LiDAR Quality Assessment Report

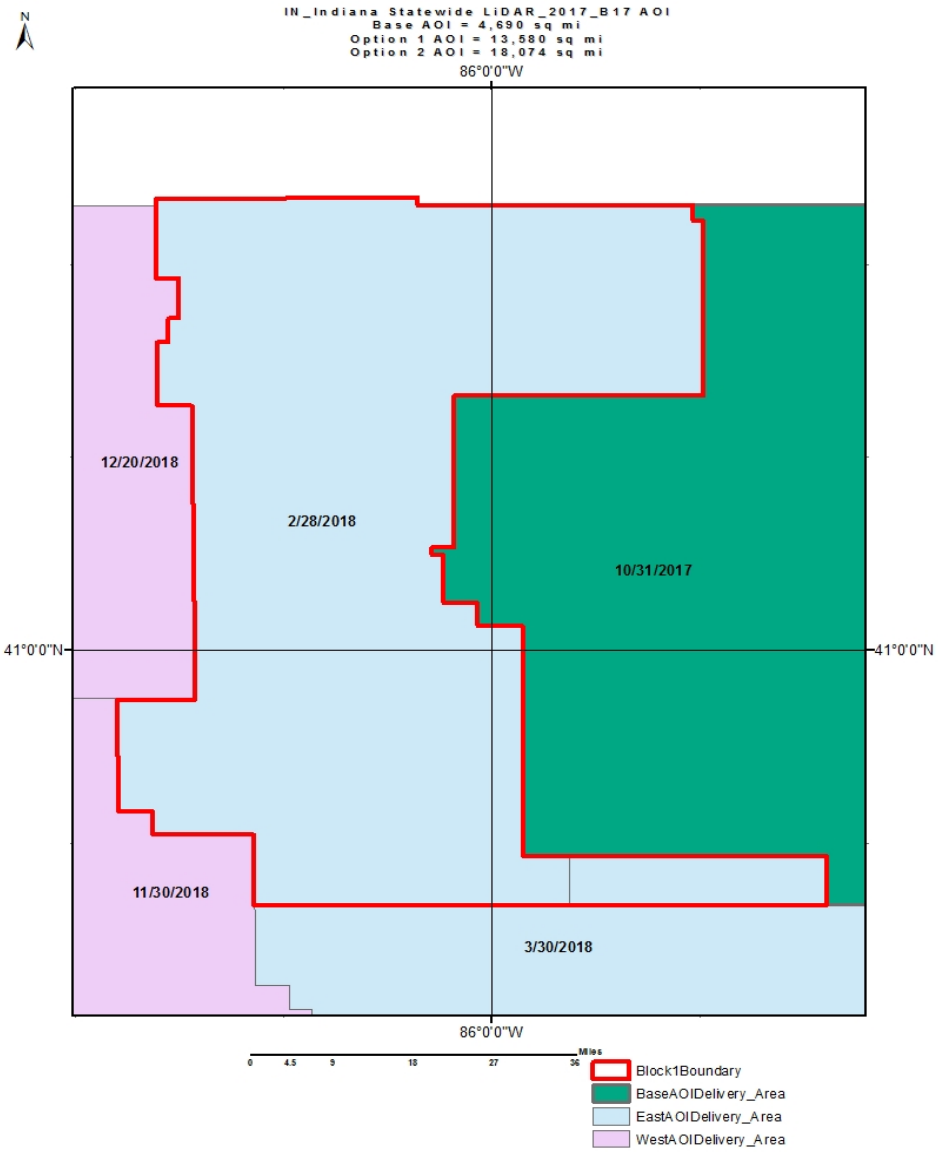
The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset. The 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.

IN_Statewide-Opt-B1_2017

NGTOC

2018-03-14

Sarah klaas



Project Information

Project: IN_Statewide-Opt-B1_2017

Contractor: Woolpert, Inc.

Project Type:
GPSC

Applicable Specification:
NGP LiDAR Base Specification V 1.2

Project Points of Contact:

Name:	Type:	Email:
Pat Emmett	CPT	pemmett@usgs.gov

REPORT QUALIFICATION SUMMARY:

Task Order Overall:
Meets Requirements

Metadata:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

Vertical Accuracy:
0 of 1 Reviews Accepted
0 Reviews Not Accepted

Swath/Raw LAS:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

Tiled/Classified LAS:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

Breakline:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

DEM(s):
1 of 1 Reviews Accepted
0 Reviews Not Accepted

NED Review:
1 of 1 DEM tile reviews recommended for NED 1/3rd
0 of 1 DEM tile reviews recommended for NED 1/9th

Project Subdivision: Lots

List Subdivision:
- 3 (Option 1 Block 1)
-

of: 12

Dates Collected Range:
Collection Start: *3/8/2017*
Collection End: *4/2/2017*

Project Aliases:

Licensing:
Public Domain

Project Description:

This task order is for Planning, Acquisition, processing, and derivative products of QL2 lidar data to be collected at an aggregate nominal pulse spacing (ANPS) of 0.7 meters, including overlap. Lidar data and derivative products produced in compliance with this task order are based on the ***"National Geospatial Program Lidar Base Specification Version 1.2",*** which are incorporated by reference to this task order. This specification may be viewed at ***http://pubs.usgs.gov/tm/11b4/.*** 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 1.2 specifications will be the required specification authority.

This task order requests spring 2017 (Base), fall/winter 2017 (Option 1) and spring 2018 (Option 2) LiDAR surveys to be collected over three (3) distinct Areas of

Interest (AOIs) in Indiana which cover approximately **36,344** square miles in total. This project will support the state of Indiana and the Natural Resources Conservation Service (NRCS) in Indiana. The Defined Project Area (DPA) and associated AOIs are delineated in “Attachment A” and are further defined in “Attachment B.” The execution of this task order is to be through the use of one (1) Base Order and two (2) Options.

- Base Order = Acquisition and Processing of Base AOI (4,690 sq mi)
- Option 1 = Acquisition and Processing of Option 1 AOI (13,580 sq mi).
- Option 2 = Acquisition and Processing of Option 2 AOI (18,074 sq mi).

USGS requests one proposal for the task order. Contractor shall supply a **Delivery Diagram** as defined in Section C.1.d.(vii) Delivery Diagram. The adjusted delivery diagram will replace the current diagram delineated in “Attachment C” of the executed task order. This project will require hydro-flattening.

Review Information

Reviewer:	Sarah klaas	*Date Delivered:*	3/2/2018
3rd Party QA Performed:	☐	*Date Assigned:*	3/2/2018

Action To Contractor Date:	*Issue Description:*	*Return Date:*
3/14/2018	*see report 14 DEM errors reported Metadata and Vertical Accuracy is pending final deliveries	4/3/2018
4/4/2018	Project acceptance relies upon Vertical Accuracy of all final deliverables and delivery of Metadata	

Review Complete:

3/14/2018

Dates Project Worked:

Start:	3/7/2018	4/4/2018
End:	3/14/2018	4/4/2018

Project Materials Received

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 Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

METADATA

Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
Collection Report:	☑		☑	*PDF*	*1*	
Survey Report:	☑		☑	*PDF*	*1*	delivered with the Base (blocks 1 & 2) delivery
Processing Report:	☑		☑	*PDF*	*1*	
QA/QC Report:	☐		☐	*Select...*	*1*	
Project Level XML Metadata:	☐		☐	*XML*		
Project Extent:	☑	☐	☑	*.shp*	*1*	
Tile Scheme:	☑	☐	☑	*.shp*	*1*	

Control (Calibration) Points:	☑	☐	☑	.shp	1	
Check (Validation) Points:	☑	☐	☑	.shp	1	
Additional Comments:	Metadata and reports for Blocks 1-5 will be delivered with Block 5 on June 30, 2018.					

LIDAR DATA

Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
Swath Data:	☑	☑	☐	.las	209	
Classified/ Tiled Data:	☑	☑	☑	.las	3,070	
Additional Comments:						

DERIVED DELIVERABLES

Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
DEM Tiles:	☑	☑	☑	IMG	3,070	
Breaklines:	☑	☑	☑	FGD	1	
Additional Comments:						

OTHER

Additional Comments:	

Geographic Information

Area Extent: 2753 *Sq. Miles*

Tile Size: 5000 x 5000 *Feet*

DEM/DTM Grid Spacing: 2.5 *U.S. Feet*

Coordinate Reference System:

StatePlane Indiana EastFIPS 1301

Projection: state plane

Horizontal Datum: NAD83_HARN
StatePlane Indiana EastFIPS 1301
○ Meters ◉ U.S. Feet ○ Int'l Feet

Vertical Datum: NAVD88
GEOID12B
○ Meters ◉ U.S. Feet ○ Int'l Feet

THIS PROJECTION COORDINATE REFERENCE SYSTEM IS CONSISTENT ACROSS THE FOLLOWING DELIVERABLES

- ☑ *Project Extent*
- ☑ *Project Tile Scheme*
- ☑ *Control Points*
- ☑ *Checkpoints*
- ☑ *Tiled/Classified XML Metadata*
- ☑ *Tiled/Classified LiDAR*
- ☑ *Swath/Raw LiDAR XML Metadata*
- ☑ *Swath/Raw LiDAR*
- ☑ *DEM(s)*
- ☑ *DEM XML Metadata*
- ☑ *Breakline(s)*
- ☑ *Breakline XML Metadata*

Additional Comments:

Collection Information

Quality Level: ***2***

Configured Nominal Pulse Spacing:

0.7 Meters

Additional Comments:

Metadata Review Accepted

Vendor 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.
Parser can be found @ http://geo-nsdi.er.usgs.gov/validation/

The Swath XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED: ☐

The Classified XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED: ☐

The DEM XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED: ☐

The Breakline XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED: ☐

Additional Comments: **Metadata and reports for Blocks 1-5 will be delivered with Block 5 on June 30, 2018. Metadata acceptance pending delivery**

Based on this review, the USGS accepts the xml metadata provided.

End of Metadata Review

Vertical Accuracy 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.

Required Vertical Accuracy

◉ *Yes* ○ *No*

REQUIRED NON-VEGETATED VERTICAL ACCURACY FOR SWATH AND DEM FILES

Required Unit:	Meters
Required # of checkpoints:	47
Required RMSEz:	.036
*Required Vertical Accuracy (RMSEz * 95th CI)*	0.071

REQUIRED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Required Unit:	Meters
Required # of checkpoints:	34
Required Vertical Accuracy (@ 95th percentile)	0.069

Additional Required Vertical Accuracy Information: Accuracy information will be delivered with Block 5 on June 30, 2018.

This delivery (Option 1 Block 1) contains 47 NVA and 34 VVA checkpoints.

This is delivery 3 of 12 for the entire state of Indiana. The number of required checkpoints was based on the **aggregate** square mileage of the entire state (36,344 sq mi) resulting in 607 NVA and 413 VVA checkpoints for the **entire** project. Check points are to be dispersed throughout the project to the extent possible where there is adequate access.

Reported Vertical Accuracy

○ *Yes* ◉ *No*

Vertical Accuracy information was not reported.

Reviewed Vertical Accuracy

◉ *Yes* ○ *No*

CHECKPOINT REVIEW

Checkpoints are well distributed? ☐

Enough checkpoints for task order? ☐

Checkpoints meet USGS LiDAR base-spec in quantity and quality? ☐

REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

Reviewed Unit: Select or type...

Reviewed # of checkpoints:

Reviewed RMSEz:

*Reviewed Vertical Accuracy (RMSEz * 95th CI)*

REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reviewed Unit: Select or type...

Reviewed # of checkpoints:

Reviewed RMSEz:

*Reviewed Vertical Accuracy (RMSEz * 95th CI)*

REVIEWED VEGETATED VERTICAL ACCURACY

Required Unit: Select or type...

Required # of checkpoints:

Reviewed Vertical Accuracy (95th percentile)

Checkpoint Distribution Image

Vertical Accuracy Results:

Additional Reviewed Vertical Accuracy Information: **Vertical Accuracy is pending entire delivery of total project lots**

Based on this review, the USGS Select... the vertical accuracy.

End of Vertical Accuracy Review

Raw-Swath LiDAR Review Accepted

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 Non-Vegetated Vertical Accuracy using ground control checkpoints measured in clear open terrain (*see Vertical Accuracy Review Section*).

Review Required: ◉ *Yes* ○ *No*

RAW-SWATH LIDAR FILE CHARACTERISTICS

☑ *Separate folder for swath/raw LiDAR files*

LAS Version: 1.4

Point Record Format: Select...

*If specified, *.wpd files for full waveform data have been provided:* Select...

☑ *Correct and properly formatted georeference information is included in all LAS file headers, including the use of OGC 2001 Well Known Text (WKT).*

☐ *Adjusted GPS time used with the global encoder id set to 1*

global encoder is set to 17

Additional comments:

Based on this review, the USGS accepts the swath/raw LiDAR data.

End of Swath/Raw LiDAR Review

Tiled/Classified LiDAR Review Accepted

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. Classified LAS Tiles are comprised as follows, "all project swaths, returns, and collected points, fully calibrated, adjusted to ground, and classified and cut, by tiles, excluding calibration swaths, cross-ties, and other swaths not used, or intended to be used, in product generation".

Review Required: ◉ *Yes* ○ *No*

CLASSIFIED LIDAR TILE CHARACTERISTICS

☑ *Separate folder for classified/tiled LiDAR files*

LAS Version: 1.4

Point Record Format: 6

*If specified, *.wpd files for full waveform data have been provided:* Not Required

☑ *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*

☑ *Correct and properly formatted georeference information is included in all LAS file headers, including the use of OGC 2001 Well Known Text (WKT).*

☐ *Adjusted GPS time used with the global encoder id set to 1*

global encoder is set ot 17

☑ *Classified LAS tile files have no points classified as '12' (Overlap) and correctly use overlap bit.*

☑ *Point classifications are limited to the standard values listed below:*

Code	Description	Used
1	Processed, but unclassified	☑
2	Bare-earth/Ground	☑
7	Noise (low, manually identified, if needed)	☑
8	Model key points	☐
9	Water	☑
10	Ignored ground (breakline proximity)	☑
11	Withheld (if the "Withheld Bit" is not implemented in the processing software	☐
17	Bridges	☑
18	Noise (high, manually identified, if needed)	☑

Additional comments:

Based on this review, the USGS accepts classified/tiled LiDAR data.

End of Tiled/Classified LiDAR Review

Breakline Review Accepted

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

Review Required: ◉ *Yes* ○ *No*

BREAKLINE FILE CHARACTERISTICS:

☑ Separate folder for breakline files.

☑ Breaklines contain elevation values.

Elevation values stored in Geometery (ZEnabled) .

Units: U.S. Feet

☑ Waterbody Breaklines.

Polyline ☐ Polygon ☑

☑ Single elevation value per waterbody feature.

☑ Required.

Waterbody Elevations were created via Mean waterbody level techniques.

☑ Double Line Stream Breaklines (Streams Approximately > 100 ft).

Polyline ☑ Polygon ☐

Downstream DLS Flow is Stairstepped .

☑ Required.

☐ Single Line Breaklines.

☑ No missing or misplaced breaklines.

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

End of Breakline Review

DEM Review Accepted

The derived bare-earth file(s) receive a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by the USGS using supplied and independent checkpoints (*see the prior Vertical Accuracy Review Section*), and a thorough visual review for any anomalies or inconsistencies in assessing the quality of the DEM(s).

BARE-EARTH DEM TILE CHARACTERISTICS:

☑ Separate folder for bare-earth DEM files

Raster File Type: IMG

Raster Cell Size: 2.5 U.S. Feet

Tile bit depth/pixel Type: Select or type...

Interpolation or Resampling Technique: Triangulated Irregular Network (TIN)

☑ DEM tiles do not overlap

☑ DEM tiles conform to Project Tiling Scheme

☑ Quantity of DEM files conforms to Project Tiling Scheme

☑ DEM tiles are uniform in size

☑ DEM tiles properly edge match and free of edge artifacts

☑ Tiles are free from Spikes and Pits

☑ Tiles are free from Data Holidays (*voids due to processing or collection errors*)

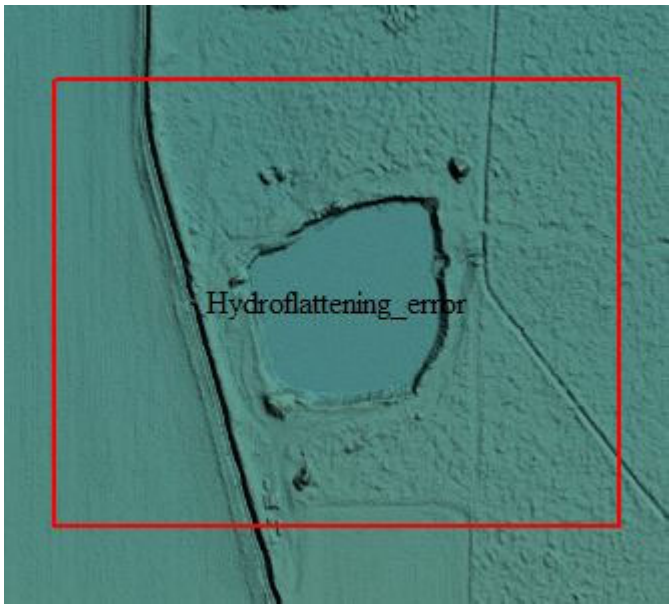
☑ Tiles do not exhibit systematic sensor error or cornrowing

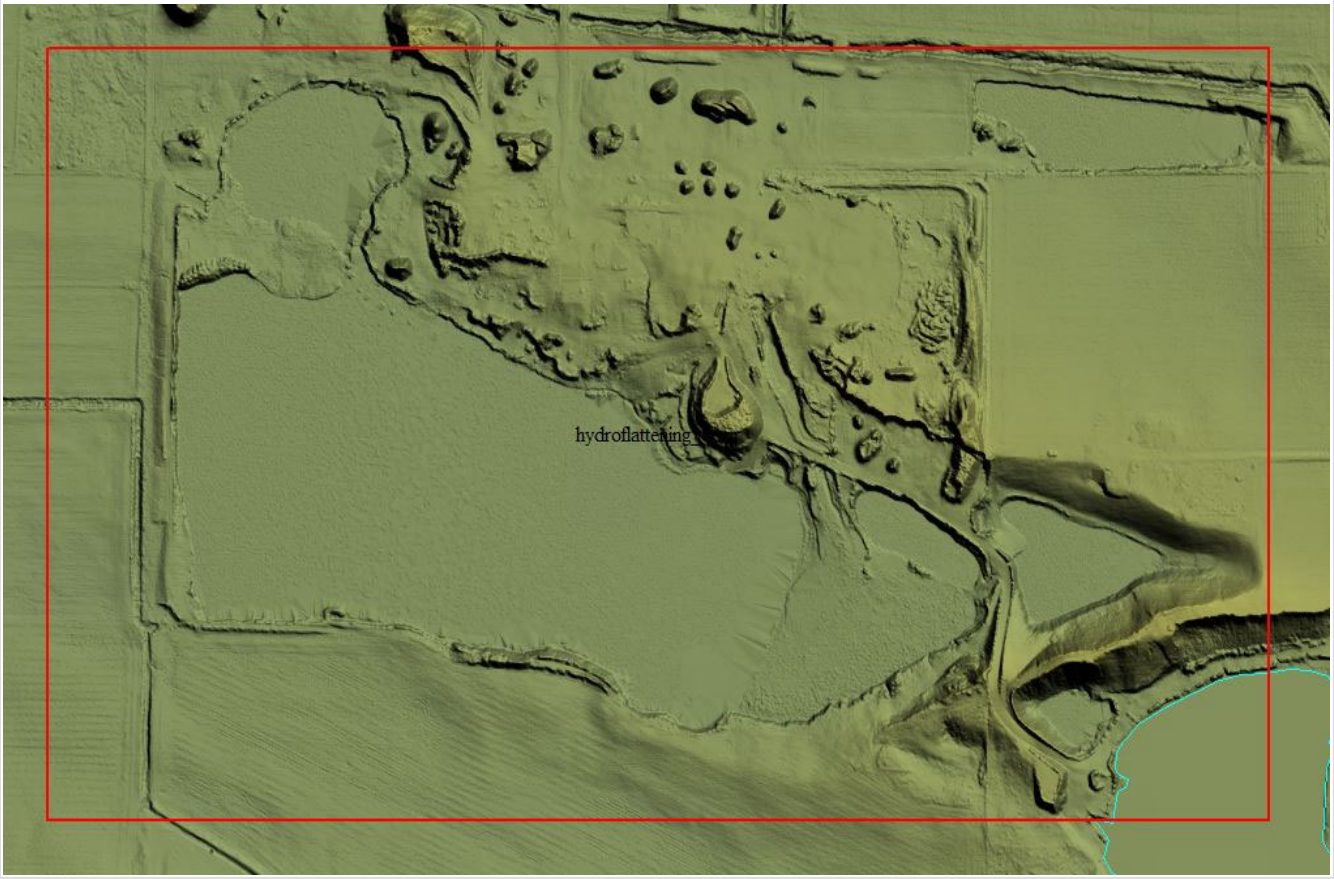
Hydro Treatment: hydro-flattened

DEM tiles are properly Hydro Flattened ◉ Yes ○ No

☐ Waterbodies 2 Acres or greater are flattened

Two waterbodies larger than 2 acres were not hydroflattened (3/14/2018) **Corrected 4/4/2018**





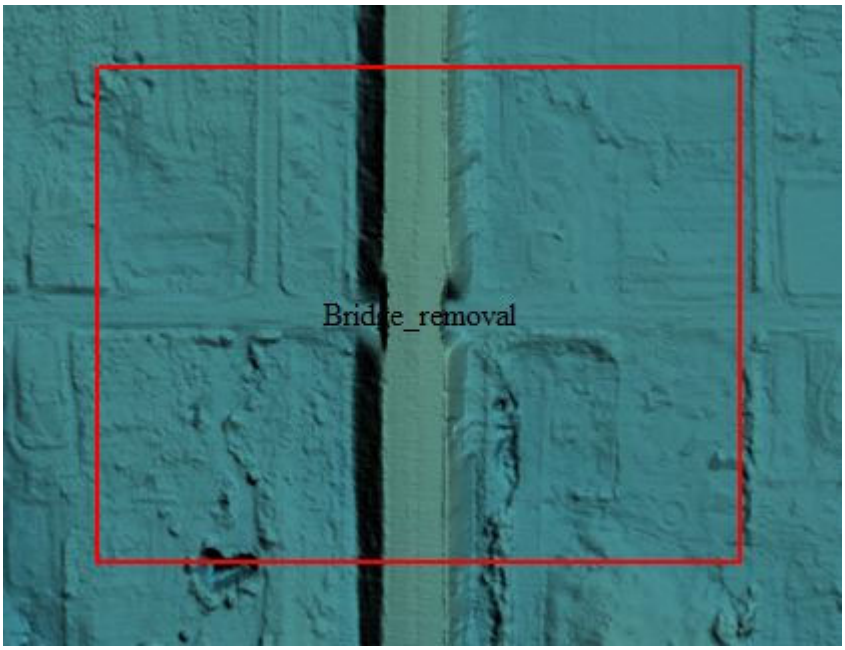
☑ Streams 100 ft. or greater are flattened in a downstream manner

☑ Tidal Boundaries/Shorelines are flattened

☑ No missing islands 1 Acre or larger

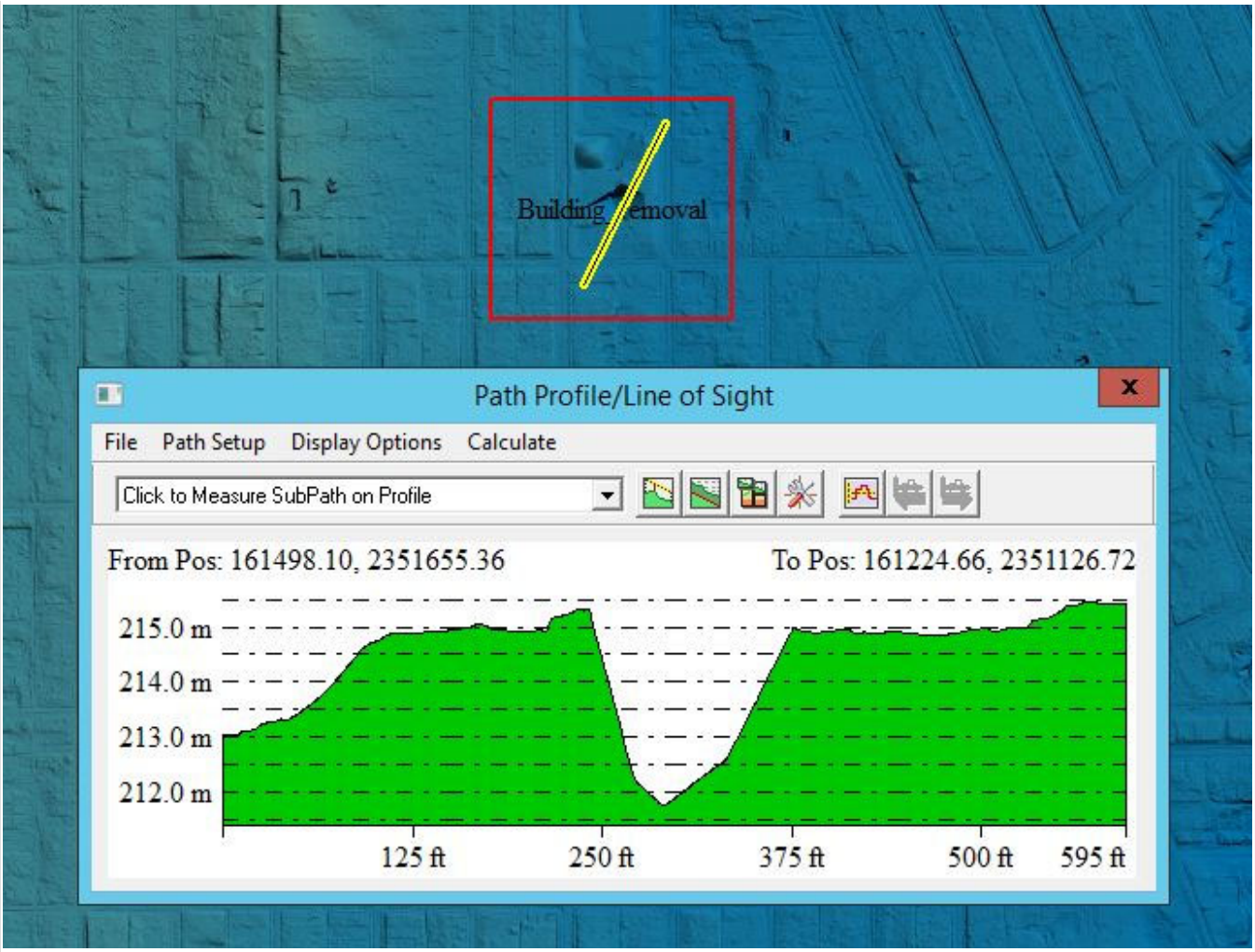
☐ Bridges/Overpasses are properly removed

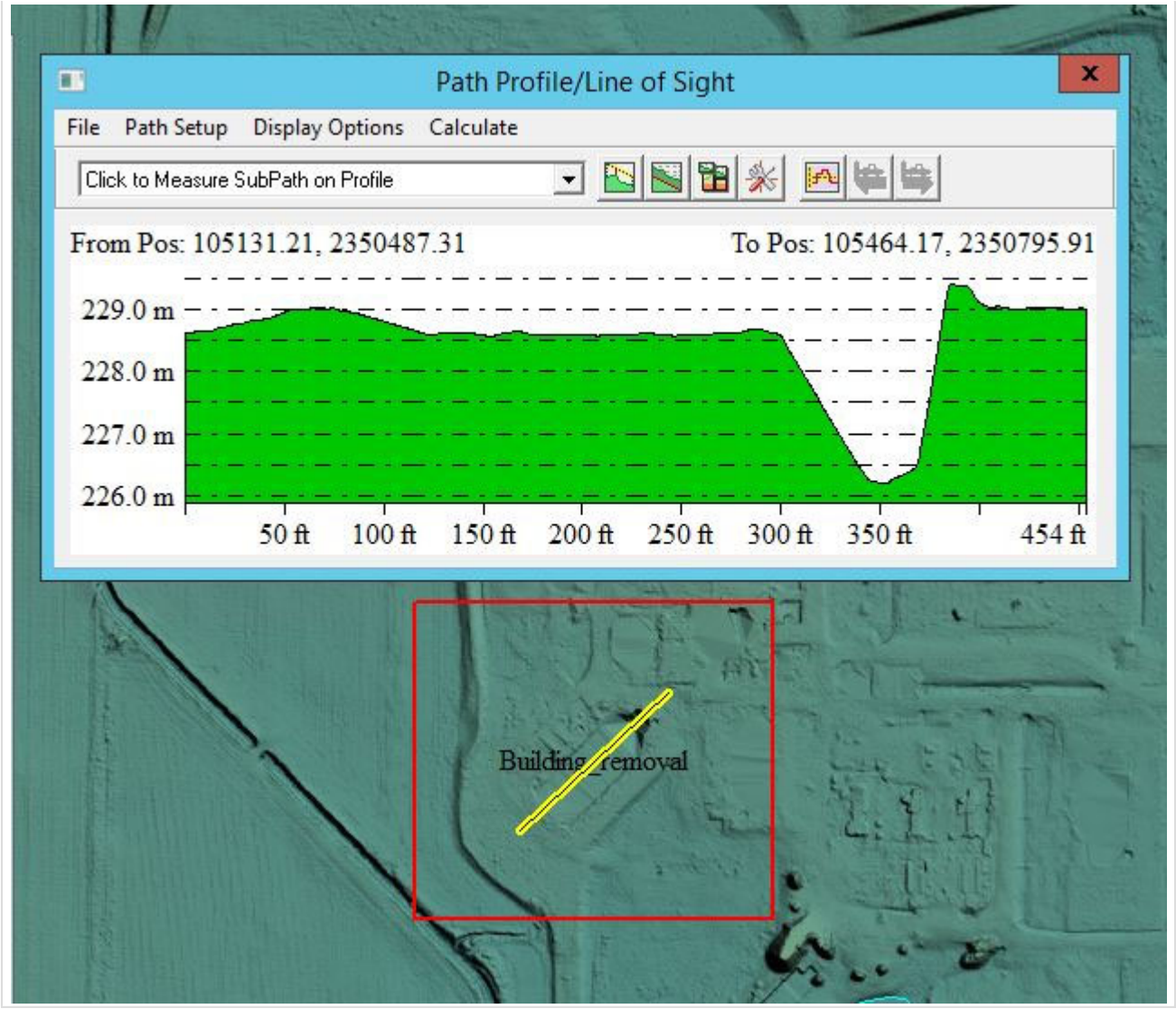
4 Bridges were not removed, two examples of this error can be seen below. (3/14/2018)
Corrected 4/4/2018



- [x] Culverts are maintained (Not Hydro Enforced)
- [x] Depressions, Sinks, are not filled in (Not Hydro Conditioned)
- [x] Vegetation properly removed
- [ ] Manmade structures properly removed

8 building removal errors were found, please try to make the ground surface more even where buildings have been removed. (3/14/2018) **Corrected 4/4/2018**


Building Removal
Path Profile/Line of Sight
File
Path Setup
Display Options
Calculate
Click to Measure SubPath on Profile
From Pos: 161498.10, 2351655.36
To Pos: 161224.66, 2351126.72
215.0 m
214.0 m
213.0 m
212.0 m
125 ft
250 ft
375 ft
500 ft
595 ft



Tiles recommended for NED 1/3rd: (•) Yes. ( ) No.
Tiles recommended for NED 1/9th: ( ) Yes. ( ) No.
Tiles recommended for NED 1 Meter: (•) Yes. ( ) No.
LAS dataset recommended for distribution: tile classified

Based on this review, the USGS accepts the DEM tiles.

End of DEM Review

Based on this review, the provided delivery Meets the Contract and/or Task Order requirements.
Additional Comments:

INTERNAL COMMENTS

END OF REPORT (v2.4.0)