



Project Report

TASK ORDER NAME: GA_Central_2019_B19

TASK ORDER NUMBER: 140G0219F0277

CONTRACT NUMBER: G16PC00042

ATLANTIC PROJECT NUMBER: 19064

USGS WORK UNIT ID: ID183179_GA_Central_1_2018

TABLE OF CONTENTS

SECTION 1: PROJECT OVERVIEW AND PURPOSE	3
1.1 Aerial LiDAR Project	3
1.1.1 Project Overview	3
1.1.2 Project Purpose	4
1.1.3 Contract Deliverables.....	4
SECTION 2: FIELD OPERATIONS	5
2.1 Aerial LiDAR Project – Aerial Acquisition	5
2.1.1 Aircraft and Sensor Information	5
2.1.2 Sensor Acquisition Information.....	6
2.1.3 Flight Plan Execution.....	6
2.1.4 GNSS Reference Stations.....	7
2.2 Aerial LiDAR Project – Ground Acquisition	10
2.2.1 Ground Control Survey.....	10
SECTION 3: DATA PRODUCTION	18
3.1 Aerial LiDAR Project – Calibration/Classification	18
3.1.1 LiDAR Point Cloud Generation	18
3.1.2 Coordinate Reference System	18
3.1.3 LiDAR Point Cloud Statistics	18
3.1.4 Smooth Surface Repeatability (Interswath).....	18
3.1.5 LiDAR Calibration	18
3.1.6 LiDAR Classification.....	19
3.1.7 LiDAR Intensity Imagery.....	19
3.1.8 Hydro-line Collection/Conflation.....	20
3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)	20
SECTION 4: ACCURACY ASSESSMENT	21
4.1 Aerial LiDAR Project – Vertical Accuracy Assessment	21
4.1.1 Requirements	21
4.1.2 Results	21
SECTION 5: CERTIFICATION STATEMENTS	22
5.1 Aerial LiDAR Project	22
SECTION 6: CONTROL POINT ASSESSMENTS	23
6.1 Aerial LiDAR Project	23
6.1.1 Point Cloud Check Point Assessment	23
6.1.2 Digital Elevation Model (DEM) Check Point Assessment.....	26

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 GA Central 1 2018 Work Unit encompasses approximately 4,273 square miles.

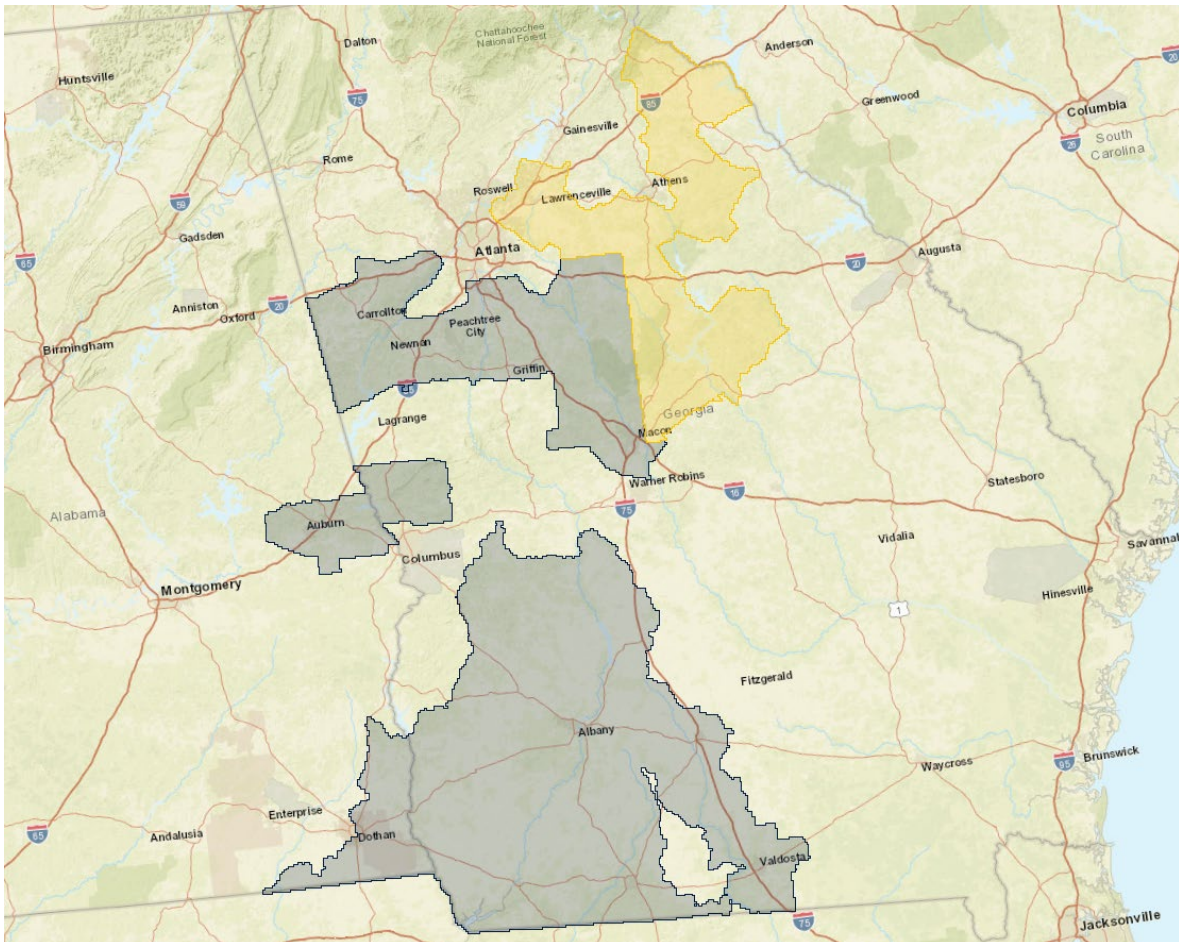


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) in Yellow and Associated Areas of Interest (AOIs) in Blue

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	Optech Galaxy Prime
Nominal Pulse Spacing (m)	.64
Nominal Pulse Density (pls/m²)	2.44
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	150
Pass Heading (°)	Varied
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)	.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 229 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 16 flight missions conducted between December 30, 2019 and January 28, 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.

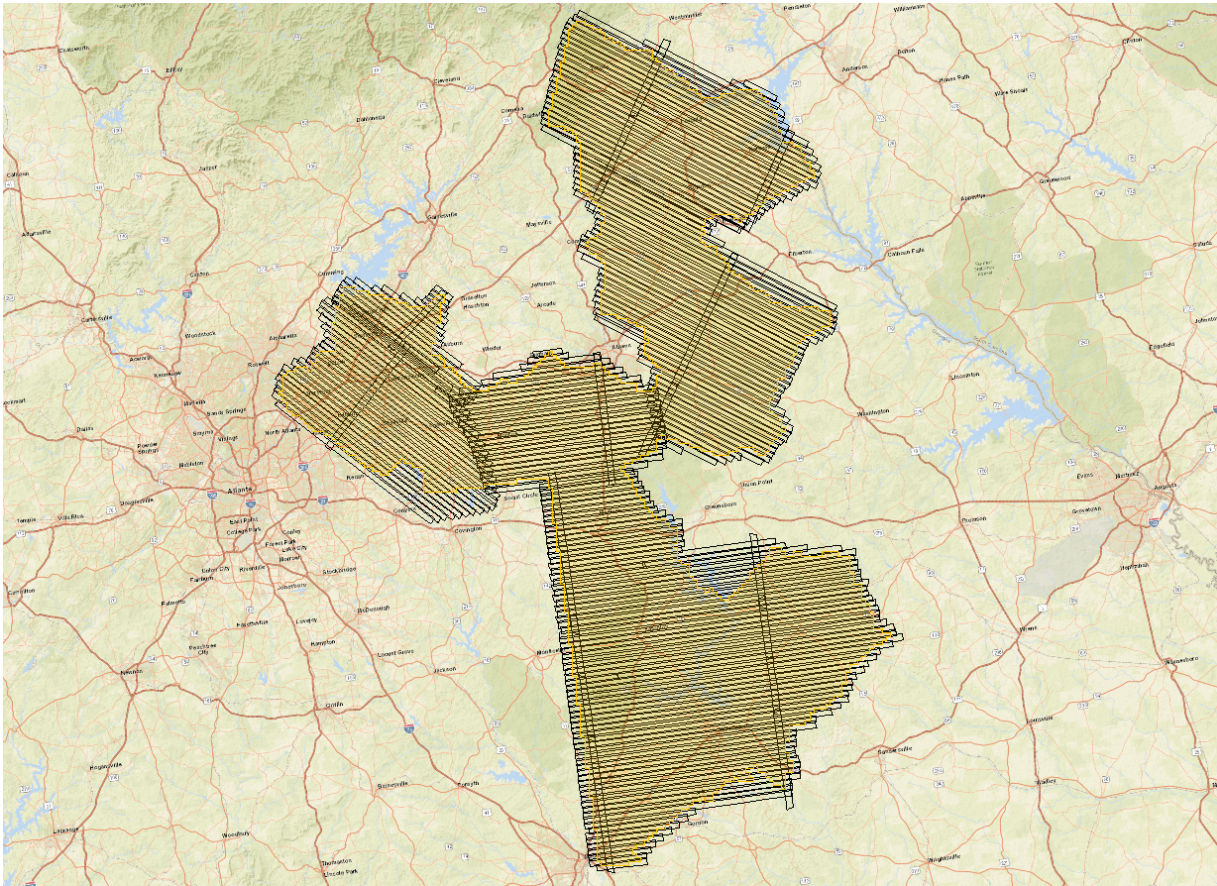


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Forty-five (45) 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°24'40.94501"	W86°16'13.97625"	44.676
AL62	CORS	AL62	N32°08'53.36427"	W85°41'12.37925"	140.811
AL76	CORS	AL76	N31°52'29.95916"	W85°13'32.48370"	100.108
ALA1	CORS	ALA1	N32°35'55.88602"	W85°30'14.13663"	184.083
ALAN	CORS	ALAN	N31°18'26.56972"	W86°29'02.25647"	85.248
ALDO	CORS	ALDO	N31°14'22.17261"	W85°26'24.71346"	79.679
ALHD	CORS	ALHD	N31°21'30.70339"	W85°15'43.45150"	71.838

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
ALLA	CORS	ALLA	N32°55'02.66210"	W85°24'01.80640"	237.158
ALLO	CORS	ALLO	N31°46'20.37200"	W85°30'06.79661"	117.211
ALNB	CORS	ALNB	N31°22'38.98303"	W85°54'57.77490"	106.888
ALRE	CORS	ALRE	N31°24'40.68451"	W87°14'03.29774"	85.24
ALSE	CORS	ALSE	N32°26'50.71020"	W87°00'42.40656"	29.745
ALTU	CORS	ALTU	N31°48'00.73672"	W85°57'15.53867"	141.125
DUNN	CORS	DUNN	N29°03'43.76395"	W82°22'15.35407"	-7.86
FL75	CORS	FL75	N30°36'45.11268"	W83°08'48.07610"	23.15
FLCB	CORS	FLCB	N29°50'33.38184"	W84°41'42.55870"	-21.079
FLMN	CORS	FLMN	N30°27'48.94548"	W83°24'46.53918"	21.051
FLTE	CORS	FLTE	N30°25'31.35486"	W84°15'01.38582"	61.588
FRKN	CORS	FRKN	N35°11'30.71115"	W83°23'41.77455"	619.541
GAAE	CORS	GAAE	N33°25'38.07517"	W82°04'04.06813"	124.356
GAAY	CORS	GAAY	N31°39'40.91991"	W84°16'29.65338"	55.889
GABR	CORS	GABR	N31°20'26.96122"	W83°16'11.38598"	60.19
GABY	CORS	GABY	N31°22'39.31821"	W84°56'06.69097"	63.548
GACC	CORS	GACC	N33°32'44.73033"	W82°08'01.72591"	98.476
GACG	CORS	GACG	N30°39'23.51713"	W83°06'01.04606"	15.588
GACL	CORS	GACL	N30°52'20.86185"	W84°23'55.88567"	56.406
GACU	CORS	GACU	N32°27'51.70118"	W84°59'11.19604"	53.14
GACV	CORS	GACV	N33°33'14.67672"	W84°00'36.20356"	213.82
GADO	CORS	GADO	N31°18'57.63577"	W83°51'40.87879"	86.392
GAED	CORS	GAED	N31°36'01.14065"	W84°51'42.39845"	103.784
GAGR	CORS	GAGR	N33°34'35.76001"	W83°10'58.96946"	172.93
GALC	CORS	GALC	N31°14'37.74051"	W84°55'13.36666"	38.465
GAMO	CORS	GAMO	N31°08'37.61920"	W83°42'50.80405"	62.983
GAMV	CORS	GAMV	N33°05'56.63939"	W83°14'47.49447"	91.103
GARA	CORS	GARA	N32°12'58.40828"	W83°51'11.16996"	91.464
GASA	CORS	GASA	N31°42'35.50980"	W84°22'08.78398"	68.854
GAVA	CORS	GAVA	N30°50'35.11375"	W83°16'18.44500"	45.412
GAWD	CORS	GAWD	N31°02'51.98948"	W84°12'16.58539"	82.181
GAWE	CORS	GAWE	N32°00'31.56770"	W84°33'33.38027"	128.759
GNVL	CORS	GNVL	N29°41'11.57797"	W82°16'36.75907"	22.438
P805	CORS	P805	N32°57'47.65078"	W84°13'32.99336"	215.735
TALH	CORS	TALH	N30°23'47.50413"	W84°21'21.06142"	-7.292
XCTY	CORS	XCTY	N29°37'51.63332"	W83°06'29.36131"	-15.299

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
ZJX1	CORS	ZJX1	N30°41'55.89366"	W81°54'29.46878"	1.677
ZTL4	CORS	ZTL4	N33°22'46.87805"	W84°17'48.21671"	260.681

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 170 ground survey points were collected in support of this project, including 42 LiDAR Control Points (LCP), 77 Non-vegetated Vertical Accuracy (NVA) and 51 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:

Point ID	Easting	Northing	Elevation
LCP01	1163340.692	1343198.926	225.363
LCP02	1181590.158	1346850.918	240.903
LCP03	1150779.863	1329481.046	252.662
LCP04	1173397.513	1330326.421	274.419
LCP05	1167144.409	1315820.335	230.534
LCP06	1156317.383	1318210.404	244.714
LCP07	1174867.071	1309184.671	223.566
LCP08	1155200.932	1300594.836	262.632
LCP09	1173061.867	1304490.530	228.178
LCP10	1194618.037	1292259.034	193.461
LCP11	1178954.785	1281904.361	225.024
LCP12	1183739.364	1274280.019	200.110
LCP13	1158552.105	1273835.068	217.114
LCP14	1139451.155	1280456.603	256.522
LCP15	1136198.554	1264902.481	242.493
LCP16	1114757.619	1274865.254	288.460

Point ID	Easting	Northing	Elevation
LCP17	1106211.132	1293654.990	339.055
LCP18	1100094.725	1286518.934	344.608
LCP19	1093809.589	1275888.625	271.055
LCP20	1094049.347	1263972.719	262.836
LCP23	1144780.664	1254147.140	224.806
LCP28	1143589.288	1229873.265	178.659
LCP29	1160951.679	1215988.842	139.577
LCP30	1168205.954	1220349.459	193.250
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	1202329.000	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	1191922.090	145.877
LCP80	1166021.386	1173666.731	147.788
LCP82	1169574.485	1228529.589	163.539
LCP83	1125066.689	1265660.622	257.667
LCP84	1179593.169	1333480.167	279.253
LCP85	1100675.803	1266733.084	296.357

Table 5: LiDAR Control Point Coordinates

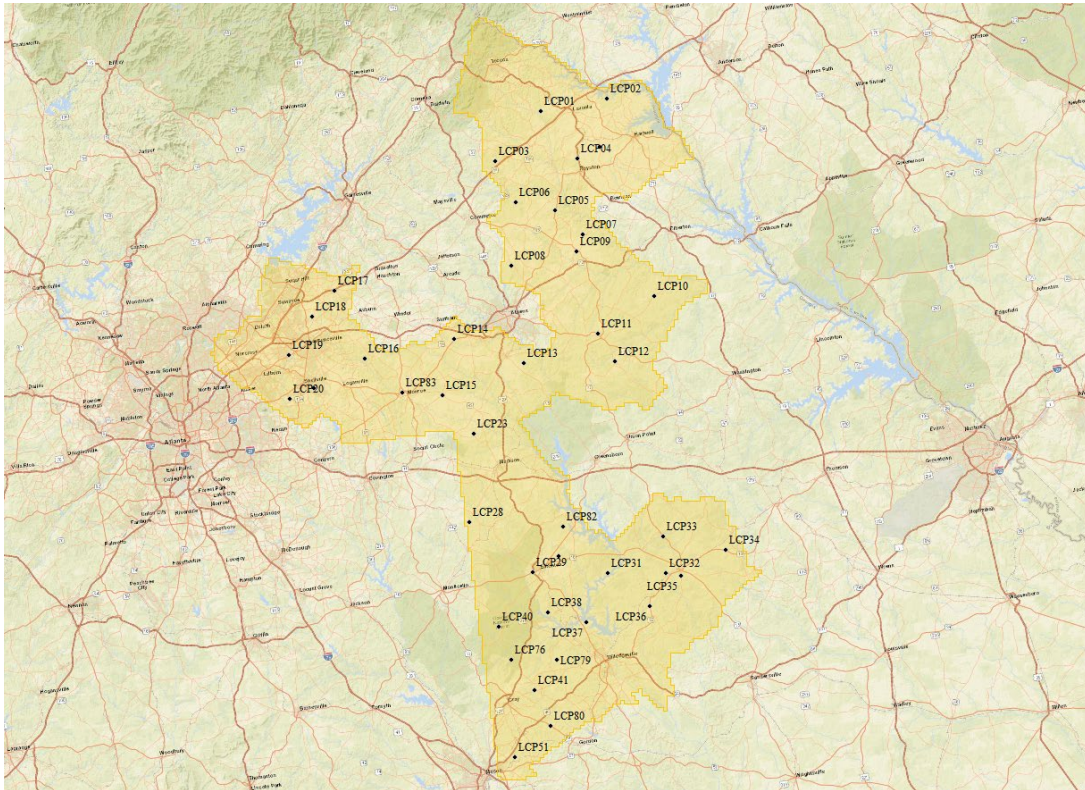


Figure 3: LiDAR Control Point Distribution

Point ID	Easting	Northing	Elevation
BE01	1150410.682	1358837.238	297.373
BE02	1159035.725	1346429.052	260.788
BE03	1176419.986	1341141.848	259.485
BE04	1192180.842	1330711.655	229.197
BE05	1167298.612	1326504.085	184.893
BE06	1159173.597	1311977.072	249.362
BE07	1162800.227	1300111.272	236.089
BE08	1179784.627	1303855.761	196.916
BE09	1198685.872	1292190.836	170.793
BE10	1188184.532	1279268.894	175.446
BE11	1173937.621	1272770.740	226.252
BE12	1152055.459	1274008.353	238.575
BE13	1117079.507	1267897.449	287.938
BE14	1099635.754	1282224.158	321.243
BE15	1091457.890	1298107.101	303.445

Point ID	Easting	Northing	Elevation
BE16	1079957.788	1274811.238	291.111
BE17	1096438.598	1261841.907	276.465
BE18	1139041.446	1255100.407	236.039
OT01	1146196.446	1347628.548	262.742
OT02	1169141.735	1346231.863	254.281
OT03	1184562.315	1334356.606	250.311
OT04	1170045.345	1312057.321	208.506
OT05	1190414.576	1289760.927	195.883
OT06	1180777.879	1269842.052	225.785
OT07	1158691.625	1268567.740	199.745
OT08	1135130.549	1274373.190	241.156
OT09	1108379.939	1274761.391	302.154
OT10	1102848.033	1293916.052	360.354
OT11	1114441.238	1255877.722	279.955
OT12	1129117.788	1259329.212	264.211
OT13	1151175.129	1256878.236	189.450
OT34	1092713.951	1270808.260	287.257
OT43	1174973.047	1287476.575	213.513
OT44	1154698.945	1333891.069	244.070
OT46	1084659.835	1282816.431	332.464
OT47	1141194.659	1266261.947	217.334
UR01	1158251.245	1355986.410	283.994
UR02	1188215.185	1346727.271	246.871
UR03	1167048.762	1339772.019	232.153
UR04	1159940.839	1324126.178	231.678
UR05	1177730.685	1324593.916	246.133
UR06	1192681.927	1336173.323	220.521
UR07	1158592.633	1305493.002	264.941
UR08	1175178.174	1296015.916	216.109
UR09	1187216.901	1295871.452	199.924
UR10	1175390.232	1276670.555	243.483
UR11	1187358.414	1269656.754	193.670
UR12	1149458.977	1268458.946	219.849
UR13	1130677.326	1268662.219	255.260
UR14	1099489.399	1273157.530	308.237
UR15	1092622.367	1286880.691	333.289

Point ID	Easting	Northing	Elevation
UR16	1105510.668	1282267.623	295.133
BE20	1159947.460	1236460.154	173.594
BE21	1175365.421	1218903.829	190.636
BE22	1201540.558	1229074.616	182.900
BE23	1214414.346	1216484.670	164.743
BE24	1193505.150	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	151.510
OT15	1204677.424	1208782.476	153.657
OT17	1158199.887	1225636.326	150.160
OT19	1148950.252	1205858.940	187.012
OT20	1178444.821	1192932.064	114.838
OT21	1151055.753	1193216.796	165.080
OT36	1181176.207	1208748.137	142.748
OT37	1154274.593	1181265.937	180.940
OT49	1165653.983	1212248.026	179.131
UR20	1154921.078	1232726.279	171.752
UR25	1156889.827	1202878.630	169.670
UR31	1158540.583	1171627.612	159.199
UR32	1163237.758	1188300.170	168.467
UR33	1183944.732	1202167.421	108.920
UR34	1185902.252	1220913.474	135.832
UR35	1201719.392	1218199.577	170.024
UR36	1213084.456	1228165.810	181.712

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

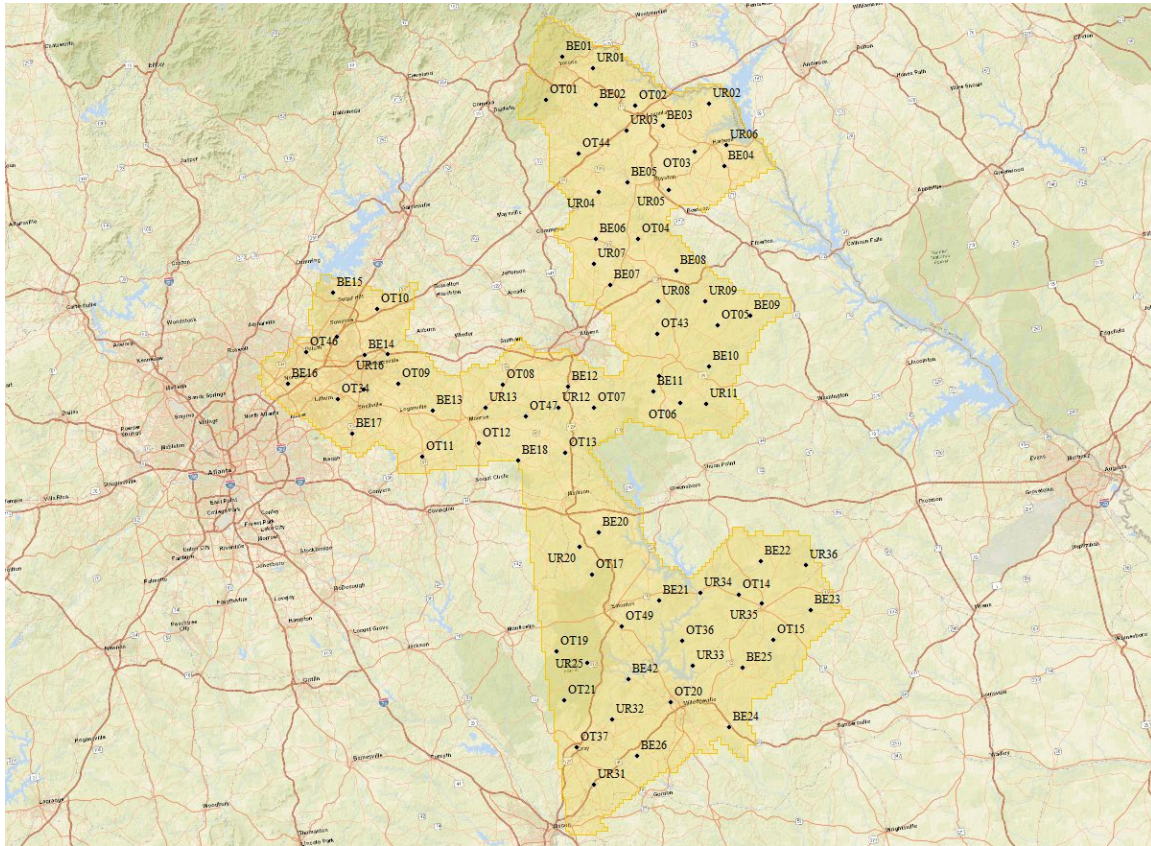


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

Point ID	Easting	Northing	Elevation
BR01	1163365.459	1350353.674	282.855
BR02	1159614.361	1337806.845	232.000
BR03	1187224.229	1325876.753	226.935
BR04	1173200.674	1319773.516	243.787
BR05	1168374.099	1305238.768	221.629
BR06	1178321.990	1292744.784	166.609
BR07	1179530.004	1278991.748	193.496
BR08	1144734.058	1260764.148	218.421
BR09	1121284.311	1260964.683	251.397
BR10	1084206.097	1271625.851	295.768
HG01	1162471.543	1330503.717	203.442
HG02	1198489.272	1331453.864	210.691
HG03	1163232.665	1310295.095	242.917
HG04	1167888.578	1290388.752	234.008

Point ID	Easting	Northing	Elevation
HG05	1190650.415	1285238.436	181.227
HG06	1153778.590	1264814.664	231.319
HG07	1127258.921	1270933.002	278.415
HG08	1095578.235	1292888.201	327.407
HG09	1111823.743	1262322.275	275.872
TR01	1153430.275	1351756.729	281.680
TR02	1153270.578	1342694.761	269.349
TR03	1183661.554	1340631.992	254.357
TR04	1172907.405	1333600.957	283.344
TR05	1162575.769	1319248.351	214.647
TR06	1181455.027	1286145.848	218.956
TR07	1167020.921	1272992.628	176.304
TR08	1145082.631	1275880.846	245.829
TR09	1106203.002	1265555.780	278.044
TR10	1089489.012	1278798.963	285.233
BR14	1157860.370	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	1205228.820	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	1207616.410	1218070.630	136.881
HG18	1176770.140	1181874.818	123.849
HG19	1161765.215	1175240.128	166.539
HG34	1144335.040	1223628.458	184.734
TR12	1143420.320	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	1194494.010	1211534.122	149.482
TR19	1192938.975	1230844.031	180.007

Point ID	Easting	Northing	Elevation
TR20	1188854.949	1195495.909	166.126

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

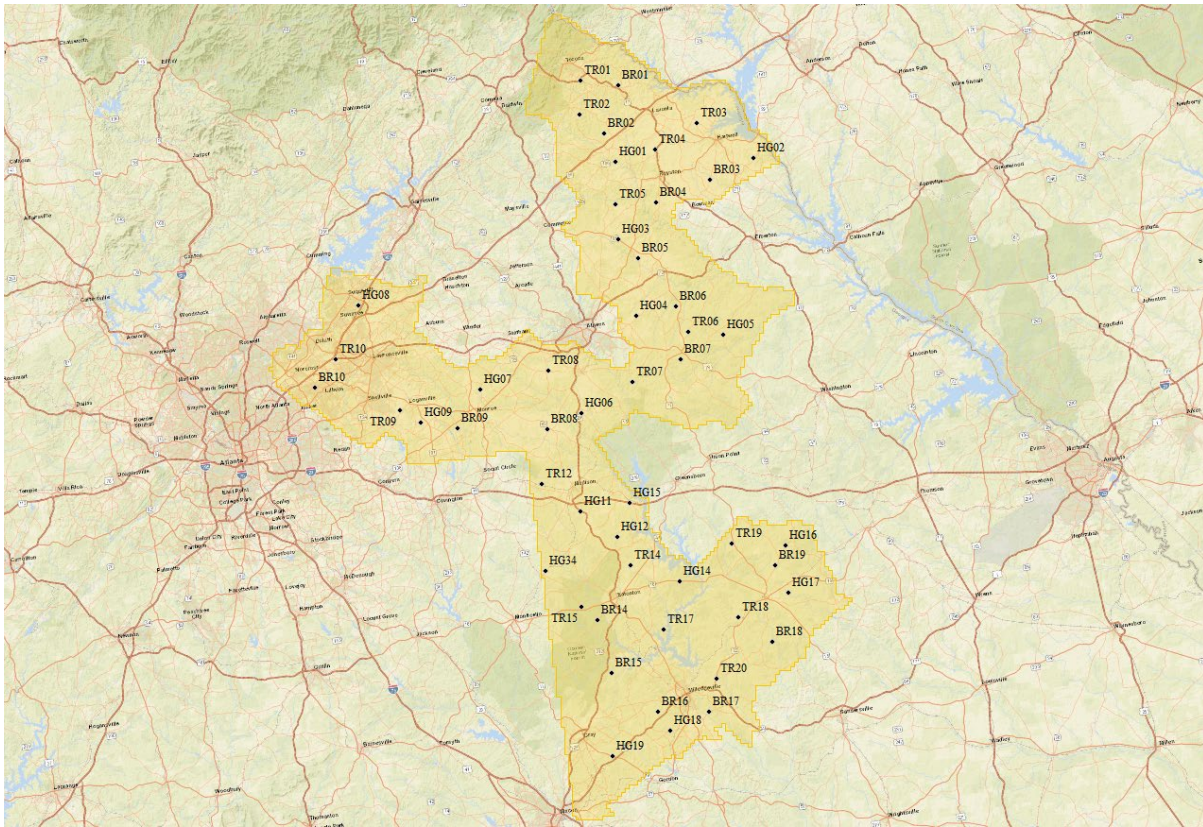


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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	6350
Units of Reference	Meter

Table 8: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	44,802,399,495
Nominal Pulse Spacing (M)	0.5760
Nominal Pulse Density (PLS/M ²)	3.0141
Total Points (Aggregate)	39,109,717,856
Aggregate Pulse Spacing (M)	0.5636
Aggregate Pulse Density (PLS/M ²)	3.1478

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 $\leq 2\text{cm}$. 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 1: 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)	77	0.0456	0.0893	0.0406
NVA (DEM)	77	0.0464	0.0910	0.0875
VVA (Point Cloud)	46	0.1259	0.2468	0.3028
VVA (DEM)	46	0.1265	0.2480	0.0686

Table 2: NVA/VVA Accuracies

SECTION 5: CERTIFICATION STATEMENTS

5.1 Aerial LiDAR Project

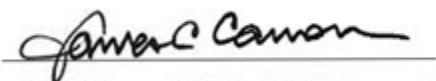
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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)	Report Point Type
BE01	1150410.6820	1358837.2380	297.3730	297.3960	0.0230	NVA
BE02	1159035.7250	1346429.0520	260.7880	260.8040	0.0160	NVA
BE03	1176419.9860	1341141.8480	259.4850	259.4810	-0.0040	NVA
BE04	1192180.8420	1330711.6550	229.1970	229.2330	0.0360	NVA
BE05	1167298.6120	1326504.0850	184.8930	184.8990	0.0060	NVA
BE06	1159173.5970	1311977.0720	249.3620	249.3450	-0.0170	NVA
BE07	1162800.2270	1300111.2720	236.0890	236.0320	-0.0570	NVA
BE08	1179784.6270	1303855.7610	196.9160	196.8730	-0.0430	NVA
BE09	1198685.8720	1292190.8360	170.7930	170.8040	0.0110	NVA
BE10	1188184.5320	1279268.8940	175.4460	175.4690	0.0230	NVA
BE11	1173937.6210	1272770.7400	226.2520	226.2360	-0.0160	NVA
BE12	1152055.4590	1274008.3530	238.5750	238.5870	0.0120	NVA
BE13	1117079.5070	1267897.4490	287.9380	287.9550	0.0170	NVA
BE14	1099635.7540	1282224.1580	321.2430	321.2360	-0.0070	NVA
BE15	1091457.8900	1298107.1010	303.4450	303.4340	-0.0110	NVA
BE16	1079957.7880	1274811.2380	291.1110	291.1470	0.0360	NVA
BE17	1096438.5980	1261841.9070	276.4650	276.4700	0.0050	NVA
BE18	1139041.4460	1255100.4070	236.0390	236.0110	-0.0280	NVA
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
BR01	1163365.4590	1350353.6740	282.8550	282.9330	0.0780	VVA
BR02	1159614.3610	1337806.8450	232.0000	232.0900	0.0900	VVA
BR03	1187224.2290	1325876.7530	226.9350	227.0040	0.0690	VVA
BR04	1173200.6740	1319773.5160	243.7870	243.7770	-0.0100	VVA
BR05	1168374.0990	1305238.7680	221.6290	221.6900	0.0610	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BR06	1178321.9900	1292744.7840	166.6090	166.5970	-0.0120	VVA
BR07	1179530.0040	1278991.7480	193.4960	193.4980	0.0020	VVA
BR08	1144734.0580	1260764.1480	218.4210	218.5280	0.1070	VVA
BR10	1084206.0970	1271625.8510	295.7680	295.8470	0.0790	VVA
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
HG01	1162471.5430	1330503.7170	203.4420	203.5120	0.0700	VVA
HG02	1198489.2720	1331453.8640	210.6910	210.7440	0.0530	VVA
HG03	1163232.6650	1310295.0950	242.9170	242.9720	0.0550	VVA
HG04	1167888.5780	1290388.7520	234.0080	234.0510	0.0430	VVA
HG05	1190650.4150	1285238.4360	181.2270	181.2810	0.0540	VVA
HG06	1153778.5900	1264814.6640	231.3190	231.3840	0.0650	VVA
HG07	1127258.9210	1270933.0020	278.4150	278.4650	0.0500	VVA
HG08	1095578.2350	1292888.2010	327.4070	327.4930	0.0860	VVA
HG09	1111823.7430	1262322.2750	275.8720	275.9790	0.1070	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
OT01	1146196.4460	1347628.5480	262.7420	262.7610	0.0190	NVA
OT02	1169141.7350	1346231.8630	254.2810	254.2840	0.0030	NVA
OT03	1184562.3150	1334356.6060	250.3110	250.3780	0.0670	NVA
OT04	1170045.3450	1312057.3210	208.5060	208.5190	0.0130	NVA
OT05	1190414.5760	1289760.9270	195.8830	195.8920	0.0090	NVA
OT06	1180777.8790	1269842.0520	225.7850	225.8010	0.0160	NVA
OT07	1158691.6250	1268567.7400	199.7450	199.7420	-0.0030	NVA
OT08	1135130.5490	1274373.1900	241.1560	241.1520	-0.0040	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
OT09	1108379.9390	1274761.3910	302.1540	302.1840	0.0300	NVA
OT10	1102848.0330	1293916.0520	360.3540	360.3450	-0.0090	NVA
OT11	1114441.2380	1255877.7220	279.9550	279.9410	-0.0140	NVA
OT12	1129117.7880	1259329.2120	264.2110	264.2470	0.0360	NVA
OT13	1151175.1290	1256878.2360	189.4500	189.4550	0.0050	NVA
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
OT34	1092713.9510	1270808.2600	287.2570	287.2350	-0.0220	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
OT43	1174973.0470	1287476.5750	213.5130	213.5060	-0.0070	NVA
OT44	1154698.9450	1333891.0690	244.0700	244.0670	-0.0030	NVA
OT46	1084659.8350	1282816.4310	332.4640	332.4330	-0.0310	NVA
OT47	1141194.6590	1266261.9470	217.3340	217.3430	0.0090	NVA
OT49	1165653.9830	1212248.0260	179.1310	179.1070	-0.0240	NVA
TR02	1153270.5780	1342694.7610	269.3490	269.4030	0.0540	VVA
TR03	1183661.5540	1340631.9920	254.3570	254.3430	-0.0140	VVA
TR05	1162575.7690	1319248.3510	214.6470	214.6380	-0.0090	VVA
TR06	1181455.0270	1286145.8480	218.9560	218.9440	-0.0120	VVA
TR07	1167020.9210	1272992.6280	176.3040	176.3120	0.0080	VVA
TR08	1145082.6310	1275880.8460	245.8290	245.8420	0.0130	VVA
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
UR01	1158251.2450	1355986.4100	283.9940	284.0170	0.0230	NVA
UR02	1188215.1850	1346727.2710	246.8710	246.8910	0.0200	NVA
UR03	1167048.7620	1339772.0190	232.1530	232.1670	0.0140	NVA
UR04	1159940.8390	1324126.1780	231.6780	231.6620	-0.0160	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR05	1177730.6850	1324593.9160	246.1330	246.1440	0.0110	NVA
UR06	1192681.9270	1336173.3230	220.5210	220.5120	-0.0090	NVA
UR07	1158592.6330	1305493.0020	264.9410	264.8670	-0.0740	NVA
UR08	1175178.1740	1296015.9160	216.1090	216.0700	-0.0390	NVA
UR09	1187216.9010	1295871.4520	199.9240	199.9360	0.0120	NVA
UR10	1175390.2320	1276670.5550	243.4830	243.4450	-0.0380	NVA
UR11	1187358.4140	1269656.7540	193.6700	193.5890	-0.0810	NVA
UR12	1149458.9770	1268458.9460	219.8490	219.8420	-0.0070	NVA
UR13	1130677.3260	1268662.2190	255.2600	255.2570	-0.0030	NVA
UR14	1099489.3990	1273157.5300	308.2370	308.2230	-0.0140	NVA
UR15	1092622.3670	1286880.6910	333.2890	333.3010	0.0120	NVA
UR16	1105510.6680	1282267.6230	295.1330	295.1920	0.0590	NVA
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
BE01	1150410.6820	1358837.2380	297.3730	297.3940	-0.0210	NVA
BE02	1159035.7250	1346429.0520	260.7880	260.7982	-0.0102	NVA
BE03	1176419.9860	1341141.8480	259.4850	259.4765	0.0085	NVA
BE04	1192180.8420	1330711.6550	229.1970	229.2364	-0.0394	NVA
BE05	1167298.6120	1326504.0850	184.8930	184.8899	0.0031	NVA
BE06	1159173.5970	1311977.0720	249.3620	249.3474	0.0146	NVA
BE07	1162800.2270	1300111.2720	236.0890	236.0310	0.0580	NVA
BE08	1179784.6270	1303855.7610	196.9160	196.8590	0.0570	NVA
BE09	1198685.8720	1292190.8360	170.7930	170.7831	0.0099	NVA
BE10	1188184.5320	1279268.8940	175.4460	175.4703	-0.0243	NVA
BE11	1173937.6210	1272770.7400	226.2520	226.2320	0.0200	NVA
BE12	1152055.4590	1274008.3530	238.5750	238.5846	-0.0096	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE13	1117079.5070	1267897.4490	287.9380	287.9510	-0.0130	NVA
BE14	1099635.7540	1282224.1580	321.2430	321.2403	0.0027	NVA
BE15	1091457.8900	1298107.1010	303.4450	303.4202	0.0248	NVA
BE16	1079957.7880	1274811.2380	291.1110	291.1462	-0.0352	NVA
BE17	1096438.5980	1261841.9070	276.4650	276.4698	-0.0048	NVA
BE18	1139041.4460	1255100.4070	236.0390	236.0030	0.0360	NVA
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
OT01	1146196.4460	1347628.5480	262.7420	262.7769	-0.0349	NVA
OT02	1169141.7350	1346231.8630	254.2810	254.2959	-0.0149	NVA
OT03	1184562.3150	1334356.6060	250.3110	250.3895	-0.0785	NVA
OT04	1170045.3450	1312057.3210	208.5060	208.5161	-0.0101	NVA
OT05	1190414.5760	1289760.9270	195.8830	195.8959	-0.0129	NVA
OT06	1180777.8790	1269842.0520	225.7850	225.7958	-0.0108	NVA
OT07	1158691.6250	1268567.7400	199.7450	199.7373	0.0077	NVA
OT08	1135130.5490	1274373.1900	241.1560	241.1587	-0.0027	NVA
OT09	1108379.9390	1274761.3910	302.1540	302.1885	-0.0345	NVA
OT10	1102848.0330	1293916.0520	360.3540	360.3428	0.0112	NVA
OT11	1114441.2380	1255877.7220	279.9550	279.9347	0.0203	NVA
OT12	1129117.7880	1259329.2120	264.2110	264.2458	-0.0348	NVA
OT13	1151175.1290	1256878.2360	189.4500	189.4585	-0.0085	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
OT34	1092713.9510	1270808.2600	287.2570	287.2368	0.0202	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

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT43	1174973.0470	1287476.5750	213.5130	213.5081	0.0049	NVA
OT44	1154698.9450	1333891.0690	244.0700	244.0649	0.0051	NVA
OT46	1084659.8350	1282816.4310	332.4640	332.4335	0.0305	NVA
OT47	1141194.6590	1266261.9470	217.3340	217.3419	-0.0079	NVA
OT49	1165653.9830	1212248.0260	179.1310	179.1002	0.0308	NVA
UR01	1158251.2450	1355986.4100	283.9940	284.0203	-0.0263	NVA
UR02	1188215.1850	1346727.2710	246.8710	246.8664	0.0046	NVA
UR03	1167048.7620	1339772.0190	232.1530	232.1497	0.0033	NVA
UR04	1159940.8390	1324126.1780	231.6780	231.6663	0.0117	NVA
UR05	1177730.6850	1324593.9160	246.1330	246.1418	-0.0088	NVA
UR06	1192681.9270	1336173.3230	220.5210	220.5097	0.0113	NVA
UR07	1158592.6330	1305493.0020	264.9410	264.8721	0.0689	NVA
UR08	1175178.1740	1296015.9160	216.1090	216.0745	0.0345	NVA
UR09	1187216.9010	1295871.4520	199.9240	199.9461	-0.0221	NVA
UR10	1175390.2320	1276670.5550	243.4830	243.4459	0.0371	NVA
UR11	1187358.4140	1269656.7540	193.6700	193.5840	0.0860	NVA
UR12	1149458.9770	1268458.9460	219.8490	219.8446	0.0044	NVA
UR13	1130677.3260	1268662.2190	255.2600	255.2627	-0.0027	NVA
UR14	1099489.3990	1273157.5300	308.2370	308.2171	0.0199	NVA
UR15	1092622.3670	1286880.6910	333.2890	333.3037	-0.0147	NVA
UR16	1105510.6680	1282267.6230	295.1330	295.1842	-0.0512	NVA
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
BR01	1163365.4590	1350353.6740	282.8550	282.9400	-0.0850	VVA
BR02	1159614.3610	1337806.8450	232.0000	232.0866	-0.0866	VVA
BR03	1187224.2290	1325876.7530	226.9350	227.0019	-0.0669	VVA
BR04	1173200.6740	1319773.5160	243.7870	243.7845	0.0025	VVA
BR05	1168374.0990	1305238.7680	221.6290	221.6984	-0.0694	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR06	1178321.9900	1292744.7840	166.6090	166.5808	0.0282	VVA
BR07	1179530.0040	1278991.7480	193.4960	193.5078	-0.0118	VVA
BR08	1144734.0580	1260764.1480	218.4210	218.5395	-0.1185	VVA
BR10	1084206.0970	1271625.8510	295.7680	295.8465	-0.0785	VVA
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
HG01	1162471.5430	1330503.7170	203.4420	203.5470	-0.1050	VVA
HG02	1198489.2720	1331453.8640	210.6910	210.7491	-0.0581	VVA
HG03	1163232.6650	1310295.0950	242.9170	242.9701	-0.0531	VVA
HG04	1167888.5780	1290388.7520	234.0080	234.0599	-0.0519	VVA
HG05	1190650.4150	1285238.4360	181.2270	181.2896	-0.0626	VVA
HG06	1153778.5900	1264814.6640	231.3190	231.3651	-0.0461	VVA
HG07	1127258.9210	1270933.0020	278.4150	278.4827	-0.0677	VVA
HG08	1095578.2350	1292888.2010	327.4070	327.4451	-0.0381	VVA
HG09	1111823.7430	1262322.2750	275.8720	275.9562	-0.0842	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
TR02	1153270.5780	1342694.7610	269.3490	269.3850	-0.0360	VVA
TR03	1183661.5540	1340631.9920	254.3570	254.3471	0.0099	VVA
TR05	1162575.7690	1319248.3510	214.6470	214.6405	0.0065	VVA
TR06	1181455.0270	1286145.8480	218.9560	218.9311	0.0249	VVA
TR07	1167020.9210	1272992.6280	176.3040	176.3097	-0.0057	VVA
TR08	1145082.6310	1275880.8460	245.8290	245.8282	0.0008	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

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
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