Project Report

TASK ORDER NAME: NM_SouthEast_2018_D19
TASK ORDER NUMBER: 140G219F0006
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 18079
PROJECT BLOCK NUMBER: BLOCK07

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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 7 portion of this project encompasses part of De Baca, Roosevelt, Lea, Lincoln, and Chaves counties, covering approximately 2,559 square miles.

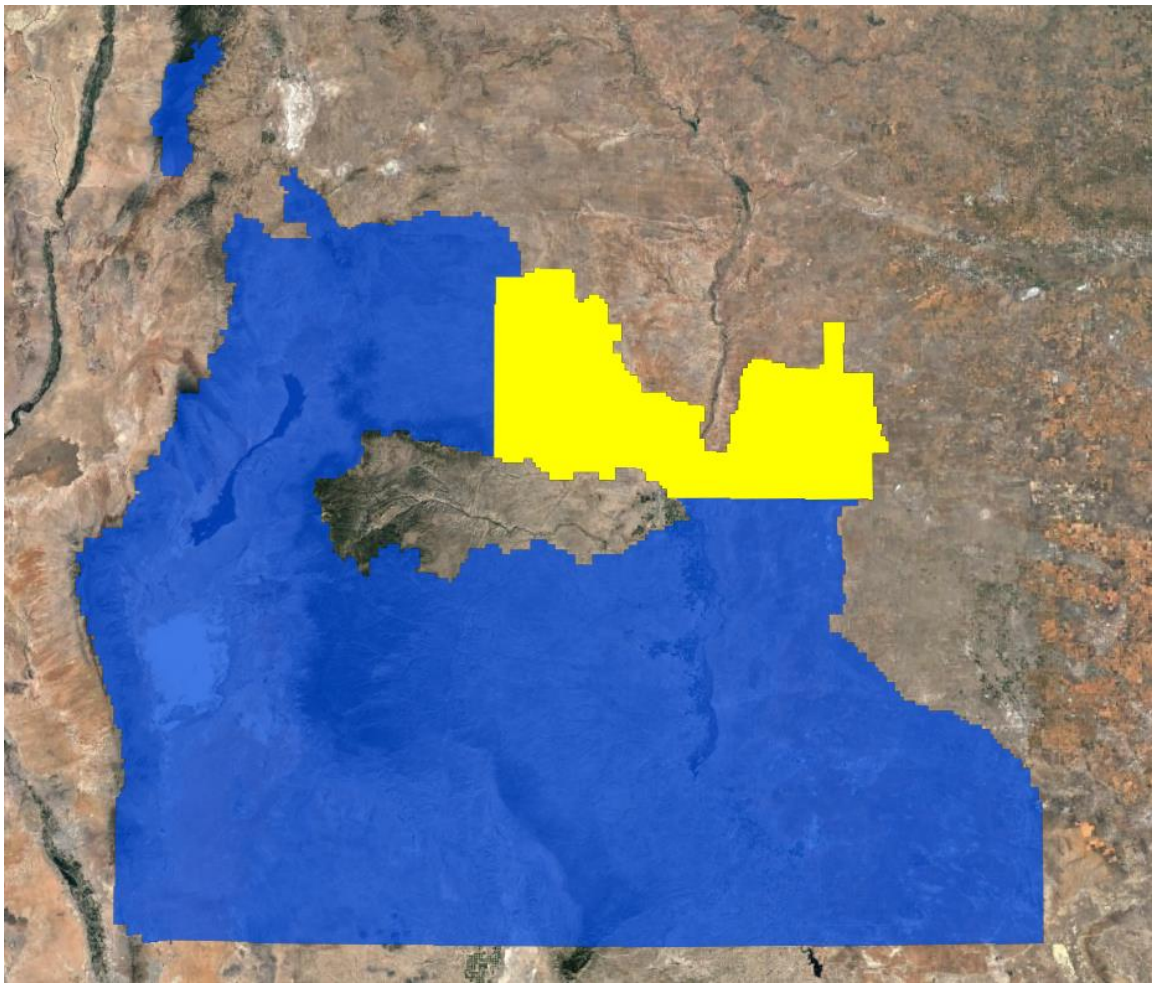


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs) Block 7 is delineated in Yellow.

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

Parameter	Specification
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 twelve (112) passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in nine (9) flight missions conducted between November 20, 2018 and November 25, 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.

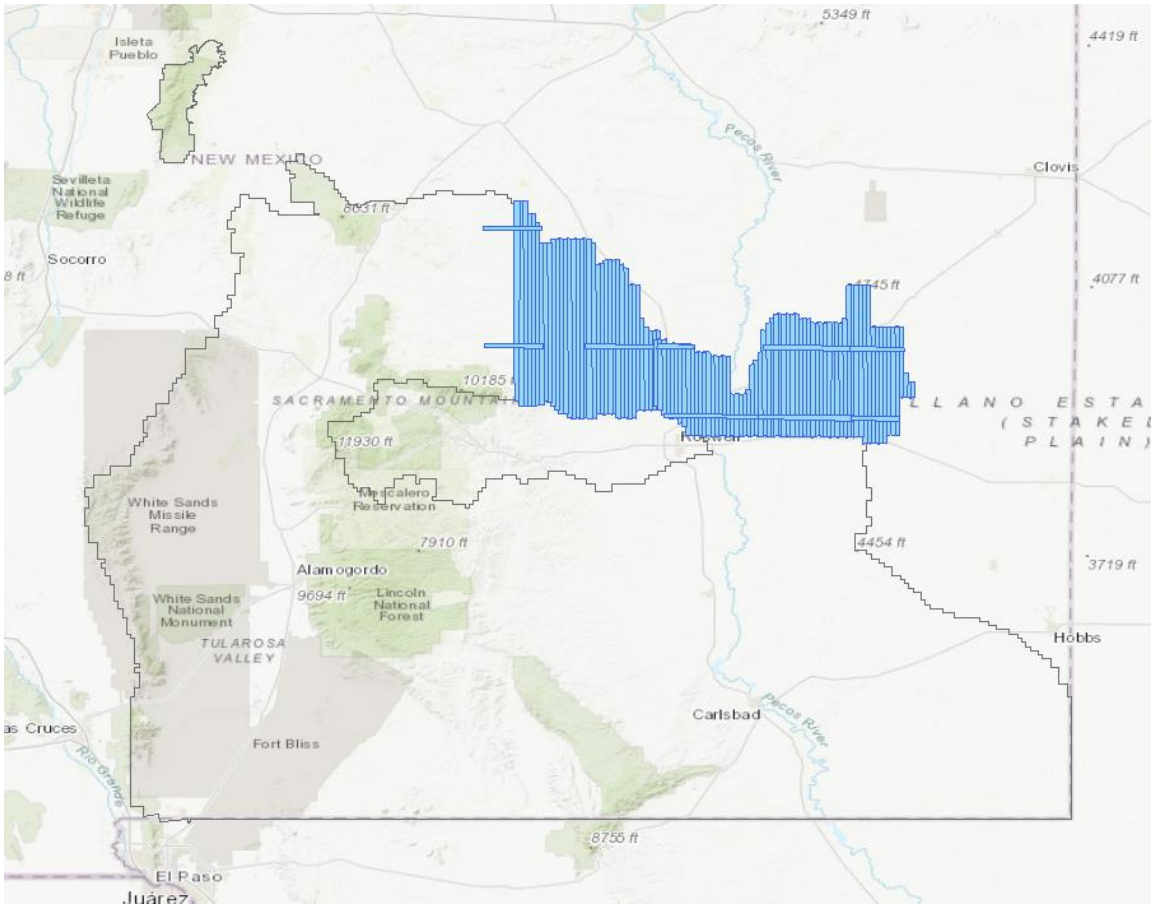


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Fourteen (14) 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
NMRO	CORS	NMRO	N33°23'41.84849"	W104°35'20.78287"	1094.692
P027	CORS	P027	N32°48'06.68834"	W105°48'14.98116"	2896.720
P034	CORS	P034	N34°56'44.22767"	W106°27'33.36615"	1810.899
P035	CORS	P035	N34°36'05.01236"	W105°11'00.97400"	1780.346
P038	CORS	P038	N34°08'50.11604"	W103°24'26.42480"	1212.964
P107	CORS	P107	N35°07'55.84636"	W107°52'48.07847"	1991.638
P120	CORS	P120	N35°00'26.83828"	W105°37'33.87922"	2089.644
TXP2	CORS	TXP2	N33°10'55.80241"	W102°49'05.38308"	1089.713
TXAD	CORS	TXAD	N32°18'28.83144"	W102°32'36.98766"	946.85
TXM1	CORS	TXM1	N33°44'16.18542"	W102°45'34.86096"	1125.573
TXS3	CORS	TXS3	N32°42'42.42331"	W102°37'47.28508"	977.768
TXKM	CORS	TXKM	N31°50'33.37093"	W103°06'31.30083"	847.989
TXL1	CORS	TXL1	N33°56'18.24243"	W102°20'58.31987"	1071.624
ZAB1	CORS	ZAB1	N35°10'24.86905"	W106°34'02.46184"	1619.667

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 93 ground survey points were collected in support of this project, including 22 LiDAR Control Points (LCP), 41 Non-vegetated Vertical Accuracy (NVA) and 30 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
LCP054	578403.394	3726758.362	1207.179
LCP055	594814.8	3736704.748	1261.588
LCP056	521156.038	3709165.62	1313.895
LCP084	597829.163	3705571.805	1207.17
LCP100	602634.031	3708618.074	1246.2
LCP101	609174.394	3729818.253	1301.819
LCP102	517949.803	3715559.341	1249.019
LCP103	505692.948	3749265.791	1452.383
LCP104	518791.421	3741741.857	1331.991
LCP139	575302.038	3701149.698	1179.095
LCP140	605023.389	3717951.41	1266.182
LCP141	595128.518	3702427.761	1202.198
LCP142	562419.742	3700073.521	1154.533
LCP143	540111.621	3728812.473	1153.287
LCP144	526612.092	3737637.356	1289.73
LCP145	507817.884	3767985.388	1491.202
LCP146	488779.341	3746770.6	1550.548
LCP147	489763.334	3768466.337	1571.823

ID	Easting	Northing	Elevation
LCP196	609343.773	3706167.049	1259.855
LCP197	552615.705	3722458.305	1116.317
LCP198	534299.724	3733242.264	1228.45
LCP199	506793.401	3716554.115	1376.201

Table 6: LiDAR Control Point Coordinates

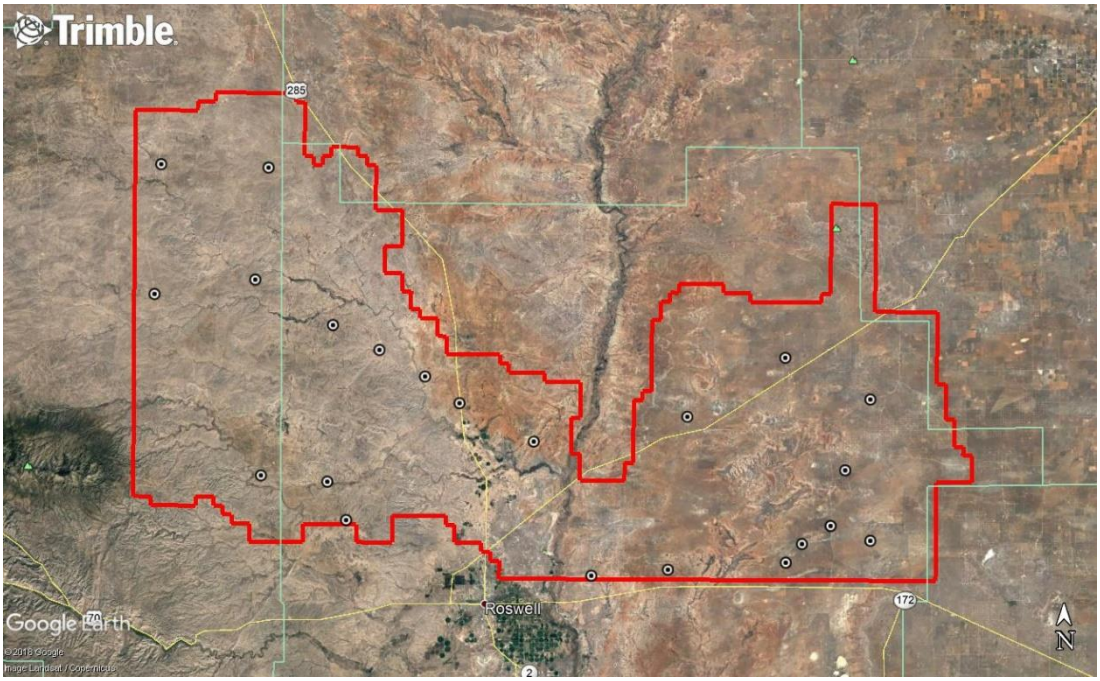


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE027	504889.97	3723534.86	1384.423
BE057	507808.679	3767988.505	1491.653
BE059	604654.996	3751381.521	1379.57
BE099	510570.329	3744288.077	1371.858
BE102	609062.92	3710708.827	1263.282
BE103	589418.91	3725431.825	1233.237
BE104	575303.703	3701157.308	1179.066
BE110	534310.037	3733247.408	1228.954
BE111	547858.159	3713361.656	1100.672
BE131	597832.201	3705562.44	1207.275
BE132	609178.331	3729802.098	1301.829
BE133	594313.246	3734107.576	1249.926
BE134	571104.111	3712347.653	1172.142
BE146	489750.385	3761430.747	1574.76
BE147	517715.54	3718809.197	1262.314

ID	Easting	Northing	Elevation
OT034	497416.556	3731795.055	1528.398
OT035	511603.807	3767204.108	1439.269
OT037	542474.356	3708336.352	1112.78
OT038	542274.028	3720164.785	1124.154
OT039	518798.348	3741727.215	1331.507
OT063	613957.825	3732694.41	1332.418
OT064	579746.363	3711581.408	1182.072
OT106	490295.351	3742835.829	1548.431
OT107	489741.891	3761422.715	1575.093
OT122	578359.237	3729950.854	1206.327
OT123	602803.923	3716577.501	1263.12
OT124	599781.371	3704632.157	1221.466
OT129	594429.098	3738457.195	1270.829
OT130	606495.066	3740780.482	1310.323
UR046	521164.87	3709155.03	1313.764
UR055	608696.186	3742207.124	1328.421
UR062	595275.327	3733658.257	1251.605
UR063	570556.907	3720972.357	1228.321
UR096	539451.436	3735928.53	1226.221
UR097	556905.592	3713931.262	1080.411
UR122	546607.991	3705399.906	1099.776
UR128	509042.245	3717931.197	1319.815
UR129	523267.912	3766152.932	1452.141
UR130	491214.498	3727366.6	1511.575
UR131	508239.799	3777146.515	1516.014
UR136	585866.161	3727627.028	1224.222

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

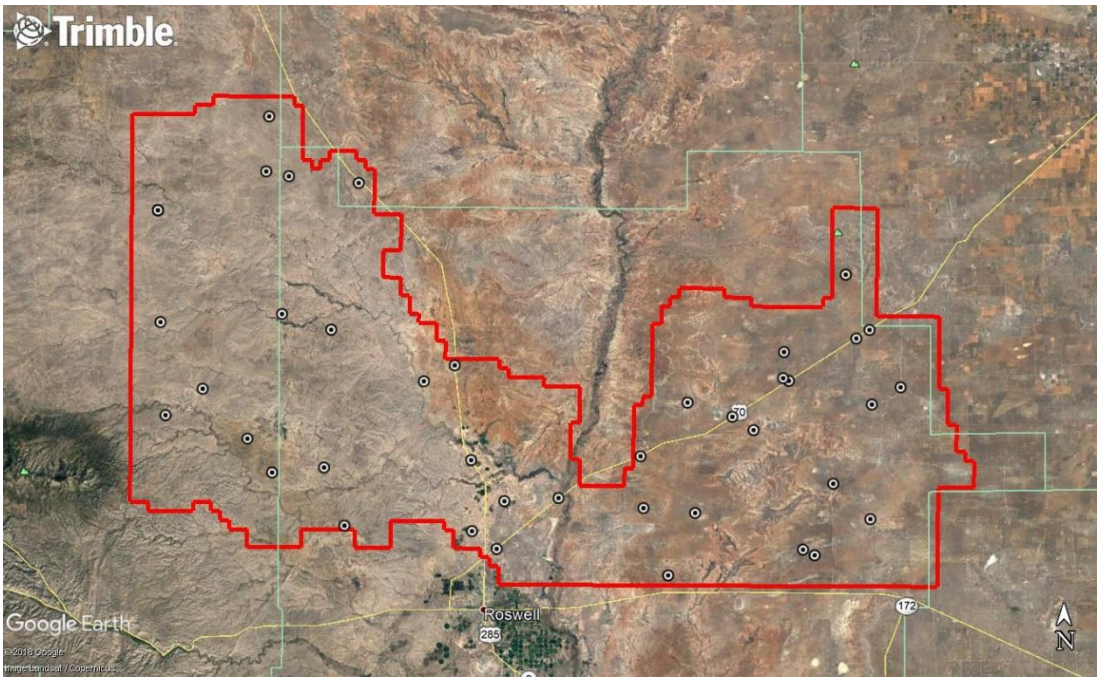


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR025	488202.96	3750054.82	1595.696
BR026	500657.118	3739964.222	1515.814
BR027	512342.204	3729219.942	1387.475
BR028	487956.906	3758078.408	1576.494
BR029	567797.667	3713147.381	1172.449
BR030	597195.882	3724601.379	1260.392
BR031	583591.571	3723872.346	1203.702
BR069	542181.495	3723614.612	1129.369
BR070	547210.173	3732442.963	1263.873
BR071	501046.238	3743402.705	1473.441
HG032	505696.7	3749278.9	1452.503
HG033	539202.038	3722497.166	1158.834
HG034	487626.008	3726008.179	1573.325
HG035	492835.149	3738136.565	1549.691
HG088	615778.08	3724545.499	1317.54
HG089	564544.699	3704279.324	1153.256
HG110	555410.998	3702253.118	1072.634
TR043	492879.381	3724293.859	1479.99
TR044	545123.189	3716169.038	1111.565

ID	Easting	Northing	Elevation
TR045	557450.639	3730847.731	1151.144
TR046	580290.949	3715745.02	1198.629
TR069	609811.616	3701532.426	1271.43
TR070	599948.44	3712306.616	1234.639
TR079	604261.776	3724346.839	1237.536
TR091	519364.659	3716099.267	1247.843
TR092	526445.246	3739824.407	1322.326
TR093	524335.41	3755652.026	1362.39
TR107	598814.75	3726806.528	1262.942
TR108	613685.786	3743783.56	1372.212
TR109	606048.335	3758155.479	1403.437

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

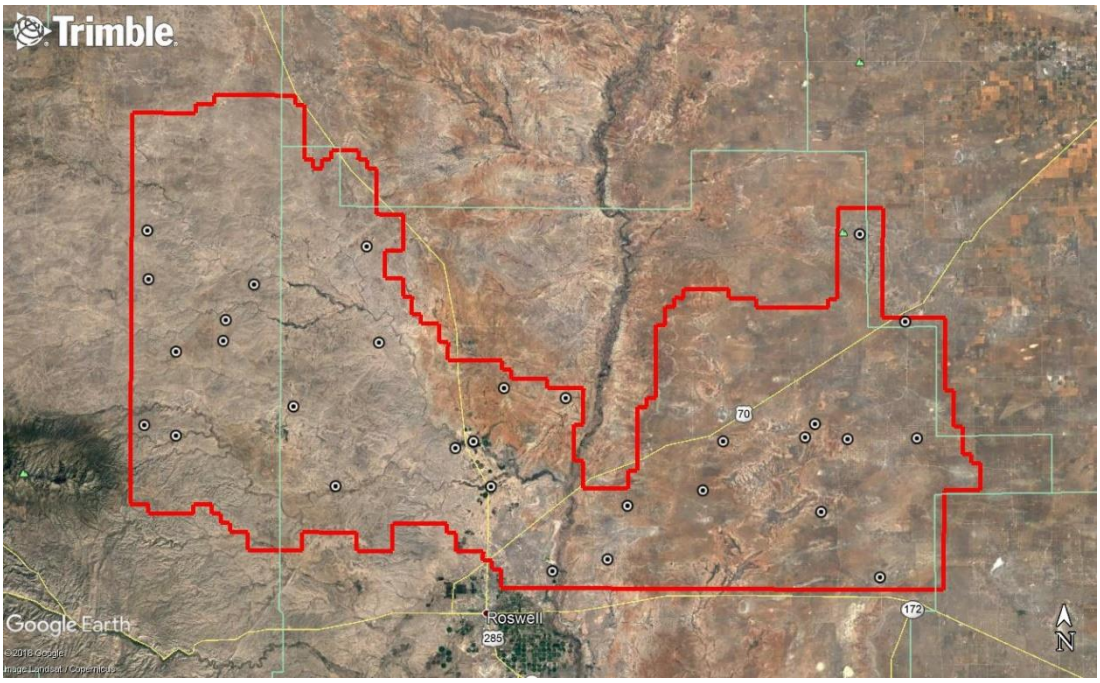


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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)	21,250,827,340
Nominal Pulse Spacing (M)	0.6235
Nominal Pulse Density (PLS/M^2)	2.5724
Total Points (Aggregate)	19,901,501,905
Aggregate Pulse Spacing (M)	0.5628
Aggregate Pulse Density (PLS/M^2)	3.1573

Table 93: 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
11	Withheld
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 41: 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)	34	0.0802	0.1572	0.1677
NVA (DEM)	34	0.0000	0.0000	0.0000
VVA (Point Cloud)	26	0.1925	0.3773	0.3975
VVA (DEM)	26	0.0000	0.0000	0.0000

Table 52: NVA/VVA Accuracies

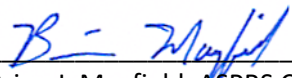
SECTION V: CERTIFICATION STATEMENTS

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
BE059	604654.9960	3751381.5210	1379.5700	1379.4940	-0.0760	NVA
BE099	510570.3290	3744288.0770	1371.8580	1372.0110	0.1530	NVA
BE102	609062.9200	3710708.8270	1263.2820	1263.2500	-0.0320	NVA
BE103	589418.9100	3725431.8250	1233.2370	1233.1890	-0.0480	NVA
BE104	575303.7030	3701157.3080	1179.0660	1179.1130	0.0470	NVA
BE110	534310.0370	3733247.4080	1228.9540	1228.9970	0.0430	NVA
BE111	547858.1590	3713361.6560	1100.6720	1100.7500	0.0780	NVA
BE131	597832.2010	3705562.4400	1207.2750	1207.2790	0.0044	NVA
BE132	609178.3310	3729802.0980	1301.8290	1301.7850	-0.0440	NVA
BE133	594313.2460	3734107.5760	1249.9260	1249.9900	0.0640	NVA
BE134	571104.1110	3712347.6530	1172.1420	1172.1670	0.0250	NVA
BE146	489750.3850	3761430.7470	1574.7600	1574.9550	0.1950	NVA
BR025	488202.9600	3750054.8200	1595.6960	1596.1390	0.4430	VVA
BR026	500657.1180	3739964.2220	1515.8140	1516.1010	0.2870	VVA
BR028	487956.9060	3758078.4080	1576.4940	1576.9170	0.4220	VVA
BR029	567797.6670	3713147.3810	1172.4490	1172.4910	0.0420	VVA
BR030	597195.8820	3724601.3790	1260.3920	1260.4160	0.0240	VVA
BR031	583591.5710	3723872.3460	1203.7020	1203.6990	-0.0032	VVA
BR069	542181.4950	3723614.6120	1129.3690	1129.3780	0.0094	VVA
BR070	547210.1730	3732442.9630	1263.8730	1263.9720	0.0990	VVA
BR071	501046.2380	3743402.7050	1473.4410	1473.7650	0.3240	VVA
HG033	539202.0380	3722497.1660	1158.8340	1158.8710	0.0370	VVA
HG035	492835.1490	3738136.5650	1549.6910	1549.3550	-0.3360	VVA
HG088	615778.0800	3724545.4990	1317.5400	1317.4950	-0.0450	VVA
HG089	564544.6990	3704279.3240	1153.2560	1153.3040	0.0480	VVA
HG110	555410.9980	3702253.1180	1072.6340	1072.8560	0.2220	VVA
OT034	497416.5560	3731795.0550	1528.3980	1528.2670	-0.1310	NVA
OT035	511603.8070	3767204.1080	1439.2690	1439.3490	0.0800	NVA
OT037	542474.3560	3708336.3520	1112.7800	1112.7980	0.0180	NVA
OT039	518798.3480	3741727.2150	1331.5070	1331.4930	-0.0140	NVA
OT063	613957.8250	3732694.4100	1332.4180	1332.4050	-0.0130	NVA
OT064	579746.3630	3711581.4080	1182.0720	1182.0670	-0.0046	NVA
OT106	490295.3510	3742835.8290	1548.4310	1548.5370	0.1060	NVA
OT107	489741.8910	3761422.7150	1575.0930	1575.2930	0.2000	NVA
OT122	578359.2370	3729950.8540	1206.3270	1206.2860	-0.0410	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
OT123	602803.9230	3716577.5010	1263.1200	1263.1470	0.0270	NVA
OT124	599781.3710	3704632.1570	1221.4660	1221.4940	0.0280	NVA
OT129	594429.0980	3738457.1950	1270.8290	1270.8800	0.0510	NVA
OT130	606495.0660	3740780.4820	1310.3230	1310.3600	0.0370	NVA
TR043	492879.3810	3724293.8590	1479.9900	1479.5850	-0.4050	VVA
TR044	545123.1890	3716169.0380	1111.5650	1111.5740	0.0087	VVA
TR045	557450.6390	3730847.7310	1151.1440	1151.2310	0.0870	VVA
TR046	580290.9490	3715745.0200	1198.6290	1198.6920	0.0630	VVA
TR069	609811.6160	3701532.4260	1271.4300	1271.3960	-0.0340	VVA
TR070	599948.4400	3712306.6160	1234.6390	1234.6610	0.0220	VVA
TR079	604261.7760	3724346.8390	1237.5360	1237.5750	0.0390	VVA
TR092	526445.2460	3739824.4070	1322.3260	1322.4150	0.0890	VVA
TR093	524335.4100	3755652.0260	1362.3900	1362.5460	0.1560	VVA
TR107	598814.7500	3726806.5280	1262.9420	1262.9630	0.0210	VVA
TR108	613685.7860	3743783.5600	1372.2120	1372.1220	-0.0900	VVA
TR109	606048.3350	3758155.4790	1403.4370	1403.3920	-0.0450	VVA
UR055	608696.1860	3742207.1240	1328.4210	1328.3150	-0.1060	NVA
UR062	595275.3270	3733658.2570	1251.6050	1251.6460	0.0410	NVA
UR063	570556.9070	3720972.3570	1228.3210	1228.4380	0.1170	NVA
UR096	539451.4360	3735928.5300	1226.2210	1226.2100	-0.0110	NVA
UR097	556905.5920	3713931.2620	1080.4110	1080.4750	0.0640	NVA
UR122	546607.9910	3705399.9060	1099.7760	1099.8520	0.0760	NVA
UR129	523267.9120	3766152.9320	1452.1410	1452.2040	0.0630	NVA
UR130	491214.4980	3727366.6000	1511.5750	1511.4840	-0.0900	NVA
UR136	585866.1610	3727627.0280	1224.2220	1224.2290	0.0072	NVA

Table 63: 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
BE059	604654.9960	3751381.5210	1379.5700	1379.4976	-0.0723	NVA
BE099	510570.3290	3744288.0770	1371.8580	1372.0038	0.1458	NVA
BE102	609062.9200	3710708.8270	1263.2820	1263.2501	-0.0319	NVA
BE103	589418.9100	3725431.8250	1233.2370	1233.1868	-0.0503	NVA
BE104	575303.7030	3701157.3080	1179.0660	1179.0772	0.0112	NVA
BE110	534310.0370	3733247.4080	1228.9540	1228.9997	0.0457	NVA
BE111	547858.1590	3713361.6560	1100.6720	1100.7492	0.0772	NVA
BE131	597832.2010	3705562.4400	1207.2750	1207.2845	0.0095	NVA
BE132	609178.3310	3729802.0980	1301.8290	1301.7838	-0.0452	NVA
BE133	594313.2460	3734107.5760	1249.9260	1249.9841	0.0581	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE134	571104.1110	3712347.6530	1172.1420	1172.1616	0.0196	NVA
BE146	489750.3850	3761430.7470	1574.7600	1574.8473	0.0873	NVA
OT034	497416.5560	3731795.0550	1528.3980	1528.2708	-0.1271	NVA
OT035	511603.8070	3767204.1080	1439.2690	1439.3054	0.0364	NVA
OT037	542474.3560	3708336.3520	1112.7800	1112.7992	0.0192	NVA
OT039	518798.3480	3741727.2150	1331.5070	1331.4954	-0.0116	NVA
OT063	613957.8250	3732694.4100	1332.4180	1332.3639	-0.0541	NVA
OT064	579746.3630	3711581.4080	1182.0720	1182.0682	-0.0038	NVA
OT106	490295.3510	3742835.8290	1548.4310	1548.4998	0.0688	NVA
OT107	489741.8910	3761422.7150	1575.0930	1575.1905	0.0975	NVA
OT122	578359.2370	3729950.8540	1206.3270	1206.2901	-0.0369	NVA
OT123	602803.9230	3716577.5010	1263.1200	1263.1546	0.0346	NVA
OT124	599781.3710	3704632.1570	1221.4660	1221.4904	0.0245	NVA
OT129	594429.0980	3738457.1950	1270.8290	1270.8307	0.0017	NVA
OT130	606495.0660	3740780.4820	1310.3230	1310.3697	0.0467	NVA
UR055	608696.1860	3742207.1240	1328.4210	1328.3114	-0.1096	NVA
UR062	595275.3270	3733658.2570	1251.6050	1251.6390	0.0340	NVA
UR063	570556.9070	3720972.3570	1228.3210	1228.4395	0.1185	NVA
UR096	539451.4360	3735928.5300	1226.2210	1226.2106	-0.0103	NVA
UR097	556905.5920	3713931.2620	1080.4110	1080.4751	0.0641	NVA
UR122	546607.9910	3705399.9060	1099.7760	1099.8463	0.0703	NVA
UR129	523267.9120	3766152.9320	1452.1410	1452.2048	0.0638	NVA
UR130	491214.4980	3727366.6000	1511.5750	1511.4875	-0.0875	NVA
UR136	585866.1610	3727627.0280	1224.2220	1224.2263	0.0043	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR025	488202.9600	3750054.8200	1595.6960	1595.9200	0.2240	VVA
BR026	500657.1180	3739964.2220	1515.8140	1516.1166	0.3026	VVA
BR028	487956.9060	3758078.4080	1576.4940	1576.6971	0.2031	VVA
BR029	567797.6670	3713147.3810	1172.4490	1172.4968	0.0478	VVA
BR030	597195.8820	3724601.3790	1260.3920	1260.4206	0.0286	VVA
BR031	583591.5710	3723872.3460	1203.7020	1203.6954	-0.0066	VVA
BR069	542181.4950	3723614.6120	1129.3690	1129.3820	0.0130	VVA
BR070	547210.1730	3732442.9630	1263.8730	1263.9863	0.1133	VVA
BR071	501046.2380	3743402.7050	1473.4410	1473.7599	0.3189	VVA
HG033	539202.0380	3722497.1660	1158.8340	1158.8604	0.0264	VVA
HG035	492835.1490	3738136.5650	1549.6910	1549.5422	-0.1488	VVA
HG088	615778.0800	3724545.4990	1317.5400	1317.4956	-0.0444	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
HG089	564544.6990	3704279.3240	1153.2560	1153.3079	0.0519	VVA
HG110	555410.9980	3702253.1180	1072.6340	1072.8593	0.2253	VVA
TR043	492879.3810	3724293.8590	1479.9900	1479.8212	-0.1688	VVA
TR044	545123.1890	3716169.0380	1111.5650	1111.5917	0.0268	VVA
TR045	557450.6390	3730847.7310	1151.1440	1151.2354	0.0914	VVA
TR046	580290.9490	3715745.0200	1198.6290	1198.6688	0.0398	VVA
TR069	609811.6160	3701532.4260	1271.4300	1271.4011	-0.0290	VVA
TR070	599948.4400	3712306.6160	1234.6390	1234.6719	0.0329	VVA
TR079	604261.7760	3724346.8390	1237.5360	1237.5566	0.0206	VVA
TR092	526445.2460	3739824.4070	1322.3260	1322.4235	0.0975	VVA
TR093	524335.4100	3755652.0260	1362.3900	1362.5536	0.1636	VVA
TR107	598814.7500	3726806.5280	1262.9420	1262.9974	0.0554	VVA
TR108	613685.7860	3743783.5600	1372.2120	1372.1342	-0.0778	VVA
TR109	606048.3350	3758155.4790	1403.4370	1403.3841	-0.0529	VVA

Table 74: DEM Check Point Assessment