Project Report

TASK ORDER NAME: GA_Central_2019_B19
TASK ORDER NUMBER: 140G0219F0277
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 19064
BLOCK NUMBER: Block 2

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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 02 area encompasses approximately 1,634 square miles.

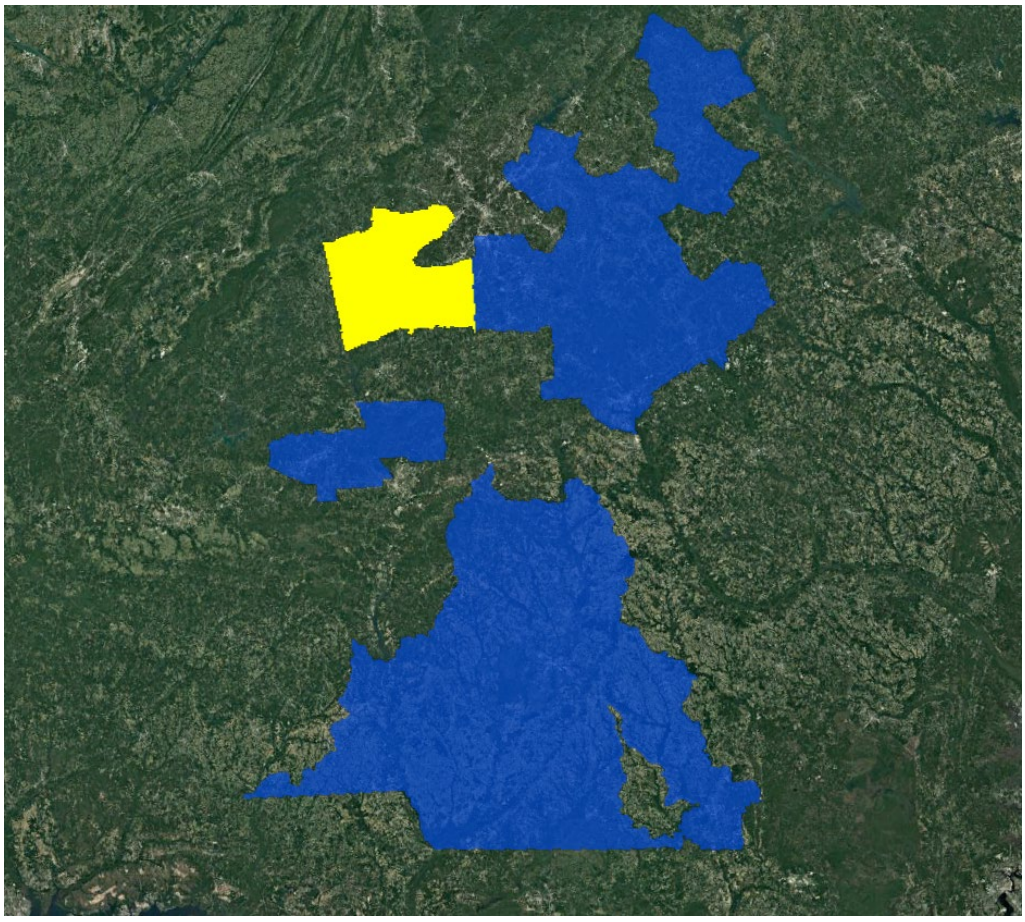

Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) in Yellow and Associated Areas of Interest (AOIs) in Blue

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 v1.4, 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	Optech Galaxy Prime
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 98 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 9 flight missions conducted between January 8, 2020 and January 29, 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.

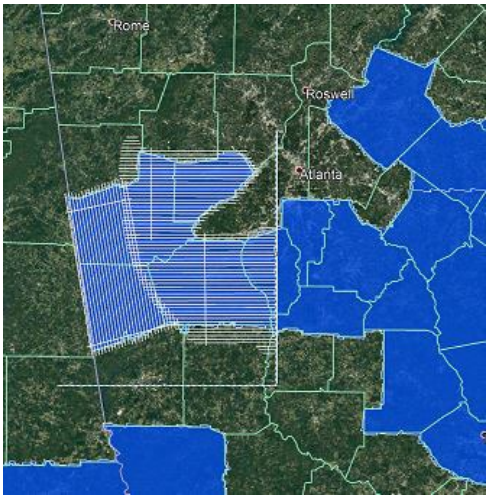

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Twenty-three (23) 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
AL60	CORS	AL60	N32°24'40.94502"	W86°16'13.97623"	44.676
AL62	CORS	AL62	N32°08'53.36427"	W85°41'12.37922"	140.811
AL76	CORS	AL76	N31°52'29.95916"	W85°13'32.48365"	100.108
ALA1	CORS	ALA1	N32°35'55.88602"	W85°30'14.13658"	184.083
ALAS	CORS	ALAS	N33°40'01.20714"	W85°49'50.49202"	203.112
ALCN	CORS	ALCN	N34°09'46.97942"	W85°39'31.04964"	164.905
ALHC	CORS	ALHC	N33°31'25.44554"	W85°38'05.50165"	256.548
ALLA	CORS	ALLA	N32°55'02.66210"	W85°24'01.80635"	237.158
ALTA	CORS	ALTA	N33°25'24.59581"	W86°07'16.31626"	148.570
FRKN	CORS	FRKN	N35°11'30.71115"	W83°23'41.77452"	619.542
GAAU	CORS	GAAU	N33°46'23.61908"	W84°32'41.71551"	213.700
GAAY	CORS	GAAY	N31°39'40.91991"	W84°16'29.65334"	55.889
GABN	CORS	GABN	N34°08'07.10673"	W83°46'38.52707"	277.224
GACA	CORS	GACA	N33°31'31.57971"	W85°06'27.80639"	98.476
GACC	CORS	GACC	N33°32'44.73032"	W82°08'01.72585"	98.476
GACR	CORS	GACR	N32°22'51.45820"	W83°20'46.43158"	97.765
GALG	CORS	GALG	N33°01'14.63304"	W84°59'51.19813"	217.572
GANW	CORS	GANW	N33°18'20.82417"	W84°46'02.51031"	260.003
GARM	CORS	GARM	N34°00'31.07365"	W85°03'49.49364"	205.844
NCMU	CORS	NCMU	N35°04'06.80197"	W83°57'59.38966"	474.779
P804	CORS	P804	N32°57'47.83548"	W84°13'32.72157"	216.363
P805	CORS	P805	N32°57'47.65078"	W84°13'32.99333"	215.735
ZTL4	CORS	ZTL4	N33°22'46.87805"	W84°17'48.21666"	260.682

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 63 ground survey points were collected in support of this project, including 13 LiDAR Control Points (LCP), 27 Non-vegetated Vertical Accuracy (NVA) and 23 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
LCP60	1056406.04	1210634.816	249.94
LCP61	1044537.132	1208868.893	282.26
LCP62	1037096.728	1199972.14	289.532
LCP63	1025932.667	1219738.329	226.009
LCP65	1022895.554	1198850.399	239.042
LCP66	1004177.387	1183006.13	227.732
LCP67	990961.606	1204647.544	375.467
LCP68	999030.586	1215487.231	319.465
LCP69	985552.898	1227271.909	322.462
LCP70	1016636.771	1223923.812	297.131
LCP71	1035959.449	1241559.266	303.907
LCP72	1016323.292	1234070.255	368.589
LCP75	1047789.114	1201818.967	276.747

Table 5: LiDAR Control Point Coordinates

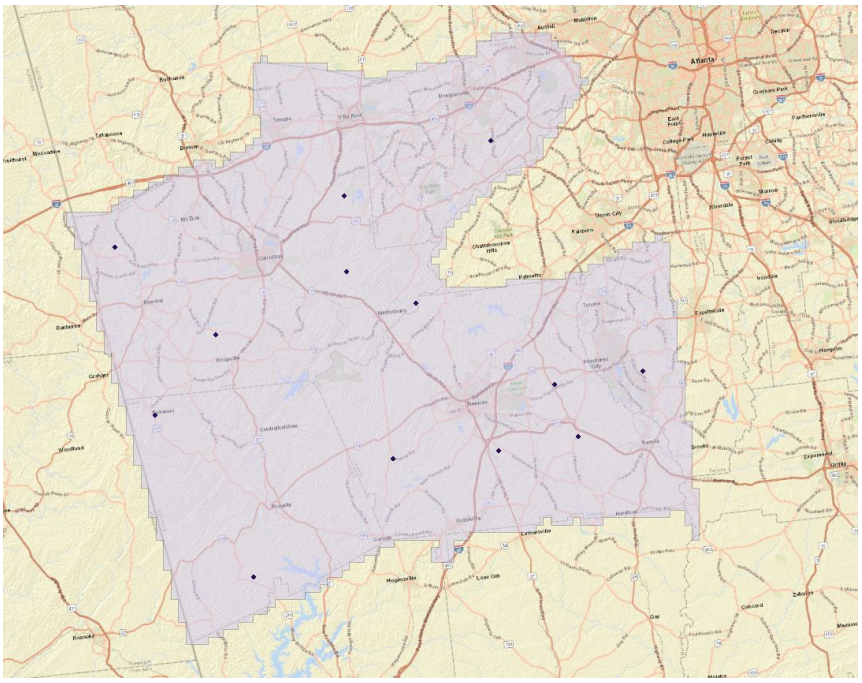

Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE30	1059072.698	1217585.878	275.964
BE31	1030954.171	1214310.695	267.476
BE32	1019276.782	1229084.759	381.411
BE33	1040562.449	1248806.31	303.837
BE34	1009777.724	1245538.219	350.16
BE35	989727.92	1226601.096	335.922
BE36	998433.039	1182589.664	262.918
BE37	1016766.203	1195994.955	252.317
BE38	1044174.908	1198730.796	248.832
OT25	1058805.212	1202328.62	245.114
OT26	1045992.656	1216380.334	280.887
OT27	1030051.662	1198779.222	266.87
OT28	1004242.302	1190812.058	216.811
OT29	995253.232	1210419.014	366.683
OT30	1003799.598	1228614.765	303.044
OT31	1024010.918	1240030.381	336.412

ID	Easting	Northing	Elevation
OT41	1016478.801	1209808.939	287.108
OT42	998093.338	1198381.228	329.794
OT48	1005689.471	1202794.211	251.554
UR42	1051117.39	1206945.33	251.049
UR43	1025888.144	1205265.975	251.057
UR44	1021151.783	1220608.297	235.339
UR45	1006293.763	1218310.796	360.904
UR46	1012907.642	1238153.457	327.569
UR47	1031637.975	1244897.541	326.655
UR48	1008943.287	1185399.654	204.382
UR49	997579.346	1219941.017	293.932

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

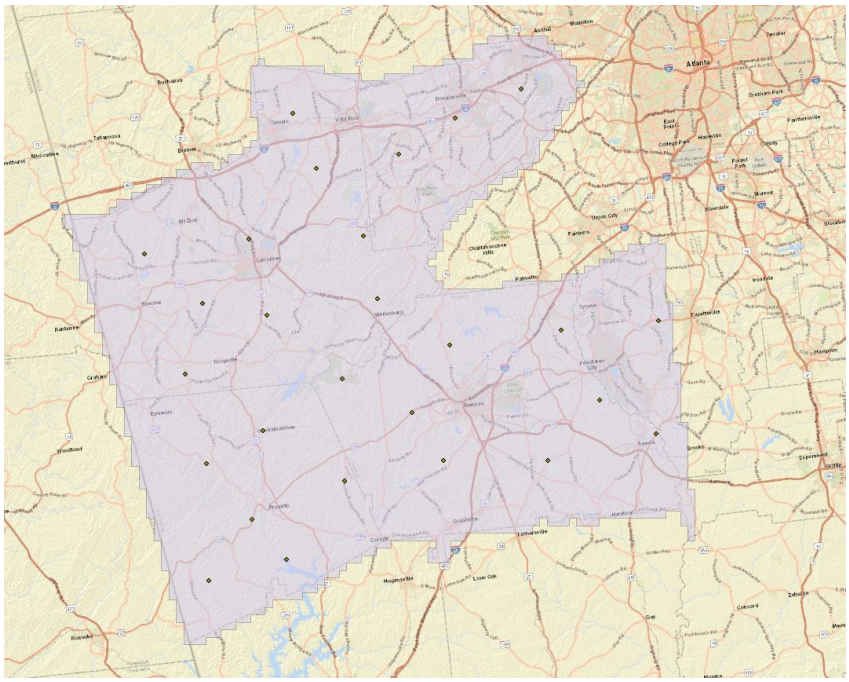

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR27	1052757.878	1197110.34	274.815
BR28	1024954.581	1194252.402	224.925

ID	Easting	Northing	Elevation
BR29	1018444.649	1204330.287	267.414
BR30	997061.772	1190663.446	266.382
BR31	989593.112	1217125.338	308.639
BR32	1009804.884	1226390.323	353.095
BR33	1030243.539	1237697.794	306.591
BR34	1051447.482	1219772.608	296.076
HG25	1058798.24	1224821.102	291.962
HG26	1038093.379	1216152.108	292.561
HG27	1023149.043	1212696.965	255.557
HG28	1006727.735	1235079.897	332.222
HG29	1012395.716	1218728.022	319.744
HG30	1000331.796	1204800.702	322.11
HG31	1013879.104	1189372.737	207.675
HG32	1062816.704	1196270.528	237.262
TR26	1038154.646	1206368.579	275.698
TR27	1036227.218	1193776.093	273.767
TR28	1009170.282	1197089.022	212.155
TR29	1006147.436	1210621.248	282.41
TR30	995304.52	1231218.122	365.859
TR31	1019617.841	1245203.032	341.784
TR32	1023604.647	1232622.09	354.051

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

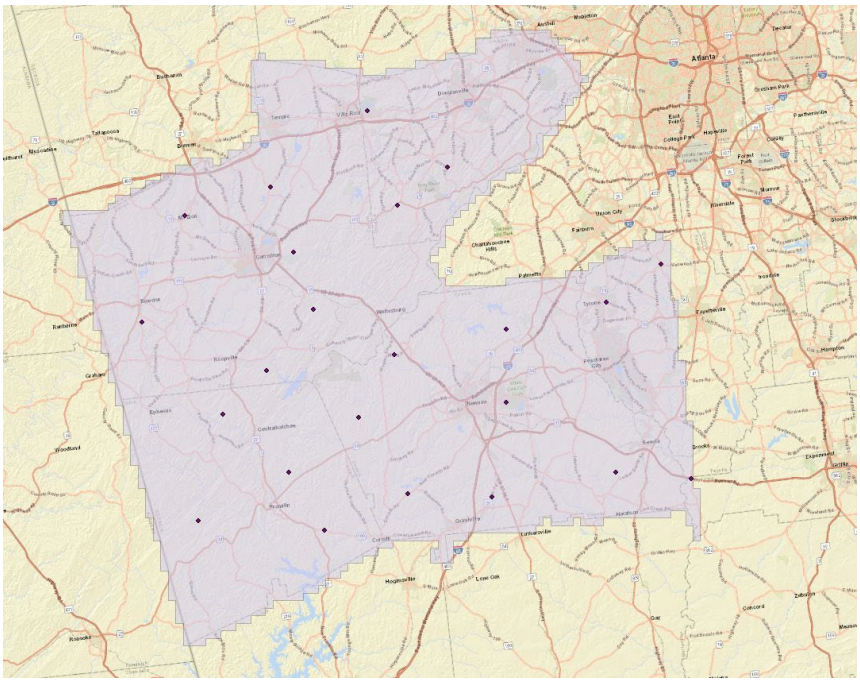

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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	6350
Units of Reference	Meter

Table 8: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	15,980,279,099
Nominal Pulse Spacing (M)	0.5302
Nominal Pulse Density (PLS/M^2)	3.5571
Total Points (Aggregate)	15,980,279,099
Aggregate Pulse Spacing (M)	0.5473
Aggregate Pulse Density (PLS/M^2)	3.3385

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 rasters (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 rasters (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 1.0-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 GeoTIFF 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 11: 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)	27	0.0785	0.1540	0.1018
NVA (DEM)	27	0.0717	0.1406	-0.0132
VVA (Point Cloud)	23	0.1112	0.2180	0.1609
VVA (DEM)	23	0.0850	0.1665	-0.0035

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.

James C. Cannon, ASPRS Certified Photogrammetrist #R1594CP

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)	Point Type
BE30	1059072.6980	1217585.8780	275.9640	276.0630	0.0990	NVA
BE31	1030954.1710	1214310.6950	267.4760	267.5270	0.0510	NVA
BE32	1019276.7820	1229084.7590	381.4110	381.5080	0.0970	NVA
BE33	1040562.4490	1248806.3100	303.8370	303.8790	0.0420	NVA
BE34	1009777.7240	1245538.2190	350.1600	350.2390	0.0790	NVA
BE35	989727.9200	1226601.0960	335.9220	335.9590	0.0370	NVA
BE36	998433.0390	1182589.6640	262.9180	262.9220	0.0040	NVA
BE37	1016766.2030	1195994.9550	252.3170	252.4130	0.0960	NVA
BE38	1044174.9080	1198730.7960	248.8320	248.9100	0.0780	NVA
BR27	1052757.8780	1197110.3400	274.8150	274.9770	0.1620	VVA
BR28	1024954.5810	1194252.4020	224.9250	224.9540	0.0290	VVA
BR29	1018444.6490	1204330.2870	267.4140	267.5230	0.1090	VVA
BR30	997061.7720	1190663.4460	266.3820	266.4690	0.0870	VVA
BR31	989593.1120	1217125.3380	308.6390	308.7100	0.0710	VVA
BR32	1009804.8840	1226390.3230	353.0950	353.2770	0.1820	VVA
BR33	1030243.5390	1237697.7940	306.5910	306.6890	0.0980	VVA
BR34	1051447.4820	1219772.6080	296.0760	296.1860	0.1100	VVA
HG25	1058798.2400	1224821.1020	291.9620	292.1130	0.1510	VVA
HG26	1038093.3790	1216152.1080	292.5610	292.6940	0.1330	VVA
HG27	1023149.0430	1212696.9650	255.5570	255.6630	0.1060	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Point Type
HG28	1006727.7350	1235079.8970	332.2220	332.3260	0.1040	VVA
HG29	1012395.7160	1218728.0220	319.7440	319.8540	0.1100	VVA
HG30	1000331.7960	1204800.7020	322.1100	322.2390	0.1290	VVA
HG31	1013879.1040	1189372.7370	207.6750	207.7180	0.0430	VVA
HG32	1062816.7040	1196270.5280	237.2620	237.3850	0.1230	VVA
OT25	1058805.2120	1202328.6200	245.1140	245.1840	0.0700	NVA
OT26	1045992.6560	1216380.3340	280.8870	281.0280	0.1410	NVA
OT27	1030051.6620	1198779.2220	266.8700	266.9690	0.0990	NVA
OT28	1004242.3020	1190812.0580	216.8110	216.8900	0.0790	NVA
OT29	995253.2320	1210419.0140	366.6830	366.7270	0.0440	NVA
OT30	1003799.5980	1228614.7650	303.0440	303.1410	0.0970	NVA
OT31	1024010.9180	1240030.3810	336.4120	336.4950	0.0830	NVA
OT41	1016478.8010	1209808.9390	287.1080	287.1930	0.0850	NVA
OT42	998093.3380	1198381.2280	329.7940	329.8730	0.0790	NVA
OT48	1005689.4710	1202794.2110	251.5540	251.6100	0.0560	NVA
TR26	1038154.6460	1206368.5790	275.6980	275.7890	0.0910	VVA
TR27	1036227.2180	1193776.0930	273.7670	273.8740	0.1070	VVA
TR28	1009170.2820	1197089.0220	212.1550	212.1990	0.0440	VVA
TR29	1006147.4360	1210621.2480	282.4100	282.4660	0.0560	VVA
TR30	995304.5200	1231218.1220	365.8590	366.0000	0.1410	VVA
TR31	1019617.8410	1245203.0320	341.7840	341.8790	0.0950	VVA
TR32	1023604.6470	1232622.0900	354.0510	354.1780	0.1270	VVA
UR42	1051117.3900	1206945.3300	251.0490	251.1180	0.0690	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Point Type
UR43	1025888.1440	1205265.9750	251.0570	251.1540	0.0970	NVA
UR44	1021151.7830	1220608.2970	235.3390	235.4180	0.0790	NVA
UR45	1006293.7630	1218310.7960	360.9040	361.0070	0.1030	NVA
UR46	1012907.6420	1238153.4570	327.5690	327.6410	0.0720	NVA
UR47	1031637.9750	1244897.5410	326.6550	326.7290	0.0740	NVA
UR48	1008943.2870	1185399.6540	204.3820	204.3940	0.0120	NVA
UR49	997579.3460	1219941.0170	293.9320	293.9830	0.0510	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)	Point Type
BE30	1059072.6980	1217585.8780	275.9640	276.0290	-0.0650	NVA
BE31	1030954.1710	1214310.6950	267.4760	267.5230	-0.0470	NVA
BE32	1019276.7820	1229084.7590	381.4110	381.4930	-0.0820	NVA
BE33	1040562.4490	1248806.3100	303.8370	303.8710	-0.0340	NVA
BE34	1009777.7240	1245538.2190	350.1600	350.1890	-0.0290	NVA
BE35	989727.9200	1226601.0960	335.9220	335.9730	-0.0510	NVA
BE36	998433.0390	1182589.6640	262.9180	262.9250	-0.0070	NVA
BE37	1016766.2030	1195994.9550	252.3170	252.3870	-0.0700	NVA
BE38	1044174.9080	1198730.7960	248.8320	248.8620	-0.0300	NVA
OT25	1058805.2120	1202328.6200	245.1140	245.1900	-0.0760	NVA
OT26	1045992.6560	1216380.3340	280.8870	281.0150	-0.1280	NVA
OT27	1030051.6620	1198779.2220	266.8700	266.9470	-0.0770	NVA
OT28	1004242.3020	1190812.0580	216.8110	216.9490	-0.1380	NVA
OT29	995253.2320	1210419.0140	366.6830	366.7100	-0.0270	NVA
OT30	1003799.5980	1228614.7650	303.0440	303.1030	-0.0590	NVA
OT31	1024010.9180	1240030.3810	336.4120	336.4380	-0.0260	NVA
OT41	1016478.8010	1209808.9390	287.1080	287.1200	-0.0120	NVA
OT42	998093.3380	1198381.2280	329.7940	329.8720	-0.0780	NVA
OT48	1005689.4710	1202794.2110	251.5540	251.6440	-0.0900	NVA
UR42	1051117.3900	1206945.3300	251.0490	251.1200	-0.0710	NVA
UR43	1025888.1440	1205265.9750	251.0570	251.1220	-0.0650	NVA
UR44	1021151.7830	1220608.2970	235.3390	235.4350	-0.0960	NVA
UR45	1006293.7630	1218310.7960	360.9040	361.0160	-0.1120	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Point Type
UR46	1012907.6420	1238153.4570	327.5690	327.6250	-0.0560	NVA
UR47	1031637.9750	1244897.5410	326.6550	326.7150	-0.0600	NVA
UR48	1008943.2870	1185399.6540	204.3820	204.3980	-0.0160	NVA
UR49	997579.3460	1219941.0170	293.9320	294.0370	-0.1050	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Point Type
BR27	1052757.8780	1197110.3400	274.8150	274.8770	-0.0620	VVA
BR28	1024954.5810	1194252.4020	224.9250	225.0160	-0.0910	VVA
BR29	1018444.6490	1204330.2870	267.4140	267.4370	-0.0230	VVA
BR30	997061.7720	1190663.4460	266.3820	266.4380	-0.0560	VVA
BR31	989593.1120	1217125.3380	308.6390	308.7340	-0.0950	VVA
BR32	1009804.8840	1226390.3230	353.0950	353.1500	-0.0550	VVA
BR33	1030243.5390	1237697.7940	306.5910	306.6330	-0.0420	VVA
BR34	1051447.4820	1219772.6080	296.0760	296.1900	-0.1140	VVA
HG25	1058798.2400	1224821.1020	291.9620	292.0840	-0.1220	VVA
HG26	1038093.3790	1216152.1080	292.5610	292.6460	-0.0850	VVA
HG27	1023149.0430	1212696.9650	255.5570	255.6480	-0.0910	VVA
HG28	1006727.7350	1235079.8970	332.2220	332.3300	-0.1080	VVA
HG29	1012395.7160	1218728.0220	319.7440	319.8010	-0.0570	VVA
HG30	1000331.7960	1204800.7020	322.1100	322.2380	-0.1280	VVA
HG31	1013879.1040	1189372.7370	207.6750	207.7320	-0.0570	VVA
HG32	1062816.7040	1196270.5280	237.2620	237.3740	-0.1120	VVA
TR26	1038154.6460	1206368.5790	275.6980	275.7770	-0.0790	VVA
TR27	1036227.2180	1193776.0930	273.7670	273.8910	-0.1240	VVA
TR28	1009170.2820	1197089.0220	212.1550	212.1450	0.0100	VVA
TR29	1006147.4360	1210621.2480	282.4100	282.4180	-0.0080	VVA
TR30	995304.5200	1231218.1220	365.8590	365.9590	-0.1000	VVA
TR31	1019617.8410	1245203.0320	341.7840	341.7870	-0.0030	VVA
TR32	1023604.6470	1232622.0900	354.0510	354.1700	-0.1190	VVA

Table 14: DEM Check Point Assessment