



atlantic

Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
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ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 11B

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c. Client Contact Information

Client Contact Information	
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Position	Floodplain Mapping Coordinator
Telephone	785-296-2513
E-Mail Address	Tara.Lanzrath@ks.gov
Mailing Address	6531 SE Forbes Ave., Suite B
City	Topeka
State or Province	Kansas
Postal Code	66619

Table 1: Aerial LiDAR Client Contact Information

d. Contract Deliverables

Item	Specification/Format
Metadata	FGDC compliant, xml format
Project Report	.pdf format
Raw Point Cloud	Swaths, LAS 1.4
Classified Point Cloud	LAS 1.4
Bare Earth DEM	ERDAS .IMG format, Hydroflattened
First Return DSM	ERDAS .IMG format
Hydro Polygon Breaklines	.gdb format
Intensity Imagery	ERDAS .IMG format

Table 2: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial LiDAR Project – Aerial Acquisition

a. Aircraft & Sensor Information

Atlantic operated a Cessna (N732JE) outfitted with a Leica ALS70-HP LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	ALS70-HP
Manufacturer	Leica
Platform	Fixed-Wing
Scan Pattern	Sine, Triangle, Raster
Maximum Scan Rate (Hz)	Sine: 200 Triangle: 158 Raster: 120
Field of View (°)	0 – 75 (Full Angle, User Adjustable)
Maximum Pulse Rate (kHz)	500
Maximum Flying Height (m AGL)	3500
Number of Returns	Unlimited
Number of Intensity Measurements	3 (First, Second, Third)
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV
Storage Media	Removable 500 GB SSD
Storage Capacity (Hours @ Max Pulse Rate)	6
Size (cm)	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
Weight (kg)	Scanner: 43 Control Electronics: 45
Operation Temperature (°C)	0 – 40
Flight Management	FCMS
Power Consumption	927 @ 22.0 – 30.3 VDC

Table3: System Specifications – ALS70-HP

b. Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Leica ALS70-HP
Nominal Pulse Spacing (m)	0.71
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	130
Pass Heading (°)	0
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	33.9
Pulse Rate of Scanner (kHz)	256,400
Line Spacing (m)	1,171

Parameter	Specification
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	.35
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	2
Beam Divergence (mrad)	.15
Nominal Swath Width (m)	1,740
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 4: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired 76 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 5 flight missions conducted between December 7, 2018 and December 15, 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.

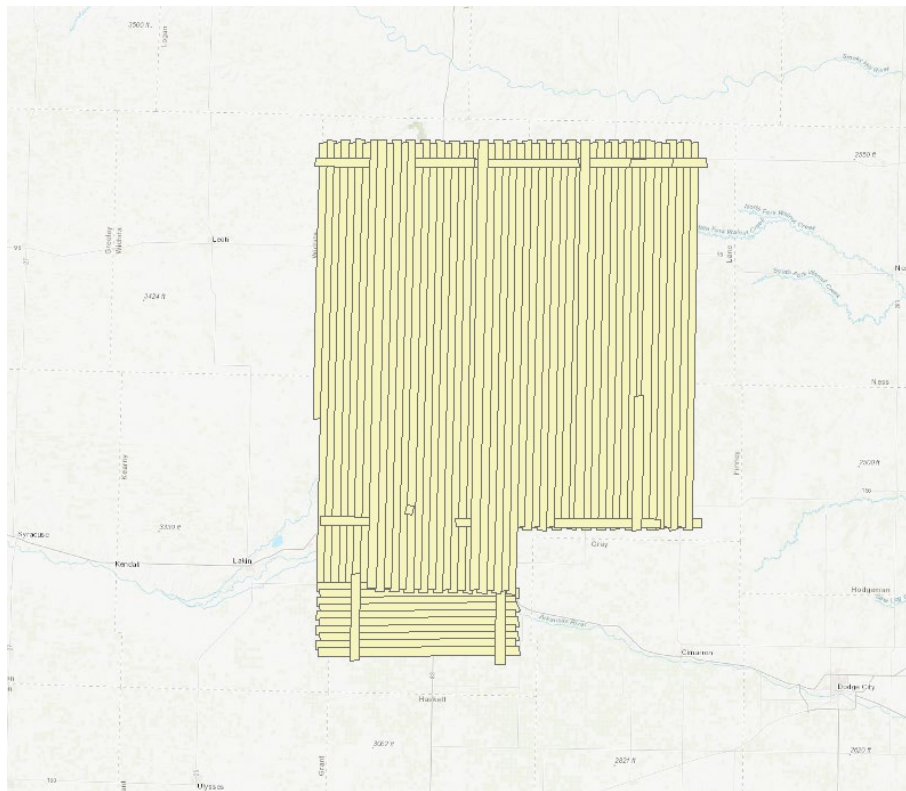


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Six (6) 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
KSDT	CORS	KSDT	N38°28'46.22580"	W100°28'06.34234"	823.395
KSNC	CORS	KSNC	N38°27'11.82816"	W99°53'40.99265"	673.0962
KSGC	CORS	KSGC	N37°58'08.68605"	W100°53'47.13441"	854.237
KSTB	CORS	KSTB	N38°28'05.28178"	W101°45'08.09436"	1083.673
KSSY	CORS	KSSY	N37°58'43.11412"	W101°45'18.18782"	964.95
KSCM	CORS	KSCM	N37°51'36.45801"	W100°21'16.74776"	816.255

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 70 ground survey points were collected in support of this project, including 19 LiDAR Control Points (LCP), 28 Non-vegetated Vertical Accuracy (NVA) and 23 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed “busts” in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA & 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
LCP277	318668.595	4271816.336	955.305
LCP278	323828.784	4249977.78	914.073
LCP279	338213.468	4240063.191	897.304
LCP280	347152.274	4247933.719	906.109
LCP281	343387.645	4264816.179	904.471
LCP282	328450.705	4219239.869	881.381
LCP283	363840.055	4242779.696	878.669
LCP284	364139.762	4250751.93	869.381
LCP413	346095.892	4219027.145	888.944
LCP414	336166.509	4211753.009	870.375
LCP415	320284.529	4211444.452	901.575
LCP416	325336.807	4206754.585	879.856
LCP507	325242.251	4216144.967	895.694
LCP573	332986.042	4204104.463	868.329
LCP575	345991.623	4213268.043	886.352
LCP584	338323.265	4275509.694	913.622
LCP586	346406.648	4254236.544	905.283
LCP588	369342.684	4268410.137	853.643
LCP597	324317.844	4225833.894	888.684

Table 6: LiDAR Control Point Coordinates

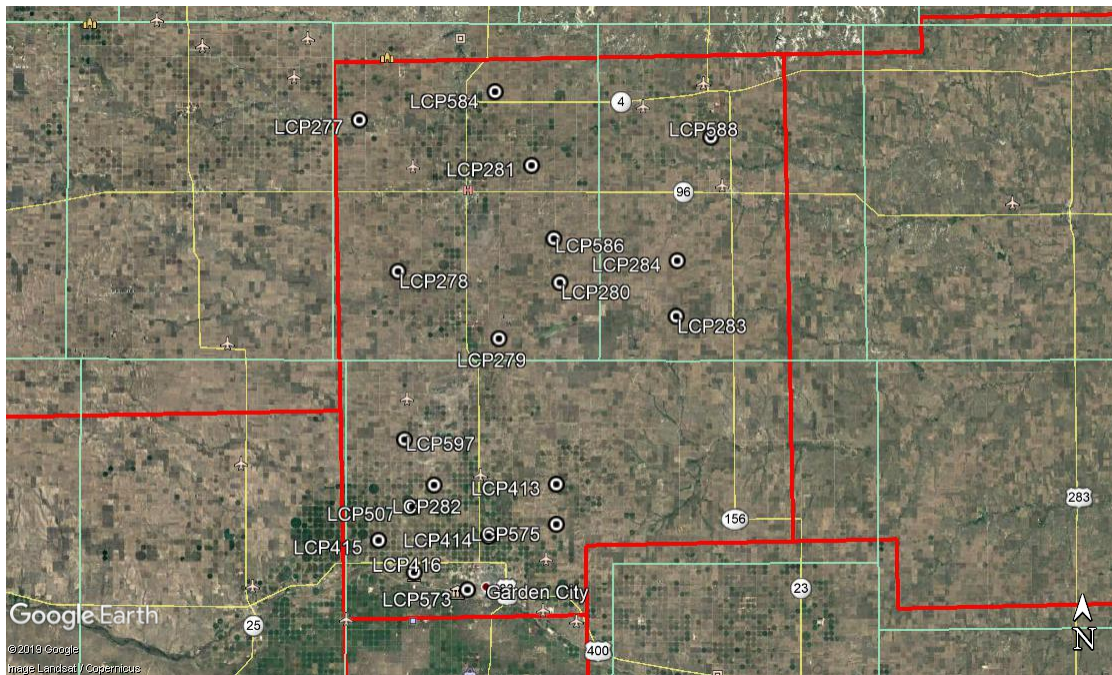


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA337	325245.033	4216136.723	895.373
NVA338	345991.201	4213256.372	886.465
NVA339	347171.79	4247917.775	905.396
NVA340	316564.47	4225951.051	915.134
NVA342	336168.83	4211744.913	870.18
NVA352	364172.713	4250733.239	869.151
NVA537	353096.242	4274427.725	882.582
NVA539	325050.372	4274110.725	942.058
NVA540	353249.083	4223581.961	884.266
NVA542	346376.552	4236594.74	879.973
NVA543	328909.724	4265982.349	917.497
NVA544	326757.869	4243445.731	905.611
NVA545	324318.122	4225820.26	888.31
NVA556	362600.884	4262358.298	865.271
NVA736	336325.048	4205898.124	865.088
NVA738	333692.239	4261285.489	907.974
NVA739	350284.983	4260992.264	891.628
NVA740	332565.311	4236431.665	888.307
NVA741	333379.715	4225676.11	879.248
NVA743	325327.604	4206766.786	879.844
NVA752	371990.921	4246636.887	858.865

ID	Easting	Northing	Elevation
NVA813	343318.471	4200722.162	862.225
NVA883	371873.255	4236032.786	865.656
NVA884	356369.357	4213858.622	865.908
NVA889	342575.973	4204486.801	885.008
NVA897	320358.153	4235566.891	910.053
NVA933	333817.067	4260703.405	906.013
NVA934	352694.829	4241745.131	869.874

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

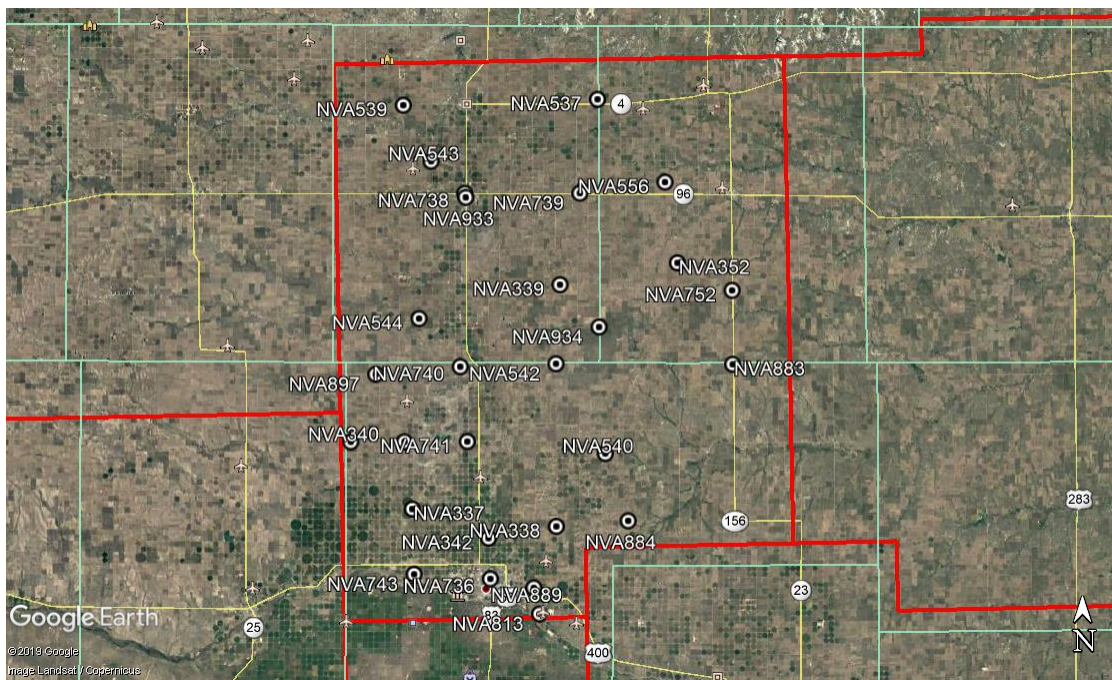


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA238	323824.768	4249938.371	914.153
VVA239	338220.273	4240086.913	897.448
VVA240	328437.818	4219249.897	881.125
VVA241	346080.777	4219063.109	889.143
VVA242	318685.857	4271822.3	954.775
VVA248	363849.258	4242760.32	878.52
VVA371	356360.331	4213814.719	866.246
VVA372	346413.157	4254255.32	905.086
VVA374	320282.298	4211432.492	901.588
VVA375	320360.522	4235597.918	910.125
VVA376	356185.879	4266955.69	876.781
VVA383	371857.903	4236044.189	865.196
VVA513	338293.721	4275520.401	913.238

ID	Easting	Northing	Elevation
VVA514	343061.769	4228536.751	903.592
VVA516	343379.957	4264800.263	904.638
VVA517	352704.421	4241761.002	869.157
VVA518	333801.13	4260679.535	905.921
VVA519	342591.432	4204476.462	885.506
VVA522	369375.706	4268402.467	853.649
VVA616	346394.769	4236586.439	879.856
VVA617	336322.285	4205908.574	864.844
VVA667	325044.296	4274082.006	942.194
VVA668	332555.904	4236410.351	887.82

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

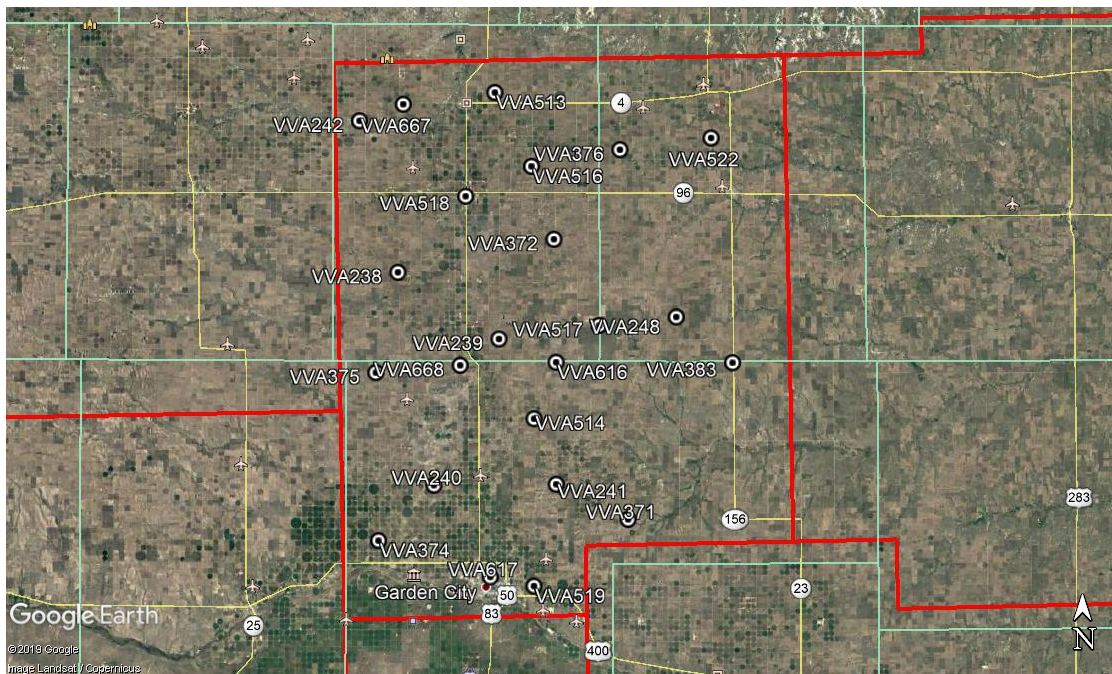


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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(HARN) (EPSG 3744)
Coordinate System: UTM, 14N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	16,307,435,430
Nominal Pulse Spacing (m)	0.6843
Nominal Pulse Density (pls/m²)	2.1358
Nominal Pulse Spacing (ft)	2.2450
Nominal Pulse Density (pls/ft²)	0.1984
Aggregate Total Points	15,509,461,350
Aggregate Nominal Pulse Spacing (m)	0.6036
Aggregate Nominal Pulse Density (pls/m²)	2.7445
Aggregate Nominal Pulse Spacing (ft)	1.9804
Aggregate Nominal Pulse Density (pls/ft²)	0.2550

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.

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 10 (Ignored Ground).

Code	Description
1	Unclassified
2	Ground
7	Low point (noise)
9	Water
10	Ignored ground (breakline proximity)
17	Bridge
18	High point (noise)

Table 10: LiDAR Point Classification Codes and Descriptions

g. 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 0.5-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .img format.

h. 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.

i. Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 1 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .img format.

j. Surface-Digital Elevation Model (DSM)

Surface digital elevation models (DSMs) were derived using all first return LiDAR points, excluding LiDAR points classified as high or low noise. All DSMs were created with a grid spacing of 1 meter. DSMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .img 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 95 th 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	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Point Cloud	36	0.0737	0.1444	0.0190
VVA of Point Cloud	27	0.1390	0.2724	0.0825
NVA of DEM	34	0.0786	0.1542	(0.0012)
VVA of DEM	24	0.0637	0.1249	0.0385

Table 12: NVA/VVA Accuracies

SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

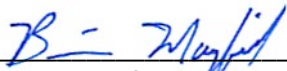
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA739	350285.742	4260991.524	891.6280	891.6300	BARE EARTH	0.0020
NVA543	328910.486	4265981.608	917.4970	917.4940	BARE EARTH	(0.0030)
NVA934	352695.588	4241744.394	869.8740	869.8780	BARE EARTH	0.0040
NVA542	346377.312	4236594.004	879.9730	879.9790	BARE EARTH	0.0060
NVA544	326758.632	4243444.993	905.6110	905.6180	BARE EARTH	0.0070
NVA609	322928.505	4197677.591	891.8080	891.8150	BARE EARTH	0.0070
NVA337	325245.797	4216135.990	895.3730	895.3610	BARE EARTH	(0.0120)
NVA339	347172.550	4247917.037	905.3960	905.4080	BARE EARTH	0.0120
NVA540	353249.842	4223581.227	884.2660	884.2510	BARE EARTH	(0.0150)
NVA539	325051.134	4274109.982	942.0580	942.0740	BARE EARTH	0.0160
NVA349	380085.845	4268120.707	833.0990	833.1270	BARE EARTH	0.0280
NVA743	325328.368	4206766.054	879.8440	879.8140	BARE EARTH	(0.0300)
NVA545	324318.886	4225819.525	888.3100	888.2770	BARE EARTH	(0.0330)
NVA556	362601.641	4262357.558	865.2710	865.2350	BARE EARTH	(0.0360)
NVA933	333817.828	4260702.665	906.0130	905.9690	BARE EARTH	(0.0440)
NVA559	383278.263	4277719.333	829.7040	829.6570	BARE EARTH	(0.0470)
NVA352	364173.470	4250732.501	869.1510	869.1020	BARE EARTH	(0.0490)
NVA338	345991.961	4213255.640	886.4650	886.4100	BARE EARTH	(0.0550)
NVA883	371874.011	4236032.050	865.6560	865.5950	BARE EARTH	(0.0610)
NVA413	333844.167	4190195.261	883.8920	883.8260	BARE EARTH	(0.0660)
NVA885	318438.259	4188845.879	905.8670	905.7930	BARE EARTH	(0.0740)
NVA889	342576.734	4204486.070	885.0080	884.9330	BARE EARTH	(0.0750)
NVA884	356370.116	4213857.890	865.9080	865.8270	BARE EARTH	(0.0810)
NVA741	333380.477	4225675.375	879.2480	879.1660	BARE EARTH	(0.0820)
NVA340	316565.235	4225950.316	915.1340	915.0510	BARE EARTH	(0.0830)
NVA897	320358.917	4235566.154	910.0530	910.1370	BARE EARTH	0.0840
NVA935	382697.055	4257952.088	806.8710	806.7870	BARE EARTH	(0.0840)
NVA610	345097.617	4186106.093	866.8150	866.7230	BARE EARTH	(0.0920)
NVA738	333693.000	4261284.749	907.9740	907.8800	BARE EARTH	(0.0940)
NVA740	332566.073	4236430.929	888.3070	888.2070	BARE EARTH	(0.1000)
NVA752	371991.677	4246636.150	858.8650	858.7620	BARE EARTH	(0.1030)
NVA342	336169.592	4211744.181	870.1800	870.0750	BARE EARTH	(0.1050)
NVA813	343319.232	4200721.432	862.2250	862.1060	BARE EARTH	(0.1190)
NVA537	353097.000	4274426.983	882.5820	882.4440	BARE EARTH	(0.1380)
NVA736	336325.810	4205897.393	865.0880	864.9390	BARE EARTH	(0.1490)

Point ID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA357	381066.499	4221293.957	791.6150	791.4630	BARE EARTH	(0.1520)
VVA522	369376.462	4268401.726	853.6490	853.6420	BRUSH	(0.0070)
VVA514	343062.530	4228536.016	903.5920	903.5830	BRUSH	(0.0090)
VVA383	371858.659	4236043.453	865.1960	865.2070	BRUSH	0.0110
VVA371	356361.090	4213813.987	866.2460	866.2320	BRUSH	(0.0140)
VVA238	323825.531	4249937.632	914.1530	914.1690	BRUSH	0.0160
VVA372	346413.917	4254254.581	905.0860	905.0700	BRUSH	(0.0160)
VVA376	356186.637	4266954.949	876.7810	876.7610	BRUSH	(0.0200)
VVA519	342592.193	4204475.731	885.5060	885.4800	BRUSH	(0.0260)
VVA248	363850.015	4242759.583	878.5200	878.5510	BRUSH	0.0310
VVA668	332556.666	4236409.615	887.8200	887.8520	BRUSH	0.0320
VVA667	325045.058	4274081.263	942.1940	942.2360	BRUSH	0.0420
VVA380	382665.000	4257977.041	807.0200	807.0650	BRUSH	0.0450
VVA616	346395.529	4236585.703	879.8560	879.9030	BRUSH	0.0470
VVA374	320283.063	4211431.759	901.5880	901.5390	BRUSH	(0.0490)
VVA518	333801.891	4260678.795	905.9210	905.8710	BRUSH	(0.0500)
VVA289	318427.267	4188849.121	906.2520	906.1980	BRUSH	(0.0540)
VVA375	320361.286	4235597.181	910.1250	910.0710	BRUSH	(0.0540)
VVA242	318686.621	4271821.558	954.7750	954.7200	BRUSH	(0.0550)
VVA240	328438.581	4219249.163	881.1250	881.1830	BRUSH	0.0580
VVA617	336323.047	4205907.843	864.8440	864.7840	BRUSH	(0.0600)
VVA241	346081.537	4219062.376	889.1430	889.0540	BRUSH	(0.0890)
VVA669	383262.732	4277693.759	829.4200	829.5130	BRUSH	0.0930
VVA618	345131.186	4186106.959	867.0630	866.9540	BRUSH	(0.1090)
VVA239	338221.034	4240086.176	897.4480	897.3090	BRUSH	(0.1390)
VVA559	335364.280	4188572.489	879.7850	879.6390	BRUSH	(0.1460)
VVA516	343380.717	4264799.522	904.6380	904.4850	BRUSH	(0.1530)
VVA246	384885.670	4269706.577	813.3030	813.9340	BRUSH	0.6310

Table 13: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA337	325245.797	4216135.990	895.3730	895.3519	BARE EARTH	(0.0211)
NVA338	345991.961	4213255.640	886.4650	886.4060	BARE EARTH	(0.0590)
NVA339	347172.550	4247917.037	905.3960	905.3799	BARE EARTH	(0.0161)
NVA340	316565.235	4225950.316	915.1340	915.0414	BARE EARTH	(0.0926)
NVA342	336169.592	4211744.181	870.1800	870.0625	BARE EARTH	(0.1175)
NVA349	380085.845	4268120.707	833.0990	833.1044	BARE EARTH	0.0054
NVA352	364173.470	4250732.501	869.1510	869.0916	BARE EARTH	(0.0594)

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA357	381066.499	4221293.957	791.6150	791.4754	BARE EARTH	(0.1396)
NVA413	333844.167	4190195.261	883.8920	883.8140	BARE EARTH	(0.0780)
NVA537	353097.000	4274426.983	882.5820	882.4271	BARE EARTH	(0.1549)
NVA539	325051.134	4274109.982	942.0580	942.0532	BARE EARTH	(0.0048)
NVA540	353249.842	4223581.227	884.2660	884.2289	BARE EARTH	(0.0371)
NVA542	346377.312	4236594.004	879.9730	879.9532	BARE EARTH	(0.0198)
NVA543	328910.486	4265981.608	917.4970	917.4848	BARE EARTH	(0.0122)
NVA544	326758.632	4243444.993	905.6110	905.6007	BARE EARTH	(0.0103)
NVA545	324318.886	4225819.525	888.3100	888.2302	BARE EARTH	(0.0798)
NVA556	362601.641	4262357.558	865.2710	865.2007	BARE EARTH	(0.0703)
NVA559	383278.263	4277719.333	829.7040	829.6496	BARE EARTH	(0.0544)
NVA609	322928.505	4197677.591	891.8080	891.7944	BARE EARTH	(0.0136)
NVA736	336325.810	4205897.393	865.0880	864.9378	BARE EARTH	(0.1502)
NVA738	333693.000	4261284.749	907.9740	907.8891	BARE EARTH	(0.0849)
NVA739	350285.742	4260991.524	891.6280	891.5530	BARE EARTH	(0.0750)
NVA740	332566.073	4236430.929	888.3070	888.1963	BARE EARTH	(0.1107)
NVA741	333380.477	4225675.375	879.2480	879.1735	BARE EARTH	(0.0745)
NVA743	325328.368	4206766.054	879.8440	879.7557	BARE EARTH	(0.0883)
NVA752	371991.677	4246636.150	858.8650	858.7834	BARE EARTH	(0.0816)
NVA813	343319.232	4200721.432	862.2250	862.1015	BARE EARTH	(0.1235)
NVA883	371874.011	4236032.050	865.6560	865.5885	BARE EARTH	(0.0675)
NVA884	356370.116	4213857.890	865.9080	865.8177	BARE EARTH	(0.0903)
NVA889	342576.734	4204486.070	885.0080	884.9326	BARE EARTH	(0.0754)
NVA897	320358.917	4235566.154	910.0530	910.0598	BARE EARTH	0.0068
NVA933	333817.828	4260702.665	906.0130	905.9619	BARE EARTH	(0.0511)
NVA934	352695.588	4241744.394	869.8740	869.8602	BARE EARTH	(0.0138)
NVA935	382697.055	4257952.088	806.8710	806.7710	BARE EARTH	(0.1000)
VVA238	323825.531	4249937.632	914.1530	914.1639	BRUSH	0.0109
VVA239	338221.034	4240086.176	897.4480	897.3113	BRUSH	(0.1367)
VVA240	328438.581	4219249.163	881.1250	881.1509	BRUSH	0.0259
VVA241	346081.537	4219062.376	889.1430	889.0486	BRUSH	(0.0944)
VVA242	318686.621	4271821.558	954.7750	954.7390	BRUSH	(0.0360)
VVA246	384885.670	4269706.577	813.3030	813.3407	BRUSH	0.0377
VVA248	363850.015	4242759.583	878.5200	878.5516	BRUSH	0.0316
VVA371	356361.090	4213813.987	866.2460	866.1976	BRUSH	(0.0484)
VVA372	346413.917	4254254.581	905.0860	905.0561	BRUSH	(0.0299)
VVA374	320283.063	4211431.759	901.5880	901.5252	BRUSH	(0.0628)
VVA375	320361.286	4235597.181	910.1250	910.0529	BRUSH	(0.0721)
VVA376	356186.637	4266954.949	876.7810	876.7540	BRUSH	(0.0270)

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
VVA380	382665.000	4257977.041	807.0200	807.0192	BRUSH	(0.0008)
VVA383	371858.659	4236043.453	865.1960	865.1997	BRUSH	0.0037
VVA514	343062.530	4228536.016	903.5920	903.5501	BRUSH	(0.0419)
VVA516	343380.717	4264799.522	904.6380	904.5101	BRUSH	(0.1279)
VVA518	333801.891	4260678.795	905.9210	905.8146	BRUSH	(0.1064)
VVA519	342592.193	4204475.731	885.5060	885.4150	BRUSH	(0.0910)
VVA522	369376.462	4268401.726	853.6490	853.6432	BRUSH	(0.0058)
VVA616	346395.529	4236585.703	879.8560	879.8946	BRUSH	0.0386
VVA617	336323.047	4205907.843	864.8440	864.7930	BRUSH	(0.0510)
VVA667	325045.058	4274081.263	942.1940	942.2169	BRUSH	0.0229
VVA668	332556.666	4236409.615	887.8200	887.8470	BRUSH	0.0270
VVA669	383262.732	4277693.759	829.4200	829.5153	BRUSH	0.0953

Table 14: DEM Check Point Assessment