Project Report

TASK ORDER NAME: NM_SouthEast_2018_D19
TASK ORDER NUMBER: 140G219F0006
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 18079
PROJECT BLOCK NUMBER: BLOCK01

TABLE OF CONTENTS

SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

USGS task order 140G0219F0006-NM_SouthEast_2018_D19 required Fall 2018/Spring 2019 leaf-off LiDAR surveys to be collected over 23,650 square miles covering part or all of thirteen (13) counties in Southeast New Mexico. 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 1 portion of this project encompasses part of Dona Ana, and Otero counties in New Mexico and El Paso, and Hudspeth counties in Texas, covering approximately 3,505 square miles.

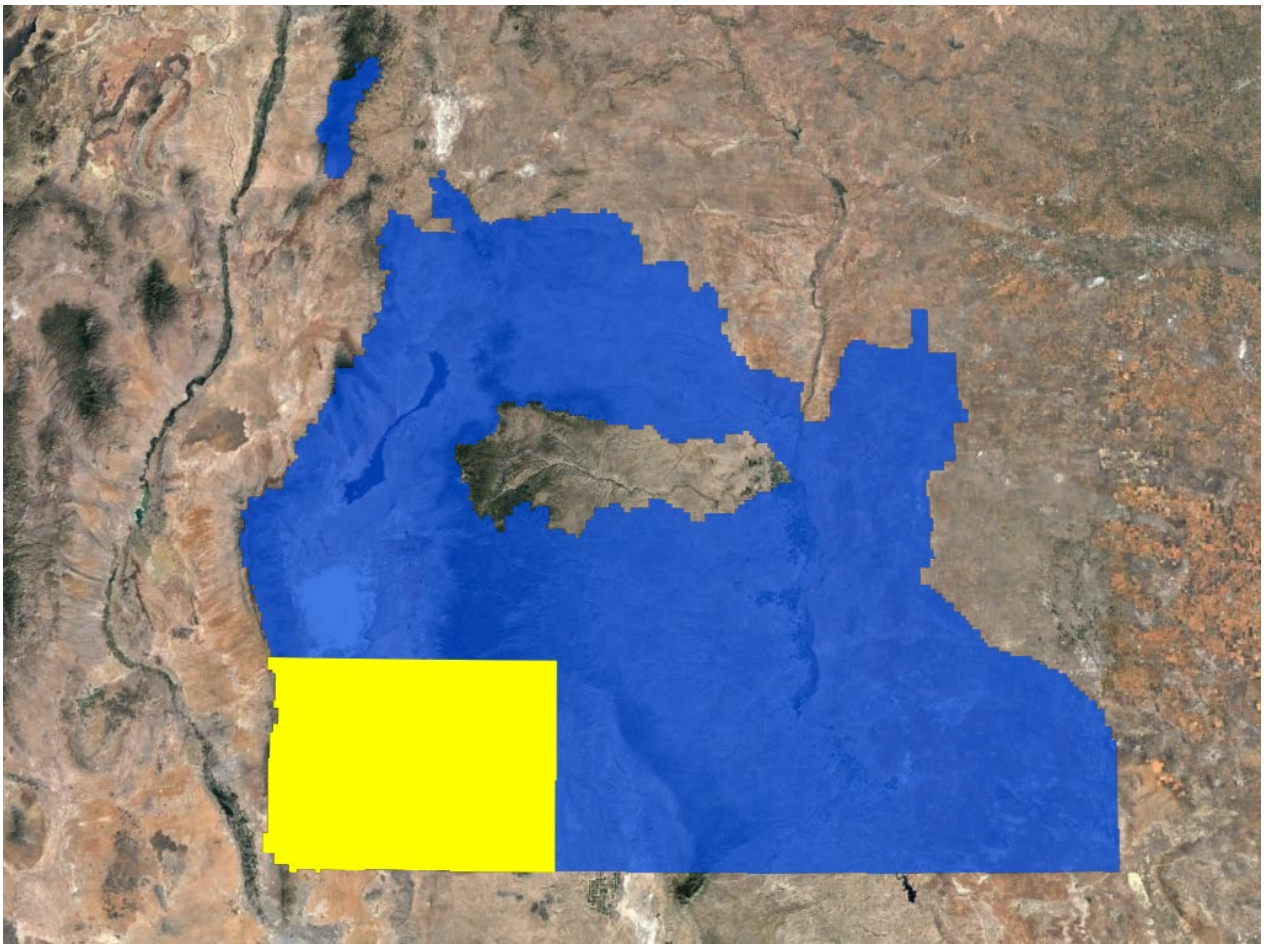


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs) Block 1 is delineated in Yellow.

b. Project Purpose

The collected QL2 LiDAR data will support the 3DEP mission, the Natural Resources Conservation Services (NRCS) high resolution elevation enterprise program and the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment and Planning (MAP) program.

c. Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS 1.4
Bare Earth Surface (Raster DEM)	1m cell size, GeoTIFF format, hydroflattened
Hydro Breaklines	.gdb format
Intensity Imagery	1m cell size, GeoTIFF format
Control	.txt
Delivery Diagram	ESRI Shapefile
Metadata	.xml format, FGDC compliant
Project Report	.pdf format

Table 1: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial LiDAR Project – Aerial Acquisition

a. Aircraft & 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

b. 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 Density (pls/m²)	2.33
Nominal Flight Height (AGL meters)	4000
Nominal Flight Speed (kts)	150
Pass Heading (°)	36

Parameter	Specification
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	60
Pulse Rate of Scanner (kHz)	350
Sensor Operated with Multiple Pulses	Yes
Nominal Swath Width (m)	1740
Nominal Swath Overlap (%)	20

Table 3: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired two hundred four (204) passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in seventeen (17) flight missions conducted between January 8, 2019 and May 4, 2019. 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.

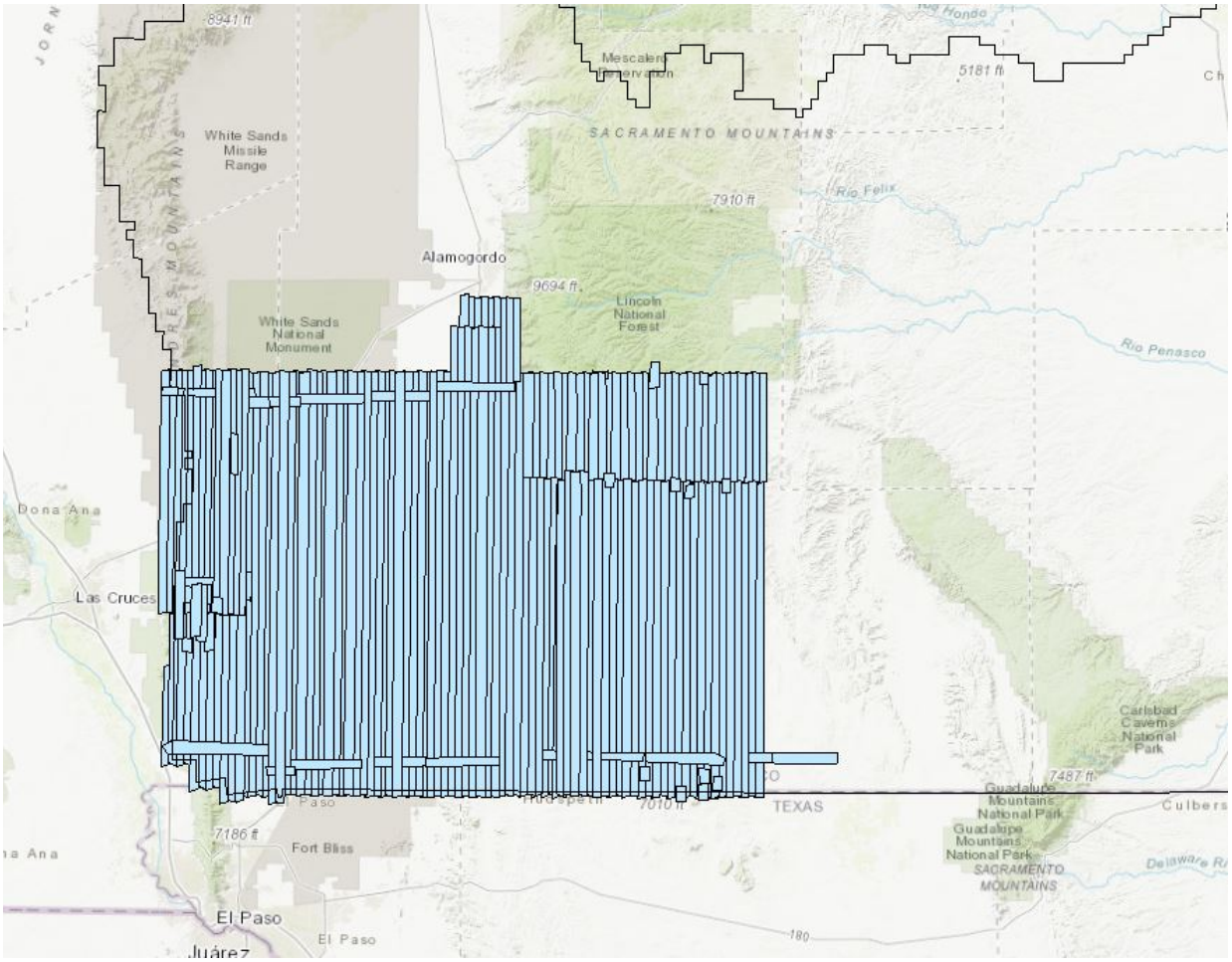


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. 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
MDO1	CORS	MDO1	N30°40'49.83667"	W104°00'53.98142"	2004.482
NMDE	CORS	NMDE	N32°16'02.16037"	W107°43'33.87426"	1297.79
NMRO	CORS	NMRO	N33°23'41.84858"	W104°35'20.78299"	1094.689
NMSU	CORS	NMSU	N32°16'27.36557"	W106°44'40.85697"	1187.507
P026	CORS	P026	N32°39'32.25698"	W107°11'41.54827"	1236.854
P027	CORS	P027	N32°48'06.68832"	W105°48'14.98122"	2896.731
P034	CORS	P034	N34°56'44.22757"	W106°27'33.36638"	1810.899
RG03	CORS	RG03	N33°39'16.88785"	W105°09'14.99564"	1572.584
RG07	CORS	RG07	N32°29'47.37491"	W106°50'35.93667"	1400.664
RG08	CORS	RG08	N32°43'42.06690"	W104°59'38.63128"	1488.626
SC01	CORS	SC01	N34°04'04.62680"	W106°57'59.55969"	2097.38
TNCU	CORS	TNCU	N28°27'01.99482"	W106°47'38.57916"	2106.944
TXBA	CORS	TXBA	N31°45'56.13787"	W106°26'47.18145"	1113.103
TXEL	CORS	TXEL	N31°41'29.45123"	W106°16'17.64946"	1122.015
TXKM	CORS	TXKM	N31°50'33.37118"	W103°06'31.30102"	847.998
TXP2	CORS	TXP2	N33°10'55.80238"	W102°49'05.38314"	1089.713
TXWT	CORS	TXWT	N31°52'12.41235"	W106°26'33.66123"	1193.335
USMX	CORS	USMX	N29°49'17.95043"	W109°40'51.78340"	625.458
UTEP	CORS	UTEP	N31°46'22.44640"	W106°30'22.71340"	1210.485

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 118 ground survey points were collected in support of this project, including 35 LiDAR Control Points (LCP), 50 Non-vegetated Vertical Accuracy (NVA) and 33 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
LCP103	379976.2	3612077	1208.72
LCP104	379828.4	3549744	1242.125
LCP105	418527.6	3544574	1616.2
LCP106	424257.7	3551914	1575.399
LCP108	426232.5	3578448	1604.132
LCP109	417740	3599331	1373.914
LCP111R	461987	3611988	1888.189
LCP138R	375257.6	3611162	1204.655
LCP139	381196.9	3587389	1226.468
LCP140	411158.8	3591913	1261.334
LCP141	434268.8	3574044	1498.825
LCP142	432608.1	3550423	1545.698
LCP15R	406703.2	3618064	1220.385
LCP15RR	406703.2	3618064	1220.385
LCP16	453827.8	3607672	1989.497
LCP167	440381.2	3553641	1489.675
LCP168	452426.7	3558933	1385.03
LCP169	435502	3604473	1915.514

ID	Easting	Northing	Elevation
LCP17	458876.7	3604852	1886.127
LCP18	459161	3575326	1311.088
LCP197	458921.1	3615493	1974.719
LCP198	430236.7	3619385	2345.569
LCP218	397346.2	3582140	1275.112
LCP219	372167.6	3600637	1205.997
LCP227	360715.1	3584020	1297.307
LCP228	365794.7	3568640	1234.842
LCP229	365374.7	3552416	1242.314
LCP230	443005.8	3557808	1458.803
LCP43	428655.1	3584829	1479.123
LCP45	391250.9	3549972	1253.087
LCP46	365028	3572827	1246.583
LCP47	384841.7	3585685	1234.309
LCP48	432617.4	3556540	1490.144
LCP49	428379	3578642	1567.822
LCP50	439946.4	3584198	1437.875

Table 5: LiDAR Control Point Coordinates

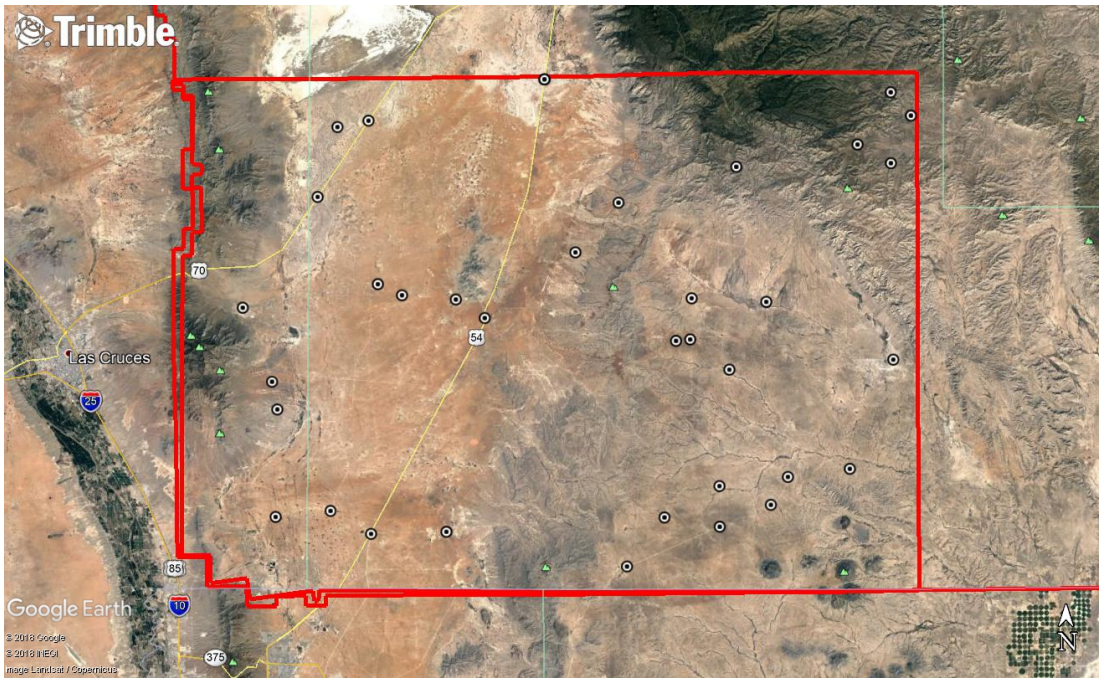


Figure 2: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE11	375430.5	3615323	1208.246
BE12	385794.5	3593143	1228.458
BE122	446294.2	3559387	1412.373
BE123	387337.3	3554322	1253.342
BE124	363860.5	3575873	1248.623
BE125	405573.9	3583466	1253.024
BE126	444474	3581890	1427.887
BE13R	393285.4	3580471	1248.482
BE14	439200	3567678	1440.028
BE24	457406.4	3599657	1951.242
BE25R	406637.3	3618085	1219.978
BE25RR	406637.3	3618085	1219.977
BE62	416692.6	3555453	1596.379
BE63	362171	3560297	1241.895
BE64	376527.6	3585582	1233.692
BE66R	407537.1	3619671	1224.265
BE67	423796.2	3595017	1503.295
BE92	435511.1	3604468	1916.017
OT106	398624	3597171	1258.742
OT11	364595.7	3602911	1347.435
OT12	387400.4	3571990	1247.669
OT122R	406302.3	3585929	1245.479
OT126	459173.1	3575328	1311.029
OT127	424916.2	3548996	1566.398
OT13	407032.4	3557373	1424.519
OT14	458210.5	3557710	1351.875
OT15R	455162	3571522	1344.217
OT44R	444534.5	3606571	1912.142
OT45	432215.8	3578992	1521.257
OT46	428705.1	3558439	1562.721
OT96	369972.8	3546485	1241.839
UR10	443281.4	3593763	1594.964
UR107	391178.6	3570607	1247.09
UR108	393011.5	3584935	1286.039
UR10Base	443281.4	3593763	1594.964
UR114	435124.7	3611649	2124.75
UR135	361717.8	3545599	1261.853
UR23	397532.8	3584069	1299.768

ID	Easting	Northing	Elevation
UR24	360693.8	3584053	1297.663
UR25	379960.5	3612056	1208.736
UR47	376005.3	3543318	1216.145
UR48	383234.4	3556273	1251.341
UR49	358460.4	3557815	1242.157
UR50	368173.6	3566087	1201.144
UR51	368340.7	3603058	1201.752
UR52	438752.8	3589689	1510.513
UR53R	457579.9	3618439	2064.638
UR9	403574.8	3599757	1227.108
UR90	353680.2	3589007	1675.35
UR91	405650.4	3611175	1219.426

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

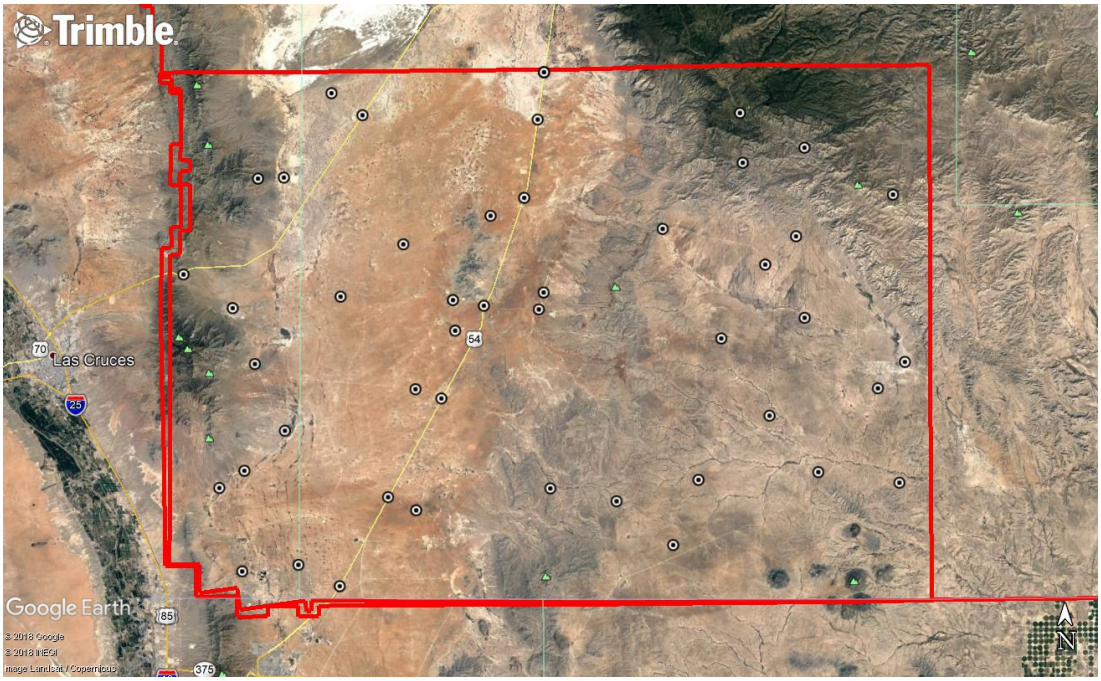


Figure 3: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR2	373665.4	3553293	1219.423
BR24	406879.3	3590216	1233.134
BR25	418510.8	3544584	1617.406
BR25A	418505.9	3544567	1615.873
BR3	415944.2	3596812	1312.212
BR65	392978.2	3609971	1218.163

ID	Easting	Northing	Elevation
BR66	360830.6	3617665	1286.15
BR67	421809.1	3600472	1488.624
BR70	458860.6	3604840	1886.875
BR81	443646.7	3563913	1420.743
BR82	424637.8	3553547	1583.242
HG1	376289.8	3559042	1240.272
HG2	428856.1	3568810	1548.41
HG23	436644.7	3596782	1678.692
HG24	422787.4	3561908	1611.135
HG25R	400305.8	3590503	1278.464
HG28	450803.6	3569539	1376.27
HG3	365750.6	3594739	1232.137
HG79	447632.7	3591402	1547.888
HG83	392984.9	3601455	1222.063
HG84	432173.8	3616961	2268.986
HG85	453830.1	3607679	1989.435
TR1R	400662.1	3575613	1285.662
TR27	430194.1	3593228	1543.004
TR28	439796.7	3578506	1498.057
TR2R	392630.9	3553795	1254.323
TR3	450771.2	3576526	1342.1
TR52	440191.1	3570169	1453.491
TR53R	403839.9	3579906	1262.476
TR54	378615.6	3577174	1237.784
TR55	381126.5	3559840	1243.22
TR56	368721.1	3612425	1204.488
TR57	393066.3	3605687	1218.253

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

Figure 4: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION III: DATA PRODUCTION

3. Aerial LiDAR Project – Calibration/Classification

a. 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.

b. Coordinate Reference System

Horizontal Datum: NAD83(NSRS2011)
Coordinate System: UTM 13N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	37,880,956,438
Nominal Pulse Spacing (M)	0.5820
Nominal Pulse Density (PLS/M^2)	2.9522
Total Points (Aggregate)	33,141,377,836
Aggregate Pulse Spacing (M)	0.5209
Aggregate Pulse Density (PLS/M^2)	3.6854

Table 8: LiDAR Point Cloud Statistics

d. 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. The following figure depicts a sample of the assessment.

e. 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.

f. 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 classes 9 (Water) and 20 (Ignored Ground).

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
6	Building
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground (breakline proximity)
21	Snow (if present and identifiable)
22	Temporal exclusion

Table 9: LiDAR Point Classification Codes and Descriptions

a. 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 .tif format.

b. 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.

c. 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 1.0 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 IV: ACCURACY ASSESSMENT

1. Aerial LiDAR Project – Vertical Accuracy Assessment

a. 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 10: 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).

b. 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)	48	0.0749	0.1468	0.0704
NVA (DEM)	48	0.0903	0.1769	0.1870
VVA (Point Cloud)	33	0.0578	0.1133	0.0758
VVA (DEM)	33	0.0672	0.1316	0.1499

Table 11: NVA/VVA Accuracies

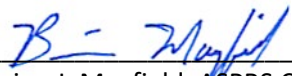
SECTION V: CERTIFICATION STATEMENTS

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 VI: CONTROL POINT ASSESSMENTS

1. Aerial LiDAR Project

a. Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE11	375430.5040	3615323.1090	1208.2460	1208.2120	-0.0340	NVA
BE12	385794.4950	3593142.9590	1228.4580	1228.5130	0.0550	NVA
BE122	446294.1800	3559387.0570	1412.3730	1412.4310	0.0580	NVA
BE123	387337.3050	3554322.4610	1253.3420	1253.3750	0.0330	NVA
BE124	363860.4630	3575872.6990	1248.6230	1248.5710	-0.0520	NVA
BE125	405573.8710	3583466.2120	1253.0240	1253.0200	-0.0040	NVA
BE126	444474.0090	3581889.6950	1427.8870	1427.9430	0.0560	NVA
BE13R	393285.3780	3580471.2370	1248.4820	1248.4740	-0.0080	NVA
BE14	439200.0460	3567677.9910	1440.0280	1440.1050	0.0770	NVA
BE24	457406.4010	3599656.6020	1951.2420	1951.2490	0.0070	NVA
BE25R	406637.3320	3618085.1020	1219.9780	1220.2980	0.3200	NVA
BE62	416692.5880	3555452.8480	1596.3790	1596.3070	-0.0720	NVA
BE63	362171.0030	3560296.9640	1241.8950	1241.8580	-0.0370	NVA
BE64	376527.6390	3585582.3640	1233.6920	1233.7360	0.0440	NVA
BE67	423796.2000	3595016.5930	1503.2950	1503.2340	-0.0610	NVA
BE92	435511.1450	3604467.5390	1916.0170	1915.9760	-0.0410	NVA
BR2	373665.4350	3553293.4580	1219.4230	1219.4020	-0.0210	VVA
BR24	406879.2870	3590215.8000	1233.1340	1233.1800	0.0460	VVA
BR25	418510.8070	3544584.0490	1617.4060	1617.2720	-0.1340	VVA
BR25A	418505.8930	3544566.6520	1615.8730	1615.7770	-0.0960	VVA
BR3	415944.1770	3596812.3050	1312.2120	1312.1000	-0.1120	VVA
BR65	392978.2000	3609970.6380	1218.1630	1218.1840	0.0210	VVA
BR66	360830.6420	3617664.6100	1286.1500	1286.1200	-0.0300	VVA
BR67	421809.1120	3600471.6590	1488.6240	1488.5660	-0.0580	VVA
BR70	458860.5890	3604840.1880	1886.8750	1886.9550	0.0800	VVA
BR81	443646.6890	3563913.3960	1420.7430	1420.8240	0.0810	VVA
BR82	424637.8390	3553547.1830	1583.2420	1583.2310	-0.0110	VVA
HG1	376289.7840	3559042.1360	1240.2720	1240.3450	0.0730	VVA
HG2	428856.1470	3568809.7280	1548.4100	1548.3510	-0.0590	VVA
HG23	436644.7470	3596781.8280	1678.6920	1678.7330	0.0410	VVA
HG24	422787.3970	3561908.3340	1611.1350	1611.1290	-0.0060	VVA
HG25R	400305.8300	3590502.7300	1278.4640	1278.4560	-0.0080	VVA
HG28	450803.6310	3569539.3700	1376.2700	1376.1780	-0.0920	VVA
HG3	365750.5710	3594739.1810	1232.1370	1232.1080	-0.0290	VVA
HG79	447632.7430	3591401.5720	1547.8880	1547.9610	0.0730	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
HG83	392984.8640	3601454.6540	1222.0630	1222.0770	0.0140	VVA
HG84	432173.7610	3616961.0520	2268.9860	2268.9860	0.0000	VVA
HG85	453830.1120	3607679.1760	1989.4350	1989.4170	-0.0180	VVA
OT106	398624.0400	3597171.0970	1258.7420	1258.7290	-0.0130	NVA
OT11	364595.7290	3602911.4170	1347.4350	1347.3840	-0.0510	NVA
OT12	387400.4030	3571989.7930	1247.6690	1247.6660	-0.0030	NVA
OT122R	406302.2790	3585929.0510	1245.4790	1245.4580	-0.0210	NVA
OT126	459173.0570	3575327.9360	1311.0290	1311.0310	0.0020	NVA
OT127	424916.1870	3548995.6360	1566.3980	1566.3540	-0.0440	NVA
OT13	407032.4380	3557373.4700	1424.5190	1424.5470	0.0280	NVA
OT14	458210.5450	3557710.3780	1351.8750	1351.8940	0.0190	NVA
OT15R	455161.9970	3571522.1750	1344.2170	1344.1900	-0.0270	NVA
OT44R	444534.5390	3606570.9010	1912.1420	1912.1850	0.0430	NVA
OT45	432215.8110	3578991.8850	1521.2570	1521.2310	-0.0260	NVA
OT46	428705.0840	3558438.6270	1562.7210	1562.6620	-0.0590	NVA
OT96	369972.7530	3546485.0400	1241.8390	1241.8370	-0.0020	NVA
TR1R	400662.0630	3575613.0020	1285.6620	1285.6650	0.0030	VVA
TR27	430194.0980	3593227.5040	1543.0040	1542.9010	-0.1030	VVA
TR28	439796.6580	3578506.4180	1498.0570	1498.0750	0.0180	VVA
TR2R	392630.8500	3553795.1890	1254.3230	1254.3840	0.0610	VVA
TR3	450771.2350	3576525.5210	1342.1000	1342.0150	-0.0850	VVA
TR52	440191.1050	3570169.1110	1453.4910	1453.5010	0.0100	VVA
TR53R	403839.9070	3579905.6500	1262.4760	1262.4400	-0.0360	VVA
TR54	378615.5600	3577174.3980	1237.7840	1237.7860	0.0020	VVA
TR55	381126.5200	3559839.9630	1243.2200	1243.2270	0.0070	VVA
TR56	368721.1080	3612424.8210	1204.4880	1204.4750	-0.0130	VVA
TR57	393066.3210	3605686.8250	1218.2530	1218.2850	0.0320	VVA
UR10	443281.4290	3593763.0890	1594.9640	1594.9800	0.0160	NVA
UR107	391178.6080	3570606.7780	1247.0900	1247.1090	0.0190	NVA
UR108	393011.4660	3584935.0950	1286.0390	1286.0350	-0.0040	NVA
UR10Base	443281.4290	3593763.0890	1594.9640	1594.9800	0.0160	NVA
UR114	435124.6740	3611648.8750	2124.7500	2124.6690	-0.0810	NVA
UR135	361717.7550	3545599.1140	1261.8530	1261.8250	-0.0280	NVA
UR23	397532.7960	3584069.3520	1299.7680	1299.7750	0.0070	NVA
UR24	360693.7560	3584052.5450	1297.6630	1297.6530	-0.0100	NVA
UR25	379960.5300	3612055.5430	1208.7360	1208.7360	0.0000	NVA
UR47	376005.2910	3543317.7310	1216.1450	1216.1460	0.0010	NVA
UR48	383234.3810	3556273.4370	1251.3410	1251.3690	0.0280	NVA
UR49	358460.4130	3557815.4980	1242.1570	1242.1490	-0.0080	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR50	368173.5940	3566087.3170	1201.1440	1201.1630	0.0190	NVA
UR51	368340.6660	3603057.7080	1201.7520	1201.7550	0.0030	NVA
UR52	438752.8060	3589688.7860	1510.5130	1510.5450	0.0320	NVA
UR53R	457579.8940	3618438.9200	2064.6380	2064.9600	0.3220	NVA
UR9	403574.7800	3599756.9770	1227.1080	1227.1210	0.0130	NVA
UR90	353680.2420	3589007.1260	1675.3500	1675.2830	-0.0670	NVA
UR91	405650.4140	3611174.9900	1219.4260	1219.4460	0.0200	NVA

Table 12: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE11	375430.5040	3615323.1090	1208.2460	1208.2332	-0.0128	NVA
BE12	385794.4950	3593142.9590	1228.4580	1228.4575	-0.0005	NVA
BE122	446294.1800	3559387.0570	1412.3730	1412.3293	-0.0437	NVA
BE123	387337.3050	3554322.4610	1253.3420	1253.3403	-0.0017	NVA
BE124	363860.4630	3575872.6990	1248.6230	1248.7572	0.1342	NVA
BE125	405573.8710	3583466.2120	1253.0240	1252.9872	-0.0368	NVA
BE126	444474.0090	3581889.6950	1427.8870	1427.8494	-0.0376	NVA
BE13R	393285.3780	3580471.2370	1248.4820	1248.4072	-0.0749	NVA
BE14	439200.0460	3567677.9910	1440.0280	1440.1983	0.1703	NVA
BE24	457406.4010	3599656.6020	1951.2420	1951.1947	-0.0472	NVA
BE25R	406637.3320	3618085.1020	1219.9780	1219.9672	-0.0108	NVA
BE62	416692.5880	3555452.8480	1596.3790	1596.3434	-0.0356	NVA
BE63	362171.0030	3560296.9640	1241.8950	1242.0693	0.1743	NVA
BE64	376527.6390	3585582.3640	1233.6920	1233.7312	0.0392	NVA
BE67	423796.2000	3595016.5930	1503.2950	1503.2285	-0.0665	NVA
BE92	435511.1450	3604467.5390	1916.0170	1915.9436	-0.0734	NVA
OT106	398624.0400	3597171.0970	1258.7420	1258.7243	-0.0176	NVA
OT11	364595.7290	3602911.4170	1347.4350	1347.5741	0.1390	NVA
OT12	387400.4030	3571989.7930	1247.6690	1247.6323	-0.0366	NVA
OT122R	406302.2790	3585929.0510	1245.4790	1245.4469	-0.0321	NVA
OT126	459173.0570	3575327.9360	1311.0290	1310.9658	-0.0633	NVA
OT127	424916.1870	3548995.6360	1566.3980	1566.4531	0.0552	NVA
OT13	407032.4380	3557373.4700	1424.5190	1424.5282	0.0092	NVA
OT14	458210.5450	3557710.3780	1351.8750	1351.8250	-0.0500	NVA
OT15R	455161.9970	3571522.1750	1344.2170	1344.2082	-0.0088	NVA
OT44R	444534.5390	3606570.9010	1912.1420	1912.1054	-0.0366	NVA
OT45	432215.8110	3578991.8850	1521.2570	1521.3012	0.0442	NVA
OT46	428705.0840	3558438.6270	1562.7210	1562.7420	0.0211	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT96	369972.7530	3546485.0400	1241.8390	1242.0755	0.2365	NVA
UR10	443281.4290	3593763.0890	1594.9640	1594.9761	0.0121	NVA
UR107	391178.6080	3570606.7780	1247.0900	1247.0914	0.0014	NVA
UR108	393011.4660	3584935.0950	1286.0390	1285.9808	-0.0581	NVA
UR10Base	443281.4290	3593763.0890	1594.9640	1594.9761	0.0121	NVA
UR114	435124.6740	3611648.8750	2124.7500	2124.6359	-0.1141	NVA
UR135	361717.7550	3545599.1140	1261.8530	1262.0469	0.1939	NVA
UR23	397532.7960	3584069.3520	1299.7680	1299.7369	-0.0310	NVA
UR24	360693.7560	3584052.5450	1297.6630	1297.7751	0.1121	NVA
UR25	379960.5300	3612055.5430	1208.7360	1208.7013	-0.0347	NVA
UR47	376005.2910	3543317.7310	1216.1450	1216.1583	0.0133	NVA
UR48	383234.3810	3556273.4370	1251.3410	1251.3522	0.0113	NVA
UR49	358460.4130	3557815.4980	1242.1570	1242.3744	0.2174	NVA
UR50	368173.5940	3566087.3170	1201.1440	1201.2960	0.1520	NVA
UR51	368340.6660	3603057.7080	1201.7520	1201.9199	0.1679	NVA
UR52	438752.8060	3589688.7860	1510.5130	1510.6182	0.1053	NVA
UR53R	457579.8940	3618438.9200	2064.6380	2064.5499	-0.0880	NVA
UR9	403574.7800	3599756.9770	1227.1080	1227.0798	-0.0282	NVA
UR90	353680.2420	3589007.1260	1675.3500	1675.4472	0.0972	NVA
UR91	405650.4140	3611174.9900	1219.4260	1219.4198	-0.0062	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR2	373665.4350	3553293.4580	1219.4230	1219.5167	0.0937	VVA
BR24	406879.2870	3590215.8000	1233.1340	1233.1498	0.0158	VVA
BR25	418510.8070	3544584.0490	1617.4060	1617.3541	-0.0519	VVA
BR25A	418505.8930	3544566.6520	1615.8730	1615.8192	-0.0538	VVA
BR3	415944.1770	3596812.3050	1312.2120	1312.2503	0.0383	VVA
BR65	392978.2000	3609970.6380	1218.1630	1218.1452	-0.0178	VVA
BR66	360830.6420	3617664.6100	1286.1500	1286.2210	0.0710	VVA
BR67	421809.1120	3600471.6590	1488.6240	1488.6176	-0.0064	VVA
BR70	458860.5890	3604840.1880	1886.8750	1886.8431	-0.0319	VVA
BR81	443646.6890	3563913.3960	1420.7430	1420.7298	-0.0132	VVA
BR82	424637.8390	3553547.1830	1583.2420	1583.2764	0.0345	VVA
HG1	376289.7840	3559042.1360	1240.2720	1240.2240	-0.0480	VVA
HG2	428856.1470	3568809.7280	1548.4100	1548.4644	0.0544	VVA
HG23	436644.7470	3596781.8280	1678.6920	1678.6471	-0.0449	VVA
HG24	422787.3970	3561908.3340	1611.1350	1611.0765	-0.0585	VVA
HG25R	400305.8300	3590502.7300	1278.4640	1278.4504	-0.0136	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
HG28	450803.6310	3569539.3700	1376.2700	1376.2206	-0.0494	VVA
HG3	365750.5710	3594739.1810	1232.1370	1232.2609	0.1239	VVA
HG79	447632.7430	3591401.5720	1547.8880	1547.8395	-0.0484	VVA
HG83	392984.8640	3601454.6540	1222.0630	1222.0254	-0.0376	VVA
HG84	432173.7610	3616961.0520	2268.9860	2269.0130	0.0269	VVA
HG85	453830.1120	3607679.1760	1989.4350	1989.4619	0.0268	VVA
TR1R	400662.0630	3575613.0020	1285.6620	1285.6399	-0.0221	VVA
TR27	430194.0980	3593227.5040	1543.0040	1542.9739	-0.0301	VVA
TR28	439796.6580	3578506.4180	1498.0570	1498.2263	0.1693	VVA
TR2R	392630.8500	3553795.1890	1254.3230	1254.3620	0.0390	VVA
TR3	450771.2350	3576525.5210	1342.1000	1342.0587	-0.0413	VVA
TR52	440191.1050	3570169.1110	1453.4910	1453.6383	0.1473	VVA
TR53R	403839.9070	3579905.6500	1262.4760	1262.4077	-0.0683	VVA
TR54	378615.5600	3577174.3980	1237.7840	1237.7377	-0.0464	VVA
TR55	381126.5200	3559839.9630	1243.2200	1243.2875	0.0675	VVA
TR56	368721.1080	3612424.8210	1204.4880	1204.6418	0.1538	VVA
TR57	393066.3210	3605686.8250	1218.2530	1218.2195	-0.0336	VVA

Table 13: DEM Check Point Assessment