



TASK ORDER NAME: 2018 Kansas QL2 LiDAR
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ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 2A

TABLE OF CONTENTS

SECTION I: PROJECT OVERVIEW & PURPOSE	3
1. Aerial LiDAR Project.....	3
<i>a. Project Overview</i>	3
<i>b. Project Purpose</i>	3
<i>c. Client Contact Information</i>	4
<i>d. Contract Deliverables</i>	4
SECTION II: FIELD OPERATIONS	5
1. Aerial LiDAR Project – Aerial Acquisition	5
<i>a. Aircraft & Sensor Information</i>	5
<i>b. Sensor Acquisition Information</i>	5
<i>c. Flight Plan Execution</i>	6
<i>d. GNSS Reference Stations</i>	6
2. Aerial LiDAR Project – Ground Acquisition	7
<i>a. Ground Control Survey</i>	7
SECTION III: DATA PRODUCTION	12
3. Aerial LiDAR Project – Calibration/Classification	12
<i>a. LiDAR Point Cloud Generation</i>	12
<i>b. Coordinate Reference System</i>	12
<i>c. LiDAR Point Cloud Statistics</i>	12
<i>d. Smooth Surface Repeatability (Interswath)</i>	12
<i>e. LiDAR Calibration</i>	12
<i>f. LiDAR Classification</i>	13
<i>g. LiDAR Intensity Imagery</i>	13
<i>h. Hydro-line Collection/Conflation</i>	13
<i>i. Bare-Earth Surface – Digital Elevation Model (DEM)</i>	13
<i>j. Surface-Digital Elevation Model (DSM)</i>	13
SECTION IV: ACCURACY ASSESSMENT	14
1. Aerial LiDAR Project – Vertical Accuracy Assessment.....	14
<i>a. Requirements</i>	14
<i>b. Results</i>	14
SECTION V: CERTIFICATION STATEMENTS	15
1. Aerial LiDAR Project.....	15
SECTION VI: CONTROL POINT ASSESSMENTS	16
1. Aerial LiDAR Project.....	16
<i>a. Point Cloud Check Point Assessment</i>	16
<i>b. Digital Elevation Model (DEM) Check Point Assessment</i>	18

SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 00000000000000000000000039891 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 2A encompasses part or all of 9 counties in Kansas and covers approximately 2917 square miles.

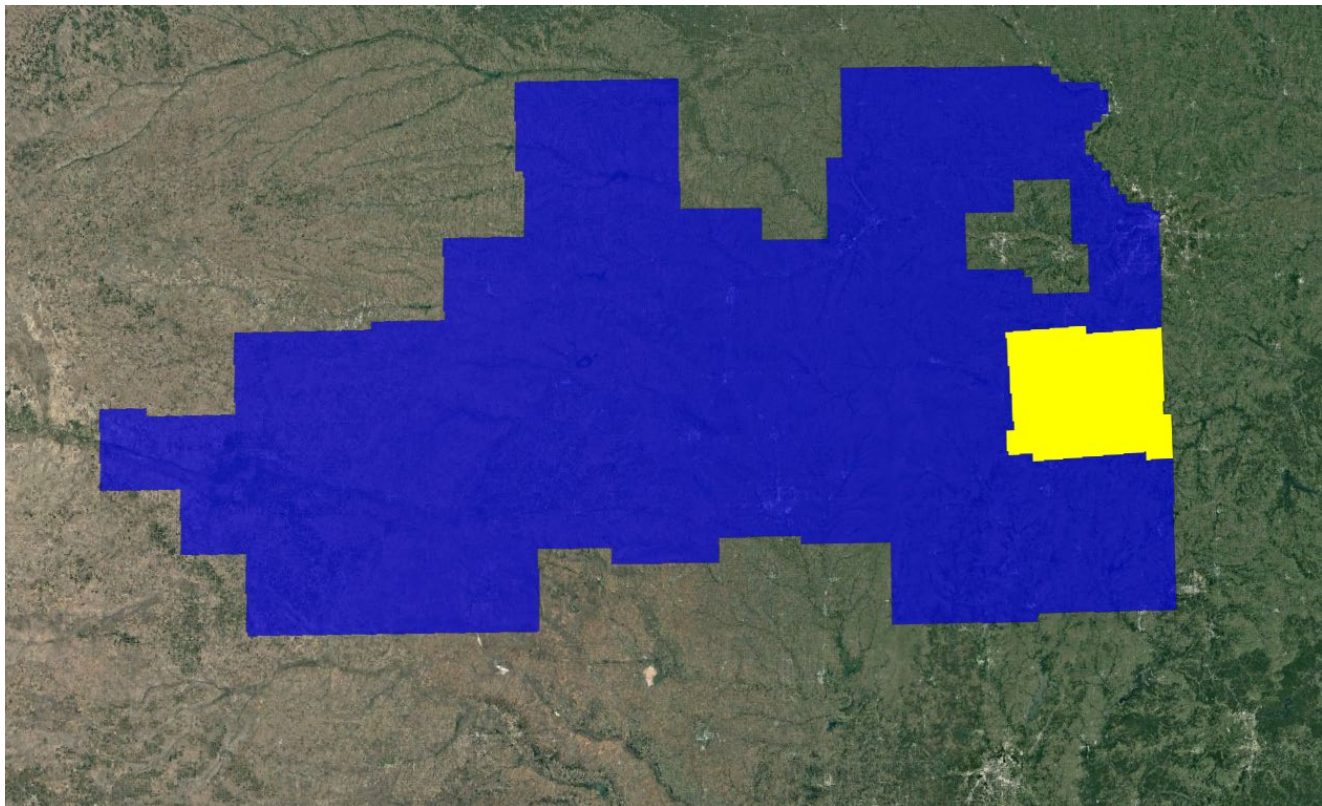


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 95 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 9 flight missions conducted between March 13, 2018 and March 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

Seven (7) 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
KSBU	CORS	KSBU	38°11'44.87410"	95°44'17.05409"	291.002
KSCP	CORS	KSCP	38°58'16.52297"	97°01'11.87249"	321.566
KSEM	CORS	KSEM	38°24'14.59433"	96°10'42.29040"	342.398
KSEU	CORS	KSEU	37°51'06.27235"	96°17'23.73014"	345.374
MONE	CORS	MONE	37°51'56.74271"	94°20'58.40827"	221.254
MOSB	CORS	MOSB	38°49'48.71034"	94°32'04.48758"	301.135
ZKC1	CORS	ZKC1	38°52'48.57351"	94°47'27.00464"	305.466

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 121 ground survey points were collected in support of this project, including 34 LiDAR Control Points (LCP), 50 Non-vegetated Vertical Accuracy (NVA) and 37 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
LCP132	876525.8680	4238681.3330	247.5000
LCP133	836013.6130	4221632.3880	325.2660
LCP15	883051.0730	4211549.5010	260.9510
LCP151	847640.2720	4265451.0650	274.8940
LCP153	882018.3590	4262842.8330	302.3510
LCP154	840406.7880	4256408.0410	281.4410
LCP16	881870.9640	4212423.0430	261.1220
LCP17	867550.9840	4205539.0900	266.7930
LCP18	864181.3480	4235336.4580	317.3140
LCP19	864368.2090	4233435.0450	297.6950
LCP20	863003.6860	4225097.0440	322.0760
LCP21	847322.9010	4239625.7760	300.4550
LCP22	839773.9560	4230019.6110	320.0700
LCP23	837975.6360	4239627.9830	310.4120
LCP24	831786.3940	4251893.7500	271.5410
LCP25	821475.6710	4247929.2530	298.7630
LCP26	828419.0810	4237658.1030	336.1880
LCP27	802041.8160	4223737.7320	326.8200

ID	Easting	Northing	Elevation
LCP28	801520.0740	4240227.3330	360.8820
LCP33	792359.9210	4212139.8700	342.0680
LCP34	802963.8540	4207605.6230	304.0030
LCP35	801150.0780	4201789.3680	307.8940
LCP64	838188.4770	4265081.4750	310.5030
LCP68	881029.4260	4272441.3570	340.3380
LCP69	863307.1860	4266059.8820	254.6180
LCP70	864202.8100	4256392.9190	272.5460
LCP71	853043.2280	4262418.6760	286.0330
LCP72	864359.6040	4243473.9420	248.6800
LCP73	877019.7240	4256206.8790	291.8450
LCP74	803335.7010	4254838.6200	347.1950
LCP75	811858.0640	4244660.2560	302.8140
LCP76	807179.3220	4240855.0420	323.1340
LCP77	811375.6300	4235429.0260	320.3550
LCP78	813222.5000	4233896.0940	313.2480

Table 6: LiDAR Control Point Coordinates

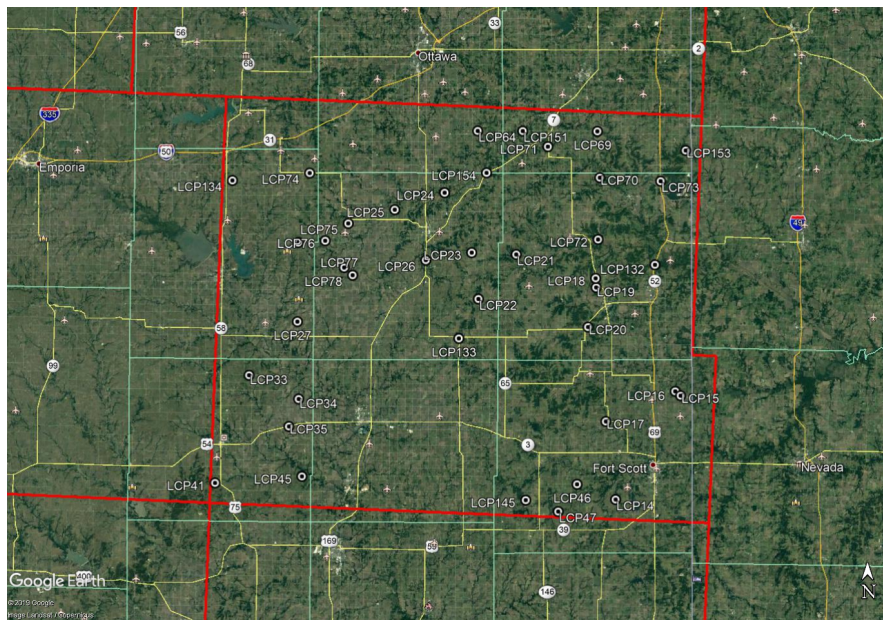


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA07	839775.7050	4230022.2710	320.0980
NVA09	792356.0210	4212139.7770	341.9770
NVA11	838050.3640	4208912.7140	308.6550

ID	Easting	Northing	Elevation
NVA12	847323.6600	4239612.4260	300.6200
NVA127	813139.3680	4231042.2170	320.1080
NVA128	882053.9370	4262858.0670	302.1510
NVA129	872532.2020	4252777.7320	247.7120
NVA13	864187.2340	4235343.7190	316.9890
NVA14	862991.7370	4225082.7520	322.6100
NVA15	883046.6570	4211549.5210	261.0190
NVA155	828415.8660	4237659.6750	336.0320
NVA157	817845.9010	4219566.5690	342.5430
NVA158	836017.2160	4221640.6110	325.4070
NVA159	877619.8470	4196547.9100	256.2780
NVA160	876303.6750	4230548.1800	253.8410
NVA161	876529.0910	4238687.6490	247.3290
NVA165	878200.6240	4193204.7540	281.3920
NVA196	825602.7210	4267082.9370	292.4880
NVA198	840404.4650	4256386.8910	281.3070
NVA200	813849.8690	4203181.6460	291.9270
NVA201	841452.5210	4202815.3800	327.6270
NVA202	853739.5430	4198168.5020	284.3190
NVA203	858889.6070	4244175.3970	286.0290
NVA204	858365.5040	4252576.1770	276.9290
NVA205	876492.3090	4267479.1890	316.4940
NVA22	815861.8260	4265453.2110	311.4480
NVA229	880291.1740	4234949.2640	245.7230
NVA230	836262.5930	4213795.7980	327.6680
NVA231	790053.1280	4239797.0230	339.8690
NVA243	837136.9070	4195997.6830	314.3780
NVA249	831940.8440	4267146.7910	300.0480
NVA251	872507.0610	4262232.1900	298.9040
NVA252	814330.3970	4258507.3450	305.1700
NVA51	811373.9620	4235450.3830	319.4390
NVA52	853006.4780	4262431.2950	287.4730
NVA53	863317.6580	4266045.9900	254.3400
NVA54	877020.0870	4256231.6020	292.2210
NVA77	826973.4450	4202353.6520	312.1480
NVA79	823230.8310	4216045.3580	329.6790
NVA82	821458.5440	4247928.5910	298.9400
NVA84	793382.3210	4264221.9530	340.7650
NVA85	848818.2060	4250102.2710	303.6690

ID	Easting	Northing	Elevation
NVA86	847116.6540	4228702.6870	301.2530
NVA87	849221.6470	4210393.8040	313.5620
NVA88	867720.8180	4211833.3850	279.6470
NVA89	883392.1880	4204156.5800	254.3390

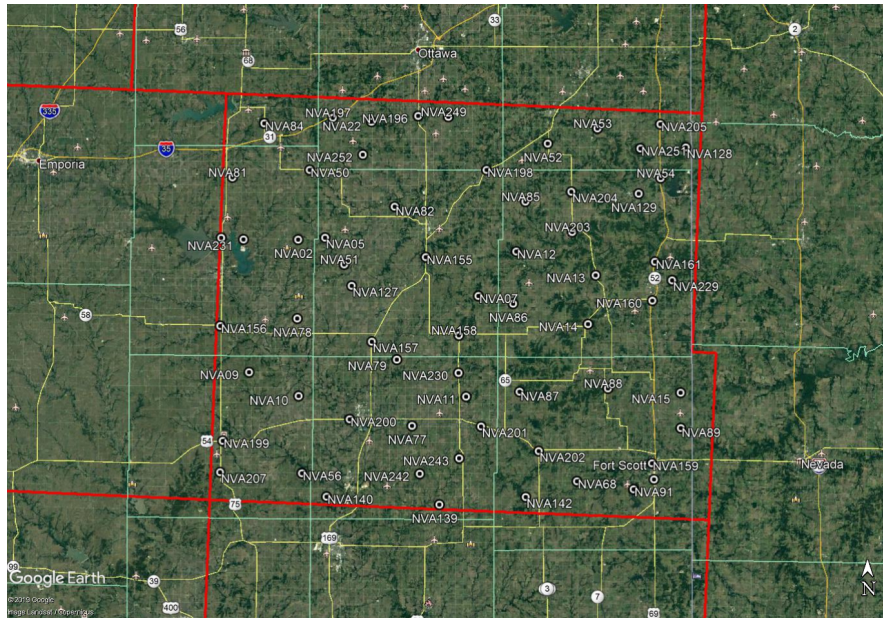


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA03	831801.5350	4251886.0000	271.4140
VVA05	837961.0040	4239648.7000	310.6690
VVA06	813187.3260	4233909.2780	311.9350
VVA07	836249.4100	4213802.6340	327.5860
VVA08	801141.1700	4201781.9710	307.6370
VVA09	867534.9290	4205547.7110	265.8370
VVA095	802432.5350	4211737.8010	298.4110
VVA098	790049.4840	4239775.6200	338.6820
VVA10	881883.4770	4212428.9870	261.5940
VVA100	856109.6690	4212895.9270	276.0480
VVA101	880297.6320	4234962.0030	245.7730
VVA102	864376.8260	4233448.7350	296.8260
VVA127	837138.8300	4195980.2100	314.0700
VVA128	838218.1660	4265086.4400	310.1330
VVA129	847609.9110	4265440.7150	273.3680
VVA130	858181.5650	4270998.3700	278.7480

ID	Easting	Northing	Elevation
VVA148	876316.9380	4230548.0340	253.4620
VVA149	826976.8540	4202378.5350	312.6470
VVA150	802004.0250	4223728.3190	326.2880
VVA153	876483.1990	4267455.7710	319.2240
VVA173	815897.7390	4265458.7170	311.3890
VVA36	811877.2650	4244675.5020	303.0350
VVA37	864454.8590	4243459.2370	247.0600
VVA38	881013.7430	4272446.5840	340.1190
VVA49	802065.2060	4223763.1080	325.7200
VVA50	834825.8610	4228187.0580	354.3580
VVA53	872503.4920	4262274.5690	297.9960
VVA54	848961.3420	4246376.3510	297.6380
VVA55	846838.8030	4234782.4170	300.5630
VVA56	864884.7160	4219823.5120	278.2460
VVA77	814334.7570	4258474.4260	305.0890
VVA78	831941.8970	4267167.4190	298.9480
VVA79	872630.3180	4241917.6580	239.8860

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

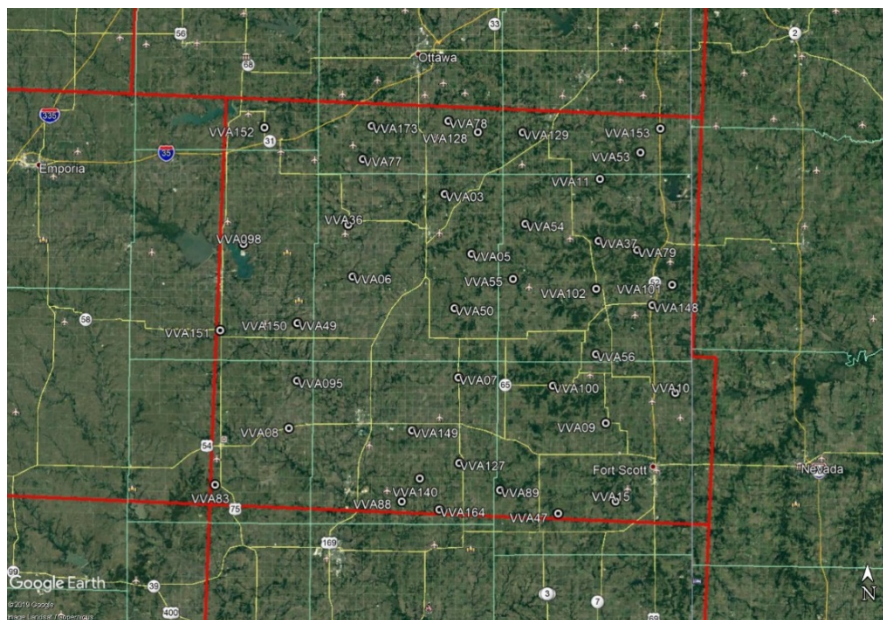


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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 2011(HARN)
Coordinate System: UTM, 15N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	24,169,308,954
Nominal Pulse Spacing (m)	0.6581
Nominal Pulse Density (pls/m²)	2.3091
Aggregate Total Points	24,409,872,052
Aggregate Nominal Pulse Spacing (m)	0.6075
Aggregate Nominal Pulse Density (pls/m²)	2.7096

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 1.0-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	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	46	0.0828	0.1624	0.1143
NVA (DEM)	46	0.0977	0.1915	0.1100
VVA (Point Cloud)	33	0.1213	0.2378	0.2226
VVA (DEM)	33	0.1974	0.3870	0.0390

Table 12: NVA/VVA Accuracies

SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

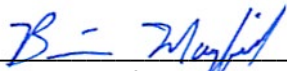
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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
NVA07	839775.7050	4230022.2710	320.0980	320.0490	-0.0490	NVA
NVA09	792356.0210	4212139.7770	341.9770	341.9810	0.0040	NVA
NVA10	802949.5400	4207604.7850	304.0870	304.0010	-0.0860	NVA
NVA11	838050.3640	4208912.7140	308.6550	308.6400	-0.0150	NVA
NVA12	847323.6600	4239612.4260	300.6200	300.6280	0.0080	NVA
NVA127	813139.3680	4231042.2170	320.1080	320.0480	-0.0600	NVA
NVA128	882053.9370	4262858.0670	302.1510	302.3050	0.1540	NVA
NVA129	872532.2020	4252777.7320	247.7120	247.8110	0.0990	NVA
NVA13	864187.2340	4235343.7190	316.9890	317.1040	0.1150	NVA
NVA14	862991.7370	4225082.7520	322.6100	322.6950	0.0850	NVA
NVA15	883046.6570	4211549.5210	261.0190	261.0030	-0.0160	NVA
NVA155	828415.8660	4237659.6750	336.0320	335.9400	-0.0920	NVA
NVA157	817845.9010	4219566.5690	342.5430	342.4730	-0.0700	NVA
NVA158	836017.2160	4221640.6110	325.4070	325.1690	-0.2380	NVA
NVA159	877619.8470	4196547.9100	256.2780	256.2580	-0.0200	NVA
NVA160	876303.6750	4230548.1800	253.8410	253.8420	0.0010	NVA
NVA161	876529.0910	4238687.6490	247.3290	247.3690	0.0400	NVA
NVA165	878200.6240	4193204.7540	281.3920	281.3820	-0.0100	NVA
NVA196	825602.7210	4267082.9370	292.4880	292.4200	-0.0680	NVA
NVA198	840404.4650	4256386.8910	281.3070	281.2750	-0.0320	NVA
NVA200	813849.8690	4203181.6460	291.9270	291.8130	-0.1140	NVA
NVA201	841452.5210	4202815.3800	327.6270	327.5220	-0.1050	NVA
NVA202	853739.5430	4198168.5020	284.3190	284.2450	-0.0740	NVA
NVA203	858889.6070	4244175.3970	286.0290	286.0280	-0.0010	NVA
NVA204	858365.5040	4252576.1770	276.9290	276.9030	-0.0260	NVA
NVA205	876492.3090	4267479.1890	316.4940	316.4690	-0.0250	NVA
NVA22	815861.8260	4265453.2110	311.4480	311.3400	-0.1080	NVA
NVA229	880291.1740	4234949.2640	245.7230	245.8350	0.1120	NVA
NVA230	836262.5930	4213795.7980	327.6680	327.5880	-0.0800	NVA
NVA231	790053.1280	4239797.0230	339.8690	339.8900	0.0210	NVA
NVA243	837136.9070	4195997.6830	314.3780	314.1790	-0.1990	NVA
NVA249	831940.8440	4267146.7910	300.0480	300.0380	-0.0100	NVA
NVA251	872507.0610	4262232.1900	298.9040	298.9840	0.0800	NVA
NVA252	814330.3970	4258507.3450	305.1700	305.0480	-0.1220	NVA
NVA51	811373.9620	4235450.3830	319.4390	319.3360	-0.1030	NVA

NVA52	853006.4780	4262431.2950	287.4730	287.4480	-0.0250	NVA
NVA53	863317.6580	4266045.9900	254.3400	254.4190	0.0790	NVA
NVA54	877020.0870	4256231.6020	292.2210	292.2820	0.0610	NVA
NVA77	826973.4450	4202353.6520	312.1480	312.1400	-0.0080	NVA
NVA79	823230.8310	4216045.3580	329.6790	329.6750	-0.0040	NVA
NVA82	821458.5440	4247928.5910	298.9400	298.8790	-0.0610	NVA
NVA84	793382.3210	4264221.9530	340.7650	340.8280	0.0630	NVA
NVA85	848818.2060	4250102.2710	303.6690	303.6680	-0.0010	NVA
NVA86	847116.6540	4228702.6870	301.2530	301.2390	-0.0140	NVA
NVA87	849221.6470	4210393.8040	313.5620	313.5970	0.0350	NVA
NVA88	867720.8180	4211833.3850	279.6470	279.7660	0.1190	NVA
NVA89	883392.1880	4204156.5800	254.3390	254.4390	0.1000	NVA
VVA03	831801.5350	4251886.0000	271.4140	271.4740	0.0600	VVA
VVA05	837961.0040	4239648.7000	310.6690	310.5980	-0.0710	VVA
VVA06	813187.3260	4233909.2780	311.9350	312.1460	0.2110	VVA
VVA07	836249.4100	4213802.6340	327.5860	327.5470	-0.0390	VVA
VVA08	801141.1700	4201781.9710	307.6370	307.7860	0.1490	VVA
VVA09	867534.9290	4205547.7110	265.8370	266.0190	0.1820	VVA
VVA095	802432.5350	4211737.8010	298.4110	298.3160	-0.0950	VVA
VVA098	790049.4840	4239775.6200	338.6820	338.7730	0.0910	VVA
VVA10	881883.4770	4212428.9870	261.5940	261.6720	0.0780	VVA
VVA100	856109.6690	4212895.9270	276.0480	276.1730	0.1250	VVA
VVA101	880297.6320	4234962.0030	245.7730	245.8920	0.1190	VVA
VVA102	864376.8260	4233448.7350	296.8260	296.9500	0.1240	VVA
VVA127	837138.8300	4195980.2100	314.0700	314.0270	-0.0430	VVA
VVA128	838218.1660	4265086.4400	310.1330	310.0650	-0.0680	VVA
VVA129	847609.9110	4265440.7150	273.3680	273.4590	0.0910	VVA
VVA130	858181.5650	4270998.3700	278.7480	278.7870	0.0390	VVA
VVA148	876316.9380	4230548.0340	253.4620	253.6640	0.2020	VVA
VVA149	826976.8540	4202378.5350	312.6470	312.6650	0.0180	VVA
VVA150	802004.0250	4223728.3190	326.2880	326.2720	-0.0160	VVA
VVA153	876483.1990	4267455.7710	319.2240	319.2830	0.0590	VVA
VVA173	815897.7390	4265458.7170	311.3890	311.2850	-0.1040	VVA
VVA36	811877.2650	4244675.5020	303.0350	303.0680	0.0330	VVA
VVA37	864454.8590	4243459.2370	247.0600	247.3800	0.3200	VVA
VVA38	881013.7430	4272446.5840	340.1190	340.3590	0.2400	VVA
VVA49	802065.2060	4223763.1080	325.7200	325.7190	-0.0010	VVA
VVA50	834825.8610	4228187.0580	354.3580	354.3340	-0.0240	VVA
VVA53	872503.4920	4262274.5690	297.9960	298.1260	0.1300	VVA
VVA54	848961.3420	4246376.3510	297.6380	297.6780	0.0400	VVA

VVA55	846838.8030	4234782.4170	300.5630	300.6330	0.0700	VVA
VVA56	864884.7160	4219823.5120	278.2460	278.3860	0.1400	VVA
VVA77	814334.7570	4258474.4260	305.0890	305.0440	-0.0450	VVA
VVA78	831941.8970	4267167.4190	298.9480	299.0410	0.0930	VVA
VVA79	872630.3180	4241917.6580	239.8860	240.0270	0.1410	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
NVA07	839775.7050	4230022.2710	320.0980	320.2817	-0.1837	NVA
NVA09	792356.0210	4212139.7770	341.9770	342.1478	-0.1708	NVA
NVA11	838050.3640	4208912.7140	308.6550	308.7435	-0.0885	NVA
NVA12	847323.6600	4239612.4260	300.6200	300.7041	-0.0841	NVA
NVA127	813139.3680	4231042.2170	320.1080	320.0982	0.0098	NVA
NVA128	882053.9370	4262858.0670	302.1510	302.3589	-0.2079	NVA
NVA129	872532.2020	4252777.7320	247.7120	247.8176	-0.1056	NVA
NVA13	864187.2340	4235343.7190	316.9890	317.1081	-0.1191	NVA
NVA14	862991.7370	4225082.7520	322.6100	322.7436	-0.1336	NVA
NVA15	883046.6570	4211549.5210	261.0190	261.0646	-0.0456	NVA
NVA155	828415.8660	4237659.6750	336.0320	335.9682	0.0638	NVA
NVA157	817845.9010	4219566.5690	342.5430	342.4440	0.0990	NVA
NVA158	836017.2160	4221640.6110	325.4070	325.3588	0.0482	NVA
NVA159	877619.8470	4196547.9100	256.2780	256.2938	-0.0158	NVA
NVA160	876303.6750	4230548.1800	253.8410	253.8740	-0.0330	NVA
NVA161	876529.0910	4238687.6490	247.3290	247.3501	-0.0211	NVA
NVA165	878200.6240	4193204.7540	281.3920	281.4002	-0.0082	NVA
NVA196	825602.7210	4267082.9370	292.4880	292.3788	0.1092	NVA
NVA198	840404.4650	4256386.8910	281.3070	281.4310	-0.1240	NVA
NVA200	813849.8690	4203181.6460	291.9270	291.8167	0.1103	NVA
NVA201	841452.5210	4202815.3800	327.6270	327.6435	-0.0165	NVA
NVA202	853739.5430	4198168.5020	284.3190	284.2510	0.0680	NVA
NVA203	858889.6070	4244175.3970	286.0290	286.1017	-0.0727	NVA
NVA204	858365.5040	4252576.1770	276.9290	276.9239	0.0051	NVA
NVA205	876492.3090	4267479.1890	316.4940	316.4638	0.0302	NVA
NVA22	815861.8260	4265453.2110	311.4480	311.4105	0.0375	NVA
NVA229	880291.1740	4234949.2640	245.7230	245.8730	-0.1500	NVA
NVA230	836262.5930	4213795.7980	327.6680	327.7353	-0.0673	NVA
NVA231	790053.1280	4239797.0230	339.8690	340.0190	-0.1500	NVA
NVA243	837136.9070	4195997.6830	314.3780	314.3390	0.0390	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA249	831940.8440	4267146.7910	300.0480	300.1509	-0.1029	NVA
NVA251	872507.0610	4262232.1900	298.9040	298.9811	-0.0771	NVA
NVA252	814330.3970	4258507.3450	305.1700	305.0542	0.1158	NVA
NVA51	811373.9620	4235450.3830	319.4390	319.4368	0.0022	NVA
NVA52	853006.4780	4262431.2950	287.4730	287.4974	-0.0244	NVA
NVA53	863317.6580	4266045.9900	254.3400	254.4169	-0.0769	NVA
NVA54	877020.0870	4256231.6020	292.2210	292.2950	-0.0740	NVA
NVA77	826973.4450	4202353.6520	312.1480	312.1210	0.0270	NVA
NVA79	823230.8310	4216045.3580	329.6790	329.5741	0.1049	NVA
NVA82	821458.5440	4247928.5910	298.9400	298.7424	0.1976	NVA
NVA84	793382.3210	4264221.9530	340.7650	340.7064	0.0586	NVA
NVA85	848818.2060	4250102.2710	303.6690	303.7311	-0.0621	NVA
NVA86	847116.6540	4228702.6870	301.2530	301.2683	-0.0153	NVA
NVA87	849221.6470	4210393.8040	313.5620	313.6834	-0.1214	NVA
NVA88	867720.8180	4211833.3850	279.6470	279.7561	-0.1091	NVA
NVA89	883392.1880	4204156.5800	254.3390	254.4964	-0.1574	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA03	831801.5350	4251886.0000	271.4140	271.5920	-0.1780	VVA
VVA05	837961.0040	4239648.7000	310.6690	310.7991	-0.1301	VVA
VVA06	813187.3260	4233909.2780	311.9350	311.8537	0.0813	VVA
VVA07	836249.4100	4213802.6340	327.5860	327.7170	-0.1310	VVA
VVA08	801141.1700	4201781.9710	307.6370	307.9632	-0.3262	VVA
VVA09	867534.9290	4205547.7110	265.8370	266.0654	-0.2284	VVA
VVA095	802432.5350	4211737.8010	298.4110	298.6659	-0.2549	VVA
VVA098	790049.4840	4239775.6200	338.6820	338.9007	-0.2187	VVA
VVA10	881883.4770	4212428.9870	261.5940	261.7257	-0.1317	VVA
VVA100	856109.6690	4212895.9270	276.0480	276.3039	-0.2559	VVA
VVA101	880297.6320	4234962.0030	245.7730	245.9626	-0.1896	VVA
VVA102	864376.8260	4233448.7350	296.8260	296.9599	-0.1339	VVA
VVA127	837138.8300	4195980.2100	314.0700	314.1168	-0.0468	VVA
VVA128	838218.1660	4265086.4400	310.1330	310.3702	-0.2372	VVA
VVA129	847609.9110	4265440.7150	273.3680	273.5470	-0.1790	VVA
VVA130	858181.5650	4270998.3700	278.7480	278.7768	-0.0288	VVA
VVA148	876316.9380	4230548.0340	253.4620	253.6881	-0.2261	VVA
VVA149	826976.8540	4202378.5350	312.6470	312.6014	0.0456	VVA
VVA150	802004.0250	4223728.3190	326.2880	326.6938	-0.4058	VVA
VVA153	876483.1990	4267455.7710	319.2240	319.2902	-0.0662	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA173	815897.7390	4265458.7170	311.3890	311.3630	0.0260	VVA
VVA36	811877.2650	4244675.5020	303.0350	303.1215	-0.0865	VVA
VVA37	864454.8590	4243459.2370	247.0600	247.4019	-0.3419	VVA
VVA38	881013.7430	4272446.5840	340.1190	340.4089	-0.2899	VVA
VVA49	802065.2060	4223763.1080	325.7200	326.0558	-0.3358	VVA
VVA50	834825.8610	4228187.0580	354.3580	354.4982	-0.1402	VVA
VVA53	872503.4920	4262274.5690	297.9960	298.1560	-0.1600	VVA
VVA54	848961.3420	4246376.3510	297.6380	297.7253	-0.0873	VVA
VVA55	846838.8030	4234782.4170	300.5630	300.7081	-0.1451	VVA
VVA56	864884.7160	4219823.5120	278.2460	278.4110	-0.1650	VVA
VVA77	814334.7570	4258474.4260	305.0890	305.0545	0.0345	VVA
VVA78	831941.8970	4267167.4190	298.9480	299.1533	-0.2053	VVA
VVA79	872630.3180	4241917.6580	239.8860	240.0471	-0.1611	VVA

Table 14: DEM Check Point Assessment