Project Report

TASK ORDER NAME: GA_Central_2019_B19
TASK ORDER NUMBER: 140G0219F0277
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 19064
BLOCK NUMBER: Block 4

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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS task order 140G0219F0277 required Winter 2019/Spring 2020 LiDAR surveys to be collected over 20,320 square miles covering part or all of 60 counties in Georgia and 6 counties in Alabama in support of the USGS 3DEP Program. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of ≤0.71 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3. The Block 04 area encompasses approximately 1,796 square miles.

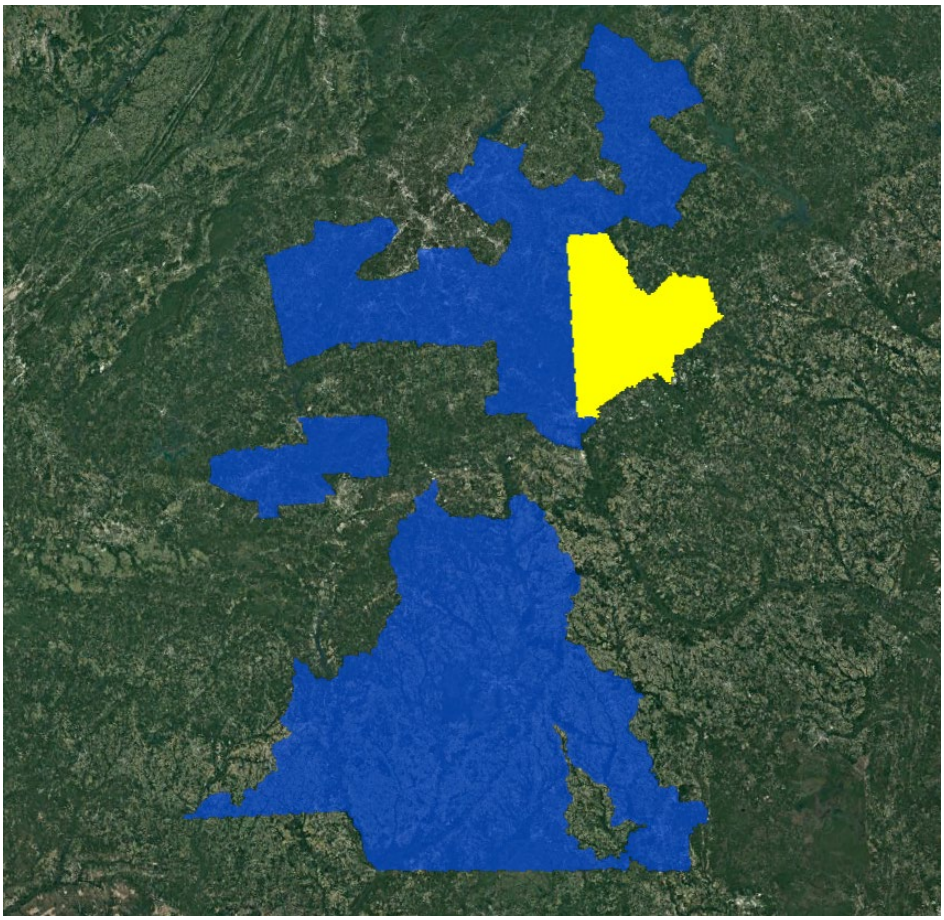

Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) in Yellow and Associated Areas of Interest (AOIs) in Blue

1.1.2 Project Purpose

Aerial lidar was collected to support the mapping efforts of individual counties in the State of Georgia and Alabama and the USGS 3DEP program.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS v.14, tiled delivery
Bare Earth Surface	Raster DEM, 1m cell size, hydro flattened, GeoTIFF format
Breaklines	Hydro breaklines to BPA limit, .gdb format
Intensity Imagery	1m cell size, 8-bit, 256 gray scale, GeoTIFF format
Delivery Diagram	.gdb format
Metadata	Per product, FGDC compliant, .xml format
Project Report	Field work procedures, QC procedures and results, overall accuracy, .pdf format

Table 1: Aerial LiDAR Contract Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a PACDV (N750DV) outfitted with an Optech Galaxy Prime LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	Galaxy Prime
Manufacturer	Optech
Performance Envelope	150 – 4700 m AGL, nominal
Absolute Horizontal Accuracy	1/10,000 x altitude
Absolute Elevation Accuracy	< 0.03 – 0.20 m RMSE from 150 – 4700 m AGL
Topographic Laser	1064-nm near-infrared
Laser Classification	Class IV
Pulse Repetition Frequency (Effective)	Programmable, 50 – 1000 kHz
Beam Divergence	0.25 mrad (1/e)
Laser Range Precision	< 0.008 m
Minimum Target Separation Distance	< 0.7 m (discrete)
Range Capture	Up to 8 range measurements, including last
Intensity Capture	Up to 8 intensity measurements, including last (12-bit)
Scan Angle (Fov)	10 – 60°
Swath Width	10 – 115% of altitude AGL
Scan Frequency	0 – 120 Hz advertised (0 – 240 scan lines/sec)
Scan Product	2000 maximum
Roll Compensation	±5° minimum
Data Storage	Internal solid-state drive (SSD)
Power Requirements	28 V; 300 W
Dimensions and Weight	Sensor: 0.34 x 0.34 x 0.25 m, 27 kg PDU: 0.42 x 0.33 x 0.10 m, 6.5 kg
Operation Temperature	0 to +35°C

Table 2: System Specifications – Galaxy Prime

2.1.2 Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Choose an item.
Nominal Pulse Spacing (m)	0.64

Parameter	Specification
Nominal Pulse Density (pls/m²)	2.44
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	150
Pass Heading (°)	W-E
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	60
Pulse Rate of Scanner (kHz)	350
Line Spacing (m)	1325.48
Pulse Width of Scanner (m)	1664
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	6
Beam Divergence (mrad)	0.25
Nominal Swath Width (m)	1657
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 75 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 6 flight missions conducted between December 30, 2019 and January 8, 2020. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

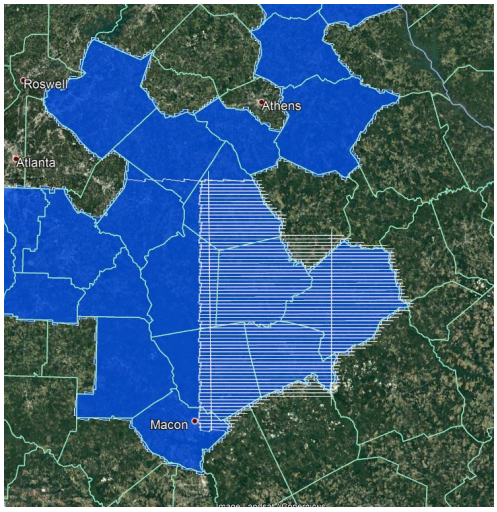

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Nineteen (19) Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
AL76	CORS	AL76	N31°52'29.95916"	W85°13'32.48364"	100.108
ALCN	CORS	ALCN	N34°09'46.97942"	W85°39'31.04964"	164.905
FRKN	CORS	FRKN	N35°11'30.71115"	W83°23'41.77451"	619.542
GAAE	CORS	GAAE	N33°25'38.07518"	W82°04'04.06892"	124.363
GAAY	CORS	GAAY	N31°39'40.91991"	W84°16'29.65332"	55.889
GACC	CORS	GACC	N33°32'44.73014"	W82°08'01.72593"	98.491
GACR	CORS	GACR	N32°22'51.45809"	W83°20'46.43097"	97.883
GAET	CORS	GAET	N33°23'59.10329"	W83°29'19.86876"	148.128
GAFO	CORS	GAFO	N33°02'06.87606"	W83°56'14.39528"	194.595
GAMV	CORS	GAMV	N33°05'56.61670"	W83°14'47.46836"	92.446
GANW	CORS	GANW	N33°18'20.82420"	W84°46'02.50966"	259.991
GASA	CORS	GASA	N32°01'25.51600"	W81°03'36.78483"	-22.753
GASN	CORS	GASN	N32°58'54.70717"	W82°48'33.11652"	115.825
GAWN	CORS	GAWN	N33°24'23.60839"	W82°39'57.94083"	126.6
NCMU	CORS	NCMU	N35°04'06.80197"	W83°57'59.38964"	474.779
P804	CORS	P804	N32°57'47.83548"	W84°13'32.72156"	216.363
P805	CORS	P805	N32°57'47.65078"	W84°13'32.99330"	215.735
P806	CORS	P806	N32°57'47.92265"	W84°13'33.05745"	215.87
ZTL4	CORS	ZTL4	N33°22'46.87791"	W84°17'48.21557"	260.69

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 65 ground survey points were collected in support of this project, including 18 LiDAR Control Points (LCP), 25 Non-vegetated Vertical Accuracy (NVA) and 22 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed "busts" in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA and VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

The following tables and figures outline the coordinate values and distribution of LCP, NVA and VVA points collected in support of this project:

ID	Easting	Northing	Elevation
LCP28	1143589.288	1229873.265	178.659
LCP29	1160951.679	1215988.842	139.577
LCP30	1168205.954	1220349.459	193.25
LCP31	1181806.888	1215767.683	111.737
LCP32	1197812.388	1215685.761	174.033
LCP33	1197064.182	1225873.876	151.118
LCP34	1214323.757	1222089.107	159.194
LCP35	1202089.743	1215063.947	165.105
LCP36	1193291.709	1206644.347	178.889
LCP37	1175959.846	1202329	111.941
LCP38	1165330.704	1204907.234	124.123
LCP40	1151733.968	1201007.396	180.214
LCP41	1161455.098	1183364.876	170.511
LCP51	1156120.966	1165068.178	144.912
LCP76	1155226.443	1191929.833	160.898
LCP79	1167759.044	1191922.09	145.877
LCP80	1166021.386	1173666.731	147.788
LCP82	1169574.485	1228529.589	163.539

Table 51: LiDAR Control Point Coordinates

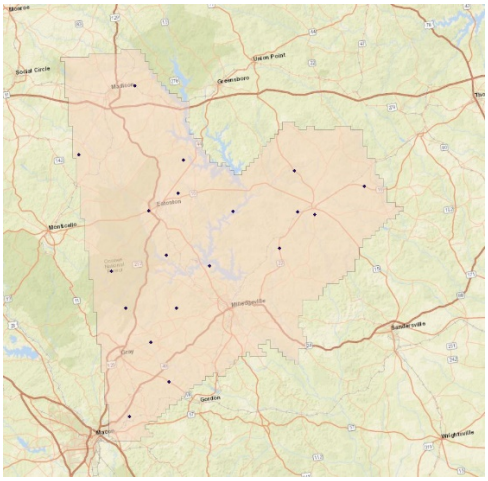

Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE20	1159947.46	1236460.154	173.594
BE21	1175365.421	1218903.829	190.636
BE22	1201540.558	1229074.616	182.9
BE23	1214414.346	1216484.67	164.743
BE24	1193505.15	1186332.908	105.295
BE25	1196923.198	1201672.388	175.432
BE26	1169678.121	1179002.563	162.754
BE42	1167418.938	1198857.807	134.506
OT14	1195971.232	1220416.365	151.51
OT15	1204677.424	1208782.476	153.657
OT17	1158199.887	1225636.326	150.16
OT19	1148950.252	1205858.94	187.012
OT20	1178444.821	1192932.064	114.838
OT21	1151055.753	1193216.796	165.08
OT36	1181176.207	1208748.137	142.748
OT37	1154274.593	1181265.937	180.94
OT49	1165653.983	1212248.026	179.131
UR20	1154921.078	1232726.279	171.752
UR25	1156889.827	1202878.63	169.67
UR31	1158540.583	1171627.612	159.199
UR32	1163237.758	1188300.17	168.467
UR33	1183944.732	1202167.421	108.92
UR34	1185902.252	1220913.474	135.832
UR35	1201719.392	1218199.577	170.024
UR36	1213084.456	1228165.81	181.712

Table 6: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

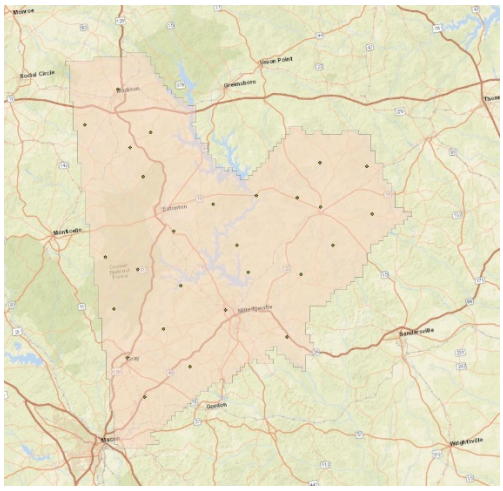

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR14	1157860.37	1210958.757	157.593
BR15	1161471.121	1197031.151	127.755
BR16	1173773.088	1186993.339	146.466
BR17	1186918.325	1186997.044	115.685
BR18	1203530.804	1205228.82	136.142
BR19	1204355.865	1225098.684	184.272
HG11	1153517.116	1239299.434	199.063
HG12	1163048.302	1232536.047	145.009
HG14	1179367.101	1221028.688	202.857
HG15	1166368.643	1241395.078	181.085
HG16	1206866.648	1230287.545	184.648
HG17	1207616.41	1218070.63	136.881
HG18	1176770.14	1181874.818	123.849
HG19	1161765.215	1175240.128	166.539
HG34	1144335.04	1223628.458	184.734
TR12	1143420.32	1246474.526	221.063
TR14	1166471.281	1225124.476	186.845
TR15	1153627.093	1214382.844	171.683
TR17	1175147.938	1208301.681	123.971
TR18	1194494.01	1211534.122	149.482
TR19	1192938.975	1230844.031	180.007
TR20	1188854.949	1195495.909	166.126

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

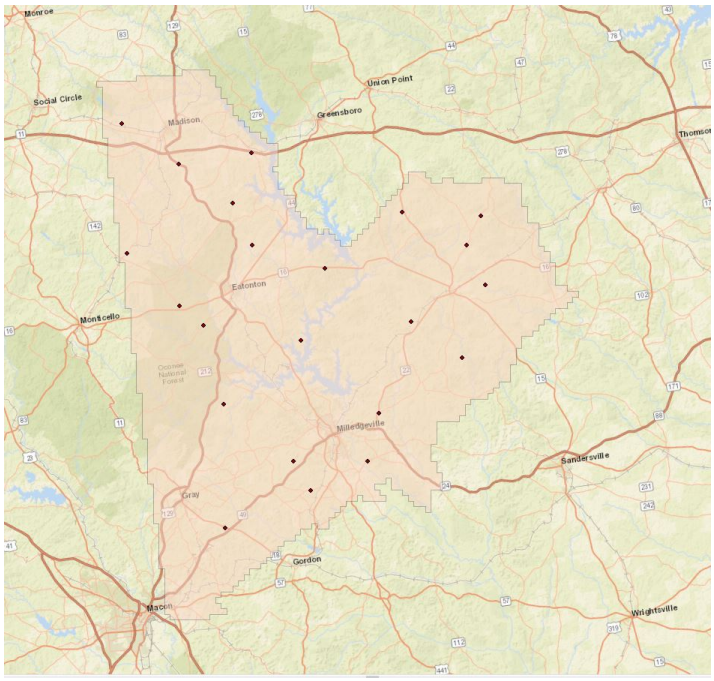

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBETs are combined with the raw laser scan files to export the LiDAR ASCII Standard (*.las) formatted swath point clouds.

3.1.2 Coordinate Reference System

Parameter	Specification
Horizontal Datum	Albers Equal Area
Coordinate System	NAD83 2011
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	63530
Units of Reference	Meter

Table 8: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points	19,784,357,352
Nominal Pulse Spacing (m)	0.5851
Nominal Pulse Density (pls/m²)	2.9215
Aggregate Total Points	16,135,505,669
Aggregate Nominal Pulse Spacing (m)	0.5466
Aggregate Nominal Pulse Density (pls/m²)	3.3473

Table 9: LiDAR Point Cloud Statistics

3.1.4 Smooth Surface Repeatability (Interswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference raster's (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer.

3.1.5 LiDAR Calibration

Using a combination of GeoCue, TerraScan and TerraMatch; overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤2cm.

A final analysis of the calibrated lidar is preformed using a TerraMatch tie line report for an overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

Upon completion of the data calibration, a complete set of elevation difference intensity raster's (dZ Orthos) are produced. A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

3.1.6 LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds. Atlantic utilized collected breakline data to preform classification for class 9 (Water).

Code	Description
1	Processed but unclassified
2	Bare-earth ground
3	Low Vegetation (0.5 – 5 feet)
4	Medium Vegetation (5 – 20 feet)
5	High Vegetation (>20 feet)
6	Buildings
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground (breakline proximity)
21	Snow (where reliable identifiable)
22	Temporal Exclusion (typically non-favored data in intertidal zones)

Table 10: LiDAR Point Classification Codes and Descriptions

3.1.7 LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 1-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in GeoTIFF format.

3.1.8 Hydro-line Collection/Conflation

Hydro breaklines were compiled using LiDAR intensity data and surface terrain models of the entire project area. After the collection, all delineated hydro features were validated for monotonicity and vertical variance. This procedure ensures that no points were floating above ground. Hydro-lines were then encoded into the LiDAR

surface and used to hydro-enforce/flatten all significant water bodies. These final hydro-lines were then used in the production of bare Earth digital models to hydro flatten significant water bodies. This product was delivered as an ESRI geodatabase for the entire project area.

3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 1 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .tif format.

SECTION 4: ACCURACY ASSESSMENT

4.1 Aerial LiDAR Project – Vertical Accuracy Assessment

4.1.1 Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 2: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

*The terms NVA and VVA are from the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single LiDAR returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return LiDAR).

4.1.2 Results

An overall statistical assessment of the check points can be found in the following two tables (values provided in meters):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	25	0.0689	0.1350	0.0746
NVA (DEM)	25	0.0694	0.1360	0.0998
VVA (Point Cloud)	22	0.1711	0.3353	0.4165
VVA (DEM)	22	0.1719	0.3369	0.0774

Table 12: NVA/VVA Accuracies

SECTION 5: CERTIFICATION STATEMENTS

5.1 Aerial LiDAR Project

This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the United States Geological Survey.

It should also be noted that LiDAR points do not represent a continuous surface model. LiDAR points are discrete measurements of the surface and any values derived within a triangle of three LiDAR points are interpolated. As such, the user should not use the resultant LiDAR dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated LiDAR point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this LiDAR dataset was developed differently and separately than previous LiDAR datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer LiDAR technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.

Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

SECTION 6: CONTROL POINT ASSESSMENTS

6.1 Aerial LiDAR Project

6.1.1 Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE20	1159947.4600	1236460.1540	173.5940	173.4380	-0.1560	NVA
BE21	1175365.4210	1218903.8290	190.6360	190.7350	0.0990	NVA
BE22	1201540.5580	1229074.6160	182.9000	182.8250	-0.0750	NVA
BE23	1214414.3460	1216484.6700	164.7430	164.6870	-0.0560	NVA
BE24	1193505.1500	1186332.9080	105.2950	105.2780	-0.0170	NVA
BE25	1196923.1980	1201672.3880	175.4320	175.4220	-0.0100	NVA
BE26	1169678.1210	1179002.5630	162.7540	162.6560	-0.0980	NVA
BE42	1167418.9380	1198857.8070	134.5060	134.4280	-0.0780	NVA
BR14	1157860.3700	1210958.7570	157.5930	157.6130	0.0200	VVA
BR15	1161471.1210	1197031.1510	127.7550	127.7440	-0.0110	VVA
BR16	1173773.0880	1186993.3390	146.4660	146.5060	0.0400	VVA
BR17	1186918.3250	1186997.0440	115.6850	115.7350	0.0500	VVA
BR18	1203530.8040	1205228.8200	136.1420	136.1520	0.0100	VVA
BR19	1204355.8650	1225098.6840	184.2720	184.2500	-0.0220	VVA
HG11	1153517.1160	1239299.4340	199.0630	199.4820	0.4190	VVA
HG12	1163048.3020	1232536.0470	145.0090	144.9670	-0.0420	VVA
HG14	1179367.1010	1221028.6880	202.8570	202.7900	-0.0670	VVA
HG15	1166368.6430	1241395.0780	181.0850	181.6160	0.5310	VVA
HG16	1206866.6480	1230287.5450	184.6480	184.6330	-0.0150	VVA
HG17	1207616.4100	1218070.6300	136.8810	136.8700	-0.0110	VVA
HG18	1176770.1400	1181874.8180	123.8490	123.8550	0.0060	VVA
HG19	1161765.2150	1175240.1280	166.5390	166.4900	-0.0490	VVA
HG34	1144335.0400	1223628.4580	184.7340	184.6770	-0.0570	VVA
OT14	1195971.2320	1220416.3650	151.5100	151.5070	-0.0030	NVA
OT15	1204677.4240	1208782.4760	153.6570	153.6660	0.0090	NVA
OT17	1158199.8870	1225636.3260	150.1600	150.1090	-0.0510	NVA
OT19	1148950.2520	1205858.9400	187.0120	187.0010	-0.0110	NVA
OT20	1178444.8210	1192932.0640	114.8380	114.7820	-0.0560	NVA
OT21	1151055.7530	1193216.7960	165.0800	165.0710	-0.0090	NVA
OT36	1181176.2070	1208748.1370	142.7480	142.6910	-0.0570	NVA
OT37	1154274.5930	1181265.9370	180.9400	180.9040	-0.0360	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
OT49	1165653.9830	1212248.0260	179.1310	179.1070	-0.0240	NVA
TR12	1143420.3200	1246474.5260	221.0630	221.4310	0.3680	VVA
TR14	1166471.2810	1225124.4760	186.8450	186.7660	-0.0790	VVA
TR15	1153627.0930	1214382.8440	171.6830	171.6800	-0.0030	VVA
TR17	1175147.9380	1208301.6810	123.9710	123.8220	-0.1490	VVA
TR18	1194494.0100	1211534.1220	149.4820	149.4400	-0.0420	VVA
TR19	1192938.9750	1230844.0310	180.0070	179.9510	-0.0560	VVA
TR20	1188854.9490	1195495.9090	166.1260	166.1380	0.0120	VVA
UR20	1154921.0780	1232726.2790	171.7520	171.6520	-0.1000	NVA
UR25	1156889.8270	1202878.6300	169.6700	169.6110	-0.0590	NVA
UR31	1158540.5830	1171627.6120	159.1990	159.1640	-0.0350	NVA
UR32	1163237.7580	1188300.1700	168.4670	168.3730	-0.0940	NVA
UR33	1183944.7320	1202167.4210	108.9200	108.8730	-0.0470	NVA
UR34	1185902.2520	1220913.4740	135.8320	135.9230	0.0910	NVA
UR35	1201719.3920	1218199.5770	170.0240	169.9360	-0.0880	NVA
UR36	1213084.4560	1228165.8100	181.7120	181.6300	-0.0820	NVA

Table 13: Point Cloud Check Point Assessment

6.1.2 Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE20	1159947.4600	1236460.1540	173.5940	173.4419	0.1521	NVA
BE21	1175365.4210	1218903.8290	190.6360	190.7475	-0.1115	NVA
BE22	1201540.5580	1229074.6160	182.9000	182.8230	0.0770	NVA
BE23	1214414.3460	1216484.6700	164.7430	164.6972	0.0458	NVA
BE24	1193505.1500	1186332.9080	105.2950	105.2819	0.0131	NVA
BE25	1196923.1980	1201672.3880	175.4320	175.4197	0.0123	NVA
BE26	1169678.1210	1179002.5630	162.7540	162.6721	0.0819	NVA
BE42	1167418.9380	1198857.8070	134.5060	134.4165	0.0895	NVA
OT14	1195971.2320	1220416.3650	151.5100	151.5045	0.0055	NVA
OT15	1204677.4240	1208782.4760	153.6570	153.6616	-0.0046	NVA
OT17	1158199.8870	1225636.3260	150.1600	150.0823	0.0777	NVA
OT19	1148950.2520	1205858.9400	187.0120	186.9994	0.0126	NVA
OT20	1178444.8210	1192932.0640	114.8380	114.7785	0.0595	NVA
OT21	1151055.7530	1193216.7960	165.0800	165.0626	0.0174	NVA
OT36	1181176.2070	1208748.1370	142.7480	142.6967	0.0513	NVA
OT37	1154274.5930	1181265.9370	180.9400	180.9022	0.0378	NVA
OT49	1165653.9830	1212248.0260	179.1310	179.1002	0.0308	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
UR20	1154921.0780	1232726.2790	171.7520	171.6591	0.0929	NVA
UR25	1156889.8270	1202878.6300	169.6700	169.6166	0.0534	NVA
UR31	1158540.5830	1171627.6120	159.1990	159.1592	0.0398	NVA
UR32	1163237.7580	1188300.1700	168.4670	168.3654	0.1016	NVA
UR33	1183944.7320	1202167.4210	108.9200	108.8724	0.0476	NVA
UR34	1185902.2520	1220913.4740	135.8320	135.9192	-0.0872	NVA
UR35	1201719.3920	1218199.5770	170.0240	169.9370	0.0870	NVA
UR36	1213084.4560	1228165.8100	181.7120	181.6361	0.0759	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR14	1157860.3700	1210958.7570	157.5930	157.5999	-0.0069	VVA
BR15	1161471.1210	1197031.1510	127.7550	127.7405	0.0145	VVA
BR16	1173773.0880	1186993.3390	146.4660	146.5320	-0.0660	VVA
BR17	1186918.3250	1186997.0440	115.6850	115.7460	-0.0610	VVA
BR18	1203530.8040	1205228.8200	136.1420	136.1459	-0.0039	VVA
BR19	1204355.8650	1225098.6840	184.2720	184.2537	0.0183	VVA
HG11	1153517.1160	1239299.4340	199.0630	199.5062	-0.4432	VVA
HG12	1163048.3020	1232536.0470	145.0090	144.9827	0.0263	VVA
HG14	1179367.1010	1221028.6880	202.8570	202.7822	0.0748	VVA
HG15	1166368.6430	1241395.0780	181.0850	181.6044	-0.5194	VVA
HG16	1206866.6480	1230287.5450	184.6480	184.6356	0.0124	VVA
HG17	1207616.4100	1218070.6300	136.8810	136.8515	0.0295	VVA
HG18	1176770.1400	1181874.8180	123.8490	123.8677	-0.0187	VVA
HG19	1161765.2150	1175240.1280	166.5390	166.4912	0.0478	VVA
HG34	1144335.0400	1223628.4580	184.7340	184.6838	0.0502	VVA
TR12	1143420.3200	1246474.5260	221.0630	221.4278	-0.3648	VVA
TR14	1166471.2810	1225124.4760	186.8450	186.7674	0.0776	VVA
TR15	1153627.0930	1214382.8440	171.6830	171.6567	0.0263	VVA
TR17	1175147.9380	1208301.6810	123.9710	123.8302	0.1408	VVA
TR18	1194494.0100	1211534.1220	149.4820	149.4440	0.0380	VVA
TR19	1192938.9750	1230844.0310	180.0070	179.9682	0.0388	VVA
TR20	1188854.9490	1195495.9090	166.1260	166.1370	-0.0110	VVA

Table 14: DEM Check Point Assessment