



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:

9/11/2012

Project Type: GPSC

Project ID:

AK_BrooksCamp_2012

Project Description:

The National Park Service (NPS) is requesting ortho imagery and elevation data to support ongoing research of various archeological sites located within Katmai National Park and Preserve along the Brooks River near Brooks Camp, AK. The overall purpose of this task order is to provide elevation data of suitable accuracy from which 1-foot contours can be generated. The Brooks Camp, AK Ortho/Lidar Task Order consists of two parts: (1) aerial imagery acquisition and subsequent digital orthophoto production, and (2) the planning, acquisition, processing, and creating derivative products of lidar data to be collected at a nominal pulse spacing (NPS) of 0.7 meters. The task order applies to a project area of approximately 10 square miles. Both the USGS and NPS will be performing a validation on the deliverables within a sixty (60) day timeframe.

Project Alias(es):

Brooks Camp, AK Ortho/Lidar

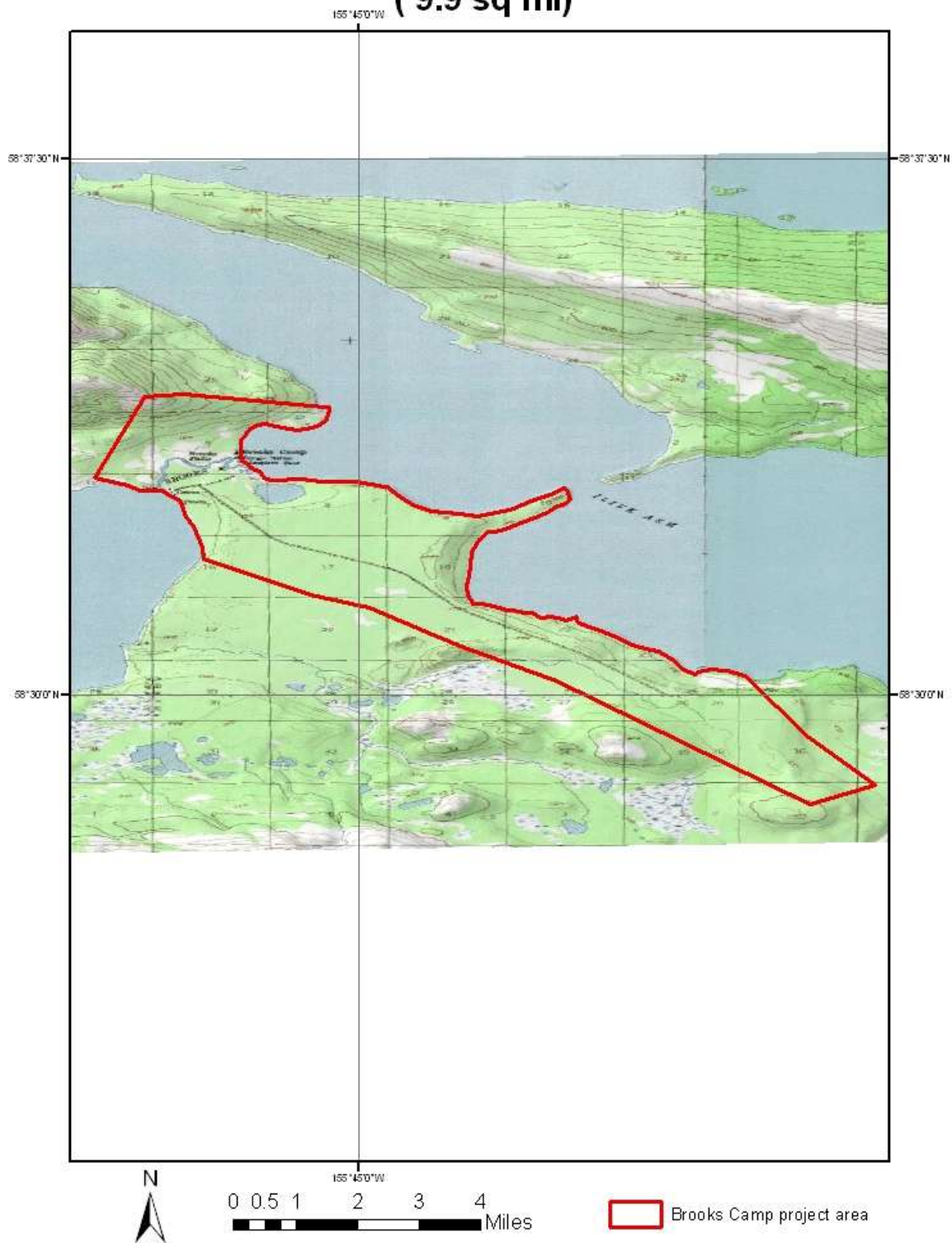
Year of Collection: 2012

Lot 1 of 1 lots.

Project Extent:

☒ Project Extent image?

Brooks Camp AK Ortho / Lidar task (9.9 sq mi)



Project Tiling Scheme:

☐ Project Tiling Scheme image?

Contractor:

Aerometric, Inc.

Applicable Specification:

V13

Licensing Restrictions:

None

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Joe Scott	CPT	573-308-3700	jwscott@USGS.gov
Dale Vinson	NPS-AK	907-644-3632	Dale_Vinson@NPS.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.

- | | |
|--|---|
| <input checked="" type="checkbox"/> Collection Report | <input checked="" type="checkbox"/> Project Shapefile/Geodatabase |
| <input checked="" type="checkbox"/> Survey Report | <input checked="" type="checkbox"/> Project Tiling Scheme Shapefile/Gdb |
| <input checked="" type="checkbox"/> Processing Report | <input checked="" type="checkbox"/> Control Point Shapefile/Gdb |
| <input checked="" type="checkbox"/> QA/QC Report | <input checked="" type="checkbox"/> Breakline Shapefile/Gdb |
| <input checked="" type="checkbox"/> Control and Calibration Points | <input checked="" type="checkbox"/> Project XML Metadata |

Multi-File Deliverables

File Type	Quantity
<input checked="" type="checkbox"/> Swath LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	<input type="text" value="28"/>
<input checked="" type="checkbox"/> Intensity Image Files <input checked="" type="checkbox"/> Required?	<input type="text" value="41"/>
<input checked="" type="checkbox"/> Tiled LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	<input type="text" value="41"/>
<input checked="" type="checkbox"/> Breakline Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	<input type="text" value="2"/>
<input checked="" type="checkbox"/> Bare-Earth DEM Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	<input type="text" value="41"/>

Additional Deliverables

	Item
<input checked="" type="checkbox"/>	40 1-ft contours shapefiles that cover the project area
<input checked="" type="checkbox"/>	Terrain Dataset

Errors, Anomalies, Other Issues to document? ☒ Yes ☐ No

The lidar shall be collected at a nominal point spacing (NPS) of 0.7m. Vertical RMSE associated with the elevation data shall be 9.25 cm and suitable for generation of 1-foot contours. The elevation data will be hydro-flattened AND hydro-enforced.

Project Geographic Information

Areal Extent:

10

Sq Mi

Grid Size:

meters

Tile Size:

1500

meters

Nominal Pulse Spacing:

.68

meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: NAD_1983_UTM_Zone 5N meters.

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

- | | |
|---|--|
| <input checked="" type="checkbox"/> Project Shapefile/Geodatabase | <input checked="" type="checkbox"/> Breaklines XML Metadata File |
| <input type="checkbox"/> Project Tiling Scheme Shapefile/Gdb | <input checked="" type="checkbox"/> Bare-Earth DEM XML Metadata File |
| <input checked="" type="checkbox"/> Checkpoints Shapefile/Geodatabase | <input checked="" type="checkbox"/> Swath LAS Files |
| <input checked="" type="checkbox"/> Project XML Metadata File | <input checked="" type="checkbox"/> Classified LAS Files |
| <input checked="" type="checkbox"/> Swath LAS XML Metadata File | <input checked="" type="checkbox"/> Breaklines Files |
| <input checked="" type="checkbox"/> Classified LAS XML Metadata File | <input checked="" type="checkbox"/> Bare-Earth DEM Files |

Project Tiling Scheme Shapefile/Geodatabase CRS

Please see note above about no tiling scheme being delivered.

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:

K. Mantey

Review Start Date:

10/5/2012

**Action
to Contractor Date**

Issue Description

Return Date

10/15/2012

Breaklines: do not match shoreline,
please fix.

12/5/2012

12/5/2012

Wrong format of Bare earth rasters
sent (16 bit signed
integer). Requested new rasters in
correct format.

12/10/2012

Review Complete:

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.

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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.

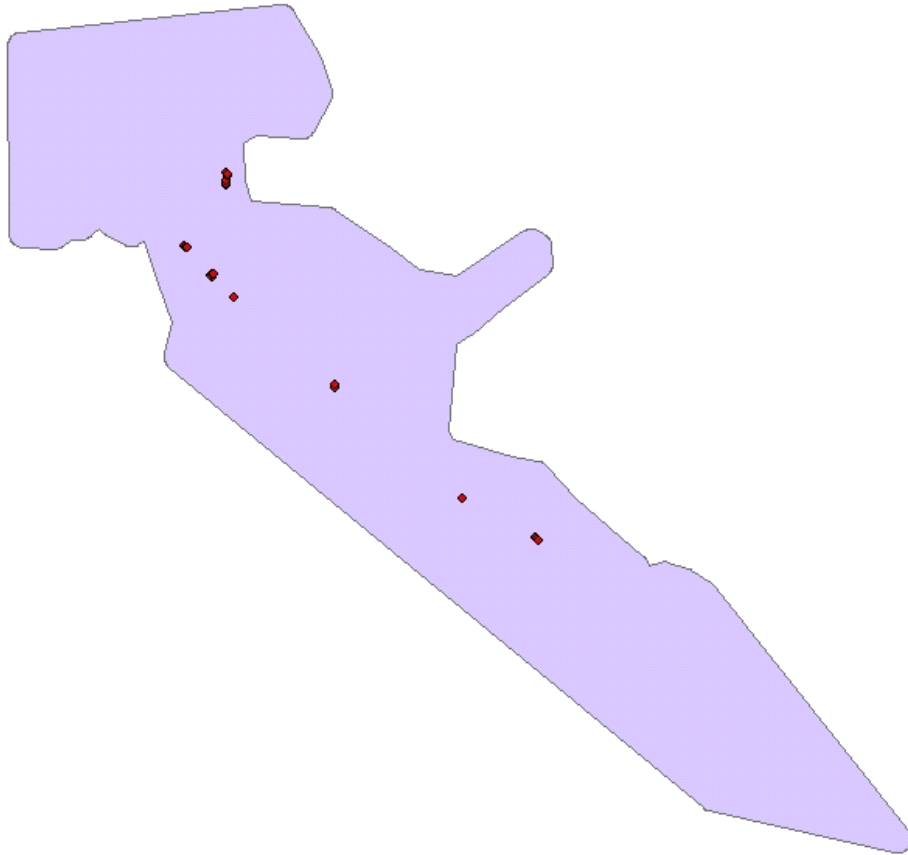
NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be 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?

**Brooks Camp AK Ortho/Lidar Task
checkpoint layout**



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

- ☒ Bare Earth
- ☐ 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 notable to locate independent checkpoints for this analysis. USGS does not accept at this time the quality of the checkpoint data for these LiDAR datasets.

Errors, Anomalies, Other Issues to document? ☒ Yes ☐ No

☐ Image?

The lack of well-dispersed control checkpoints may be due to the fact that this project area is also grizzly bear habitat and could be considered hazardous to human intervention.

Further examination of the checkpoint distribution shows limited areas of open, flat terrain. This may also explain the "clumping" of the checkpoints. Looking at imagery and lidar, as well as creating buffers around breaklines, it is the opinion of the NGTOC that there were additional open, flat, terrain areas where independent checkpoints could have been collected, increasing the distribution of the checkpoints.

☐ Image?

The project task order references the Version 13 Spec regarding vertical accuracy, and requires that this spec be followed for vertical accuracy. While checkpoint deliver for SVA is not specifically mentioned, the task order does say that any items not specifically mentioned the V13 baseline specs will be the required spec authority.

The task order also says that assessment must comply with FEMA authority. The FEMA document mentioned here refers to the Flood Hazard Mapping Partners document. This standard does mention that a minimum of 20 checkpoints need to be selected for each major vegetation category including bare earth. It is the opinion of the NGTOC that the vertical accuracy statement "8) Vertical Accuracy Requirements: Lidar collected under this task order shall be at a vertical accuracy NSSDA RMSEZ = 9.25 cm (NSSDA AccuracyZ 95% = 15cm) or better; assessment procedures to comply with FEMA guidelines." is referring to the LAS point cloud, based on both the FEMA specs and the fact that it is under "Lidar Acquisition" section. Also, since the requested RMSE(z) is 9.25 cm, the Accuracy(z) needs to be 18.2 cm Accuracy (z). This standard meets the NSSDA requirement for 1 foot contours. However, in another part of the task order, requirement is for a 24.5 cm Accuracy(z) with RMSE of 18.5 cm. This is impossible. The RMSEz for 24.5 cm is 12.5 cm. To produce 1 foot contours which is the purpose of this task order, RMSE must be 9.25 cm or less.

Due to the fact that 1 foot contours are a deliverable for this task order, the maximum allowable RMSE(z) is 9.25 cm. The other DEM fundamental vertical accuracy requirements are to be disregarded.

While the task order does require assessment of SVA (supplemental vertical accuracy) and CVA (consolidated vertical accuracy), these requirements were waived on a later date due to the nature of the area (bears, remoteness, etc.). This was verified in a conference call with Tim Saultz, Pat Emmett, and Deb Cochran on Friday October 14th 2012.

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:

Required FVA Value is or less.
 Target SVA Value is or less.
 Required CVA Value is or less.

The reported FVA of the LAS Swath data is .

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

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	<input type="text" value=""/>	N/A

Brush Lands and Low Trees		N/A
Forested Areas Fully Covered by Trees		N/A
Urban Areas with Dense Man-Made Structu...		N/A

The reported CVA of this data set is: .

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

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

The reported FVA of the LAS swath data is .

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

☒ Yes
 ☐ No

☒ Image?

Control Points Report

Surface

Method:
Triangulation (TIN)
Filter...

Calculate Errors

Control Points

	N...	Control...	Control...	Control...	Surfac...	Error
<input checked="" type="checkbox"/>	6001	339926.232	6490791.298	51.629	51.641	-0.012
<input checked="" type="checkbox"/>	6002	339932.084	6490839.847	51.482	51.485	-0.003
<input checked="" type="checkbox"/>	6003	342812.603	6488648.395	77.541	77.550	-0.009
<input checked="" type="checkbox"/>	6004	342829.491	6488627.156	78.254	78.311	-0.057
<input checked="" type="checkbox"/>	6005	342862.965	6488612.603	79.323	79.318	0.005
<input checked="" type="checkbox"/>	6006	341771.763	6489221.447	58.546	58.575	-0.029
<input checked="" type="checkbox"/>	6007	338153.020	6492392.526	37.539	37.550	-0.011

Points that exceed limits of 90% CI
Points that exceed limits of 95% CI

Precision:
3

Output Summary

Mean Error: -0.004
Error Range: [-0.084,0.057]
Skew: -0.486
RMSE_z: 0.032
NMA5/VMA5
Accuracy_z (90% CI): ±0.053
ASPRS/NSSDA
Accuracy_z (95% CI): ±0.063

20 control points included in summary out of 20
0 control points turned off
0 control points returned no-data

View Disclaimer...
Export Report

The NGTOC did a calculation of FVA on the delivered swath las files. The RMSE(z) was 0.032 meters, the Accuracy(z) at 95th CI was 0.063 meters. While this vertical accuracy does pass, these checkpoints are not well distributed throughout the dataset. There are other areas of what appear to be open, flat terrain across this project where checkpoints could be collected to create a better distribution.

While the distribution of checkpoints is not good, these will be accepted due to the nature of the geographic hazards of this area. This was verified in a conference call with Tim Saultz, Pat Emmett, and Deb Cochran on Friday October 14th 2012.

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

None.

Breakline File Review

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

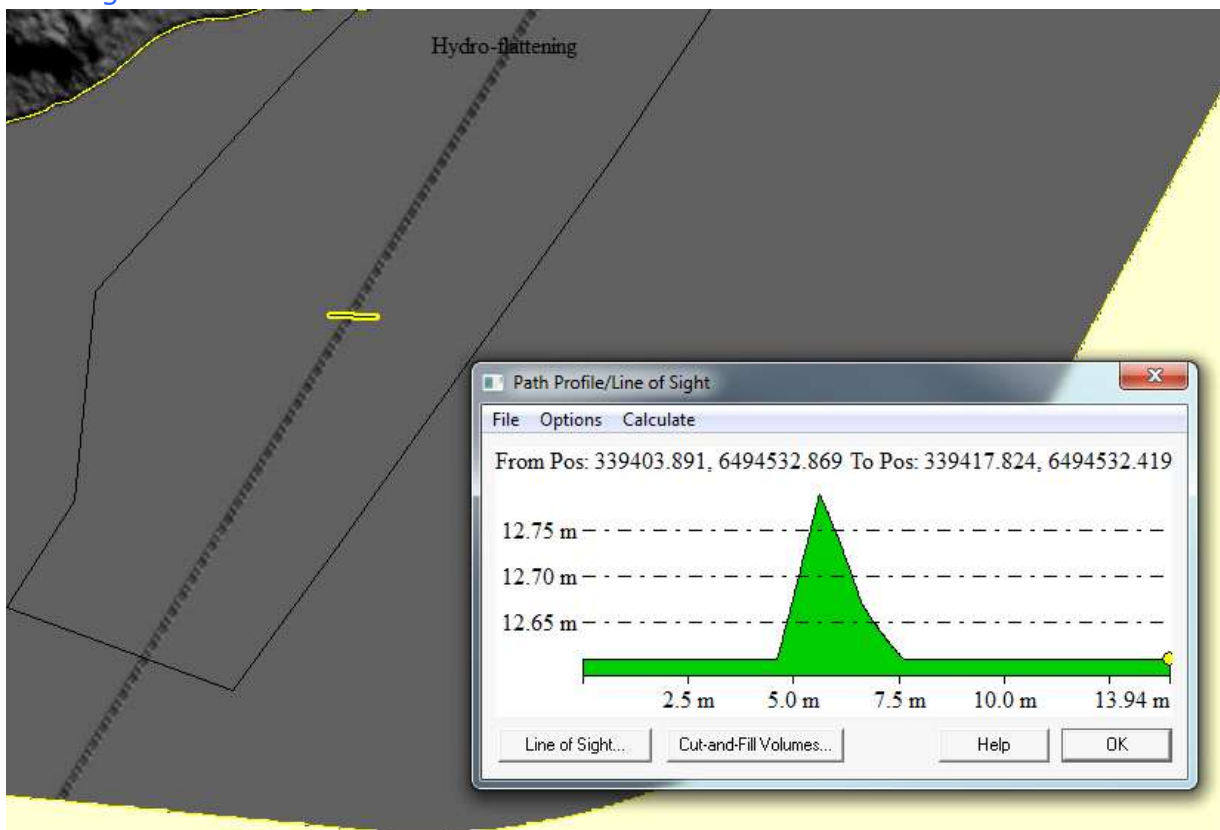
Breakline File Characteristics

- ☒ Separate folder for breakline files
- ☒ All breaklines captured as PolylineZ or PolygonZ features
- ☒ 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?



10/15/2012: This water feature at the boundary should be flat, however there is an artifact that is causing a ridge in the surface. This should be corrected. All instances of this occurrence are georeferenced in the delivered shapefile.

☒ Image for error?



10/15/2012: The breakline is covering bare earth. Additionally, there is an island that is not shown when hydro-flattening occurs because there is not a breakline around it. This island should show in the DEM, and the breakline should be closer to the shoreline.

☒ Image for error?



10/15/2012: This breakline appears to be randomly placed. Breaklines should be continuous across surface.

☒ Image for error?



10/15/2012: This breakline is covering bare earth. The breakline should be set closer to the actual shoreline to preserve bare earth surface.

☐ Image for error?

12/11/2012: All hydro-flattening and breakline issues have been corrected. The breaklines are accepted.

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: **.DEM**

Bare-Earth DEM Tile File Characteristics

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

All accuracy values reported in **meters**.

Reported Accuracies

Land Cover Category	# of Points	<u>Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy_z)</u> Required FVA = 0.245 or less.	<u>Supplemental Vertical Accuracy @95th Percentile Error</u> Target SVA = Not Applicable or less.	<u>Consolidated Vertical Accuracy @95th Percentile Error</u> Required CVA = Not Applicable or less.
Open Terrain	20	0.057		
Tall Weeds and Crops	1		1	
Brush Lands and Low Trees	1		1	

Forested Areas Fully Covered by Trees	1		1	
Urban Areas with Dense Man-Made Structures	1		1	
Consolidated	20			Not Applicable

☒ QA performed Accuracy Calculations?

Calculated Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy _z) Required FVA = .245 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = Not Applicable or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = Not Applicable or less.
Open Terrain	20	0.05		
Tall Weeds and Crops	1		1	
Brush Lands and Low Trees	1		1	
Forested Areas Fully Covered by Trees	1		1	
Urban Areas with Dense Man-Made Structures	1		1	
Consolidated	20			1

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

None.

Based on this review, the deliverables provided meet the Task Order requirements.

Internal Note:

12/11/2012: All issues with breaklines have been resolved. Data will be accepted and is recommended for the NED 1/3rd dataset.

This is the end of the report.

QA Form V1.4 12OCT11.xsn