



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 NGTOCooperations@usgs.gov.

Materials Received:

8/1/2013

Project ID:

Territory of Guam

Project Alias(es):

Guam_2012

Project Type: GPSC

Project Description:

This task order is for Planning, Acquisition, processing, and derivative products of lidar data to be collected at a nominal pulse spacing (NPS) of 1.0 meter. Specifications listed below are based on the *“U.S. Geological Survey National Geospatial Program Base Lidar Specification, Version 13 (ILMF)”*, of which sections I through IV are incorporated by reference to this task order. This specification may be viewed at [http://lidar.cr.usgs.gov/USGS-NGP Lidar Guidelines and Base Specification v13 \(ILMF\).pdf](http://lidar.cr.usgs.gov/USGS-NGP Lidar Guidelines and Base Specification v13 (ILMF).pdf). These lidar specifications are required baseline specifications. In addition to the requirements listed below, variations from the specifications will be shown and noted below. For any item which is not specifically addressed, the referenced Version 13 specifications will be the required specification authority. This task is for a high resolution data set of lidar over the island of Guam comprising approximately 211 square miles. The elevation data from this task will then be utilized to orthorectify the 1-foot imagery that will be collected in the subsequent *Guam - 0.30 meter GSD Ortho task order*.

Year of Collection:

early 2012, late 2012, early 2013

Lot of lots.

Project Extent:

Project Extent image?



1m NPS v.13 lidar & 1-ft GSD ortho
Guam - 211 sq mi

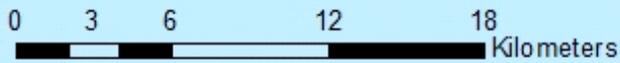
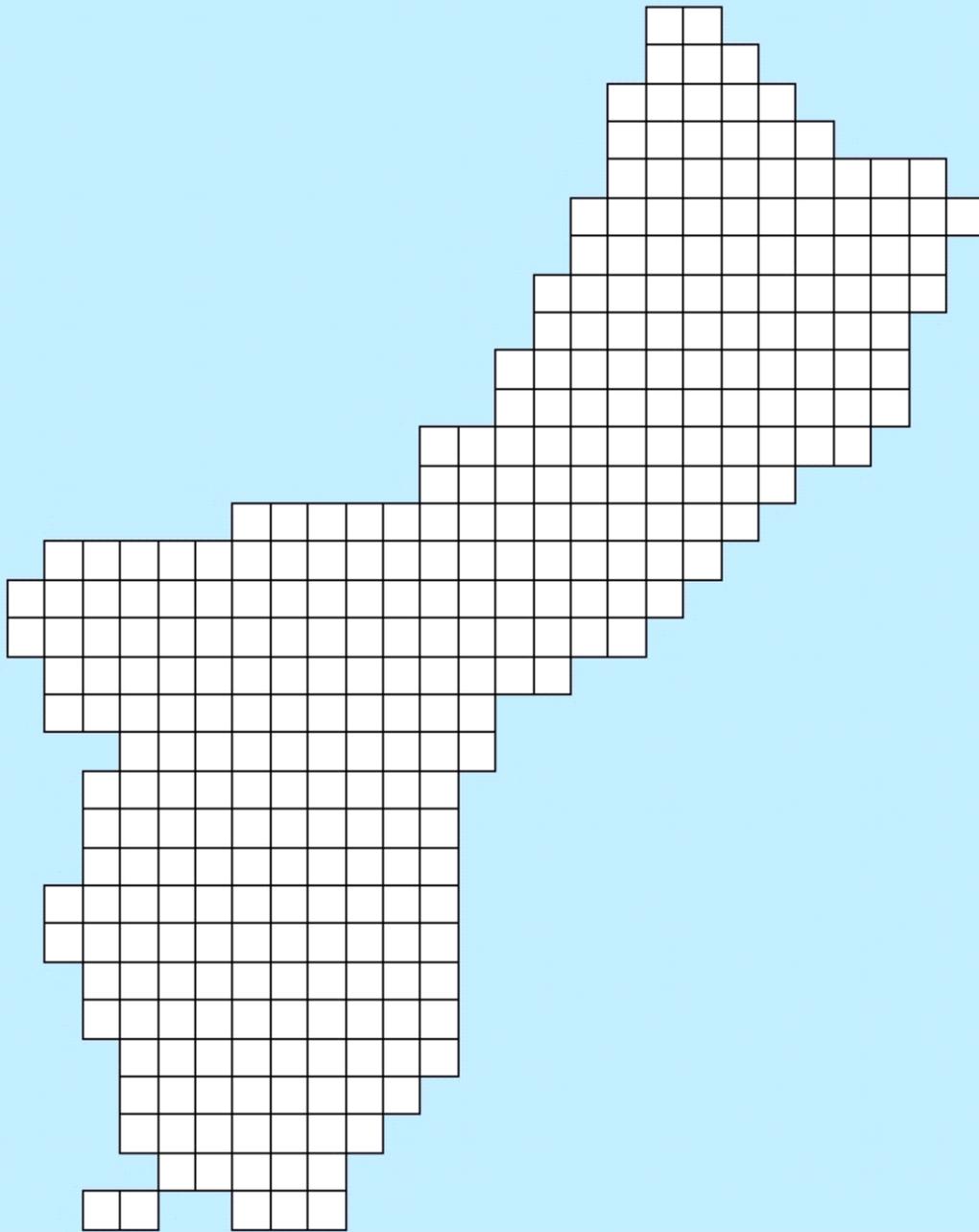


Project Tiling Scheme:

Project Tiling Scheme image?



US Territory of Guam Lidar Tile Layout



 1500 x 1500 meters

Contractor:

Aerometric, Inc.

Applicable Specification:

V13

Licensing Restrictions:

None

Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Patrick Emmett	CPT	573-308-3587	pemmett@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.

- | | |
|---------------------------------------------------------|-------------------------------------------------------------------------|
| <input type="checkbox"/> Collection Report | <input checked="" type="checkbox"/> Project Shapefile/Geodatabase |
| <input type="checkbox"/> Survey Report | <input checked="" type="checkbox"/> Project Tiling Scheme Shapefile/Gdb |
| <input type="checkbox"/> Processing Report | <input type="checkbox"/> Control Point Shapefile/Gdb |
| <input type="checkbox"/> QA/QC Report | <input checked="" type="checkbox"/> Breakline Shapefile/Gdb |
| <input 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?	434
<input checked="" type="checkbox"/> Intensity Image Files <input checked="" type="checkbox"/> Required?	345
<input checked="" type="checkbox"/> Tiled LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	320
<input checked="" type="checkbox"/> Breakline Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	1
<input checked="" type="checkbox"/> Bare-Earth DEM Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	320

Additional Deliverables

Errors, Anomalies, Other Issues to document? Yes No

Project Geographic Information

Areal Extent:

222.72

Sq Mi

Grid Size:

1.0

meters

Tile Size:

1500 x 1500

meters

Nominal Pulse Spacing:

1.0

meters

Vertical Datum: meters

Horizontal Datum: meters

Project Projection/Coordinate Reference System: 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 checked="" 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 |

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:

T. Jerris

Review Start Date:

8/7/2013

Action to Contractor Date	Issue Description	Return Date
8/22/2013	<p>This dataset contains the following error-types:</p> <ul style="list-style-type: none">5 @ bridge-structures not removed from DEM2 @ incomplete bridge-structure removals from DEM1 @ man-made structures not removed from DEM <p>and near-shore water elevation differences around the whole island of Guam.</p> <p>**All errors mentioned above, except the near-shore elevation differences were corrected by contractor ...(9/12/2013)</p> <p>Please see Internal Notes (below) for more detail about the near-shore irregularities</p>	9/9/2013

Review Complete: 9/12/2013

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

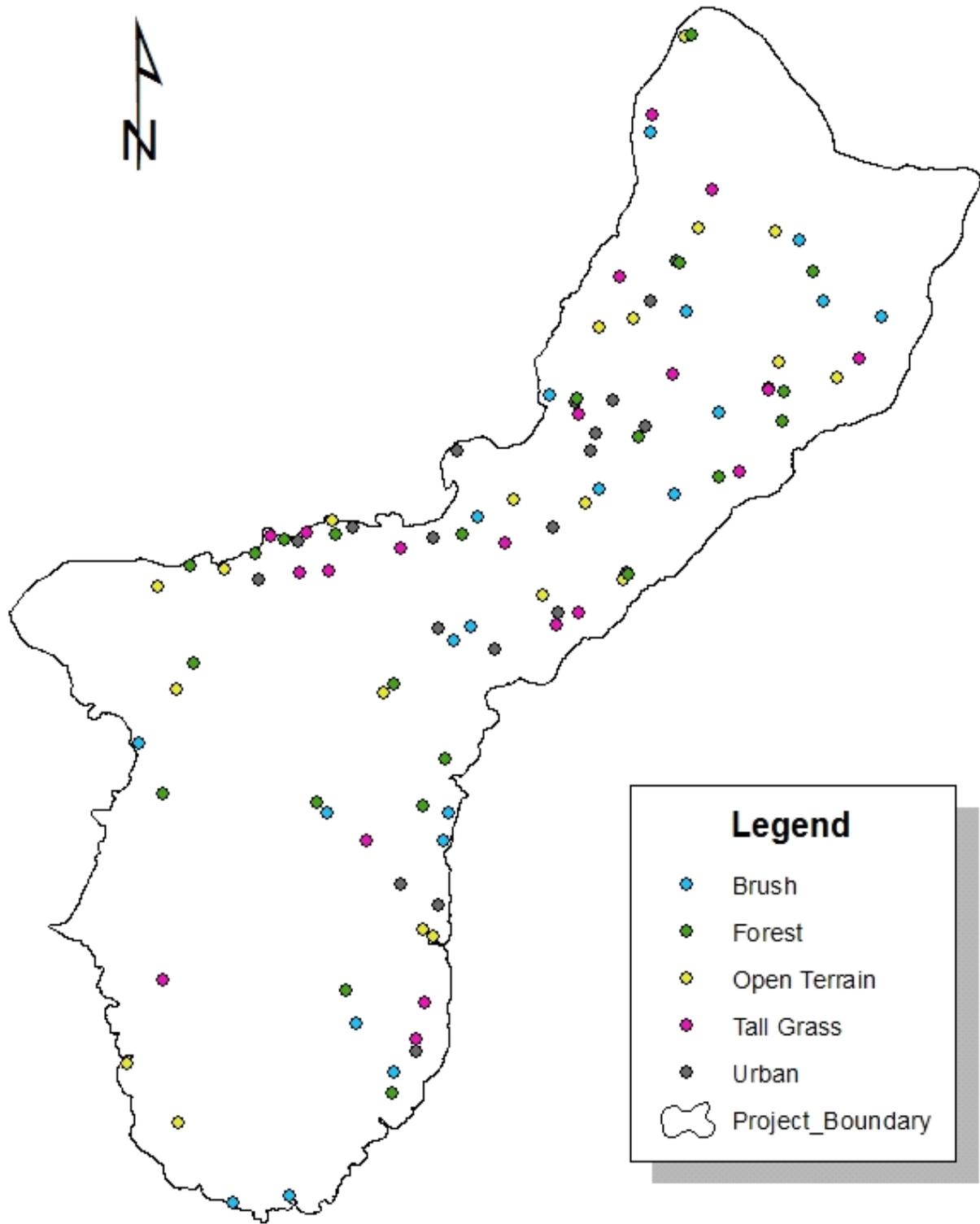
ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the 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):

- 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 able to locate independent checkpoints for this analysis. USGS accepts the quality of the checkpoint data for these LiDAR datasets.

Errors, Anomalies, Other Issues to document? Yes No

None.

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 centimeters or less.

Target SVA Value is centimeters or less.

Required CVA Value is centimeters or less.

The reported FVA of the LAS Swath data is centimeters.

The reported FVA of the Bare-Earth DEM data is 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	<input type="text" value="30.0"/>	<input type="text" value="centimeters"/>
Brush Lands and Low Trees	<input type="text" value="22.7"/>	<input type="text" value="centimeters"/>
Forested Areas Fully Covered by Trees	<input type="text" value="15.2"/>	<input type="text" value="centimeters"/>
Urban Areas with Dense Man-Made Structu...	<input type="text" value="09.9"/>	<input type="text" value="centimeters"/>

The reported CVA of this data set is: 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

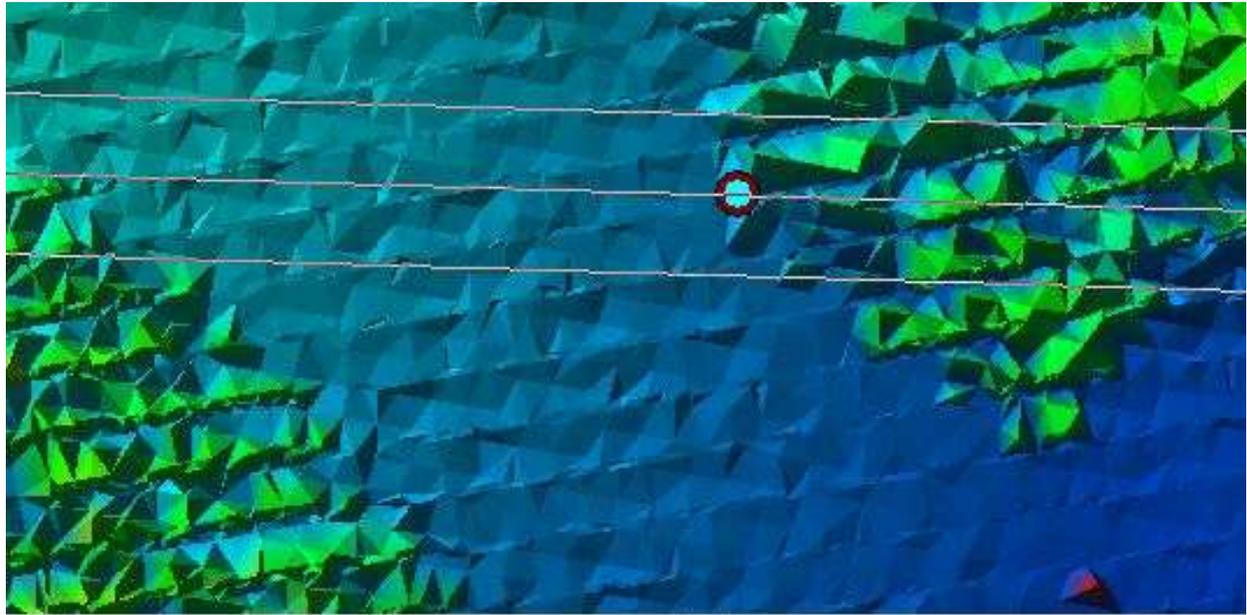
- Separate folder for LAS swath files
- Each swath files <= 2GB
- *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is .

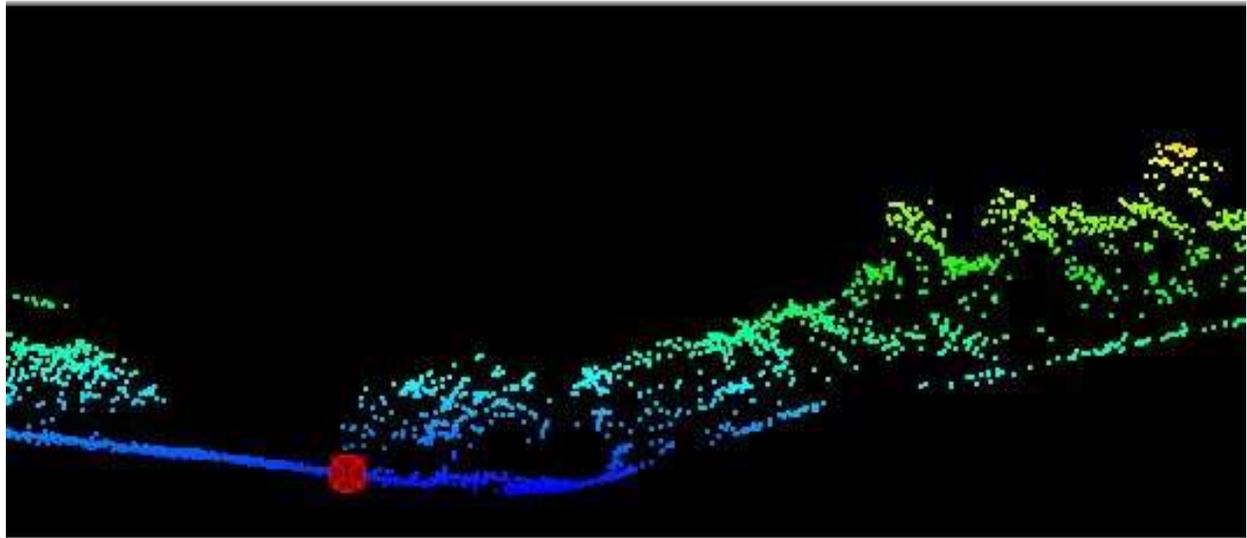
Based on this review, the USGS accepts the LAS swath file data.

Yes No

Image?

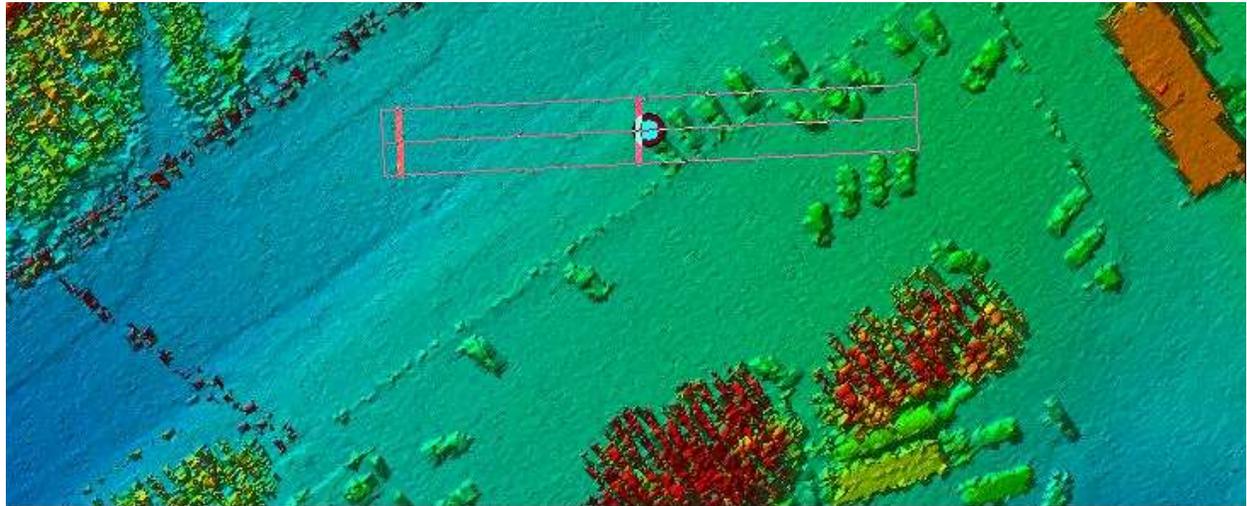


ISS:



Check point 204: Removed from the vertical accuracy assessment for Swath FVA. This point is located in an area with tree cover; it has a z-error of -0.719 meters which indicates that the survey ground elevation is 0.719 meters less than the swath LAS TIN surface elevation.

Image?



ation Class:



Check point 207: Removed from the vertical accuracy assessment for Swath FVA. This point is located in an area near a vehicle; it has a z-error of -1.007 meters which indicates that the survey ground elevation is 1.007 meters less than the swath LAS TIN surface elevation.

Image?

**NGTOC's accuracy of Swath FVA is 16.8 cm after exclusion of the two points mentioned above.

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?

Additional classifications in this data set.

- 3 - Tall weeds and crops (low vegetation)
- 4 - Brush lands and low trees (medium vegetation)
- 5 - Forested areas fully covered by trees
- 6 - Urban area with dense man-made structures

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

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: Erdas Imagine *.img

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 centimeters .

Reported Accuracies

Land Cover Category	# of Points	<u>Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy_z)</u> Required FVA =	<u>Supplemental Vertical Accuracy @95th Percentile Error</u> Target SVA = 36.3 or less.	<u>Consolidated Vertical Accuracy @95th Percentile Error</u> Required CVA = 36.3 or less.

		24.5 or less.		
Open Terrain	21	17.1		
Tall Weeds and Crops	22		30.0	
Brush Lands and Low Trees	20		22.7	
Forested Areas Fully Covered by Trees	22		15.2	
Urban Areas with Dense Man-Made Structures	20		09.9	
Consolidated	105			21.8

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	21	17.1		
Tall Weeds and Crops	22		30.0	
Brush Lands and Low Trees	20		22.7	
Forested Areas Fully Covered by Trees	22		15.2	
Urban Areas with Dense Man-Made Structures	20		09.9	
Consolidated	105			21.8

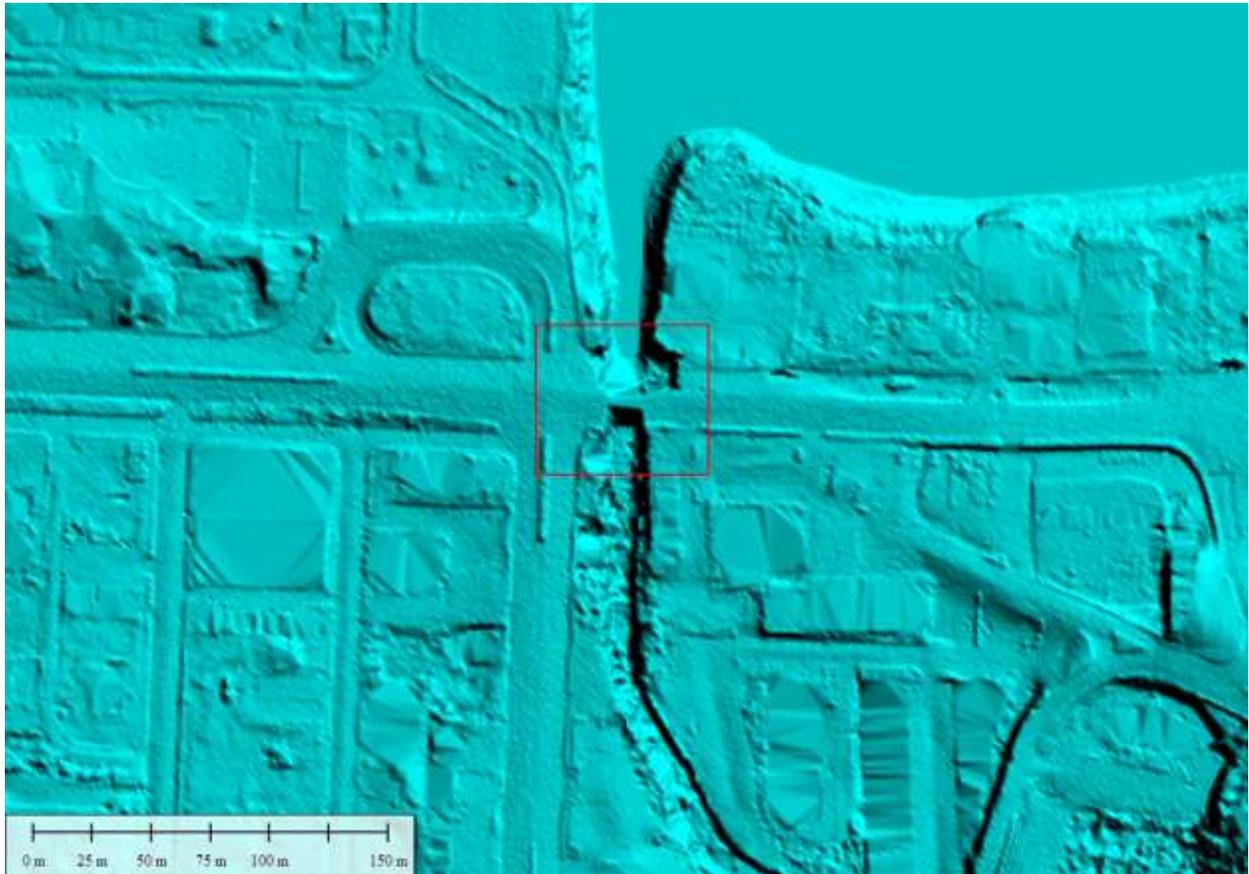
Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

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

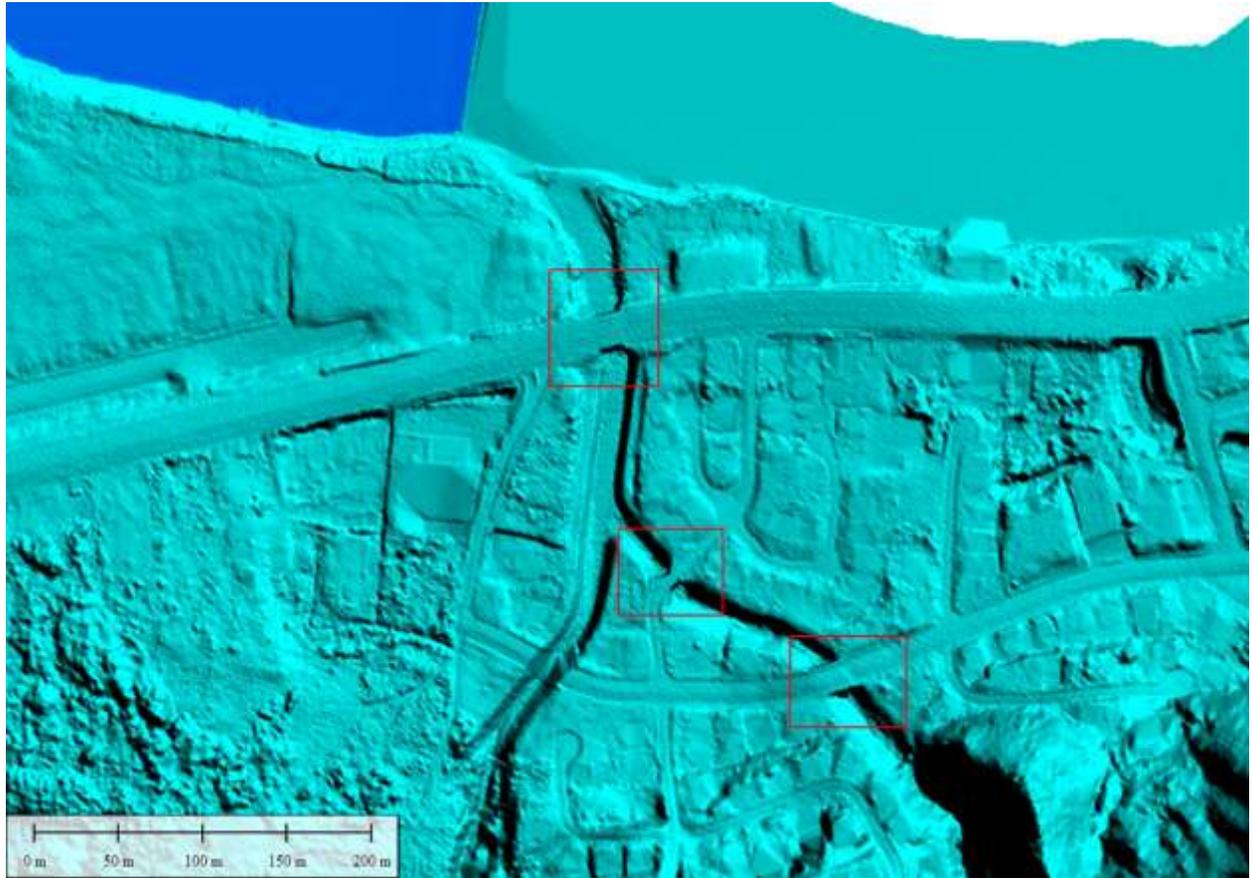
Image?



incomplete_bridge_removal_1: The roadway (bridge) over the waterway is not completely removed. There are two of this error-type.

**Error fixed by contractor... (9/12/2013)

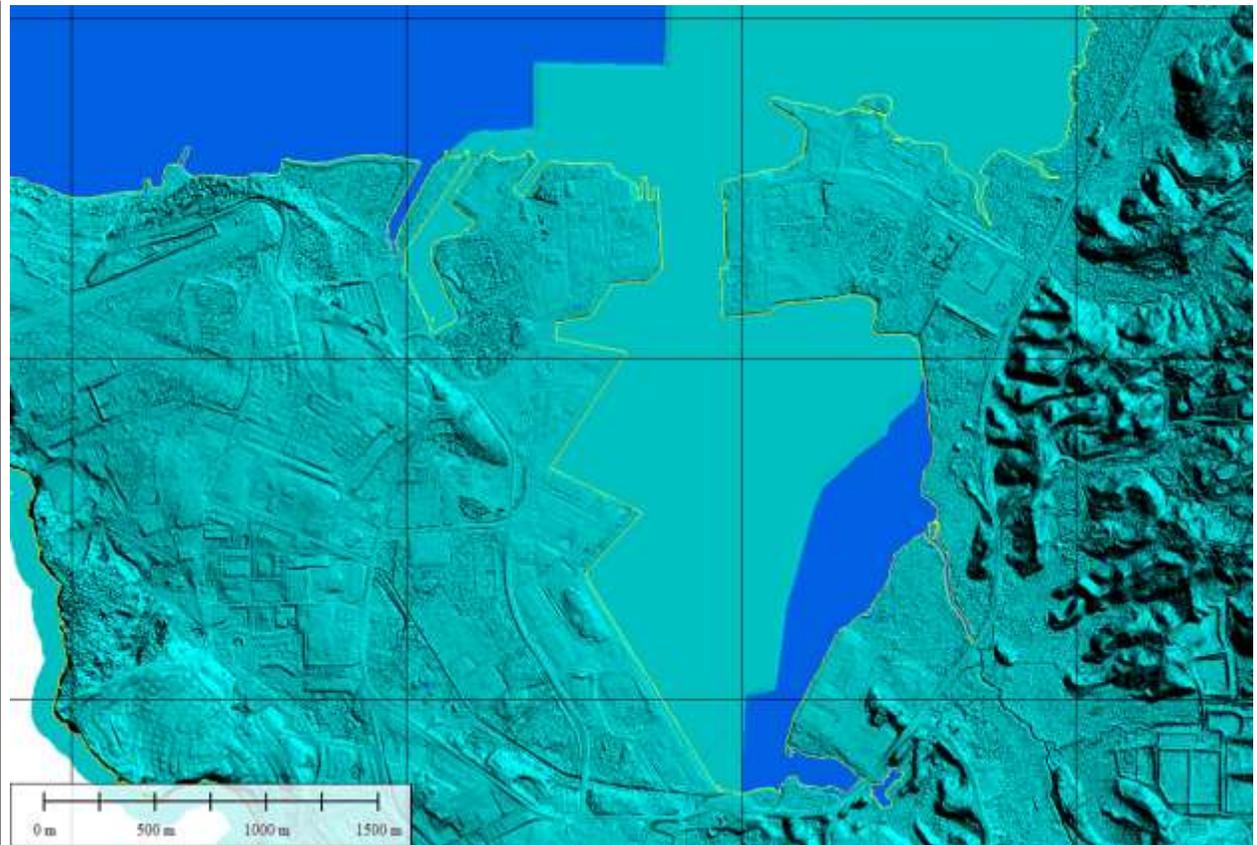
Image?



bridge_1-3: Roadways (bridges) over the waterways have not been removed; these are interpreted as bridges and not culverts. There are five of these error-types... three are represented in this image.

**Error fixed by contractor...(9/12/2013)

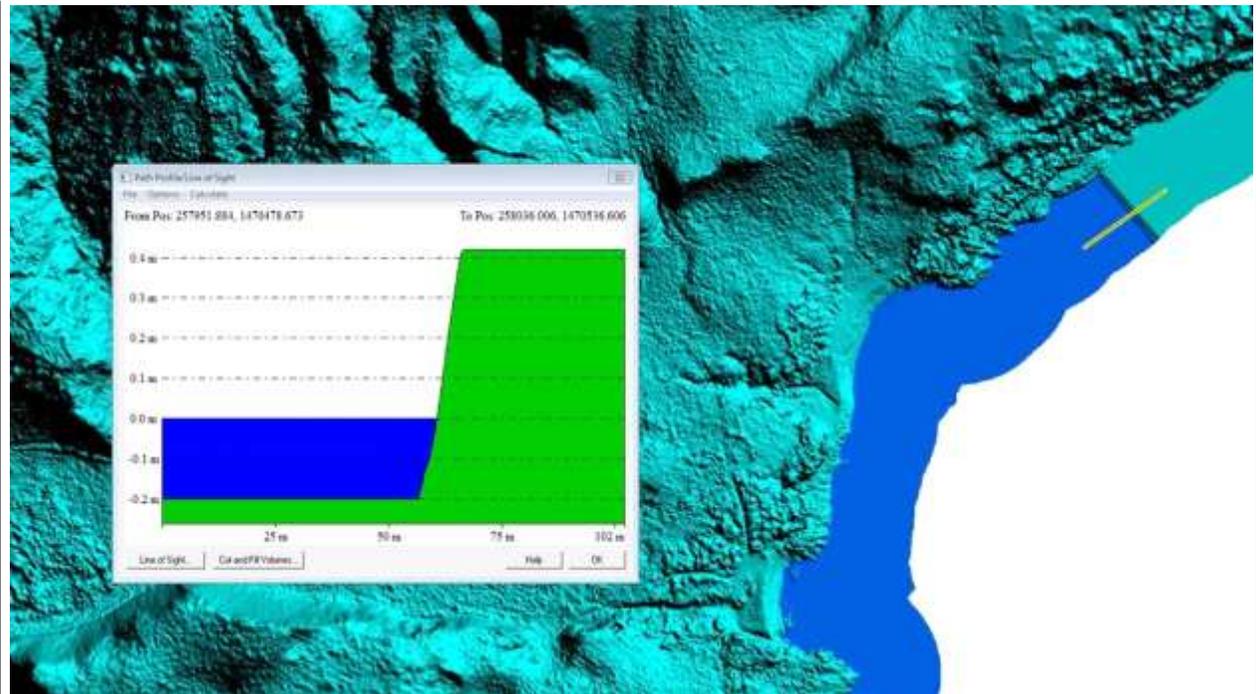
Image?



near-shore_water_elevation_differences: Water levels located on the shore of the entire project contain different elevations.

**Error not corrected by contractor; see Internal Notes for details...(9/12/2013)

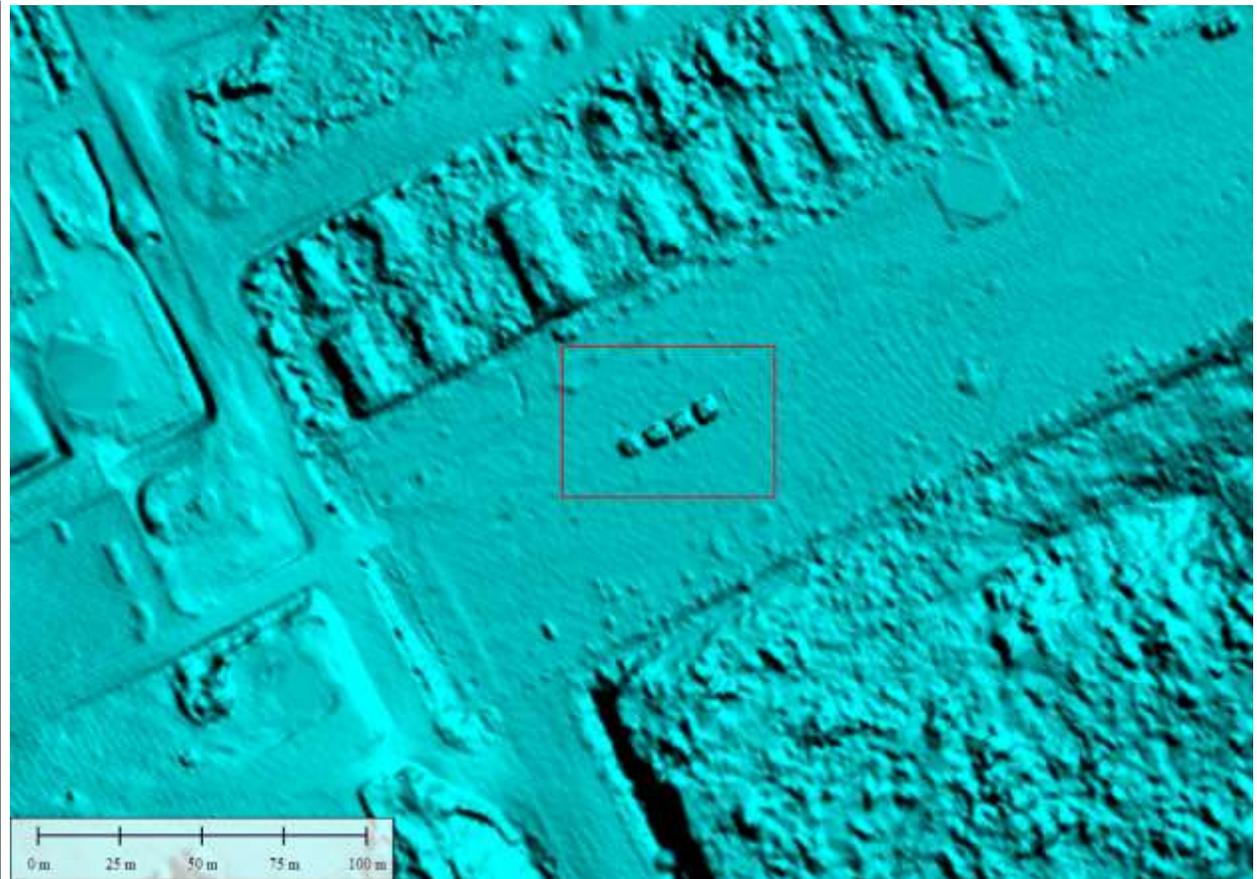
Image?



surface_elevation_change: The yellow line is the location of the cross-section in the inset image. This near-shore water level difference is another example of the error-type mentioned in the previous image. This error-type is prevalent around the entire project....but only along the shorelines..not inland ponds/lakes.

**Error not corrected by contractor; see Internal Notes for details...(9/12/2013)

Image?



structures_1: Structures within this image are interpreted as man-made and not natural features. These items should be removed from the DEM. This is the only error of this type.

**Error fixed by contractor...(9/12/2013)

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

Internal Note:

All errors corrected by vendor except the water 'elevation' issues around the coastline of entire island. This lidar was collected over 1.5 years thus tidal variations resulted in irregularities within the coastal regions. According to NGP, USGS Lidar Base Specifications Version 1.0, notes:

- Tidal variations over the course of a collection or between different collections, will result in lateral and vertical discontinuities along shorelines. This is considered normal and these anomalies should be retained.
- Water surface is to be flat and level, to the degree allowable by the irregularities noted above.

This is the end of the report.

QA Form V1.4 12OCT11.xsn