_line 0 0

scan\_direction\_flag 0 0

classification 1 13

scan\_angle\_rank 15 15

user\_data 0 0

point\_source\_ID 0 0

gps\_time 175398128.000000 175417456.000000

extended\_return\_number 1 1

extended\_number\_of\_returns 1 1

extended\_classification 1 13

extended\_scan\_angle 2500 2500

extended\_scanner\_channel 0 0

number of first returns: 26814115

number of intermediate returns: 0

number of last returns: 26814115

number of single returns: 26814115

overview over extended number of returns of given pulse: 26814115 0 0 0 0 0 0 0 0 0 0 0 0 0 0

histogram of classification of points:

675053 unclassified (1)

3878780 ground (2)

1933011 low vegetation (3)

2810787 medium vegetation (4)

16683893 high vegetation (5)

282225 building (6)

550366 wire guard (13)

classification histogram with bin size 1.000000

bin 1 has 675053

bin 2 has 3878780

bin 3 has 1933011

bin 4 has 2810787

bin 5 has 16683893

bin 6 has 282225

bin 13 has 550366

average classification 4.391059223845351 for 26814115 element(s)

**LAStools command line**

**C:\LAStools\bin\lasinfo -i "C:\Users\richard\Downloads\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las"**

LAStools console output

lasinfo (240115) report for 'C:\Users\richard\Downloads\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las'

reporting all LAS header entries:

file signature: 'LASF'

file source ID: 0

global\_encoding: 17

project ID GUID data 1-4: 00000000-0000-0000-0000-000000000000

version major.minor: 1.4

system identifier: 'IntelliEarth GmAPD Sensors #1-3'

generating software: 'ESP ANALYST'

file creation day/year: 57/2018

header size: 375

offset to point data: 377

number var. length records: 0

point data format: 6

point data record length: 30

number of point records: 0

number of points by return: 0 0 0 0 0

scale factor x y z: 0.01 0.01 0.01

offset x y z: 0 0 0

min x y z: 947500.01 690000.00 2188.53

max x y z: 950000.00 692500.00 2680.43

start of waveform data packet record: 0

start of first extended variable length record: 804423827

number of extended\_variable length records: 1

extended number of point records: 26814115

extended number of points by return: 26814115 0 0 0 0 0 0 0 0 0 0 0 0 0 0

extended variable length header record 1 of 1:

reserved 0

user ID 'LASF\_Projection'

record ID 2112

length after header 1396

description 'Georeference Info'

OGC COORDINATE SYSTEM WKT:

COMPD\_CS["NAD83(2011) / North Carolina (ftUS) + NAVD88 height - Geoid12B (ftUS)",

PROJCS["NAD83(2011) / North Carolina (ftUS)",

GEOGCS["NAD83(2011)",

DATUM["NAD83\_National\_Spatial\_Reference\_System\_2011",

SPHEROID["GRS 1980",6378137,298.257222101,

AUTHORITY["EPSG","7019"]],

AUTHORITY["EPSG","1116"]],

PRIMEM["Greenwich",0,

AUTHORITY["EPSG","8901"]],

UNIT["degree",0.0174532925199433,

AUTHORITY["EPSG","9122"]],

AUTHORITY["EPSG","6318"]],

PROJECTION["Lambert\_Conformal\_Conic\_2SP"],

PARAMETER["standard\_parallel\_1",36.16666666666666],

PARAMETER["standard\_parallel\_2",34.33333333333334],

PARAMETER["latitude\_of\_origin",33.75],

PARAMETER["central\_meridian",-79],

PARAMETER["false\_easting",2000000],

PARAMETER["false\_northing",0],

UNIT["US survey foot",0.3048006096012192,

AUTHORITY["EPSG","9003"]],

AXIS["X",EAST],

AXIS["Y",NORTH],

AUTHORITY["EPSG","6543"]],

VERT\_CS["NAVD88 height - Geoid12B (ftUS)",

VERT\_DATUM["North American Vertical Datum 1988",2005,

AUTHORITY["EPSG","5103"]],

UNIT["US survey foot",0.3048006096012192,

AUTHORITY["EPSG","9003"]],

AXIS["Up",UP],

AUTHORITY["EPSG","6360"]]]

the header is followed by 2 user-defined bytes

reporting minimum and maximum for all LAS point record entries ...

X 94750001 95000000

Y 69000000 69250000

Z 218853 268043

intensity 0 48316

return\_number 1 1

number\_of\_returns 1 1

edge\_of\_flight\_line 0 0

scan\_direction\_flag 0 0

classification 1 13

scan\_angle\_rank 15 15

user\_data 0 0

point\_source\_ID 0 0

gps\_time 175398128.000000 175417456.000000

extended\_return\_number 1 1

extended\_number\_of\_returns 1 1

extended\_classification 1 13

extended\_scan\_angle 2500 2500

extended\_scanner\_channel 0 0

number of first returns: 26814115

number of intermediate returns: 0

number of last returns: 26814115

number of single returns: 26814115

overview over extended number of returns of given pulse: 26814115 0 0 0 0 0 0 0 0 0 0 0 0 0 0

histogram of classification of points:

675053 unclassified (1)

3878780 ground (2)

1933011 low vegetation (3)

2810787 medium vegetation (4)

16683893 high vegetation (5)

282225 building (6)

550366 wire guard (13)

Execution completed in 12.08 seconds

Results:

{'commands': ['C:\\LAStools\\bin\\lasinfo',

'-i',

'"C:\\Users\\richard\\Downloads\\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las"']}

**pdal (2.6.0) info --input "C:\\Users\\richard\\Downloads\\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las" --metadata**

{

"file\_size": 804425283,

"filename": "C:\\\\Users\\\\richard\\\\Downloads\\\\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las",

"metadata":

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"dataoffset": 377,

"filesource\_id": 0,

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"major\_version": 1,

"maxx": 950000,

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"maxz": 2680.43,

"minor\_version": 4,

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"miny": 690000,

"minz": 2188.53,

"offset\_x": 0,

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"offset\_z": 0,

"point\_length": 30,

"project\_id": "00000000-0000-0000-0000-000000000000",

"scale\_x": 0.01,

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"scale\_z": 0.01,

"software\_id": "ESP ANALYST",

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"srs":

{

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"isgeographic": false,

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"base\_crs": {

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"datum": {

"type": "GeodeticReferenceFrame",

"name": "NAD83 (National Spatial Reference System 2011)",

"ellipsoid": {

"name": "GRS 1980",

"semi\_major\_axis": 6378137,

"inverse\_flattening": 298.257222101

}

},

"coordinate\_system": {

"subtype": "ellipsoidal",

"axis": [

{

"name": "Geodetic latitude",

"abbreviation": "Lat",

"direction": "north",

"unit": "degree"

},

{

"name": "Geodetic longitude",

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"direction": "east",

"unit": "degree"

}

]

},

"id": {

"authority": "EPSG",

"code": 6318

}

},

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"code": 9802

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"unit": "degree",

"id": {

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"code": 8823

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"value": 33.75,

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"record\_id": 2112,

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"now": "2024-01-24T18:52:12-0700",

"pdal\_version": "2.6.0 (git-version: 3fced5)",

"reader": "readers.las"

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"filename":"C:\\Users\\richard\\Downloads\\USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las",

"spatialreference":"EPSG:4326"

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"type":"filters.chipper",

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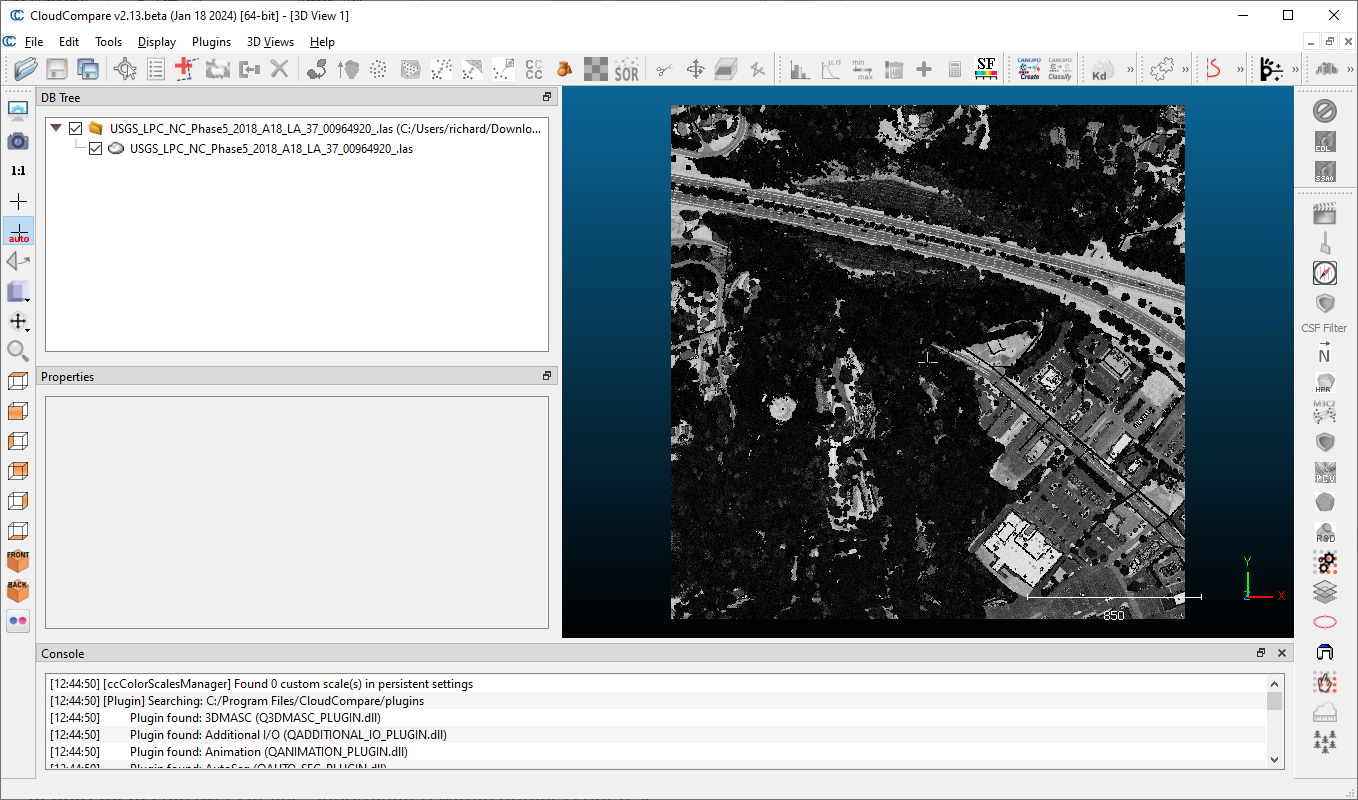
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**CloudCompare Review/Visual Inspection of USGS\_LPC\_NC\_Phase5\_2018\_A18\_LA\_37\_00964920\_.las:**

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