Lidar Error Dictionary v. 3.2

October 2024

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The purpose of this dictionary is to provide standardized language to describe commonly encountered errors associated with Light Detection and Ranging (lidar) datasets submitted to the USGS data validation unit for ingestion into the National Map. This document will improve communication between 3D Elevation Program operations personnel, the project's point of contact, contributors, partners, and contractors.

Although errors may be identified in secondary data products, the intent with error types in this document is to identify which product is causing the errors. For example, an error visually detected in the Digital Elevation Model (DEM) may be due to a point misclassification in the point cloud; therefore, this error would be referenced in the classified point cloud section.

The organization of this document is based on deliverable type. Within each deliverable type there are error types (in blue) and subtypes (in black bulleted under each type). Example images of most error subtypes are hyperlinked in its definition and can be found at the end of this document.

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Breaklines

Breakline Enforcement

Appears as though the breakline was not enforced to the water feature, bridge, island, or structure correctly.

Figure 1: Breakline Enforcement

File Format

There is an issue with the file type or format of the delivered breakline features. Lidar Base Specification 2024 rev. A, and beyond, requires a standard breakline Geopackage format.

Geometry Error

Error in feature's breakline shape, length, or elevation.

Downstream Constraint

Water feature does not present a gradient downhill surface that follows the immediately surrounding terrain.

Figure 2: Downstream Constraint

Overextended Breakline

Breakline that goes beyond the full extent of the water body.

Figure 3: Overextended Breakline

Underextended Breakline

Breakline that underrepresents the full extent of the water body.

Figure 4: Underextended Breakline

River/Stream Segment(s)

A stream or river feature that is broken up into discontinuous segments when it should be a single collected water feature.

Figure 5: River/Stream Segments

Z-Values

The elevation value of a breaklines vertices are not at or below the immediately surrounding terrain. This can result in waterbodies that appear to be sunken or floating.

Figure 6: Z-Values

Z-Enabled

A breakline that has no elevation values and is a 2D feature. A 3D feature is required.

Figure 7: Z-Enabled

Incorrect Geopackage Feature/Attribute

There is an issue with the Geopackage feature layers or attribution of the breakline deliverable.

Misplaced Breakline

A breakline whose placement is erroneous and/or compromises the quality of the DEM surface. For example, a breakline that does not delineate a feature or alters elevation values in a way that is undesirable.

Figure 8: Misplaced Breakline

Missing Feature

A breakline is absent for a feature that requires breakline collection. This can be a water feature, structure, bridge, part of a breakline, or island.

Breakline

A segment or piece of a breakline on a feature that is missing.

Figure 9: Breakline

Bridge

There is a bridge artifact, not caused by a point misclassification, that requires a breakline in order to remove it completely.

Figure 10: Bridge

Centerline

A centerline feature layer is not present in a breakline geopackage deliverable. This is a required deliverable beginning with Lidar Base Specification 2024 rev A.

Island

There is an island greater than the contracted collection size that is not encompassed with a breakline.

Figure 11: Island

River/Stream

There is a river or stream that meets the contracted collection size that is

not encompassed with a breakline.

Figure 12: River/Stream

Structure

A breakline is absent for a building or non-organic feature that requires breakline collection or a breakline is needed to remove artifacts.

Waterbody

There is a waterbody that meets the contracted collection size that is not encompassed with a breakline.

Figure 13: Waterbody

Spatial Reference

Spatial Reference information is incorrect or is not correctly reported for some or all Breaklines.

Classified Lidar Point Cloud

Collection

Errors that are related to the processing and creation of lidar point cloud data.

Corrupt File

LAS files will not load into visualization software or there is an invalid data type.

Data Void

Lapses in lidar data collection in the point cloud that are not due to surface environmental conditions. Examples would include but are not limited to lapse in coverage due to atmospheric interference, GPS outages, or cloud cover.

Figure 14: Data Void

Figure 15: Data Void

Density

Point density for specific file(s) appears to be excessively high or low compared to the expected values.

Figure 16: Density

Las Version

Lidar point cloud data is stored in a version of LAS format inconsistent with Lidar Base Specification, American Society for Photogrammetry and

Remote Sensing (ASPRS) guidelines, or contract/task order.

Relative Accuracy

Issues pertaining to the geometric accuracy of the point cloud. These errors can be related to the interswath and intraswath precision and may or may not have visual indication in the DEM surface.

Figure 17: Relative Accuracy, Interswath

Figure 18: Relative Accuracy, Intraswath

Header Properties

The LAS file header characteristics are incorrect according to the LAS version, Lidar Base Specification, American Society for Photogrammetry and Remote Sensing (ASPRS) guidelines, or contract/task order.

EVLR/VLR

Incorrect treatment of the Extended Variable Length or Variable Length Records. Typically, when one or many records are not superseded.

File Creation

The file creation (day and/or year) was incorrectly populated.

File Source ID

The file source ID is set incorrectly.

Generating Software

The type of software used to generate the LAS files was incorrectly populated.

Global Encoder

The global encoder value is set incorrectly.

PDRF/PDRL

The Point Data Record Format or Point Data Record Length are set to the incorrect value.

Spatial Reference

The Coordinate Reference System information is incorrect for some or all LAS files.

System ID

The system ID is not populated with an acceptable value.

XYZ Scale Factor

Scale factor not appropriately populated or applied.

XYZ Offset

Overall offset for point records is an incorrect value.

Point Data Records

Properties of the LAS Points are incorrect for some or all LAS files according to applicable USGS Lidar Base Specification, American Society for Photogrammetry and Remote Sensing (ASPRS), or contract/task order.

Classification Flags

Classification flags are set incorrectly. This includes overlap, withheld, key-point, and synthetic flags. Text field will be used to specify.

Figure 19: Classification, Overlap

Figure 20: Classification, Withheld

Edge of Flight Line

The Edge of Flight Line data bit is set incorrectly.

GPS Time

The Global Positioning System of a LAS file is incorrect. Either incorrect GPS time format, incorrect date, or missing information.

Intensity

Intensity values of the LAS points are not normalized to 16 bit and/or did not use linear normalization.

Figure 21: Intensity

Point Source ID

Point Source ID values are set incorrectly.

Figure 22: Point Source ID

Return 0

A pulse return of 0 has been found in some or all LAS files.

Scan Angle

The Scan Angle Rank appears to be an incorrect value.

Scan Direction Flag

The Scan Direction Flag bit is set incorrectly.

XYZ Position

There is an issue with the X, Y, Z values in some or all the LAS files.

Point/Header Mismatch

There is a discrepancy between the information recorded in the points and their respective header information.

Point Count

Point count header information does not match the actual point count.

Return Counts

Return count header information does not match the actual return count.

Returns

Return header information does not match the actual returns.

XYZ Min/Max

The X, Y, and/or Z header information does not match the X, Y, and/or Z point information.

Point Misclassification

There is an incorrect classification of points. Text field will be used to specify.

Figure 23: Misclassification Example 1

Figure 24: Misclassification Example 2

Figure 25: Misclassification Example 3

Figure 26: Misclassification Example 4

Figure 27: Misclassification Example 5

Figure 28: Misclassification Example 6

Figure 29: Misclassification Example 7

Figure 30: Misclassification Example 8

Digital Elevation Model (DEM)

Export

Errors that are related to or caused by the exportation process in creating rasters from point cloud data.

Interpolation

Any artifacts relating to interpolation of the DEM from the lidar point cloud that appear erroneous. This is to include edge artifacts.

Figure 31: Interpolation

Mismatch

Elevation changes or gaps between two or more DEM tiles.

Figure 32: Mismatch

Overlap

When two or more adjacent DEM tiles overlay one another instead of edge matching.

Figure 33: Overlap

Void

A specific type of interpolation error that is an area lacking data in the DEM, not due to point misclassifications or data voids in the point cloud.

Figure 34: Void

Properties

Characteristics of DEM raster files are incorrect for some or all tiles according to applicable USGS Lidar Base Specification or contract/task order.

Ground Sample Distance

The resolution of the DEM raster files is incorrect for some or all tiles.

NoData Value

The value used for 'NoData' is incorrect or more than one value was used. Guidance starting with LBS 2.1 states: "The NODATA value of '-999999' shall be defined in GDAL_NODATA tag #42113".

Pixel Depth

The value range for DEM bit depth is incorrect. 32-bit depth is typical.

Raster Format

The DEM file format is incorrect and/or not the format contracted to be delivered for the project.

Spatial Reference

The Coordinate Reference System used for some or all DEM files is incorrectly formatted or does not match the projects required CRS.

Tile size is not an integer multiple of the ground sample distance

The tile size of some or all raster files is not evenly divisible by the ground sample distance.

FGDC XML Metadata

Content Inaccurate

There is incorrect information in the XML metadata files. Tag location and description of occurrence will be indicated in text field.

Spatial Reference

The Coordinate Reference System is incorrect and/or does not match the projects contracted CRS.

Failed Parser

FGDC XML Metadata parses with errors through the USGS Geospatial Metadata Validation Service.

Missing Elements

A required tag is missing from an XML metadata file.

Misplaced Elements

A tag is in the wrong section of an XML metadata file.

Elements with Improper Domains

A tag contains incorrect domain value in an XML metadata file.

Missing Tag

FGDC XML Metadata file that has a required tag that is missing but still passed the XML metadata parser.

Reports

To encompass all contractor delivered reports. E.g., collection, survey, and processing report

Content Inaccurate

There is incorrect information in a contractor report. Description of error will be in text field.

Missing Information

A required aspect of the report is missing. Description of error will be in text field.
Includes all spatial features delivered with project that are not breaklines. E.g.: tile index, DPA/boundary, checkpoints, flight line index.

Raster Metadata

Includes all raster type deliverables that are not the DEM. E.g.: intensity imagery, digital surface models, swath separation images.

Does Not Match Project Extent

A delivered raster metadata product does not match the project's extent.

Figure 35: Does Not Match Project Extent

Export

Errors that are related to or caused by the exportation process in creating rasters from point cloud data.

Interpolation

Any artifacts relating to creation of the raster spatial metadata from the lidar point cloud that appear erroneous. For example, interpolation should not exist across voids in the Maximum Surface Height Raster (MSHR).

Not Re-delivered with New LPC Files

Raster metadata files were not re-created when LPC files have been updated. New raster metadata files should be re-generated on the amended files and delivered with new LPC. This includes Maximum Surface Height Raster (MSHR) and Swath Separation Imagery (SSI) deliveries.

Properties

Characteristics of raster files are incorrect for some or all files according to applicable USGS Lidar Base Specification or contract/task order.

Ground Sample Distance

The resolution of the raster files is incorrect for some or all files.

NoData Value

The value used for 'NoData' is incorrect or more than one value was used.

Pixel Depth

The value range for raster bit depth is incorrect.

Raster Format

The raster file format is incorrect and/or not the format contracted to be delivered for the project.

Spatial Reference

The Coordinate Reference System does not match the projects required CRS.

Tile size is not an integer multiple of the ground sample distance

The tile size of some or all raster files is not evenly divisible by the ground sample distance.

Spatial Metadata

Includes all spatial features delivered with project that are not breaklines; for example, tile index, DPA/boundary, checkpoints, flight line index.

Incorrect Attribution

One or many aspects of the spatial features' attribution is incorrect. Description of error will be in text field.

Incorrect Geometry

One or many aspects of the spatial features' geometry is incorrect. Description of error will be in text field.

Figure 36: Incorrect Geometry

Missing Feature

A spatial feature that has not been included in the shapefile, geodatabase, or Geopackage.

Properties

Characteristics of vector files are incorrect for some or all files according to applicable USGS Lidar Base Specification or contract/task order.

Spatial Reference

The Coordinate Reference System does not match the projects required CRS.

Example Images

Breaklines

Breakline Enforcement

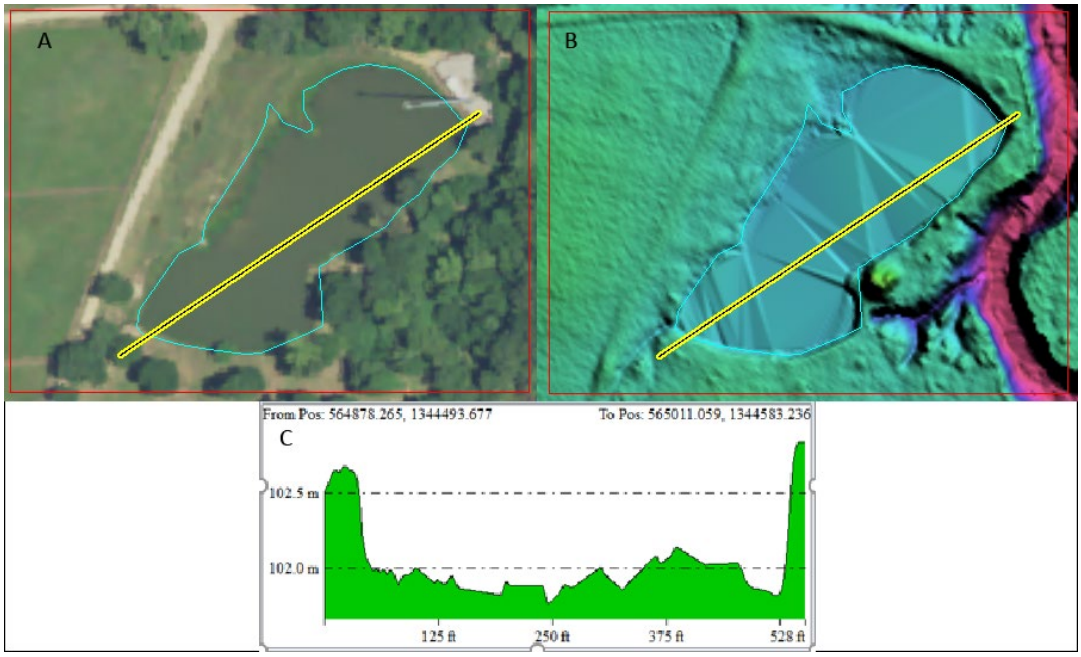


Figure 1. Lack of breakline enforcement. Breakline (blue) and cross-section line (yellow double line) overlain on aerial photo (A) and digital elevation model (B). Elevation cross section (C) shows varying elevation that would be monotonic across the waterbody if the breakline had been properly enforced.

Geometry Error

Downstream Constraint

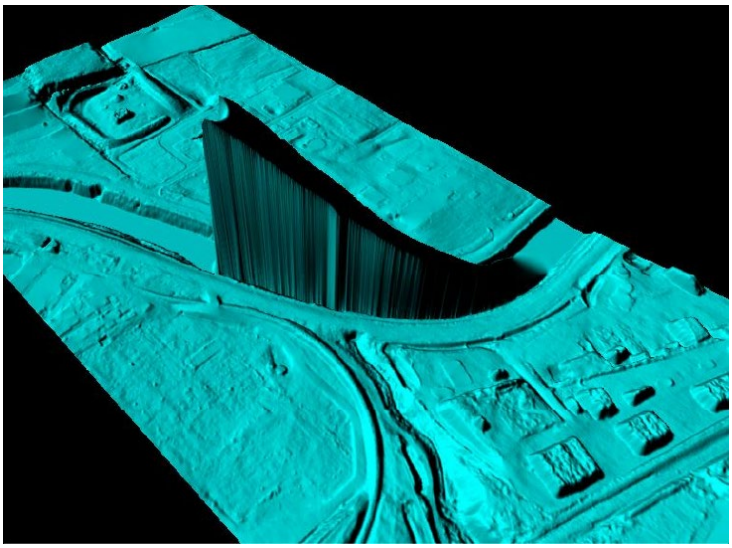


Figure 2. Digital elevation model showing an error in a downstream constraint. The water surface should have a downhill gradient following the surrounding terrain.

Over Extended Breakline

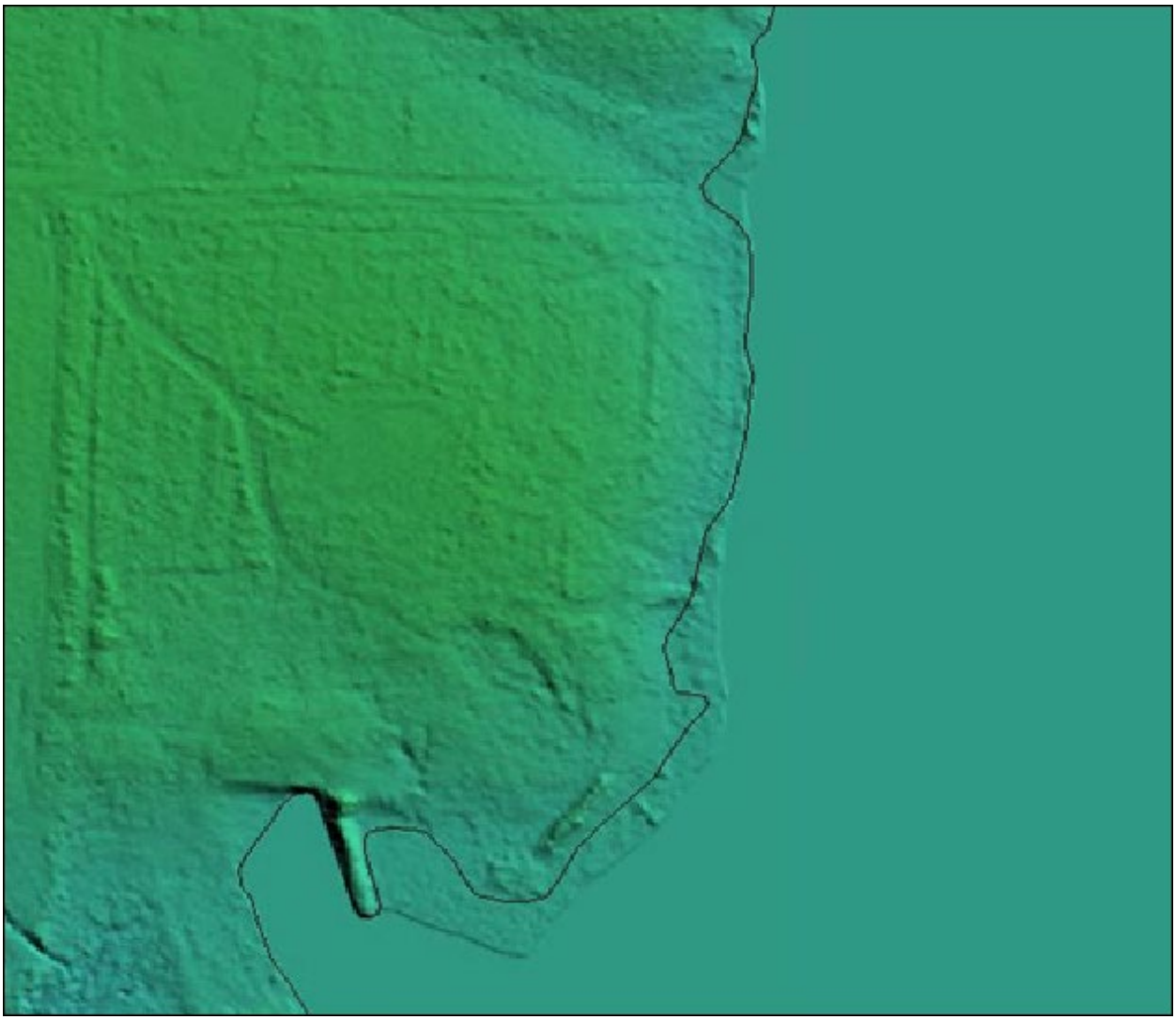


Figure 3. Digital elevation model showing a breakline (black) that does not follow the edge of the waterbody but instead is overextended landward. There should not be land on the waterward of the breakline.

Under Extended Breaklines

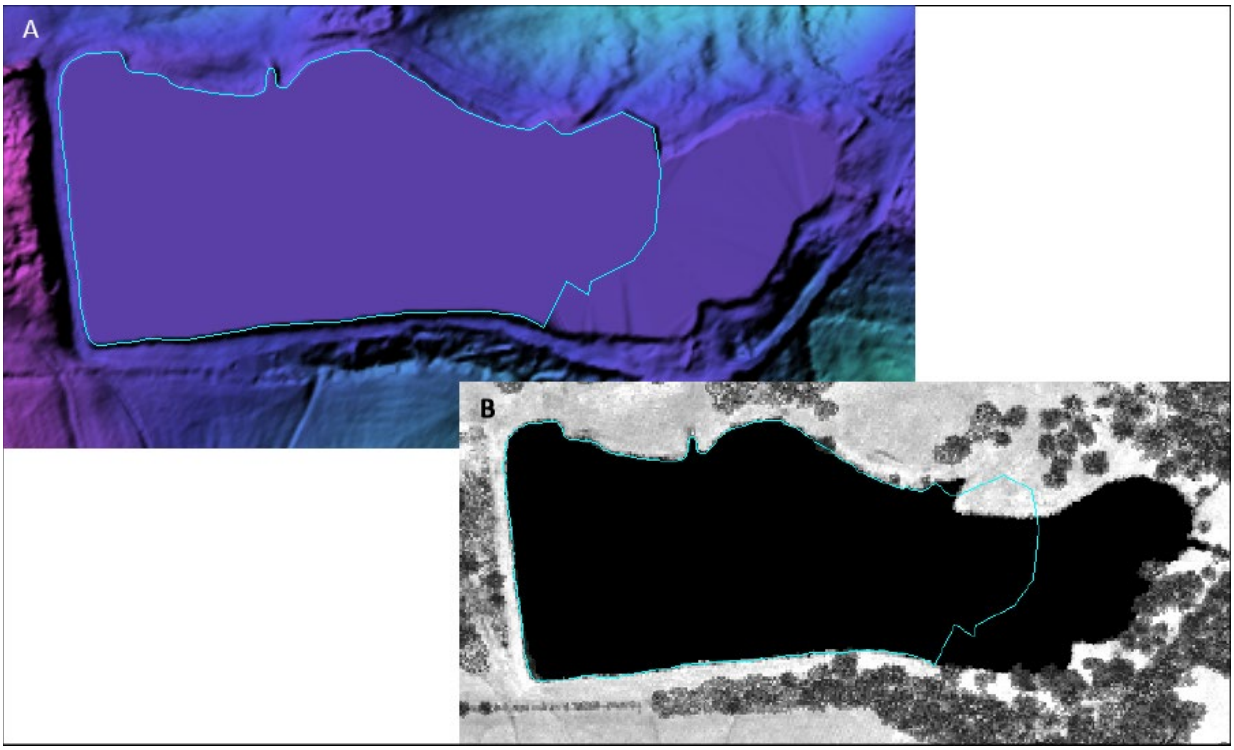


Figure 4. In this digital elevation model (A), a breakline (blue) does not follow the edge of the waterbody but instead is underextended. The intensity image (B) clearly shows water beyond the breakline. This breakline is also underextended in places (see figure 3).

River/Stream Segment

Figure 5. Digital elevation model (A) and intensity image (B) showing a discontinuous stream segment that should have been collected as a single water feature.

Z Values

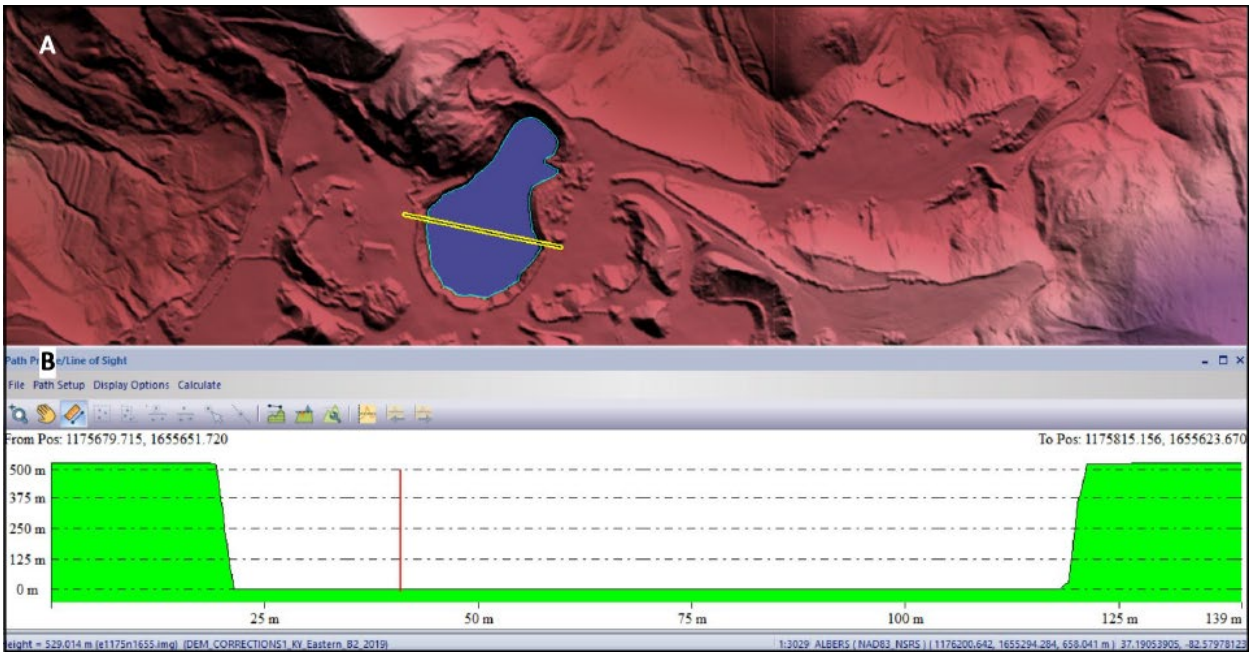


*Figure 6. Elevation cross section (B) showing Z-values that are well below the terrain instead of being at or immediately below the surrounding land surface. Top image (**A**) is a digital elevation model showing the waterbody (blue), breakline (blue line) and cross section location (yellow double line).*

Z Enabled

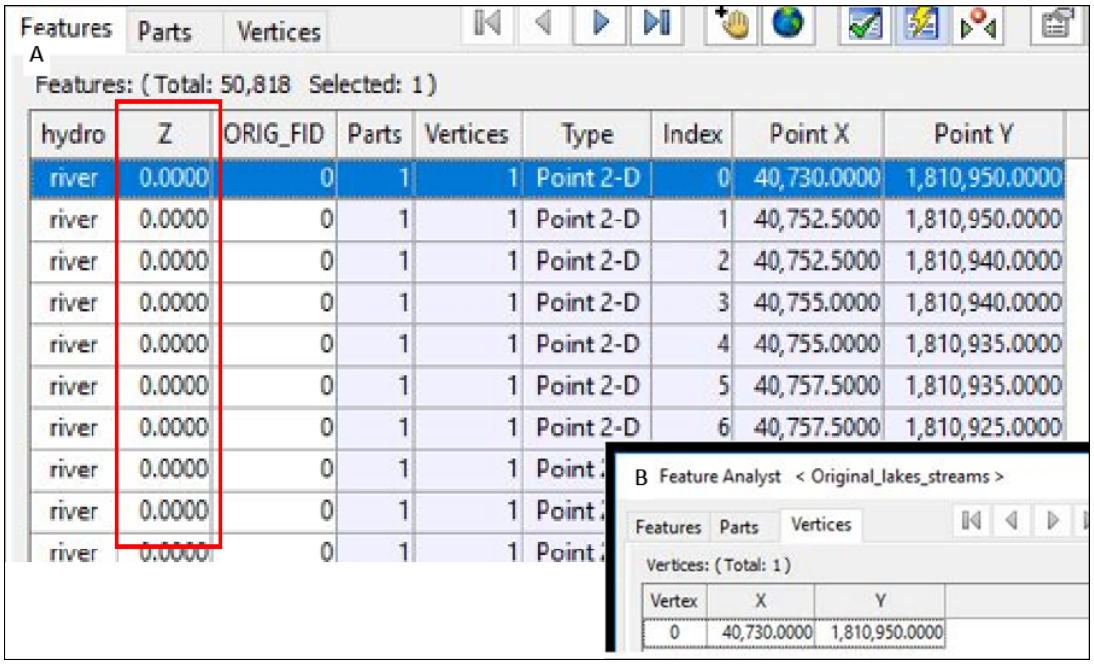


Figure 7. Screen capture showing attributes of a breakline that is a 2D feature, not a 3D feature with Z-values as required.

Misplaced Breakline

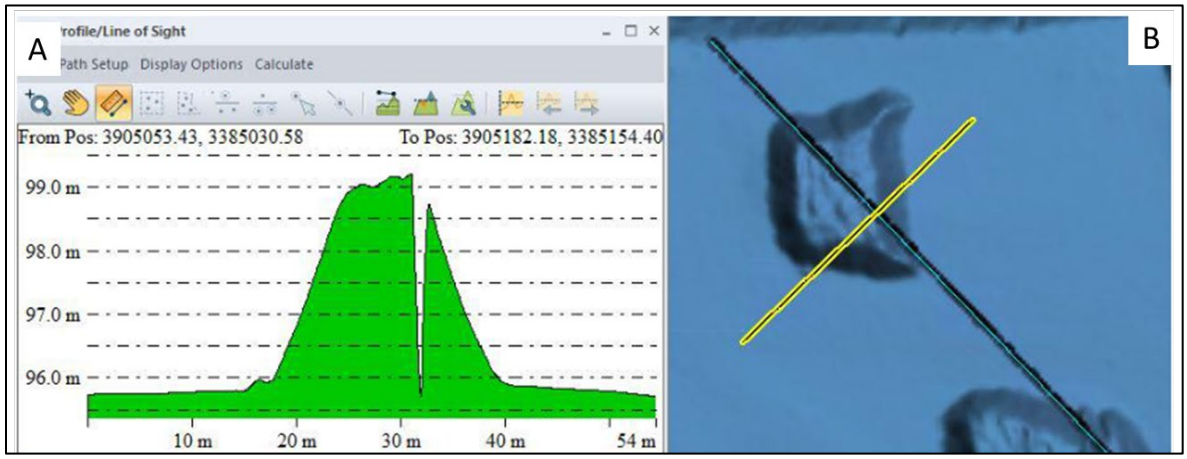


Figure 8: Image on right (B), showing a breakline that's not delineating a feature and is disrupting the DEM surface. Profile of area seen in image A.

Missing Feature

Missing Breakline

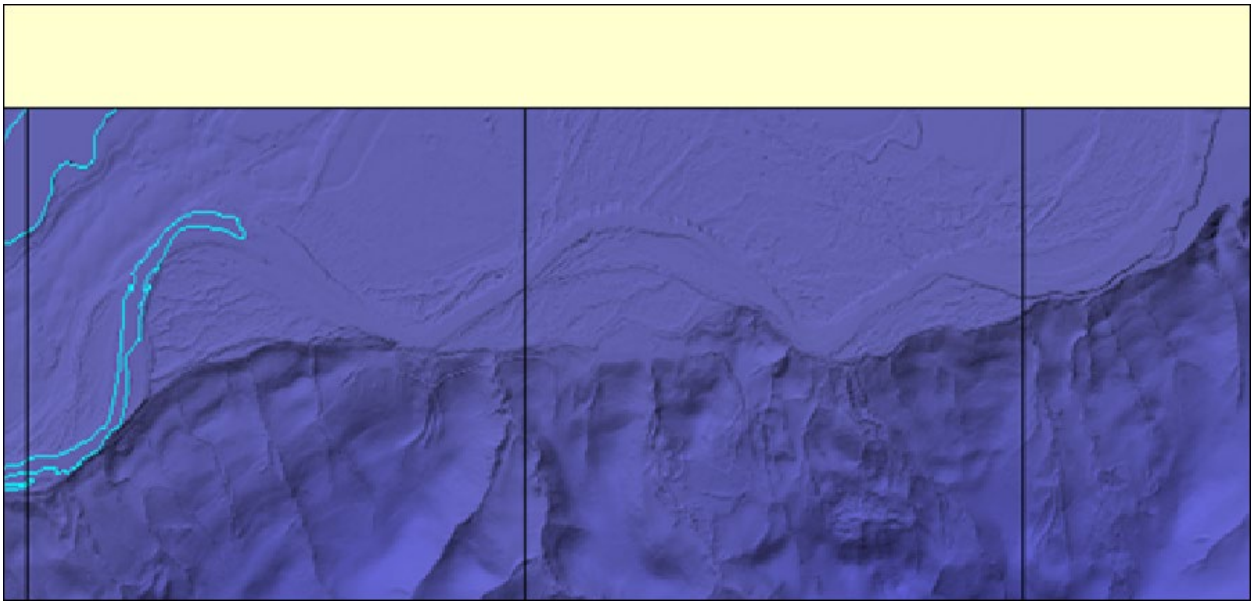


Figure 9. Digital elevation model showing a missing feature. The blue breakline should have continued along the river.

Missing Bridge Breakline

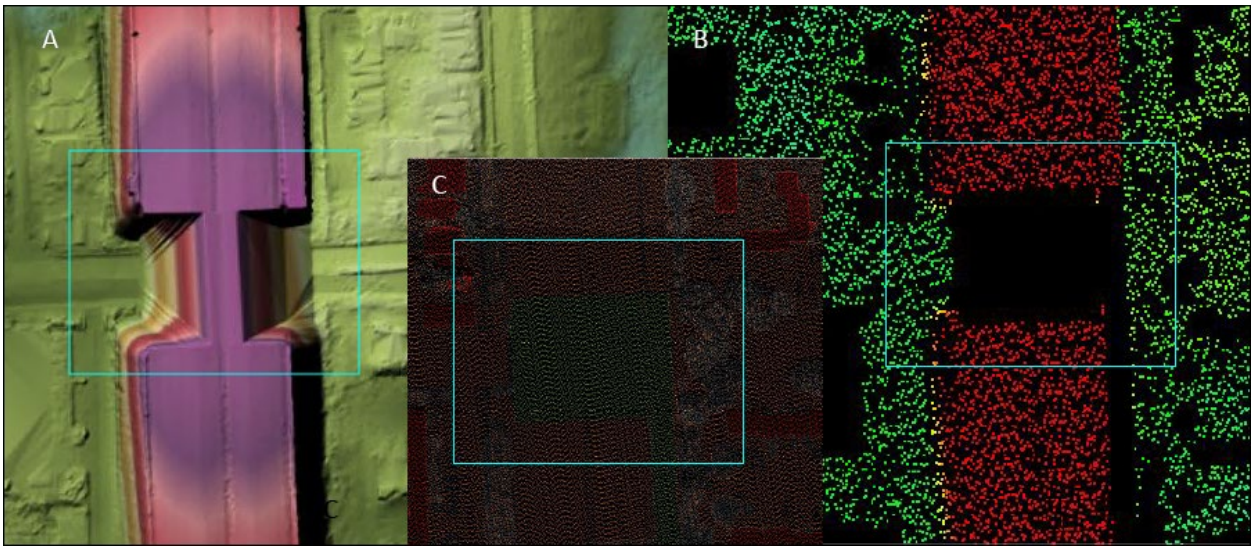


Figure 10. Digital elevation model (DEM) (A), point cloud colored by elevation (B), and classified point cloud (C) showing a bridge that is classified correctly, as can be seen in the center and right images, but lacks sufficient breaklines leading to artifacts in the DEM.

Missing Island Breakline

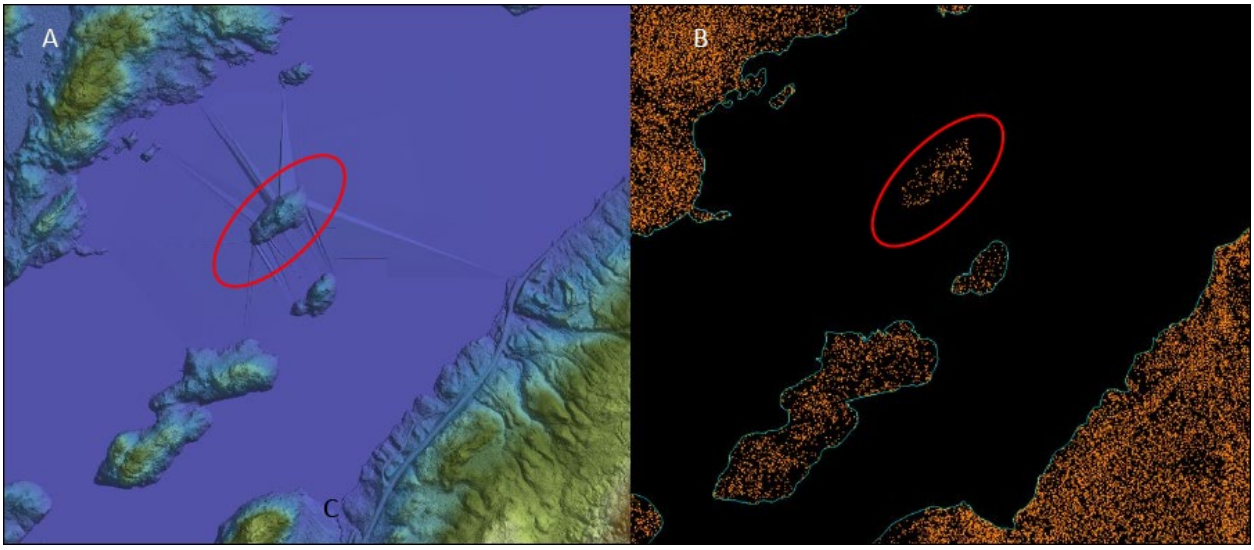


Figure 11. Digital elevation model (A) and classified lidar point cloud (B) showing an island (in red ellipse) that is classified correctly but is missing a breakline leading to an uneven water surface. The water surface should be flat. This island meets contracted minimum collection size for breaklines.

Missing Stream/River Breakline

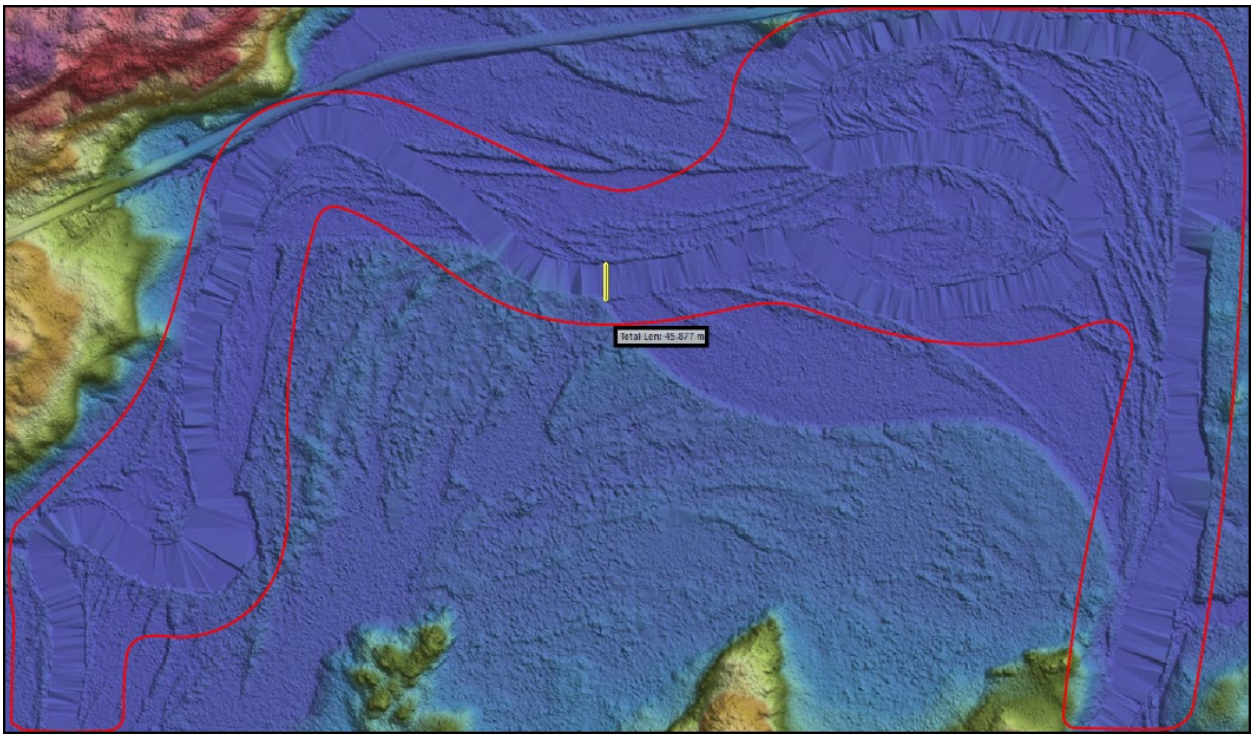


Figure 12. Digital elevation model showing a river (in red polygon) that is not encompassed with a breakline and so is left unflattened. This river meets contracted collection size for waterbodies requiring breaklines.

Missing Waterbody Breakline

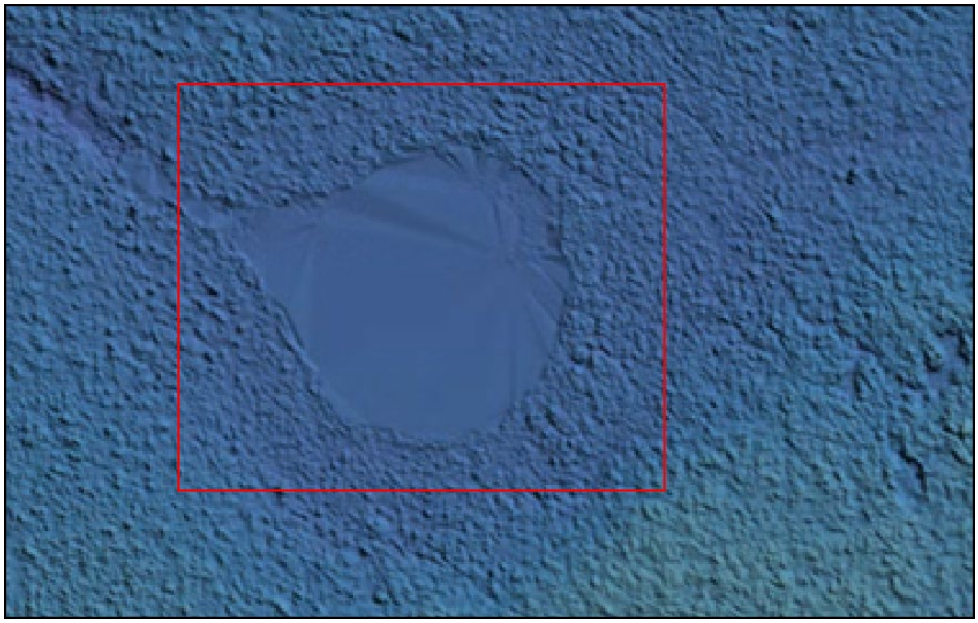


Figure 13. Digital elevation model showing a waterbody not encompassed with a breakline. This waterbody meets the contracted collection size for waterbodies requiring breaklines.

Classified Point Cloud

Collection

Point Cloud Data Void

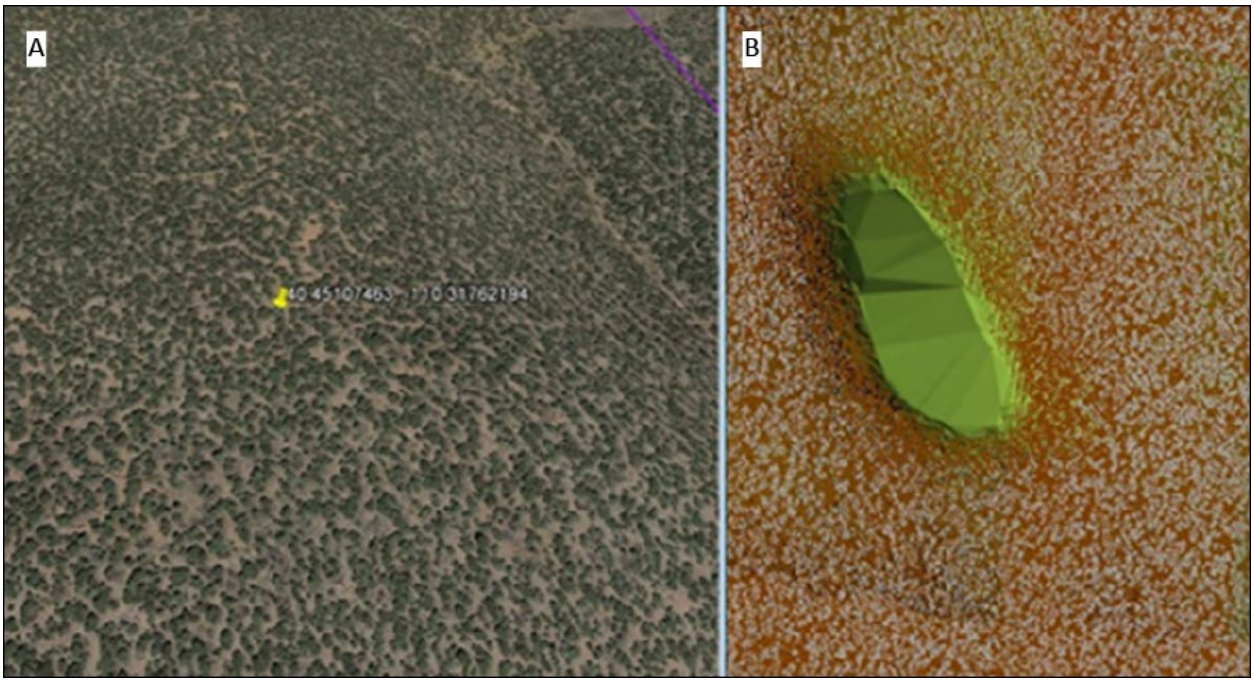


Figure 14. Aerial imagery (A) and classified lidar point cloud (B) showing a void in the point cloud (green area in B).

Point Cloud Data Void

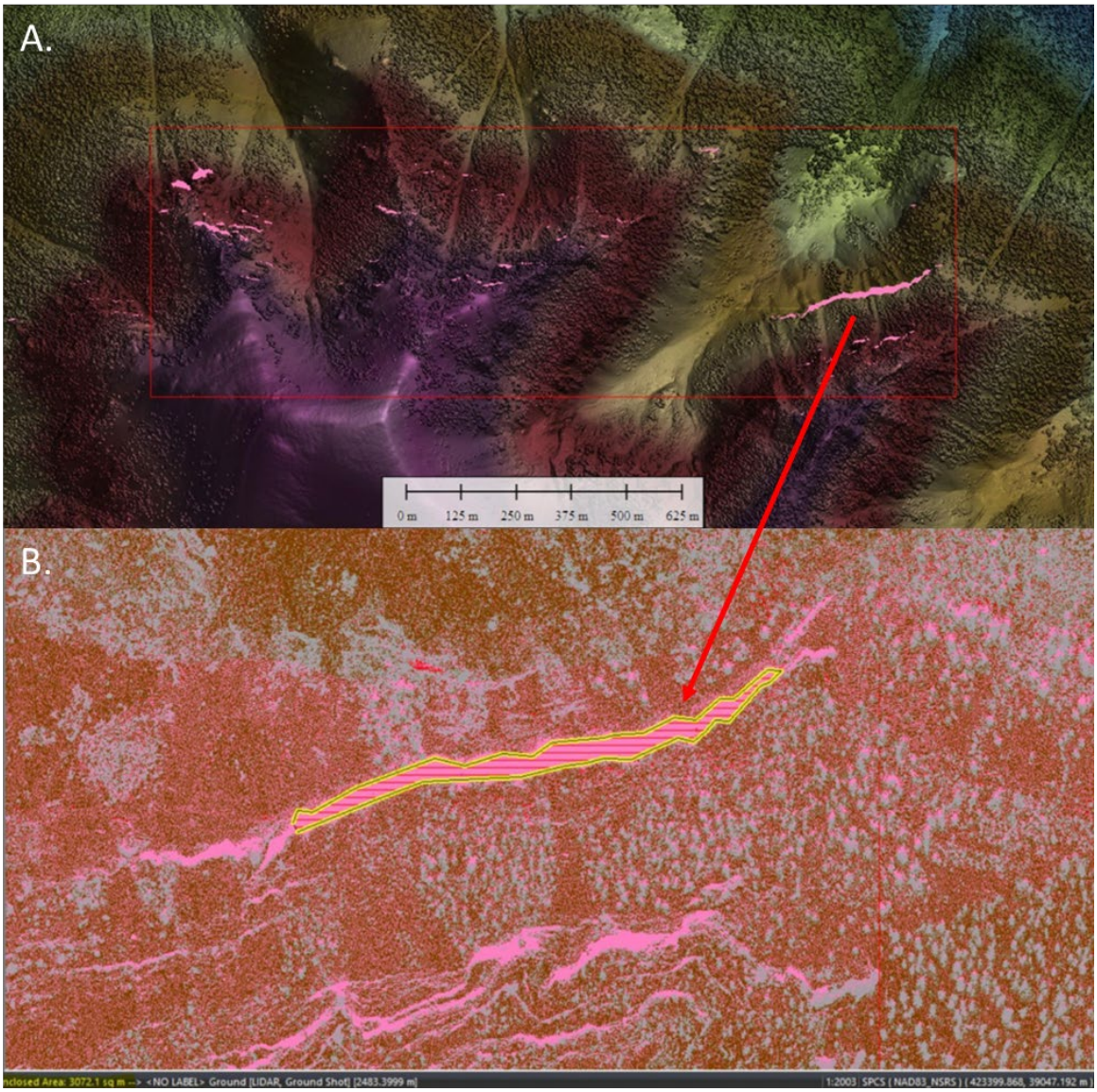


Figure 15. Maximum Surface Height Raster (A) and Lidar Point Cloud (B) showing a void in the point cloud (Pink areas showing through loaded data and area circled in yellow lines in B) that measures more than 3,072 sq meters.

Density

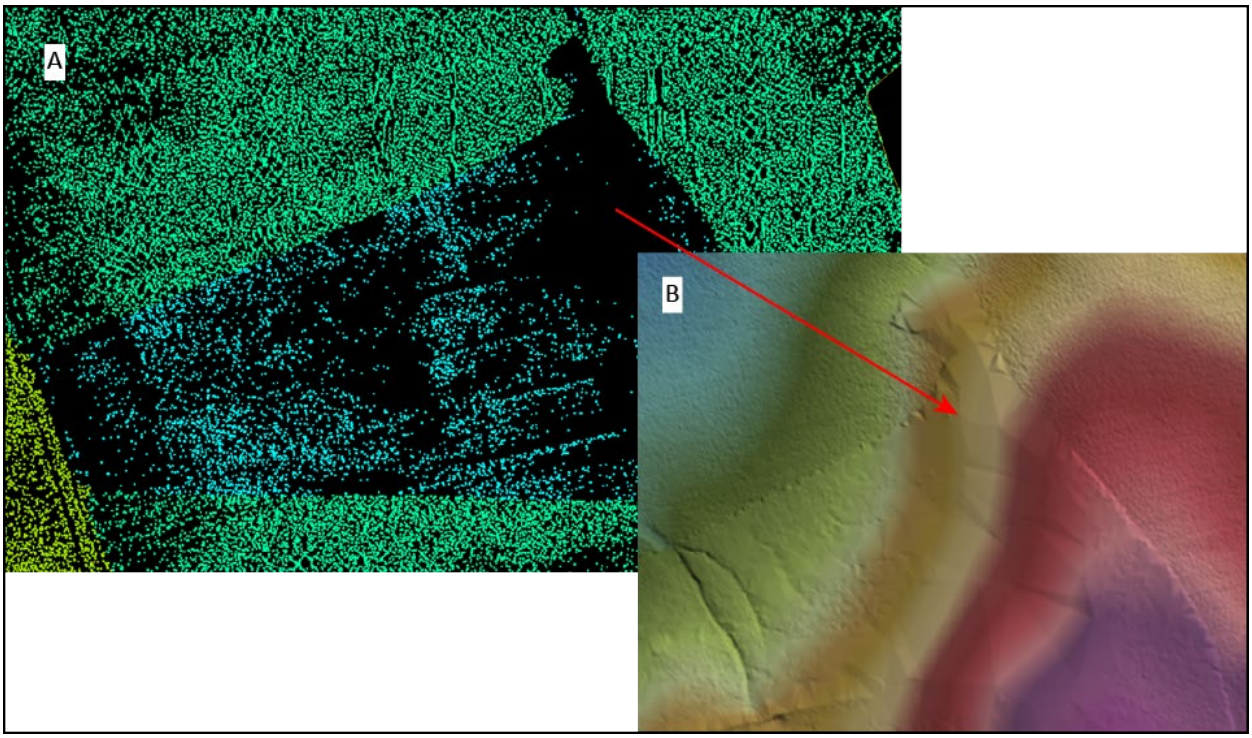


Figure 16. Classified point cloud (A) with an area of lower point density that detrimentally affects the digital elevation model (DEM) (B). An area with TIN artifacts can be seen in the DEM in the area of lower density.

Relative Accuracy (Interswath)

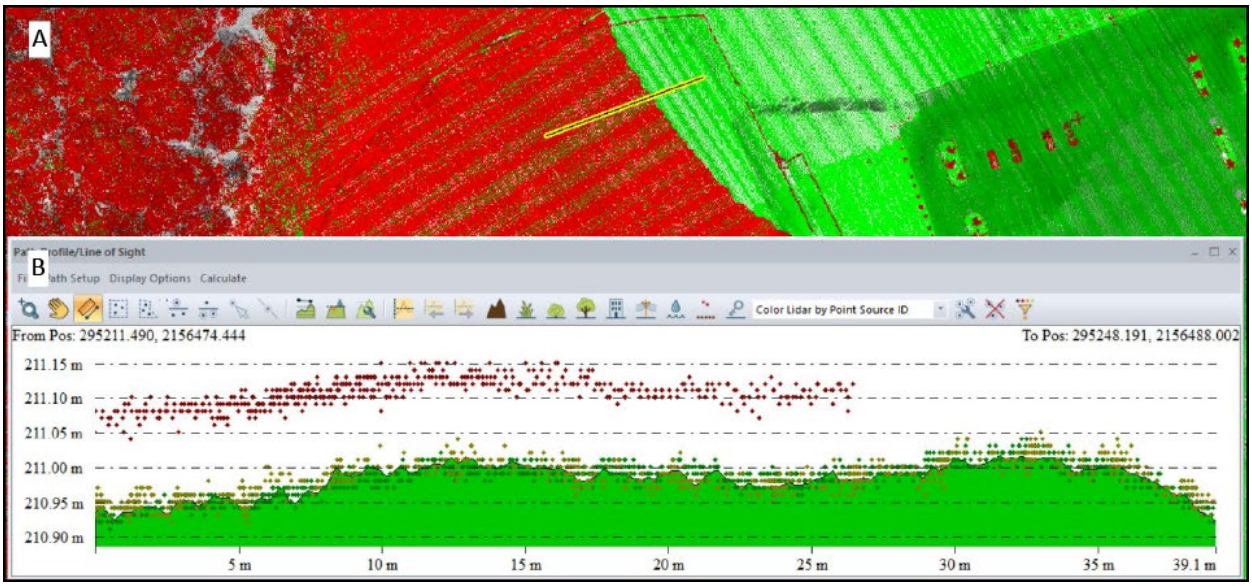
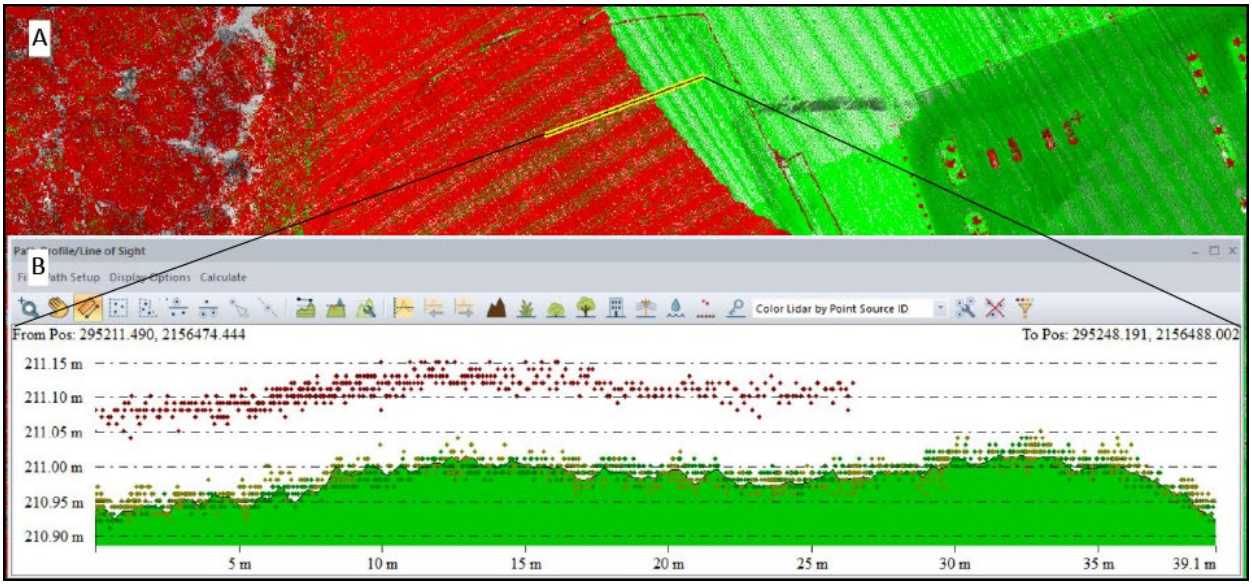


Figure 17. Classified point cloud (A) and elevation cross-section (B, taken along yellow double line in top image) illustrating an elevation mismatch between swaths (red and green).

Alternate image with lines indicating cross-section line:



Relative Accuracy (Intraswath)

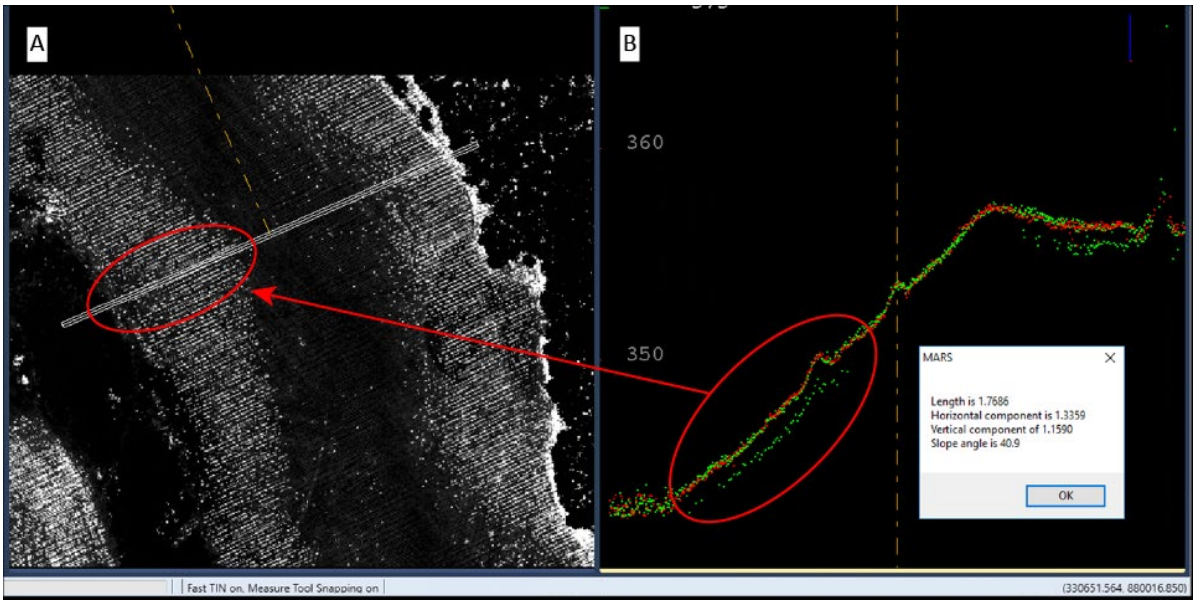


Figure 18. Lidar point cloud by channel (A) and elevation cross section (B, along double-line in left image) showing an elevation error between intraswath channels. The vertical difference is greater than one foot.

Point Data Records

Classification Flags - Overlap

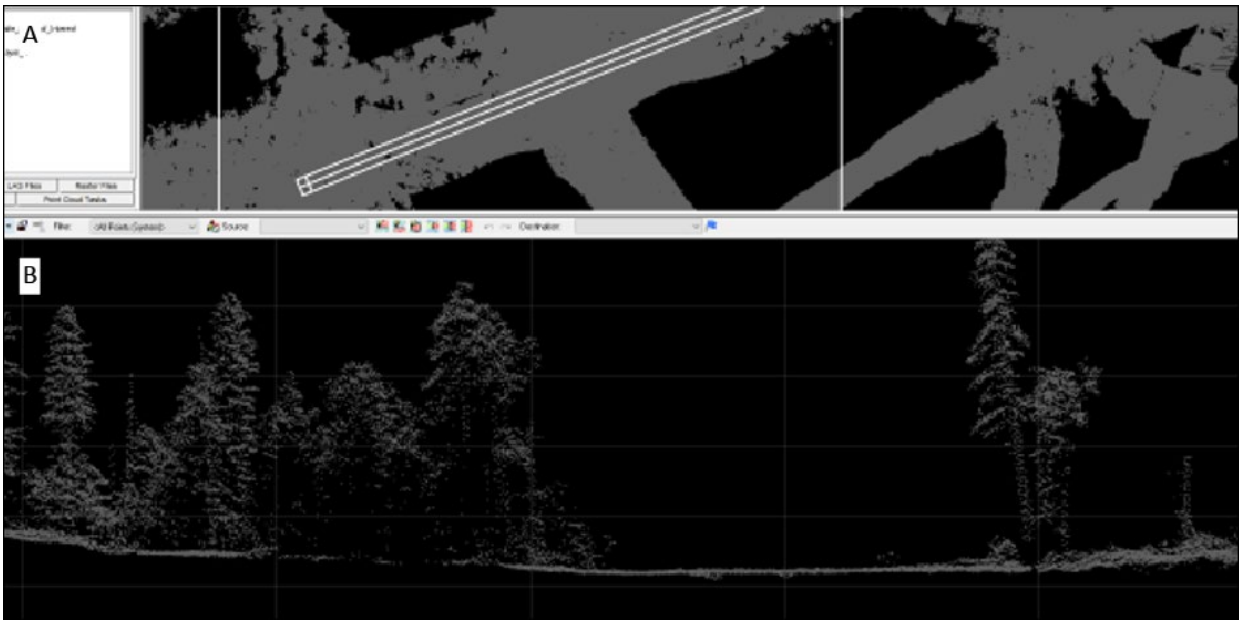


Figure 19. Points flagged as overlap are not properly classified. Plan view (A) and cross-section (B) in overlap area shows points remaining unclassified.

Classification Flags - Withheld

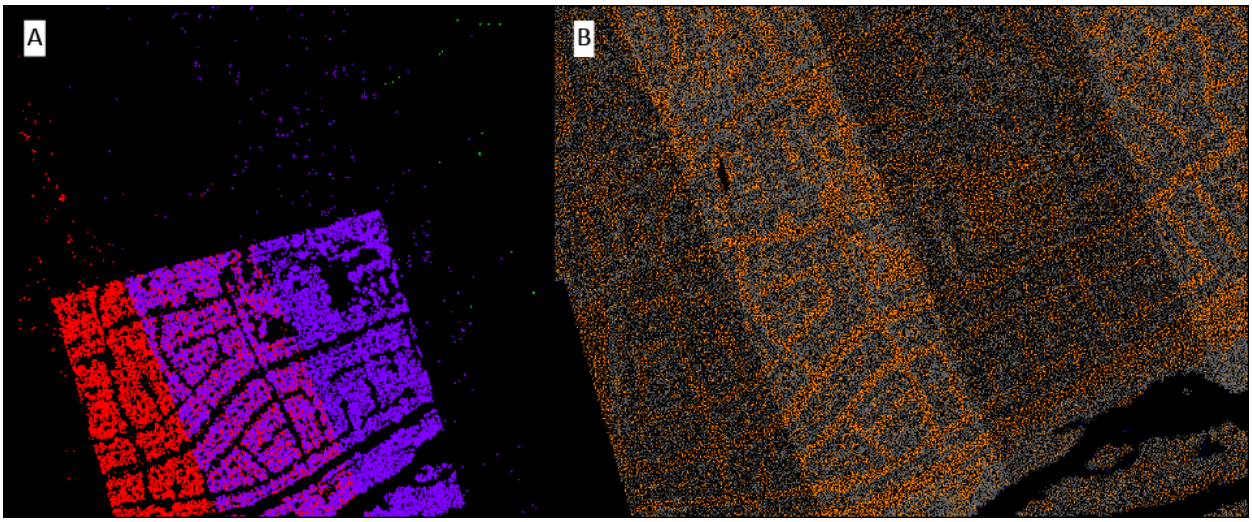


Figure 20. Geometrically valid points flagged as withheld (A, colored by swath). Points in B are colored by classification and shaded by swath.

Intensity

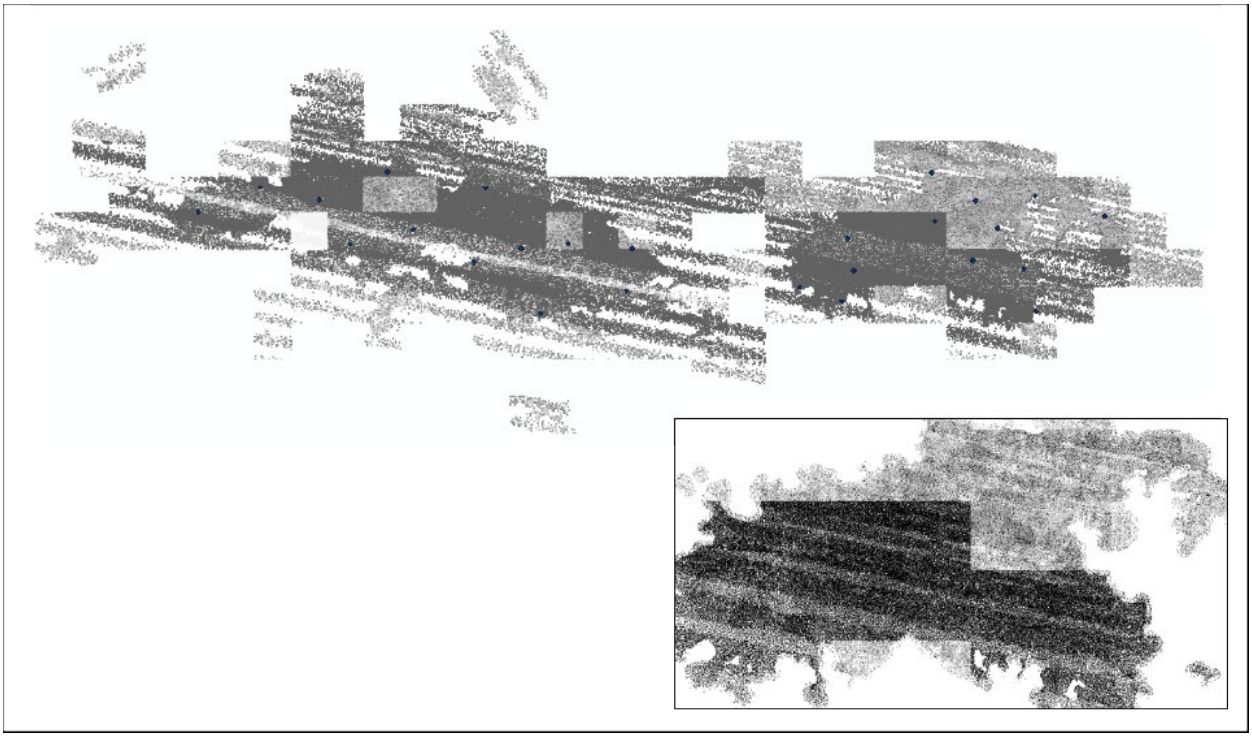


Figure 21. Image of LAS intensity values showing inconsistent normalization.

Point Source IDs

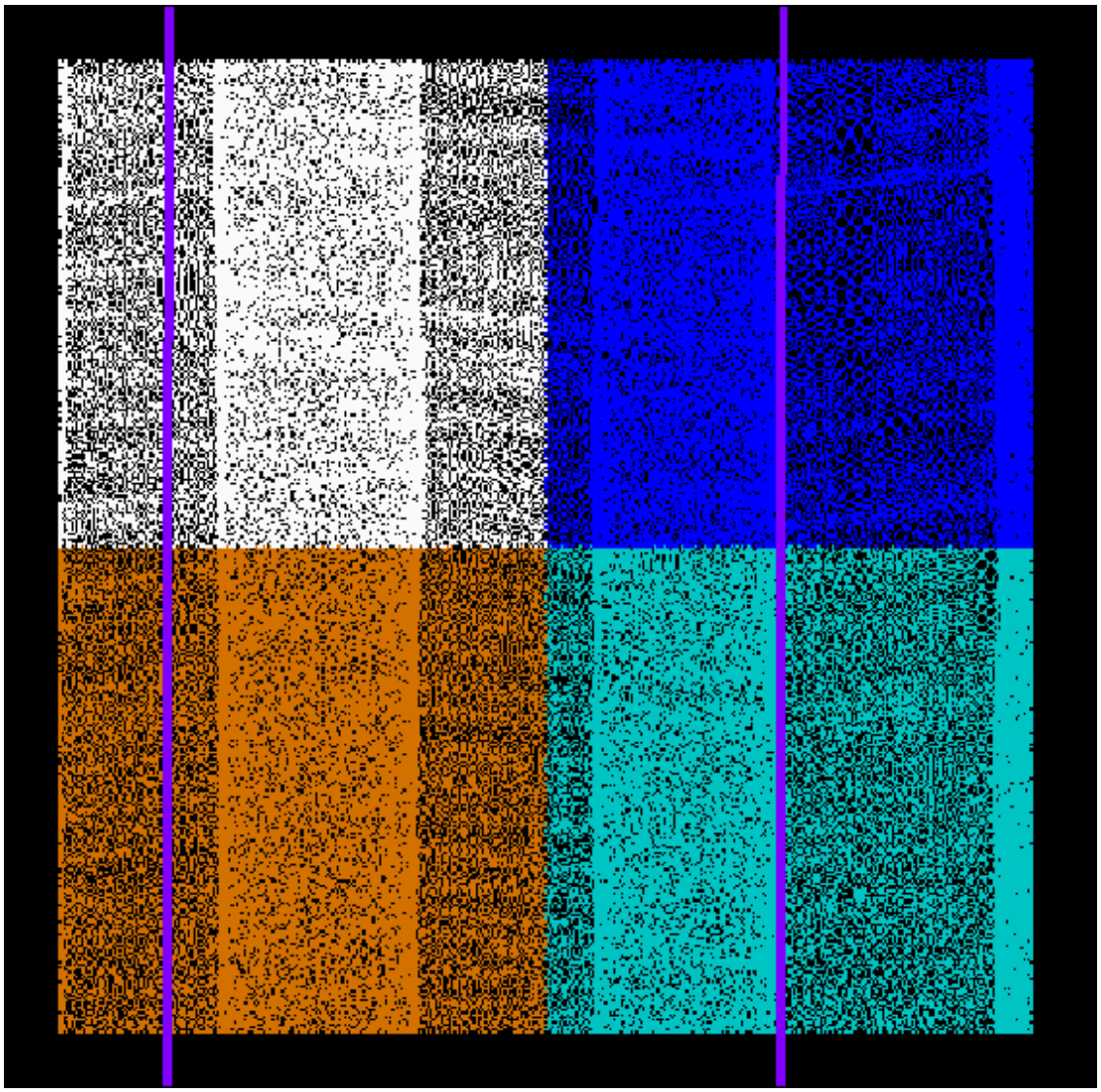


Figure 22. A lidar point cloud colored by Point Source ID. The Point Source IDs in this dataset have been set incorrectly and do not align with the flight lines (purple).

Point Misclassification

Misclass 1

Figure 23. High noise from reflective surfaces on a runway (aerial photograph, A) have been left in the ground classification (digital elevation model, B).

Misclass 2

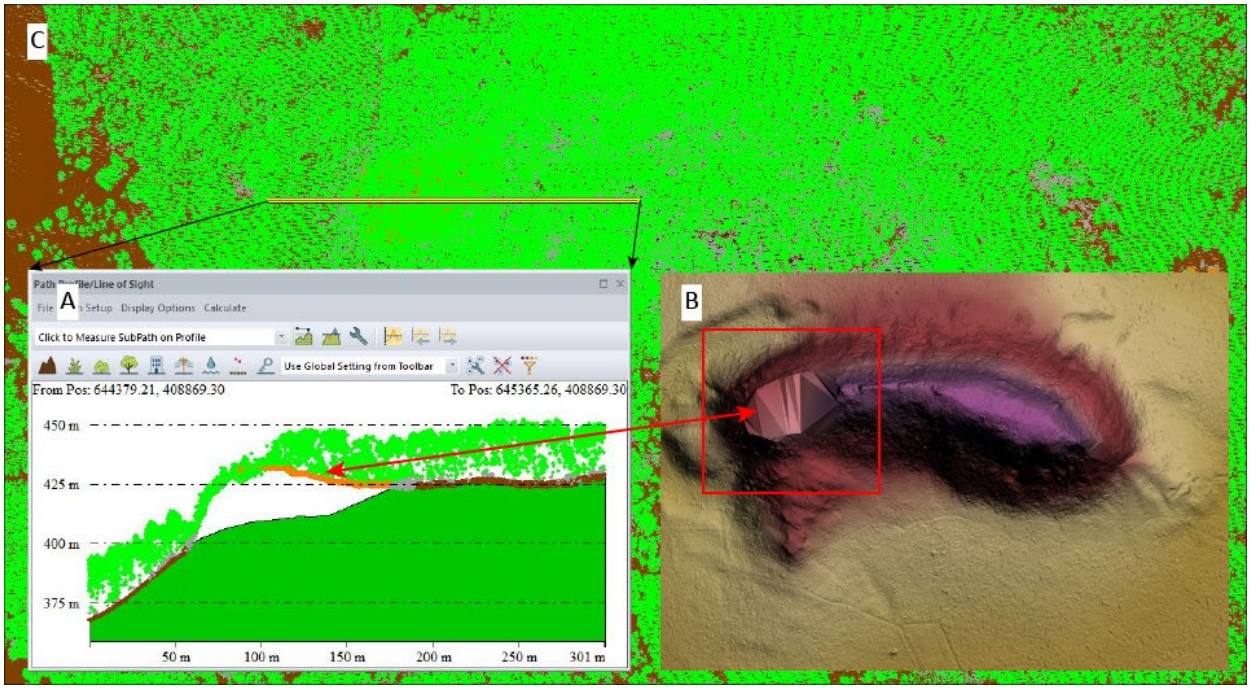


Figure 24. Elevation profile (A) and digital elevation model (B) show a void due to misclassification of ground points. Elevation profile taken along double line shown in lidar point cloud image (background, C).

Misclass 3

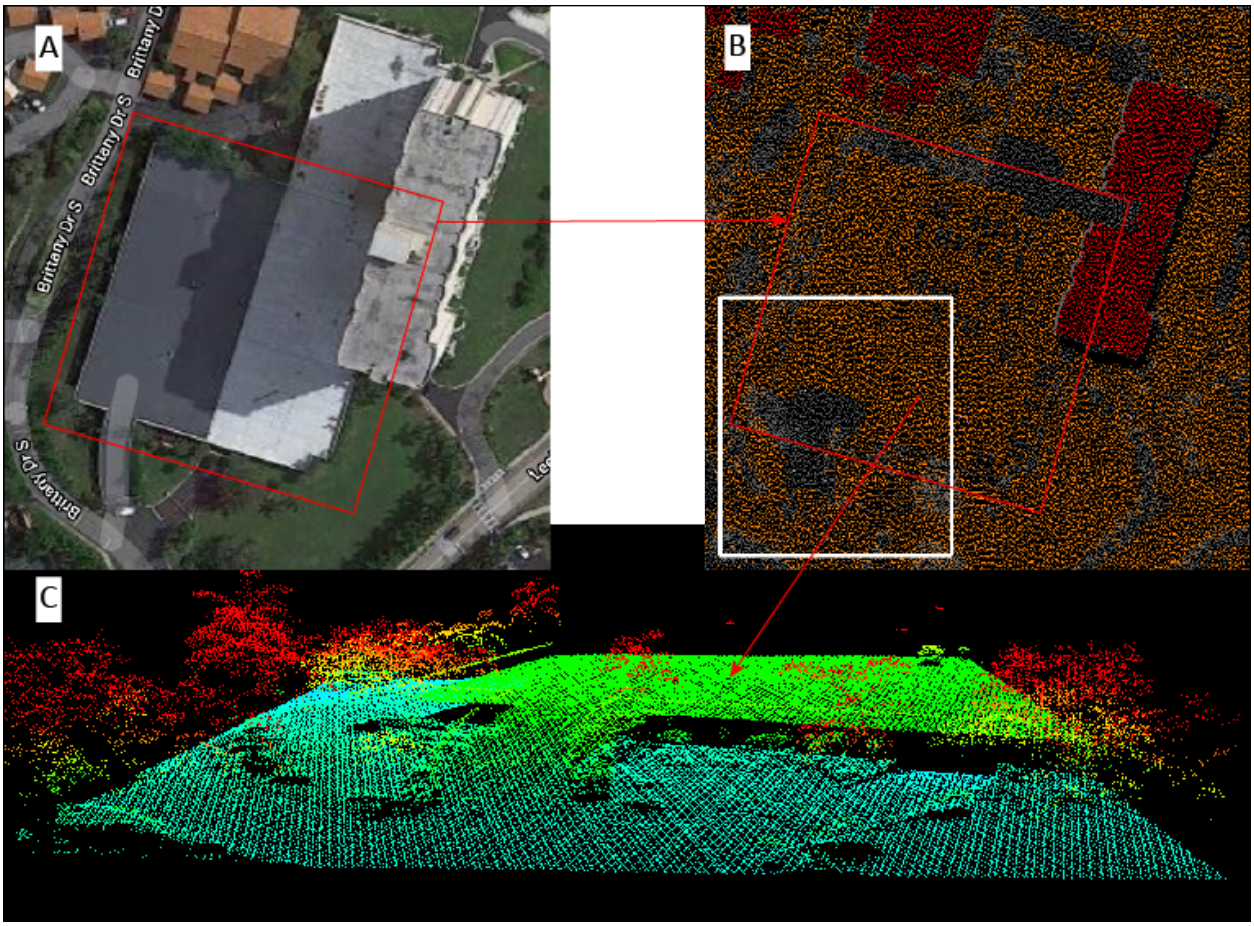


Figure 25. In this set of images, an elevated parking garage (aerial photograph, A) has been classified as ground. This can be seen in the lidar point cloud colored by classification (B) and by elevation (C).

Misclass 4

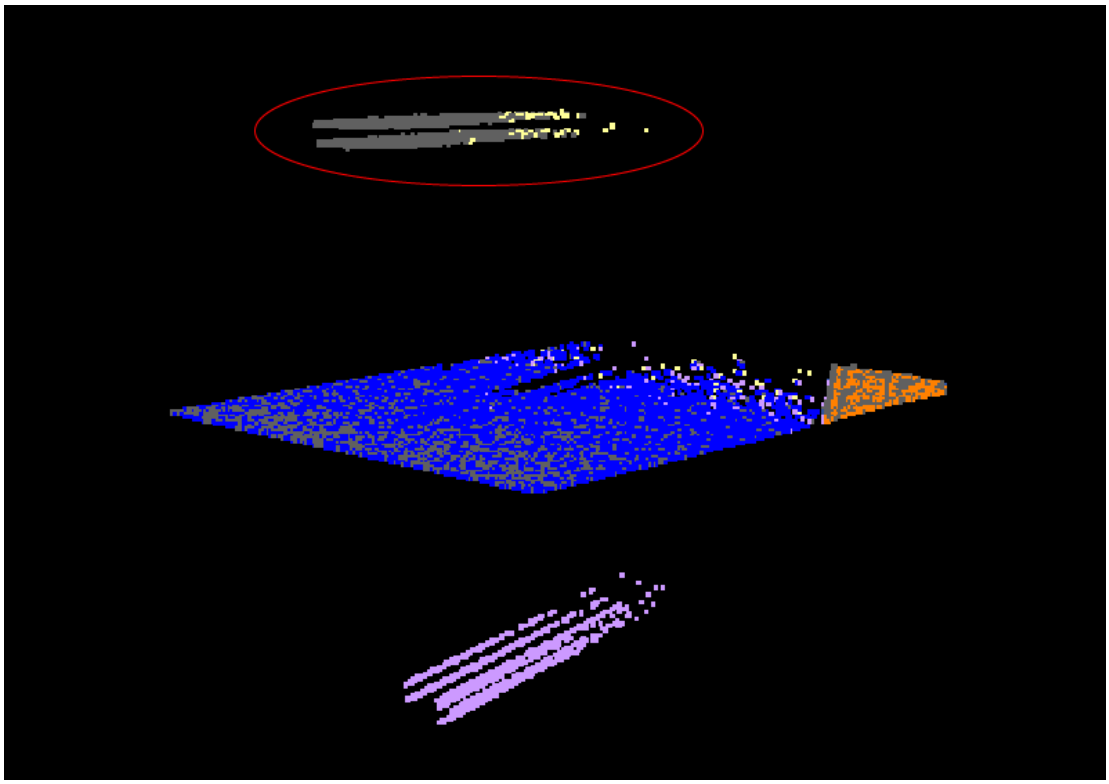


Figure 26. High noise (circled, top) has been left in class 1.

Misclass 5

Figure 27. A dock (aerial photograph, A) has sections that have been misclassified as low noise (purple, 1) and water (blue, 2) in the classified point cloud (B).

Misclass 6

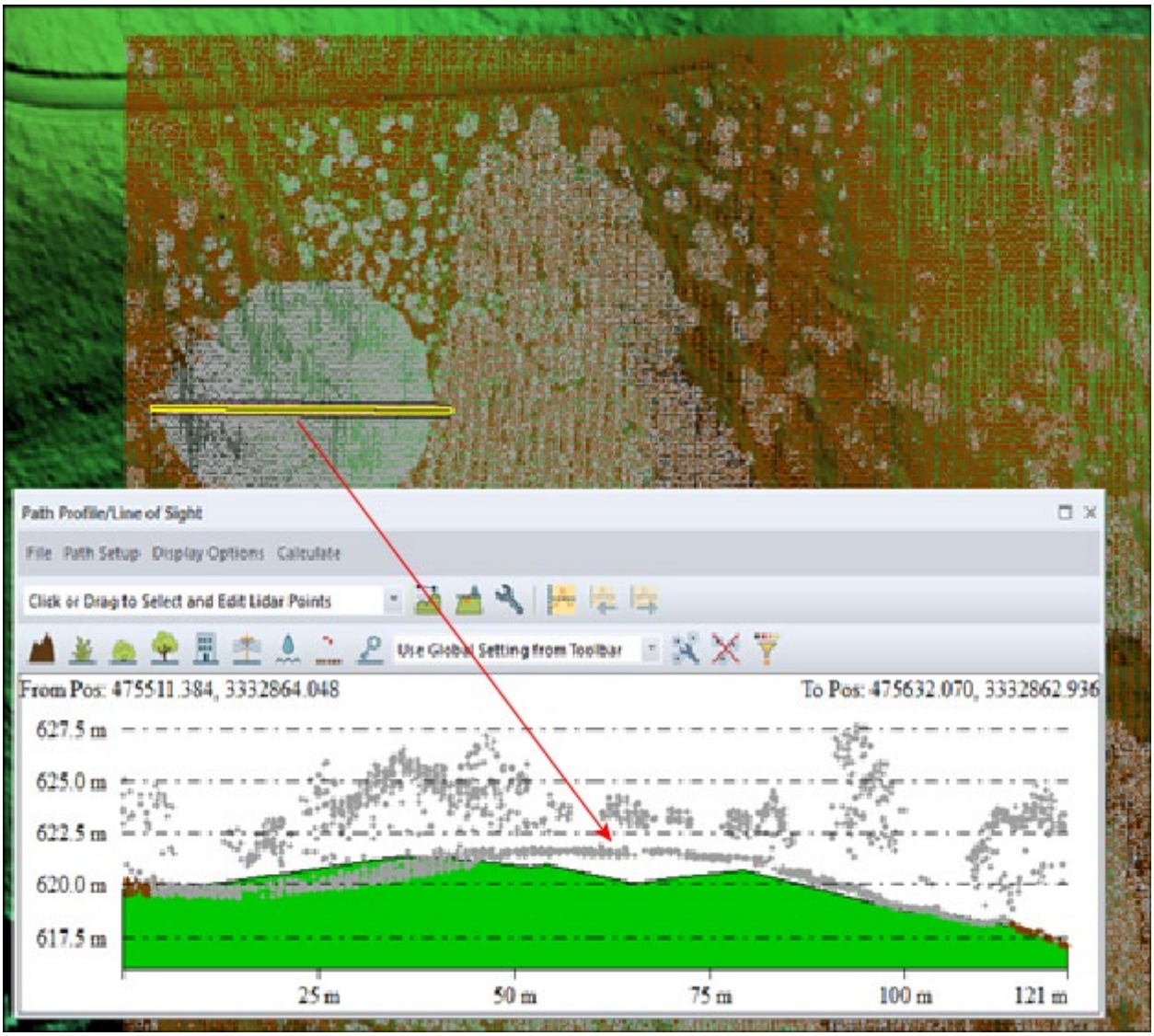


Figure 28. Elevation profile showing ground points that have been misclassified as unclassified (gray points). Elevation profile along yellow double line in classified point cloud image.

Misclass 7

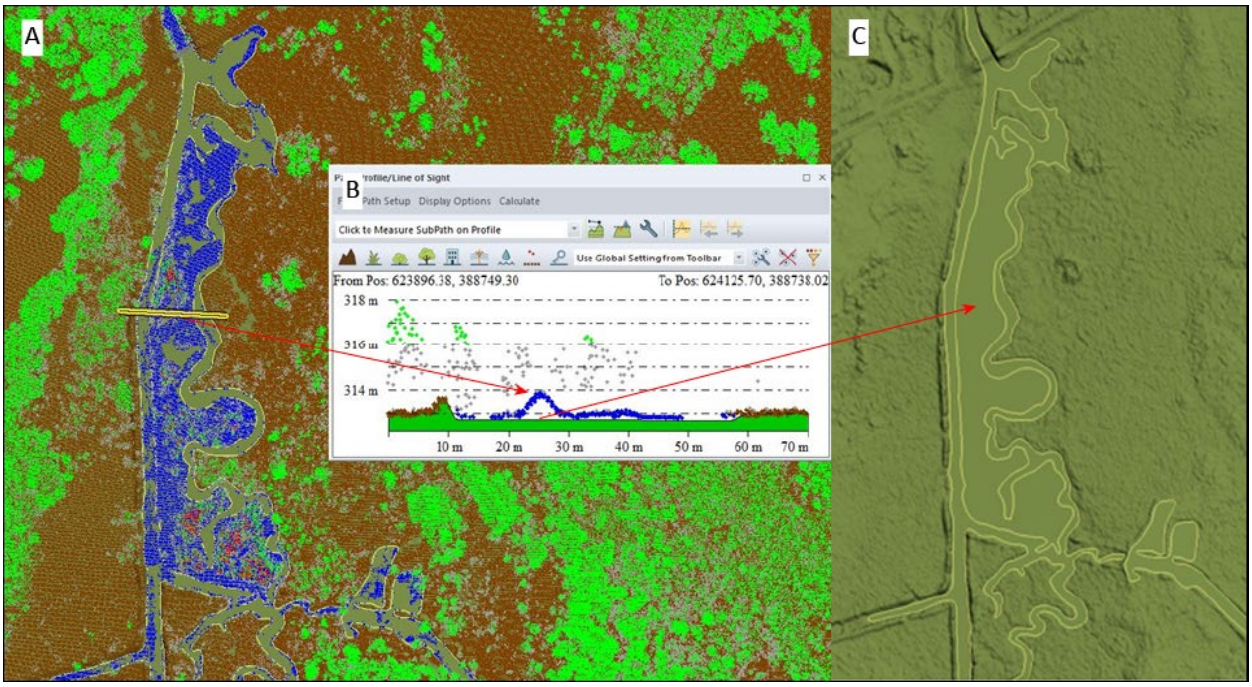


Figure 29. Elevation profile (B, along yellow double line shown in classified point cloud, A) shows ground points that have been misclassified as water (blue points) and inappropriately hydroflattened as seen in the digital elevation model (C) showing breakline (yellow line).

Misclass 8

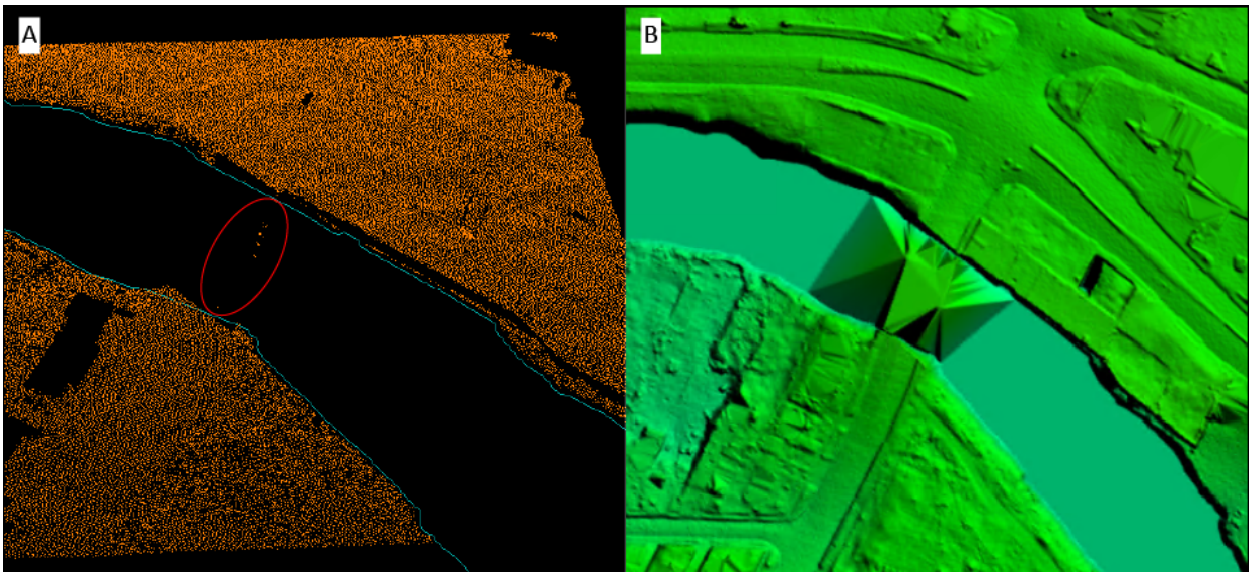


Figure 30. Points on a bridge deck have been left classified as ground (brown points, classified point cloud, A). This causes an incomplete removal of the bridge as seen in the digital elevation model (B).

Digital Elevation Model

Export

Interpolation

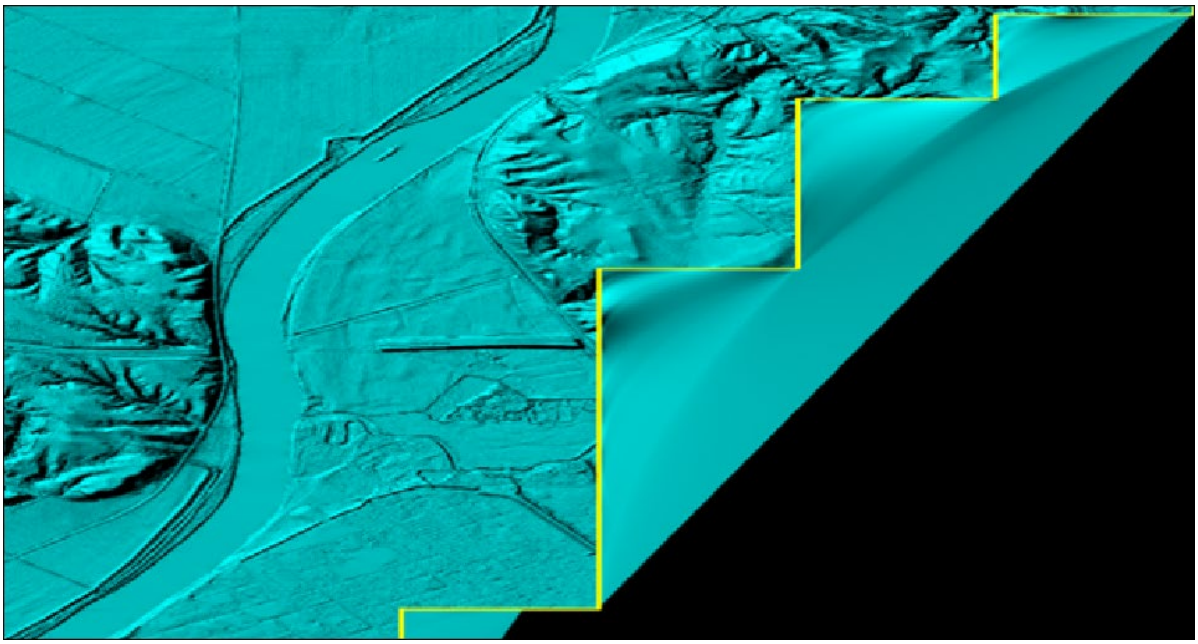


Figure 31. The digital elevation model has been extrapolated beyond the DPA boundary (yellow line).

Mismatch

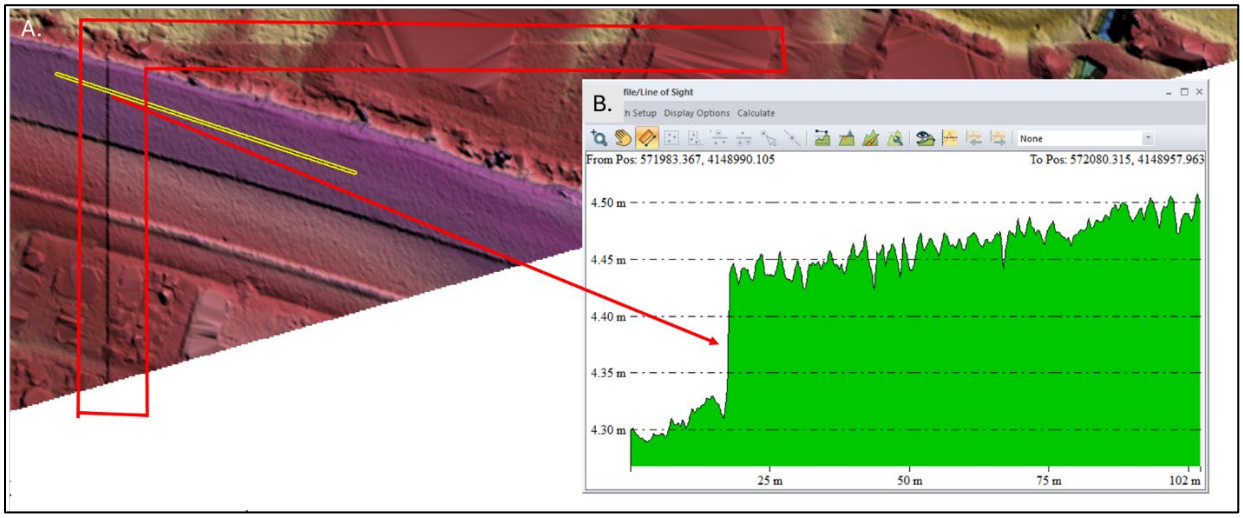


Figure 32. This illustration shows a mismatch in digital elevation models (A) along a tile border that shows up as a distortion. The mismatch can be seen in the elevation cross section (B) taken along double yellow line in A.

Overlap

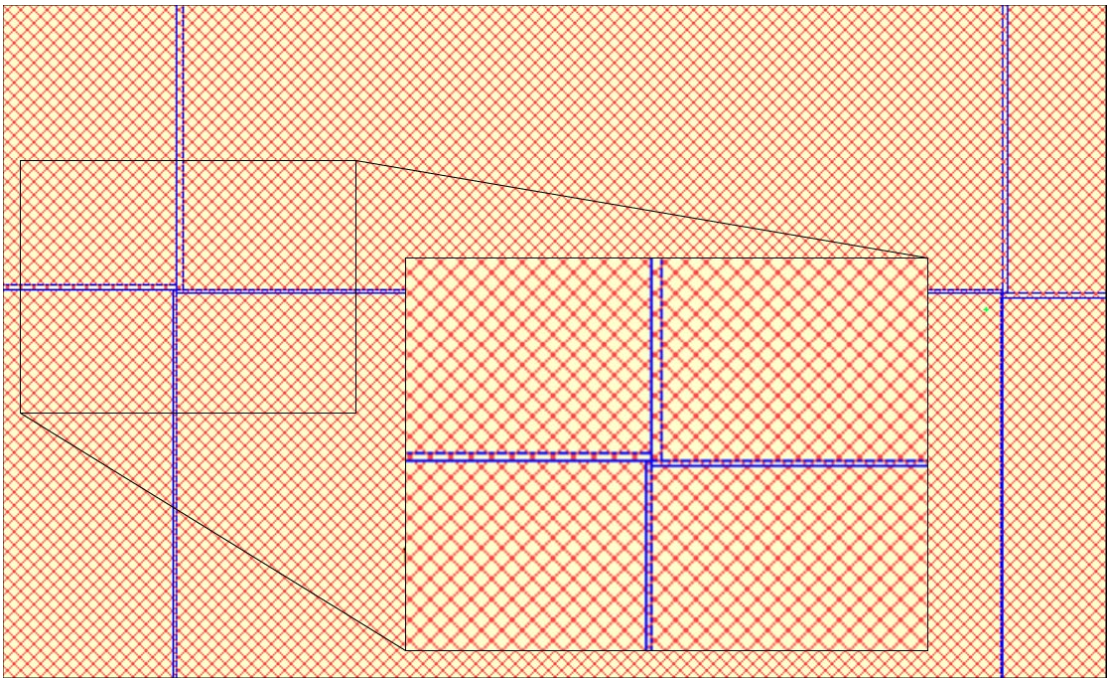


Figure 33. Digital elevation tiles overlapping along tile boundaries (blue lines). The tiles should not overlap.

DEM Void

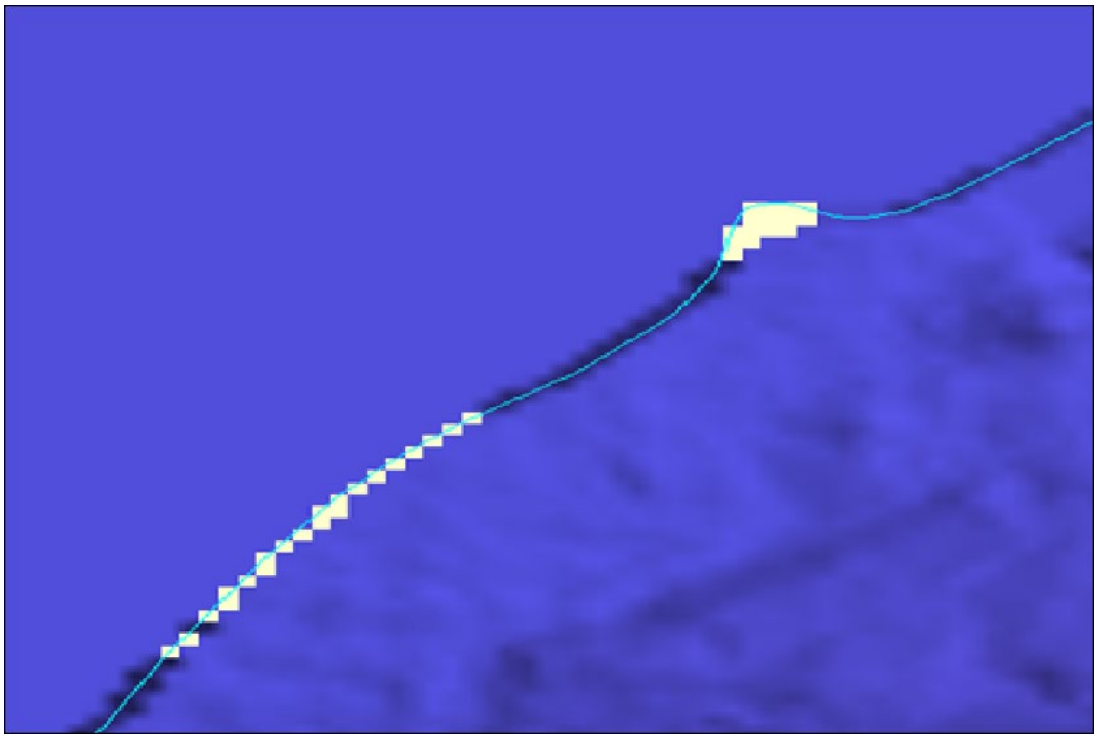


Figure 34. Void (white pixels) in the digital elevation model occuring along a hydro breakline (green line).

Raster Metadata

Does Not Match Project Extent

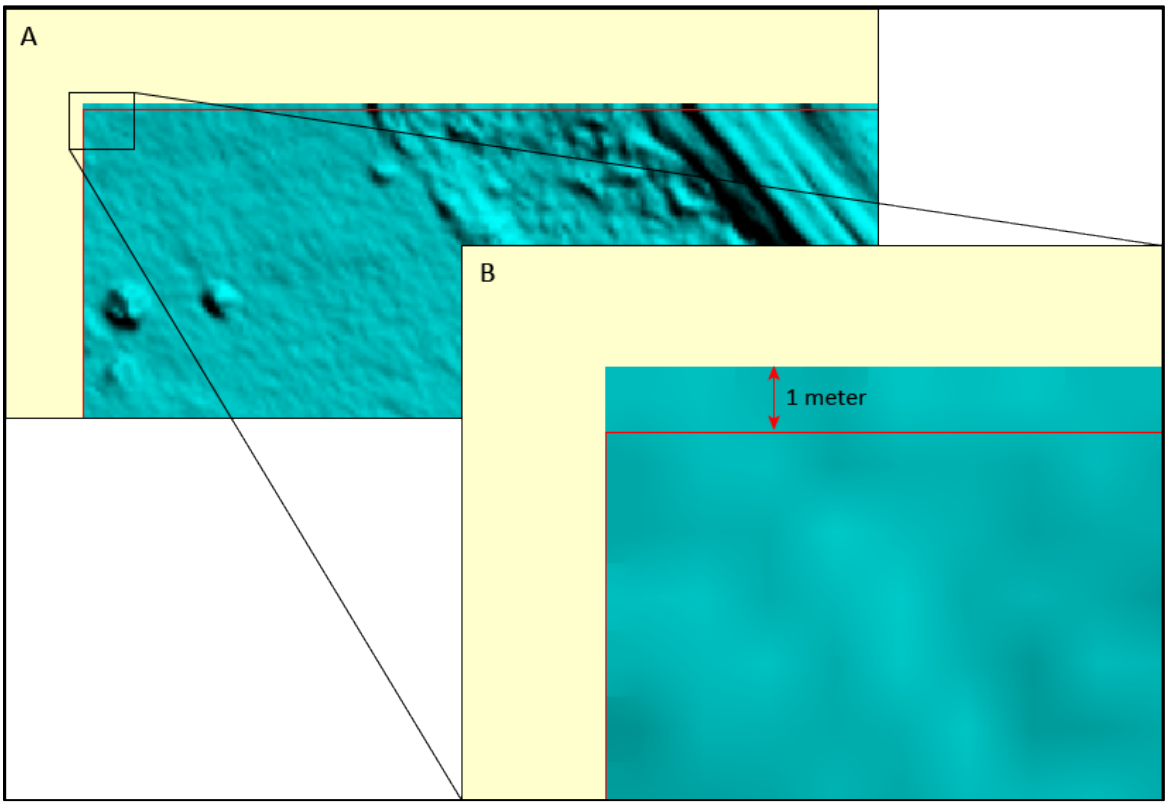


Figure 34: Digital elevation model raster metadata boundary (dark red) does not match the extent of the digital elevation model (blue).

Spatial Metadata

Incorrect Geometry

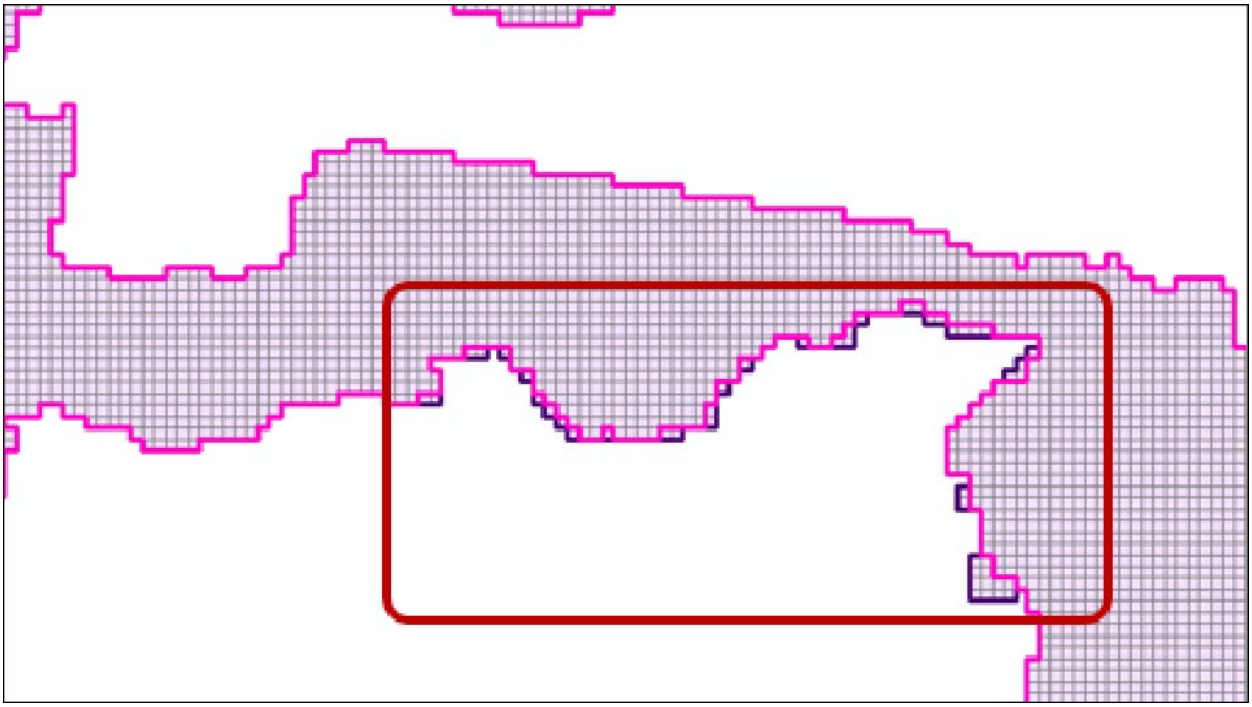


Figure 35. Illustration of DPA boundary showing an incorrect geometry in the project (purple line) in the area enclosed by the red rectangle.