



**TASK ORDER NAME: 2018 Kansas QL2 LiDAR**  
**CONTRACT ID: 00000000000000000000039891**  
**EVENT ID: EVT0003259**  
**ATLANTIC PROJECT NUMBER: 18006**  
**PROJECT BLOCK NUMBER: Block 8B**

# TABLE OF CONTENTS

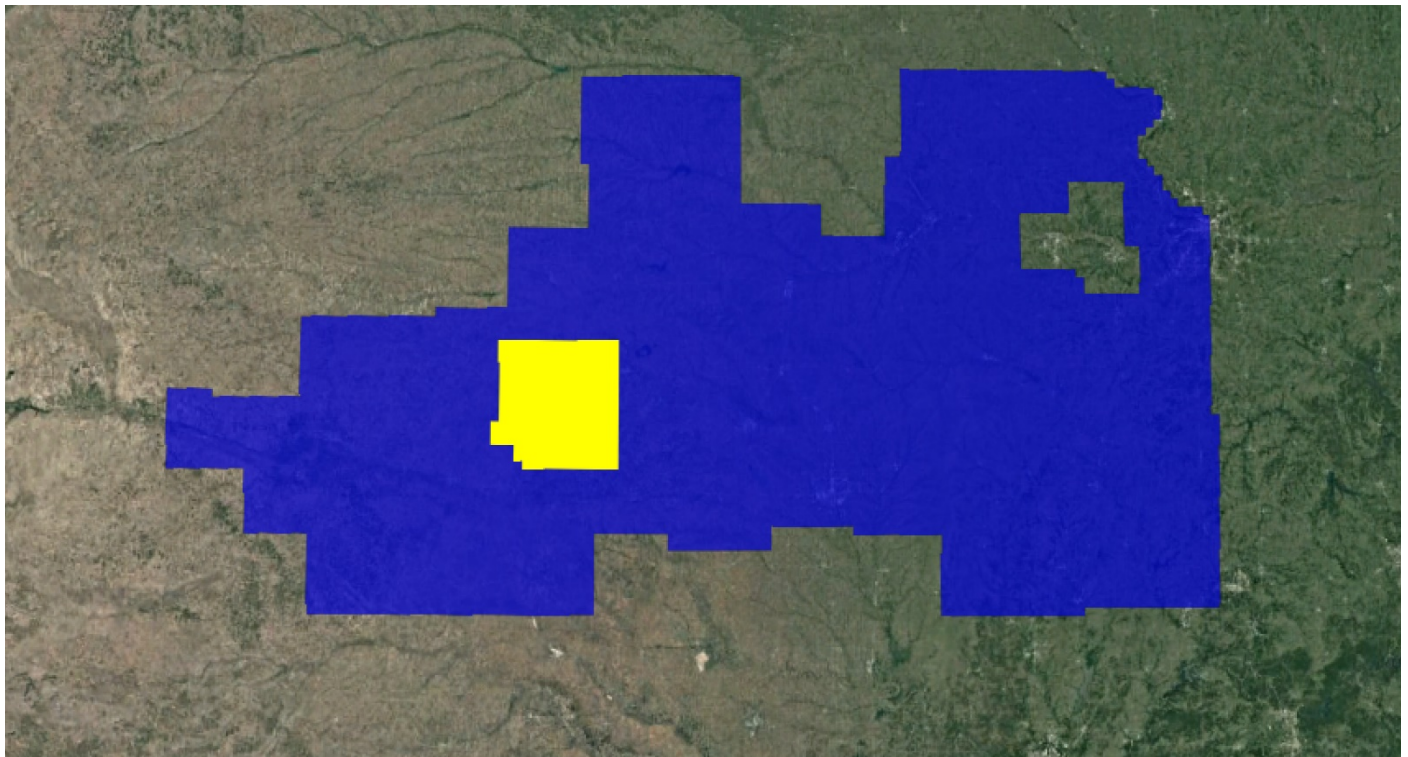
<b>SECTION I: PROJECT OVERVIEW &amp; PURPOSE</b> .....	<b>3</b>
1. Aerial LiDAR Project.....	3
<i>a. Project Overview</i> .....	3
<i>b. Project Purpose</i> .....	3
<i>c. Client Contact Information</i> .....	4
<i>d. Contract Deliverables</i> .....	4
<b>SECTION II: FIELD OPERATIONS</b> .....	<b>5</b>
1. Aerial LiDAR Project – Aerial Acquisition .....	5
<i>a. Aircraft &amp; Sensor Information</i> .....	5
<i>b. Sensor Acquisition Information</i> .....	5
<i>c. Flight Plan Execution</i> .....	6
<i>d. GNSS Reference Stations</i> .....	7
2. Aerial LiDAR Project – Ground Acquisition .....	8
<i>a. Ground Control Survey</i> .....	8
<b>SECTION III: DATA PRODUCTION</b> .....	<b>13</b>
3. Aerial LiDAR Project – Calibration/Classification .....	13
<i>a. LiDAR Point Cloud Generation</i> .....	13
<i>b. Coordinate Reference System</i> .....	13
<i>c. LiDAR Point Cloud Statistics</i> .....	13
<i>d. Smooth Surface Repeatability (Interswath)</i> .....	13
<i>e. LiDAR Calibration</i> .....	13
<i>f. LiDAR Classification</i> .....	14
<i>g. LiDAR Intensity Imagery</i> .....	14
<i>h. Hydro-line Collection/Conflation</i> .....	14
<i>i. Bare-Earth Surface – Digital Elevation Model (DEM)</i> .....	14
<i>j. Surface-Digital Elevation Model (DSM)</i> .....	14
<b>SECTION IV: ACCURACY ASSESSMENT</b> .....	<b>15</b>
1. Aerial LiDAR Project – Vertical Accuracy Assessment.....	15
<i>a. Requirements</i> .....	15
<i>b. Results</i> .....	15
<b>SECTION V: CERTIFICATION STATEMENTS</b> .....	<b>16</b>
1. Aerial LiDAR Project.....	16
<b>SECTION VI: CONTROL POINT ASSESSMENTS</b> .....	<b>17</b>
1. Aerial LiDAR Project.....	17
<i>a. Point Cloud Check Point Assessment</i> .....	17
<i>b. Digital Elevation Model (DEM) Check Point Assessment</i> .....	19

## **SECTION I: PROJECT OVERVIEW & PURPOSE**

### ***1. Aerial LiDAR Project***

#### **a. Project Overview**

The State of Kansas Contract 0000000000000000000039891 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 8B encompasses part or all of 8 counties in Southern Kansas and covers approximately 2278 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	
<b>Name of Contact</b>	Tara Lanzrath, CFM
<b>Organization</b>	Kansas Department of Agriculture
<b>Position</b>	Floodplain Mapping Coordinator
<b>Telephone</b>	785-296-2513
<b>E-Mail Address</b>	Tara.Lanzrath@ks.gov
<b>Mailing Address</b>	6531 SE Forbes Ave., Suite B
<b>City</b>	Topeka
<b>State or Province</b>	Kansas
<b>Postal Code</b>	66619

*Table 1: Aerial LiDAR Client Contact Information*

### d. Contract Deliverables

Item	Specification/Format
<b>Metadata</b>	FGDC compliant, xml format
<b>Project Report</b>	.pdf format
<b>Raw Point Cloud</b>	Swaths, LAS 1.4
<b>Classified Point Cloud</b>	LAS 1.4
<b>Bare Earth DEM</b>	ERDAS .IMG format, Hydroflattened
<b>First Return DSM</b>	ERDAS .IMG format
<b>Hydro Polygon Breaklines</b>	.gdb format
<b>Intensity Imagery</b>	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
<b>Model</b>	ALS70-HP
<b>Manufacturer</b>	Leica
<b>Platform</b>	Fixed-Wing
<b>Scan Pattern</b>	Sine, Triangle, Raster
<b>Maximum Scan Rate (Hz)</b>	Sine: 200 Triangle: 158 Raster: 120
<b>Field of View (°)</b>	0 – 75 (Full Angle, User Adjustable)
<b>Maximum Pulse Rate (kHz)</b>	500
<b>Maximum Flying Height (m AGL)</b>	3500
<b>Number of Returns</b>	Unlimited
<b>Number of Intensity Measurements</b>	3 (First, Second, Third)
<b>Roll Stabilization (Automatic Adaptive, °)</b>	75 - Active FOV
<b>Storage Media</b>	Removable 500 GB SSD
<b>Storage Capacity (Hours @ Max Pulse Rate)</b>	6
<b>Size (cm)</b>	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
<b>Weight (kg)</b>	Scanner: 43 Control Electronics: 45
<b>Operation Temperature (°C)</b>	0 – 40
<b>Flight Management</b>	FCMS
<b>Power Consumption</b>	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
<b>System</b>	Leica ALS70-HP
<b>Nominal Pulse Spacing (m)</b>	0.71
<b>Nominal Pulse Density (pls/m<sup>2</sup>)</b>	2.2
<b>Nominal Flight Height (AGL meters)</b>	2100
<b>Nominal Flight Speed (kts)</b>	130
<b>Pass Heading (°)</b>	0
<b>Sensor Scan Angle (°)</b>	45
<b>Scan Frequency (Hz)</b>	33.9
<b>Pulse Rate of Scanner (kHz)</b>	256,400
<b>Line Spacing (m)</b>	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 75 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 7 flight missions conducted between May 4, 2018 and November 24, 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.

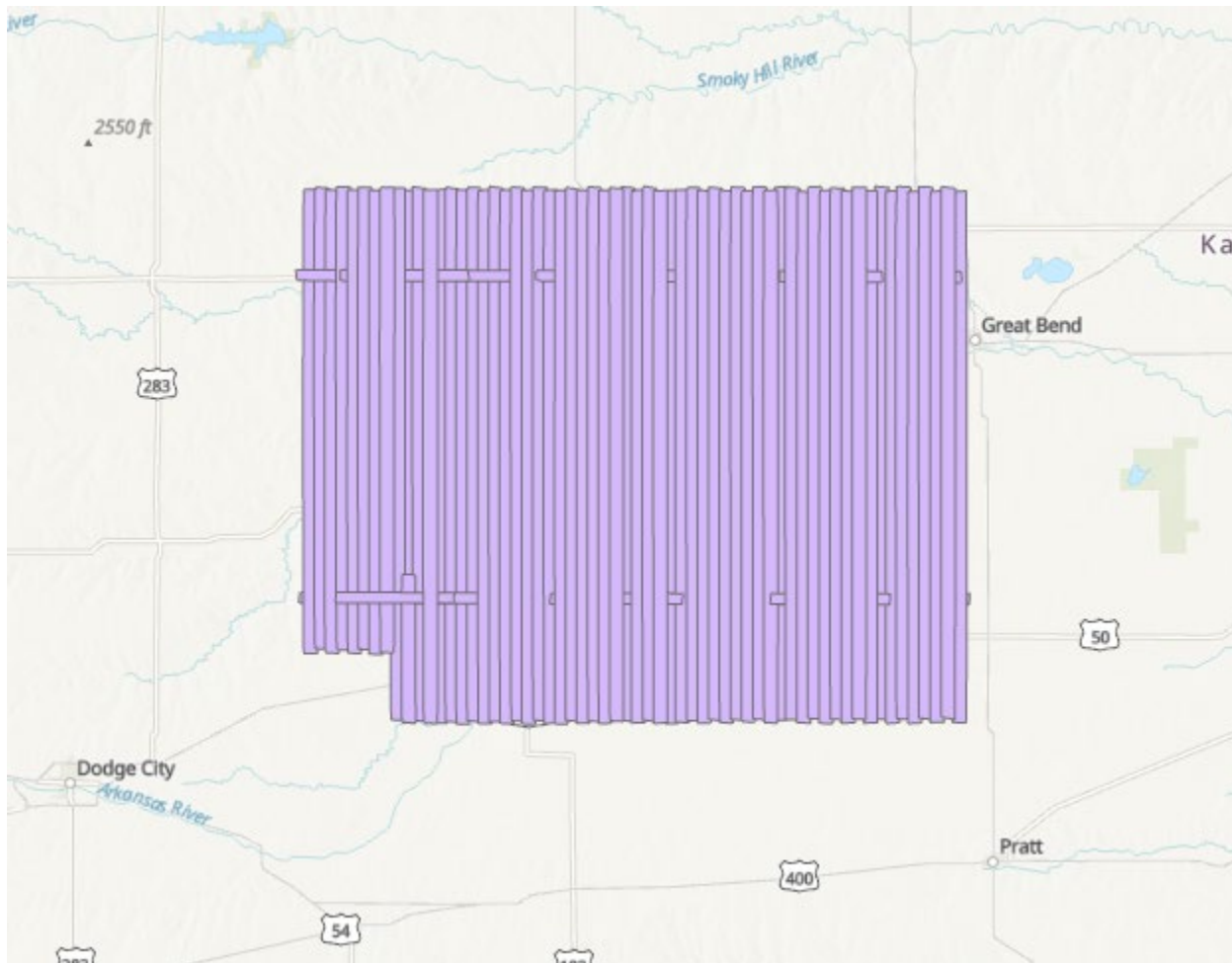


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

#### 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
<b>KSBK</b>	CORS	KSBK	N37°33'03.94780"	W99°38'06.30707"	720.243
<b>KSCW</b>	CORS	KSCW	N37°16'24.87324"	W99°19'39.34067"	624.848
<b>KSGB</b>	CORS	KSGB	N38°21'16.83108"	W98°45'53.40654"	545.627
<b>KSJM</b>	CORS	KSJM	N38°04'01.31691"	W99°53'51.41926"	706.353
<b>KSKY</b>	CORS	KSKY	N37°54'40.30614"	W99°24'21.76286"	641.963
<b>KSPR</b>	CORS	KSPR	N37°41'26.44138"	W98°44'27.53387"	573.45

*Table 5: GNSS Reference Stations*



## 2. Aerial LiDAR Project – Ground Acquisition

### a. Ground Control Survey

A total of 101 ground survey points were collected in support of this project, including 28 LiDAR Control Points (LCP), 43 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 & 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
LCP231	506763.794	4257225.82	585.095
LCP242	510834.649	4221907.027	594.68
LCP243	504426.644	4217123.737	605.877
LCP244	497169.367	4238080.376	628.783
LCP245	477771.259	4233230.629	639.495
LCP246	461816.906	4239042.079	667.227
LCP247	511573.82	4234909.108	582.896
LCP248	487546.238	4246118.393	625.477
LCP249	474596.924	4255889.349	607.223
LCP251	494772.603	4255719.976	593.394
LCP252	466641.101	4261029.664	633.143
LCP254	469354.837	4246269.425	657.25
LCP379	436331.147	4214138.298	664.225
LCP382	444069.124	4235338.762	689.382
LCP383	446937.88	4225404.638	646.608
LCP384	457082.441	4212428.809	705.196
LCP385	463106.682	4205933.431	662.592
LCP386	480379.775	4205817.007	645.432



ID	Easting	Northing	Elevation
LCP494	499599.84	4188049.127	618.32
LCP495	492358.956	4185951.741	635.711
LCP499	509299.433	4194145.667	607.139
LCP500	514818.99	4194525.324	597.371
LCP561	452269.738	4205975.482	696.814
LCP564	506053.388	4223535.206	598.816
LCP566	485191.724	4234661.489	622.503
LCP568	445672.293	4255631.105	669.161
LCP571	445631.65	4246495.474	690.966
LCP594	497276.087	4196128.707	627.25

Table 6: LiDAR Control Point Coordinates

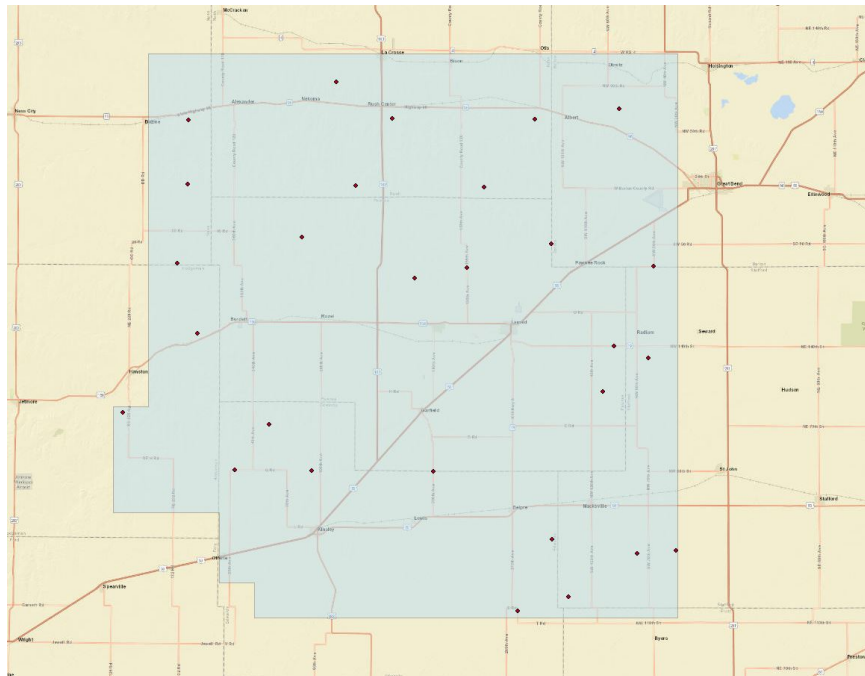


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA360	436313.195	4214136.751	664.371
NVA362	474623.9	4255867.226	606.854
NVA363	506813.452	4257201.44	583.775
NVA364	461809.217	4239014.379	666.972
NVA365	487514.367	4246134.891	625.697
NVA366	497195.245	4238099.098	629.797
NVA367	444068.362	4235343.02	689.416
NVA368	477795.009	4233210.218	638.866
NVA369	511571.273	4234871.49	582.981

ID	Easting	Northing	Elevation
NVA370	457082.423	4212419.066	705.166
NVA371	480370.186	4205814.401	645.05
NVA372	504396.775	4217157.562	605.572
NVA373	514815.649	4194518.343	597.236
NVA427	499592.037	4188034.168	618.367
NVA563	445633.039	4255653.274	669.057
NVA564	486736.735	4263816.206	614.713
NVA565	514854.639	4255600.828	576.927
NVA566	461978.304	4246260.289	679.386
NVA567	479538.774	4246305.342	667.265
NVA568	508120.682	4247590.942	580.961
NVA569	450037.282	4216812.812	679.534
NVA570	485802.167	4221980.719	616.186
NVA571	506032.046	4223512.026	598.455
NVA572	452277.582	4205986.71	696.933
NVA573	483980.339	4194530.937	646.377
NVA574	514126.6	4207434.48	590.769
NVA575	497272.554	4196122.1	627.21
NVA618	492301.745	4185263.371	634.541
NVA758	451867.242	4258110.371	632.575
NVA759	473436.17	4264237.807	625.244
NVA761	453843.585	4227155.873	647.649
NVA762	453845.151	4227541.801	646.428
NVA765	464806.201	4227565.552	631.765
NVA767	478655.358	4214251.904	632.078
NVA768	491285.671	4200377.421	636.316
NVA770	464030.19	4196465.051	661.092
NVA771	502818.55	4201387.313	617.323
NVA828	457863.735	4186574.875	676.258
NVA893	492296.687	4185252.635	634.714
NVA894	502804.228	4201381.846	617.767
NVA902	486797.046	4210421.662	632.714
NVA924	505266.679	4240756.09	593.83
NVA926	481105.563	4260924.965	613.54

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

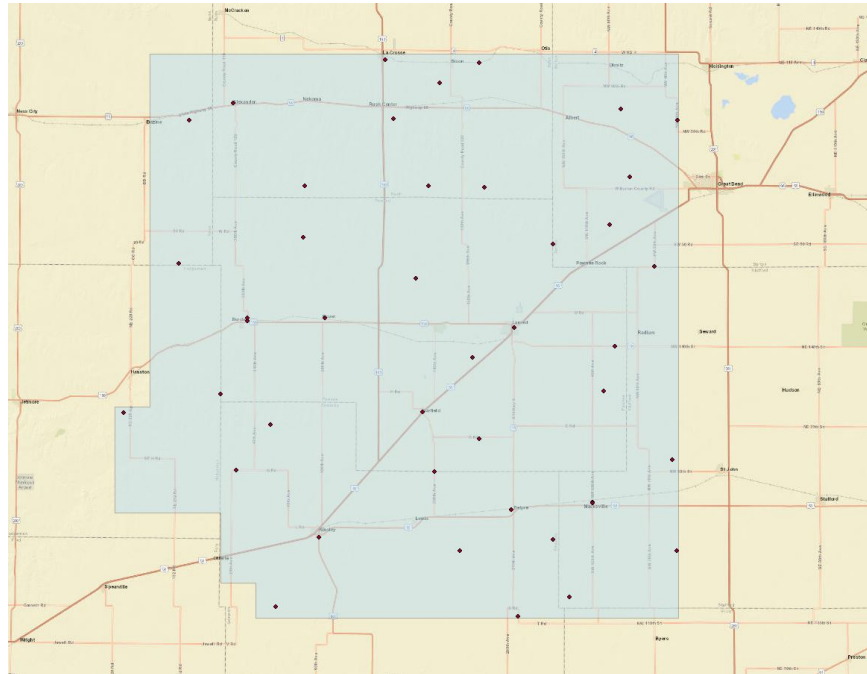


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA254	466631.906	4261048.934	632.461
VVA255	494797.207	4255707.888	593.294
VVA256	469331.26	4246258.361	657.466
VVA258	446925.197	4225381.374	646.351
VVA259	510857.101	4221882.646	594.815
VVA260	463108.292	4205942.877	662.736
VVA261	509294.397	4194146.12	607.648
VVA387	445133.651	4264153.271	654.851
VVA388	481115.348	4260952.129	613.519
VVA389	506492.95	4262834.805	601.811
VVA390	455494.542	4238221.35	655.748
VVA391	485225.094	4234652.816	621.651
VVA392	504653.167	4232426.681	589.854
VVA393	458080.065	4215683.675	681.693
VVA394	486784.083	4210415.068	632.394
VVA395	507639.686	4206418.538	605.746
VVA528	455663.733	4254388.002	650.367
VVA529	482733.753	4248154.345	647.086
VVA530	505150.018	4252160.648	590.719
VVA531	445608.08	4246461.134	690.868

ID	Easting	Northing	Elevation
VVA532	470797.022	4233563.313	638.945
VVA533	505223.514	4240758.879	593.499
VVA534	491678.512	4218602.504	621.465
VVA535	491603.095	4195062.389	634.947
VVA569	492376.332	4185959.306	634.958
VVA610	464065.866	4196452.247	660.965
VVA630	507639.874	4206414.722	605.977
VVA658	453876.624	4227538.914	646.514
VVA659	479480.996	4246302.152	666.849
VVA660	486748.585	4263849.04	615.326

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

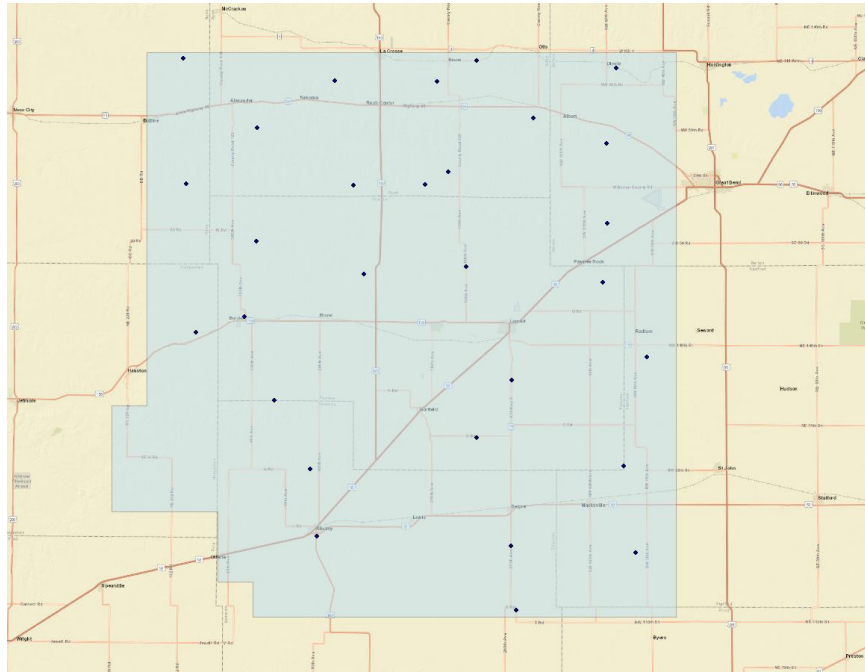


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

## 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
<b>Total Points (Nominal)</b>	19,857,817,801
<b>Nominal Pulse Spacing (M)</b>	0.6680
<b>Nominal Pulse Density (PLS/M<sup>2</sup>)</b>	2.2410
<b>Total Points (Aggregate)</b>	20,099,838,954
<b>Aggregate Pulse Spacing (M)</b>	0.6141
<b>Aggregate Pulse Density (PLS/M<sup>2</sup>)</b>	2.6516

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 95 <sup>th</sup> 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)	43	0.0938	0.1838	0.1361
NVA (DEM)	43	0.0925	0.1812	0.1139
VVA (Point Cloud)	30	0.1323	0.2593	0.2516
VVA (DEM)	30	0.1318	0.2582	0.1705

Table 12: NVA/VVA Accuracies



## SECTION V: CERTIFICATION STATEMENTS

### *1. Aerial LiDAR Project*

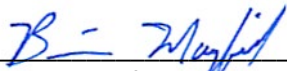
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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
NVA360	436313.9410	4214136.0200	664.3710	664.3100	-0.0610	NVA
NVA362	474624.6390	4255866.4890	606.8540	606.8240	-0.0300	NVA
NVA363	506814.1860	4257200.7040	583.7750	583.8170	0.0420	NVA
NVA364	461809.9580	4239013.6450	666.9720	667.1090	0.1370	NVA
NVA365	487515.1040	4246134.1560	625.6970	625.6980	0.0010	NVA
NVA366	497195.9800	4238098.3650	629.7970	629.7770	-0.0200	NVA
NVA367	444069.1060	4235342.2860	689.4160	689.4180	0.0020	NVA
NVA368	477795.7480	4233209.4850	638.8660	638.8510	-0.0150	NVA
NVA369	511572.0060	4234870.7570	582.9810	583.0040	0.0230	NVA
NVA370	457083.1650	4212418.3360	705.1660	705.2940	0.1280	NVA
NVA371	480370.9250	4205813.6730	645.0500	644.9190	-0.1310	NVA
NVA372	504397.5100	4217156.8320	605.5720	605.6930	0.1210	NVA
NVA373	514816.3820	4194517.6170	597.2360	597.2530	0.0170	NVA
NVA427	499592.7730	4188033.4430	618.3670	618.4320	0.0650	NVA
NVA563	445633.7830	4255652.5370	669.0570	669.0160	-0.0410	NVA
NVA564	486737.4720	4263815.4680	614.7130	614.6570	-0.0560	NVA
NVA565	514855.3710	4255600.0920	576.9270	576.9320	0.0050	NVA
NVA566	461979.0450	4246259.5540	679.3860	679.5120	0.1260	NVA
NVA567	479539.5120	4246304.6070	667.2650	667.2660	0.0010	NVA
NVA568	508121.4160	4247590.2070	580.9610	581.0380	0.0770	NVA
NVA569	450038.0260	4216812.0810	679.5340	679.5330	-0.0010	NVA
NVA570	485802.9050	4221979.9880	616.1860	616.2280	0.0420	NVA
NVA571	506032.7800	4223511.2950	598.4550	598.4370	-0.0180	NVA
NVA572	452278.3250	4205985.9810	696.9330	697.0320	0.0990	NVA
NVA573	483981.0770	4194530.2100	646.3770	646.4460	0.0690	NVA
NVA574	514127.3330	4207433.7520	590.7690	590.8870	0.1180	NVA
NVA575	497273.2900	4196121.3730	627.2100	627.2010	-0.0090	NVA
NVA618	492302.4820	4185262.6460	634.5410	634.3660	-0.1750	NVA
VA758	451867.9840	4258109.6330	632.5750	632.6810	0.1060	NVA
NVA759	473436.9090	4264237.0690	625.2440	625.1510	-0.0930	NVA
NVA761	453844.3280	4227155.1410	647.6490	647.5150	-0.1340	NVA
NVA762	453845.8940	4227541.0680	646.4280	646.3310	-0.0970	NVA
NVA765	464806.9420	4227564.8200	631.7650	631.6810	-0.0840	NVA
NVA767	478656.0970	4214251.1740	632.0780	632.0820	0.0040	NVA
NVA768	491286.4080	4200376.6940	636.3160	636.0910	-0.2250	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA770	464030.9320	4196464.3240	661.0920	661.0000	-0.0920	NVA
NVA771	502819.2850	4201386.5860	617.3230	617.4480	0.1250	NVA
NVA828	457864.4780	4186574.1490	676.2580	676.4720	0.2140	NVA
NVA893	492297.4240	4185251.9100	634.7140	634.6220	-0.0920	NVA
NVA894	502804.9630	4201381.1190	617.7670	617.8190	0.0520	NVA
NVA902	486797.7840	4210420.9330	632.7140	632.7020	-0.0120	NVA
NVA924	505267.4130	4240755.3560	593.8300	593.9800	0.1500	NVA
NVA926	481106.3010	4260924.2280	613.5400	613.5900	0.0500	NVA
VVA254	466632.6460	4261048.1960	632.4610	632.5080	0.0470	VVA
VVA255	494797.9430	4255707.1520	593.2940	593.1560	-0.1380	VVA
VVA256	469332.0000	4246257.6260	657.4660	657.5440	0.0780	VVA
VVA258	446925.9410	4225380.6420	646.3510	646.3850	0.0340	VVA
VVA259	510857.8340	4221881.9150	594.8150	594.9660	0.1510	VVA
VVA260	463109.0340	4205942.1480	662.7360	663.0240	0.2880	VVA
VVA261	509295.1310	4194145.3940	607.6480	607.6260	-0.0220	VVA
VVA387	445134.3940	4264152.5320	654.8510	654.8160	-0.0350	VVA
VVA388	481116.0860	4260951.3920	613.5190	613.4680	-0.0510	VVA
VVA389	506493.6840	4262834.0680	601.8110	601.8540	0.0430	VVA
VVA390	455495.2840	4238220.6160	655.7480	655.6290	-0.1190	VVA
VVA391	485225.8310	4234652.0830	621.6510	621.7130	0.0620	VVA
VVA392	504653.9010	4232425.9490	589.8540	589.9800	0.1260	VVA
VVA393	458080.8070	4215682.9450	681.6930	681.6390	-0.0540	VVA
VVA394	486784.8210	4210414.3390	632.3940	632.5680	0.1740	VVA
VVA395	507640.4200	4206417.8100	605.7460	605.8570	0.1110	VVA
VVA528	455664.4750	4254387.2650	650.3670	650.3960	0.0290	VVA
VVA529	482734.4910	4248153.6100	647.0860	647.2930	0.2070	VVA
VVA530	505150.7520	4252159.9120	590.7190	590.7650	0.0460	VVA
VVA531	445608.8240	4246460.3980	690.8680	690.9190	0.0510	VVA
VVA532	470797.7620	4233562.5800	638.9450	638.9450	0.0000	VVA
VVA533	505224.2480	4240758.1450	593.4990	593.8150	0.3160	VVA
VVA534	491679.2490	4218601.7740	621.4650	621.2040	-0.2610	VVA
VVA535	491603.8320	4195061.6630	634.9470	634.8130	-0.1340	VVA
VVA569	492377.0690	4185958.5810	634.9580	634.8360	-0.1220	VVA
VVA610	464066.6080	4196451.5200	660.9650	660.9770	0.0120	VVA
VVA630	507640.6080	4206413.9940	605.9770	605.7720	-0.2050	VVA
VVA658	453877.3670	4227538.1810	646.5140	646.5620	0.0480	VVA
VVA659	479481.7340	4246301.4170	666.8490	666.9050	0.0560	VVA
VVA660	486749.3220	4263848.3020	615.3260	615.4170	0.0910	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
----------	-----------	-----------	-----------	-----------	-----------	-------------------

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
NVA360	436313.9410	4214136.0200	664.3710	664.3490	0.0220	NVA
NVA362	474624.6390	4255866.4890	606.8540	606.8360	0.0180	NVA
NVA363	506814.1860	4257200.7040	583.7750	583.8480	-0.0730	NVA
NVA364	461809.9580	4239013.6450	666.9720	667.1160	-0.1440	NVA
NVA365	487515.1040	4246134.1560	625.6970	625.6880	0.0090	NVA
NVA366	497195.9800	4238098.3650	629.7970	629.7710	0.0260	NVA
NVA367	444069.1060	4235342.2860	689.4160	689.3990	0.0170	NVA
NVA368	477795.7480	4233209.4850	638.8660	638.8320	0.0340	NVA
NVA369	511572.0060	4234870.7570	582.9810	582.9950	-0.0140	NVA
NVA370	457083.1650	4212418.3360	705.1660	705.2580	-0.0920	NVA
NVA371	480370.9250	4205813.6730	645.0500	644.9450	0.1050	NVA
NVA372	504397.5100	4217156.8320	605.5720	605.6790	-0.1070	NVA
NVA373	514816.3820	4194517.6170	597.2360	597.2760	-0.0400	NVA
NVA427	499592.7730	4188033.4430	618.3670	618.4450	-0.0780	NVA
NVA563	445633.7830	4255652.5370	669.0570	669.0090	0.0480	NVA
NVA564	486737.4720	4263815.4680	614.7130	614.6540	0.0590	NVA
NVA565	514855.3710	4255600.0920	576.9270	576.9330	-0.0060	NVA
NVA566	461979.0450	4246259.5540	679.3860	679.5520	-0.1660	NVA
NVA567	479539.5120	4246304.6070	667.2650	667.2730	-0.0080	NVA
NVA568	508121.4160	4247590.2070	580.9610	581.0390	-0.0780	NVA
NVA569	450038.0260	4216812.0810	679.5340	679.5370	-0.0030	NVA
NVA570	485802.9050	4221979.9880	616.1860	616.1980	-0.0120	NVA
NVA571	506032.7800	4223511.2950	598.4550	598.4440	0.0110	NVA
NVA572	452278.3250	4205985.9810	696.9330	697.0240	-0.0910	NVA
NVA573	483981.0770	4194530.2100	646.3770	646.4140	-0.0370	NVA
NVA574	514127.3330	4207433.7520	590.7690	590.8740	-0.1050	NVA
NVA575	497273.2900	4196121.3730	627.2100	627.2160	-0.0060	NVA
NVA618	492302.4820	4185262.6460	634.5410	634.3840	0.1570	NVA
NVA758	451867.9840	4258109.6330	632.5750	632.6620	-0.0870	NVA
NVA759	473436.9090	4264237.0690	625.2440	625.1310	0.1130	NVA
NVA761	453844.3280	4227155.1410	647.6490	647.5360	0.1130	NVA
NVA762	453845.8940	4227541.0680	646.4280	646.3490	0.0790	NVA
NVA765	464806.9420	4227564.8200	631.7650	631.7010	0.0640	NVA
NVA767	478656.0970	4214251.1740	632.0780	632.0740	0.0040	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA768	491286.4080	4200376.6940	636.3160	636.0580	0.2580	NVA
NVA770	464030.9320	4196464.3240	661.0920	660.9780	0.1140	NVA
NVA771	502819.2850	4201386.5860	617.3230	617.4550	-0.1320	NVA
NVA828	457864.4780	4186574.1490	676.2580	676.4690	-0.2110	NVA
NVA893	492297.4240	4185251.9100	634.7140	634.6540	0.0600	NVA
NVA894	502804.9630	4201381.1190	617.7670	617.8260	-0.0590	NVA
NVA902	486797.7840	4210420.9330	632.7140	632.7120	0.0020	NVA
NVA924	505267.4130	4240755.3560	593.8300	593.9760	-0.1460	NVA
NVA926	481106.3010	4260924.2280	613.5400	613.5750	-0.0350	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA254	466632.6460	4261048.1960	632.4610	632.5450	-0.0840	VVA
VVA255	494797.9430	4255707.1520	593.2940	593.1560	0.1380	VVA
VVA256	469332.0000	4246257.6260	657.4660	657.5090	-0.0430	VVA
VVA258	446925.9410	4225380.6420	646.3510	646.3780	-0.0270	VVA
VVA259	510857.8340	4221881.9150	594.8150	594.9590	-0.1440	VVA
VVA260	463109.0340	4205942.1480	662.7360	663.0610	-0.3250	VVA
VVA261	509295.1310	4194145.3940	607.6480	607.6400	0.0080	VVA
VVA387	445134.3940	4264152.5320	654.8510	654.8240	0.0270	VVA
VVA388	481116.0860	4260951.3920	613.5190	613.4720	0.0470	VVA
VVA389	506493.6840	4262834.0680	601.8110	601.8590	-0.0480	VVA
VVA390	455495.2840	4238220.6160	655.7480	655.6220	0.1260	VVA
VVA391	485225.8310	4234652.0830	621.6510	621.7150	-0.0640	VVA
VVA392	504653.9010	4232425.9490	589.8540	589.9750	-0.1210	VVA
VVA393	458080.8070	4215682.9450	681.6930	681.6340	0.0590	VVA
VVA394	486784.8210	4210414.3390	632.3940	632.5740	-0.1800	VVA
VVA395	507640.4200	4206417.8100	605.7460	605.8610	-0.1150	VVA
VVA528	455664.4750	4254387.2650	650.3670	650.3980	-0.0310	VVA
VVA529	482734.4910	4248153.6100	647.0860	647.3000	-0.2140	VVA
VVA530	505150.7520	4252159.9120	590.7190	590.8570	-0.1380	VVA
VVA531	445608.8240	4246460.3980	690.8680	690.9190	-0.0510	VVA
VVA532	470797.7620	4233562.5800	638.9450	638.9600	-0.0150	VVA
VVA533	505224.2480	4240758.1450	593.4990	593.7850	-0.2860	VVA
VVA534	491679.2490	4218601.7740	621.4650	621.2530	0.2120	VVA
VVA535	491603.8320	4195061.6630	634.9470	634.8100	0.1370	VVA
VVA569	492377.0690	4185958.5810	634.9580	634.8480	0.1100	VVA
VVA610	464066.6080	4196451.5200	660.9650	660.9660	-0.0010	VVA
VVA630	507640.6080	4206413.9940	605.9770	605.7800	0.1970	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA658	453877.3670	4227538.1810	646.5140	646.5430	-0.0290	VVA
VVA659	479481.7340	4246301.4170	666.8490	666.8960	-0.0470	VVA
VVA660	486749.3220	4263848.3020	615.3260	615.4190	-0.0930	VVA

*Table 14: DEM Check Point Assessment*