Automatic Road Feature Extraction from Mobile LiDAR Data

USDOT Safety Data Initiative Project

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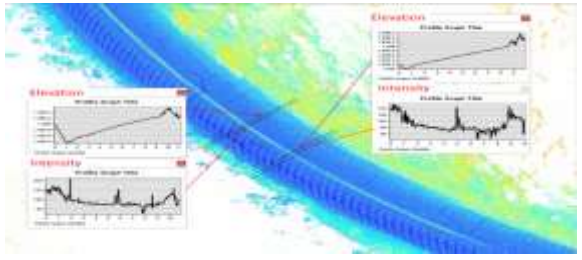
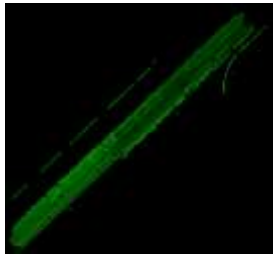




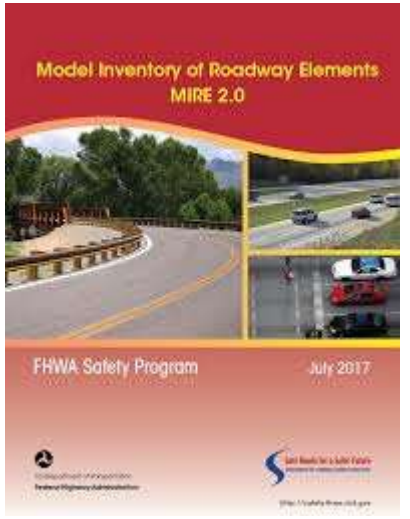
Project Team Introduction

- Regional Transportation Commission of Washoe County (RTC)
- University of Nevada, Reno (UNR)
- Texas Tech University (TTU) (subcontract)

Data Requirements to Address

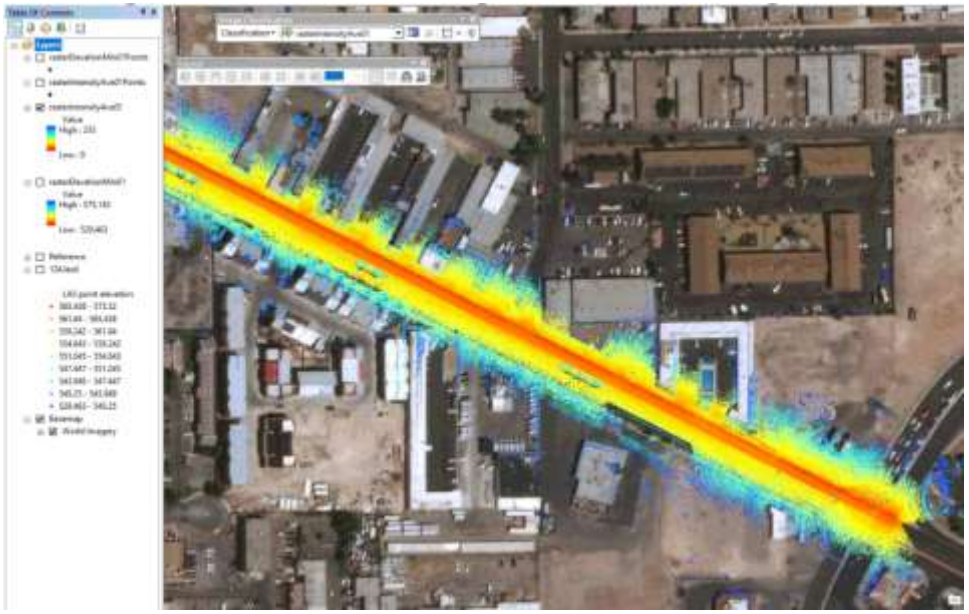
Accurate, up-to-date road feature data for multimodal traffic planning and data-driven traffic safety analysis

Model Inventory of Roadway Element (FHWA MIRE)



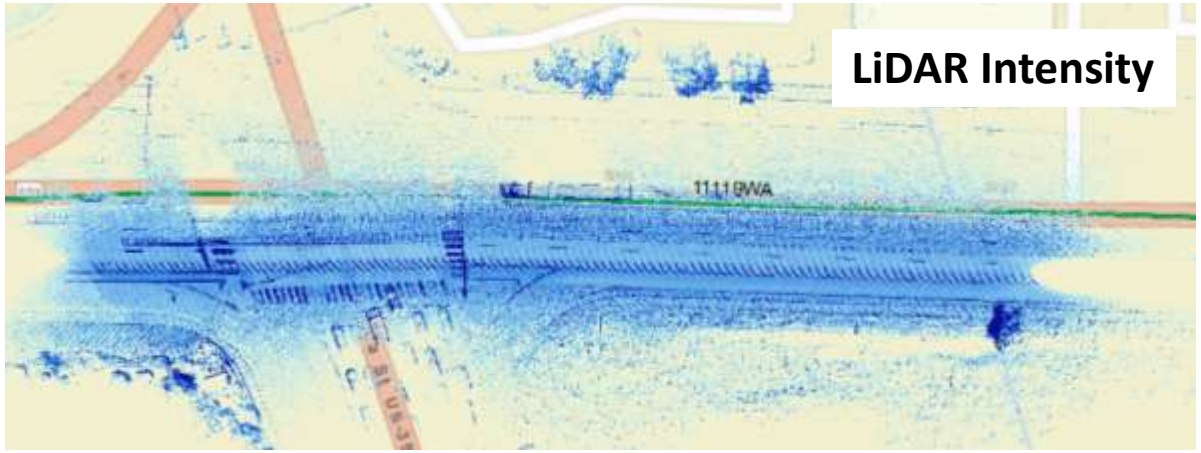
NDOT Mobile LiDAR Data

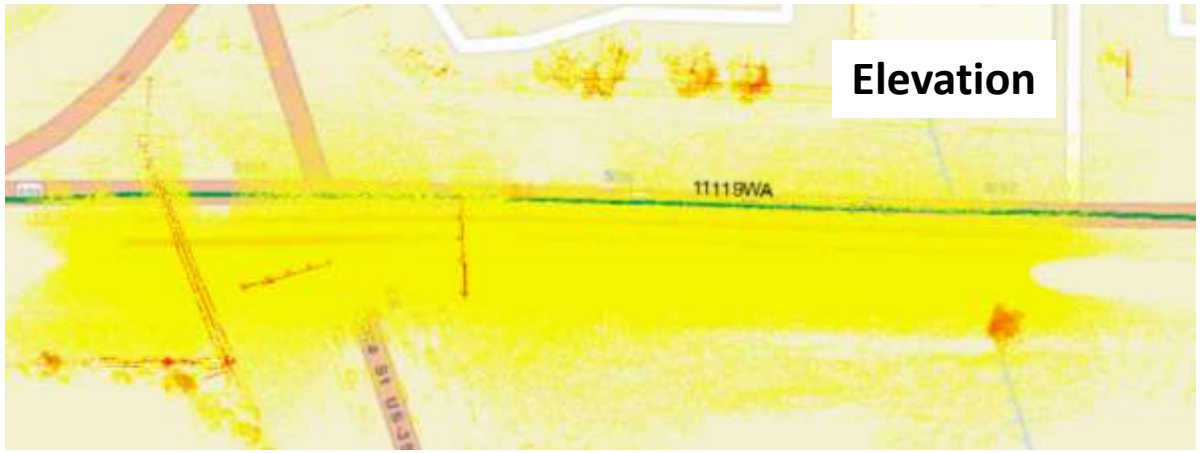
- All NDOT routes in both directions.
- The GPS corrections are applied for accurate linear referencing length and position.
- Mobile LiDAR data on a total of 10,854 miles of road
- Linear Referencing
- LAS format, each point includes location, laser reflection intensity, and elevation information.
- Manual data extraction using LiDAR data operation software for review and measurement.

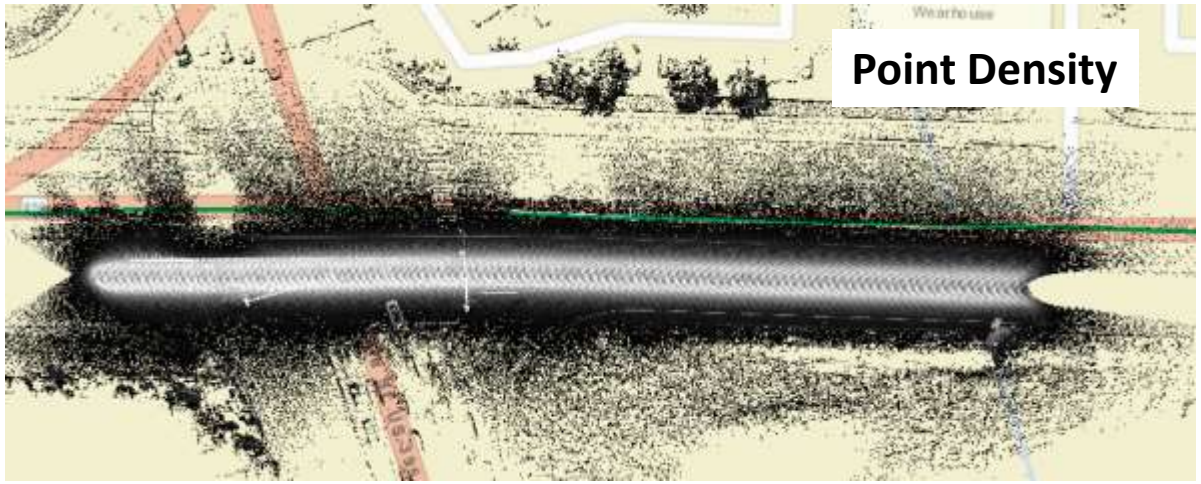


Mobile LiDAR Data

- LAS (LASer) is a file format for the interchange of 3-dimensional point cloud data
  - x, y, z (elevation), laser intensity
- ArcGIS supports LAS cloud point data, often as a LAS dataset
- 8.75 million points in a range of 1000-ft length and 650-ft width
  - High-density in the central 60-ft width
  - Max density - 178,500 points per square meter

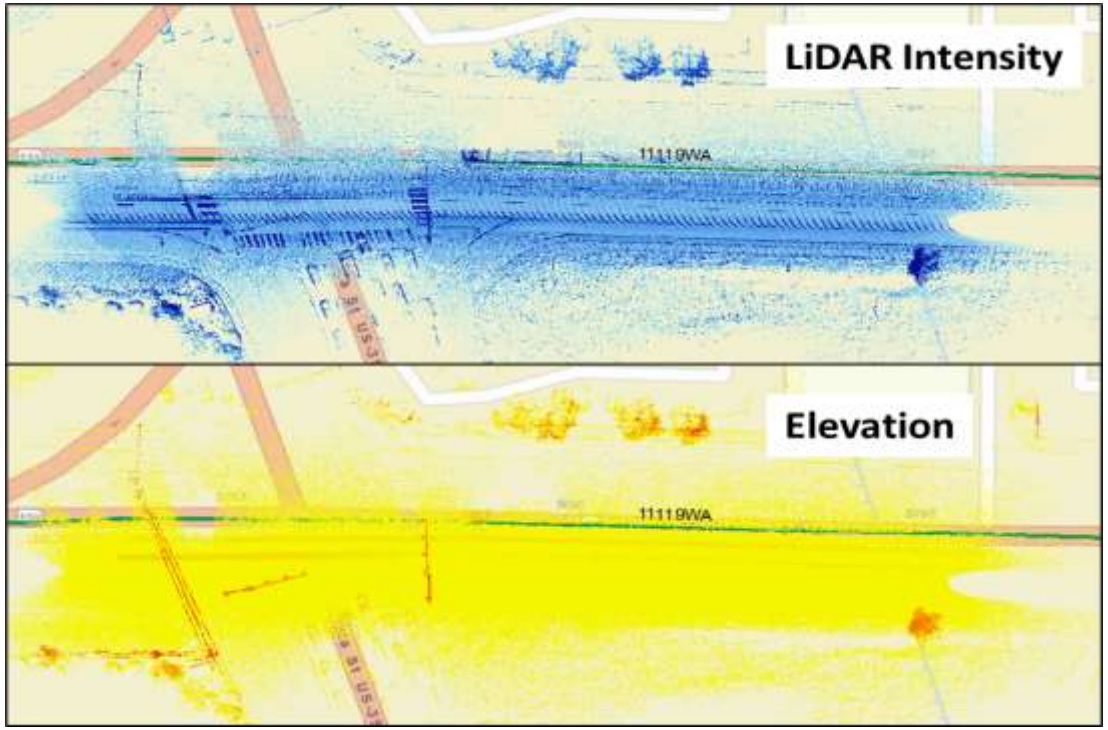






Automatic Road Feature Extraction Tool

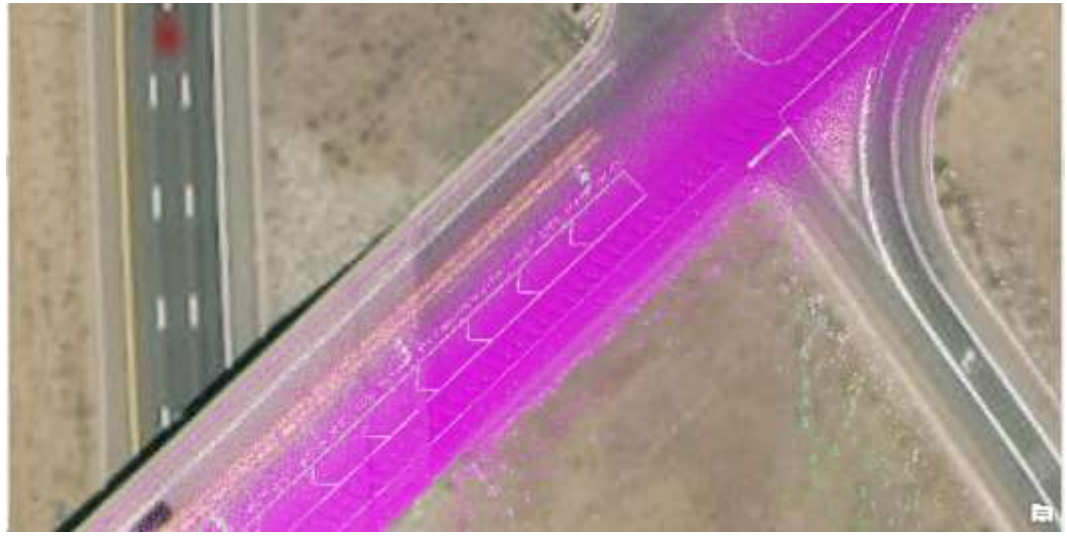
Mobile LiDAR Data

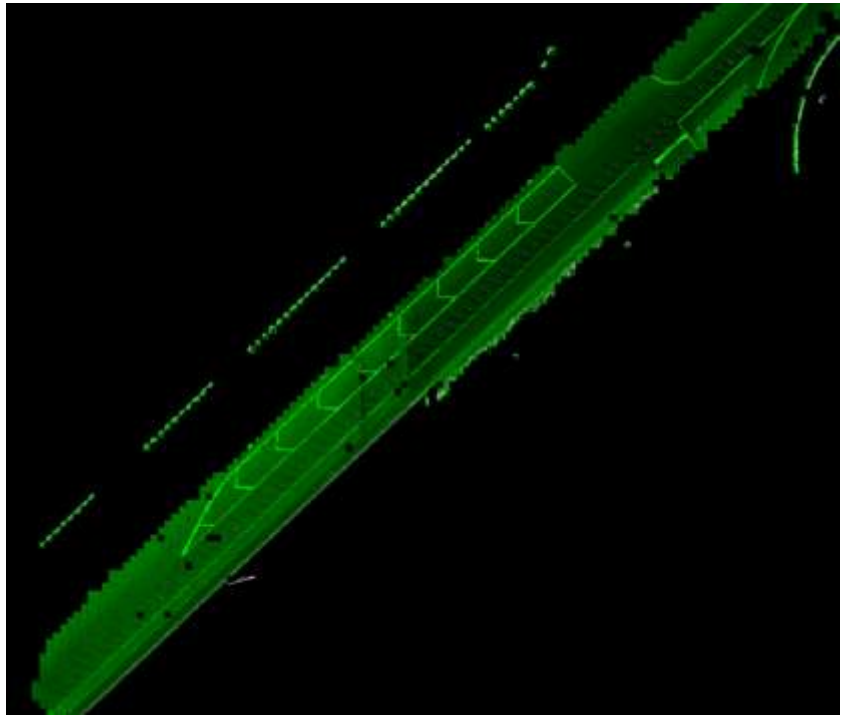


Road Feature Inventory

Convert LAS Cloud Points to Raster Files

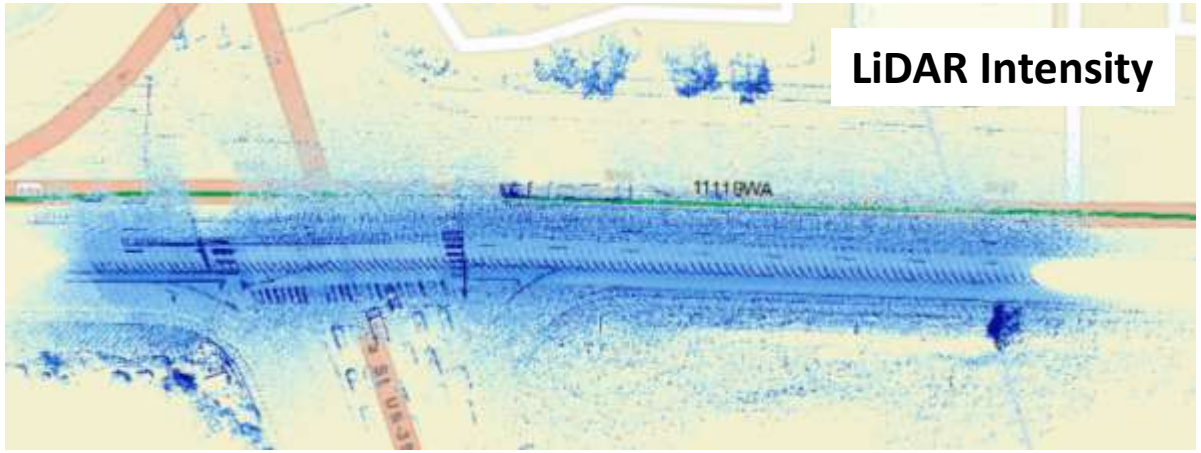
- ArcGIS support LAS cloud points data, but efficiency is low.
- Redundant data with hundreds and thousands of points in each square feet
- The raster data format (pixels of images) is more efficient for ArcGIS and AI algorithms and avoids redundant information.
- The key information of elevation and intensity can easily be represented by raster files.

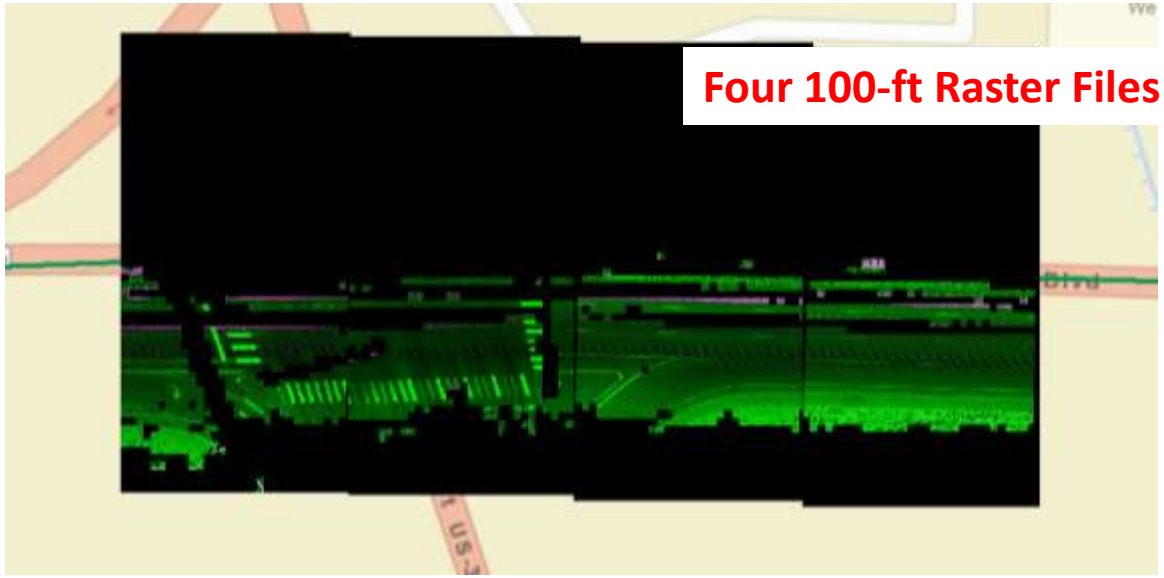




Convert LAS Cloud Points to Raster Files - Filter

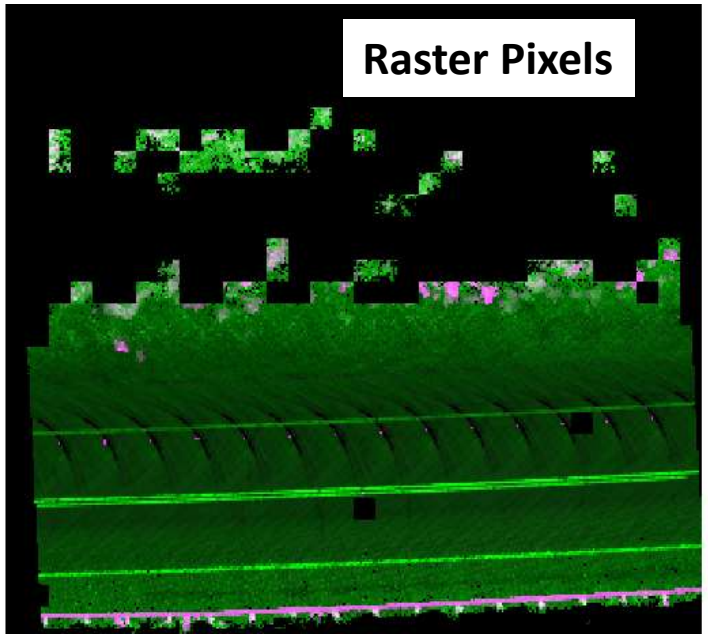
- Filter low-LiDAR-density zones
- Filter roadside infrastructure, like streetlight poles, and other vehicles
- 3-channel RGB raster files are created
  - R-channel – elevation (z-range)
    G-channel – intensity
  - B-channel –reserved for classification

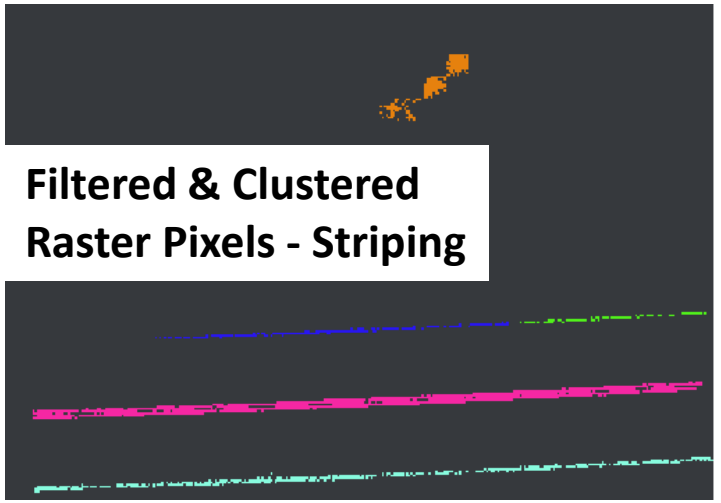




Road Feature Clustering Raster Data (Pixels)

- The key information in roadway data extraction from LiDAR is the lane markings, curbs, guard rails, …
- Clustering (or sometime is named segmentation) is to identify and group pixels related to road features, without feature classification information for this step.
  - Interesting line features are with high intensity values or high elevation difference (z-range) values





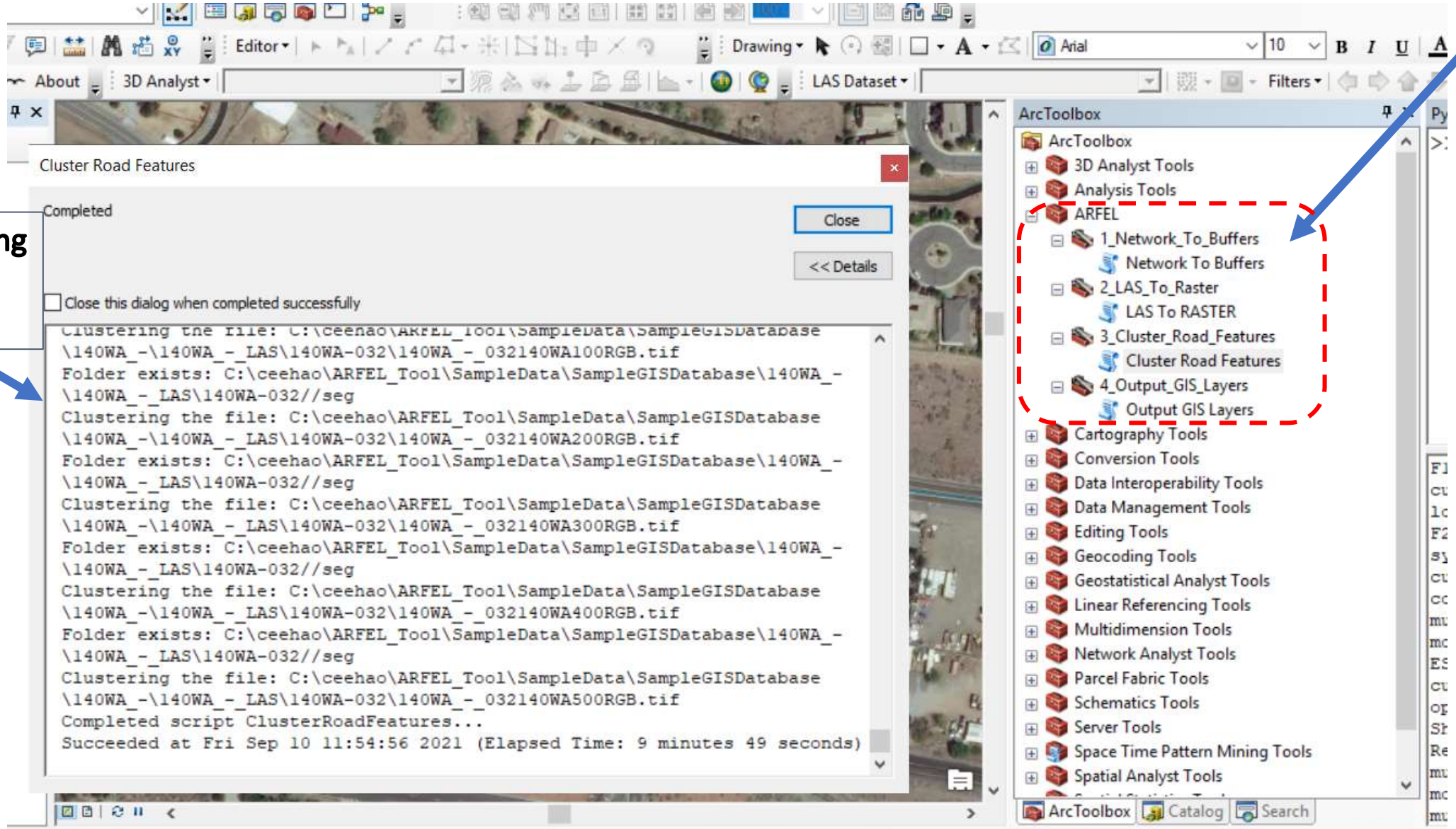
Classification Linear Clusters

- Based on properties of each cluster:
  - Count of points
  - Distribution direction
  - Average elevation-change
  - Deviation of elevation-change
  - Average intensity
  - Deviation of intensity
- Classification tools
  - Calibrated thresholds for each property
  - Artificial Neural Network
  - Random Forest
  - Random Undersampling Boost (RUSBoost)
  - Adaptive Boosting for Multiclass Classification (AdaBoostM2)

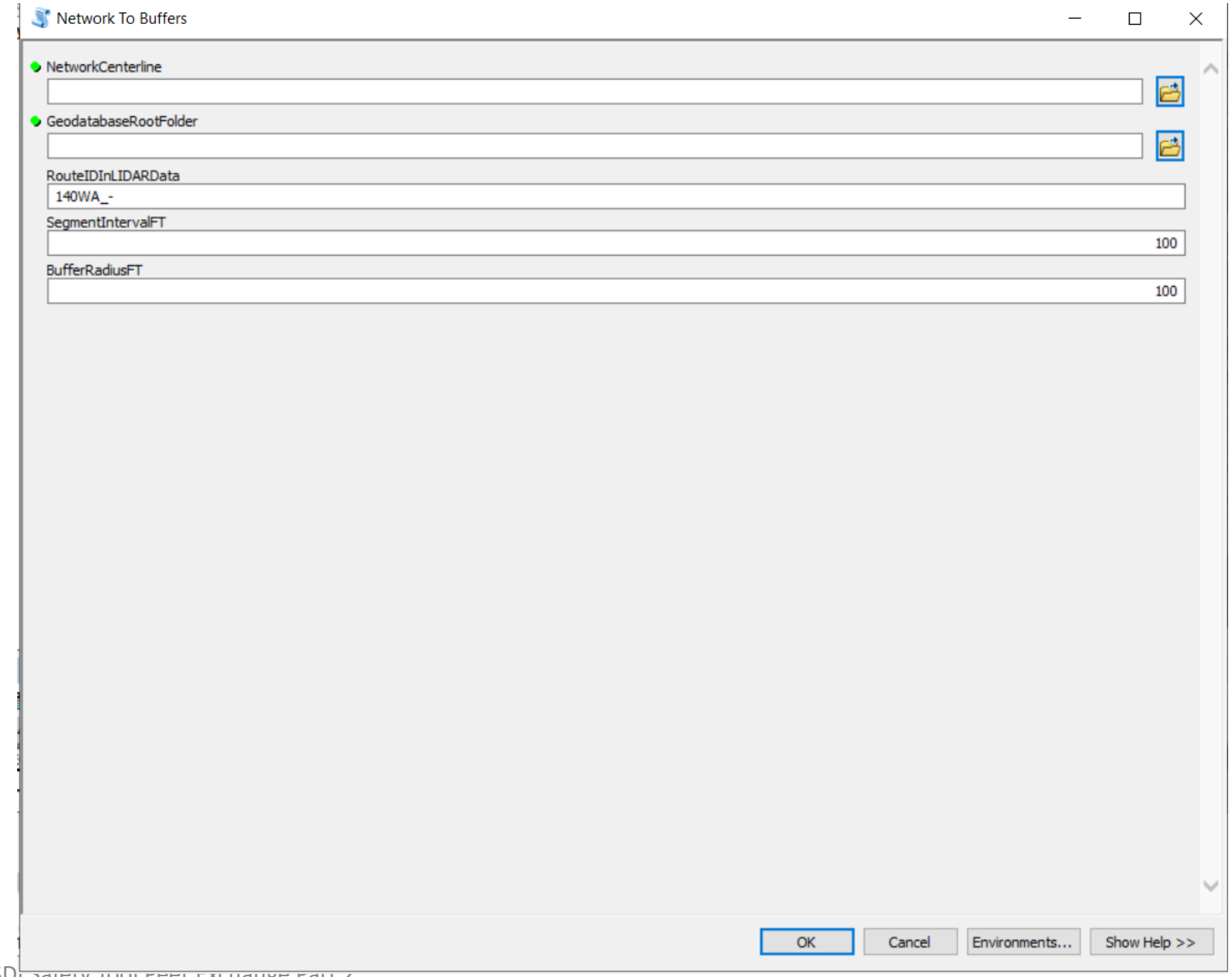
ARFEL Tool Interface

Four-Step ARFEL ArcGIS Toolbox

Processing Status Window



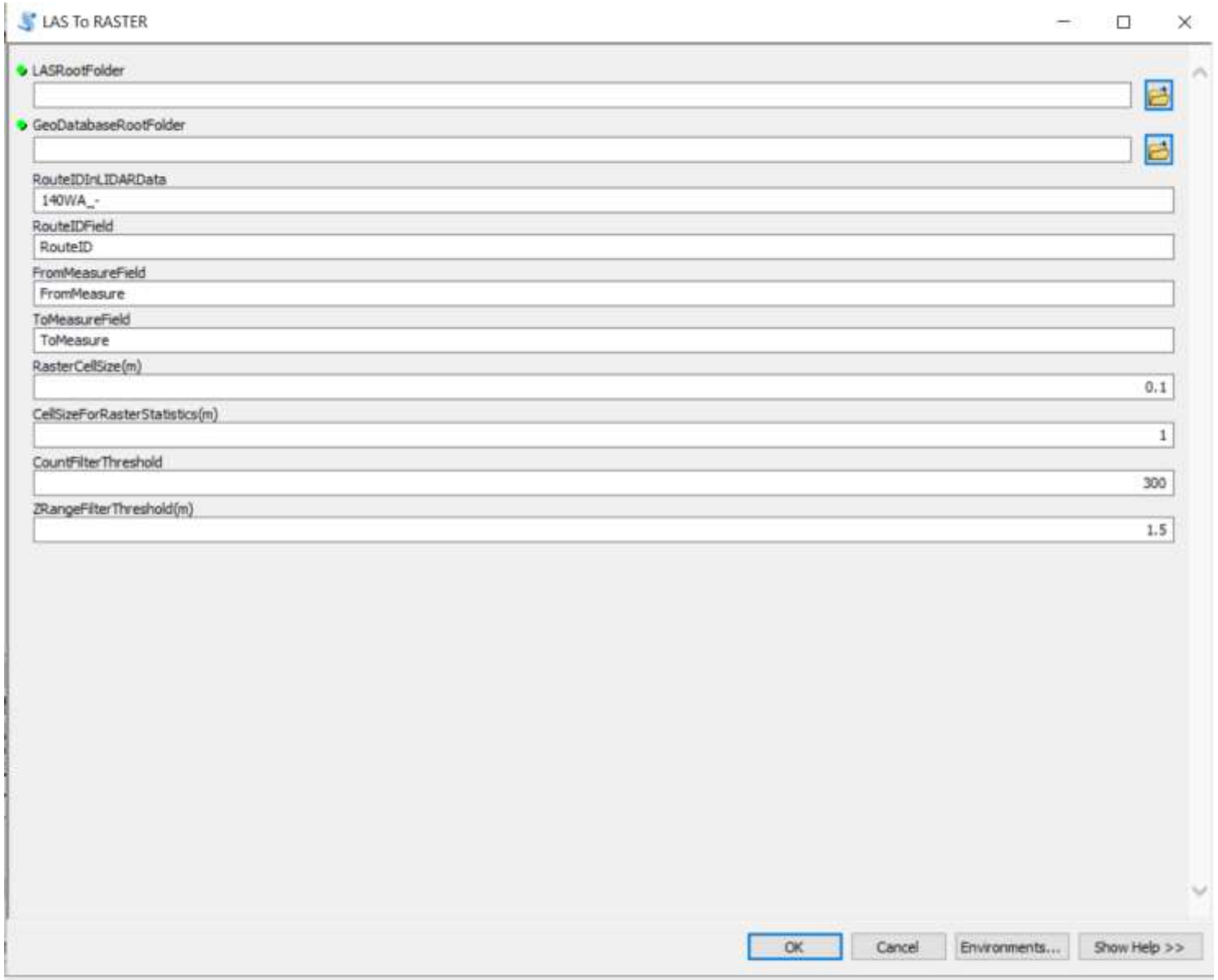
Step 1 - Input


Network To Buffers
NetworkCenterline
GeodatabaseRootFolder
RouteIDInLIDARData
140WA_-
SegmentIntervalFT
100
BufferRadiusFT
100
OK
Cancel
Environments...
Show Help >>

Output of Step 1

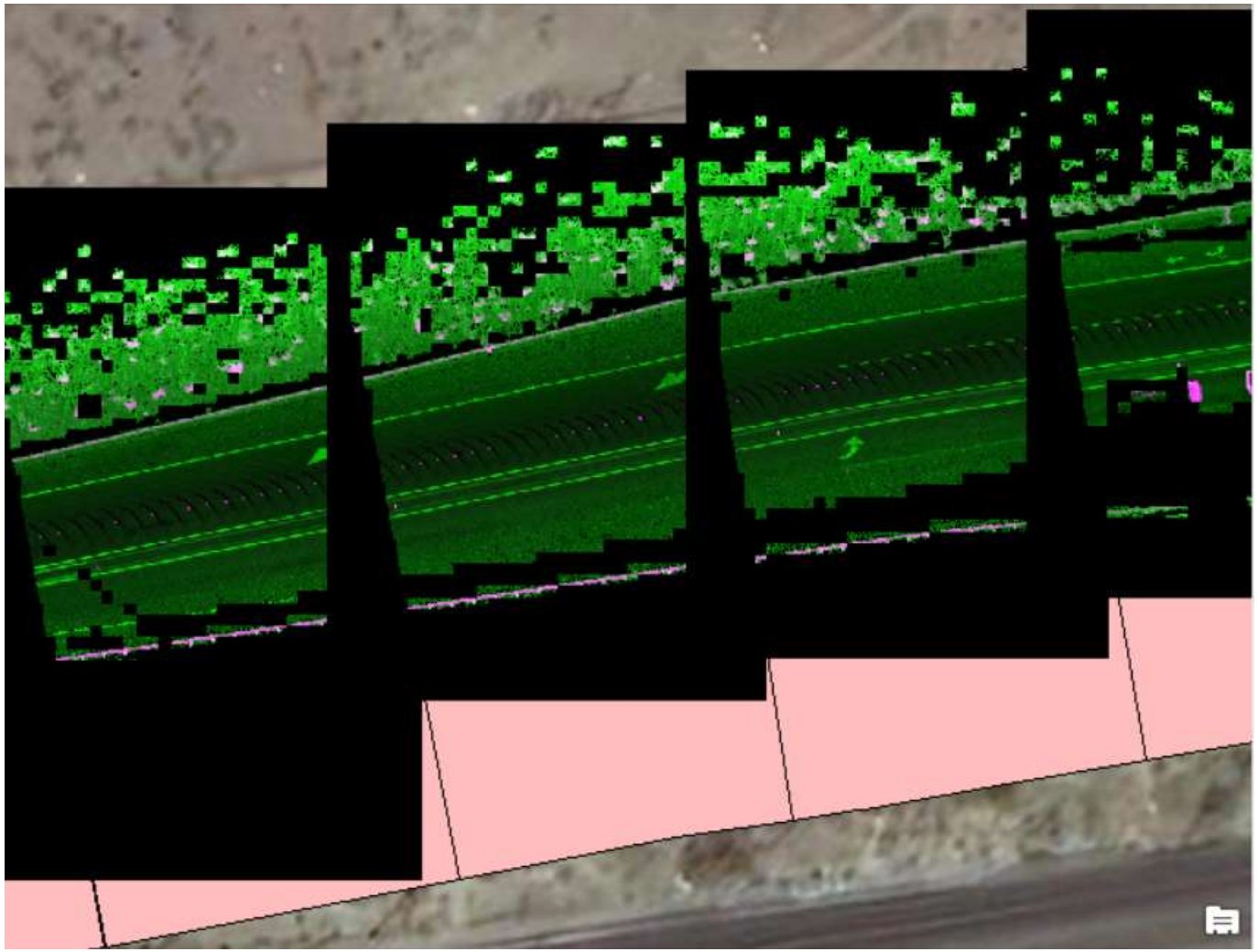
100-ft buffer generation along road centerline GIS layer

Step 2 - Input

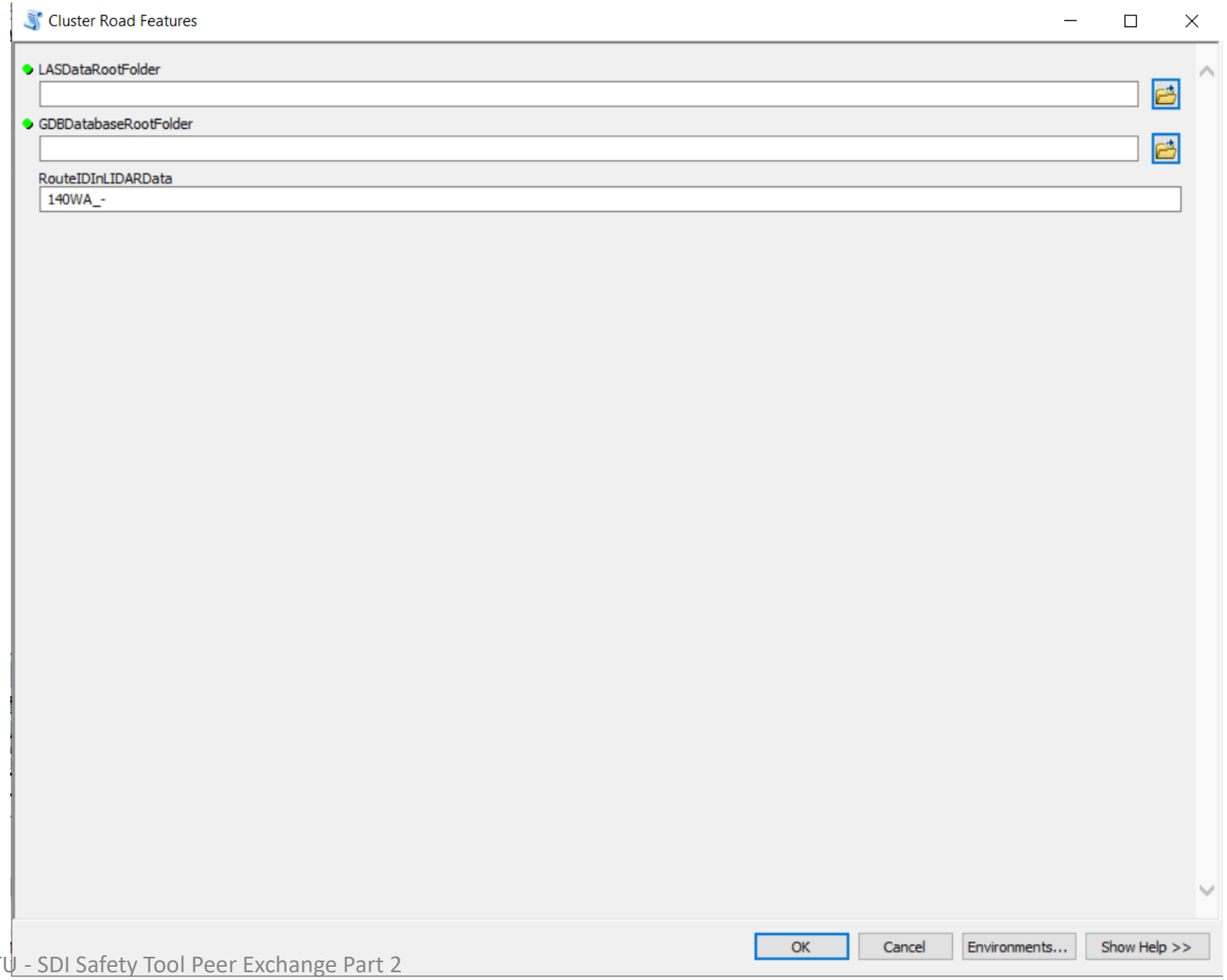

LAS To RASTER
LASRootFolder
GeoDatabaseRootFolder
RouteIDInLIDARData
140WA_-
RouteIDField
RouteID
FromMeasureField
FromMeasure
ToMeasureField
ToMeasure
RasterCellSize(m)
0.1
CellSizeForRasterStatistics(m)
1
CountFilterThreshold
300
ZRangeFilterThreshold(m)
1.5
OK
Cancel
Environments...
Show Help >>

Output of Step 2

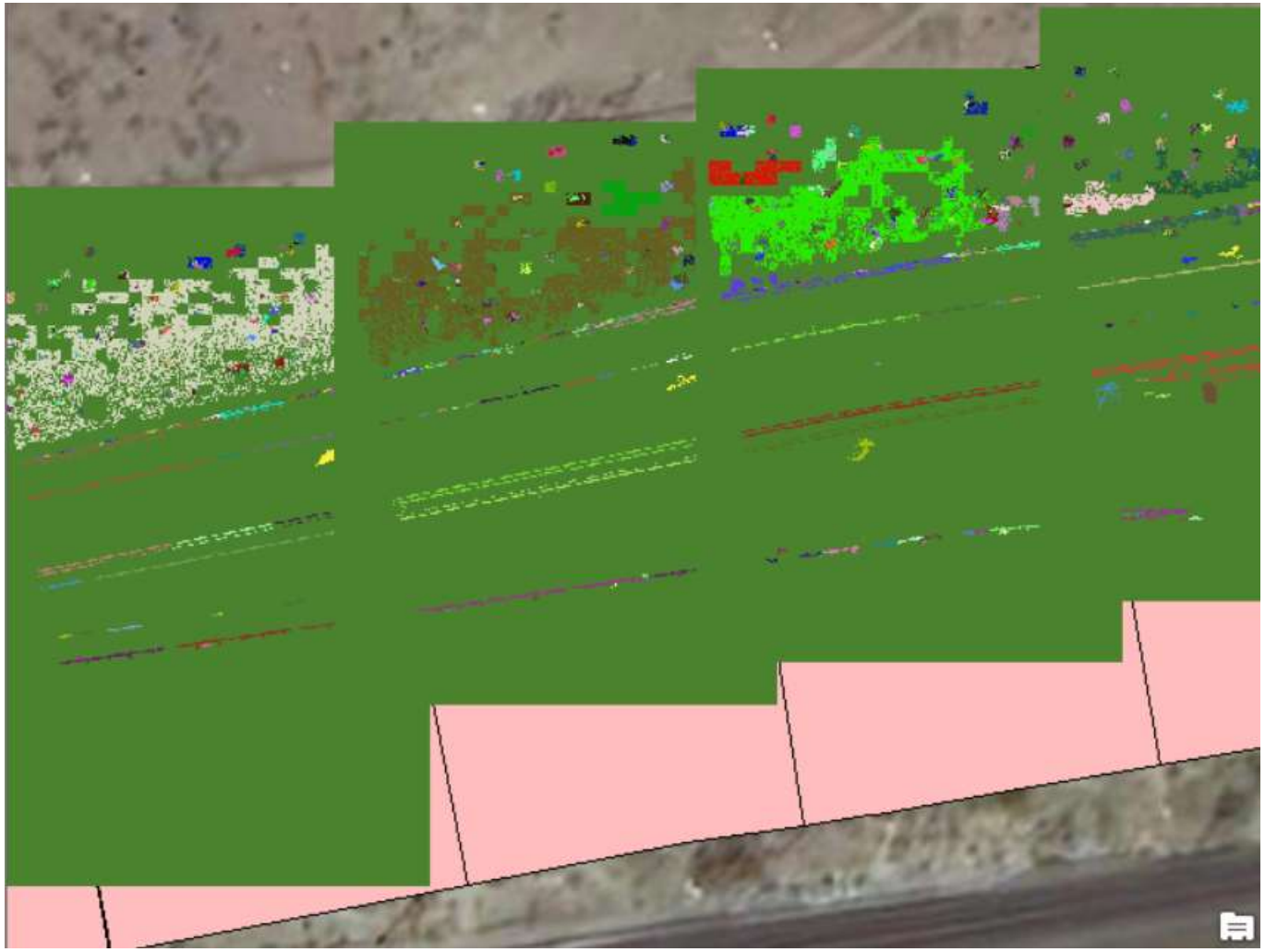
Convert LAS LiDAR data into raster format (like 2D images) data in each buffer



Step 3 - Input

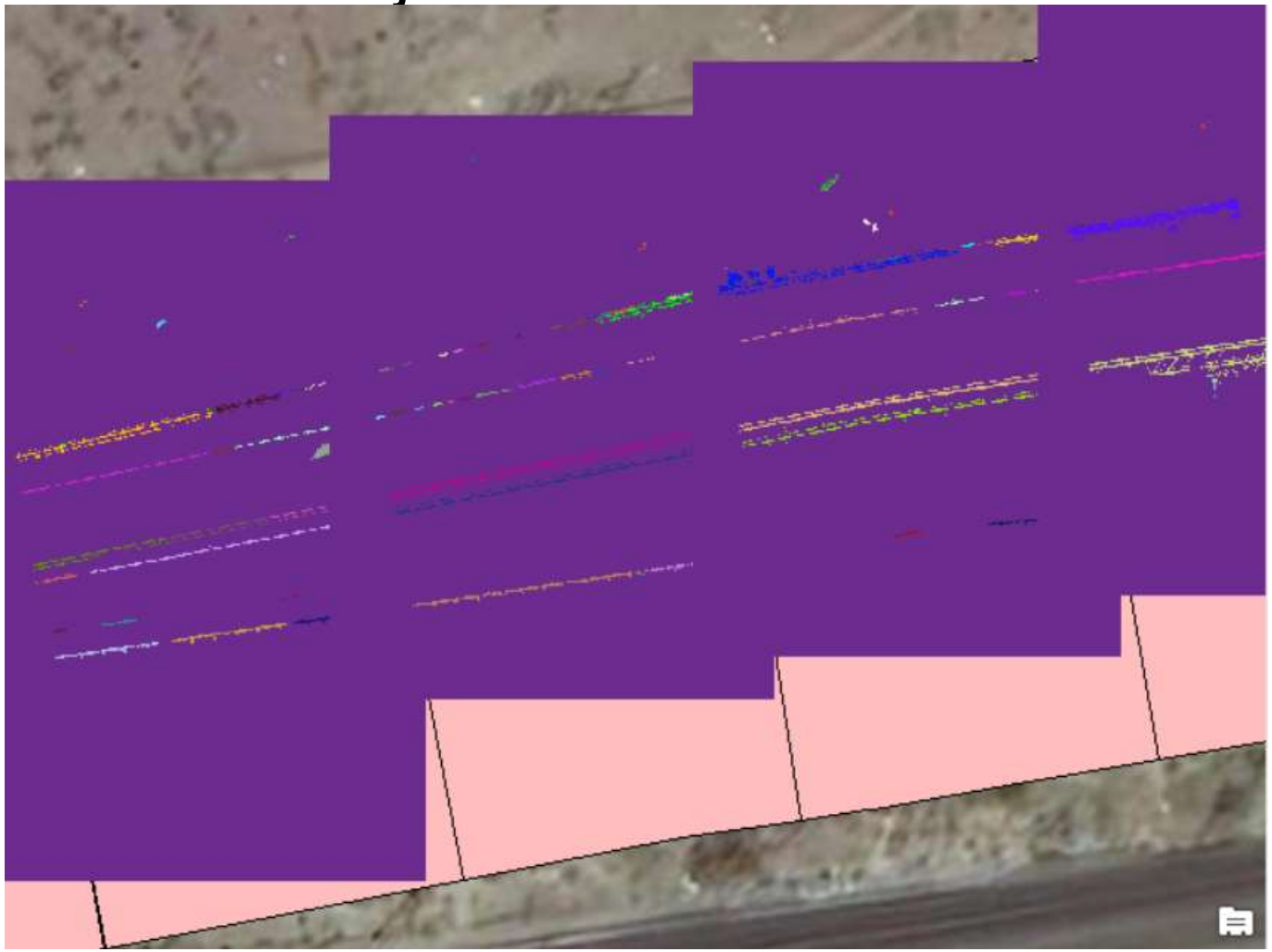

Cluster Road Features
LASDataRootFolder
GDBDatabaseRootFolder
RouteIDInLIDARData
140WA_-
OK
Cancel
Environments...
Show Help >>

Output of Step 3 – DDBSCAN Clustering Results



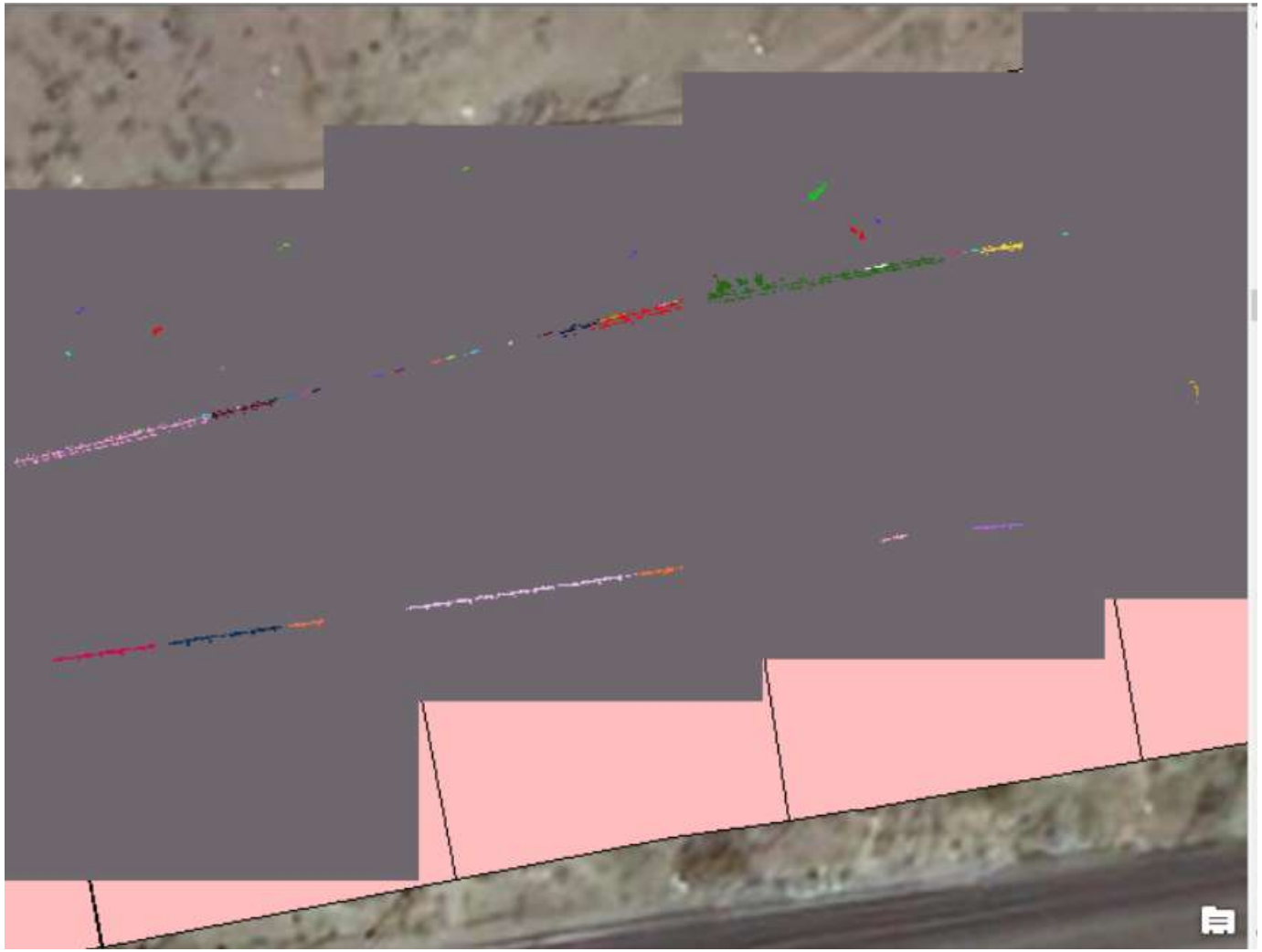
Output of Step 3 – Classification

Classify and exclude noise objects

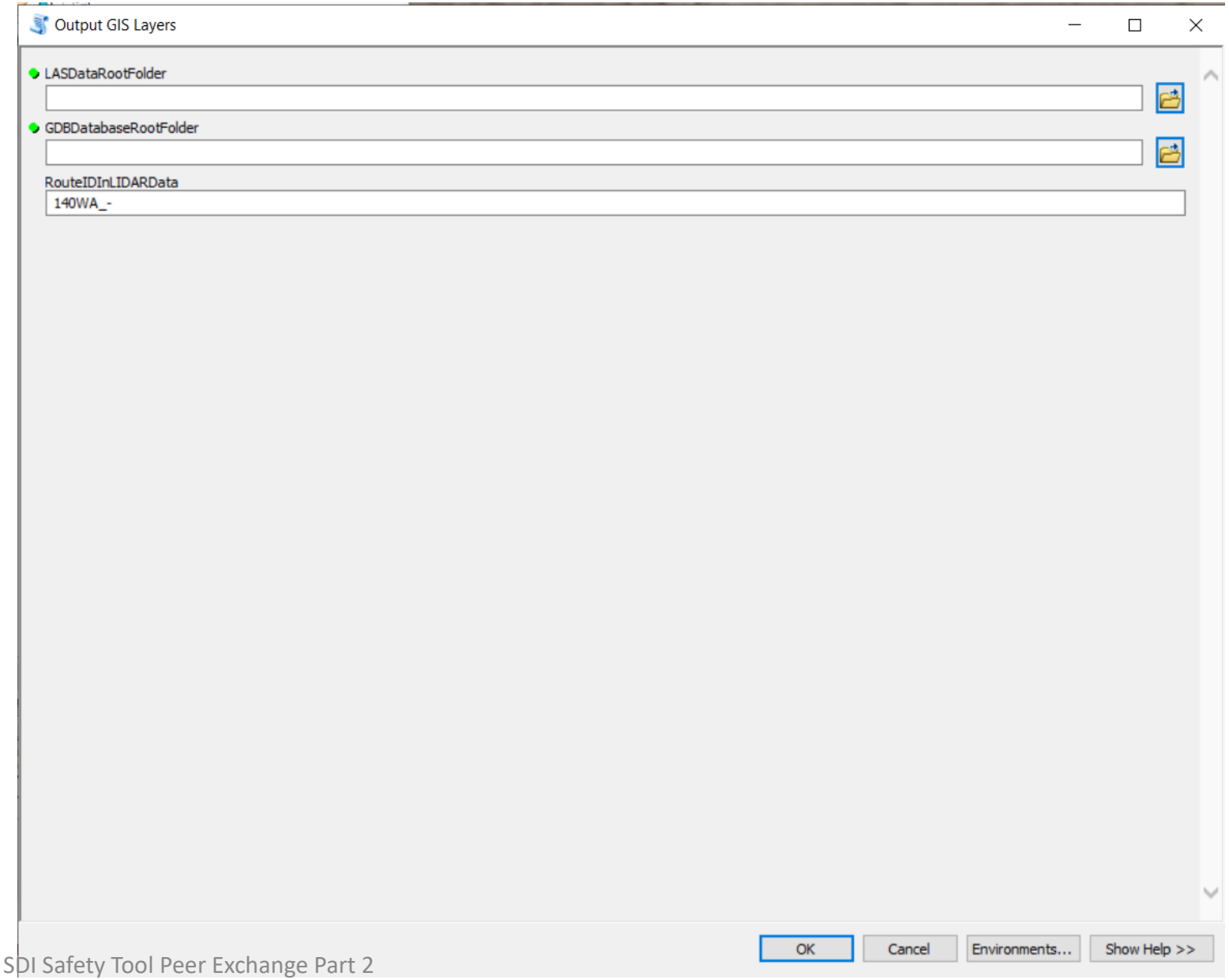


Output of Step 3 – Average Z-range Feature

Classify and keep guard rails

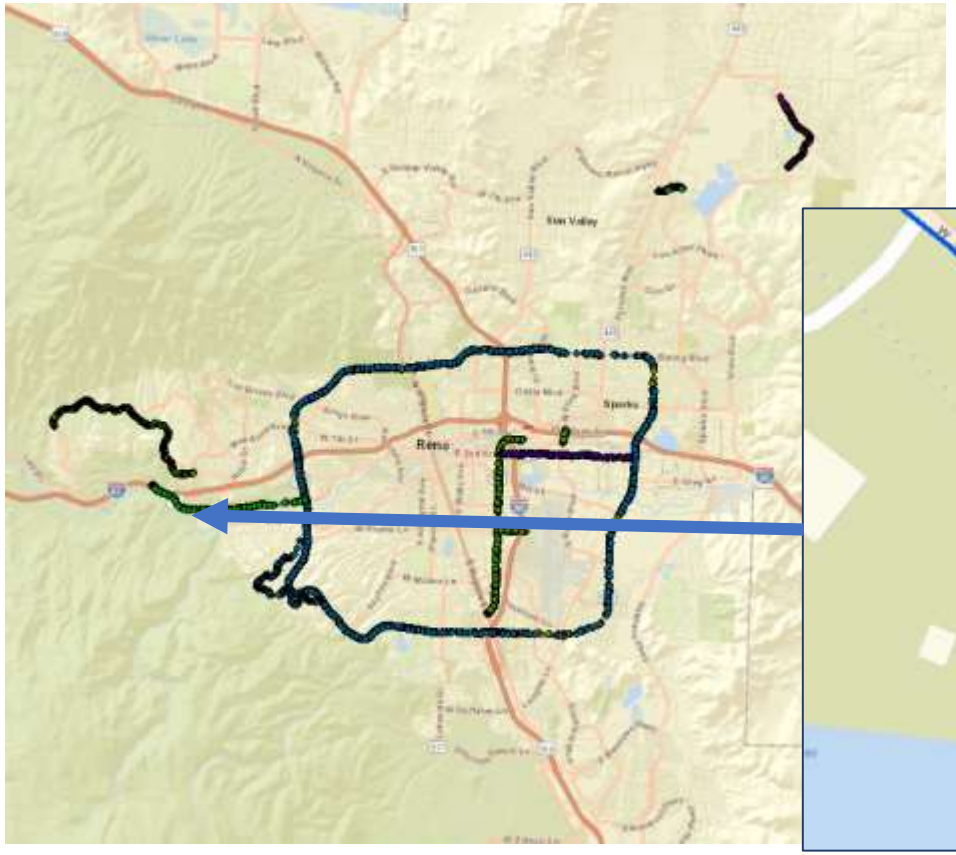


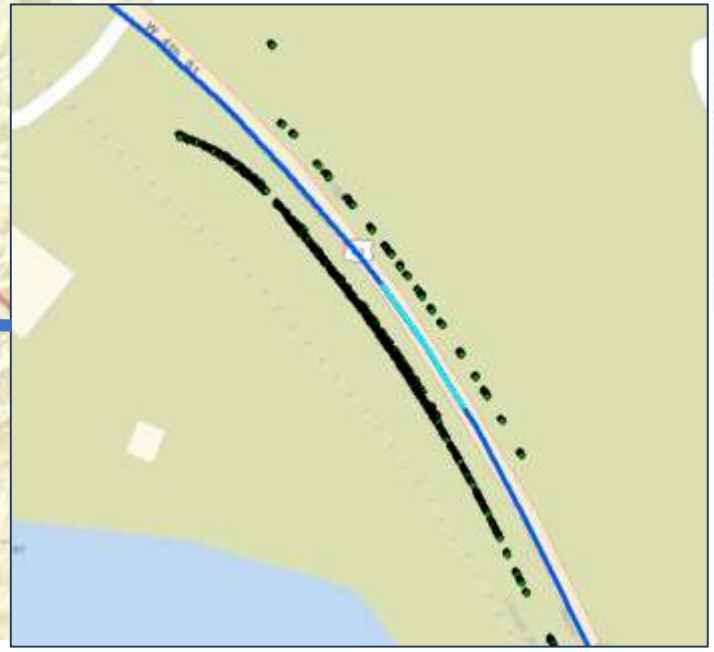
Step 4 Input


Output GIS Layers
LASDataRootFolder
GDBDatabaseRootFolder
RouteIDInLIDARData
140WA_-
OK
Cancel
Environments...
Show Help >>

Output of Step 4 – Raster Pixels to GIS Feature (Guard Rail Sample)

Guardrail GIS Output Examples





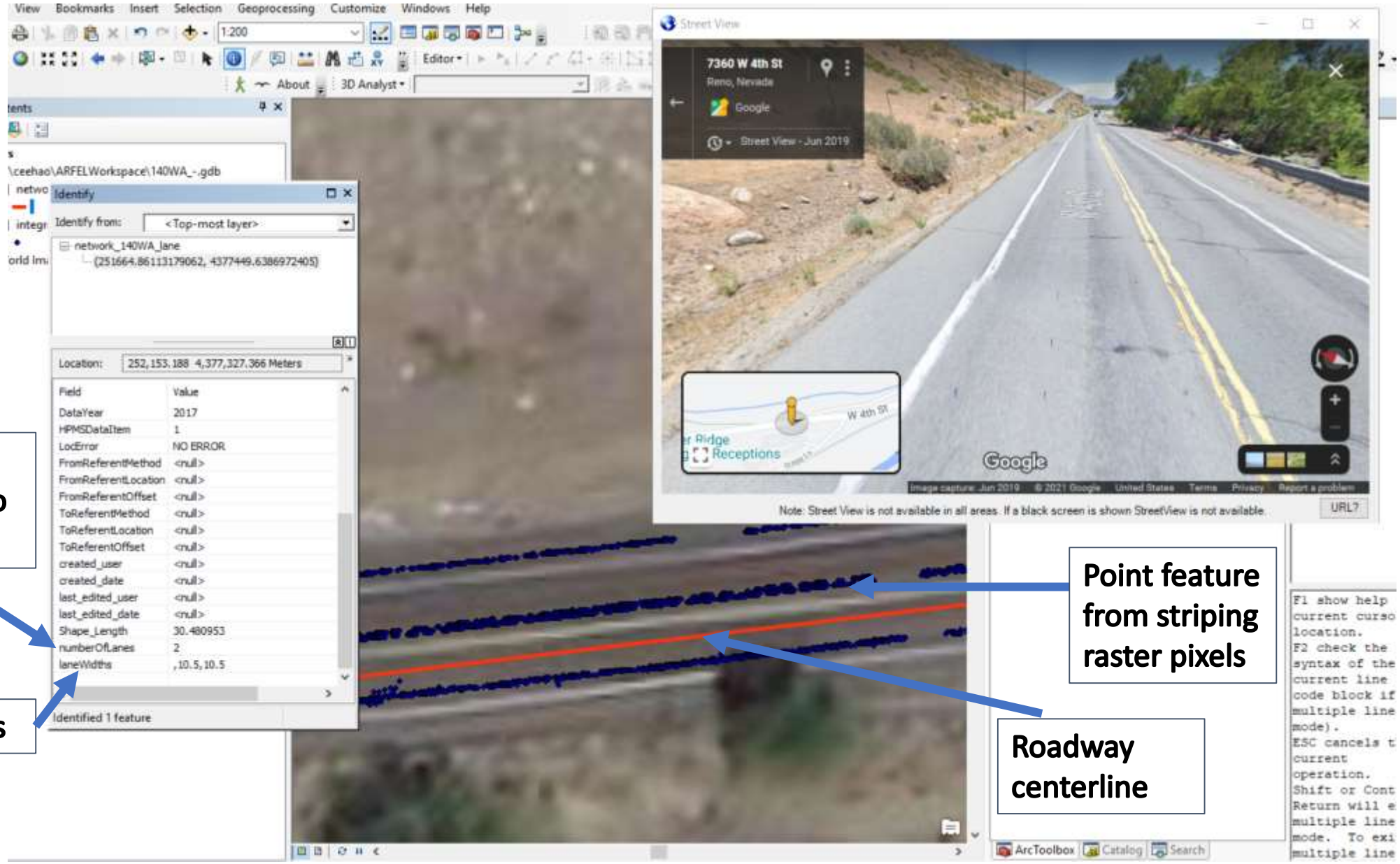
ToReferentOffset	<null>
created_user	<null>
created_date	<null>
last_edited_user	<null>
last_edited_date	<null>
Shape_Length	30.481036
GuardRail	1
GuardRail_value	1444

Identified 1 feature

1-Guardrail
0-No-Gardrail

Number of guardrail points from LiDAR raster analysis

Lane Number & Lane Width GIS Output Examples



Road Features to Extract

- Implemented functions
  - Number of vehicle lanes
  - Lane width
  - Guardrail
  - Curb
  - Sidewalk
- Now we are calibrating the tool for:
  - Median type
  - Median width