Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 9B

TABLE OF CONTENTS

SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 00000000000000000000039891 required Leaf-off 2018 QL 2 LiDAR surveys to be collected over 54,663 square miles covering part or all of 86 counties in Kansas in support of the Kansas Department of Agriculture and Kansas Data Access and Support Center. 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 1.2. Project Block 9B encompasses part or all of 9 counties in Southern Kansas and covers approximately 1887 square miles.

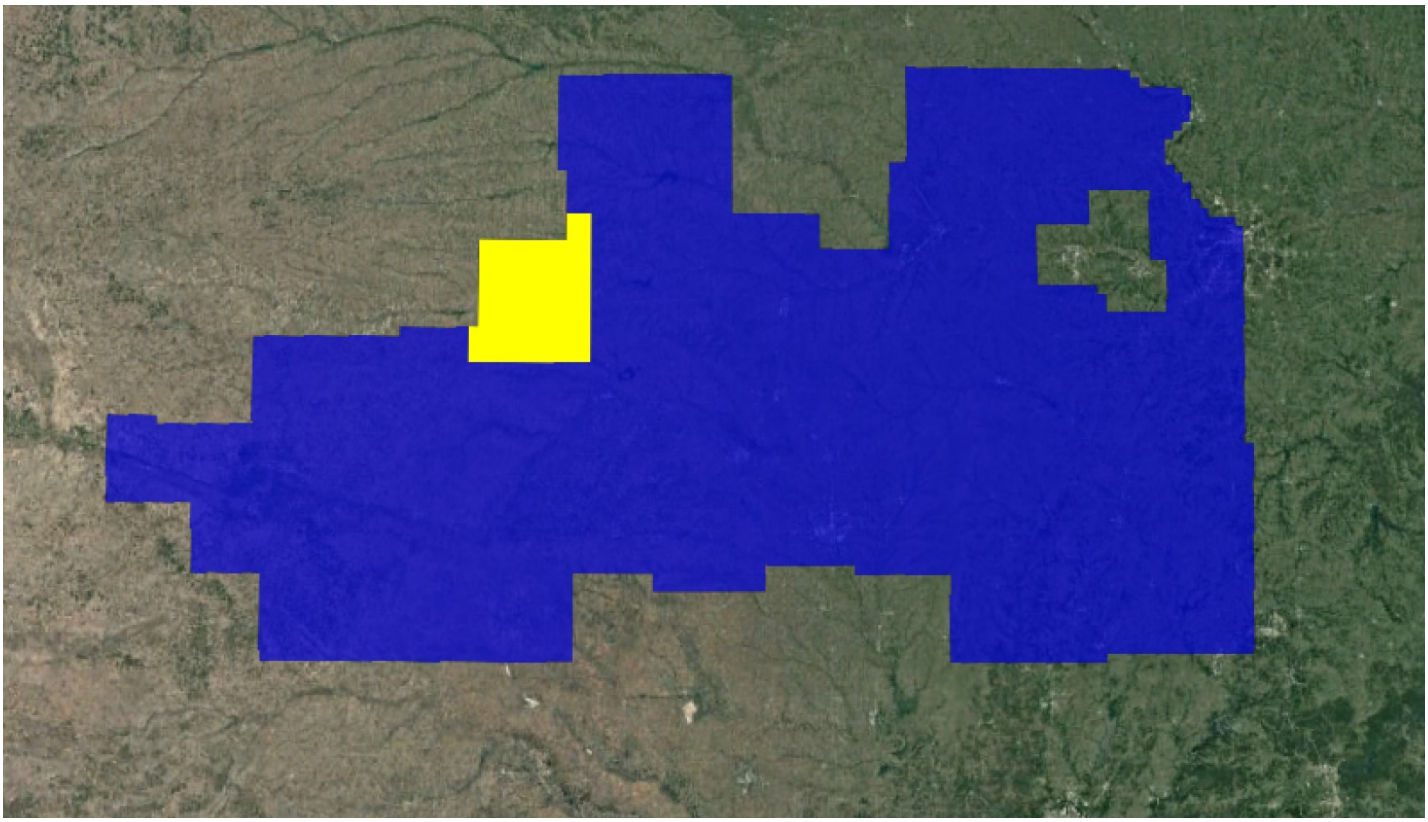


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

b. Project Purpose

The State of Kansas, on behalf of the Kansas Department of Agriculture and Kansas Data Access and Support Center, has contracted with Atlantic for professional services related to the development of Light Detection and Ranging (LiDAR). Additional partners include the USDA Natural Resource Conservation Service, the U.S. Geological Survey, the Kansas GIS Policy Board, the Kansas Department of Transportation and the Kansas Water Office. These LiDAR elevation data will be used for conservation planning, design, research, floodplain mapping, wetlands identification, dam safety assessments, hydrologic modeling, and subsidence monitoring.

c. Client Contact Information

Client Contact Information	
Name of Contact	Tara Lanzrath, CFM
Organization	Kansas Department of Agriculture
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 65 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 7 flight missions conducted between January 4, 2019 and March 20, 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.

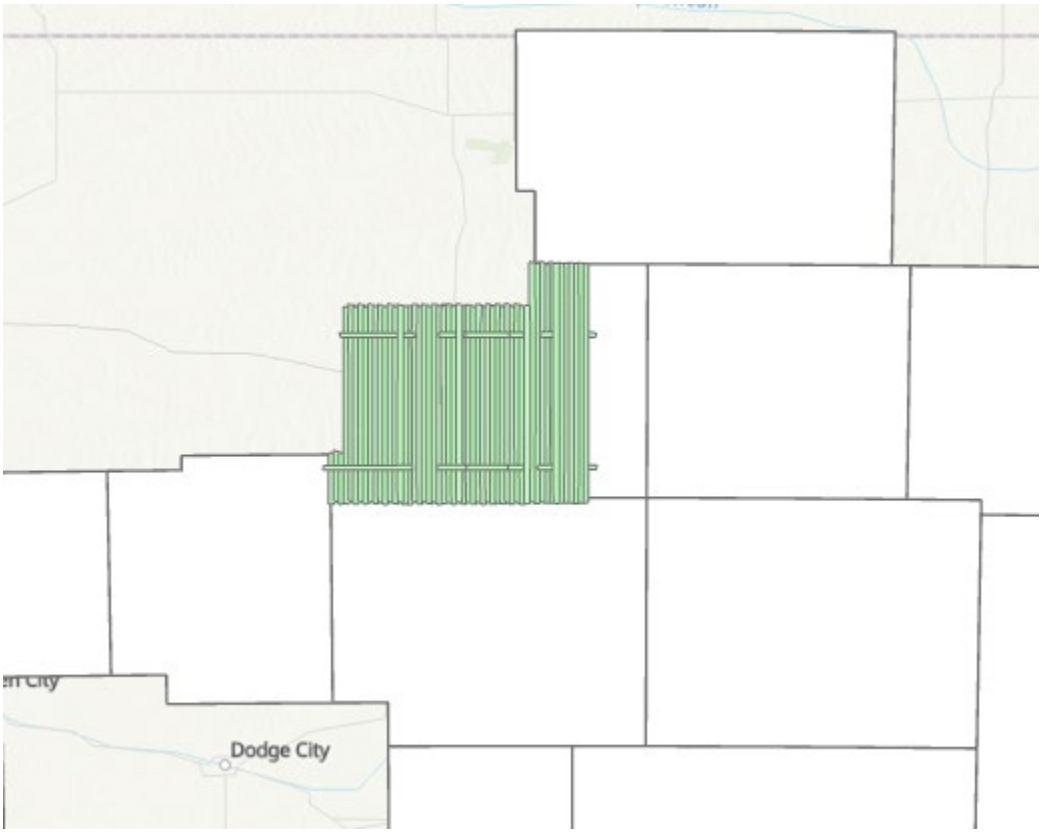


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Eleven (11) 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
KSKY		KSKY	37° 54' 40.30613" N	99° 24' 21.76288" W	641.963m
KSNC		KSNC	38° 27' 11.82814" N	99° 53' 40.99235" W	673.103m
KSSL		KSSL	38° 47' 59.76013" N	97° 38' 12.75892" W	359.195m
KSWK		KSWK	39° 01' 3.68192" N	99° 52' 5.22725" W	729.828m
KSDT		KSDT	38° 28' 46.20565" N	100° 28' 6.29580" W	824.380m
KSLC		KSLC	38° 31' 55.07206" N	99° 18' 19.63542" W	609.947m
KSCC		KSCC	39° 22' 55.99555" N	97° 10' 10.61979" W	349.885m
KSCO		KSCO	39° 36' 37.76224" N	97° 39' 44.33600" W	400.376m
KSHU		KSHU	38° 01' 52.62368" N	97° 54' 8.45874" W	440.099m
KSGB		KSGB	38° 21' 16.85202" N	98° 45' 53.45159" W	544.608m
KSHR		KSHR	38° 35'32.79658" N	98° 24' 51.97980" W	531.162m

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 64 ground survey points were collected in support of this project, including 18 LiDAR Control Points (LCP), 29 Non-vegetated Vertical Accuracy (NVA) and 17 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
LCP253	461774.676	4268129.873	671.615
LCP255	489066.612	4276882.005	596.143
LCP256	474674.738	4279966.285	619.926
LCP257	451469.644	4297781.42	655.681
LCP258	456564.384	4318693.788	654.874
LCP262	445694.689	4273316.475	668.747
LCP263	450073.082	4281863.989	678.473
LCP264	478967.979	4312570.462	625.625
LCP265	488426.486	4312184.462	614.052
LCP266	498231.415	4321854.469	529.908
LCP267	481080.993	4328264.79	569.303
LCP268	463168.759	4327881.926	604.97
LCP269	454922.151	4332922.194	671.776
LCP454	507067.988	4341208.094	615.809
LCP570	456392.555	4270509.074	640.991
LCP572	498019.465	4287608.208	552.703
LCP574	486859.495	4291240.089	574.928
LCP578	472762.617	4327149.596	577.929

Table 6: LiDAR Control Point Coordinates

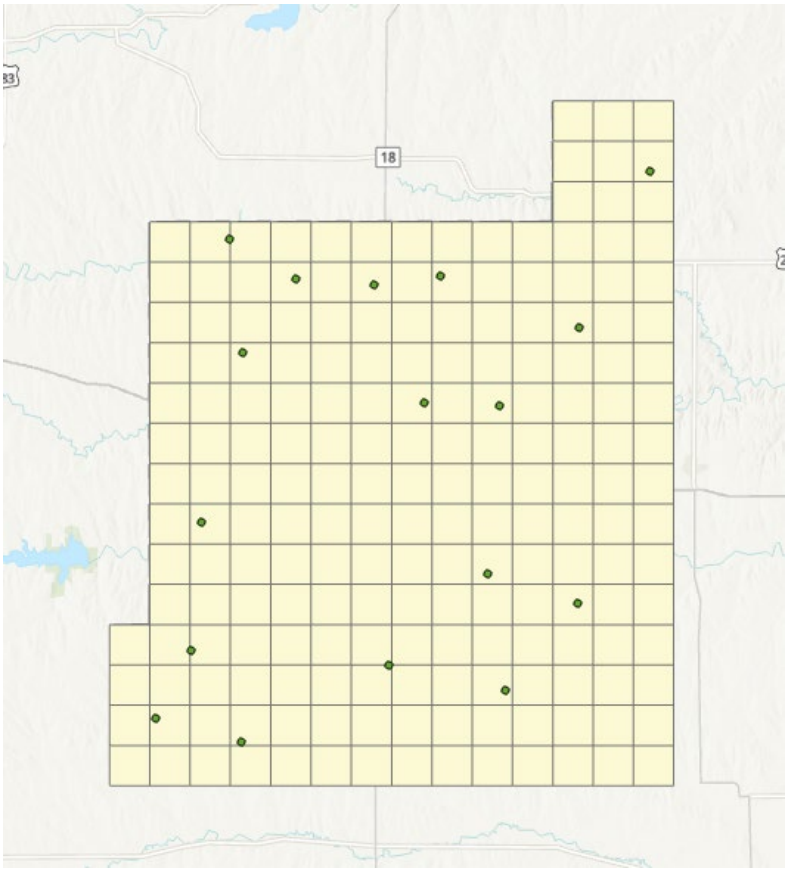


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA300	481063.633	4328272.966	569.583
NVA302	454950.495	4332962.888	670.779
NVA303	450074.312	4281889.271	678.381
NVA304	456544.367	4318680.206	655.701
NVA305	509437.767	4320195.645	550.998
NVA306	498258.303	4321877.117	530.965
NVA308	478987.442	4312543.785	623.871
NVA309	474657.909	4279942.237	618.938
NVA310	451447.077	4297774.088	653.815
NVA361	461786.29	4268106.447	670.668
NVA494	486878.315	4291223.866	573.791
NVA497	497962.159	4285585.026	561.299
NVA498	461088.346	4292030.829	626.761
NVA499	462734.154	4306905.079	624.197
NVA500	458648.835	4317069.278	680.74
NVA501	467085.847	4277026.736	619.9

ID	Easting	Northing	Elevation
NVA502	506929.168	4299263.052	572.053
NVA503	502937.44	4292263.177	554.667
NVA504	483823.819	4317405.379	651.811
NVA696	473398.977	4303395.922	617.112
NVA697	503546.281	4277038.621	609.887
NVA698	471103.326	4284951.725	586.216
NVA699	487104.714	4301155.028	593.284
NVA701	497922.11	4303769.909	583.916
NVA704	507081.535	4329526.151	519.026
NVA705	451452.24	4310650.543	646.464
NVA760	495405.473	4265218.234	621.11
NVA928	481336.168	4296042.115	597.9
NVA930	489925.192	4327482.809	540.434

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

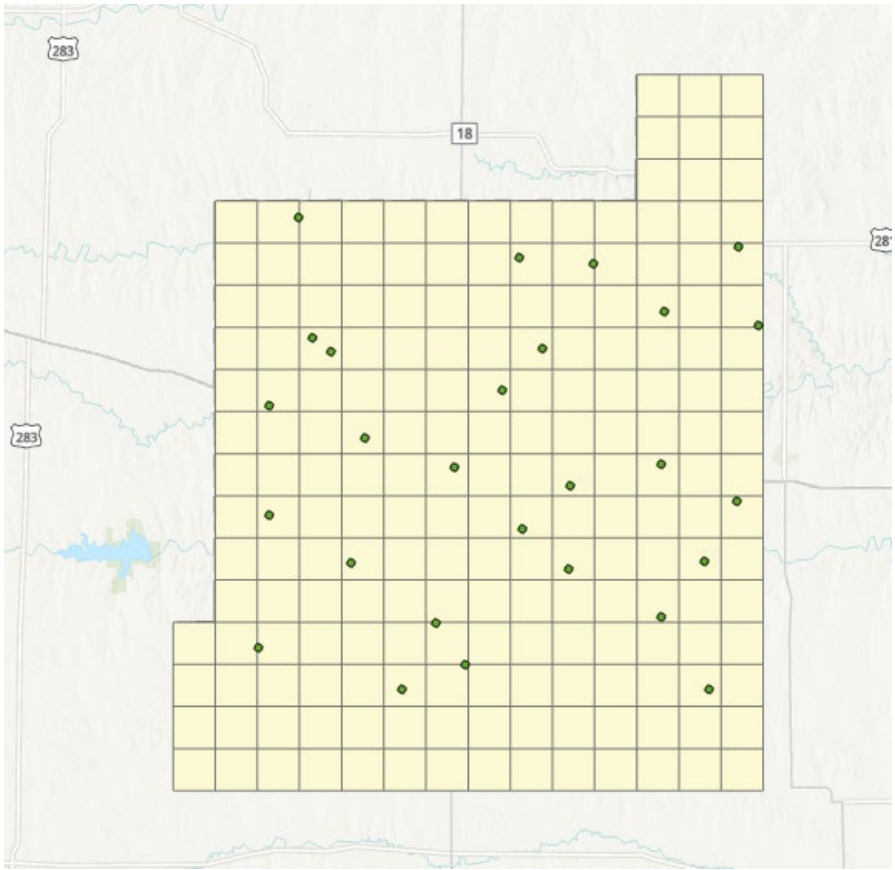


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA208	507079.665	4341213.632	616.601

ID	Easting	Northing	Elevation
VVA209	488426.995	4312207.746	613.729
VVA210	463168.925	4327578.301	596.788
VVA211	489077.293	4276859.109	595.774
VVA212	445729.71	4273335.149	666.91
VVA341	470596.182	4285960.867	598.498
VVA344	472750.374	4327180.096	577.392
VVA346	456221.569	4291862.48	616.7
VVA347	456408.547	4270482.501	641.634
VVA485	498525.006	4347604.595	618.067
VVA487	489932.373	4327461.481	539.397
VVA488	481361.093	4296087.085	598.393
VVA489	498031.377	4287622.733	551.626
VVA490	461530.243	4326375.057	595.004
VVA661	502899.241	4292265.922	554.264
VVA662	471115.688	4284932.866	586.557
VVA664	483802.384	4317437.427	652.236

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

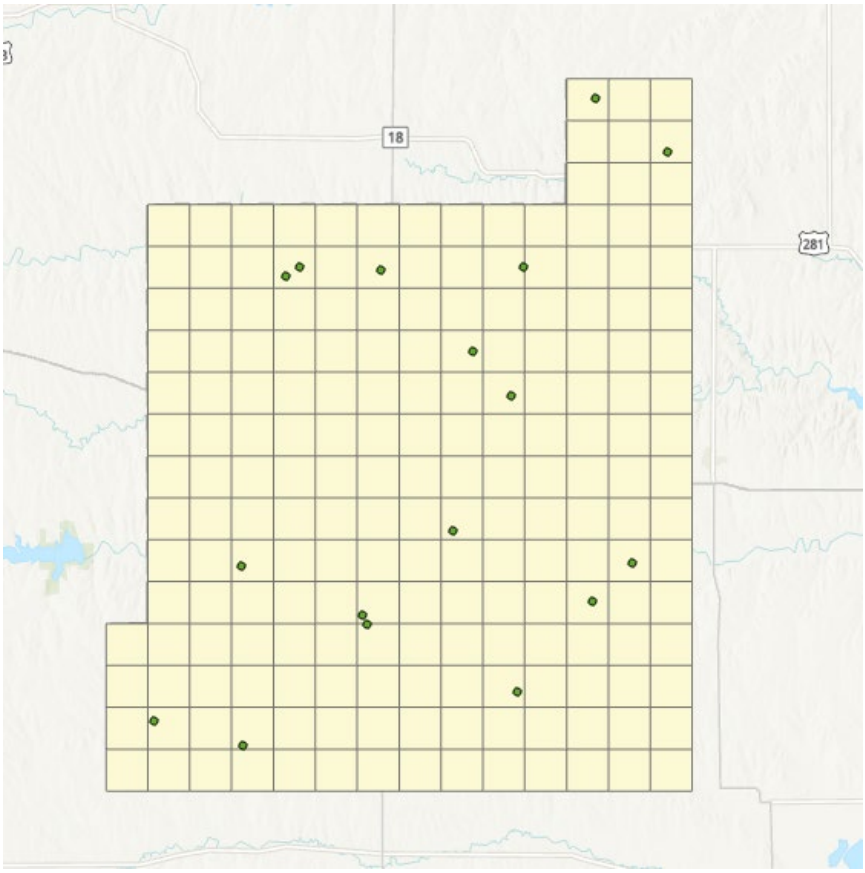


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	17,850,022,122
Nominal Pulse Spacing (m)	0.6513
Nominal Pulse Density (pls/m²)	2.3578
Aggregate Total Points	17,869,602,798
Aggregate Nominal Pulse Spacing (m)	0.5718
Aggregate Nominal Pulse Density (pls/m²)	3.0586

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 1-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 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)	25	0.0991	0.1943	0.1512
NVA (DEM)	25	0.0991	0.1942	0.1654
VVA (Point Cloud)	17	0.1564	0.3066	0.2348
VVA (DEM)	17	0.1880	0.3685	0.1820

Table 12: NVA/VVA Accuracies

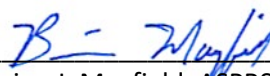
SECTION V: CERTIFICATION STATEMENTS

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
NVA300	481064.3700	4328272.2180	569.5830	569.5990	0.0160	NVA
NVA302	454951.2360	4332962.1380	670.7790	670.6310	-0.1480	NVA
NVA303	450075.0540	4281888.5300	678.3810	678.3090	-0.0720	NVA
NVA305	509438.4990	4320194.8980	550.9980	551.0730	0.0750	NVA
NVA308	478988.1790	4312543.0390	623.8710	623.8760	0.0050	NVA
NVA309	474658.6470	4279941.4960	618.9380	619.0940	0.1560	NVA
NVA310	451447.8190	4297773.3440	653.8150	653.8240	0.0090	NVA
NVA361	461787.0310	4268105.7080	670.6680	670.7110	0.0430	NVA
NVA494	486879.0510	4291223.1240	573.7910	573.7820	-0.0090	NVA
NVA497	497962.8940	4285584.2850	561.2990	561.2210	-0.0780	NVA
NVA498	461089.0860	4292030.0860	626.7610	626.8930	0.1320	NVA
NVA499	462734.8940	4306904.3340	624.1970	624.1780	-0.0190	NVA
NVA500	458649.5750	4317068.5310	680.7400	680.7550	0.0150	NVA
NVA501	467086.5870	4277025.9960	619.9000	619.9380	0.0380	NVA
NVA502	506929.9010	4299262.3090	572.0530	572.2450	0.1920	NVA
NVA503	502938.1740	4292262.4350	554.6670	554.6100	-0.0570	NVA
NVA696	473399.7150	4303395.1780	617.1120	617.2010	0.0890	NVA
NVA697	503547.0150	4277037.8810	609.8870	609.7540	-0.1330	NVA
NVA698	471104.0650	4284950.9830	586.2160	586.2610	0.0450	NVA
NVA699	487105.4500	4301154.2840	593.2840	593.3010	0.0170	NVA
NVA701	497922.8440	4303769.1650	583.9160	583.7140	-0.2020	NVA
NVA704	507082.2670	4329525.4030	519.0260	519.1290	0.1030	NVA
NVA705	451452.9820	4310649.7970	646.4640	646.3050	-0.1590	NVA
NVA928	481336.9050	4296041.3720	597.9000	598.0080	0.1080	NVA
NVA930	489925.9270	4327482.0610	540.4340	540.5000	0.0660	NVA
VVA208	507080.3970	4341212.8820	616.6010	616.7470	0.1460	VVA
VVA209	488427.7310	4312207.0000	613.7290	613.8310	0.1020	VVA
VVA210	463169.6640	4327577.5520	596.7880	597.0150	0.2270	VVA
VVA211	489078.0290	4276858.3690	595.7740	596.0010	0.2270	VVA
VVA212	445730.4530	4273334.4090	666.9100	666.9790	0.0690	VVA
VVA341	470596.9210	4285960.1250	598.4980	598.5980	0.1000	VVA
VVA344	472751.1120	4327179.3480	577.3920	577.6580	0.2660	VVA
VVA346	456222.3100	4291861.7370	616.7000	616.7930	0.0930	VVA
VVA347	456409.2880	4270481.7620	641.6340	641.6390	0.0050	VVA
VVA485	498525.7390	4347603.8440	618.0670	617.8710	-0.1960	VVA

VVA487	489933.1080	4327460.7330	539.3970	539.2550	-0.1420	VVA
VVA488	481361.8300	4296086.3420	598.3930	598.4340	0.0410	VVA
VVA489	498032.1110	4287621.9910	551.6260	551.7750	0.1490	VVA
VVA490	461530.9830	4326374.3090	595.0040	594.8510	-0.1530	VVA
VVA661	502899.9750	4292265.1800	554.2640	554.3610	0.0970	VVA
VVA662	471116.4270	4284932.1240	586.5570	586.6990	0.1420	VVA
VVA664	483803.1200	4317436.6800	652.2360	652.4630	0.2270	VVA

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
NVA300	481063.6330	4328272.9660	569.5830	569.6850	-0.1020	NVA
NVA302	454950.4950	4332962.8880	670.7790	670.6750	0.1040	NVA
NVA303	450074.3120	4281889.2710	678.3810	678.3340	0.0470	NVA
NVA304	456544.3670	4318680.2060	655.7010	655.5210	0.1800	NVA
NVA305	509437.7670	4320195.6450	550.9980	550.9980	0.0000	NVA
NVA308	478987.4420	4312543.7850	623.8710	623.9630	-0.0920	NVA
NVA309	474657.9090	4279942.2370	618.9380	619.0810	-0.1430	NVA
NVA310	451447.0770	4297774.0880	653.8150	653.7770	0.0380	NVA
NVA494	486878.3150	4291223.8660	573.7910	573.8950	-0.1040	NVA
NVA497	497962.1590	4285585.0260	561.2990	561.2190	0.0800	NVA
NVA498	461088.3460	4292030.8290	626.7610	626.8960	-0.1350	NVA
NVA499	462734.1540	4306905.0790	624.1970	624.1550	0.0420	NVA
NVA500	458648.8350	4317069.2780	680.7400	680.7450	-0.0050	NVA
NVA501	467085.8470	4277026.7360	619.9000	619.9410	-0.0410	NVA
NVA502	506929.1680	4299263.0520	572.0530	572.1640	-0.1110	NVA
NVA503	502937.4400	4292263.1770	554.6670	554.6000	0.0670	NVA
NVA696	473398.9770	4303395.9220	617.1120	617.2410	-0.1290	NVA
NVA697	503546.2810	4277038.6210	609.8870	609.7800	0.1070	NVA
NVA698	471103.3260	4284951.7250	586.2160	586.2260	-0.0100	NVA
NVA699	487104.7140	4301155.0280	593.2840	593.3240	-0.0400	NVA
NVA701	497922.1100	4303769.9090	583.9160	583.7290	0.1870	NVA
NVA704	507081.5350	4329526.1510	519.0260	519.1250	-0.0990	NVA
NVA705	451452.2400	4310650.5430	646.4640	646.3630	0.1010	NVA
NVA928	481336.1680	4296042.1150	597.9000	598.0210	-0.1210	NVA
NVA930	489925.1920	4327482.8090	540.4340	540.4980	-0.0640	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA208	507079.6650	4341213.6320	616.6010	616.7170	-0.1160	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA209	488426.9950	4312207.7460	613.7290	613.8250	-0.0960	VVA
VVA210	463168.9250	4327578.3010	596.7880	597.0100	-0.2220	VVA
VVA211	489077.2930	4276859.1090	595.7740	596.0900	-0.3160	VVA
VVA212	445729.7100	4273335.1490	666.9100	666.9680	-0.0580	VVA
VVA341	470596.1820	4285960.8670	598.4980	598.6390	-0.1410	VVA
VVA344	472750.3740	4327180.0960	577.3920	577.6160	-0.2240	VVA
VVA346	456221.5690	4291862.4800	616.7000	616.5500	0.1500	VVA
VVA347	456408.5470	4270482.5010	641.6340	641.5330	0.1010	VVA
VVA485	498525.0060	4347604.5950	618.0670	617.7570	0.3100	VVA
VVA487	489932.3730	4327461.4810	539.3970	539.7250	-0.3280	VVA
VVA488	481361.0930	4296087.0850	598.3930	598.3760	0.0170	VVA
VVA489	498031.3770	4287622.7330	551.6260	551.7600	-0.1340	VVA
VVA490	461530.2430	4326375.0570	595.0040	594.8730	0.1310	VVA
VVA661	502899.2410	4292265.9220	554.2640	554.2840	-0.0200	VVA
VVA662	471115.6880	4284932.8660	586.5570	586.6600	-0.1030	VVA
VVA664	483802.3840	4317437.4270	652.2360	652.5060	-0.2700	VVA

Table 14: DEM Check Point Assessment