Project Report

TASK ORDER NAME: NM_SouthEast_2018_D19
TASK ORDER NUMBER: 140G219F0006
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 18079
PROJECT BLOCK NUMBER: BLOCK08

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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 26,650 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 8 portion of this project encompasses part of Socorro, Guadalupe, Lincoln, Torrance, Valencia, and Bernalillo counties, covering approximately 1,203 square miles.

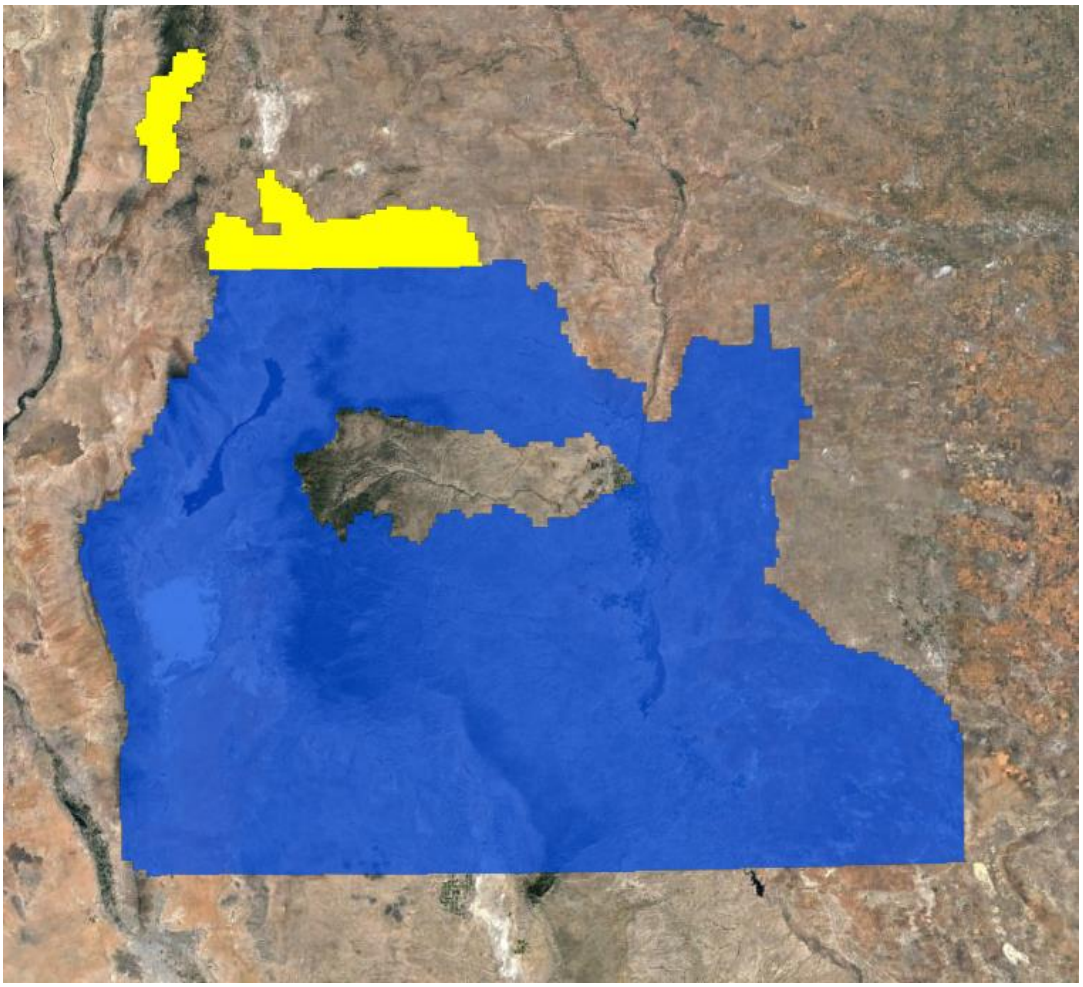


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs) Block 8 is delineated in Yellow.

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. Client Contact Information

Client Contact Information	
Name of Contact	Brent Marz
Organization	United States Geological Survey
Position	Government Point of Contact
Telephone	573-308-3538
E-Mail Address	bmarz@usgs.gov
Mailing Address	1400 Independence Road
City	Rolla
State or Province	Missouri
Postal Code	65401

Table 1: Aerial LiDAR Client Contact Information

d. 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 2: 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 3: 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 (°)	360/180
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 4: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired one hundred fifty (150) passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 11 flight missions conducted between November 17, 2018 and December 23, 2018. 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.

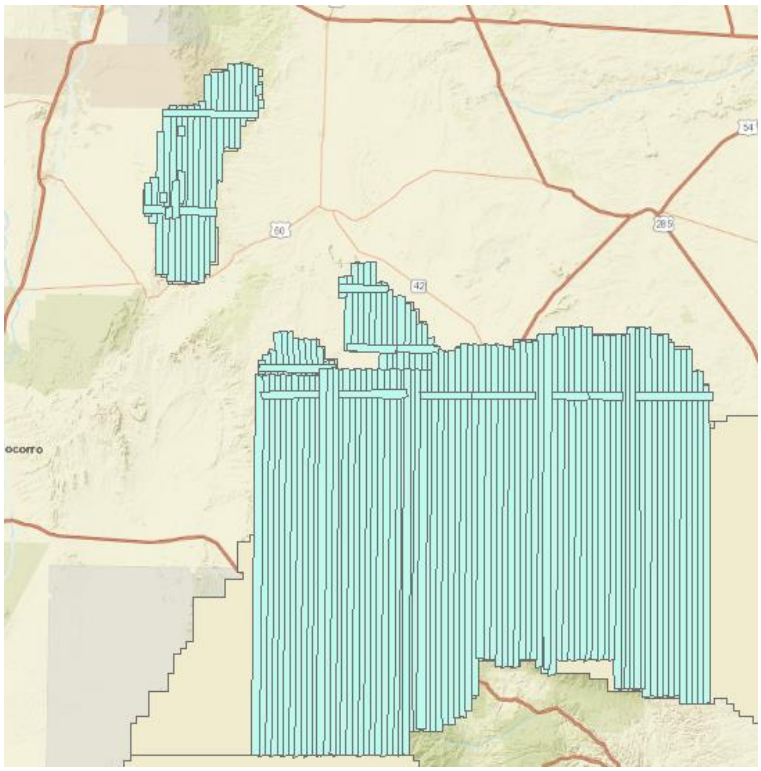


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

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°40'49.83668"	W104°00'53.98138"	2004.482
NMRO	CORS	NMRO	N33°23'41.84850"	W104°35'20.78284"	1094.692
P026	CORS	P026	N32°39'32.25694"	W107°11'41.54812"	1236.844
P027	CORS	P027	N32°48'06.68836"	W105°48'14.98112"	2896.72
P034	CORS	P034	N34°56'44.22768"	W106°27'33.36615"	1810.899
P035	CORS	P035	N34°36'05.01237"	W105°11'00.97396"	1780.346
P038	CORS	P038	N34°08'50.11604"	W103°24'26.42480"	1212.964
P107	CORS	P107	N35°07'55.84636"	W107°52'48.07846"	1991.638
P120	CORS	P120	N35°00'26.83828"	W105°37'33.87922"	2089.644
RG01	CORS	RG01	N34°40'01.45862"	W108°02'37.73037"	2157.523
RG03	CORS	RG03	N33°39'16.88787"	W105°09'14.99556"	1572.585
RG07	CORS	RG07	N32°29'47.37490"	W106°50'35.93656"	1400.676
RG08	CORS	RG08	N32°43'42.06691"	W104°59'38.63121"	1488.626
SC01	CORS	SC01	N34°04'04.62684"	W106°57'59.55961"	2097.38
TXEL	CORS	TXEL	N31°41'29.45124"	W106°16'17.64942"	1122.015
TXKM	CORS	TXKM	N31°50'33.37123"	W103°06'31.30090"	847.998
TXP2	CORS	TXP2	N33°10'55.80241"	W102°49'05.38308"	1089.713
ZAB1	CORS	ZAB1	N35°10'24.86905"	N35°10'24.86905"	1619.667
ZAB2	CORS	ZAB2	N35°10'24.86690"	W106°34'02.24093"	1619.74

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 101 ground survey points were collected in support of this project, including 23 LiDAR Control Points (LCP), 46 Non-vegetated Vertical Accuracy (NVA) and 32 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
LCP012	369531.108	3816579.048	1876.779
LCP013	368164.003	3823819.402	2071.315
LCP014	370999.758	3837227.019	2351.909
LCP015	385817.564	3856470.321	2077.325
LCP016	375201.318	3850664.898	2228.875
LCP017	365423.651	3841448.978	1827.479
LCP018	370699.78	3830193.729	2459.593
LCP019	375529.96	3836975.192	2187.29
LCP020	374878.242	3845170.691	2211.236
LCP021	362626.982	3829800.206	1901.793
LCP045	408380.23	3783487.547	1913.312
LCP061	436705.776	3778178.467	2073.402
LCP126	459878.515	3792537.759	1909.46
LCP149	468805.162	3778135.81	1787.645
LCP203	484009.411	3781842.551	1693.064
LCP204	456811.938	3791080.101	1919.877
LCP217	369967.527	3818660.502	1891.129
LCP218	375886.687	3823865.906	2099.172

ID	Easting	Northing	Elevation
LCP219	374724.494	3837266.681	2196.695
LCP220	382884.562	3859362.104	2177.839
LCP221	365383.928	3842491.591	1843.688
LCP222	365411.877	3838250.646	1867.508
LCP223	361877.307	3830847.651	1875.464

Table 6: LiDAR Control Point Coordinates

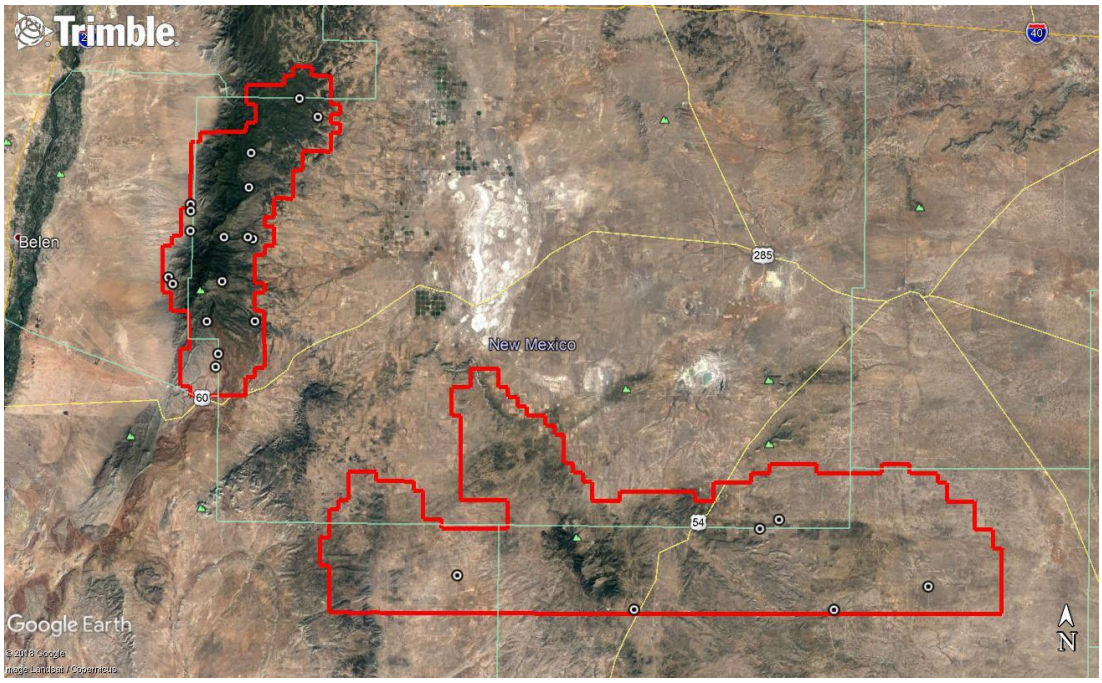


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE023	375876.128	3823868.467	2098.584
BE028	385041.57	3856581.296	2092.315
BE029	378102.514	3848363.705	2134.061
BE030	372856.644	3831369.746	2266.107
BE031	370696.947	3830179.98	2459.418
BE032	374882.773	3845169.26	2211.135
BE034	369437.414	3820124.828	1936.59
BE035	365422.918	3841464.594	1827.496
BE036	369938.438	3818664.953	1891.033
BE058	420646.594	3795542.458	2040.703
BE066	413232.714	3782991.288	1971.254
BE067	431709.86	3778701.258	2104.16
BE084	468805.136	3778150.271	1788.022
BE145	451216.389	3783385.486	1960.917
BE151	369000.958	3812835.859	1774.197
BE152	376765.476	3844719.648	2146.279
BE153	369319.544	3827411.169	2398.477
BE154	385826.404	3856469.757	2077.216
BE156	365457.594	3846016.26	1884.621
OT022	361481.513	3831170.65	1837.262
OT023	384247.179	3857481.963	2126.37
OT024	398695.806	3778579.301	1905.257
OT036	485547.876	3778424.796	1673.783
OT060	430436.418	3790216.538	2155.334
OT061	403018.922	3791507.784	1985.775
OT062	398499.473	3794436.501	1952.3
OT065	418395.316	3791677.077	2047.438
OT066	484025.269	3784270.773	1703.39
OT108	477659.716	3786988.707	1772.043
OT109	465370.058	3792588.737	1886.204
OT110	443917.224	3778060.833	1970.949
OT131	368157.617	3823808.698	2070.883
OT132	371000.899	3837235.274	2352.069
OT134	375166.03	3850675.693	2229.58
OT135	369522.165	3816586.095	1876.664
OT155	362664.108	3829782.34	1903.811
UR016	383932.986	3863288.06	2238.047
UR017	386839.626	3861171.712	2090.218

ID	Easting	Northing	Elevation
UR049	481856.111	3777963.475	1709.18
UR052	408332.098	3783455.145	1912.971
UR089	440393.98	3786887.643	2090.193
UR090	449785.03	3795876.131	1976.458
UR091	383958.34	3859498.882	2160.362
UR092	386837.868	3861169.914	2090.189
UR094	373464.572	3826043.854	2227.258
UR133	408474.143	3790351.584	1969.897

Table 7: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

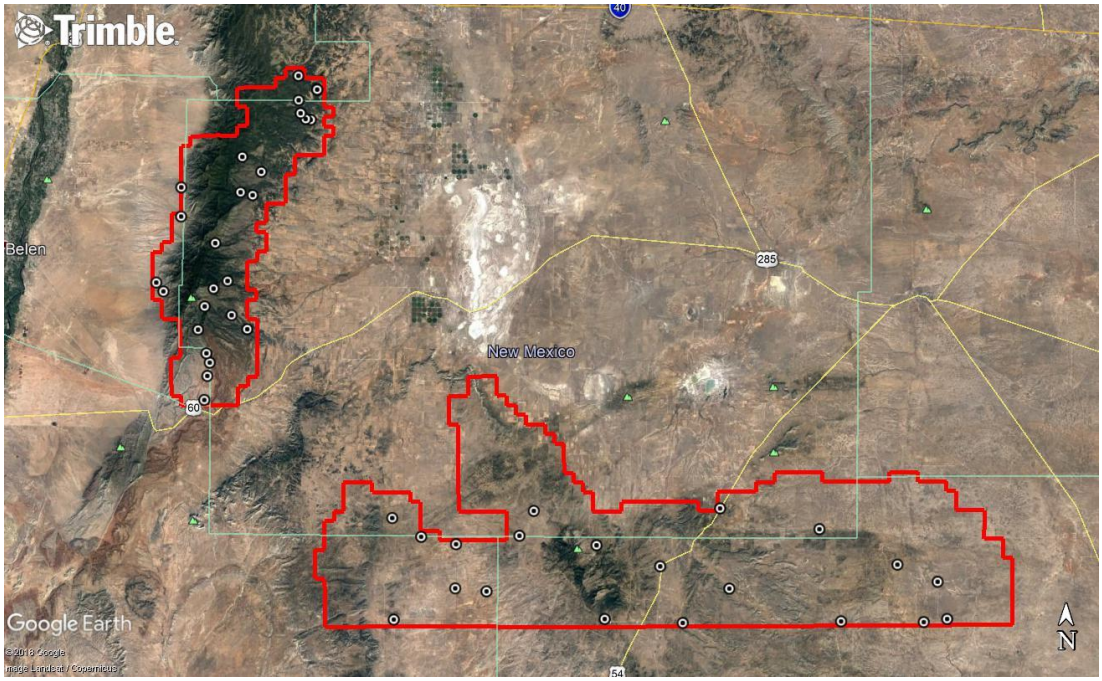


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR012	365398.014	3838228.444	1867.188
BR013	365362.582	3842496.629	1841.413
BR021	375522.494	3836966.175	2186.919
BR022	365403.215	3840267.61	1834.869
BR023	362672.07	3829836.434	1905.748
BR051	373856.606	3814316.553	1870.211
BR052	376746.491	3844732.497	2146.739
BR053	384703.243	3859704.985	2163.254
BR055	449846.394	3791142.798	1967.578
BR100	373858.3	3850553.293	2284.663

ID	Easting	Northing	Elevation
BR103	373478.947	3826050.243	2226.764
BR104	370977.279	3837234.5	2353.378
BR105	383969.907	3859477.946	2158.88
BR109	369448.577	3820132.663	1936.548
BR110	384243.177	3857461.77	2125.662
HG021	374623.67	3837377.413	2207.565
HG027	425320.506	3785443.522	2174.998
HG031	490330.654	3778900.266	1646.407
HG096	374720.764	3815951.396	1912.359
HG097	379912.631	3847387.096	2076.095
HG111	361461.545	3831150.485	1836.191
TR014	371507.902	3831558.833	2346.397
TR015	361936.113	3830916.283	1881.394
TR016	365459.34	3846041.818	1886.304
TR058	427978.356	3781991.319	2213.84
TR059	369307.921	3827406.33	2399.173
TR060	376960.5	3849728.452	2179.961
TR061	382873.014	3859362.877	2177.96
TR100	456844.985	3791072.678	1919.44
TR101	478563.347	3786263.829	1757.659
TR110	418026.149	3786445.451	2045.761
TR111	398227.29	3785718.066	1899.184

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

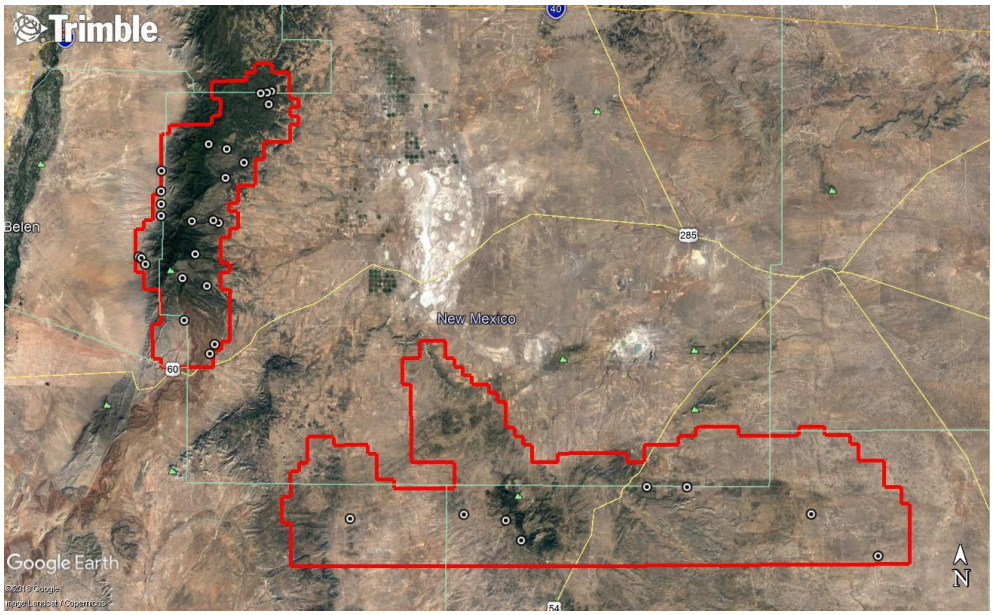


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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)	9,922,052,918
Nominal Pulse Spacing (M)	0.5620
Nominal Pulse Density (PLS/M^2)	3.1664
Total Points (Aggregate)	9,155,957,406
Aggregate Pulse Spacing (M)	0.5067
Aggregate Pulse Density (PLS/M^2)	3.8951

Table 9: 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
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 10: 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 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).

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)	44	0.0833	0.1634	0.0860
NVA (DEM)	44	0.0845	0.1656	0.0843
VVA (Point Cloud)	32	0.0965	0.1892	0.1581
VVA (DEM)	32	0.0940	0.1842	0.1340

Table 12: NVA/VVA Accuracies

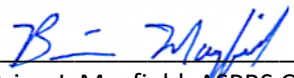
SECTION V: CERTIFICATION STATEMENTS

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
BE023	375876.1280	3823868.4670	2098.5840	2098.4830	-0.1010	NVA
BE028	385041.5700	3856581.2960	2092.3150	2092.2680	-0.0470	NVA
BE029	378102.5140	3848363.7050	2134.0610	2133.9490	-0.1120	NVA
BE030	372856.6440	3831369.7460	2266.1070	2265.9380	-0.1680	NVA
BE031	370696.9470	3830179.9800	2459.4180	2459.2570	-0.1610	NVA
BE032	374882.7730	3845169.2600	2211.1350	2211.0910	-0.0440	NVA
BE034	369437.4140	3820124.8280	1936.5900	1936.4820	-0.1080	NVA
BE035	365422.9180	3841464.5940	1827.4960	1827.4680	-0.0280	NVA
BE036	369938.4380	3818664.9530	1891.0330	1890.9580	-0.0750	NVA
BE058	420646.5940	3795542.4580	2040.7030	2040.6880	-0.0150	NVA
BE066	413232.7140	3782991.2880	1971.2540	1971.2340	-0.0200	NVA
BE067	431709.8600	3778701.2580	2104.1600	2104.1740	0.0140	NVA
BE084	468805.1360	3778150.2710	1788.0220	1788.0890	0.0670	NVA
BE145	451216.3890	3783385.4860	1960.9170	1960.8190	-0.0980	NVA
BE151	369000.9580	3812835.8590	1774.1970	1774.1090	-0.0880	NVA
BE152	376765.4760	3844719.6480	2146.2790	2146.1670	-0.1120	NVA
BE153	369319.5440	3827411.1690	2398.4770	2398.3330	-0.1440	NVA
BE154	385826.4040	3856469.7570	2077.2160	2077.1660	-0.0510	NVA
BE156	365457.5940	3846016.2600	1884.6210	1884.6230	0.0024	NVA
BR012	365398.0140	3838228.4440	1867.1880	1867.1410	-0.0470	VVA
BR013	365362.5820	3842496.6290	1841.4130	1841.4660	0.0530	VVA
BR021	375522.4940	3836966.1750	2186.9190	2186.8720	-0.0470	VVA
BR022	365403.2150	3840267.6100	1834.8690	1834.8420	-0.0270	VVA
BR023	362672.0700	3829836.4340	1905.7480	1905.7490	0.0013	VVA
BR051	373856.6060	3814316.5530	1870.2110	1870.1400	-0.0720	VVA
BR052	376746.4910	3844732.4970	2146.7390	2146.6720	-0.0670	VVA
BR053	384703.2430	3859704.9850	2163.2540	2163.2090	-0.0450	VVA
BR055	449846.3940	3791142.7980	1967.5780	1967.5530	-0.0250	VVA
BR100	373858.3000	3850553.2930	2284.6630	2284.6600	-0.0034	VVA
BR103	373478.9470	3826050.2430	2226.7640	2226.6750	-0.0890	VVA
BR104	370977.2790	3837234.5000	2353.3780	2353.3270	-0.0510	VVA
BR105	383969.9070	3859477.9460	2158.8800	2158.9360	0.0560	VVA
BR109	369448.5770	3820132.6630	1936.5480	1936.4380	-0.1090	VVA
BR110	384243.1770	3857461.7700	2125.6620	2125.6100	-0.0520	VVA
HG021	374623.6700	3837377.4130	2207.5650	2207.5080	-0.0570	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
HG027	425320.5060	3785443.5220	2174.9980	2174.9770	-0.0210	VVA
HG031	490330.6540	3778900.2660	1646.4070	1646.5920	0.1850	VVA
HG096	374720.7640	3815951.3960	1912.3590	1912.3090	-0.0500	VVA
HG097	379912.6310	3847387.0960	2076.0950	2076.0780	-0.0170	VVA
HG111	361461.5450	3831150.4850	1836.1910	1836.1690	-0.0220	VVA
OT022	361481.5130	3831170.6500	1837.2620	1837.2430	-0.0190	NVA
OT023	384247.1790	3857481.9630	2126.3700	2126.3280	-0.0420	NVA
OT060	430436.4180	3790216.5380	2155.3340	2155.3500	0.0160	NVA
OT061	403018.9220	3791507.7840	1985.7750	1985.7540	-0.0210	NVA
OT062	398499.4730	3794436.5010	1952.3000	1952.2540	-0.0460	NVA
OT065	418395.3160	3791677.0770	2047.4380	2047.4740	0.0360	NVA
OT066	484025.2690	3784270.7730	1703.3900	1703.4760	0.0860	NVA
OT108	477659.7160	3786988.7070	1772.0430	1772.1380	0.0950	NVA
OT109	465370.0580	3792588.7370	1886.2040	1886.2950	0.0910	NVA
OT110	443917.2240	3778060.8330	1970.9490	1970.8820	-0.0670	NVA
OT131	368157.6170	3823808.6980	2070.8830	2070.7820	-0.1010	NVA
OT132	371000.8990	3837235.2740	2352.0690	2352.0280	-0.0410	NVA
OT134	375166.0300	3850675.6930	2229.5800	2229.4980	-0.0820	NVA
OT135	369522.1650	3816586.0950	1876.6640	1876.5900	-0.0740	NVA
OT155	362664.1080	3829782.3400	1903.8110	1903.8390	0.0280	NVA
TR014	371507.9020	3831558.8330	2346.3970	2346.1680	-0.2290	VVA
TR015	361936.1130	3830916.2830	1881.3940	1881.5300	0.1360	VVA
TR016	365459.3400	3846041.8180	1886.3040	1886.2580	-0.0460	VVA
TR058	427978.3560	3781991.3190	2213.8400	2213.7880	-0.0520	VVA
TR059	369307.9210	3827406.3300	2399.1730	2399.0350	-0.1380	VVA
TR060	376960.5000	3849728.4520	2179.9610	2179.7420	-0.2190	VVA
TR061	382873.0140	3859362.8770	2177.9600	2177.9460	-0.0140	VVA
TR100	456844.9850	3791072.6780	1919.4400	1919.3870	-0.0530	VVA
TR101	478563.3470	3786263.8290	1757.6590	1757.7230	0.0630	VVA
TR110	418026.1490	3786445.4510	2045.7610	2045.8280	0.0670	VVA
TR111	398227.2900	3785718.0660	1899.1840	1899.4170	0.2330	VVA
UR016	383932.9860	3863288.0600	2238.0470	2237.9280	-0.1190	NVA
UR017	386839.6260	3861171.7120	2090.2180	2090.2200	0.0022	NVA
UR049	481856.1110	3777963.4750	1709.1800	1709.2320	0.0520	NVA
UR052	408332.0980	3783455.1450	1912.9710	1913.0570	0.0860	NVA
UR089	440393.9800	3786887.6430	2090.1930	2090.1050	-0.0880	NVA
UR090	449785.0300	3795876.1310	1976.4580	1976.4150	-0.0430	NVA
UR091	383958.3400	3859498.8820	2160.3620	2160.1750	-0.1870	NVA
UR092	386837.8680	3861169.9140	2090.1890	2090.1570	-0.0320	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR094	373464.5720	3826043.8540	2227.2580	2227.1250	-0.1330	NVA
UR133	408474.1430	3790351.5840	1969.8970	1969.8840	-0.0130	NVA

Table 13: 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
BE023	375876.1280	3823868.4670	2098.5840	2098.4830	-0.1010	NVA
BE028	385041.5700	3856581.2960	2092.3150	2092.2696	-0.0453	NVA
BE029	378102.5140	3848363.7050	2134.0610	2133.9448	-0.1162	NVA
BE030	372856.6440	3831369.7460	2266.1070	2265.9392	-0.1677	NVA
BE031	370696.9470	3830179.9800	2459.4180	2459.2571	-0.1609	NVA
BE032	374882.7730	3845169.2600	2211.1350	2211.0815	-0.0535	NVA
BE034	369437.4140	3820124.8280	1936.5900	1936.4794	-0.1106	NVA
BE035	365422.9180	3841464.5940	1827.4960	1827.4718	-0.0242	NVA
BE036	369938.4380	3818664.9530	1891.0330	1890.9559	-0.0771	NVA
BE058	420646.5940	3795542.4580	2040.7030	2040.6965	-0.0065	NVA
BE066	413232.7140	3782991.2880	1971.2540	1971.2308	-0.0232	NVA
BE067	431709.8600	3778701.2580	2104.1600	2104.1717	0.0118	NVA
BE084	468805.1360	3778150.2710	1788.0220	1788.0893	0.0673	NVA
BE145	451216.3890	3783385.4860	1960.9170	1960.8154	-0.1016	NVA
BE151	369000.9580	3812835.8590	1774.1970	1774.1038	-0.0932	NVA
BE152	376765.4760	3844719.6480	2146.2790	2146.1668	-0.1123	NVA
BE153	369319.5440	3827411.1690	2398.4770	2398.3280	-0.1491	NVA
BE154	385826.4040	3856469.7570	2077.2160	2077.1625	-0.0536	NVA
BE156	365457.5940	3846016.2600	1884.6210	1884.6308	0.0098	NVA
OT022	361481.5130	3831170.6500	1837.2620	1837.2419	-0.0201	NVA
OT023	384247.1790	3857481.9630	2126.3700	2126.3158	-0.0543	NVA
OT060	430436.4180	3790216.5380	2155.3340	2155.3601	0.0261	NVA
OT061	403018.9220	3791507.7840	1985.7750	1985.7574	-0.0176	NVA
OT062	398499.4730	3794436.5010	1952.3000	1952.2658	-0.0342	NVA
OT065	418395.3160	3791677.0770	2047.4380	2047.4845	0.0465	NVA
OT066	484025.2690	3784270.7730	1703.3900	1703.4692	0.0792	NVA
OT108	477659.7160	3786988.7070	1772.0430	1772.1385	0.0955	NVA
OT109	465370.0580	3792588.7370	1886.2040	1886.2914	0.0874	NVA
OT110	443917.2240	3778060.8330	1970.9490	1970.8806	-0.0684	NVA
OT131	368157.6170	3823808.6980	2070.8830	2070.7799	-0.1032	NVA
OT132	371000.8990	3837235.2740	2352.0690	2352.0219	-0.0472	NVA
OT134	375166.0300	3850675.6930	2229.5800	2229.5012	-0.0789	NVA
OT135	369522.1650	3816586.0950	1876.6640	1876.5871	-0.0768	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT155	362664.1080	3829782.3400	1903.8110	1903.8423	0.0313	NVA
UR016	383932.9860	3863288.0600	2238.0470	2237.9268	-0.1203	NVA
UR017	386839.6260	3861171.7120	2090.2180	2090.2048	-0.0132	NVA
UR049	481856.1110	3777963.4750	1709.1800	1709.2320	0.0519	NVA
UR052	408332.0980	3783455.1450	1912.9710	1913.0562	0.0853	NVA
UR089	440393.9800	3786887.6430	2090.1930	2090.0971	-0.0960	NVA
UR090	449785.0300	3795876.1310	1976.4580	1976.4166	-0.0414	NVA
UR091	383958.3400	3859498.8820	2160.3620	2160.1777	-0.1844	NVA
UR092	386837.8680	3861169.9140	2090.1890	2090.1531	-0.0359	NVA
UR094	373464.5720	3826043.8540	2227.2580	2227.1244	-0.1337	NVA
UR133	408474.1430	3790351.5840	1969.8970	1969.8715	-0.0255	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR012	365398.0140	3838228.4440	1867.1880	1867.1404	-0.0476	VVA
BR013	365362.5820	3842496.6290	1841.4130	1841.4577	0.0447	VVA
BR021	375522.4940	3836966.1750	2186.9190	2186.8454	-0.0735	VVA
BR022	365403.2150	3840267.6100	1834.8690	1834.8359	-0.0331	VVA
BR023	362672.0700	3829836.4340	1905.7480	1905.7663	0.0183	VVA
BR051	373856.6060	3814316.5530	1870.2110	1870.1367	-0.0744	VVA
BR052	376746.4910	3844732.4970	2146.7390	2146.6660	-0.0730	VVA
BR053	384703.2430	3859704.9850	2163.2540	2163.2054	-0.0485	VVA
BR055	449846.3940	3791142.7980	1967.5780	1967.5620	-0.0160	VVA
BR100	373858.3000	3850553.2930	2284.6630	2284.6552	-0.0079	VVA
BR103	373478.9470	3826050.2430	2226.7640	2226.6782	-0.0857	VVA
BR104	370977.2790	3837234.5000	2353.3780	2353.3345	-0.0434	VVA
BR105	383969.9070	3859477.9460	2158.8800	2158.9384	0.0585	VVA
BR109	369448.5770	3820132.6630	1936.5480	1936.4313	-0.1167	VVA
BR110	384243.1770	3857461.7700	2125.6620	2125.6463	-0.0158	VVA
HG021	374623.6700	3837377.4130	2207.5650	2207.5161	-0.0488	VVA
HG027	425320.5060	3785443.5220	2174.9980	2174.9732	-0.0248	VVA
HG031	490330.6540	3778900.2660	1646.4070	1646.5997	0.1927	VVA
HG096	374720.7640	3815951.3960	1912.3590	1912.3131	-0.0459	VVA
HG097	379912.6310	3847387.0960	2076.0950	2076.0687	-0.0263	VVA
HG111	361461.5450	3831150.4850	1836.1910	1836.1705	-0.0205	VVA
TR014	371507.9020	3831558.8330	2346.3970	2346.1960	-0.2010	VVA
TR015	361936.1130	3830916.2830	1881.3940	1881.4800	0.0860	VVA
TR016	365459.3400	3846041.8180	1886.3040	1886.2714	-0.0326	VVA
TR058	427978.3560	3781991.3190	2213.8400	2213.7845	-0.0556	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
TR059	369307.9210	3827406.3300	2399.1730	2399.0331	-0.1400	VVA
TR060	376960.5000	3849728.4520	2179.9610	2179.7328	-0.2281	VVA
TR061	382873.0140	3859362.8770	2177.9600	2177.9505	-0.0095	VVA
TR100	456844.9850	3791072.6780	1919.4400	1919.3916	-0.0483	VVA
TR101	478563.3470	3786263.8290	1757.6590	1757.7110	0.0519	VVA
TR110	418026.1490	3786445.4510	2045.7610	2045.8301	0.0691	VVA
TR111	398227.2900	3785718.0660	1899.1840	1899.4178	0.2338	VVA

Table 14: DEM Check Point Assessment