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:
7/11/2012

Project ID:
AL_Colbert-Lauderdale_2011

Project Alias(es):
None

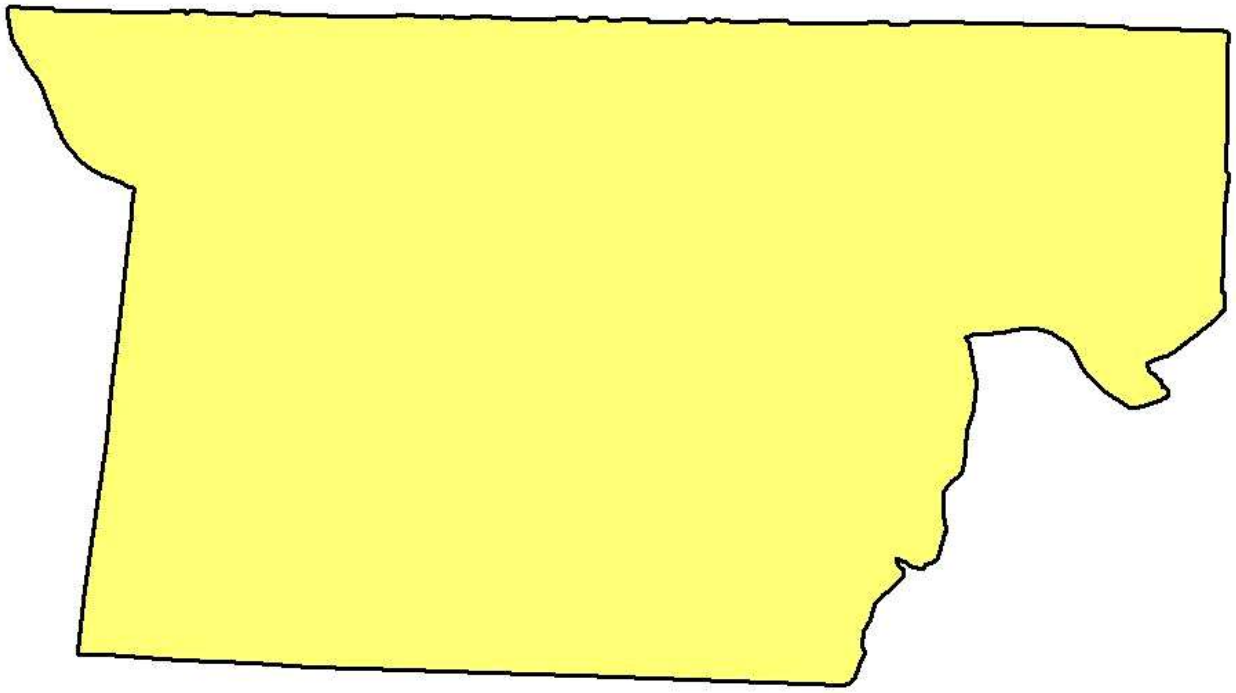
Project Type: Donated Data

Project Description:
The Atlantic Group will provide LiDAR topographic products to support AMEC for a variety of purposes including hydrologic analysis, hydraulic analysis, floodplain boundary delineation and/or test of floodplain boundary standard compliance. The project entails the acquisition of LiDAR for approximately 1306 square miles encompassing the full extents of Colbert and Lauderdale Counties.

Year of Collection: 2011

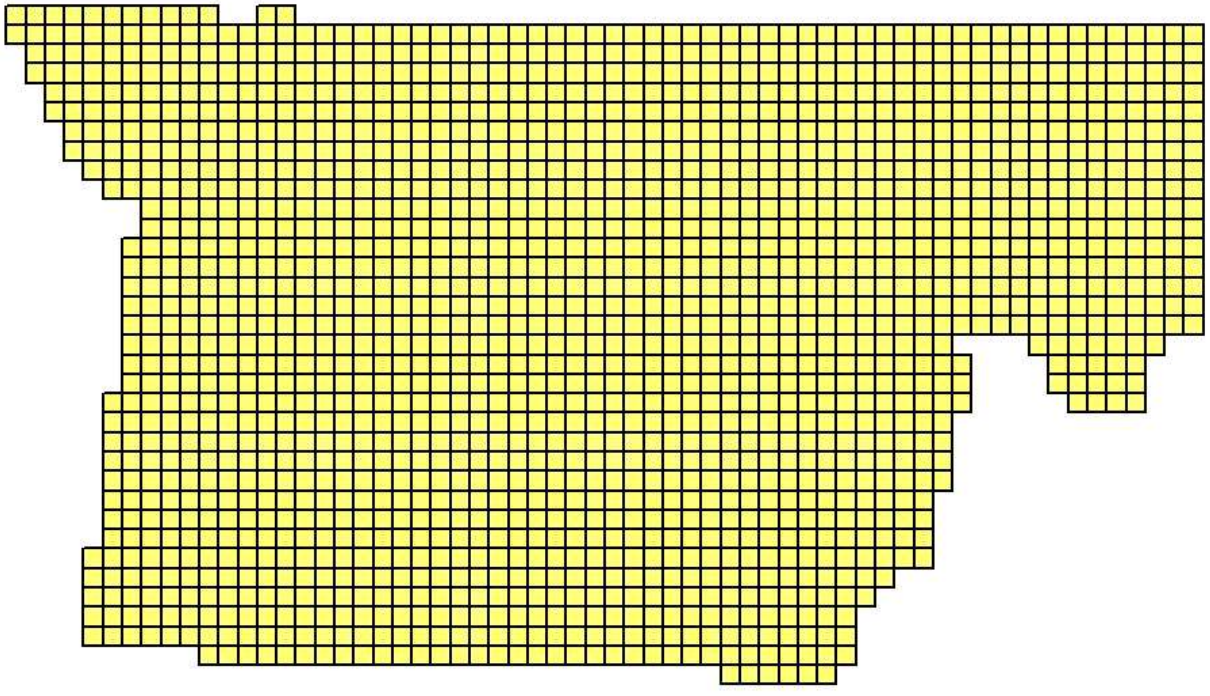
Lot 1 of 1 lots.

Project Extent:
☑ Project Extent image?



Project Tiling Scheme:

☑ Project Tiling Scheme image?



Contractor:

Applicable Specification:

The Atlantic Group	V13, FEMA Appendix A, FEMA PM 61

Licensing Restrictions:

None

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
George Heleine	NSDI Liaison	601-933-2950	gheleine@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
- [x] QA/QC Report
- [ ] Control and Calibration Points
- [x] Project Shapefile/Geodatabase
- [x] Project Tiling Scheme Shapefile/Gdb
- [x] Control Point Shapefile/Gdb
- [x] Breakline Shapefile/Gdb
- [ ] Project XML Metadata

Multi-File Deliverables

File Type	Quantity
[x] Swath LAS Files [x] Required? [ ] XML Metadata?	173
[ ] Intensity Image Files [ ] Required?	
[x] Tiled LAS Files [x] Required? [x] XML Metadata?	1689
[x] Breakline Files [x] Required? [x] XML Metadata?	1
[x] Bare-Earth DEM Files [x] Required? [x] XML Metadata?	1689

Additional Deliverables

	Item
[x]	Low Confidence Polygons, shapefile format; 1.
[x]	Terrain.mdb; 1.

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

Classified LAS tile 4185_38310.las has a large data void throughout the center portion of the tile. The void is evident in the derived DEM delivered in float format to the reviewer at NGTOC. On July 17, 2012 reviewer requested that the classified LAS and DEM tile be redelivered. Corrections delivered to NGTOC 8/20/13, accepted 8/26/13.

Checkpoint shapefile delivered to NGTOC 8/20/13.

Swath las files delivered to NGTOC 8/20/13.

Project Geographic Information

Areal Extent:

1378.13

Sq Mi

Grid Size:

1

meters

Tile Size:

1500

meters

Nominal Pulse Spacing:

0.9

meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: UTM Zone 16N meters.

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

- [x] Project Shapefile/Geodatabase
- [x] Project Tiling Scheme Shapefile/Gdb
- [x] 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
- [x] Classified LAS Files
- [x] Breaklines Files
- [x] Bare-Earth DEM Files

Project XML Metadata CRS

Not delivered

Swath LAS XML Metadata CRS

Datums defined, not projected

Classified LAS XML Metadata CRS

Datums defined, not projected

Breakline XML Metadata CRS

Datums defined, not projected

DEM XML Metadata CRS

Datums defined, not projected

Swath LAS Files CRS

WGS 84/ UTM Zone 16N

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.

Reviewer:
H. Boggs

Review Start Date:
7/16/2012

Action to Contractor Date	Issue Description	Return Date
7/17/2012	Requested missing deliverables from ADECA. ADECA graciously agreed to review QA and possibly deliver missing data, though not contractually obligated.	8/20/2013

Review Complete: 8/27/2013

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 witherrors.

No project XMl metadata file delivered to reviewer at NGTOC.

The Classified LAS XML Metadata file parsed witherrors.

```
Executing: mp "J:\Colbert &
Lauderdale\Northwest_Alabama\METADATA\NW_Alabama_LiDAR.xml" # # #
Start Time: Tue Jul 17 14:18:31 2012
Running script mp...
"C:\ArcGIS\bin\mp.exe" NW_Alabama_LiDAR.xml   2>&1
mp NW_Alabama_LiDAR.xml
: mp 2.9.6 - Peter N. Schweitzer (U.S. Geological Survey)
: Info: input file = NW_Alabama_LiDAR.xml
: Error (line 211): Time_of_Day is not permitted in Process_Step
: 1 errors: 1 misplaced
Completed script mp...
Executed (mp) successfully.
End Time: Tue Jul 17 14:18:32 2012 (Elapsed Time: 1.00 seconds)
```

The Breakline XML Metadata file parsed with errors.

```
Executing: mp "J:\Colbert &
Lauderdale\Northwest_Alabama\METADATA\NW_Alabama_Breaklines.xml" # # #
Start Time: Tue Jul 17 14:20:26 2012
Running script mp...
"C:\ArcGIS\bin\mp.exe" NW_Alabama_Breaklines.xml   2>&1
mp NW_Alabama_Breaklines.xml
: mp 2.9.6 - Peter N. Schweitzer (U.S. Geological Survey)
: Info: input file = NW_Alabama_Breaklines.xml
: Error (line 7): City is not permitted in Metadata
: Error (line 7): Country is not permitted in Metadata
: Error (line 7): City is not permitted in Metadata
: Error (line 7): Country is not permitted in Metadata
: Error (line 7): City is not permitted in Metadata
: Error (line 7): Country is not permitted in Metadata
: Error (line 7): City is not permitted in Metadata
: Error (line 7): Country is not permitted in Metadata
: Error (line 7): City is not permitted in Metadata
: Error (line 7): Country is not permitted in Metadata
: Error (line 7): City is not permitted in Metadata
: Error (line 7): Country is not permitted in Metadata
: Error (line 2): Theme_Keyword_Thesaurus is required in Theme
: Error (line 7): Time_of_Day is not permitted in Process_Step
: Error (line 7): Attribute_Domain_Values is required in Attribute
: Error (line 7): Attribute_Definition_Source is required in Attribute
: Error (line 7): Attribute_Domain_Values is required in Attribute
: Error (line 7): Attribute_Definition_Source is required in Attribute
: Error (line 7): Attribute_Domain_Values is required in Attribute
: Error (line 7): Attribute_Definition_Source is required in Attribute
: Error (line 7): Attribute_Domain_Values is required in Attribute
: Error (line 7): Attribute_Definition_Source is required in Attribute
: Error (line 7): Enumerated_Domain_Value_Definition_Source is required in
Enumerated_Domain
: Error (line 7): Enumerated_Domain_Value_Definition_Source is required in
Enumerated_Domain
: 24 errors: 13 misplaced, 11 missing
Completed script mp...
Executed (mp) successfully.
End Time: Tue Jul 17 14:20:26 2012 (Elapsed Time: 0.00 seconds)
```

The Bare-Earth DEM XML Metadata file parsed with errors.

```
Executing: mp "J:\Colbert &
Lauderdale\Northwest_Alabama\METADATA\NW_Alabama_DEMS.xml" # # #
Start Time: Tue Jul 17 14:27:35 2012
Running script mp...
"C:\ArcGIS\bin\mp.exe" NW_Alabama_DEMS.xml   2>&1
mp NW_Alabama_DEMS.xml
: mp 2.9.6 - Peter N. Schweitzer (U.S. Geological Survey)
: Info: input file = NW_Alabama_DEMS.xml
: Error (line 70): City is not permitted in Metadata
```

```
  : Error (line 70): Country is not permitted in Metadata
  : Error (line 70): City is not permitted in Metadata
  : Error (line 70): Country is not permitted in Metadata
  : Error (line 70): City is not permitted in Metadata
  : Error (line 70): Country is not permitted in Metadata
  : Error (line 70): City is not permitted in Metadata
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  : Error (line 70): City is not permitted in Metadata
  : Error (line 70): Country is not permitted in Metadata
  : Error (line 70): City is not permitted in Metadata
  : Error (line 70): Country is not permitted in Metadata
  : Error (line 70): Time_of_Day is not permitted in Process_Step
  : Error (line 70): Attribute_Domain_Values is required in Attribute
  : 14 errors: 13 misplaced, 1 missing
 Completed script mp...
 Executed (mp) successfully.
End Time: Tue Jul 17 14:27:35 2012 (Elapsed Time: 0.00 seconds)
```

This is the best use metadata for this project. Reviewer at NGTOC renamed the file BESTUSE.xml and copied the file to the Metadata-Documents folder.

Project QA/QC Report Review

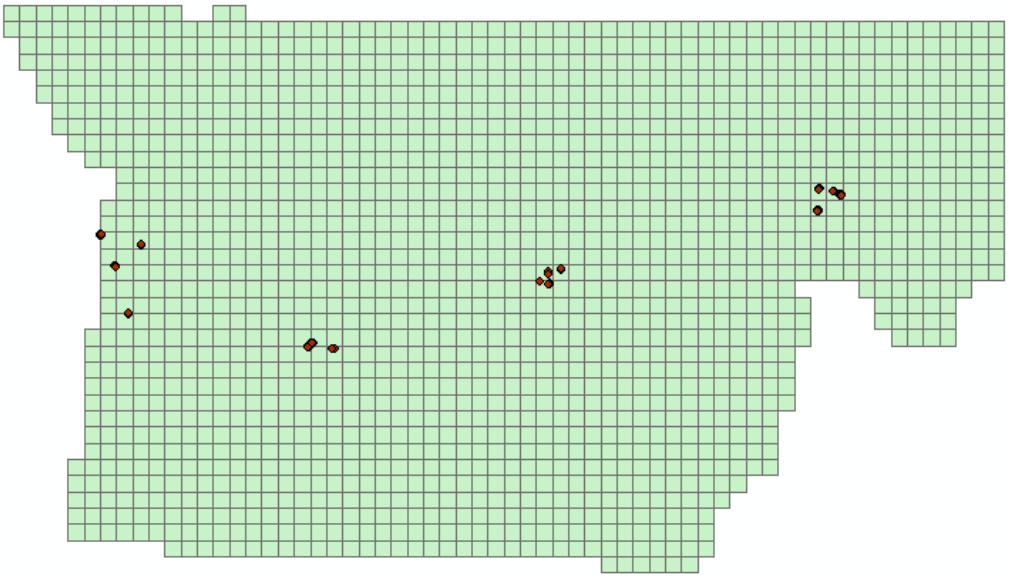
ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the 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
- [x] Brush Lands and Low Trees
- [ ] Forested Areas Fully Covered by Trees
- [x] 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 wasable to locate independent checkpoints for this analysis. USGS acceptsthe quality of the checkpoint data for these LiDAR datasets.

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

- [ ] Image?

Reviewer was unable to locate independent checkpoints. Reviewer contacted ADECA on 07/17/12 and requested that the checkpoints used to determine vertical accuracy be resent to the reviewer in shapefile format. Checkpoints delivered to NGTOC 8/20/13 in shapefile format.

☐ Image?

Report lists RMSE as one value then reports the FVA as the same value. These values should not be identical as the RMSE needs to be multiplied by 1.96 in order to be equal to the FVA.

☐ Image?

DEM xml metadata reports FVA as 4.5cm, as does LAS xml metadata. It is unlikely that both datasets would have the exact same FVA value. Reviewer is unsure which dataset was tested for vertical accuracy and reported by the vendor.

☐ Image?

Neither report nor xml metadata files report SVA or CVA values. Please see DEM review below for reviewer's detailed accuracy findings.

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 36.3 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 **4.5** centimeters.

The reported FVA of the Bare-Earth DEM data is **4.5** 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	**N/A**	centimeters
Brush Lands and Low Trees	**N/A**	centimeters
Forested Areas Fully Covered by Trees		N/A
Urban Areas with Dense Man-Made Structu...	**N/A**	centimeters

The reported CVA of this data set is: **N/A** 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 4.5 centimeters.

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

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

☐ Image?

Swath las file 01140.las delivered 8/20/13, does not contain any points. This is acceptable as no additional corrections are possible.

☐ Image?

File source ID field not populated in swath las files delivered to NGTOC 8/20/13. This is acceptable as no additional corrections are possible.

☐ Image?

The point source ID field for each point within each LAS swath file was not set equal to the File Source ID prior to any processing of the data. This is acceptable as no additional corrections are possible.

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:

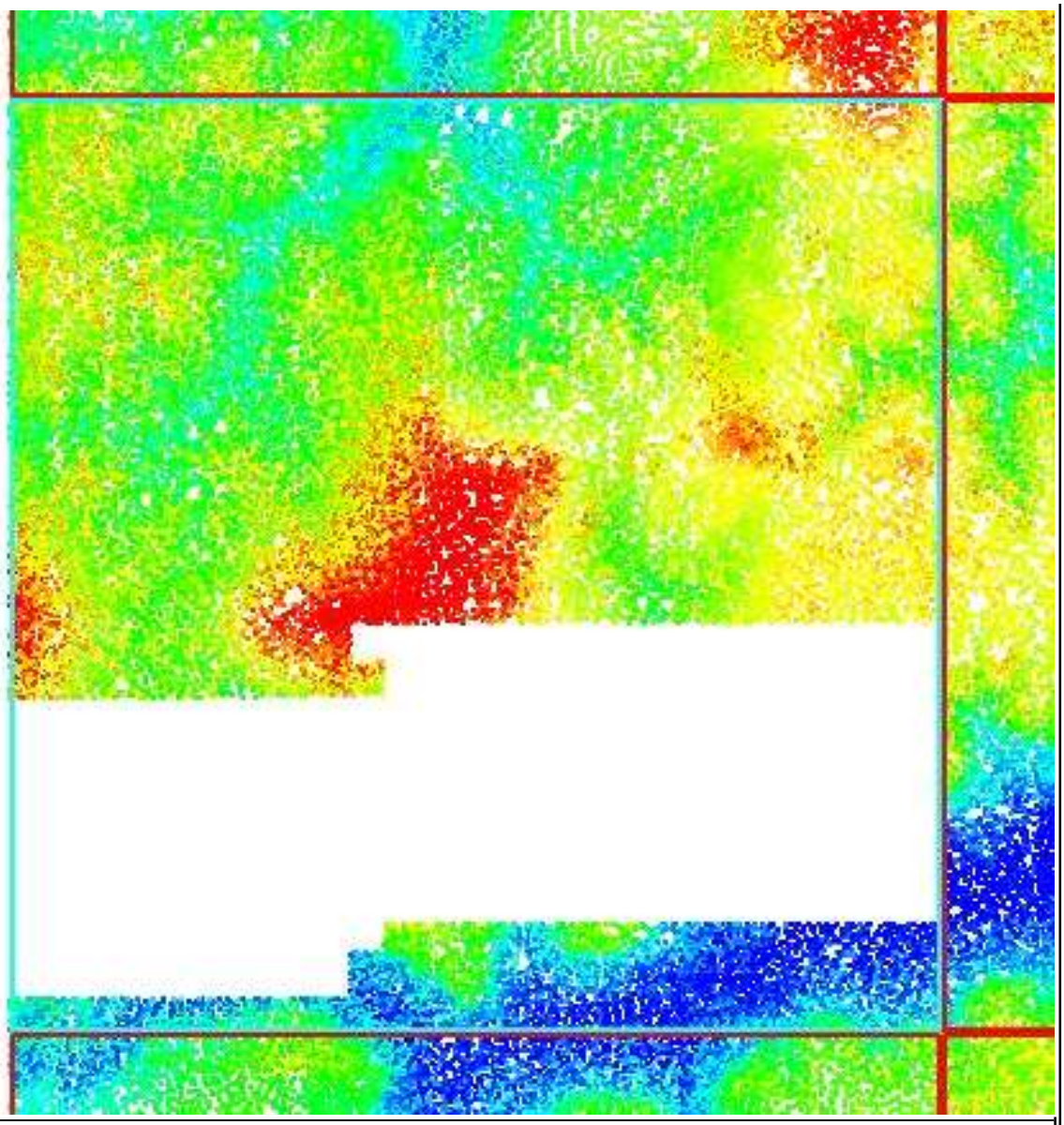
Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high, manually identified, if needed)
9	Water
10	Ignored ground (breakline proximity)
11	Withheld (if the "Withheld" bit is not implemented in processing software)

☐ Buy up?

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

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

☑ Image?



Large void in las file 4185_38310.las. Reviewer contacted ADECA on 07/17/12 and requested that the file be re-sent to the reviewer at NGTOC. Corrected las tile delivered to NGTOC on 8/20/13, accepted 8/26/13.

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

None.

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: TIF

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
- [ ] Independent check points are well distributed

All accuracy values reported in centimeters.

Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 36.3 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	20	**4.5**		
Tall Weeds and Crops			**N/A**	

Brush Lands and Low Trees			N/A	
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures			N/A	
Consolidated	20			N/A

☑ QA performed Accuracy Calculations?

Calculated Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 36.3 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	442	11.41		
Tall Weeds and Crops	104		21.69	
Brush Lands and Low Trees	24		15.28	
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures	526		10.27	
Consolidated	1,096			13.22

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

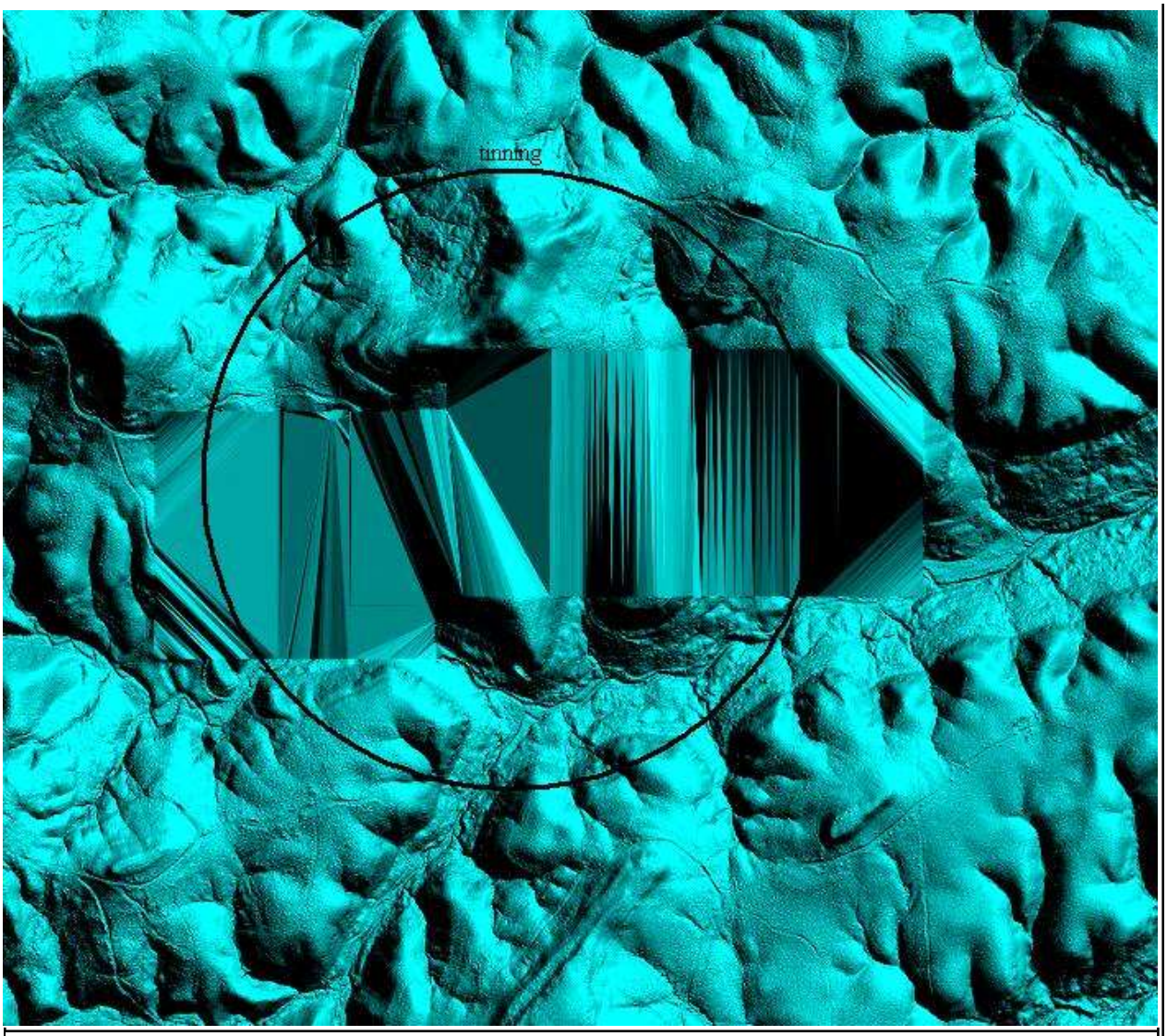
☐ Image?

Checkpoints are not well distributed, rather they are clustered.

☐ Image?

There were not an equal number of checkpoints per land cover class, therefore some land cover classes may be over or under represented in the accuracy testing and reporting section located above.

☑ Image?



Area of extreme tinning in DEM tile 4185_38310.tif. Corresponds to las tile with data voids noted above in classified las section. Reviewer at NGTOC created a shapefile documenting the location of this error. The file is named errors.shp. Corrected DEM tile delivered to NGTOC on 8/20/13, accepted 8/26/13.

Internal Note:

This is the end of the report.

QA Form V1.4 12OCT11.xsn