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.

MO_Nodaway_2013

NGTOC

2014-08-19

Michael Bradford

Project Information

Project: MO_Nodaway_2013

Contractor: Surdex

Project Type: Partnership

Applicable Specification: NGP LiDAR Base Specification V 1.0

Project Points of Contact:

Name:	Type:	Email:
William Sneed	NSDI Liaison	wsneed@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
1 of 1 DEM tile reviews recommended for NED 1/9th

Project Delivery Lots: None

Dates Collected Range:
Collection Start: 12/2/2013
Collection End: 4/11/2014

Project Aliases:
MO/AR Counties Lidar Project Area

Licensing:
Public Domain

Project Description:
The St. Louis District of the United States Army Corps of Engineers (USACE) contracted with Surdex Corporation in the fall of 2013 to collect high resolution LiDAR elevation data over multiple counties as part of the Missouri & Arkansas Counties Lidar Project. The project combines the varied interests of the NRCS, DNR, USGS & USACE totaling over 20,200 square miles of coverage. This report covers the collection of LiDAR data over 793 square miles in Nodaway County in Missouri. The average laser ground sample distance required for this area is 1.0 meters.

Review Information

Reviewer:	Michael Bradford	*Date Delivered:*	7/21/2014
3rd Party QA Performed:	☐	*Date Assigned:*	7/22/2014

Action To Contractor Date:	***Issue Description:***	***Return Date:***
8/19/2014		10/10/2014

Review Complete:
8/19/2014

Dates Project Worked:

Start:	7/22/2014	8/8/2014
End:	7/23/2014	8/19/2014

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:	☐		☐	*Select...*	0	
Project Level XML Metadata:	☐		☐	*XML*	5	
Project Extent:	☐	☐	☐	*.shp*	0	
Tile Scheme:	☐	☐	☐	*.shp*	1	
Control (Calibration) Points:	☐	☐	☐	*.shp*	1	

Check (Validation) Points:	☐	☐	☐	.shp	1	
Additional Comments:						

LIDAR DATA

Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
Swath Data:	☐	☐	☐	.las	65	Split up, 26 in one folder, 39 in the other.
Classified/ Tiled Data:	☐	☐	☐	.las	104	Bare Earth
Additional Comments:						

DERIVED DELIVERABLES

Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
DEM Tiles:	☐	☐	☐	IMG	104	
Breaklines:	☐	☐	☐	.shp	1	
Additional Comments:						

OTHER

Additional Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
First Return	☐	☐	☐	.las	104	
Accuracy	☐	☐	☐	Excel	3	
MO North Boundary	☐	☐	☐	.shp	1	
Swath Path	☐	☐	☐	.shp	1	
Additional Comments:						

Geographic Information

Area Extent: 723.67 *Sq. Miles*

Tile Size: 4500 x 4500 *Meters*

DEM/DTM Grid Spacing: 1 *Meters*

Coordinate Reference System:

UTM Zone 15 NAD83, NAVD88 Geoid12A, meters

Projection: 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 Tile Scheme*
- [ ] *Control Points*
- [ ] *Checkpoints*
- [ ] *Project Level XML Metadata*
- [ ] *Tiled/Classified XML Metadata*
- [ ] *Tiled/Classified LiDAR*
- [ ] *Swath/Raw LiDAR XML Metadata*
- [ ] *Swath/Raw LiDAR*
- [ ] *DEM(s)*
- [ ] *Breakline(s)*
- [ ] *Breakline XML Metadata*

Additional Comments:

Collection Information

Configured Project Nominal Pulse Spacing:

1 Meters

Detailed Date(s) Collected:

Start Date: 12/2/2013 *End Date:* 12/17/2013

Details:

Start Date: 1/23/2014 *End Date:* 1/23/2014

Details: *reflight lines captured*

Start Date: 4/11/2014 *End Date:* 4/11/2014

Details: *reflight lines captured*

Sensor Information:

Sensor Type: Aerial

Sensor Used: Leica ALS70-IIHP multi-pulse sensor

Configured Scan Angle ± from nadir: 40 *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 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 Breakline XML Metadata parsed without errors.
Check if 'Best Use' metadata for NED: ☐

Additional Comments:

All provided metadata state that it is for Shannon County, not Nodaway County. Correct metadata needs to be provided.
*Vendor corrected issue, corrected metadata provided 11/24/14

Project level metadata was not provided, needs to be delivered.
*Project level metadata still not provided as of 11/24/14
*Vendor corrected issue, project level metadata provided 11/25/14

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 FUNDAMENTAL VERTICAL ACCURACY FOR SWATH AND DEM FILES

Confidence Interval Required: 95 th % CI

Required Unit: Centimeters

Required # of checkpoints: 20

Required RMSEz: 15.0

*Required Vertical Accuracy (RMSEz * .% CI)* 29.4

REQUIRED SUPPLEMENTAL VERTICAL ACCURACY FOR DEM FILES

SVA Statistic Required: Percentile

SVA Confidence Level/Percentile Required: 95

Class	# of Checkpoints	SVA Required 95 th Percentile	
Grass	20	36.3	Centimeters
Trees	20	36.3	Centimeters
Urban	20	36.3	Centimeters

REQUIRED CONSOLIDATED VERTICAL ACCURACY FOR DEM FILES

CVA Statistic Required: Percentile

CVA Confidence Level/Percentile Required: 95

Total number of checkpoints: 80

Required CVA: 36.3 Centimeters *at the* 95 th *Percentile*

Additional Required Vertical Accuracy Information:

Reported Vertical Accuracy

☐ Yes ☐ No

REPORTED FUNDAMENTAL VERTICAL ACCURACY FOR SWATH LIDAR FILES

Confidence Interval Reported: 95 th % CI

Reported Unit: Centimeters

Reported # of checkpoints: 21

Reported RMSEz: 5.2

*Reported Vertical Accuracy (RMSEz * .% CI)* 10.2

REPORTED FUNDAMENTAL VERTICAL ACCURACY FOR DEM FILES

Confidence Interval Reported: 95 th % CI

Reported Unit: Centimeters

Reported # of checkpoints: 20

Reported RMSEz: 6.5

*Reported Vertical Accuracy (RMSEz * .% CI)* 12.8

REPORTED SUPPLEMENTAL VERTICAL ACCURACY FOR DEM FILES

SVA Statistic Reported: Percentile

SVA Confidence Level/Percentile Reported: 95

Class	# of Checkpoints	SVA Reported 95 th Percentile	
Grass	20	16.8	Centimeters
Trees	21	22.7	Centimeters
Urban	20	25.4	Centimeters

REPORTED CONSOLIDATED VERTICAL ACCURACY FOR DEM FILES

CVA Statistic Reported: Percentile

CVA Confidence Level/Percentile Reported: 95

Total number of checkpoints: 81

Reported CVA: 20.6 Centimeters *at the* 95 th *Percentile*

Additional Reported Vertical Accuracy Information:

The LiDAR Accuracy Report for the Area of Nodaway County, MO states "The table below presents the results of the QC accuracy analysis for the Atchison-Holt-Andrew Co., MO derived bare-earth Imagine DEM tile data. All values are in meters."

FVA is not reported for Swath files in the report either.

FVA needs to be reported for Swath files, SVA and FVA needs to be reported for DEM files for Nodaway County, MO.

*Number of checkpoints reported by vendor do not match reviewers reported number of checkpoints within project area due to outliers in the checkpoint .shp provided by the vendor.
*Vendor fixed issue, correct reports provided to reviewer. 11/24/14

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 FUNDAMENTAL VERTICAL ACCURACY FOR SWATH LIDAR FILES

Confidence Interval Reviewed: 95 th % CI

Reviewed Unit: Centimeters

Reviewed # of checkpoints: 8

Reviewed RMSEz: 5.3

*Reviewed Vertical Accuracy (RMSEz * .% CI)* 10.3

REVIEWED FUNDAMENTAL VERTICAL ACCURACY FOR DEM FILES

Confidence Interval Reviewed: 95 th % CI

Reviewed Unit: Centimeters

Reviewed # of checkpoints: 15

Reviewed RMSEz: 8.3

*Reviewed Vertical Accuracy (RMSEz * .% CI)* 16.3

REVIEWED SUPPLEMENTAL VERTICAL ACCURACY

SVA Statistic Reviewed: Percentile

SVA Confidence Level/Percentile Reviewed: 95

Class	# of Checkpoints	SVA Reviewed 95 th Percentile	
Grass	16	16.4	Centimeters
Trees	16	15.6	Centimeters
Urban	20	27.4	Centimeters

REVIEWED CONSOLIDATED VERTICAL ACCURACY

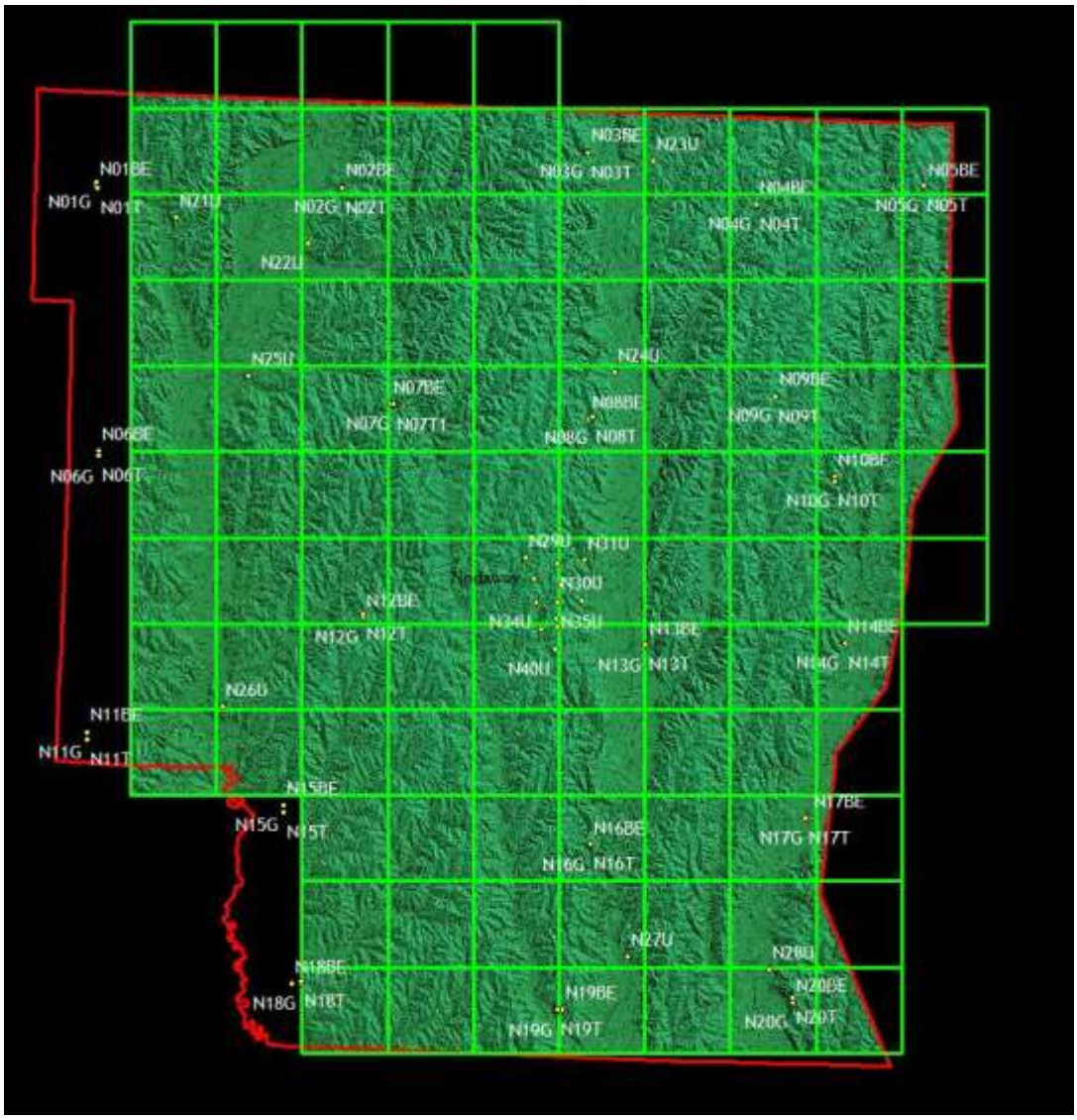
CVA Statistic Reviewed: Percentile

CVA Confidence Level/Percentile Reviewed: 95

Total number of checkpoints: 67

Reviewed CVA: 20.02 Centimeters *at the* 95 th *Percentile*

Checkpoint Distribution Image



Vertical Accuracy Results:

Additional Reviewed Vertical Accuracy Information:	The project area of Nodaway as portrayed in the provided reports does not match the area of the tiling scheme/DEM tiles. The checkpoint shapefiles do match the outline of the portrayed project area in the reports, but go outside the DEM area since the DEM does not cover the entire project area. This leaves checkpoints outside the DEM tile boundary as delivered. Please deliver a new project area shapefile that contains the correct amount of checkpoints within the DEM boundary provided. **Vertical accuracy will not be assessed on the DEM or Swath until a new checkpoint shapefile is delivered.** *New checkpoint .shp not provided, reviewer created a new checkpoint .shp that excluded the checkpoints outside the project area.

Based on this review, the USGS <u>accepts</u> 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 Fundamental 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: 1.2

Point Record Format: 1

☐ *Each swath file ≤ 2 GB and properly segmented*

☐ *Correct and properly formatted georeference information is included in all LAS file headers*

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

☐ *Scan Angles conform to USGS base-spec recommendations*

☐ *All points set to class '0' (not classified)*

Additional comments:

*Appears that not all swath was delivered for entire project area. Vertical Accuracy of the swath could only be assessed on the provided swath files using only 8 of the checkpoints provided.

*Vendor corrected issue, all Swath delivered 12/05/14

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: 1.2

Point Record Format: 1

☐ *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*

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

☐ *Classified LAS tile files have no points classified as '12' (Overlap)*

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

Code	Description	Used
1	Processed, but unclassified	☐
2	Bare-earth/Ground	☐
7	Noise(low or high, 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	☐

Additional Classes:

Class	Description
17	Overlap - Unclassified

Additional comments:

The project plan states that all classified points (bare-earth, first return & intensity data) will be delivered in ASPRS LAS V1.2 format. LAS tiles will use the following classes: 1-processed, but unclassified, 2-bare-earth ground, 7-noise, 9-water, 10-ignored, 11-withheld, 12-overlap points shall not be used.

Reviewer ran Point Cloud Statistics, Class 11 was not present, Class 17 was present.

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: Meters

☐ Waterbody Breaklines.

Polyline ☐ Polygon ☐

☐ Single elevation value per waterbody feature.

☐ Required.

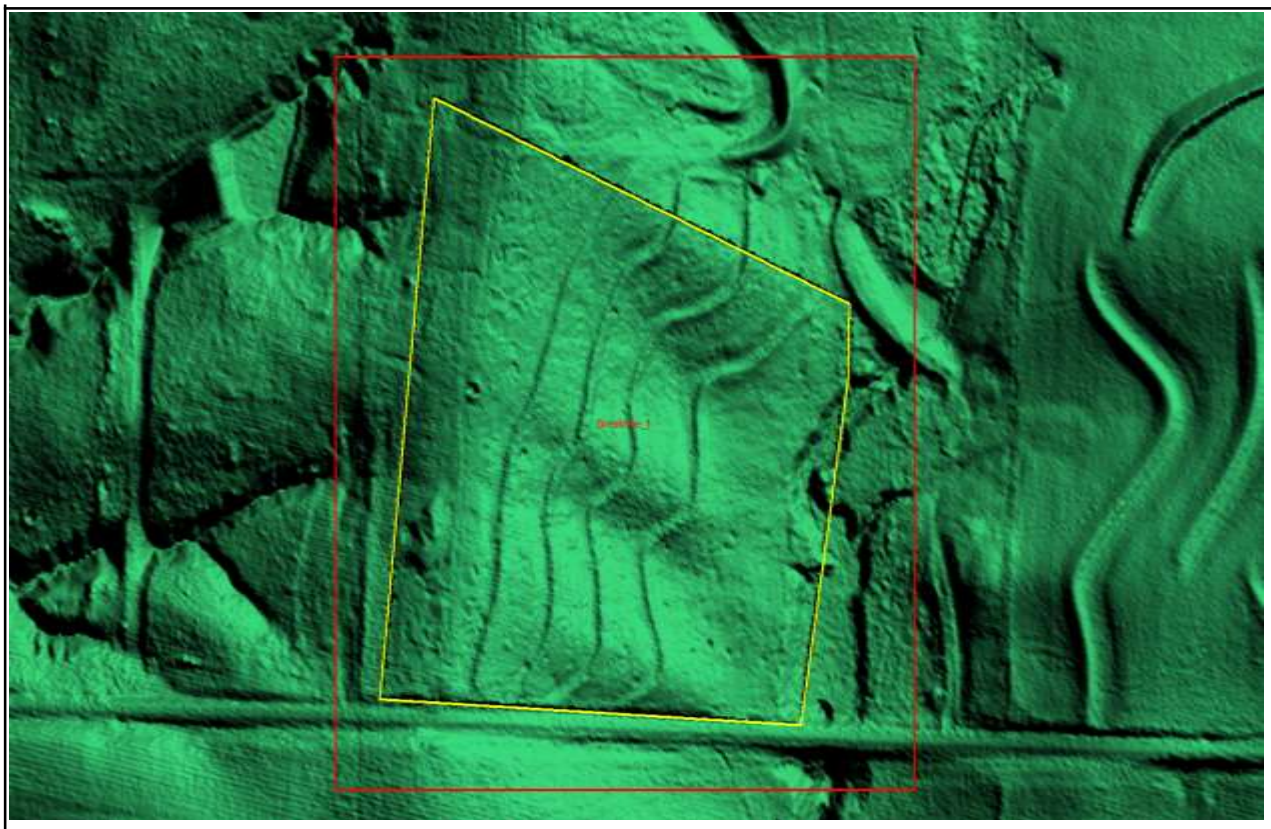
Waterbody Elevations were created via Unknown waterbody level techniques.

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

Polyline ☐ Polygon ☐
Downstream DLS Flow is Select... .
☐ Required.

☐ Single Line Breaklines.
☐ No missing or misplaced breaklines.

ADDITIONAL COMMENTS, ERRORS, ANOMALIES, OR OTHER ISSUES:



Misplaced breakline, located at: 40° 24' 11.6960" N, 94° 46' 18.5385" W

Vendor corrected issue 11/21/14

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: 1 Meters

Tile bit depth/pixel Type: 32_BIT_FLOAT

Interpolation or Resampling Technique: Nearest Neighbor

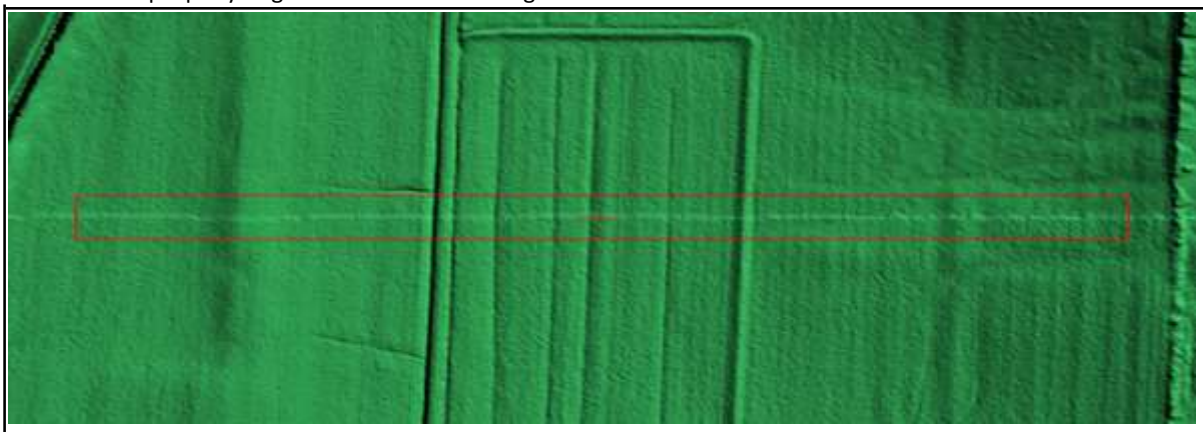
☐ DEM tiles do not overlap

☐ 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



Line present, visual anomaly, please check. located at: 40° 08' 11.7916" N, 94° 48' 59.8681" W

Vendor corrected issue 11/21/14

☐ 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

DEM tiles are properly Hydro Flattened ☐ Yes ☐ No

☐ Waterbodies 2 Acres or greater are flattened

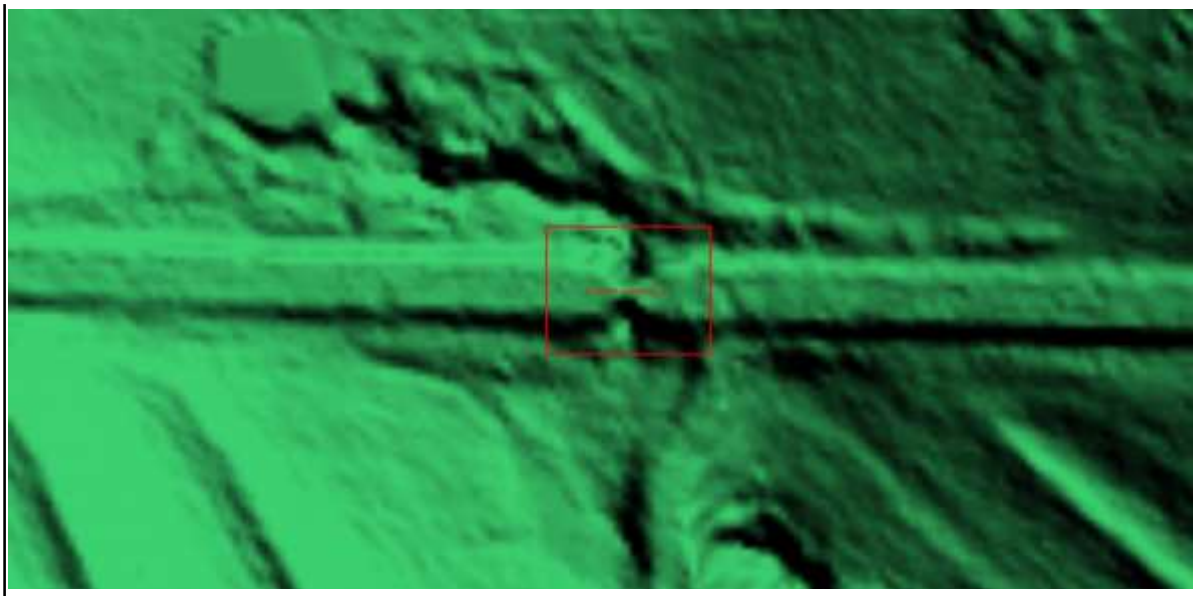
☐ Streams 100 ft. or greater are flattened in a downstream manner

☐ Tidal Boundaries/Shorelines are flattened

☐ No missing islands 1 Acre or larger

☐ Bridges/Overpasses are properly removed

☐ Culverts are maintained (Not Hydro Enforced)

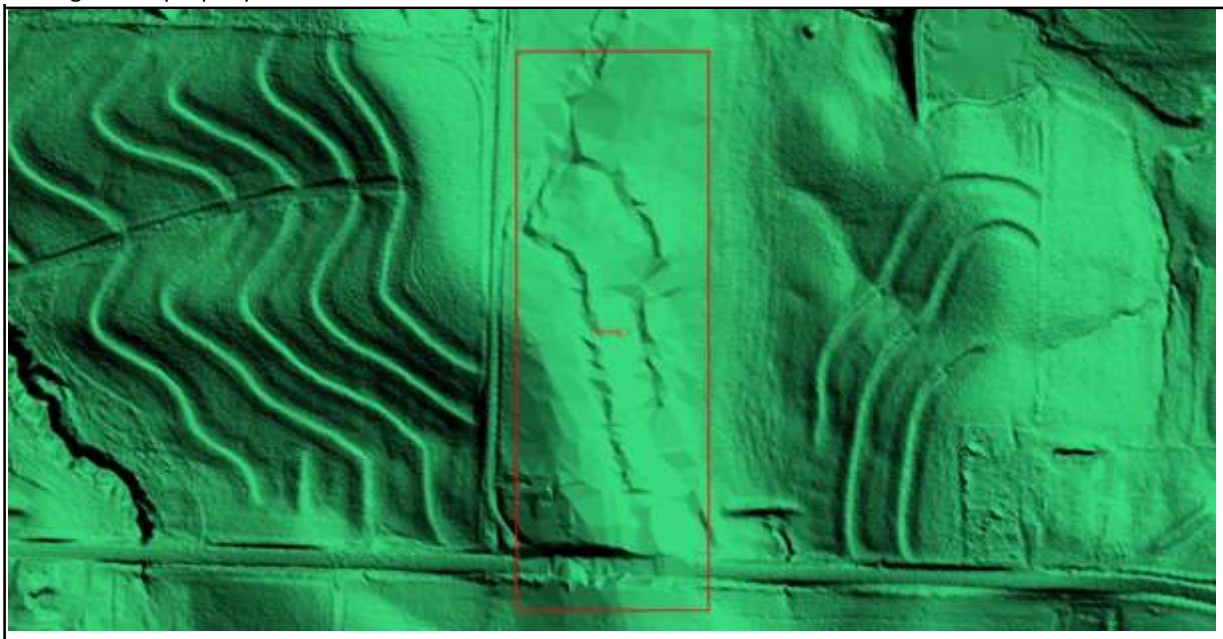


Culvert partially removed. Reviewer found 12 culverts needing to be touched up.
Example above is Culvert_Cleanup_2, located at: 40° 27' 49.3147" N, 95° 07' 41.1771" W

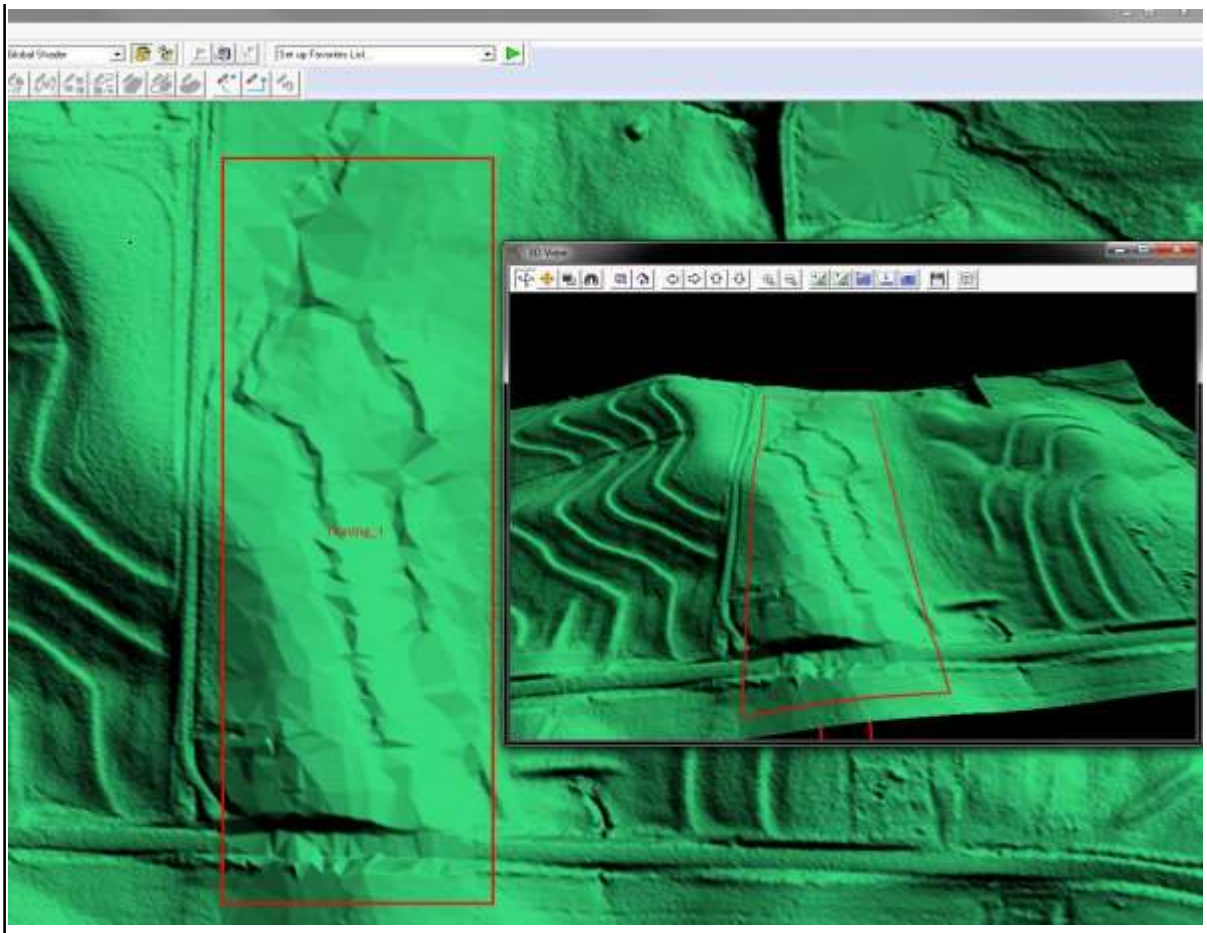
Vendor corrected issue 11/21/14

☐ Depressions, Sinks, are not filled in (Not Hydro Conditioned)

☐ Vegetation properly removed



Vendor corrected issue 11/21/14



Excessive Tinning present at: 40° 25' 15.8804" N, 94° 59' 05.9937" W. This runs in a "strip" about ~140 meters wide running North & South.

Vendor corrected issue 11/21/14

☐ Manmade structures properly removed

ADDITIONAL COMMENTS, ERRORS, ANOMALIES, OR OTHER ISSUES:

The project area of Nodaway as portrayed in the provided reports does not match the area of the tiling scheme/DEM tiles. The checkpoint shapefiles do match the outline of the portrayed project area in the reports, but since the DEM does not cover the entire project area, this leaves checkpoints outside the DEM tile boundary as delivered. Please deliver a new project area shapefile that contains the correct amount of checkpoints within the DEM boundary.

New checkpoint .shp not provided, reviewer created a new checkpoint .shp that excluded the checkpoints outside the project area.

Tiles recommended for NED 1/3rd: ☐ Yes. ☐ No.
Tiles recommended for NED 1/9th: ☐ Yes. ☐ No.

Based on this review, the USGS <u>accepts</u> 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 (v2.1.1)