LiDAR Quality Assessment Report

The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset and the Center for LiDAR Information Coordination and Knowledge. The USGS recognizes the complexity of LiDAR collection and processing performed by the data suppliers and has developed this Quality Assessment (QA) procedure to accommodate USGS collection and processing specifications with flexibility. The goal of this process is to assure LiDAR data are of sufficient quality for database population and scientific analysis. Concerns regarding the assessment of these data should be directed to the Chief, Data Operations Branch, 1400 Independence Road, Rolla, Missouri 65401 or NGTOCoperations@usgs.gov.

Materials Received:
1/10/2013

Project ID:
KS_Area1_2012

Project Alias(es):
KS_25 COUNTIES LIDAR#2

Project Type: Partnership

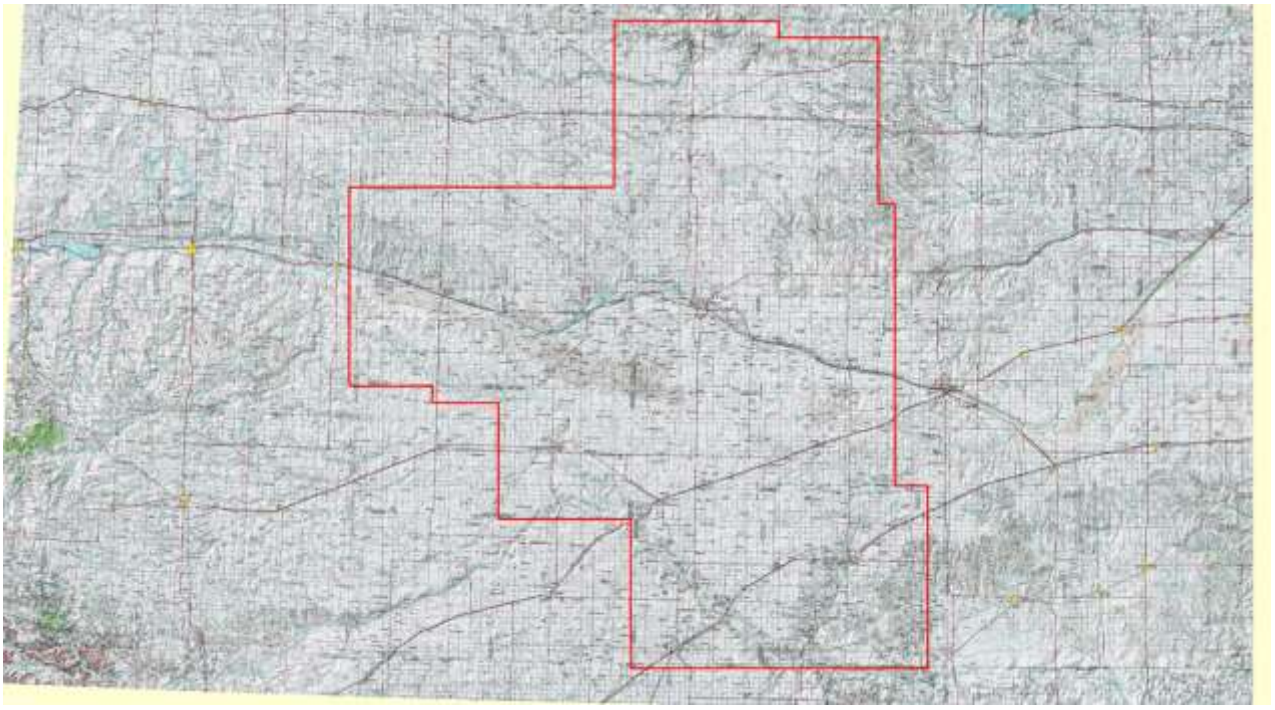
Project Description:
KS-25 Counties Lidar project has 3 Project Areas consisting of 5 lots: Area 1, Area 2 and Area 3 (which is divided into 3 delivery lots). This dataset is Area 1 and encompasses 10 counties in southwestern Kansas: Scott, Lane, Hamilton, Kearny, Finney, Grant, Haskell, Gray, Seward and Meade.

Year of Collection:
January 19 - March 26, 2012

Lot 2 of 6 lots.

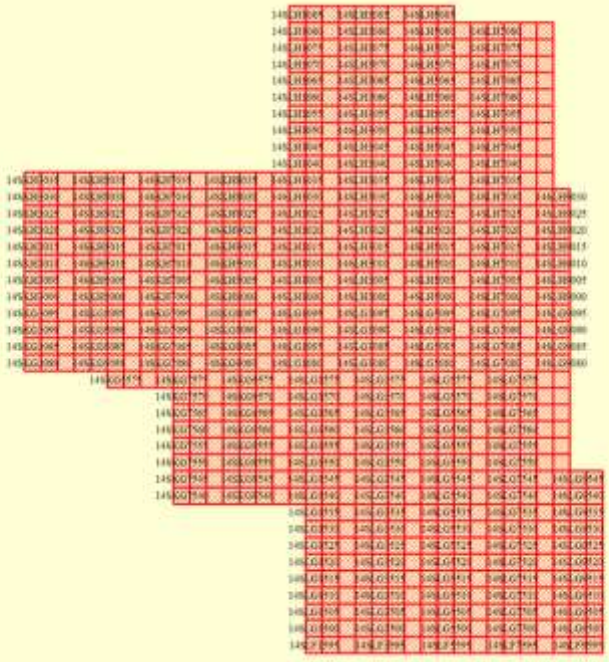
Project Extent:

☑ Project Extent image?



Project Tiling Scheme:

☑ Project Tiling Scheme image?



Contractor:	Applicable Specification:
Sanborn	V13

Licensing Restrictions:

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Ingrid Landgraf	NSDI Liaison	785-832-3566	imlandgraf@usgs.gov

Project Deliverables

All project deliverables must be supplied according to collection and processing specifications. The USGS will postpone the QA process when any of the required deliverables are missing. When deliverables are missing, the Contracting Officer Technical Representative (COTR) will be contacted by the Elevation/Orthoimagery Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

- [x] Collection Report
- [x] Survey Report
- [x] Processing Report
- [ ] QA/QC Report
- [x] Control and Calibration Points
- [ ] Project Shapefile/Geodatabase
- [x] Project Tiling Scheme Shapefile/Gdb
- [ ] Control Point Shapefile/Gdb
- [x] Breakline Shapefile/Gdb
- [x] Project XML Metadata

Multi-File Deliverables

File Type	Quantity
Swath LAS Files Required? XML Metadata?	478
Intensity Image Files Required?	911
Tiled LAS Files Required? XML Metadata?	911
Breakline Files Required? XML Metadata?	15
Bare-Earth DEM Files Required? XML Metadata?	911

Additional Deliverables

( ) Yes (•) No

Project Geographic Information

Areal Extent:

8793.4

Sq Mi

Grid Size:

1

meters
Tile Size:
5000 x 5000
meters
Nominal Pulse Spacing: 1.4 meters
Vertical Datum: NAVD88 meters
Horizontal Datum: NAD83_HARN meters

Project Projection/Coordinate Reference System: NAD_1983_UTM_Zone_14N (HARN) meters.

This Projection Coordinate Reference System is consistent across the following deliverables:

- ☑ Project Shapefile/Geodatabase
- ☑ Project Tiling Scheme Shapefile/Gdb
- ☑ Checkpoints Shapefile/Geodatabase
- ☑ Project XML Metadata File
- ☑ Swath LAS XML Metadata File
- ☑ Classified LAS XML Metadata File
- ☑ Breaklines XML Metadata File
- ☑ Bare-Earth DEM XML Metadata File
- ☑ Swath LAS Files
- ☑ Classified LAS Files
- ☑ Breaklines Files
- ☑ Bare-Earth DEM Files

Review Cycle

This section documents who performed the QA Review on a project as well as when QA reviews were started, actions passed, received, and completed.

Review Start Date: 1/23/2013

Action to Contractor Date	Issue Description	Return Date
2/6/2013	Metadata issues with vertical accuracy; vertical accuracy not reported for swath or DEM (FVA, SVA, CVA); no project-level metadata for Area 1; errors in DEM	6/10/2013
8/13/2013	Some culverts were not corrected in the DEM; Report FVA, SVA and CVA according to spec; Swath metadata file does not open	11/7/2013

Review Complete: 12/24/2013

Metadata Review

Provided metadata files have been parsed using 'mp' metadata parser. Any errors generated by the parser are documented below for reference and/or corrective action.

The Project XML Metadata file parsed without errors.

The Swath LAS XML Metadata file parsed without errors.

The Classified LAS XML Metadata file parsed without errors.

The Breakline XML Metadata file parsed without errors.

The Bare-Earth DEM XML Metadata file parsed without errors.

Project QA/QC Report Review

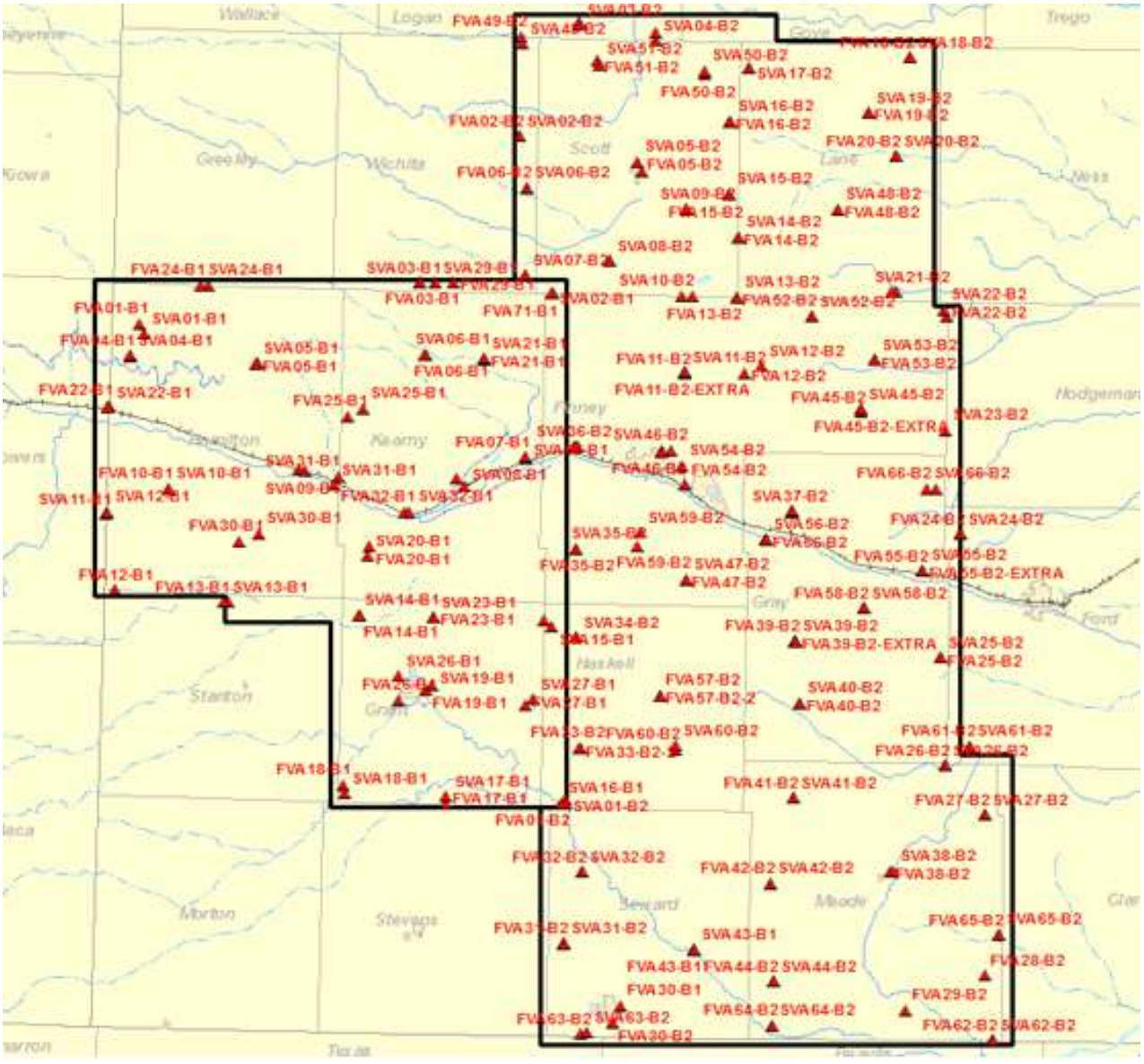
ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the dataset. National Standards for Spatial Data Accuracy (NSSDA) guidance states that checkpoints may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. Checkpoints should be distributed so that points are spaced at intervals of at least ten percent of the diagonal distance across the dataset and at least twenty percent of the points are located in each quadrant of the dataset.

NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be selected near severe breaks in slope, such as bridge abutments, edges of roads, or near river bluffs. Checkpoints are an important component of the USGS QA process. There is the presumption that the checkpoint surveys are error free and the discrepancies are attributable to the LiDAR dataset supplied.

For this dataset, USGS checked the spatial distribution of checkpoints with an emphasis on the bare-earth (open terrain) points; the number of points per class; the methodology used to collect these points; and the relationship between the data supplier and checkpoint collector. When independent control data are available, USGS has incorporated this into the analysis.

Checkpoint Shapefile or Geodatabase:

☑ Checkpoint Distribution Image?



The following land cover classes are represented in this dataset (uncheck any that do not apply):

- [x] Bare Earth
- [x] Tall Weeds and Crops
- [ ] Brush Lands and Low Trees
- [ ] Forested Areas Fully Covered by Trees
- [ ] Urban Areas with Dense Man-Made Structures

There are a minimum of 20 checkpoints for each land cover class represented. Points within each class are uniformly distributed throughout the dataset. USGS was able to locate independent checkpoints for this analysis. USGS accepts the quality of the

checkpoint data for these LiDAR datasets.

See comments below. ◉ Yes ○ No

☑ Image?

Table 4: Accuracy Statistics by Block

Block	Ave. Dz	Min. Dz	Max. Dz	Ave. Magnitude	Std. Deviation	RMSE
1	0.032	-0.058	0.177	0.05	0.062	**0.068**
2	0.021	-0.229	0.292	0.081	0.11	**0.11**
3	0.072	-0.165	0.171	0.099	0.088	**0.112**
4	0.006	-0.084	0.144	0.038	0.049	**0.049**
5	-0.041	-0.179	0.049	0.053	0.056	**0.068**
6	-0.002	-0.234	0.168	0.094	0.119	**0.117**
7	-0.007	-0.268	0.168	0.077	0.101	**0.098**
8	0.023	-0.134	0.266	0.083	0.103	**0.103**
9	-0.061	-0.175	0.181	0.098	0.097	**0.112**
10	0.001	-0.156	0.153	0.094	0.11	**0.105**

Per pages 5 & 6 of the Kansas Ground Control Survey Report: Two hundred (200) LiDAR Check Points control points were established throughout project area to serve as LiDAR data Quality Control and adjustments. There are 2 classes of check points surveyed throughout the project area: FVA (main bare earth or low vegetation class) and SVA (supplemental or higher vegetation class). According to the spreadsheets in the block documents both FVA and SVA points were used to calculate the above RMSE.

The RMSE reported in all the metadata for Block 9 is reported as 0.128m, which differs from the vertical accuracy reported in the Survey Report. Block 10 metadata (all) is reported as 0.120m, which differs from the vertical accuracy reported in the Survey Report. **Corrected issue 8/6/2013**

No checkpoints shapefile was provided for NGTOC to perform vertical accuracy calculations of the data. Shapefile was created at NGTOC.

FVA not reported for swath data (**Corrected issue, but problem opening document**). Three points (FVA07-B1, 27-B1, 32-B1) had to be removed due to their location in areas of tree cover (see images in next section below). The FVA with all the points included yielded a result of 123 cm. These three points were evaluated against the dataset and excluded from the calculations yielding a final FVA of the swath data of 23.0 cm.

SVA and CVA not reported. Report final numbers as ACCz or RMSEz for FVA and as 95th percentile for SVA and CVA.

**No corrections given for reporting vertical accuracy as requested and according to the specs. Could not list the reported values below for SVA and CVA.

Accuracy values are reported in terms of Fundamental Vertical Accuracy (FVA), Supplemental Vertical Accuracy(s) (SVA), and Consolidated Vertical Accuracy (CVA).

Accuracy values are reported in: centimeters

Required FVA Value is 24.5 centimeters or less.
Target SVA Value is 36.3 centimeters or less.
Required CVA Value is 36.3 centimeters or less.

The reported FVA of the LAS Swath data is 24.4 centimeters.

The reported FVA of the Bare-Earth DEM data is 22.5 centimeters.

SVA are required for each land cover type present in the data set with the exception of bare-earth. SVA is calculated and reported as a 95th Percentile Error.

Land Cover Type	SVA Value	Units
Tall Weeds and Crops	**Not Reported**	centimeters
Brush Lands and Low Trees		centimeters
Forested Areas Fully Covered by Trees		centimeters

Urban Areas with Dense Man-Made Structu...		centimeters

The reported CVA of this data set is: **Not Reported** centimeters.

LAS Swath File Review

LAS swath files or raw unclassified LiDAR data are reviewed to assess the quality control used by the data supplier during collection. Furthermore, LAS swath data are checked for positional accuracy. The data supplier should have calculated the Fundamental Vertical Accuracy using ground control checkpoints measured in clear open terrain. The following was determined for LAS swath data for this project:

LAS Version

(•) LAS 1.2 ( ) LAS1.3 ( ) LAS 1.4

Swath File Characteristics

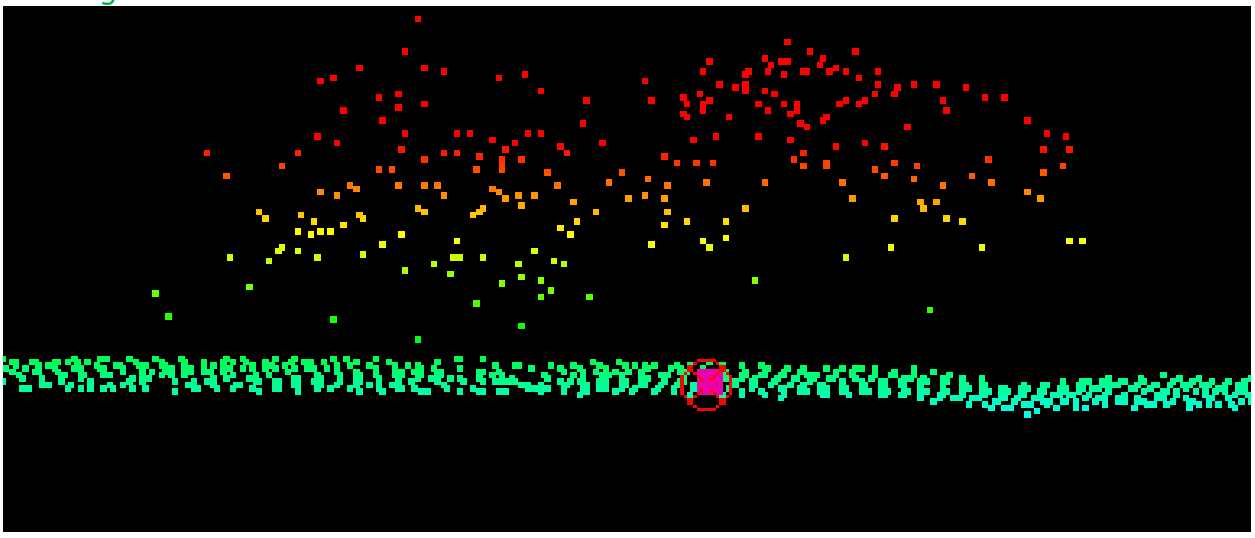
- [x] Separate folder for LAS swath files
- [x] Each swath files <= 2GB
- [ ] *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is 24.4 centimeters.

Based on this review, the USGS accepts the LAS swath file data.

Swath files divided by block # (•) Yes ( ) No

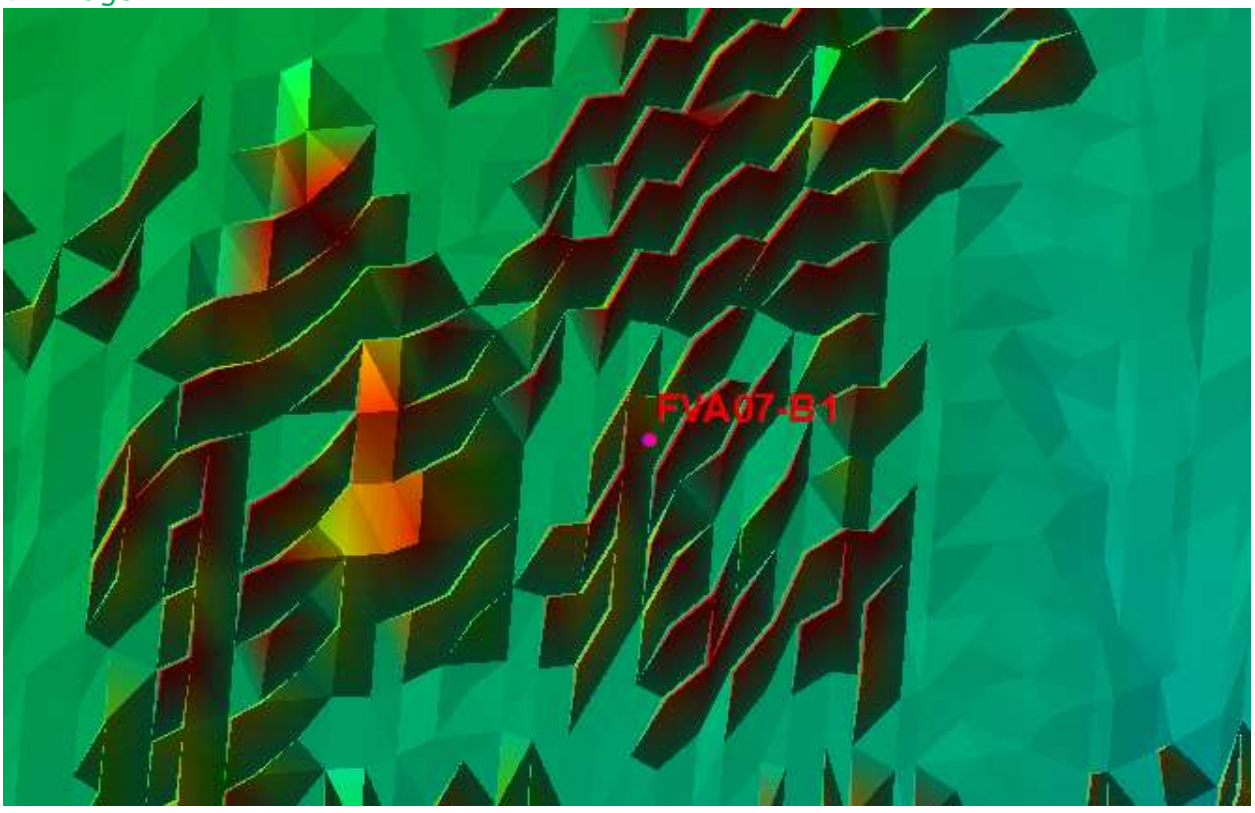
[x] Image?



3D profile of survey point FVA07-B1 (in magenta above). The point is located in the

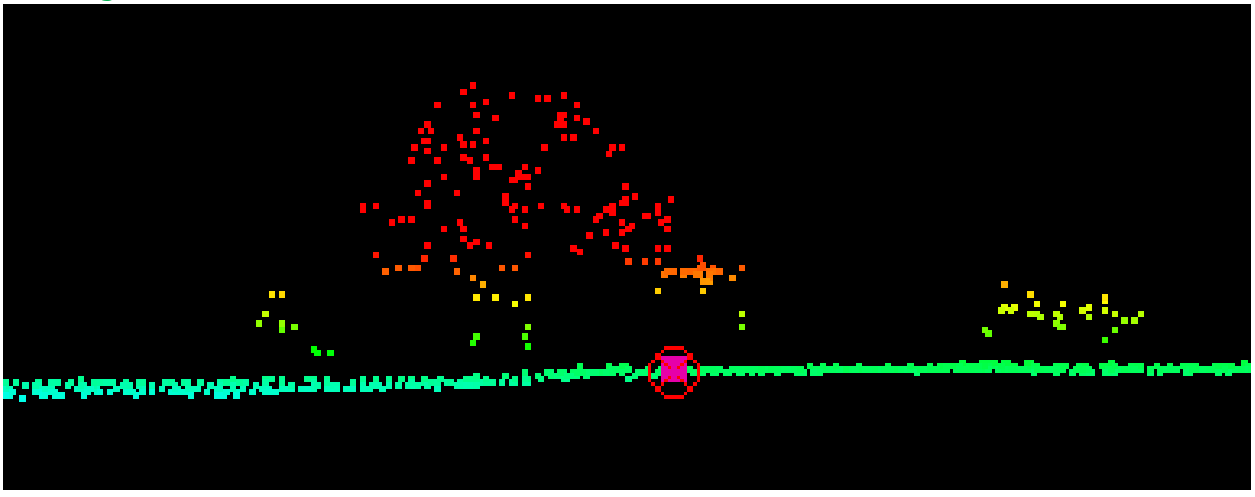
town of Deerfield in an area with tree cover. The point has a z-error of -5.949 meters which indicates that the survey ground elevation is 5.949 meters less than the swath LAS TIN surface elevation.

Image?



FVA07-B1 survey point on the TIN surface.

Image?



3D profile of survey point FVA32-B1. The survey point had to be removed due to its location in an area of tree cover. The point has a z-error of -0.701 meters.

☑ Image?

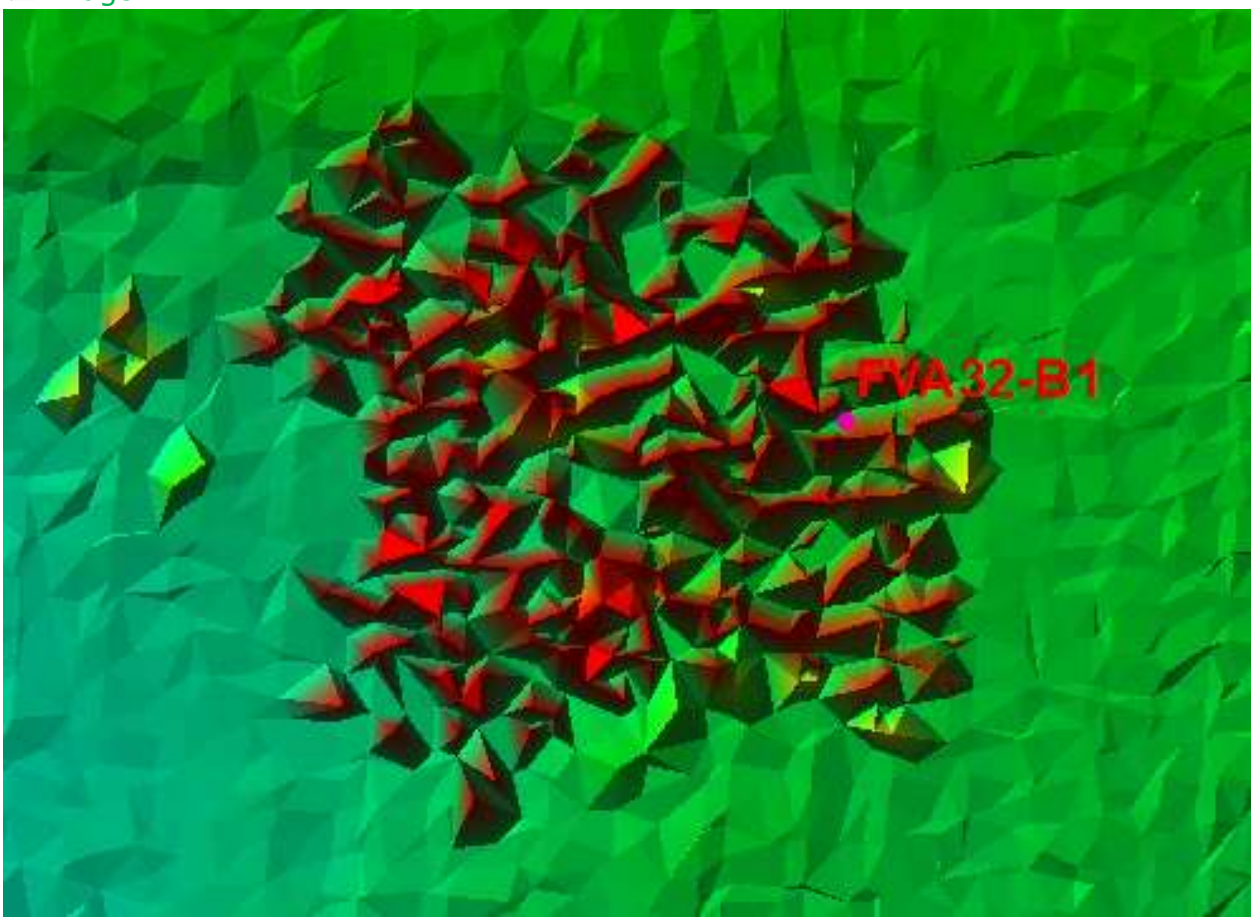
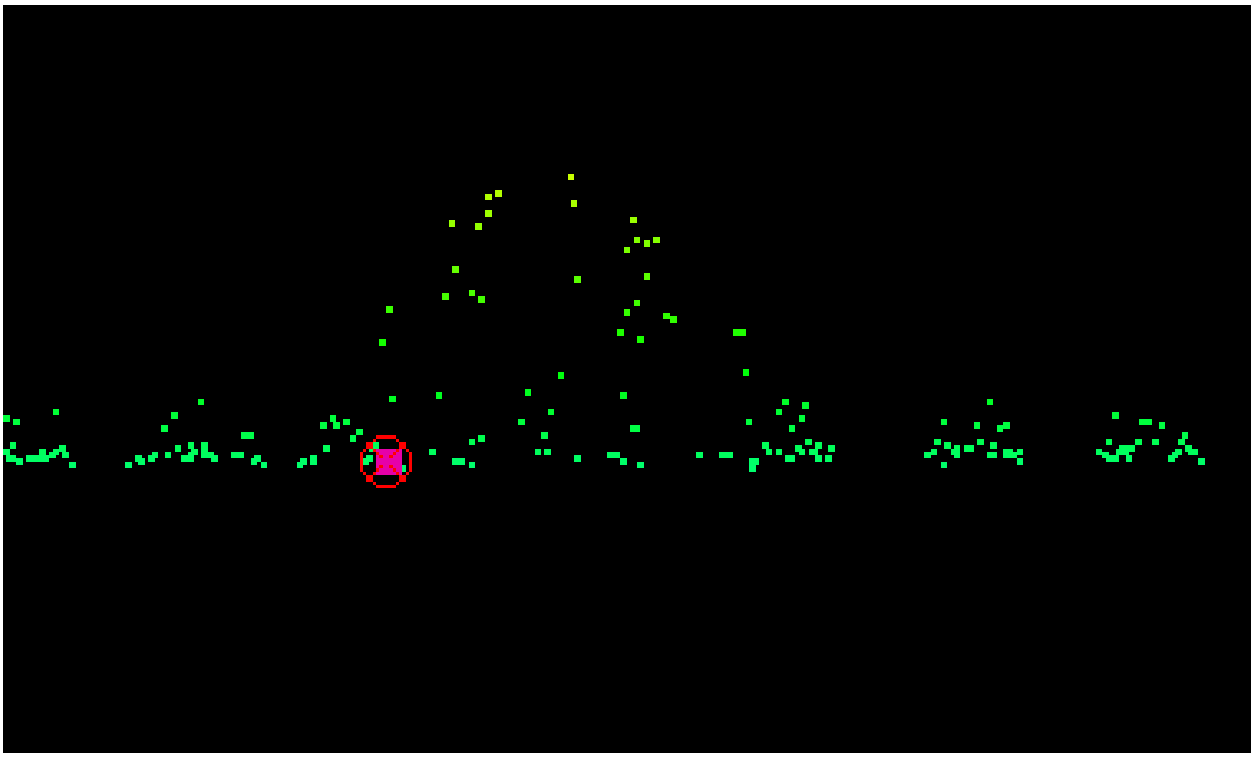


Image showing the TIN of the swath LAS points and the location of the removed point FVA32-B1.

☑ Image?



3D profile of survey point FVA27-B1. The survey point had to be removed due to its location in an area of tree cover. The survey point has a z-error of -0.542 meters.

☑ Image?

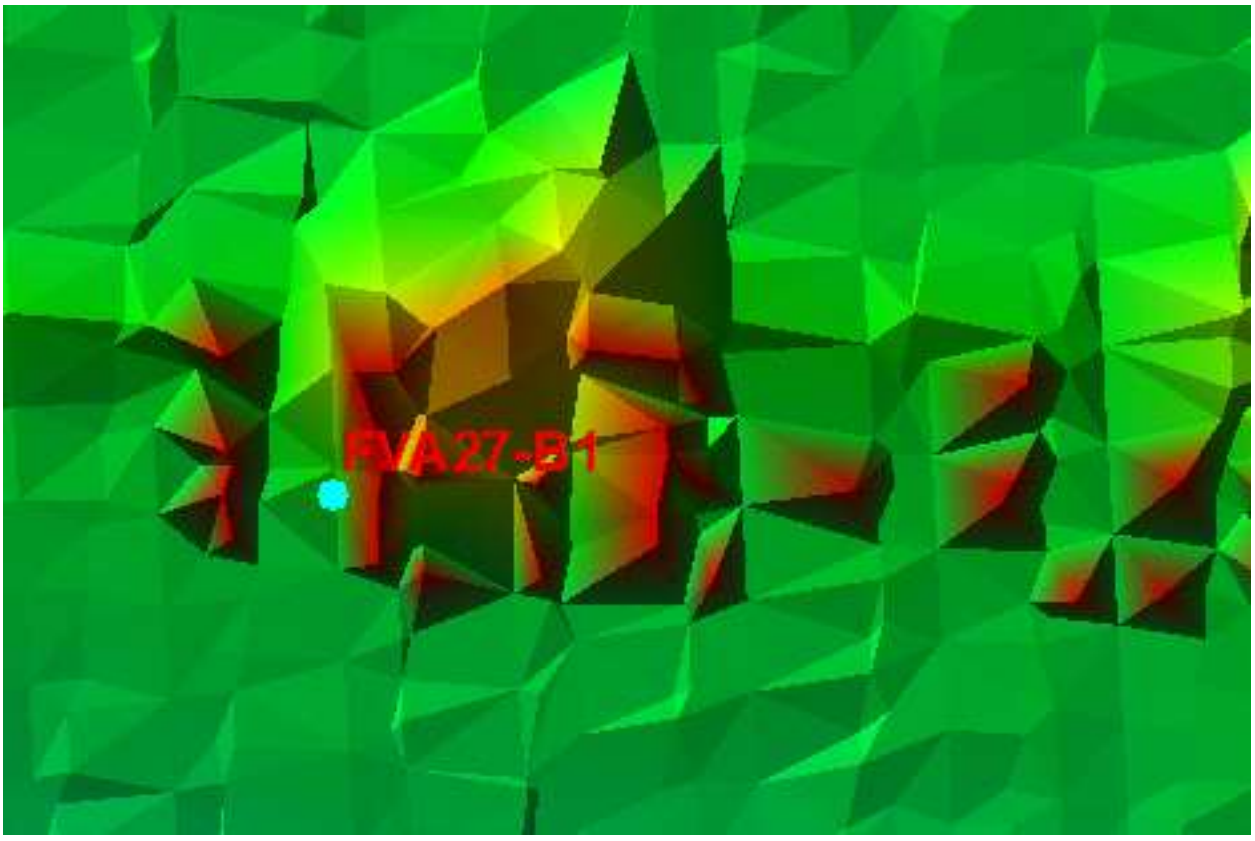


Image showing the TIN of the swath LAS points and the location of the removed point FVA27-B1.

LAS Tile File Review

Classified LAS tile files are used to build digital terrain models using the points classified as ground. Therefore, it is important that the classified LAS are of sufficient quality to ensure that the derivative product accurately represents the landscape that was measured. The following was determined for classified LAS files for this project:

Classified LAS Tile File Characteristics

- ☑ Separate folder for Classified LAS tile files
- ☑ Classified LAS tile files conform to Project Tiling Scheme
- ☑ Quantity of Classified LAS tile files conforms to Project Tiling Scheme
- ☑ Classified LAS tile files do not overlap

☑ Classified LAS tile files are uniform in size
☑ Classified LAS tile files have no points classified as '12'

☐ Point classifications are limited to the standard values listed below:

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high, manually identified, if needed)
9	Water
10	Ignored ground (breakline proximity)
11	Withheld (if the "Withheld" bit is not implemented in processing software)

☐ Buy up?

Based on this review, the USGS accepts the classified LAS tile file data.

Errors, Anomalies, Other Issues to document? ○ Yes ○ No

☐ Image?

Standard point classes in use (Classes 1, 2, 7, 9, 10)
Other point classes in use:
Class 17 - Overlap (unclassified)
Class 18 - Overlap (bare earth)
Class 23 - Overlap (noise)
Class 24 - Overlap (water)

Breakline File Review

Breaklines are vector feature classes that are used to hydro-flatten the bare earth Digital Elevation Models.

Breakline File Characteristics

- [x] Separate folder for breakline files
- [x] All breaklines captured as PolylineZ or PolygonZ features
- [x] No missing or misplaced breaklines

Based on this review, the USGS accepts the breakline files.

Errors, Anomalies, Other Issues to document? ○ Yes ○ No

☐ Image for error?

Bare-Earth DEM Tile File Review

The derived bare-earth DEM file receives a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by USGS using supplied and independent checkpoints, and a manual check of the appearance of the DEM layer.

Bare-Earth DEM files provided in the following format: Erdas Imagine *.img

Bare-Earth DEM Tile File Characteristics

- [x] Separate folder for bare-earth DEM files
- [x] DEM files conform to Project Tiling Scheme
- [x] Quantity of DEM files conforms to Project Tiling Scheme
- [x] DEM files do not overlap
- [x] DEM files are uniform in size
- [x] DEM files properly edge match
- [x] Independent check points are well distributed

All accuracy values reported in centimeters.

Reported Accuracies

	# of	Fundamental Vertical Accuracy @95% Confidence	Supplemental Vertical Accuracy @95th Percentile	Consolidated Vertical Accuracy @95th Percentile

Land Cover Category	Points	Interval ($Accuracy_z$) Required FVA = 24.5 or less.	Error Target SVA = 36.3 or less.	Error Required CVA = 36.3 or less.
Open Terrain		22.5		
Tall Weeds and Crops			**Not Reported**	
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated	0			**Not Reported**

☑ QA performed Accuracy Calculations?

Calculated Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 24.5 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 36.3 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 36.3 or less.
Open Terrain	95	21.9		
Tall Weeds and Crops	91		18.2	
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated	186			19.5

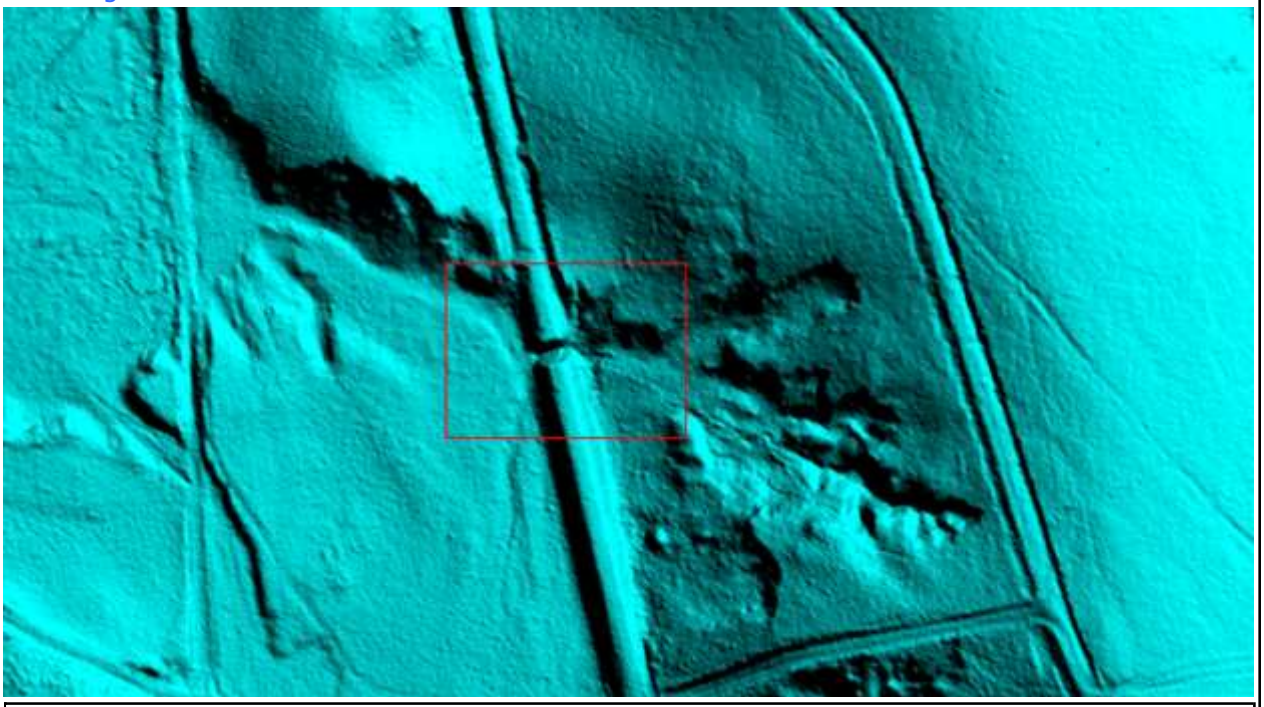
Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

Based on this review, the USGS accepts the bare-earth DEM files.

Bare-Earth DEM Anomalies, Errors, Other Issues

Errors, Anomalies, Other Issues to document? (•) Yes ( ) No

☑ Image?

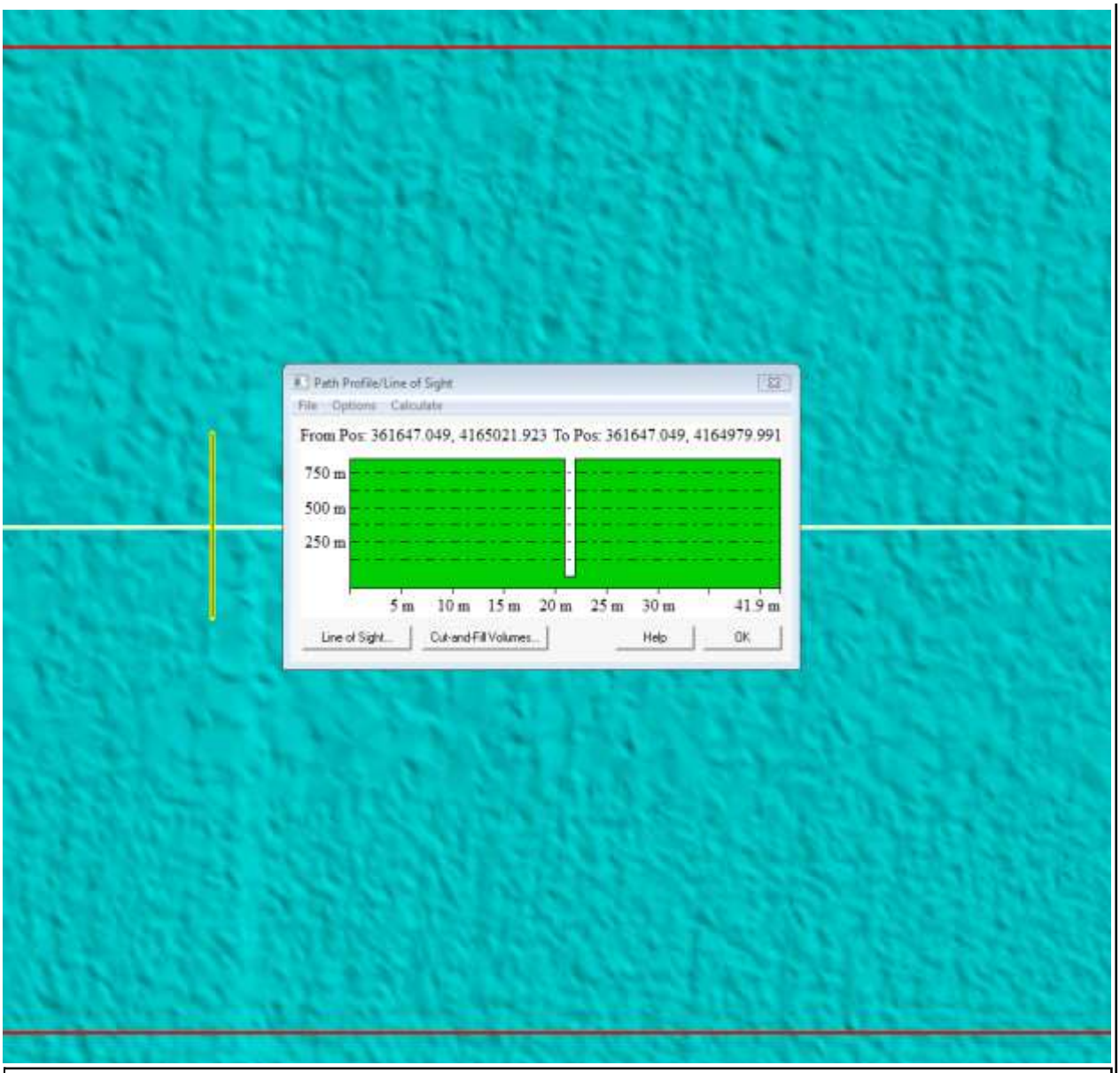


19 errors in which culverts have been removed. This is a representative image.

**8/2/13 Four of the culverts were corrected by the contractor. The remaining 15 errors, the culvert was completely removed. Culverts are to remain in the data per the V13 specifications.

**12/18/2013 Contractor corrected all culvert errors. Culverts were put back into DEMs.

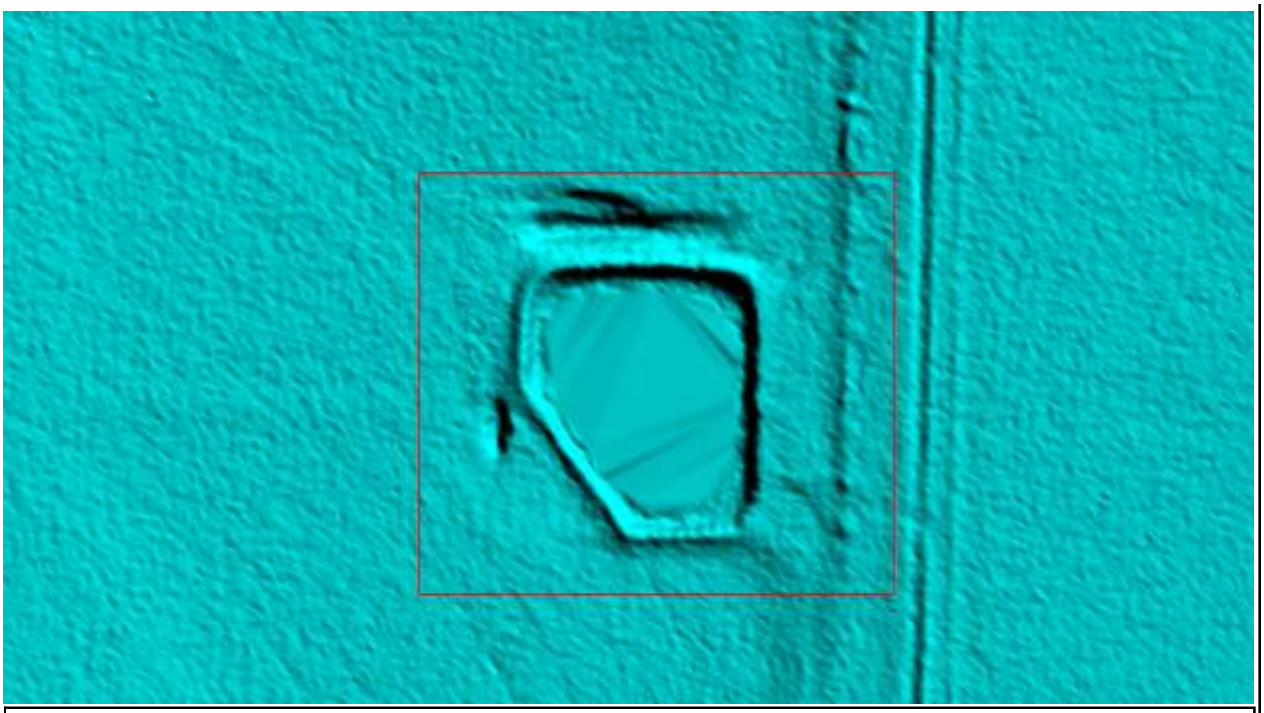
☑ Image?



There are two Data gap errors in Block 8 that follows tile boundaries. Locations at 37° 37' 18.9419" N, 100° 33' 24.8270" W and 37° 48' 8.9936" N, 100° 31' 1.5398" W

**8/2/13 The two data gaps were corrected by the contractor.

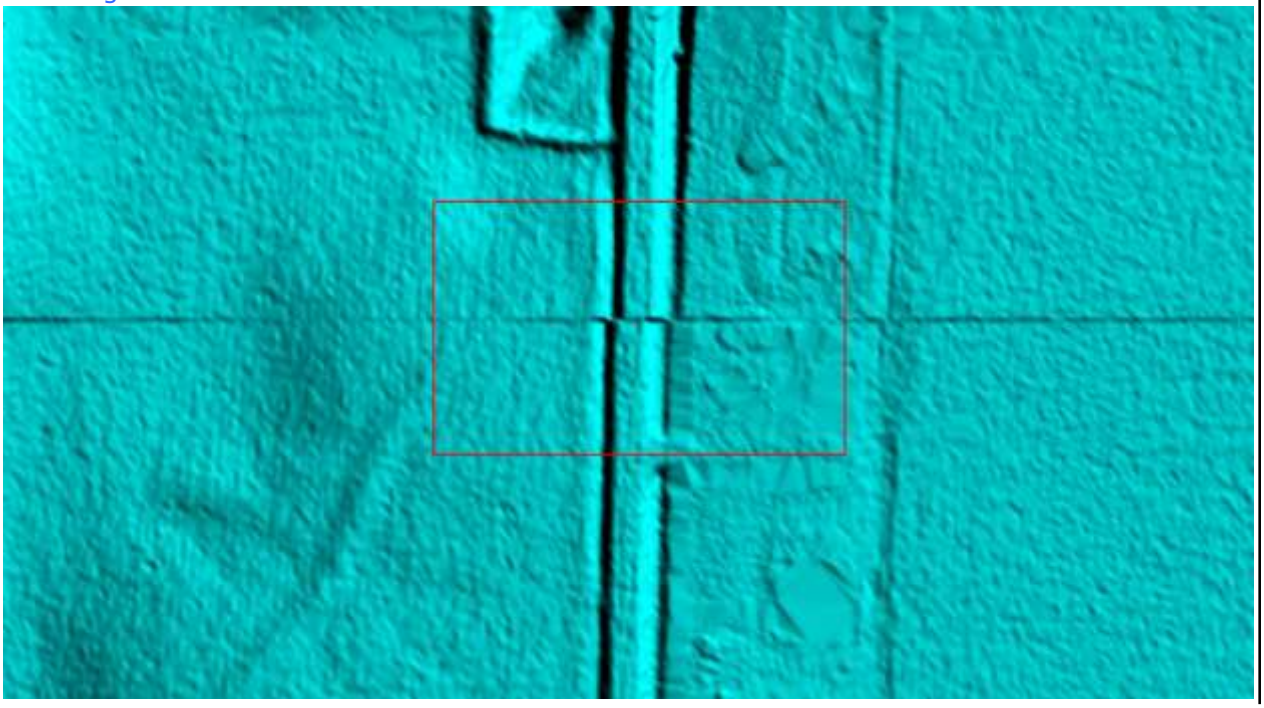
☑ Image?



4 errors in which water body is greater than 3/4 of an acre and needs to be hydroflattened. This is a representative image.

** 8/2/13 The four hydroflattening errors were corrected by the contractor.

☑ Image?



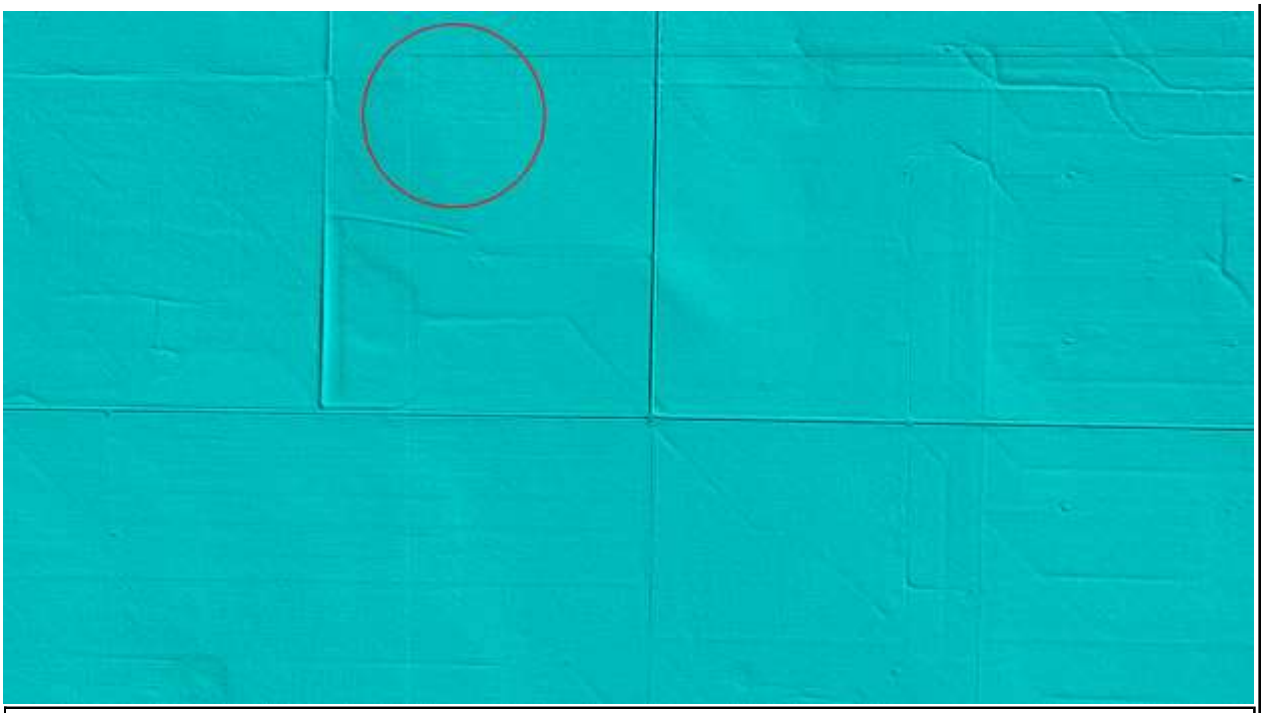
Several places along tile boundaries have a slight shift in the data where they are joined. A check of the tile boundaries is needed to correct shifts in data.

**Corrected by contractor

☑ Image?

ArcMap also shows the same shift in the cells.

☑ Image?



Several anomaly errors along block boundaries. This error is at location 38° 11' 59.6949" N, 101° 03' 20.3119" W and is lower in elevation all along Block 6 boundary. This is a representative image.

**Corrected by contractor

This is the end of the report.