# LiDAR Quality Assessment Report

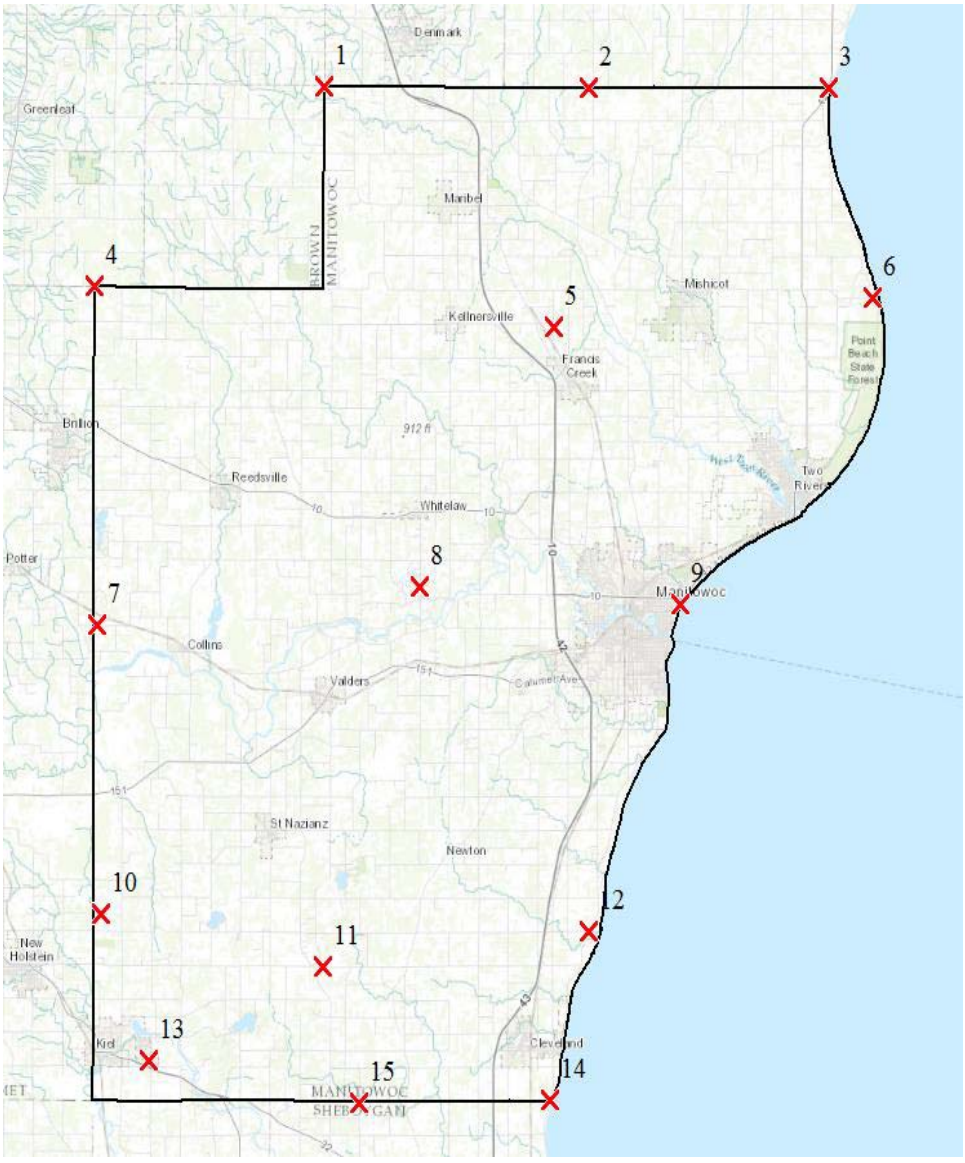
The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset. The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

**WI_MonitowacCo_2015**

NGTOC

2017-02-03

Jessica Self



# Project Information

*Project:* WI_MonitowacCo_2015

*Contractor:* Ayres Associates

*Project Type:*
*Partnership*

*Applicable Specification:*
*NGP LiDAR Base Specification V 1.2*

*Project Points of Contact:*

| ***Name:*** | ***Type:*** | ***Email:*** |
|---|---|---|
| Claire Devaughn/Ron Wencl | NGP Liaison | cdevaugh@usgs.gov rwencl@usgs.gov |

## REPORT QUALIFICATION SUMMARY:

***Task Order Overall:***
*Meets Requirements*

***Metadata:***
1 of 1 Reviews Accepted
0 Reviews Not Accepted

***Vertical Accuracy:***
1 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
Final to NED mosaic(s) created
Mosaic(s) recommended for NED 1/3rd
Mosaic(s) recommended for NED 1/9th

*Project Subdivision:* Select...

*Dates Collected Range:*
*Collection Start:* *11/2/2015*
*Collection End:* *11/10/2015*

*Project Aliases:*

*Licensing:*
Public Domain

*Project Description:*
The LiDAR project boundary covers approximately 602 square miles and entirely covers Manitowoc County, Wisconsin. . A buffer of 100 meters was created for the area.

## Review Information

| | | | |
|---|---|---|---|
| *Reviewer:* | Jessica Self | *Date Delivered:* | |
| *3rd Party QA Performed:* | ☐ | *Date Assigned:* | 1/11/2017 |

| *Action To Contractor Date:* | *Issue Description:* | *Return Date:* |
|---|---|---|
| 5/26/2017 | | |

***Review Complete:***

2/3/2017

Dates Project Worked:

| | | |
|---|---|---|
| Start: | 1/11/2017 | 5/26/2017 |
| End: | 2/3/2017 | 5/26/2017 |

## 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* | |
| *Processing Report:* | ☑ | | ☑ | *PDF* | *1* | |
| *QA/QC Report:* | ☑ | | ☑ | *PDF* | *1* | |
| *Project Level XML Metadata:* | ☑ | | ☑ | *XML* | *1* | |
| *Project Extent:* | ☑ | ☑ | ☐ | *.shp* | *1* | |
| *Tile Scheme:* | ☑ | ☐ | ☑ | *.shp* | *1* | |
| *Control (Calibration) Points:* | ☐ | ☐ | ☐ | *Select...* | *0* | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Check (Validation) Points:* | ☑ | ☐ | ☑ | .shp | 1 | |
| *Additional Comments:* | | | | | | |

### LIDAR DATA

| Deliverables | Delivered | XML Metadata | Required | Format | Quantity | Additional Details |
|---|---|---|---|---|---|---|
| *Swath Data:* | ☑ | ☑ | ☑ | .las | 61 | |
| *Classified/ Tiled Data:* | ☑ | ☑ | ☑ | .las | 909 | |
| *Additional Comments:* | | | | | | |

### DERIVED DELIVERABLES

| Deliverables | Delivered | XML Metadata | Required | Format | Quantity | Additional Details |
|---|---|---|---|---|---|---|
| *DEM Tiles:* | ☑ | ☑ | ☑ | IMG | 910 | |
| *Breaklines:* | ☑ | ☑ | ☑ | .shp | 1 | |
| *Additional Comments:* | | | | | | |

### OTHER

| | |
|---|---|
| *Additional Comments:* | |

## Geographic Information

*Area Extent:* 606.1 *Sq. Miles*

*Tile Size:* 4500 *Feet*

*DEM/DTM Grid Spacing:* 2 *U.S. Feet*

*Coordinate Reference System:*

NAD_1983_2011_WISCRS_Manitowoc_Feet

*Projection:* Transverse Mercator

*Horizontal Datum:* NAD83 ○ Meters ◉ U.S. Feet ○ Int'l Feet

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

**THIS PROJECTION COORDINATE REFERENCE SYSTEM IS CONSISTENT ACROSS THE FOLLOWING DELIVERABLES**

- ☑ *Project Extent*
- ☑ *Project Extent XML Metadata*
- ☑ *Project Tile Scheme*
- ☑ *Checkpoints*
- ☑ *Project Level XML Metadata*
- ☑ *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:***

.70 Meters

***Sensor Information:***

*Sensor Type:* Select...

*Sensor Used:* Optech Orion H300

*Configured Scan Angle ± from nadir:* 19 *Degrees*

***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 Project Level XML Metadata parsed without errors.***

*Check if 'Best Use' metadata for NED:* ☑

***The Project Extent XML Metadata parsed select... errors.***

*Check if 'Best Use' metadata for NED:* ☐

***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:*

5/26/2017
The following xml metadata issues were corrected by the reviewer.
- PDRF Format is 1 in metadata instead of 6.
- SWATH xml metadata has class "1 - Processed, but Unclassified"
should be "0 - Processed, but Unclassified"

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

End of Metadata Review

## Vertical Accuracy Review Accepted

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:* | U.S. Feet |
| *Required # of checkpoints:* | 40 |
| *Required RMSEz:* | .328 |
| *Required Vertical Accuracy (RMSEz * 95th CI)* | 0.643 |

**REQUIRED VEGETATED VERTICAL ACCURACY FOR DEM FILES**

| | |
|---|---|
| *Required Unit:* | U.S. Feet |
| *Required # of checkpoints:* | 30 |
| *Required Vertical Accuracy (@ 95th percentile)* | 0.965 |
| *Additional Required Vertical Accuracy Information:* | |

## Reported Vertical Accuracy

◉ *Yes* ○ *No*

### REPORTED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

| | |
|---|---|
| *Reported Unit:* | U.S. Feet |
| *Reported # of checkpoints:* | 45 |
| *Reported RMSEz:* | 0.155 |
| *Reported Vertical Accuracy (RMSEz * 95th CI)* | 0.303 |

### REPORTED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

| | |
|---|---|
| *Reported Unit:* | U.S. Feet |
| *Reported # of checkpoints:* | 45 |
| *Reported RMSEz:* | 0.154 |
| *Reported Vertical Accuracy (RMSEz * 95th CI)* | 0.302 |

### REPORTED VEGETATED VERTICAL ACCURACY FOR DEM FILES

| | |
|---|---|
| *Reported Unit:* | U.S. Feet |
| *Reported # of checkpoints:* | 35 |
| *Reported Vertical Accuracy (95th percentile)* | 0.501 |
| *Additional Reported Vertical Accuracy Information:* | |

# 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:* | U.S. Feet |
| *Reviewed # of checkpoints:* | 45 |
| *Reviewed RMSEz:* | .151 |
| *Reviewed Vertical Accuracy (RMSEz * 95th CI)* | 0.296 |

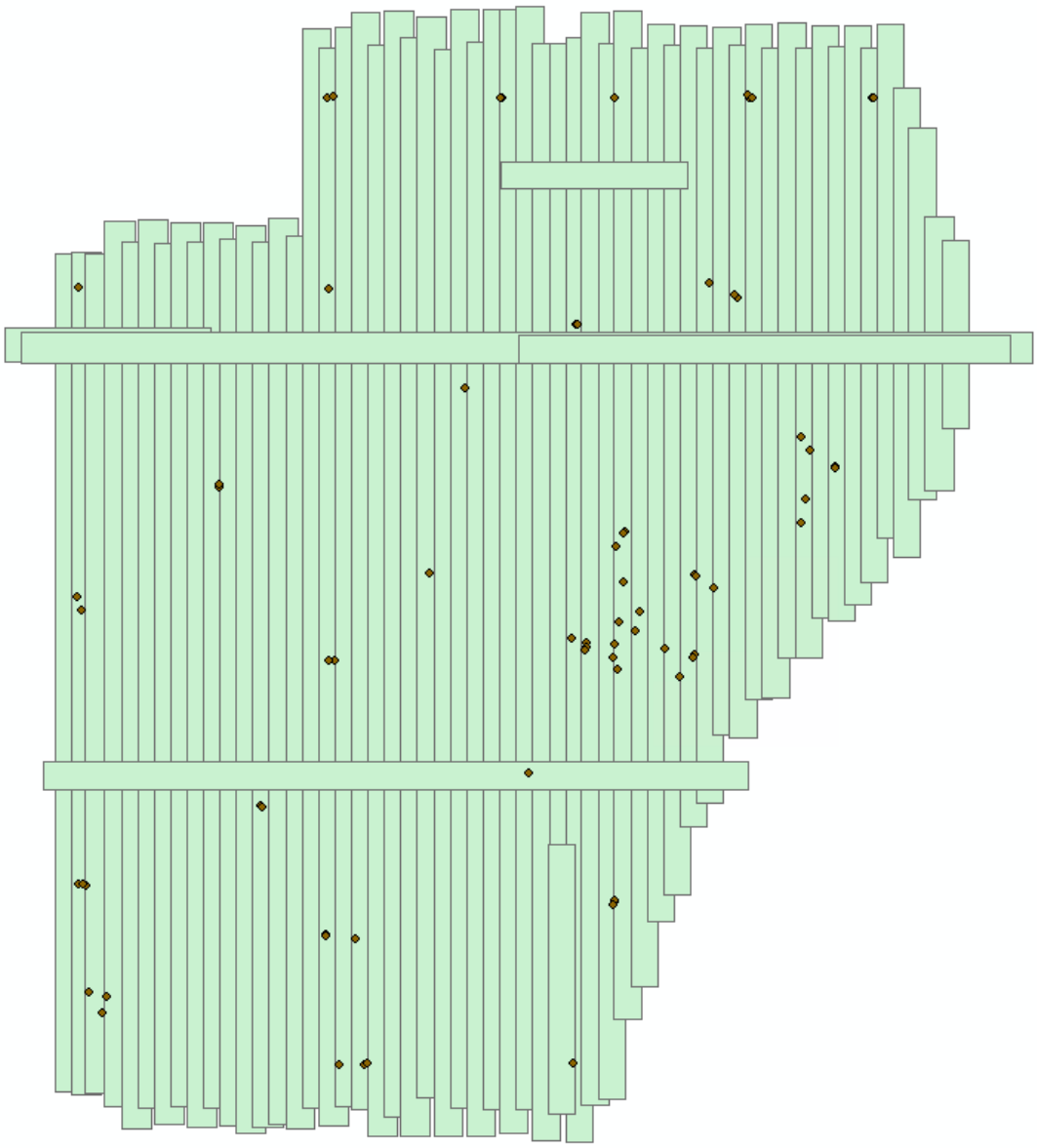
## REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

| | |
|---|---|
| *Reviewed Unit:* | U.S. Feet |
| *Reviewed # of checkpoints:* | 45 |
| *Reviewed RMSEz:* | .156 |
| *Reviewed Vertical Accuracy (RMSEz * 95th CI)* | 0.306 |

## REVIEWED VEGETATED VERTICAL ACCURACY

| | |
|---|---|
| *Required Unit:* | U.S. Feet |
| *Required # of checkpoints:* | 30 |
| *Reviewed Vertical Accuracy (95th percentile)* | 0.519 |

Checkpoint Distribution Image



*Vertical Accuracy Results:*

*Additional Reviewed Vertical Accuracy Information:*

**Based on this review, the USGS accepts 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:* 6

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

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

Corrected 5/26/2017
WKT is missing authority tags

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

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).*

Corrected 5/26/2017
WKT is missing authority tags

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

Set to 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 Classes:***

| *Class* | *Description* |
|---|---|
| 5 | *Vegetation (High)* |
| 6 | *Building* |

*Additional comments:*

- 3 Classified las tiles (208.las, 335.las, 342.las) have a GPS Time Min set to 0.

- 4 Classified las tiles (22.las, 133.las, 172.las, 584.las) have an XYZ Offset greater than 0.
  Tiles render correctly in LP360.

***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 Geometry and Attribute Table .

Units: U.S. Feet

☑ Waterbody Breaklines.

Polyline ☑ Polygon ☐

☑ Single elevation value per waterbody feature.

☑ Required.

Waterbody Elevations were created via Unknown waterbody level techniques.

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

Polyline ☑ Polygon ☐

Downstream DLS Flow is Not Applicable .

☑ 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 U.S. Feet

Tile bit depth/pixel Type: 32_BIT_FLOAT

Interpolation or Resampling Technique: Select...

☑ 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

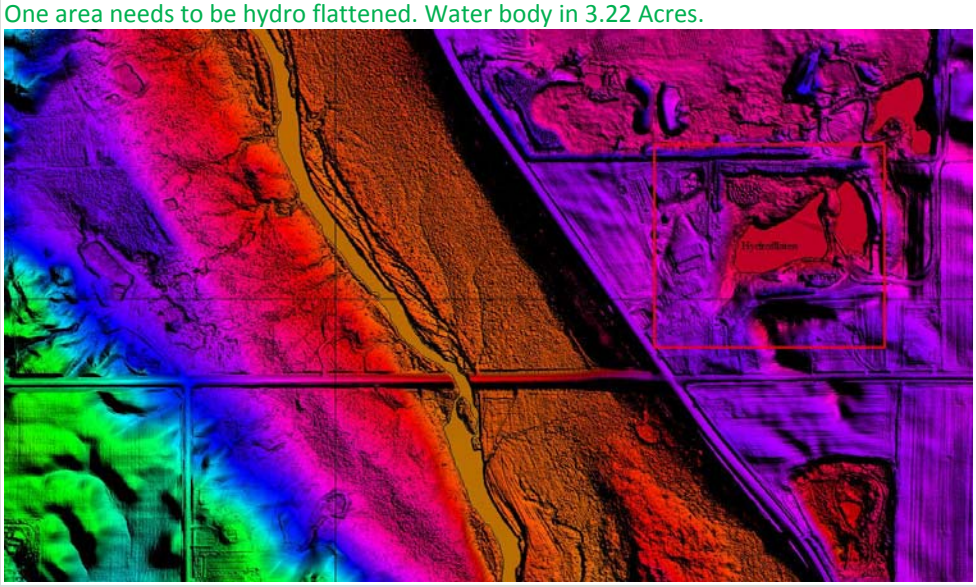
**Hydro Treatment:** hydro-flattened

DEM tiles are properly Hydro Flattened ○ Yes ◉ No

☐ Waterbodies 2 Acres or greater are flattened

Corrected 5/26/2017

One area needs to be hydro flattened. Water body in 3.22 Acres.



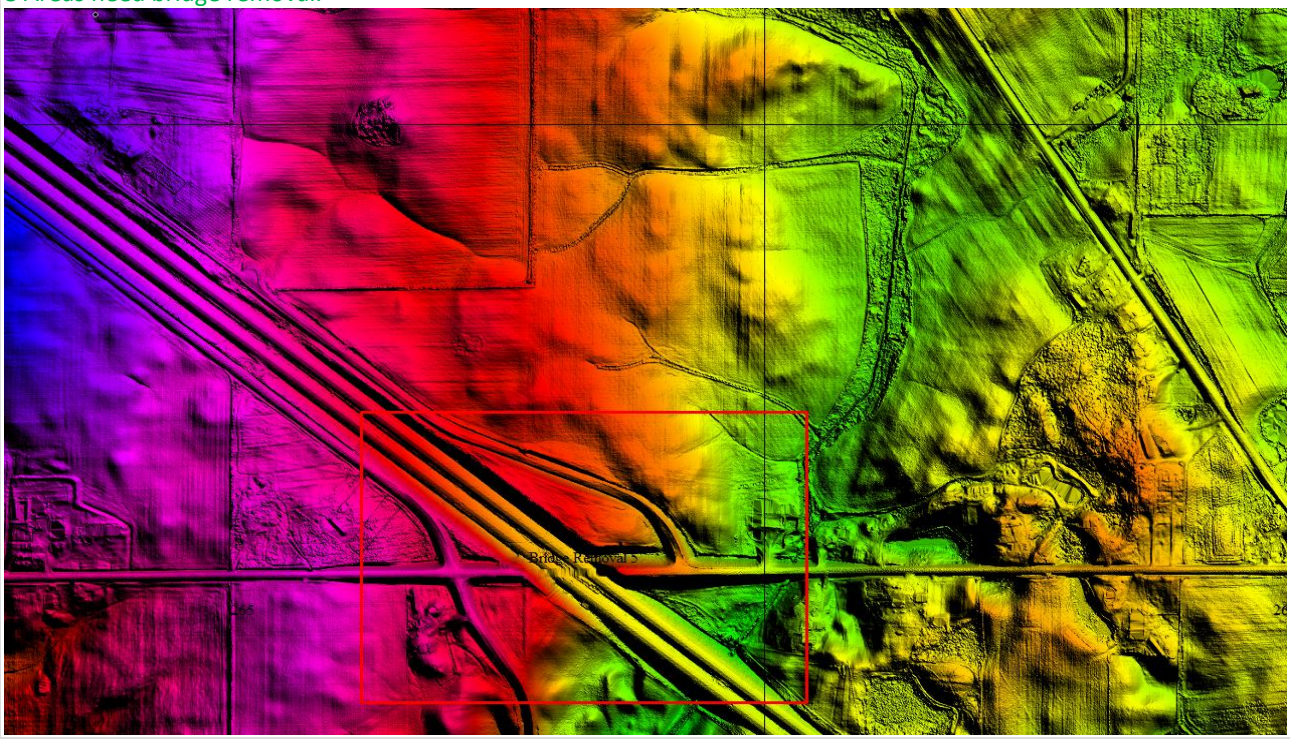
☑ Streams 100 ft. or greater are flattened in a downstream manner

☑ Tidal Boundaries/Shorelines are flattened

☑ No missing islands 1 Acre or larger

☐ Bridges/Overpasses are properly removed

Corrected 5/26/2017
8 Areas need bridge removal.




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

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)