



# 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:

7/24/2012

Project Type: NSDI Agreement

Project ID:

IN\_Statewide-BooneCo\_2011

Project Description:

Data originally created for IndianaMap

Project Alias(es):

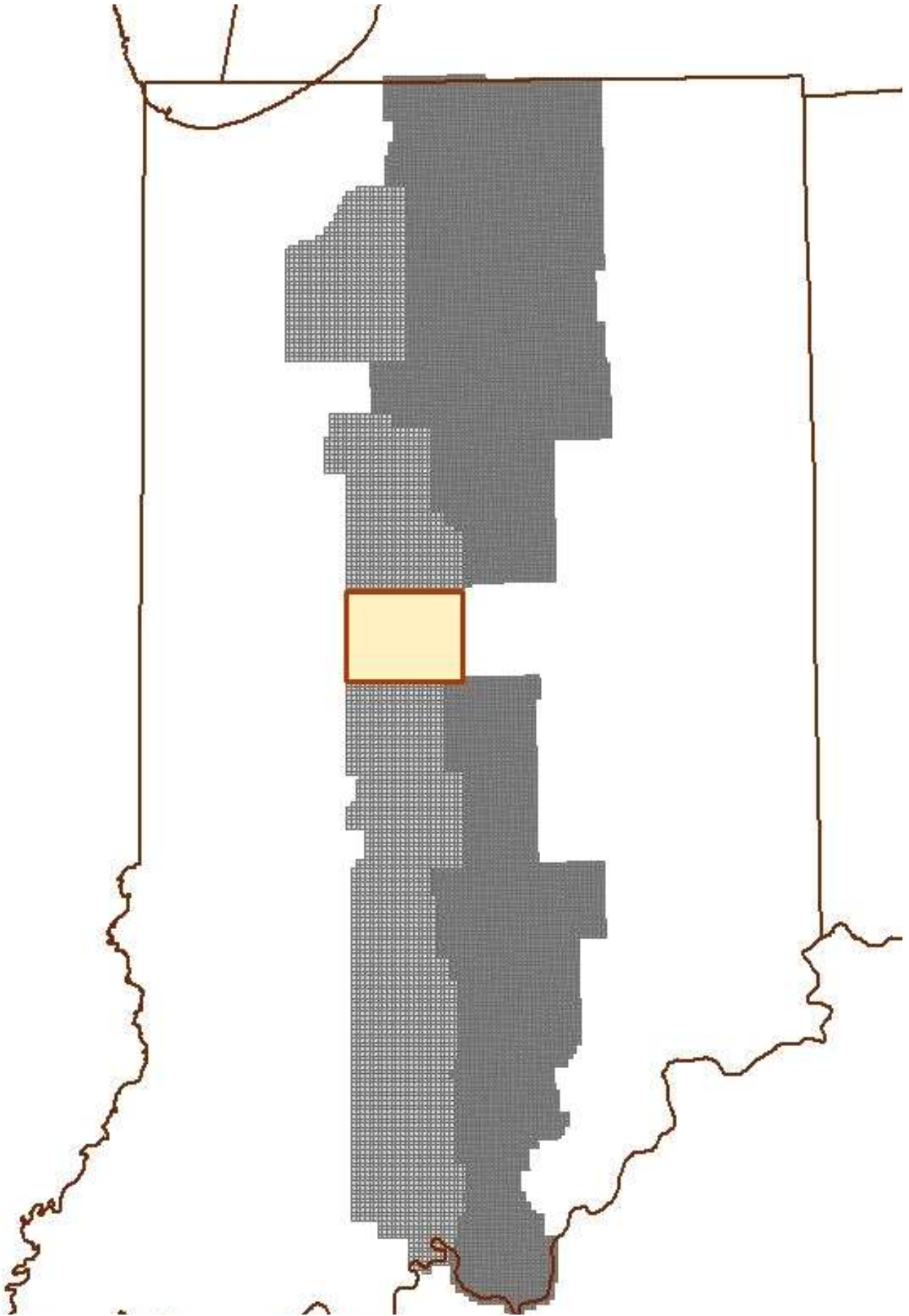
IN Central Tier

Year of Collection: 2011

Lot 1 of 1 lots.

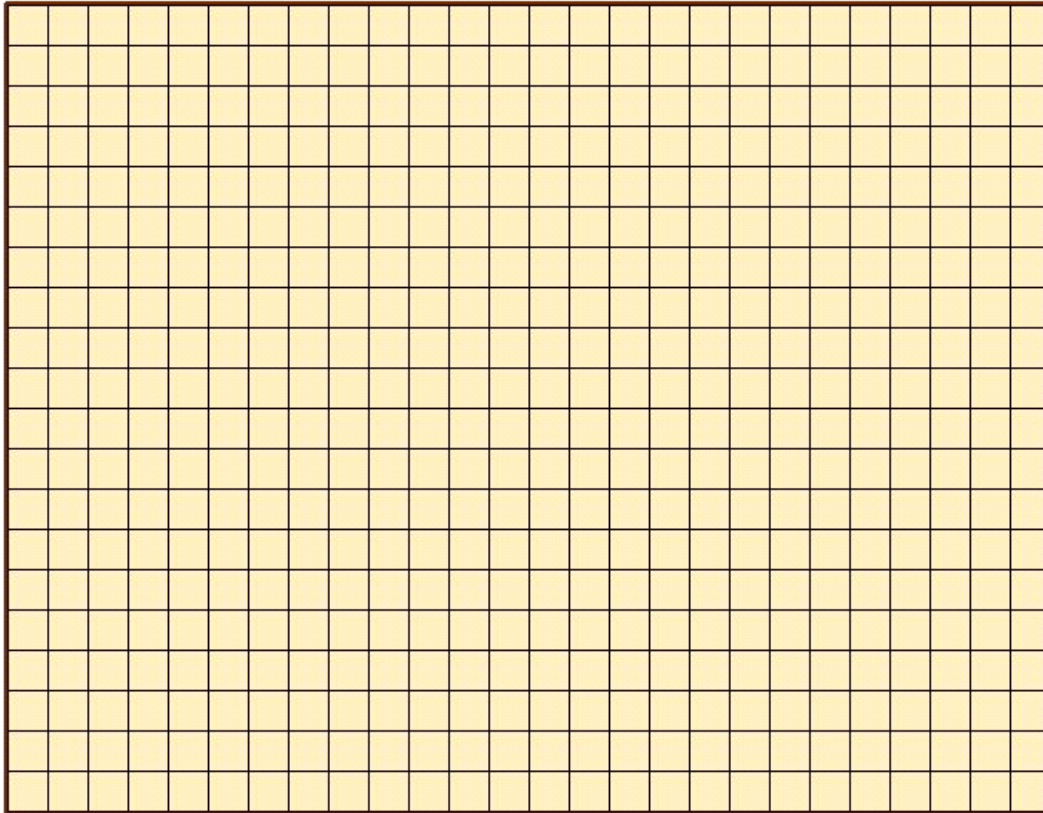
Project Extent:

Project Extent image?



Project Tiling Scheme:

Project Tiling Scheme image?



Contractor:

Woolpert, Inc.

Applicable Specification:

V12, V13, FEMA, ASPRS, NSSDA

Licensing Restrictions:

none

Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
David S. Nail	NSDI Liaison	317-600-2722	dnail@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 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 type="checkbox"/> Project XML Metadata                           |

## Multi-File Deliverables

File Type	Quantity
<input checked="" type="checkbox"/> Swath LAS Files <input checked="" type="checkbox"/> Required? <input type="checkbox"/> XML Metadata?	<input type="text" value="see below"/>
<input type="checkbox"/> Intensity Image Files <input checked="" type="checkbox"/> Required?	<input type="text" value="0"/>
<input checked="" type="checkbox"/> Tiled LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	<input type="text" value="520"/>
<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="520"/>

Yes  No

'Scope of Services' report references USGS NGP Base LiDAR Specification, version 12 (which lists swath las files as a required deliverable). The 'Airborne LiDAR Report' also includes las v1.2 raw unclassified point cloud as a final deliverable; however, no swath las files were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of swath las files. Swath files received by reviewer at NGTOC on 1/28/13. Swath were not consistently projected, corrections requested 2/11/13. Corrected swath las files received at NGTOC on 4/2/13. Swath not organized by county. Multiple issues with swath las file headers, corrections requested 4/16/13. On 8/8/13 reviewer was notified that no corrections will be delivered to NGTOC. Please see swath las review section below for additional details. All Indiana Central Tier swath will be delivered to EROS at one time as pre-approved by Michael Steuck on 2/5/13.

'Airborne LiDAR Task Order Report' lists independent control points used to test vertical accuracy in shapefile format as a required deliverable, however, no control points were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of control point shapefile. All available checkpoints received 3/18/13.

No project level xml metadata delivered to reviewer at NGTOC. Not required by Scope of Services report. Reviewer read all delivered xml metadata files and determined the best use xml metadata. Reviewer at NGTOC renamed the file BESTUSE.XML and copied it to the Metadata-Documents folder.

The delivered 'Airborne LiDAR Task Order Report' lists the dates of acquisition on pages 2-8 and 2-9. Woolpert reported the last date of acquisition as April 20, 2011. The xml metadata delivered with the project lists the dates of acquisition with the last date of acquisition being April 30, 2011. The reviewer contacted NSDI Liaison David Nail on 09/27/2012 requesting the correct dates of acquisition. On 10/24/2012 James Sparks replied that the correct dates are in the metadata, there was a typo in the report. The correct dates of acquisition are 03/13/2011-04/30/2011.

Reviewer created Project Extent Shapefile from delivered Tiling Scheme. Reviewer also created a new Project Tiling Scheme shapefile to match exact extent of delivered data.

## Project Geographic Information

Areal Extent:

466.31

Sq Mi

Grid Size:

5

U.S. Feet

Tile Size:

5000 x 5000

U.S. feet

Nominal Pulse Spacing:

1.0

meters

Vertical Datum: NAVD88 U.S. feet

Horizontal Datum: NAD83 U.S. feet

Project Projection/Coordinate Reference System:

NAD\_1983\_StatePlane\_Indiana\_West\_1302\_FT\_US U.S. feet.

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 type="checkbox"/> Swath LAS Files                             |
| <input type="checkbox"/> Project XML Metadata File                      | <input checked="" type="checkbox"/> Classified LAS Files             |
| <input 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 XML Metadata CRS

No project xml metadata delivered to reviewer at NGTOC. Reviewer created a 'Bes...

Swath LAS XML Metadata CRS

No Swath LAS XML Metadata delivered to reviewer at NGTOC.

Swath LAS Files CRS

Swath las delivered in WGS84 UTM 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:

Review Start Date:

9/5/2012

Action to Contractor Date	Issue Description	Return Date
9/27/2012	Contacted David Nail to confirm dates of acquisition.	10/24/2012
9/28/2012	Requested delivery of collected raw swath las files.	1/28/2013
11/19/2012	Requested delivery of checkpoint shapefile used to test and report vertical accuracy.	2/11/2013
2/11/2013	Corrections required. Swath las not consistently projected.	4/2/2013
4/17/2013	Corrections required for swath las, classified las and DEMs.	8/8/2013
9/6/2013	Multiple corrections completed at NGTOC.	12/9/2013

Review Complete: 12/12/2013

## 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 with errors.

Project xml metadata was not delivered to reviewer at NGTOC. 'Bestuse' xml was created by reviewer using best available data from image file metadata and copied to the Metadata-Documents folder.

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

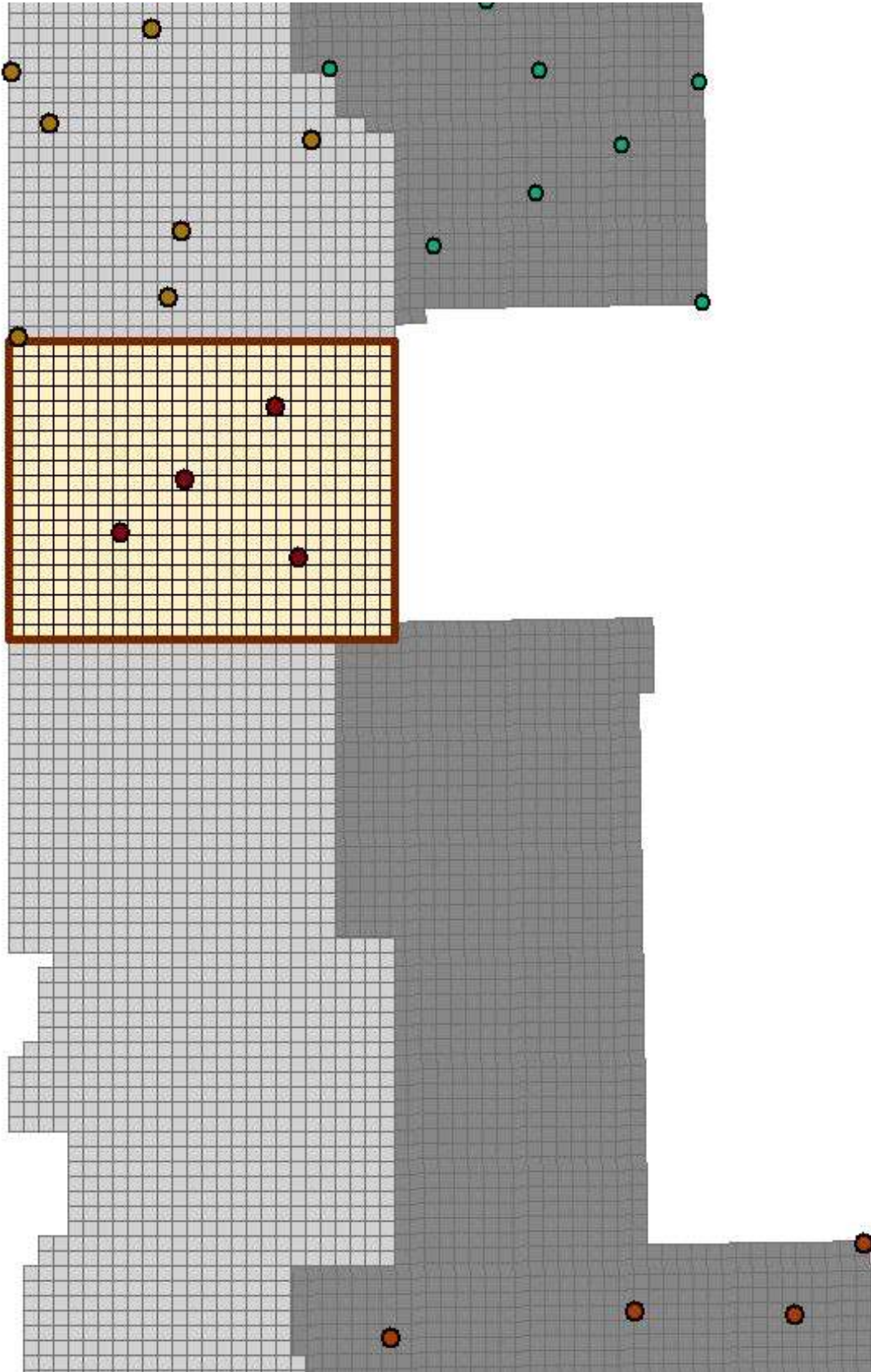
ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the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

Image?

'Airborne LiDAR Task Order Report' lists independent control points used to test vertical accuracy in shapefile format as a required deliverable; however, no control points (checkpoints) were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of control point shapefile. All available checkpoints delivered to NGTOC on 2/11/13, and 3/19/13.

Image?

Contractor performed vertical accuracy assessment by comparison of the LiDAR bare earth points to the ground surveyed QA/QC points (see Airborne Lidar Task Order Report, pg. 5-6). Reported FVA of Boone County is 0.593 feet ( 18.07 cm).

Image?

Task Order requires that the data collected meet the NSSDA accuracy standards. The task order requires FVA and CVA assessment (but does not require SVA) and references USGS Base Spec v12. The reviewer has determined USGS Base Spec v12 does not mention CVA.

Image?

Page 2-5 of the task order ('Scope of Services') reads, "Woolpert will not be using land use category test areas. Woolpert will use 20 test points per LiDAR acquisition block." Boone County is located in Block 2, there are 4 blocks comprising the central tier of Indiana flown in 2011. On page 2-6 of the Scope of Services, CVA testing requirements are detailed. The reviewer has determined that CVA for the entire central tier of Indiana (including multiple other counties) was calculated using FVA testing methodology (95% confidence level), rather than CVA testing methodology at the 95th percentile. Woolpert reported CVA as 0.393 feet vertical accuracy at the 95% confidence level (pg. 5-7 of Airborne Lidar Task Order Report).

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

The reported CVA of this data set is: **see above** U.S. feet.

### 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 N/A U.S. feet.

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

Errors, Anomalies, Other Issues to document?  Yes  No

Image?

'Attachment A, Scope of Services' page 2-5 references the USGS Ver. 12 NGP Base Lidar Specification as Woolpert's guidelines for obtaining and processing the Lidar data. The Ver. 12 spec. requires raw swath LAS files as a deliverable. The 'Airborne

LiDAR Task Order Report' also states las v1.2 raw unclassified point cloud as a final deliverable. Swath files were not delivered to reviewer at USGS. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of swath las files. The files were received at NGTOC on 1/28/13. Corrections were then requested 2/11/13 as many swath las files were found to be missing projection information. First corrections were received 4/2/13. Additional corrections requested 4/17/13 because many swath las files did not meet the las specifications. Point source count field not properly populated, file source ID's not assigned to each file, point source not set identical to file source prior to processing, 2 delivered swath las files contain NO returns, 2 delivered swath las files did not contain projection information, and system ID field is required yet many delivered swath las files did not contain any information regarding system ID. On 8/8/13 reviewer was notified that no corrections would be delivered to NGTOC.

## 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?

Task Order ('Scope of Services') does not match 'Airborne Lidar Task Order Report' or delivered .las files regarding classification scheme. Task Order 'Scope of Services' lists eligible classes 1, 2, 7, 9, 10, and 13. Airborne Lidar Task Order Report lists classes 1, 2, 7, 9, 10, 12, and 13. The delivered classified las tiles include class 12 in the classification scheme. The delivered classified las tiles also include classes 3, 4, 5, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, and 31. Reviewer was notified on 8/8/13 that no corrections would be delivered to NGTOC.

## 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?



Some water bodies over two acres were not flattened; as a result, the corresponding breaklines were not provided. Also, some bridges were not removed, thus breaklines were not provided. Corrections performed at NGTOC, accepted 12/12/13.

## 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 U.S. feet.

### Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy <sub>z</sub> ) Required FVA = <span style="border: 1px solid black; padding: 2px;">0.98</span> or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = <span style="border: 1px solid black; padding: 2px;">N/A</span> or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = <span style="border: 1px solid black; padding: 2px;">N/A</span> or less.
Open Terrain	<span style="border: 1px solid black; padding: 2px;">20</span>	<span style="border: 1px solid black; padding: 2px; color: red;">N/A</span>		
Tall Weeds and Crops	<span style="border: 1px solid black; padding: 2px;">1</span>		<span style="border: 1px solid black; padding: 2px;">N/A</span>	

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

QA performed Accuracy Calculations?

**Calculated Accuracies**

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy <sub>z</sub> ) Required FVA = 0.98 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = N/A or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = N/A or less.
Open Terrain	14	0.538		
Tall Weeds and Crops				
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated	14			N/A

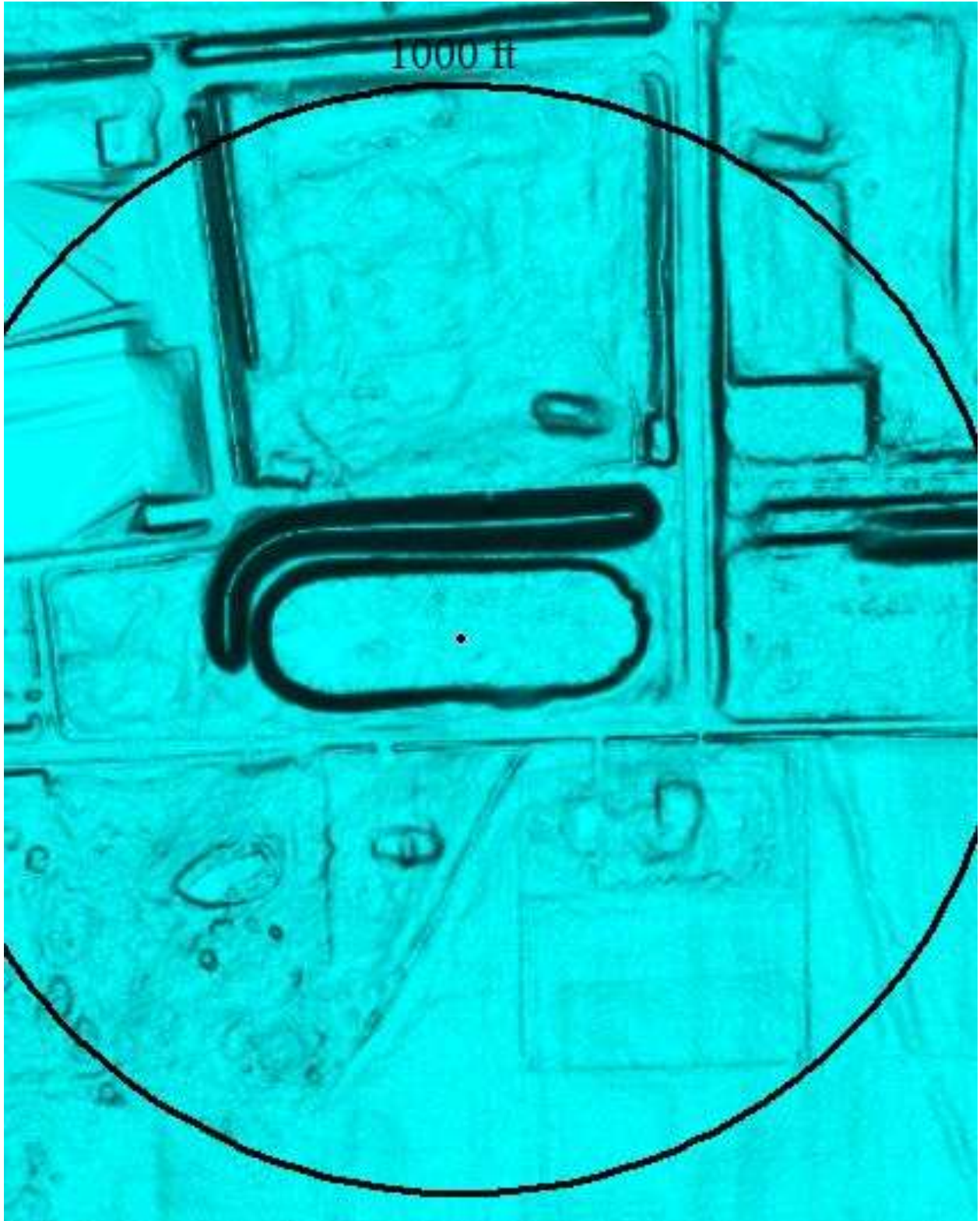
Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

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

**Bare-Earth DEM Anomalies, Errors, Other Issues**

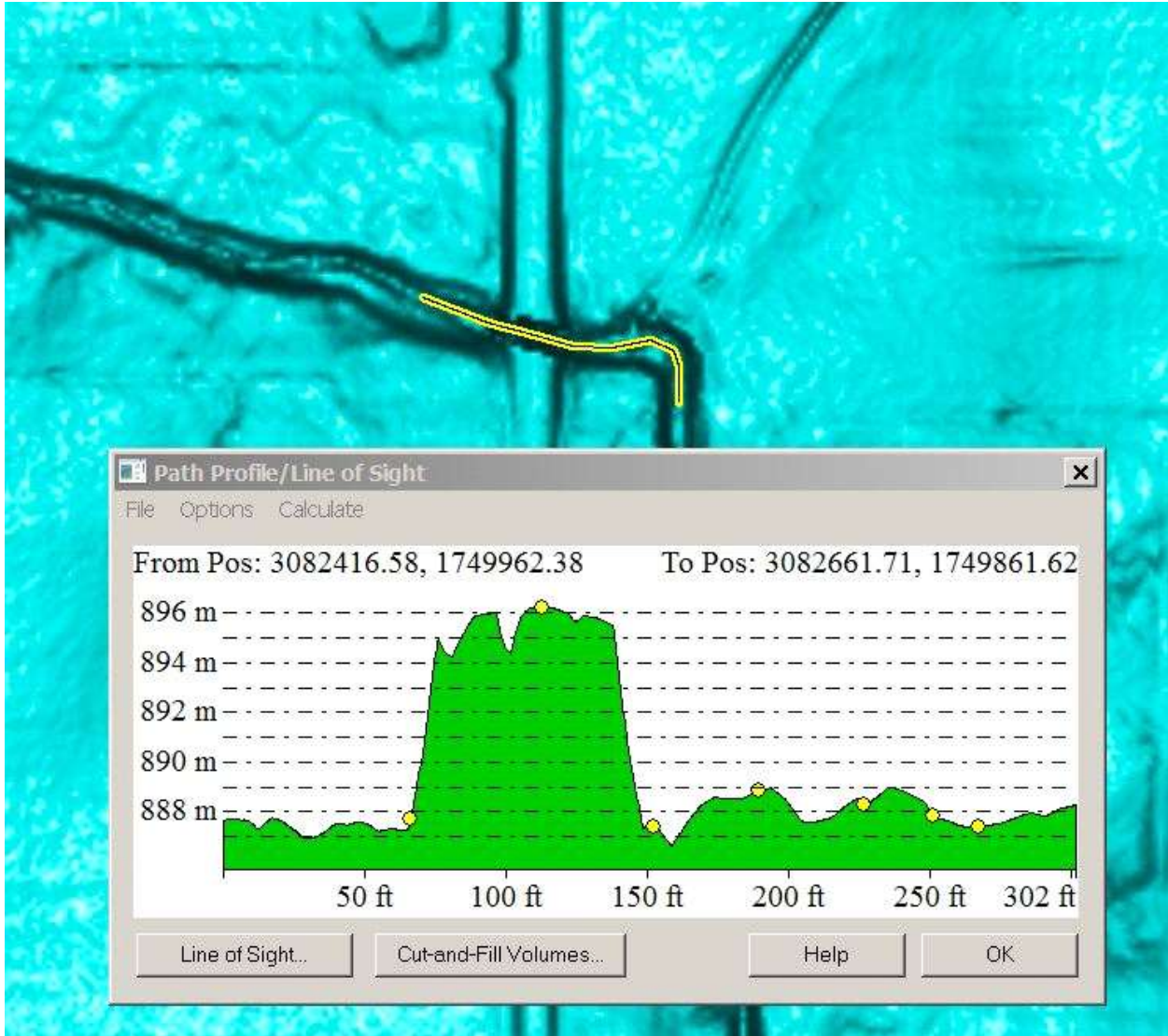
Errors, Anomalies, Other Issues to document?  Yes  No

Image?



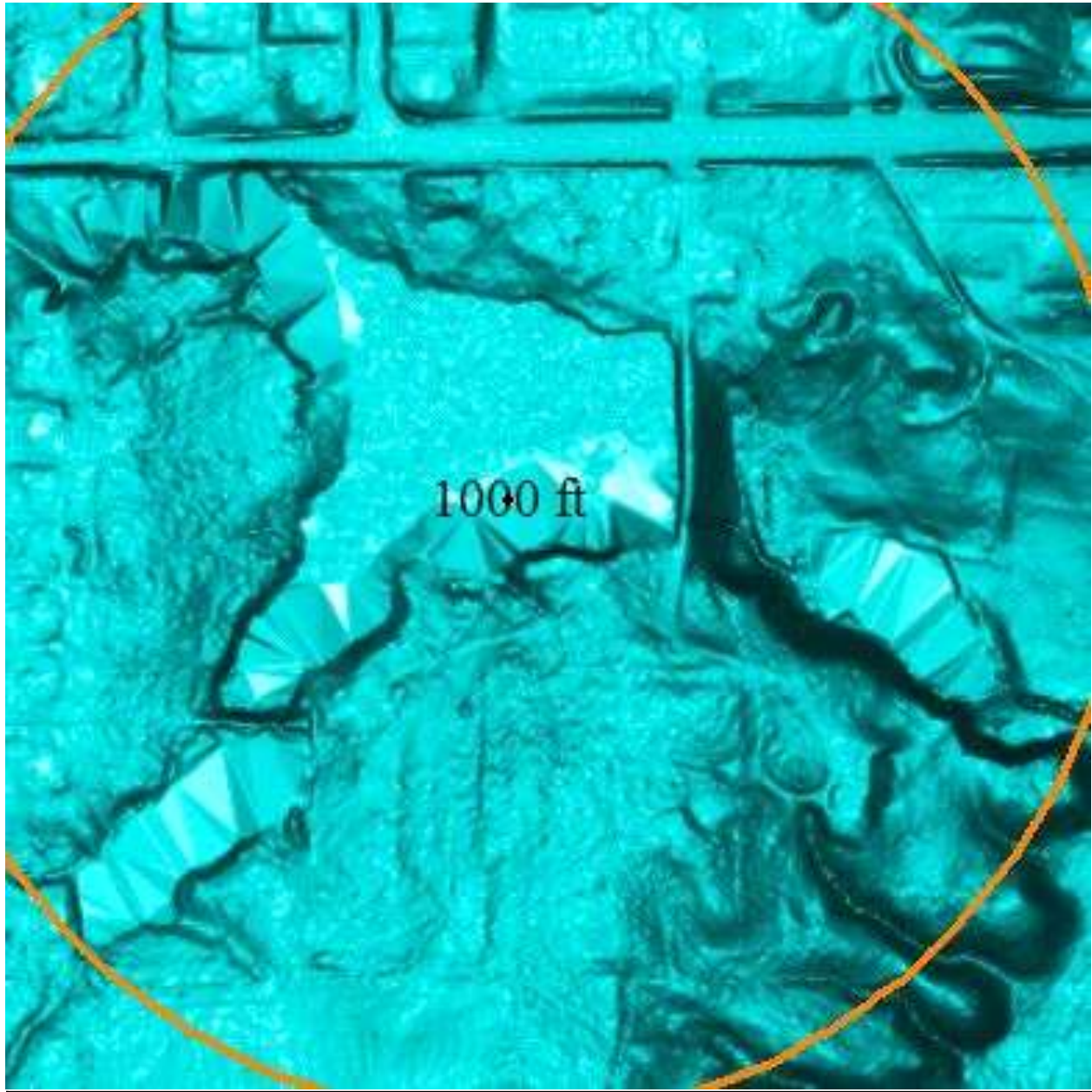
Water bodies larger than 2 acres need to be hydro flattened. Reviewer created a shapefile showing location of errors in the delivered DEMs. Shapefile is named DEM\_Errors\_BooneCo and is located in the NED\Errors folder. Scale as shown is approximately 1:6000. Radius of circle in shapefile is 1000 feet. DEM cell is in2011\_31501720\_12. Corrections performed in house, accepted 12/12/2013.

Image?



Road appears to be partially removed, indicating presence of a bridge. Fully remove bridge or restore surface of road. Reviewer created a shapefile showing location of errors in the delivered DEMs. Shapefile is named DEM\_Errors\_BooneCo and is located in the NED\Errors folder. Scale is approximately 1:2200. Cell is in2011\_30801745\_12. Corrections performed in house, accepted 12/12/2013.

Image?



Water bodies larger than 2 acres need to be hydro flattened. Reviewer created a shapefile showing location of errors in the delivered DEMs. Shapefile is named DEM\_Errors\_BooneCo and is located in the NED\Errors folder. Scale as shown is approximately 1:6500. Radius of circle in shapefile is 1000 feet. DEM cell is in2011\_31701710\_12. Corrections performed in house, accepted 12/12/13.

Internal Note:

**This is the end of the report.**

QA Form V1.4 12OCT11.xsn