
LiDAR Project Report

G17PD00464, South Dakota
NRCS QL2+ LiDAR

Prepared For:

United States Geological Survey



Prepared By:

Digital Aerial Solutions, LLC



CONTRACT: # G16PC00044
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TASK ORDER: # G17PD00464

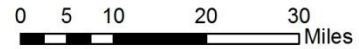
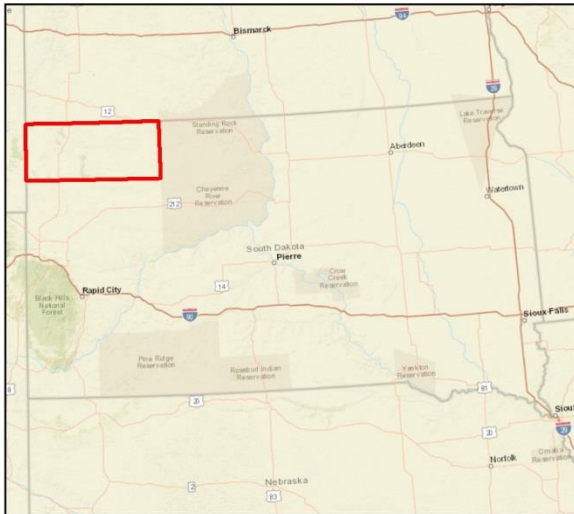
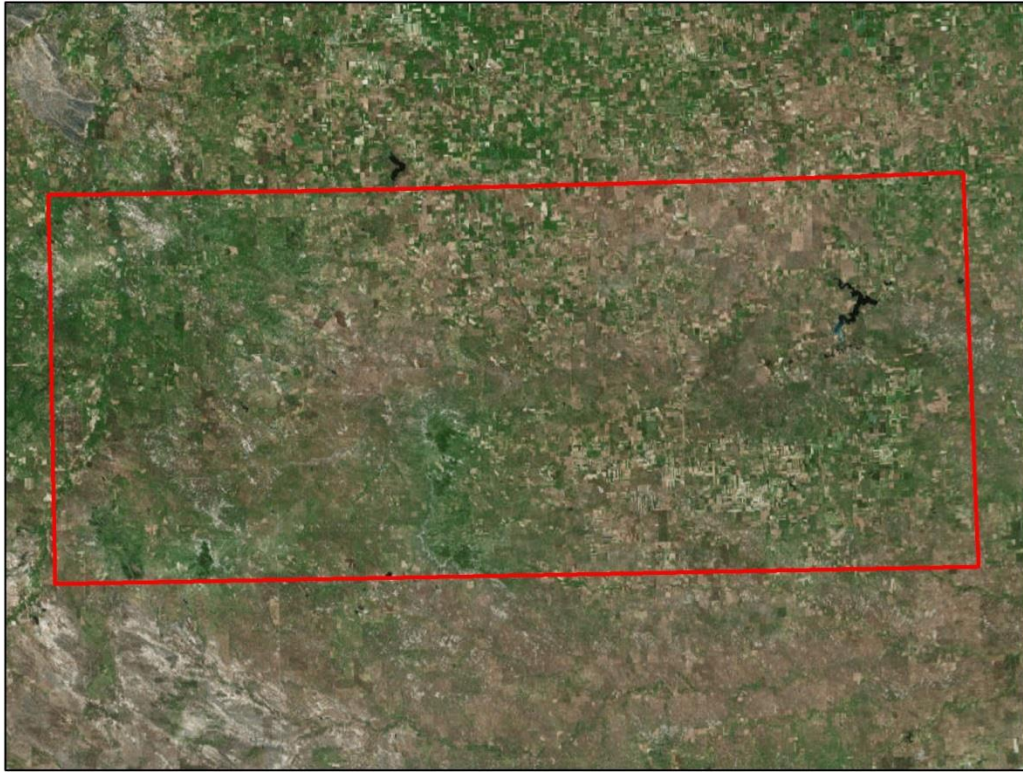
Project Report
LiDAR Collection, Processing, and QA/QC

G17PD00464, South Dakota
NRCS QL2+ LiDAR

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South Dakota NRCS QL2 LiDAR



Legend

 South Dakota NRCS 100m Buffer

Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500000.00
False Northing: 0.00000000
Central meridian: -105.00000000
Scale Factor: 0.99960000
Latitude of Origin: 0.00000000
Units: Meter

Date: 12/21/2017

Image 1: South Dakota AOI

Table of Contents

- 1 Introduction and Specifications 5
- 2 Spatial Reference System..... 5
- 3 LiDAR Acquisition 6
 - 3.1 Survey Area 6
 - 3.2 Acquisition Parameters 6
 - 3.3 Acquisition Mission 7
 - 3.4 Airborne GPS/IMU 7
- 4 LiDAR Processing 8
 - 4.1 Acquisition Post-Processing 8
 - 4.2 Geometric Calibration..... 9
 - 4.3 Point Cloud Classification..... 11
 - 4.4 Breakline Collection 11
 - 4.5 DEM Generation 12
- 5 Quality Control 12
 - 5.1 Point Clouds 12
 - 5.2 Breaklines..... 14
 - 5.3 Digital Elevation Models 15
- Appendix A. Flight Logs 16
- Appendix B. Vertical Accuracy Calculations..... 35

1 Introduction and Specifications

Digital Aerial Solutions, LLC (DAS) was tasked to collect and process a Light Detection And Ranging (LiDAR) derived elevation dataset for the G17PD00464, South Dakota. The area encompasses approximately 4149 square miles Aerial LiDAR data was collected utilizing a Leica ALS80. The ALS80 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems. LiDAR data collected for the G17PD00464, South Dakota survey has an Aggregate Nominal Pulse (ANPS) spacing of 0.5 meters, and includes up to 4 discrete returns per pulse, along with intensity values for each return.

LiDAR datasets were post processed to generate elevation point cloud swaths for each flight line. Deliverables include the point cloud swaths, tiled point clouds classified by land cover type, breaklines to support hydro-flattening of digital elevation models (DEM)s, intensity tiles, and bare-earth DEM tiles. Point cloud deliverables are stored in the LAS version 1.4, point data record format 6. The tiling scheme for tiled deliverables is a 1000 meter x 1000 meter grid. Tile number is the appropriate cell number values found in the USNG index. All deliverables were generated in conformance with the U.S. Geological Survey National Geospatial Program Guidelines and Base Specifications, Version 1.2.

2 Spatial Reference System

The spatial reference of the data is as follows:

Horizontal Spatial Reference

- Datum: NAVD88, Meters (to 3 decimal places)
- Coordinates: UTM Zone 13 N, NAD83[2011], Meters (to 2 decimal places);

Vertical Spatial Reference

All datasets are available with orthometric elevation; point cloud datasets are also available with ellipsoid heights

- Datum: North American Vertical Datum of 1983 (GEOID12B)

3 LiDAR Acquisition

3.1 Survey Area

The South Dakota, 2ppsm Lidar survey covers approximately 4149 square miles covering all of Harding and Perkins County South Dakota. The flight plan consisted of 203 survey lines and 6 control lines.

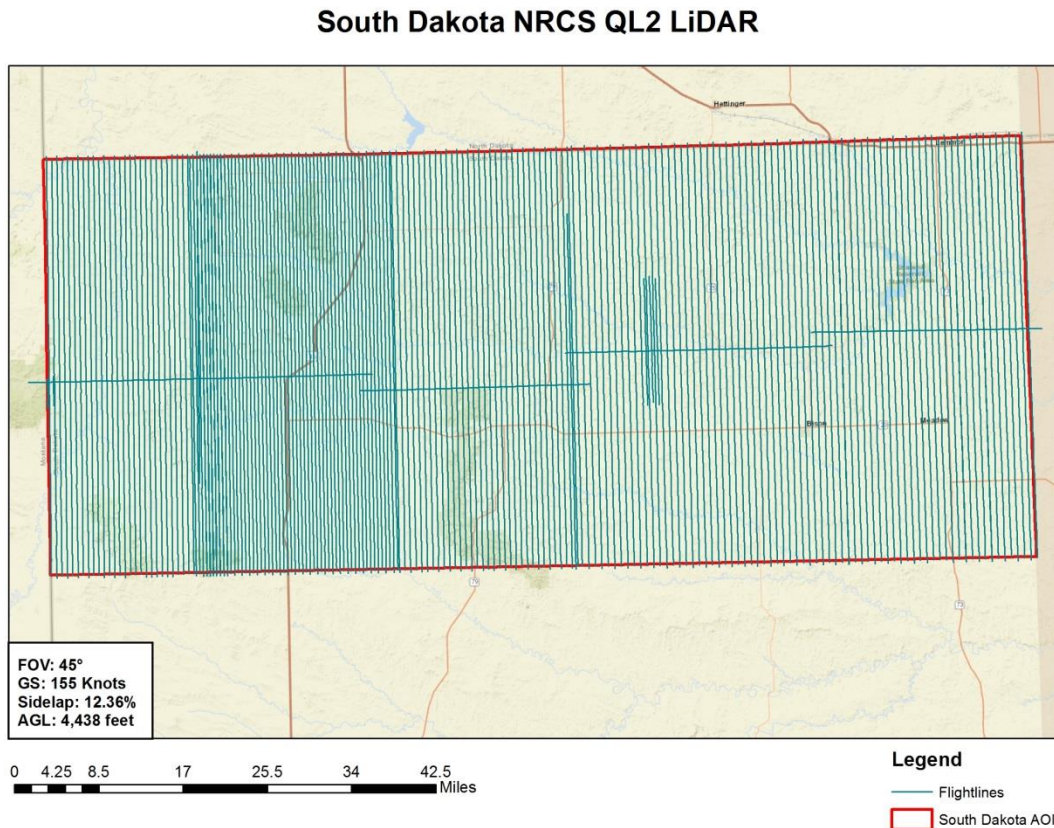


Image 2: South Dakota Flightlines

3.2 Acquisition Parameters

Acquisition parameters include the sensor configuration and the flight plan characteristics, and are selected based on a number of project specific criteria. Criteria reviewed include the required accuracies for the final dataset, the land cover types within the project survey area, and the required nominal pulse spacing. Acquisition parameters selected for the South Dakota, 2ppsm Lidar project are summarized below.

Parameter	Value
Flying Height Above Ground Level:	4,438 feet
Nominal Sidelap:	12.36%
Nominal Speed Over Ground:	155 Knots
Field of View:	45°
Laser Rate:	392.8 kHz
Scan Rate:	48.8 Hz
Maximum Cross Track Spacing:	0.83 meters
Maximum Along Track Spacing:	0.82 meters
Average point Spacing:	0.48 meters

Table 1: Flight Parameters

3.3 Acquisition Mission

The acquisition mission for the G17PD00464, South Dakota QL2+ LiDAR survey was coordinated to be acquired in 4 weeks. Collection began on May 4th 2017 and was completed on June 11th, 2017.

3.4 Airborne GPS/IMU

Airborne global positioning system (GPS) and inertial measurement unit (IMU) data was collected on the aircraft during the acquisition mission, providing sensor position and orientation information for geo-referencing the LiDAR data. Airborne GPS observations were collected at a frequency of 2Hz, and IMU observations are collected at a frequency of 200Hz.

Aircraft	Sensor	GPS Lever Arm (m)	IMU Lever Arm (m)
C441-N207SS	ALS80-UP SN# 8253	X: -0.146, Y: 0.189, Z: -1.316	X: 0.025, Y: 0.303, Z: 1.147

Table 2: Aircraft and Lever Arms

GPS data was collected with ground base stations during the acquisition missions, providing corrections to support differential post-processing of the airborne GPS. Base stations were setup at Bowman Regional Airport, Hettinger Municipal Airport and Henderson Implement & Fuel in Buffalo SD. Ground GPS observations were collected at a frequency of 2Hz. The following table's list positions used in to post-process the airborne GPS.

Name	Latitude	Longitude	Elevation (m)
Bowman Regional Airport - KBMM1	N 46° 10' 16.17756"	W 103° 18' 16.22432"	879.914
Hettinger Municipal Airport - KHEI	N 46° 00' 57.40745"	W 102° 39' 12.54234"	808.920
Hettinger Municipal Airport - Khei1	N 46° 00' 57.45472"	W 102° 39' 12.74644"	808.974
Henderson Implement & Fuel - A32	N 45° 33' 38.99967"	W 103° 32' 46.40713"	863.255

Table 3: Base Stations locations

4 LiDAR Processing

4.1 Acquisition Post-Processing

For each mission, airborne GPS was differentially corrected using the ground base station GPS for the corresponding day in Leica's IPAS software. The resulting solution is checked to assure an accuracy of +/- 3 cm combined separation for north, east and height position difference between the forward and reverse processing solutions.

Differentially corrected airborne GPS data was merged with the airborne IMU dataset in Leica's IPAS software through Kalman filtering techniques. IPAS applies the reference lever arms for the GPS and IMU measurement systems during processing to determine the trajectory (position and orientation) of the LiDAR sensor during the acquisition mission. Estimated lever arm values reported posteriori validate the measurements made during sensor installation in the aircraft.

Raw LiDAR sensor ranging data and the final sensor trajectory from IPAS were processed in Leica's ALSPP software to produce the LiDAR elevation point cloud swaths for each flight line, stored in LAS version 1.2 file format. Quality control of the swath point clouds was performed to validate proper function of the sensor systems, full coverage of the project AOI, and point density consistent with the planned nominal pulse spacing.

Swath point clouds were assigned a unique File Source ID within the LAS file format before further processing. Swath files for the G17PD00464, South Dakota NRCS QL2+ LiDAR project were numbered in chronological order of acquisition.

4.2 Geometric Calibration

Geometric and positional accuracy of the LiDAR swath point clouds is highly dependent on accurate calibration of the various subsystems within the LiDAR sensor system. Sensor calibration parameters fall into two categories, one being those parameters proprietary to the manufacturer's sensor design, and the other being parameters common to most commercial airborne LiDAR sensors, the IMU to laser reference system alignment angles (bore-site), and mirror deformation constants (scaling).

The manufacturer specific calibration parameters are applied in Leica's ALSPP software for the Leica ALS80 sensor system. Terrasolid's Terramatch software was used to calculate the IMU bore-site and mirror scale parameters for the G17PD00464, South Dakota NRCS QL2+ LiDAR. Within the TerraMatch software, the Tie- line workflow was used to solve for the parameters. The Tie-line workflow involves automated selection of numerous 'tie-lines', which represent a linear segment fit to the data that should have the same slope, azimuth, position and elevation, within the overlap sections of the survey lines and control lines. The tie- lines provide observations for algorithms within TerraMatch to solve for the bore-site and mirror scale parameters for the lift.

The Tie-line workflow is dependent upon well distributed tie-lines throughout the swath point clouds to effectively solve for bore-site and mirror scale parameters with the automated algorithms.

Manual estimation of the bore-site and mirror scale parameters was performed using the observed tie-lines in overlap areas.

The final step of geometric calibration is to determine elevation (z) offset corrections to be applied to the swath point clouds. The Z values calculated during the course of the acquisition mission can vary at the centimeter level as the GPS satellite constellation observed in the survey area changes with satellites moving through their orbits over the course of the mission. Baseline length from the ground base station GPS to the airborne GPS can also impact the z values calculated for the swath point clouds. The Z offset corrections are calculated in two steps; a relative step, where individual lines are corrected one to another using the adjusted tie-lines from the bore-site and mirror scale calculation step; and an absolute step, where groups of lines are leveled to project ground control.

For G17PD00464, South Dakota NRCS QL2+ LiDAR project, the control lines were used to determine relative z offset corrections in areas of discernible ground. The ground control points listed below were used to adjust the LiDAR by an average of -0.070 cm.

Point Id	Easting	Northing	Orth. Height
04.GCP.BG.01	620192.726	5064157.33	891.6397
08.GCP.BG.01	625950.124	5081209.372	920.0333
08.GCP.BG.01A	602777.4524	5031062.218	1066.0656

Point Id	Easting	Northing	Orth. Height
11.GCP.BG.01	619592.0105	5080020.912	923.8761
12.GCP.BG.01	630316.1833	5084246.792	889.1604
13.GCP.BG.01	579816.0812	5039228.162	963.6711
16.GCP.BG.01	584617.0792	5048096.4	964.7478
40.GCP.BG.01	680850.392	5044487.079	856.4386
43.GCP.BG.01	690748.9752	5036762.437	845.6631
52.GCP.BG.01	698050.8999	5061557.53	831.4864
53.GCP.BG.01	698000.1501	5062736.013	813.0803
55.GCP.BG.01	675880.2372	5049238.458	877.6116
60.GCP.BG.01	664012.6735	5044128.26	907.3461
61.GCP.BG.01	655661.7514	5049057.608	845.032
67.GCP.BG.01	648863.731	5038861.642	920.2112
70.GCP.BG.01	703596.6474	5091032.752	755.4999
75.GCP.BG.01	718977.1311	5087480.211	785.7938
79.GCP.BG.01	711119.003	5082381.629	723.6877
82.GCP.BG.01	710899.4877	5088824.185	778.5978
97.GCP.BG.01	671138.4039	5076391.858	827.3874
06.GCP.HP.01	605931.6605	5049240.25	900.1153
09.GCP.HP.01	619505.6225	5084842.382	892.121
10.GCP.HP.01	582682.1254	5044724.297	957.6
14.GCP.HP.01	579741.4485	5053697.835	954.9643
19.GCP.HP.01	726207.5848	5036295.634	785.0965
33.GCP.HP.01	721028.5101	5045781.241	803.4927
35.GCP.HP.01	720712.6294	5055033.583	777.4374
36.GCP.HP.01	718307.5402	5045689.433	799.8767
47.GCP.HP.01	698457.2761	5047608.472	810.545
49.GCP.HP.01	698254.2401	5054665.299	721.2047
59.GCP.HP.01	671349.8425	5039455.251	872.3068
60.GCP.HP.01	671428.7592	5036900.915	854.7039
63.GCP.HP.01	656217.9998	5056780.669	799.1011
64.GCP.HP.01	656366.0761	5062443.23	835.941
65.GCP.HP.01	656333.8719	5066521.845	823.006
66.GCP.HP.01	648805.4692	5045212.835	940.1872
68.GCP.HP.01	648177.5636	5034846.52	939.3399
74.GCP.HP.01	718880.2756	5090572.896	781.6779
77.GCP.HP.01	719207.1551	5080731.227	732.8593
90.GCP.HP.01	682002.1381	5089016.551	787.0479
02.GCP.PS.01	615094.4725	5046181.221	879.909
03.GCP.PS.01	612890.8154	5027935.043	975.1297
07.GCP.PS.01	609905.1269	5028428.211	982.7575

Point Id	Easting	Northing	Orth. Height
15.GCP.PS.01	579683.3996	5066561.038	959.4929
17.GCP.PS.01	645319.2754	5077424.035	885.7939
17.GCP.PS.02	643357.0927	5070872.118	868.4153

Table 5: Ground Control Points

The final geometrically calibrated swath point clouds were compared to the bare-earth profile survey data. The data fit the profile surveys within the vertical accuracy tolerance specified for the project. Full documentation of the vertical accuracy checks may be found in section 5.1.

4.3 Point Cloud Classification

Georeference information was applied to the swath point cloud LAS files. Geometrically calibrated swath point clouds were cut into USNG index, 1000 meter x 1000 meter LAS 1.2 format tiles for point cloud classification and derived in LAS 1.4 format for product creation.

Tiled point cloud data was processed in Terrasolid’s Terrascan software to assign initial classification values. The Terrascan software provides a number of routines to algorithmically detect and assign points to their appropriate class. Points left unclassified by the algorithmic routine remain as Class 1

– Processed, but unclassified. Automated classification routines assigned points to one of the following classes:

- Class 1 – Processed, but unclassified
- Class 2 – Bare-earth ground
- Class 7 – Low Noise (low, manually identified, if necessary)
- Class 9 – Water
- Class 10 – Ignored Ground (Breakline Proximity)
- Class 17 – Bridge Decks
- Class 18 – High Noise (high, manually identified, if necessary)

Automated classification results were reviewed for each tiled point cloud, and manual edits made where necessary to correct for misclassified points. Points remaining in Class 1 after the automated classification routines were run were left in Class 1. Points falling outside of a 100 meter buffer of the project AOI polygon were excluded from the tiled point clouds.

4.4 Breakline Collection

Manual breakline collection was performed to support the hydro-flattening requirements of the project's DEM deliverables. Breaklines were collected directly from the classified point clouds and from triangulated irregular network (TIN) surface models built from the classified point clouds, in Terrasolid's Terrascan and Terramodeler software. Breakline features were collected as design file elements in Bentley's Microstation software. Breaklines were converted to ESRI 3D shapefile format for the breakline deliverable, and tiled to USNG index.

The data collected for the G17PD00464, South Dakota QL2+ LiDAR survey maintained significant point density in the water, marsh, and swamp, limiting the usefulness of point density as guiding factor in breakline placement.

Points classified as Class 2 – Bare-earth ground, falling within a one meter buffer of the collected breaklines, were reassigned to Class 10 – Ignored Ground. These points are excluded from the surface model during DEM generation to preserve the hydro-flattening characteristics of the breaklines.

4.5 DEM Generation

The final classified point clouds and collected breaklines were reviewed for completeness and conformance to the task order scope of work. Within the Terramodeler software, points in Class 2 – Bare-earth ground and the breaklines were combined to generate TIN elevation models for each tile, from which the bare-earth DEM tiles were interpolated and exported as ERDAS Imagine 32-bit floating point raster format “.img” format.

5 Quality Control

5.1 Point Clouds

Accuracy and completeness of the LiDAR point clouds directly impacts the quality of all other derived LiDAR derived products. Ensuring a quality LiDAR dataset begins with proper mission planning and execution. Ground GPS base stations are located such that GPS baselines between the ground and airborne receivers do not exceed 30km. For the G17PD00464, South Dakota QL2+ LiDAR project, two base stations were run to meet this requirement, one at the field operations airport and one within the survey area. Static alignment is performed both before take-off and after landing to allow for GPS integer ambiguity resolution. Sensor operators carefully monitor the LiDAR unit and its various subsystems during the acquisition mission to ensure proper function. Airborne GPS positional dilution of precision (PDOP) estimates are monitored to ensure they remain less than 3. The optical system is monitored to ensure there are no ranging errors encountered during the flight lines.

During acquisition post-processing estimates of the trajectory data accuracy are reviewed to ensure they will support the required accuracies of the point cloud data. The trajectory accuracy is a function of the differentially corrected GPS data and the IMU data.

The raw swath point clouds generated from ALSPP are reviewed as another check for proper sensor function. The point clouds are reviewed for full coverage of the AOI, required point density and nominal pulse spacing, clustering, proper intensity values, full swath coverage within the planned field of view, and planned survey line overlap.

Geometric calibration quality control validates that the positional accuracy requirements of the project are met, and includes relative accuracy assessments for intra-swath (within) and inter-swath (between) accuracy, along with absolute accuracy assessments against project ground control.

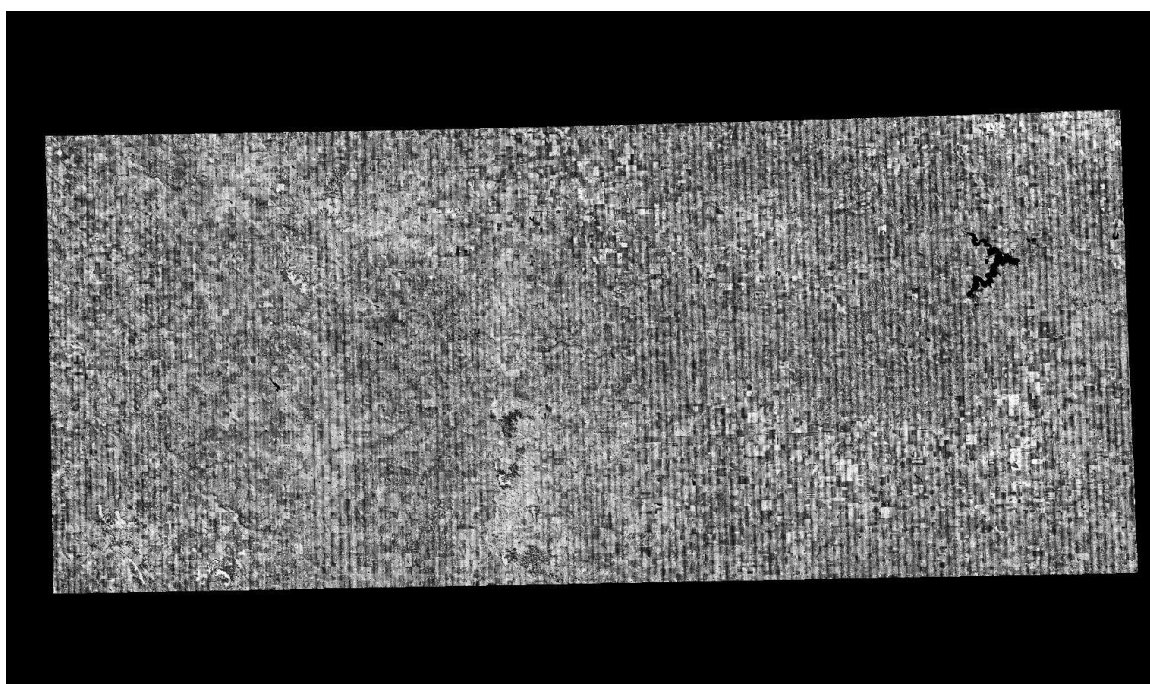


Image 3: South Dakota Intensity Image

Relative vertical accuracy assessments are normally made using the tie-lines generated in the Terramatch software, as these lines provide positional observations throughout the extent of individual swaths, and between neighboring swaths.

There is not a systematic method of testing when testing horizontal accuracy in LiDAR. The estimated Horizontal accuracy at one sigma based on the flying height for the project, is between 10cm and 20cm according to manufacturer specifications.

Absolute vertical accuracy assessments for the point cloud data are made against ground check point data. For the G17PD00464, South Dakota QL2+ LiDAR, ground check point data consisted of the ground GPS base station and real-time kinematic (RTK) GPS techniques.

Check point locations were collected at 1 – second intervals during the RTK survey. Points collected during the static pre-initialization and post-initialization was removed from the assessment so as not to bias the assessment.

Local TIN models of the elevation points are built around each ground check points. The tin model elevation is sampled at the horizontal position of the ground check point. The TIN model elevation and ground check point survey elevation values were used to calculate the Non-vegetated Vertical Accuracy (NVA) of the swath point clouds. The NVA of the TIN tested RMSE_z 0.035 meters and 0.068 meters at the 95% confidence level in open terrain. NVA of the DEM tested at an RMSE_z of 0.035 meters and 0.069 meters at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix B.

NVA of TIN:

NVA of TIN		
RMSE _z =	0.035	meters
NSSDA =	0.068	meters

NVA of DEM:

NVA of DEM		
RMSE _z =	0.035	meters
NSSDA =	0.069	meters

The tiled point cloud products were reviewed for full coverage of the AOI and proper classification. As part of the QC process, TINs are built in the Terramodeler software for each tile using the ground class and the hydro-flattening breaklines. The TINs are reviewed for non-ground features, and edited where necessary to remove any remaining non-ground features. Points were also reviewed for absolute elevation, and points falling below the selected orthometric elevation for water were removed from the ground class.

5.2 Breaklines

The final breaklines in ESRI 3D shapefile format were reviewed for topological consistency and correct elevation. Breaklines features are continuous and do not have overlaps or dangles.

5.3 Digital Elevation Models

Digital elevation models (DEMs) were reviewed for conformance with the SOW and the Base Mapping Specification version 1.2 guidelines. DEM files were loaded in the Global Mapper software and inspected visually for edge matching between tiles, void areas within the project AOI, and proper coding of the NODATA values. DEM file naming was verified for consistency with the USNG index.

Appendix A. Flight Logs



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/4/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1499.9			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1496.1	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		3.8	A		4,800		165		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						7,800			743				
	1	1095	170504_134349	13:43	13:58		180°	155	736	17	1.1	0.6	
	2	1094	170504_140215	14:02	14:16		0°	153	729	19	1	0.6	
	3	1093	170504_141953	14:19	14:34		180°	156	722	17	1.2	0.7	
	4	1092	170504_143748	14:37	14:52		0°	155	716	17	1.2	0.7	
	5	1091	170504_145516	14:55	15:09		180°	155	709	17	1.2	0.7	
	6	1090	170504_151250	15:12	15:27		0°	157	702	18	1.1	0.6	
	7	1089	170504_152955	15:29	15:44		180°	156	696	19	1	0.6	
	8	1088	170504_154746	15:47	16:02		0°	154	689	16	1.2	0.7	
	9	1087	170504_160502	16:05	16:19		180°	155	682	17	1.2	0.7	
	10	1086	170504_162246	16:22	16:37		0°	156	675	16	1.3	0.7	
	11	1085	170504_164000	16:40	16:54		180°	157	668	16	1.3	0.7	
	12	1084	170504_165752	16:57	17:12		0°	156	662	18	1.1	0.6	
	13												
	14												
	15												
	16												
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	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/4/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1502			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1499.9	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		2.1	B		4,800		155		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
B						7,800			661				
	1	1083	170504_181246	18:12	18:27		180°	155	654	19	1.1	0.6	
	2	1082	170504_183059	18:30	18:45		0°	155	648	19	1.1	0.6	
	3	1081	170504_184837	18:48	19:02		180°	154	641	18	1.2	0.6	
	4	1080	170504_190630	19:06	19:20		0°	156	634	18	1.2	0.6	
	5	1079	170504_192425	19:24	19:38		180°	155	627	18	1.2	0.6	
	6	1078	170504_194217	19:42	19:56		0°	155	621	19	1.1	0.6	
	7												
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Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/4/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1506			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1502.2	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		3.8	C		4,800		155		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
C						7,800			620				
	1	1077	170504_231849	23:18	23:33		180°	155	613	17	1.1	0.7	
	2	1076	170504_233703	23:37	23:51		0°	154	606	17	1.1	0.7	
	3	1075	170504_235517	23:55	0:09		180°	156	599	20	1	0.6	
	4	1074	170505_001336	0:13	0:27		0°	155	593	17	1.2	0.7	
	5	1073	170505_003132	0:31	0:46		180°	156	586	17	1.3	0.7	
	6	1072	170505_004942	0:49	1:04		0°	155	579	17	1.2	0.7	
	7	1071	170505_010729	1:07	1:21		180°	156	572	17	1.2	0.7	
	8	1070	170505_012527	1:25	1:39		0°	153	565	17	1.2	0.7	
	9	1069	170505_014324	1:43	1:57		180°	156	558	19	1	0.6	
	10	1068	170505_020122	2:01	2:15		0°	155	551	19	1	0.6	
	11	1067	170505_021912	2:19	2:33		180°	154	544	18	1.1	0.6	
	12	1066	170505_023727	2:37	2:51		0°	155	537	18	1.1	0.6	
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/5/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1510			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1506	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		4	A		4,800		155		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						7,800			536				
	1	1065	170505_134934	13:49	14:04		180°	155	530	18	1	0,6	
	2	1064	170505_140802	14:08	14:22		0°	154	524	18	1	0.6	
	3	1063	170505_142607	14:26	14:40		180°	155	517	16	1.5	0.9	
	4	1062	170505_144428	14:44	14:58		0°	154	510	16	1.5	0.9	
	5	1061	170505_150212	15:02	15:16		180°	155	503	17	1.1	0.7	
	6	1060	170505_152011	15:20	15:34		0°	153	496	18	1.1	0.7	
	7	1059	170505_153804	15:38	15:52		180°	153	489	17	1.1	0.7	
	8	1058	170505_155617	15:56	16:10		0°	156	482	17	1.1	0.7	
	9	1057	170505_161406	16:14	16:28		180°	153	476	16	1.2	0.7	
	10	1056	170505_163225	16:32	16:46		0°	155	468	16	1.3	0.7	
	11	1055	170505_165030	16:50	17:04		180°	155	462	18	1.1	0.6	
	12	1054	170505_170844	17:08	17:23		0°	155	455	18	1.2	0.6	
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/5/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1513.5			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1510	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		3.5	B		4,800		155		TEMP		1.500	C421-112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
B						7,800			454				
	1	1053	170506_002528	0:25	0:39		180°	155	447	16	1.2	0.7	
	2	1052	170506_004307	0:43	0:57		0°	156	441	17	1.1	0.6	
	3	1051	170506_010041	1:00	1:15		180°	155	434	18	1	0;6	
	4	1050	170506_011821	1:18	1:32		0°	156	427	15	1.4	0.8	
	5	1049	170506_013551	1:35	1:50		180°	155	420	17	1.2	0.7	
	6	1048	170506_015316	1:53	2:07		0°	155	413	18	1.1	0.6	
	7	1047	170506_021051	2:10	2:25		180°	157	406	18	1.1	0.6	
	8	1046	170506_022826	2:28	2:42		0°	155	399	19	1	0.6	
	9	1045	170506_024551	2:45	3:00		180°	156	393	18	1.1	0.6	
	10	1044	170506_030318	3:03	3:17		0°	155	386	18	1.1	0.6	Encoder Warning, Must Refly
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/24/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1545			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1541	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		4	A		4,800		165		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						7,800							
	1	1050	170524_182502	18 25	18 39		0°	155	718	21	1	0.7	
	2	1049	170524_184259	18 43	18 57		180°	152	712	19	1.1	0.7	
	3	1048	170524_190035	19 00	19 13		0°	150	705	20	1.1	0.6	
	4	1047	170524_191804	19 18	19 31		180°	157	698	21	1.1	0.6	
	5	1046	170524_193537	19 35	19 48		0°	153	691	20	1.2	0.7	
	6	1045	170524_195255	19 53	20 06		180°	156	684	21	1.1	0.7	
	7	1044	170524_201027	20 10	20 23		0°	145	677	18	1.2	0.6	
	8	1043	170524_202811	20 28	20 43		180°	155	670	21	1.1	0.6	
	9	1042	170524_204552	20 46	20 59		0°	155	662	23	1	0.6	
	10	1041	170524_211341	21 13	21 28		180°	153	657	22	1	0.6	
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		5/25/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1547.7			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST			LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time			A		4,800		165		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						8,080			656				
	1	1040	170525_165809	16:58	17:13		180°	150	649	20	1.1	0.6	
	2	1039	170525_171616	17:16	17:30		0°	155	642	19	1.2	0.6	
	3	1038	170525_173418	17:34	18:47		180°	156	636	19	1.1	0.6	
	4	1096	170525_175755	17:57	18:12	7780	0°	155	629	20	1.1	0.6	
	5	1097	170525_181642	18:17	18:31		180°	155	622	21	1.1	0.6	
	6	1098	170525_183440	18:34	18:48		0°	152	615	19	1.2	0.6	
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/5/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		6301.1			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		6297.2	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		3.9	A		4,800		165		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						7,800			1112				
	1	1028	170605_031613	3:16	3:29		180°	161	1104	19	1.1	0.6	
	2	1024	170605_033355	3:34	3:47		0°	166	1096	18	1.2	0.7	
	3	1027	170605_035057	3:51	4:04		180°	162	1089	19	1.2	0.7	
	4	1023	170605_040754	4:08	4:21		0°	162	1081	19	1.1	0.7	
	5	1026	170605_042502	4:25	4:38		180°	166	1073	19	1.2	0.6	
	6	1022	170605_044139	4:41	4:55		0°	166	1066	19	1.2	0.7	
	7	1025	170605_045829	4:59	5:12		180°	166	1058	17	1.4	0.7	
	8	1021	170605_051459	5:15	5:28		0°	166	1050	18	1.1	0.7	
	9	1017	170605_053152	5:31	5:45		180°	170	1043	19	1	0.7	
	10	1020	170605_054842	5:40	6:02		0°	167	1035	17	1.1	0.6	
	11	1018	170605_060606	6:06	6:19		180°	165	1028	18	1.1	0.7	
	12	1019	170605_062345	6:23	6:37		0°	164	1020	18	1.1	0.7	
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/5/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		6301.1			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		6297.2	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		3.9	B		4,800		165		TEMP		1.500	C421-N112MJ	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
B						9,516			1019				
	1	1016	170605_151810	15:18	15:31		180°	165	1011	20	1.2	0.6	
	2	1015	170605_153556	15:35	15:49		0°	164	1004	20	1.3	0.7	
	3	1014	170605_155310	15:53	16:06		180°	165	996	20	1.2	0.6	
	4	1013	170605_161017	16:10	16:23		0°	166	989	22	1.1	0.6	
	5	1012	170605_162737	16:27	16:41		180°	163	981	22	1.1	0.6	
	6	1011	170605_164443	16:44	16:58		0°	164	973	21	1.2	0.6	
	7	1010	170605_170202	17:02	17:16		180°	168	965	21	1.2	0.6	
	8	1096	170605_172813	17:28	17:41		0°	164	958	22	1.1	0.6	
	9	1097	170605_174528	17:45	17:58		180°	166	950	20	1.1	0.6	
	10	1098	170605_180235	18:02	18:16		0°	167	943	19	1.3	0.7	
	11	1099	170605_181946	18:19	18:33		180°	164	935	22	1.1	0.6	
	12	1100	170605_183704	18:37	19:50		0°	166	927	21	1.2	0.6	
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/6/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End		6309			1-808654A		2017SD_Lidar_Final					Mike Wasielewski	
Hobbs ST		6305	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		4	A		9,935		165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						7,800							
	1	1009	170606_1422	14:22	14:35	9,467	180°	162	927	18	1.3	0.7	
	2	X01	170606_144653	14:46	14:57	9,490	90°	163	919	19	1.1	0.6	Cross Strip. Clouds 8 Mi in from the West
	3	1101	170606_1511	15:11	15:24	9,177	0°	165	913	19	1.2	0.6	
	4	1102	170606_152904	15:29	15:42	9,176	180°	167	905	18	1.3	0.7	
	5	1103	170606_154651	15:46	16:00	9,186	0°	165	897	19	1.2	0.6	
	6	1106	170606_160320	16:03	16:17	9,188	180°	167	890	21	1.1	0.6	
	7	1107	170606_162030	16:20	16:33	9,139	0°	165	882	21	1.1	0.6	
	8	1104	170606_163710	16:36	16:50	9,142	180°	168	874	18	1.2	0.7	
	9	1105	170606_165420	16:54	17:07	9,158	0°	162	867	20	1.4	0.7	
	10	1108	170606_171204	17:11	17:25	9,156	180°	167	859	21	1.1	0.6	IMU/GNSS Error
	11												Sister Clock
	12												Data Gap
	13												Invalid Data
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s		
Date/Julian:		6/6/2017	ALS80 SN# 8253		Disk Drive MM70			Flight Plan(s):				Pilot/s		
Hobbs End		6314.6			1-808654A			2017SD_Lidar_Final				Mike Wasielewski		
Hobbs ST		6309	LIFT		TARGET ALT AGL (ft)			TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		5.6	B		9,935			165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:	
				Begin:	End:						PDOP	HDOP		
A														
	1	1003	170606_193828	19:38	19:52	9,471	180°	160	851	21	1	0.7		
	2	1002	170606_195538	19:55	20:09	9,484	0°	160	843	21	1	0.6		
	3	1005	170606_201212	20:11	20:25	9,462	180°	164	835	24	0.9	0.6		
	4	1004	170606_202915	20:28	20:42	9,483	0°	163	828	22	1	0.6		
	5	1007	170606_204618	20:46	20:59	9,472	180°	167	820	20	1	0.6		
	6	1006	170606_210333	21:03	21:17	9,490	0°	162	812	20	1.1	0.7		
	7	1009	170606_212053	21:20	21:34	9,473	180°	162	805	20	1.1	0.7		
	8	1008	170606_213738	21:37	21:51	9,480	0°	165	797	20	1.1	0.6		
	9	1108	170606_220535	22:05	22:19	9,148	180°	169	789	17	1.2	0.7	Refly	
	10	1109	170606_222255	22:23	22:36	9,116	0°	161	781	18	1.1	0.7		
	11	1110	170606_224035	22:40	22:59	9,135	180°	164	773	18	1.2	0.6		
	12	1111	170606_225755	22:57	23:11	9,146	0°	164	765	18	1.1	0.6		
	13	1112	170606_231509	23:14	23:28	9,150	180°	164	758	17	1.5	0.8		
	14	1113	170606_233229	23:32	23:46	9,143	0°	165	750	19	1.1	0.7		
	15	1114	170606_234946	23:49	:3	9,145	180°	166	742	21	1	0.6		
	16	1115	170607_000658	:6	:20	9,147	0°	164	734	19	1.1	0.6		
	17	1116	170607_002412	:23	:37	9,106	180°	167	727	20	1	0.6		
	18	1117	170607_004120	:41	:55	9,146	0°	160	719	19	1.1	0.6		
	19													
	20													
	21													
	22													
	23													
	24													
	25													



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/7/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End		6317.1			1-808654A		2017SD_Lidar_Final					Mike Wasielewski	
Hobbs ST		6313.6	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		2.5	A		9,125		165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						9,125			717				
	1	1118	170607_135913	13:59			180°	165	711	16	1.2	0.7	Stop 13 Miles to NE Cloud
B	2												
	3	1120	170607_165538	16:55	17:09		180°	162	704	19	1.2	0.6	
	4	1119	170607_171257	17:13	17:26		0°	167	696	21	1.1	0.6	
	5	1126	170607_172953	17:29	17:40		180°	166	690	21	1	0.6	12 miles to end SE
	6	2013	170607_174923	17:49	18:03		0°	167	681	17	1.2	0.7	
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
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Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/7/2017	ALS80 SN# 8253	Disk Drive MM70		Flight Plan(s):						Bertin Evina-Ze	
Hobbs End		6319.1		1-808654A		2017SD_Lidar_Final						Pilot/s	
Hobbs ST		6313.0	LIFT	TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height		Aircraft	Airport Idnt:
Flight Time		6.1	C	9,125		165		TEMP		1.500		C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
C						9,125			687				
	1	1118	170608_0218	2:18	2:32		180°	166	673	18	1.1	0.6	Reply
	2	1121	170608_023445	2:34	2:48		0°	166	666	19	1.1	0.6	
	3	1122	170608_025218	2:52	3:06		180°	165	658	19	1.1	0.6	
	4	1123	170608_030935	3:09	3:23		0°	165	650	19	1.1	0.6	
	5	1124	170608_032645	3:26	3:40		180°	163	642	18	1.1	0.6	
	6	1125	170608_034353	3:43	3:57		0°	167	635	17	1.2	0.7	Check
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm											Sensor Operator/s	
Date/Julian:		6/8/2017	ALS80 SN# 8253		Disk Drive MM70			Flight Plan(s):					Pilot/s	
Hobbs End		6325.5			1-808654A			2017SD_Lidar_Final					Mike Wasielewski	
Hobbs ST		6319.1	LIFT		TARGET ALT AGL (ft)			TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		6.4	A		9,125			165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:	
				Begin:	End:						PDOP	HDOP		
A														
	1	1126	170608_145046	14:50	15:04	9,052	180°	163	634	19	1.2	0.6		
	2	1127	170608_150821	15:08	15:21	9,035	0°	164	627	19	1.2	0.6		
	3	1128	170608_152549	15:25	15:39	9,041	180°	164	619	19	1.3	0.7		
	4	2001	170608_154502	15:44	15:56	9,984	0°	162	611	19	1.2	0.6	5 mi short	
	5	2002	170608_160213	16:01	16:18	9,962	180°	163	604	22	1	0.6		
	6	2003	170608_162038	16:20	16:35	9,986	0°	166	595	20	1.1	0.6		
	7	2004	170608_163851	16:38	16:53	9,985	180°	162	586	20	1.1	0.6		
	8	2005	170608_165614	16:55	17:09	9,990	0°	166	577	19	1.2	0.6		
	9	2006	170608_171351	17:13	17:27	9,971	180°	159	568	20	1.1	0.6		
	10	2007	170608_173223	17:31	17:46	9,937	0°	167	559	18	1.2	0.6	GNSS/IMU Error	
B	11												Air Restart	
	12	2008	170608_181056	18:10	18:25	9,925	180°	164	549	22	1	0.6		
	13	2009	170608_182848	18:28	18:42	9,936	0°	165	540	20	1.1	0.6		
	14	2010	170608_184622	18:46	18:59	9,940	180°	162	531	19	1.1	0.6		
	15	2011	170608_190400	19:03	19:17	9,944	0°	166	522	17	1.2	0.7		
	16	2012	170608_192128	19:21	19:35	9,936	180°	161	513	17	1.1	0.7		
	17	2015	170608_193832	19:38	19:52	9,919	0°	166	504	17	1.1	0.7		
	18	2014	170608_195617	19:56	20:09	9,887	180°	168	495	20	1	0.6		
	19	2017	170608_201322	20:13	20:27	9,945	0°	160	486	19	1	0.6		
	20	X03	170608_204132	20:41	20:50	8,423	270°	165	477	19	1.1	0.6	Cross Strip/FOV Error	
	21													
	22													
	23													
	24													
	25													



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/8/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		6430.3			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		0	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		6430.3	C		9,125		165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
C						9,908			744				
	1	2016	170609_014717	1:47	2:00		180°	162	765	18	1.1	0.7	
	2	2019	170609_020445	2:05	2:19		0°	167	726	20	1	0.6	
	3	2018	170609_022228	2:22	2:36		180°	162	717	17	1.1	0.7	
	4	2021	170609_023956	2:40	2:53		0°	165	708	20	1.1	0.6	
	5	2020	170609_025739	2:57	3:11		180°	162	700	20	1.1	0.6	
	6	2023	170609_031511	3:15	3:28		0°	165	690	18	1.2	0.7	
	7	2022	170609_033310	3:33	3:46		180°	165	681	19	1.1	0.7	
	8	2025	170609_035037	3:50	4:04		0°	168	673	19	1	0.6	
	9	224	170609_040826	4:08	4:22		180°	163	663	18	1.2	0.7	
	10	2027	170609_042548	4:25	4:39		0°	163	654	18	1.1	0.7	
	11	2026	170609_044344	4:43	4:57		180°	163	645	17	1.1	0.7	
	12	2029	170609_050346	5:03	5:17		0°	167	635	18	1	0.6	
	13	2028	170609_052119	5:21	5:34		180°	162	627	19	0.9	0.6	
	14	2031	170609_053827	5:38	5:52		0°	164	618	19	1	0.6	
	15	2030	170609_055613	5:56	6:10		180°	165	609	18	1.1	0.7	
	16	2033					0°						GPS/IMU Error
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/9/2017	ALS80 SN# 8253		Disk Drive MM70		Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		6336.6			1-808654A		2017SD_Lidar_Final					Pilot/s	
Hobbs ST		6330.5	LIFT		TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		6.1	A		9,125		165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						9,800			608				
	1	2032	170609_152629	15:26	15:40		180°	165	599	22	1.2	0.6	
	2	2033	170609_154428	15:44	15:57		0°	164	591	24	1.1	0.5	
	3	2034	170609_160212	16:02	16:15		180°	165	581	24	1.1	0.5	
	4	2035	170609_161954	16:19	16:33		0°	163	572	21	1.2	0.6	
	5	2036	170609_163853	16:38	16:53		180°	163	563	22	1.1	0.6	
	6	2037	170609_165754	16:57	17:11		0°	163	554	23	1.1	0.6	
	7	2038	170609_171707	17:17	17:31		180°	165	545	23	1	0.6	
	8	2039	170609_173513	17:35	17:48		0°	160	536	21	1.1	0.7	
	9	2040	170609_176633	17:55	18:09		180°	165	527	21	1.1	0.7	
	10	2041	170609_181306	18:13	18:26		0°	165	518	22	1.1	0.6	
	11	2042	170609_183048	18:30	18:44		180°	163	509	20	1.2	0.6	
	12	2043	170609_184824	18:48			0°	166	499	19	1.1	0.6	TDC Error
B	13	2044	170609_192127	19:21	19:35		180°	166	490	19	1	0.6	
	14	2043	170609_193934	19:34	19:53		0°	162	481	22	0.9	0.6	Refly
	15	2046	170609_195740	19:57	20:11		180°	163	472	21	1	0.6	
	16	2045	170609_201531	20:15	20:29		0°	161	463	20	1	0.6	
	17	2048	170609_203258	20:32	20:46		180°	164	454	19	1.1	0.6	
	18	2047	170609_205120	20:51	21:05		0°	164	444	19	1	0.6	
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm										Sensor Operator/s	
Date/Julian:		6/9/2017	ALS80 SN# 8253	Disk Drive MM70		Flight Plan(s):						Bertin Evina-Ze	
Hobbs End				1-808654A		2017SD_Lidar_Final						Pilot/s	
Hobbs ST			LIFT	TARGET ALT AGL (ft)		TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:	
Flight Time		0	A	9,125		165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)	
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
A						9,550			444				
	1	2072	170610_010802	1:08	1:21		180°	162	435	18	1.2	0.7	
	2	2071	170610_012537	1:25	1:39		0°	165	426	20	1.1	.	
	3	2070	170610_014331	1:43	1:59		180°	165	417	20	1.1	0.6	
	4	2069	170610_020048	2:00	2:14		0°	163	408	22	1	0.6	
	5	2068	170610_021808	2:18	2:31		180°	161	399	18	1.2	.7	
	6	2067	170610_023617	2:36	2:50		0°	164	389	20	1.1	0.6	
	7	2066	170610_025326	2:53	3:06		180°	163	380	20	1.1	0.6	
	8	2065	170610_031028	3:10	3:24		0°	163	371	18	1.2	0.7	
	9	2064	170610_032755	3:27	3:42		180°	162	362	17	1.2	0.7	
	10	2063	170610_034512	3:45	3:58		0°	167	353	20	1	0.6	
	11	2062	170610_040303	4:03	4:16		180°	165	344	19	1.2	0.7	
	12	2061	170610_042201	4:22			0°	164	337	19	1.1	0.7	
	13	2060	170610_043855	4:38	4:51		180°	163	328	17	1.1	0.6	Aborted
	14	2061	170610_045705	4:57	5:10		0°	167	319	18	1	0.6	Check Clouds South End
	15	2058	170610_051401	5:14	5:27		180°	164	310	21	0.9	0.6	Check Clouds South End
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												



Leica ALS80 Flight Log

Project:		17007_SD_LiDAR_4ppsm											Sensor Operator/s	
Date/Julian:		6/11/2017	ALS80 SN# 8253		Disk Drive MM70			Flight Plan(s):					Bertin Evina-Ze	
Hobbs End		1499.9			1-808654A			2017SD_Lidar_Final					Pilot/s	
Hobbs ST		1496.1	LIFT		TARGET ALT AGL (ft)			TARGET AIRSPD (KNTS)		BASE PID:		Base Height	Aircraft	Airport Idnt:
Flight Time		3.8	A		9,125			165		TEMP		1.500	C441-N207SS	KBWW(Bowman, ND)
Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:	
				Begin:	End:						PDOP	HDOP		
A						8,700			471					
	1	X02	170611_181507	18:15	18:22		90°	166		19	1.2	0.7	Cross Strip	
	2	X04	170611_134350	18:29	18:37		90°	166	462	19	1.2	0.7	Cross Strip	
	3	2056	170611_134351	18:50	19:04		180°	173	453	17	1.3	0.7		
	4	2055	170611_134352	19:08	19:21		0°	168	444	17	1.2	0.7		
	5	2054	170611_134353	19:25	19:39		180°	169	435	18	1.1	0.7		
	6	2053	170611_134354	19:43	19:57		0°	157	426	21	1	0.6		
	7	2052	170611_134355	20:00	20:14		180°	166	417	21	1	0.6		
	8	2051	170611_134356	20:19	20:33		0°	160	408	21	1	0.6		
	9	2050	170611_134357	20:37	20:50		180°	165	398	20	1.1	0.6		
	10	2049	170611_134358	20:54	21:07		0°	171	390	21	1.1	0.7		
	11	2057	170611_134359	21:13	21:56		180°	162	380	18	1.3	0.7		
	12	2059	170611_134360	21:31	21:44		0°	170	371	18	1.2	0.7		
	13	2065	170611_134361	21:49	22:03		180°	165	362	18	1.3	0.7	Refly	
	14	4003	170611_134362	22:16	22:19		0°	160	360	18	1.3	0.7		
	15	4002	170611_134363	22:24	22:28		180°	164	357	20	1.3	0.7		
	16	4001	170611_134364	22:32	22:36		0°	161	354	20	1.3	0.7		
	17	5001	170611_134365	22:54	23:05		180°	161	348	20	1.3	0.7		
	18	6001	170611_134366	23:13	23:14		0°	174	347	22	1.1	0.6		
	19	6002	170611_134367	23:19	23:20		180°	158	347	22	1.1	0.6		
	20	1115	170611_134368	23:36	23:38		0°	162	346	22	1.1	0.6	Refly 5 miles	
	21													
	22													
	23													
	24													
	25													

Appendix B. Vertical Accuracy Calculations



Project Information

Prepared By: Kenneth L Coffey
Project Name: NRCS South Dakota
Sensor Info: Leica ALS80 SN#8253
Required Nominal Pulse Spacing: 0.5
Vendor Name: Digital Aerial Solutions LLC
Units: Meters
Percent of Extent Tolerance: Extents Not Checked
Date of Aquisition: Start: 5/4/2017 Finish: 6/11/2017

Metadata Information

Tile Index:

Filename: CLIP_DAS_SD_FY17_Index.shp

Number of Polys: 0

Intensity:

Tile Index Attribute: Not Specified

Data Filename: Not Specified

DEM:

Tile Index Attribute: NAME_2

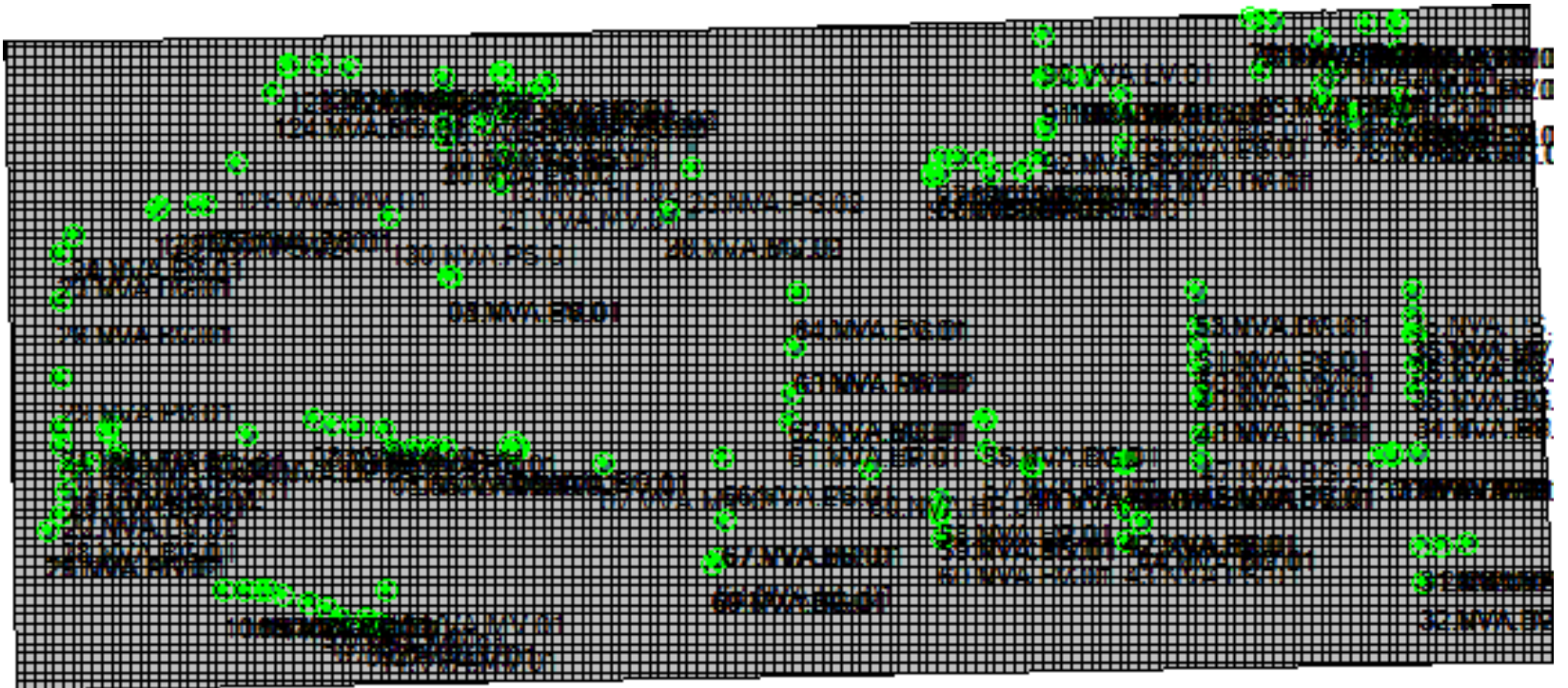
Data Filename: DEM

LAS:

Tile Index Attribute: NAME

Data Filename: LAS

Tiled-Data Area



LiDAR Accuracy Assessment Summary

LC Type	# of Points	NVA	VVA	
LAS				
Bare Ground	53	0.070		
Hard Pavement	31	0.049		
High Vegetation	10		0.305	
Low Vegetation	73		0.097	
Medium Vegetation	36		0.154	
Packed Sand	46	0.077		
Total	249			
DEM				
Bare Ground	53	0.073		
Hard Pavement	31	0.051		
High Vegetation	10		0.311	
Low Vegetation	73		0.091	
Medium Vegetation	36		0.140	
Packed Sand	46	0.076		
Total	249			

Units: Meters

Coordinates and Offsets of Analyzed Locations

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
1)	<input checked="" type="checkbox"/>	06.NVA.BG.01					
		626852.05	5046368.219	866.112	866.133	866.119	
				Bare Ground	0.021	0.007	
2)	<input checked="" type="checkbox"/>	07.NVA.BG.01					
		608712.109	5028683.707	997.713	997.707	997.716	
				Bare Ground	-0.006	0.003	
3)	<input checked="" type="checkbox"/>	09.NVA.BG.01					
		600540.052	5031496.614	1055.432	1055.381	1055.371	
				Bare Ground	-0.051	-0.061	
4)	<input checked="" type="checkbox"/>	10.NVA.BG.01					
		596768.322	5031438.462	1024.989	1025.018	1025.011	
				Bare Ground	0.029	0.022	
5)	<input checked="" type="checkbox"/>	100.NVA.BG.01					
		684924.327	5084814.906	773.501	773.517	773.518	
				Bare Ground	0.016	0.016	
6)	<input checked="" type="checkbox"/>	102.NVA.BG.01					
		690213.281	5083042.706	781.336	781.307	781.295	
				Bare Ground	-0.03	-0.041	
7)	<input checked="" type="checkbox"/>	104.NVA.BG.01					
		690367.053	5077703.579	749.753	749.76	749.753	
				Bare Ground	0.006	0	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
8)	<input checked="" type="checkbox"/>	122.NVA.BG.01					
		606637.733	5086243.495	954.52	954.53	954.532	
				Bare Ground	0.01	0.012	
9)	<input checked="" type="checkbox"/>	124.NVA.BG.01					
		601869.98	5083239.416	989.184	989.136	989.133	
				Bare Ground	-0.049	-0.051	
10)	<input checked="" type="checkbox"/>	14.NVA.BG.01					
		629149.411	5083431.811	896.176	896.177	896.161	
				Bare Ground	0	-0.016	
11)	<input checked="" type="checkbox"/>	15.NVA.BG.01					
		580602.469	5044043.301	952.303	952.251	952.242	
				Bare Ground	-0.052	-0.06	
12)	<input checked="" type="checkbox"/>	17.NVA.BG.02					
		582676.293	5044731.205	957.332	957.339	957.337	
				Bare Ground	0.007	0.005	
13)	<input checked="" type="checkbox"/>	18.NVA.BG.01					
		579777.954	5039226.871	963.516	963.521	963.513	
				Bare Ground	0.005	-0.003	
14)	<input checked="" type="checkbox"/>	19.NVA.BG.01					
		578365.434	5037581.467	973.945	973.897	973.893	
				Bare Ground	-0.047	-0.052	

Coordinates and Offsets of Analyzed Locations (Continued)

		ID				
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
15)	<input checked="" type="checkbox"/>	20.NVA.BG.02				
		579836.982	5046722.034	956.126	956.094	956.097
				Bare Ground	-0.032	-0.03
16)	<input checked="" type="checkbox"/>	21.NVA.BG.01				
		579811.035	5048583.434	968.724	968.747	968.74
				Bare Ground	0.022	0.016
17)	<input checked="" type="checkbox"/>	22.NVA.BG.01				
		579663.252	5061719.598	975.514	975.484	975.484
				Bare Ground	-0.03	-0.03
18)	<input checked="" type="checkbox"/>	23.NVA.BG.01				
		579672.189	5066542.777	959.736	959.72	959.716
				Bare Ground	-0.016	-0.019
19)	<input checked="" type="checkbox"/>	25.NVA.BG.01				
		585619.932	5045674.32	980.852	980.894	980.898
				Bare Ground	0.043	0.047
20)	<input checked="" type="checkbox"/>	26.NVA.BG.01				
		584631.691	5048092.303	965.053	965.043	965.063
				Bare Ground	-0.009	0.01
21)	<input checked="" type="checkbox"/>	28.NVA.BG.02				
		642943.723	5070862.5	852.437	852.416	852.432
				Bare Ground	-0.021	-0.005

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
22)	<input checked="" type="checkbox"/>	29.NVA.BG.01					
		723510.296	5036217.64	781.397	781.404	781.396	
				Bare Ground	0.007	-0.001	
23)	<input checked="" type="checkbox"/>	31.NVA.BG.01					
		721342.715	5036134.643	802.466	802.504	802.497	
				Bare Ground	0.038	0.03	
24)	<input checked="" type="checkbox"/>	32.NVA.BG.01					
		721520.335	5032234.108	770.43	770.444	770.456	
				Bare Ground	0.013	0.025	
25)	<input checked="" type="checkbox"/>	35.NVA.BG.01					
		720725.362	5055039.364	776.76	776.789	776.784	
				Bare Ground	0.029	0.025	
26)	<input checked="" type="checkbox"/>	37.NVA.BG.01					
		717039.172	5045614.89	805.82	805.852	805.841	
				Bare Ground	0.032	0.021	
27)	<input checked="" type="checkbox"/>	41.NVA.BG.01					
		690501.142	5044856.381	854.377	854.408	854.399	
				Bare Ground	0.031	0.022	
28)	<input checked="" type="checkbox"/>	44.NVA.BG.01					
		692186.686	5038436.305	859.62	859.616	859.604	
				Bare Ground	-0.003	-0.016	

Coordinates and Offsets of Analyzed Locations (Continued)

ID						
	Survey X	Survey Y	Z1	Z DEM	Z LAS	
			LC Type	ΔZ DEM	ΔZ LAS	
29)	<input checked="" type="checkbox"/> 46.NVA.BG.01					
	698546.694	5044980.807	846.257	846.24	846.219	
			Bare Ground	-0.017	-0.039	
30)	<input checked="" type="checkbox"/> 47.NVA.BG.01					
	698450.272	5047606.705	810.288	810.279	810.283	
			Bare Ground	-0.01	-0.006	
31)	<input checked="" type="checkbox"/> 48.NVA.BG.01					
	698371.46	5051562.385	767.406	767.413	767.421	
			Bare Ground	0.008	0.016	
32)	<input checked="" type="checkbox"/> 53.NVA.BG.01					
	698019.517	5062728.934	813.07	813.088	813.095	
			Bare Ground	0.018	0.025	
33)	<input checked="" type="checkbox"/> 55.NVA.BG.01					
	675977.905	5049244.659	875.505	875.52	875.525	
			Bare Ground	0.015	0.019	
34)	<input checked="" type="checkbox"/> 57.NVA.BG.01					
	675999.646	5046024.75	860.625	860.585	860.582	
			Bare Ground	-0.039	-0.043	
35)	<input checked="" type="checkbox"/> 59.NVA.BG.01					
	671317.176	5039453.574	873.04	873.063	873.048	
			Bare Ground	0.023	0.009	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
36)	<input checked="" type="checkbox"/>	60.NVA.BG.01					
		671420.884	5036903.125	854.518	854.542	854.534	
				Bare Ground	0.024	0.016	
37)	<input checked="" type="checkbox"/>	62.NVA.BG.01					
		655811.661	5051937.42	823.055	823.101	823.105	
				Bare Ground	0.046	0.049	
38)	<input checked="" type="checkbox"/>	63.NVA.BG.01					
		656239.764	5056773.122	798.286	798.271	798.285	
				Bare Ground	-0.015	-0.001	
39)	<input checked="" type="checkbox"/>	64.NVA.BG.01					
		656353.655	5062439.673	835.707	835.645	835.649	
				Bare Ground	-0.062	-0.058	
40)	<input checked="" type="checkbox"/>	68.NVA.BG.01					
		648198.878	5034842.879	938.964	938.925	938.939	
				Bare Ground	-0.039	-0.025	
41)	<input checked="" type="checkbox"/>	69.NVA.BG.01					
		647657.729	5034161.822	951.558	951.548	951.544	
				Bare Ground	-0.011	-0.015	
42)	<input checked="" type="checkbox"/>	70.NVA.BG.03					
		703602.912	5091041.152	755.27	755.254	755.256	
				Bare Ground	-0.016	-0.015	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
43)	<input checked="" type="checkbox"/>	71.NVA.BG.01					
		704757.129	5090717.275	762.024	762.05	762.047	
				Bare Ground	0.026	0.023	
44)	<input checked="" type="checkbox"/>	72.NVA.BG.02					
		706044.214	5090670.262	767.886	767.947	767.943	
				Bare Ground	0.061	0.057	
45)	<input checked="" type="checkbox"/>	73.NVA.BG.01					
		715673.272	5090575.574	786.7	786.625	786.625	
				Bare Ground	-0.075	-0.076	
46)	<input checked="" type="checkbox"/>	76.NVA.BG.01					
		719204.109	5082656.517	746.439	746.51	746.493	
				Bare Ground	0.07	0.054	
47)	<input checked="" type="checkbox"/>	77.NVA.BG.01					
		719234.783	5080711.038	732.097	732.155	732.149	
				Bare Ground	0.058	0.052	
48)	<input checked="" type="checkbox"/>	77.NVA.BG.02					
		719196.181	5080728.857	732.23	732.291	732.288	
				Bare Ground	0.062	0.058	
49)	<input checked="" type="checkbox"/>	78.NVA.BG.01					
		714423.62	5080932.938	737.718	737.765	737.764	
				Bare Ground	0.047	0.046	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
50)	<input checked="" type="checkbox"/>	80.NVA.BG.02					
		711066.239	5083993.948	742.738	742.796	742.793	
				Bare Ground	0.059	0.055	
51)	<input checked="" type="checkbox"/>	82.NVA.BG.01					
		710901.813	5088809.019	778.47	778.513	778.51	
				Bare Ground	0.043	0.04	
52)	<input checked="" type="checkbox"/>	83.NVA.BG.01					
		704586.469	5085581.676	774.207	774.243	774.236	
				Bare Ground	0.036	0.029	
53)	<input checked="" type="checkbox"/>	99.NVA.BG.01					
		670341.15	5074735.416	868.634	868.546	868.554	
				Bare Ground	-0.088	-0.08	
54)	<input checked="" type="checkbox"/>	01.NVA.HP.01					
		610286.359	5048531.843	881.888	881.869	881.869	
				Hard Pavement	-0.019	-0.02	
55)	<input checked="" type="checkbox"/>	01.NVA.HP.02					
		619746.162	5046281.145	879.027	879.037	879.032	
				Hard Pavement	0.01	0.005	
56)	<input checked="" type="checkbox"/>	08.NVA.HP.01					
		614433.662	5046182.132	880.422	880.413	880.399	
				Hard Pavement	-0.008	-0.023	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
57)	<input checked="" type="checkbox"/>	11.NVA.HP.02					
		599057.489	5047555.104	941.12	941.078	941.085	
				Hard Pavement	-0.043	-0.035	
58)	<input checked="" type="checkbox"/>	121.NVA.HP.01					
		609860.234	5085959.12	950.875	950.878	950.859	
				Hard Pavement	0.003	-0.016	
59)	<input checked="" type="checkbox"/>	13.NVA.HP.02					
		626140.607	5076943.795	937.988	937.995	937.985	
				Hard Pavement	0.007	-0.003	
60)	<input checked="" type="checkbox"/>	24.NVA.HP.01					
		625847.413	5085290.523	869.147	869.164	869.16	
				Hard Pavement	0.017	0.013	
61)	<input checked="" type="checkbox"/>	31.NVA.HP.01					
		721423.112	5036144.873	801.547	801.553	801.562	
				Hard Pavement	0.006	0.016	
62)	<input checked="" type="checkbox"/>	32.NVA.HP.01					
		721508.011	5032229.21	770.589	770.611	770.603	
				Hard Pavement	0.023	0.015	
63)	<input checked="" type="checkbox"/>	33.NVA.HP.01					
		720994.527	5045776.259	803.513	803.542	803.54	
				Hard Pavement	0.029	0.027	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
64)	<input checked="" type="checkbox"/>	34.NVA.HP.01					
		720808.25	5052202.847	794.141	794.167	794.163	
				Hard Pavement	0.026	0.022	
65)	<input checked="" type="checkbox"/>	35.NVA.HP.04					
		720542.633	5060058.045	763.924	763.92	763.931	
				Hard Pavement	-0.004	0.008	
66)	<input checked="" type="checkbox"/>	36.NVA.HP.01					
		718363.55	5045683.933	799.854	799.787	799.795	
				Hard Pavement	-0.067	-0.059	
67)	<input checked="" type="checkbox"/>	37.NVA.HP.01					
		717024.345	5045640.468	807.33	807.316	807.343	
				Hard Pavement	-0.014	0.013	
68)	<input checked="" type="checkbox"/>	40.NVA.HP.01					
		680828.568	5044537.924	857.945	857.929	857.926	
				Hard Pavement	-0.016	-0.019	
69)	<input checked="" type="checkbox"/>	41.NVA.HP.01					
		690497.043	5044804.027	854.025	854.017	854.024	
				Hard Pavement	-0.008	0	
70)	<input checked="" type="checkbox"/>	42.NVA.HP.01					
		690645.354	5039997.036	856.859	856.878	856.874	
				Hard Pavement	0.02	0.015	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
71)	<input checked="" type="checkbox"/>	48.NVA.HP.01					
		698343.503	5051571.051	766.656	766.693	766.679	
				Hard Pavement	0.036	0.022	
72)	<input checked="" type="checkbox"/>	49.NVA.HP.01					
		698250.156	5054691.085	721.113	721.113	721.104	
				Hard Pavement	0	-0.009	
73)	<input checked="" type="checkbox"/>	58.NVA.HP.01					
		671313.422	5041067.692	870.354	870.357	870.352	
				Hard Pavement	0.003	-0.001	
74)	<input checked="" type="checkbox"/>	60.NVA.HP.01					
		664068.861	5044112.99	908.905	908.905	908.894	
				Hard Pavement	-0.001	-0.011	
75)	<input checked="" type="checkbox"/>	61.NVA.HP.01					
		655678.694	5049035.948	845.582	845.59	845.589	
				Hard Pavement	0.009	0.007	
76)	<input checked="" type="checkbox"/>	62.NVA.HP.01					
		655830.573	5051947.499	823.606	823.63	823.652	
				Hard Pavement	0.024	0.046	
77)	<input checked="" type="checkbox"/>	67.NVA.HP.01					
		648887.701	5038864.114	920.546	920.503	920.511	
				Hard Pavement	-0.043	-0.035	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
78)	<input checked="" type="checkbox"/>	69.NVA.HP.01					
		647666.189	5034147.485	951.543	951.535	951.533	
				Hard Pavement	-0.008	-0.01	
79)	<input checked="" type="checkbox"/>	70.NVA.HP.01					
		703571.6	5091034.768	755.475	755.45	755.453	
				Hard Pavement	-0.025	-0.022	
80)	<input checked="" type="checkbox"/>	71.NVA.HP.01					
		704757.962	5090706.792	762.466	762.477	762.478	
				Hard Pavement	0.011	0.011	
81)	<input checked="" type="checkbox"/>	72.NVA.HP.01					
		706048.402	5090652.739	767.877	767.93	767.934	
				Hard Pavement	0.053	0.057	
82)	<input checked="" type="checkbox"/>	74.NVA.HP.01					
		718917.744	5090626.885	781.81	781.802	781.806	
				Hard Pavement	-0.008	-0.004	
83)	<input checked="" type="checkbox"/>	83.NVA.HP.01					
		704593.028	5085596.552	773.932	773.942	773.949	
				Hard Pavement	0.01	0.017	
84)	<input checked="" type="checkbox"/>	91.NVA.HP.01					
		682128.242	5084729.595	761.061	761.006	761.012	
				Hard Pavement	-0.056	-0.05	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
85)	<input checked="" type="checkbox"/>	04.NVA.PS.01					
		620264.525	5064138.745	892.352	892.329	892.328	
				Packed Sand	-0.022	-0.024	
86)	<input checked="" type="checkbox"/>	05.NVA.PS.01					
		613404.827	5048269.584	871.253	871.225	871.224	
				Packed Sand	-0.028	-0.029	
87)	<input checked="" type="checkbox"/>	10.NVA.PS.01					
		619572.565	5080014.253	924.781	924.804	924.801	
				Packed Sand	0.023	0.02	
88)	<input checked="" type="checkbox"/>	100.NVA.PS.01					
		684926.09	5084827.071	775.03	775.002	774.994	
				Packed Sand	-0.028	-0.037	
89)	<input checked="" type="checkbox"/>	101.NVA.PS.01					
		686903.462	5084886.057	803.863	803.802	803.802	
				Packed Sand	-0.062	-0.061	
90)	<input checked="" type="checkbox"/>	103.NVA.PS.01					
		690269.972	5081139.352	756.194	756.169	756.167	
				Packed Sand	-0.025	-0.027	
91)	<input checked="" type="checkbox"/>	11.NVA.PS.01					
		619616.872	5078420.947	929.902	929.913	929.918	
				Packed Sand	0.011	0.016	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
92)	<input checked="" type="checkbox"/>	123.NVA.PS.01					
		603424.179	5086036.065	959.826	959.84	959.841	
				Packed Sand	0.014	0.015	
93)	<input checked="" type="checkbox"/>	127.NVA.PS.01					
		594769.658	5071578.014	976.055	976.058	976.06	
				Packed Sand	0.003	0.005	
94)	<input checked="" type="checkbox"/>	13.NVA.PS.01					
		623607.206	5080087.07	908.515	908.505	908.509	
				Packed Sand	-0.01	-0.006	
95)	<input checked="" type="checkbox"/>	130.NVA.PS.01					
		613916.497	5070273.195	913.422	913.392	913.39	
				Packed Sand	-0.03	-0.032	
96)	<input checked="" type="checkbox"/>	130.NVA.PS.02					
		589606.114	5070982.9	933.96	933.979	933.977	
				Packed Sand	0.019	0.017	
97)	<input checked="" type="checkbox"/>	14.NVA.PS.01					
		626690.257	5083376.454	894.677	894.677	894.666	
				Packed Sand	0	-0.01	
98)	<input checked="" type="checkbox"/>	16.NVA.PS.02					
		630300.005	5084245.123	888.837	888.846	888.84	
				Packed Sand	0.008	0.003	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
99)	<input checked="" type="checkbox"/>	20.NVA.PS.02					
		580248.101	5041813.582	961.268	961.257	961.247	
				Packed Sand	-0.011	-0.021	
100)	<input checked="" type="checkbox"/>	21.NVA.PS.02					
		578348.628	5037610.672	972.988	972.972	972.969	
				Packed Sand	-0.015	-0.019	
101)	<input checked="" type="checkbox"/>	22.NVA.PS.01					
		579728.514	5053697.175	954.492	954.474	954.458	
				Packed Sand	-0.018	-0.034	
102)	<input checked="" type="checkbox"/>	24.NVA.PS.01					
		580995.059	5068487.482	995.048	995.004	995.019	
				Packed Sand	-0.044	-0.028	
103)	<input checked="" type="checkbox"/>	26.NVA.PS.02					
		645379.294	5075453.412	882.896	882.795	882.796	
				Packed Sand	-0.101	-0.1	
104)	<input checked="" type="checkbox"/>	28.NVA.PS.02					
		726204.237	5036341.972	784.263	784.242	784.226	
				Packed Sand	-0.021	-0.037	
105)	<input checked="" type="checkbox"/>	33.NVA.PS.01					
		721040.805	5045781.087	803.305	803.359	803.351	
				Packed Sand	0.054	0.046	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
106)	<input checked="" type="checkbox"/>	34.NVA.PS.01					
		720791.676	5052215.53	794.249	794.274	794.267	
				Packed Sand	0.025	0.017	
107)	<input checked="" type="checkbox"/>	35.NVA.PS.02					
		720626.433	5058105.767	764.416	764.46	764.453	
				Packed Sand	0.044	0.037	
108)	<input checked="" type="checkbox"/>	35.NVA.PS.06					
		720424.716	5062849.734	766.954	766.977	766.974	
				Packed Sand	0.024	0.02	
109)	<input checked="" type="checkbox"/>	40.NVA.PS.01					
		680842.573	5044474.655	856.725	856.706	856.708	
				Packed Sand	-0.02	-0.018	
110)	<input checked="" type="checkbox"/>	42.NVA.PS.01					
		690677.949	5040000.062	856.368	856.378	856.373	
				Packed Sand	0.01	0.005	
111)	<input checked="" type="checkbox"/>	43.NVA.PS.01					
		690723.988	5036758.3	845.812	845.775	845.794	
				Packed Sand	-0.036	-0.018	
112)	<input checked="" type="checkbox"/>	45.NVA.PS.01					
		698536.033	5045000.859	846.626	846.606	846.609	
				Packed Sand	-0.02	-0.018	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
113)	<input checked="" type="checkbox"/>	50.NVA.PS.01					
		698187.087	5056894.647	762.88	762.879	762.88	
				Packed Sand	-0.001	0	
114)	<input checked="" type="checkbox"/>	51.NVA.PS.01					
		698254.525	5059034.66	809.78	809.772	809.768	
				Packed Sand	-0.008	-0.012	
115)	<input checked="" type="checkbox"/>	59.NVA.PS.01					
		671381.753	5039458.009	871.632	871.644	871.64	
				Packed Sand	0.012	0.008	
116)	<input checked="" type="checkbox"/>	63.NVA.PS.01					
		656184.613	5056798.491	798.538	798.531	798.548	
				Packed Sand	-0.007	0.009	
117)	<input checked="" type="checkbox"/>	66.NVA.PS.01					
		648749.433	5045185.48	940.513	940.5	940.475	
				Packed Sand	-0.013	-0.038	
118)	<input checked="" type="checkbox"/>	67.NVA.PS.01					
		648809.735	5038867.062	920.912	920.869	920.871	
				Packed Sand	-0.043	-0.041	
119)	<input checked="" type="checkbox"/>	73.NVA.PS.01					
		715672.241	5090531.24	786.156	786.046	786.044	
				Packed Sand	-0.11	-0.111	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
120)	<input checked="" type="checkbox"/>	74.NVA.PS.01					
		718870.795	5090536.577	781.058	781.101	781.098	
				Packed Sand	0.042	0.039	
121)	<input checked="" type="checkbox"/>	75.NVA.PS.01					
		718929.989	5087487.439	784.461	784.505	784.508	
				Packed Sand	0.044	0.047	
122)	<input checked="" type="checkbox"/>	76.NVA.PS.01					
		719110.392	5082645.888	745.589	745.626	745.638	
				Packed Sand	0.037	0.049	
123)	<input checked="" type="checkbox"/>	77.NVA.PS.01					
		719242.719	5080726.533	732.421	732.446	732.444	
				Packed Sand	0.025	0.023	
124)	<input checked="" type="checkbox"/>	79.NVA.PS.01					
		711086.284	5082376.955	723.412	723.433	723.442	
				Packed Sand	0.02	0.03	
125)	<input checked="" type="checkbox"/>	81.NVA.PS.01					
		712622.755	5085653.814	748.132	748.09	748.077	
				Packed Sand	-0.042	-0.055	
126)	<input checked="" type="checkbox"/>	91.NVA.PS.01					
		682163.885	5084743.272	760.219	760.182	760.176	
				Packed Sand	-0.036	-0.043	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
127)	<input checked="" type="checkbox"/>	92.NVA.PS.01					
		682252.036	5079599.114	800.391	800.362	800.366	
				Packed Sand	-0.028	-0.025	
128)	<input checked="" type="checkbox"/>	94.NVA.PS.01					
		679780.318	5075004.447	863.318	863.243	863.24	
				Packed Sand	-0.075	-0.078	
129)	<input checked="" type="checkbox"/>	95.NVA.PS.01					
		676543.642	5074919.857	883.672	883.626	883.628	
				Packed Sand	-0.045	-0.044	
130)	<input checked="" type="checkbox"/>	96.NVA.PS.01					
		673053.881	5076423.472	840.788	840.702	840.716	
				Packed Sand	-0.087	-0.072	
131)	<input checked="" type="checkbox"/>	08.VVA.HV.01					
		627107.565	5046265.712	867.982	868.005	867.992	
				High Vegetation	0.023	0.01	
132)	<input checked="" type="checkbox"/>	12.VVA.HV.01					
		620202.923	5064184.625	891.263	891.431	891.453	
				High Vegetation	0.168	0.19	
133)	<input checked="" type="checkbox"/>	19.VVA.HV.01					
		613377.672	5048243.174	871.287	871.333	871.332	
				High Vegetation	0.046	0.045	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
134)	<input checked="" type="checkbox"/>	22.VVA.HV.01					
		625591.765	5085263.93	865.912	865.981	865.991	
				High Vegetation	0.069	0.079	
135)	<input checked="" type="checkbox"/>	35.VVA.HV.01					
		720742.226	5055050.11	775.917	776.119	776.126	
				High Vegetation	0.201	0.209	
136)	<input checked="" type="checkbox"/>	37.VVA.HV.01					
		717037.035	5045604.898	805.151	805.462	805.44	
				High Vegetation	0.311	0.289	
137)	<input checked="" type="checkbox"/>	40.VVA.HV.01					
		680826.594	5044513.338	856.223	856.462	856.528	
				High Vegetation	0.24	0.305	
138)	<input checked="" type="checkbox"/>	42.VVA.HV.01					
		690604.677	5039973.466	856.522	856.516	856.523	
				High Vegetation	-0.005	0.002	
139)	<input checked="" type="checkbox"/>	45.VVA.HV.01					
		698552.244	5045019.234	846.282	846.308	846.29	
				High Vegetation	0.027	0.008	
140)	<input checked="" type="checkbox"/>	74.VVA.HV.01					
		718903.773	5090553.486	780.369	780.38	780.36	
				High Vegetation	0.012	-0.009	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
141)	<input checked="" type="checkbox"/>	03.VVA.LV.01					
		607977.837	5048692.718	888.411	888.467	888.446	
				Low Vegetation	0.056	0.035	
142)	<input checked="" type="checkbox"/>	05.VVA.LV.01					
		618272.383	5046244.067	875.544	875.532	875.539	
				Low Vegetation	-0.012	-0.005	
143)	<input checked="" type="checkbox"/>	06.VVA.LV.01					
		599065.045	5047572.878	939.649	939.658	939.658	
				Low Vegetation	0.009	0.01	
144)	<input checked="" type="checkbox"/>	08.VVA.LV.01					
		620259.76	5064116.452	892.033	892.067	892.06	
				Low Vegetation	0.034	0.027	
145)	<input checked="" type="checkbox"/>	09.VVA.LV.01					
		611557.595	5028474.93	983.268	983.282	983.267	
				Low Vegetation	0.013	-0.002	
146)	<input checked="" type="checkbox"/>	101.VVA.LV.01					
		686897.9	5084903.478	802.829	802.8	802.801	
				Low Vegetation	-0.029	-0.028	
147)	<input checked="" type="checkbox"/>	103.VVA.LV.01					
		690301.381	5081127.685	753.975	754.041	754.046	
				Low Vegetation	0.066	0.071	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
148)	<input checked="" type="checkbox"/>	104.VVA.LV.01					
		690383.663	5077703.668	749.19	749.192	749.195	
				Low Vegetation	0.002	0.005	
149)	<input checked="" type="checkbox"/>	121.VVA.LV.01					
		609849.351	5085952.666	949.518	949.607	949.61	
				Low Vegetation	0.088	0.092	
150)	<input checked="" type="checkbox"/>	128.VVA.LV.01					
		593807.965	5071587.571	991.338	991.348	991.353	
				Low Vegetation	0.01	0.015	
151)	<input checked="" type="checkbox"/>	13.VVA.LV.01					
		605499.242	5030253.361	1016.595	1016.581	1016.579	
				Low Vegetation	-0.014	-0.016	
152)	<input checked="" type="checkbox"/>	14.VVA.LV.01					
		602774.826	5031045.597	1065.866	1065.843	1065.827	
				Low Vegetation	-0.023	-0.039	
153)	<input checked="" type="checkbox"/>	15.VVA.LV.01					
		600525.088	5031514.825	1054.44	1054.497	1054.489	
				Low Vegetation	0.057	0.049	
154)	<input checked="" type="checkbox"/>	16.VVA.LV.01					
		598813.513	5031445.698	1044.449	1044.528	1044.501	
				Low Vegetation	0.078	0.051	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
155)	<input checked="" type="checkbox"/>	17.VVA.LV.01					
		625947.315	5081242.073	917.53	917.564	917.582	
				Low Vegetation	0.034	0.052	
156)	<input checked="" type="checkbox"/>	19.VVA.LV.01					
		625618.459	5085273.093	866.975	867.02	867.011	
				Low Vegetation	0.045	0.036	
157)	<input checked="" type="checkbox"/>	20.VVA.LV.01					
		619556.45	5082537.892	898.996	899.056	899.038	
				Low Vegetation	0.059	0.042	
158)	<input checked="" type="checkbox"/>	20.VVA.LV.02					
		619596.993	5078410.342	929.537	929.586	929.594	
				Low Vegetation	0.049	0.058	
159)	<input checked="" type="checkbox"/>	21.VVA.LV.01					
		582668.87	5044702.282	956.224	956.211	956.216	
				Low Vegetation	-0.013	-0.009	
160)	<input checked="" type="checkbox"/>	21.VVA.LV.02					
		629162.998	5083423.328	895.764	895.761	895.763	
				Low Vegetation	-0.003	-0.001	
161)	<input checked="" type="checkbox"/>	21.VVA.LV.03					
		630315.133	5084216.619	889.717	889.718	889.715	
				Low Vegetation	0.001	-0.002	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
				LC Type	ΔZ DEM	ΔZ LAS	
162)	<input checked="" type="checkbox"/>	22.VVA.LV.01					
		580269.343	5041810.65	961.289	961.31	961.307	
				Low Vegetation	0.02	0.018	
163)	<input checked="" type="checkbox"/>	23.VVA.LV.01					
		579823.374	5039215.356	963.025	963.038	963.031	
				Low Vegetation	0.013	0.007	
164)	<input checked="" type="checkbox"/>	24.VVA.LV.01					
		579821.02	5048582.478	967.533	967.605	967.608	
				Low Vegetation	0.071	0.075	
165)	<input checked="" type="checkbox"/>	25.VVA.LV.01					
		579766.735	5053694.745	953.782	953.759	953.765	
				Low Vegetation	-0.023	-0.017	
166)	<input checked="" type="checkbox"/>	26.VVA.LV.01					
		579660.455	5061734.335	974.86	974.864	974.87	
				Low Vegetation	0.004	0.01	
167)	<input checked="" type="checkbox"/>	27.VVA.LV.01					
		579658.462	5066583.807	958.767	958.89	958.903	
				Low Vegetation	0.124	0.136	
168)	<input checked="" type="checkbox"/>	28.VVA.LV.01					
		581010.377	5068475.337	994.942	994.923	994.932	
				Low Vegetation	-0.019	-0.01	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
169)	<input checked="" type="checkbox"/>	29.VVA.LV.01					
		584638.418	5048068.797	965.15	965.134	965.14	
				Low Vegetation	-0.016	-0.01	
170)	<input checked="" type="checkbox"/>	30.VVA.LV.01					
		726158.892	5036345.445	784.121	784.193	784.182	
				Low Vegetation	0.072	0.06	
171)	<input checked="" type="checkbox"/>	32.VVA.LV.01					
		721520.447	5032201.143	769.31	769.408	769.397	
				Low Vegetation	0.098	0.087	
172)	<input checked="" type="checkbox"/>	33.VVA.LV.01					
		721004.478	5045748.848	802.5	802.683	802.666	
				Low Vegetation	0.183	0.167	
173)	<input checked="" type="checkbox"/>	34.VVA.LV.01					
		720795.055	5052195.416	792.955	793.033	793.055	
				Low Vegetation	0.078	0.1	
174)	<input checked="" type="checkbox"/>	35.VVA.LV.01					
		720648.126	5058123.79	765.732	765.777	765.782	
				Low Vegetation	0.045	0.05	
175)	<input checked="" type="checkbox"/>	35.VVA.LV.05					
		720518.154	5060109.554	762.794	762.819	762.827	
				Low Vegetation	0.026	0.033	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
176)	<input checked="" type="checkbox"/>	36.VVA.LV.01					
		718364.434	5045644.694	797.719	797.807	797.816	
				Low Vegetation	0.089	0.097	
177)	<input checked="" type="checkbox"/>	37.VVA.LV.01					
		717048.496	5045627.986	806.013	806.048	806.056	
				Low Vegetation	0.035	0.043	
178)	<input checked="" type="checkbox"/>	40.VVA.LV.01					
		680804.667	5044554.305	856.185	856.182	856.191	
				Low Vegetation	-0.003	0.006	
179)	<input checked="" type="checkbox"/>	41.VVA.LV.01					
		690457.027	5044760.913	849.091	849.134	849.143	
				Low Vegetation	0.043	0.052	
180)	<input checked="" type="checkbox"/>	42.VVA.LV.01					
		690625.907	5039975.443	856.469	856.472	856.481	
				Low Vegetation	0.004	0.013	
181)	<input checked="" type="checkbox"/>	46.VVA.LV.01					
		698562.479	5044967.263	845.99	845.976	845.984	
				Low Vegetation	-0.014	-0.006	
182)	<input checked="" type="checkbox"/>	48.VVA.LV.01					
		698333.413	5051592.338	766.104	766.195	766.185	
				Low Vegetation	0.091	0.082	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
183)	<input checked="" type="checkbox"/>	49.VVA.LV.01					
		698234.466	5054686.099	718.894	718.993	718.993	
				Low Vegetation	0.099	0.099	
184)	<input checked="" type="checkbox"/>	51.VVA.LV.01					
		698278.66	5058992.32	807.175	807.202	807.213	
				Low Vegetation	0.027	0.039	
185)	<input checked="" type="checkbox"/>	53.VVA.LV.01					
		698021.287	5062753.239	812.432	812.449	812.455	
				Low Vegetation	0.017	0.023	
186)	<input checked="" type="checkbox"/>	55.VVA.LV.01					
		675946.867	5049265.569	875.876	875.872	875.881	
				Low Vegetation	-0.004	0.005	
187)	<input checked="" type="checkbox"/>	57.VVA.LV.01					
		675984.643	5046046.738	859.659	859.65	859.654	
				Low Vegetation	-0.009	-0.005	
188)	<input checked="" type="checkbox"/>	58.VVA.LV.01					
		671347.117	5041051.301	868.909	868.935	868.925	
				Low Vegetation	0.027	0.016	
189)	<input checked="" type="checkbox"/>	60.VVA.LV.01					
		671446.984	5036900.183	853.653	853.652	853.666	
				Low Vegetation	-0.001	0.012	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
190)	<input checked="" type="checkbox"/>	61.VVA.LV.01					
		655701.066	5049049.689	843.764	843.781	843.794	
				Low Vegetation	0.017	0.03	
191)	<input checked="" type="checkbox"/>	62.VVA.LV.01					
		655854.057	5051938.762	822.84	822.897	822.891	
				Low Vegetation	0.057	0.051	
192)	<input checked="" type="checkbox"/>	63.VVA.LV.01					
		656271.665	5056779.268	797.979	797.987	797.993	
				Low Vegetation	0.007	0.013	
193)	<input checked="" type="checkbox"/>	64.VVA.LV.01					
		656354.514	5062416.534	834.11	834.121	834.146	
				Low Vegetation	0.011	0.036	
194)	<input checked="" type="checkbox"/>	66.VVA.LV.01					
		648751.007	5045206.958	939.206	939.287	939.283	
				Low Vegetation	0.081	0.076	
195)	<input checked="" type="checkbox"/>	67.VVA.LV.01					
		648853.608	5038857.254	920.332	920.325	920.319	
				Low Vegetation	-0.007	-0.013	
196)	<input checked="" type="checkbox"/>	69.VVA.LV.01					
		647640.281	5034182.365	951.667	951.682	951.688	
				Low Vegetation	0.015	0.021	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
197)	<input checked="" type="checkbox"/>	70.VVA.LV.01					
		703626.436	5091000.6	753.782	753.81	753.811	
				Low Vegetation	0.029	0.03	
198)	<input checked="" type="checkbox"/>	71.VVA.LV.01					
		704760.272	5090737.398	761.88	761.922	761.929	
				Low Vegetation	0.042	0.049	
199)	<input checked="" type="checkbox"/>	72.VVA.LV.01					
		706042.481	5090688.81	767.477	767.511	767.521	
				Low Vegetation	0.034	0.044	
200)	<input checked="" type="checkbox"/>	73.VVA.LV.01					
		715659.218	5090548.843	785.856	785.826	785.815	
				Low Vegetation	-0.03	-0.041	
201)	<input checked="" type="checkbox"/>	75.VVA.LV.01					
		718923.997	5087509.352	784.598	784.593	784.607	
				Low Vegetation	-0.005	0.009	
202)	<input checked="" type="checkbox"/>	76.VVA.LV.01					
		719173.345	5082635.158	745.588	745.651	745.677	
				Low Vegetation	0.063	0.089	
203)	<input checked="" type="checkbox"/>	76.VVA.LV.02					
		719205.11	5082666.332	746.509	746.587	746.582	
				Low Vegetation	0.078	0.073	

Coordinates and Offsets of Analyzed Locations (Continued)

		ID				
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
204)	<input checked="" type="checkbox"/>	78.VVA.LV.01				
		714388.896	5080911.612	738.502	738.519	738.512
				Low Vegetation	0.018	0.011
205)	<input checked="" type="checkbox"/>	81.VVA.LV.01				
		712597.664	5085674.922	747.482	747.524	747.517
				Low Vegetation	0.042	0.035
206)	<input checked="" type="checkbox"/>	83.VVA.LV.01				
		704563.673	5085566.182	774.881	774.942	774.945
				Low Vegetation	0.06	0.064
207)	<input checked="" type="checkbox"/>	90.VVA.LV.01				
		682025.254	5089028.551	785.437	785.413	785.426
				Low Vegetation	-0.025	-0.012
208)	<input checked="" type="checkbox"/>	91.VVA.LV.01				
		682153.34	5084715.876	759.887	759.873	759.886
				Low Vegetation	-0.014	-0.001
209)	<input checked="" type="checkbox"/>	93.VVA.LV.01				
		681484.294	5076268.687	859.641	859.68	859.668
				Low Vegetation	0.04	0.027
210)	<input checked="" type="checkbox"/>	95.VVA.LV.01				
		676527.731	5074928.775	883.001	883.003	883.023
				Low Vegetation	0.003	0.022

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
211)	<input checked="" type="checkbox"/>	96.VVA.LV.01					
		673091.21	5076413.152	840.772	840.74	840.723	
				Low Vegetation	-0.032	-0.049	
212)	<input checked="" type="checkbox"/>	98.VVA.LV.01					
		671114.123	5074921.008	843.476	843.435	843.431	
				Low Vegetation	-0.041	-0.045	
213)	<input checked="" type="checkbox"/>	9L.VVA.LV.01					
		675937.782	5076343.679	882.127	882.148	882.157	
				Low Vegetation	0.022	0.03	
214)	<input checked="" type="checkbox"/>	05.VVA.MV.01					
		616722.318	5046246.138	874.945	875.001	874.981	
				Medium Vegetation	0.056	0.036	
215)	<input checked="" type="checkbox"/>	07.VVA.MV.01					
		636123.018	5044676.95	899.666	899.905	899.871	
				Medium Vegetation	0.239	0.205	
216)	<input checked="" type="checkbox"/>	08.VVA.MV.01					
		605967.96	5049255.561	897.261	897.284	897.313	
				Medium Vegetation	0.022	0.052	
217)	<input checked="" type="checkbox"/>	122.VVA.MV.01					
		606645.055	5086242.076	954.376	954.504	954.5	
				Medium Vegetation	0.129	0.124	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
218)	<input checked="" type="checkbox"/>	123.VVA.MV.01					
		603453.713	5086017.15	958.611	958.665	958.657	
				Medium Vegetation	0.054	0.046	
219)	<input checked="" type="checkbox"/>	124.VVA.MV.01					
		601897.65	5083218.107	989.231	989.295	989.293	
				Medium Vegetation	0.064	0.062	
220)	<input checked="" type="checkbox"/>	126.VVA.MV.01					
		597921.541	5075857.994	971.938	971.964	971.983	
				Medium Vegetation	0.026	0.044	
221)	<input checked="" type="checkbox"/>	129.VVA.MV.01					
		590009.447	5071330.433	944.788	944.856	944.853	
				Medium Vegetation	0.069	0.066	
222)	<input checked="" type="checkbox"/>	13.VVA.MV.01					
		613695.18	5031540.639	930.313	930.341	930.338	
				Medium Vegetation	0.029	0.025	
223)	<input checked="" type="checkbox"/>	14.VVA.MV.01					
		612896.853	5027910.47	973.428	973.5	973.505	
				Medium Vegetation	0.072	0.077	
224)	<input checked="" type="checkbox"/>	15.VVA.MV.01					
		607472.356	5029593.223	1005.437	1005.464	1005.47	
				Medium Vegetation	0.027	0.033	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
225)	<input checked="" type="checkbox"/>	18.VVA.MV.01					
		601175.913	5031518.611	1062.915	1062.944	1062.943	
				Medium Vegetation	0.03	0.028	
226)	<input checked="" type="checkbox"/>	19.VVA.MV.01.A					
		619521.796	5084809.91	892.323	892.401	892.399	
				Medium Vegetation	0.078	0.075	
227)	<input checked="" type="checkbox"/>	20.VVA.MV.01					
		623628.395	5080086.538	908.135	908.137	908.158	
				Medium Vegetation	0.001	0.023	
228)	<input checked="" type="checkbox"/>	21.VVA.MV.01					
		625533.082	5073829.475	933.412	933.492	933.5	
				Medium Vegetation	0.08	0.088	
229)	<input checked="" type="checkbox"/>	24.VVA.MV.01					
		580626.595	5044055.114	951.662	951.762	951.803	
				Medium Vegetation	0.1	0.141	
230)	<input checked="" type="checkbox"/>	26.VVA.MV.01					
		578404.533	5037608.715	972.68	972.688	972.68	
				Medium Vegetation	0.008	0	
231)	<input checked="" type="checkbox"/>	29.VVA.MV.01					
		584750.826	5048652.283	990.928	990.966	990.961	
				Medium Vegetation	0.038	0.034	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
			LC Type				ΔZ DEM
232)	<input checked="" type="checkbox"/>	30.VVA.MV.01					
		642956.079	5070843.374	852.308	852.371	852.382	
				Medium Vegetation	0.063	0.073	
233)	<input checked="" type="checkbox"/>	35.VVA.MV.02					
		720668.087	5058077.676	764.772	764.96	764.973	
				Medium Vegetation	0.188	0.2	
234)	<input checked="" type="checkbox"/>	35.VVA.MV.05					
		720487.244	5060067.663	762.367	762.451	762.463	
				Medium Vegetation	0.084	0.097	
235)	<input checked="" type="checkbox"/>	40.VVA.MV.01					
		680875.492	5044494.91	855.711	855.851	855.843	
				Medium Vegetation	0.14	0.132	
236)	<input checked="" type="checkbox"/>	44.VVA.MV.01					
		692211.468	5038438.29	859.578	859.686	859.691	
				Medium Vegetation	0.108	0.113	
237)	<input checked="" type="checkbox"/>	50.VVA.MV.01					
		698207.357	5056780.451	761.139	761.207	761.201	
				Medium Vegetation	0.067	0.062	
238)	<input checked="" type="checkbox"/>	59.VVA.MV.01					
		671328.561	5039472.665	872.921	872.97	872.976	
				Medium Vegetation	0.049	0.055	

Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
							LC Type
239)	<input checked="" type="checkbox"/>	62.VVA.MV.01					
		655813.485	5051966.347	822.521	822.618	822.615	
				Medium Vegetation	0.097	0.094	
240)	<input checked="" type="checkbox"/>	63.VVA.MV.02					
		656185.719	5056775.025	797.354	797.43	797.437	
				Medium Vegetation	0.077	0.084	
241)	<input checked="" type="checkbox"/>	67.VVA.MV.01					
		648921.356	5038854.197	919.647	919.651	919.655	
				Medium Vegetation	0.004	0.008	
242)	<input checked="" type="checkbox"/>	74.VVA.MV.01					
		718904.691	5090653.714	781.474	781.54	781.53	
				Medium Vegetation	0.066	0.056	
243)	<input checked="" type="checkbox"/>	75.VVA.MV.02					
		718913.595	5087486.149	784.247	784.348	784.348	
				Medium Vegetation	0.1	0.1	
244)	<input checked="" type="checkbox"/>	79.VVA.MV.01					
		711086.629	5082398.886	723.04	723.144	723.184	
				Medium Vegetation	0.104	0.145	
245)	<input checked="" type="checkbox"/>	80.VVA.MV.01					
		711084.007	5083997.922	743.292	743.418	743.422	
				Medium Vegetation	0.126	0.13	

Coordinates and Offsets of Analyzed Locations (Continued)

		ID				
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
246)	<input checked="" type="checkbox"/>	82.VVA.MV.01				
		710894.781	5088807.481	778.516	778.632	778.67
				Medium Vegetation	0.116	0.154
247)	<input checked="" type="checkbox"/>	92.VVA.MV.01				
		682253.398	5079566.465	799.678	799.767	799.73
				Medium Vegetation	0.089	0.052
248)	<input checked="" type="checkbox"/>	97.VVA.MV.01				
		671162.184	5076392.468	826.519	826.534	826.525
				Medium Vegetation	0.015	0.006
249)	<input checked="" type="checkbox"/>	99.VVA.MV.01				
		670338.829	5074719.869	868.566	868.56	868.551
				Medium Vegetation	-0.006	-0.014

LAS

Nonvegetated Vertical Accuracy

LandCover Type: Bare Ground, Hard Pavement, Packed Sand

Minimum DZ: -0.111

Maximum DZ: 0.058

Mean DZ: -0.004

Mean Magnitude DZ: 0.167

Number Observations: 130

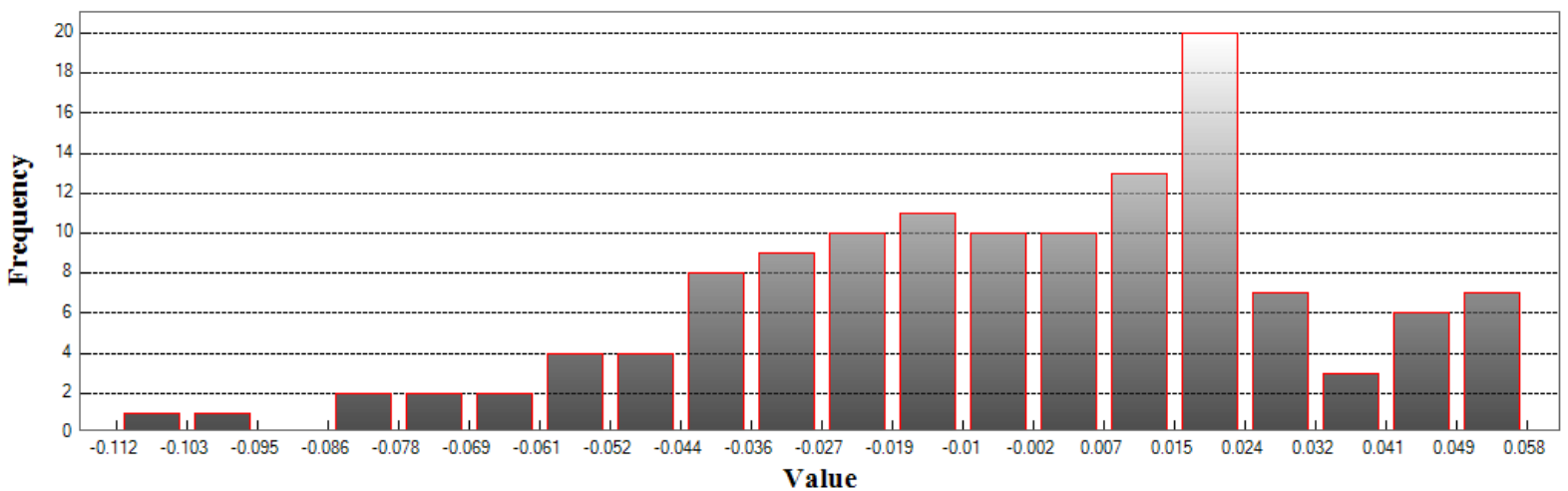
Standard Deviation DZ: 0.035

RMSE Z: 0.035

95% Confidence Level Z: 0.068

Units: Meters

Histogram



Min: -0.111

Max: 0.058

Number Of Bins: 20

Bin Interval: 0.008

LAS (Continued)

Vegetated Vertical Accuracy

LandCover Type: High Vegetation

Minimum DZ: -0.009

Maximum DZ: 0.305

Mean DZ: 0.113

Mean Magnitude DZ: 0.338

Number Observations: 10

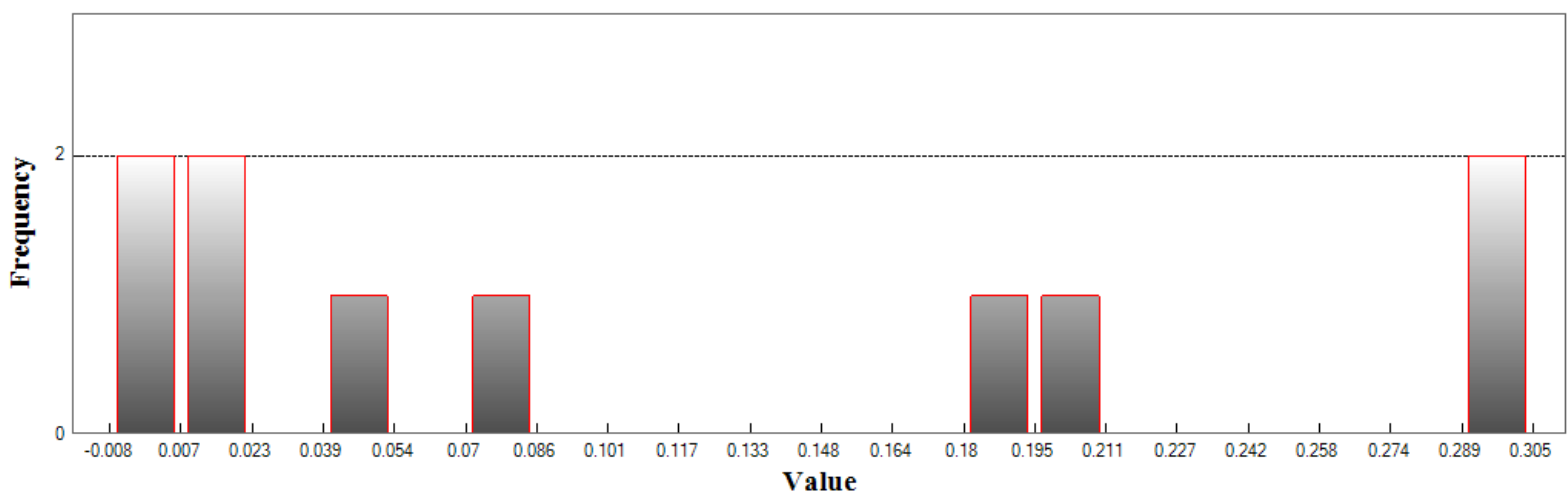
Standard Deviation DZ: 0.124

RMSE Z: 0.163

95th Percentile: 0.305

Units: Meters

Histogram



Min: -0.009

Max: 0.305

Number Of Bins: 20

Bin Interval: 0.016

LAS (Continued)

Vegetated Vertical Accuracy

LandCover Type: Low Vegetation

Minimum DZ: -0.049

Maximum DZ: 0.167

Mean DZ: 0.03

Mean Magnitude DZ: 0.196

Number Observations: 73

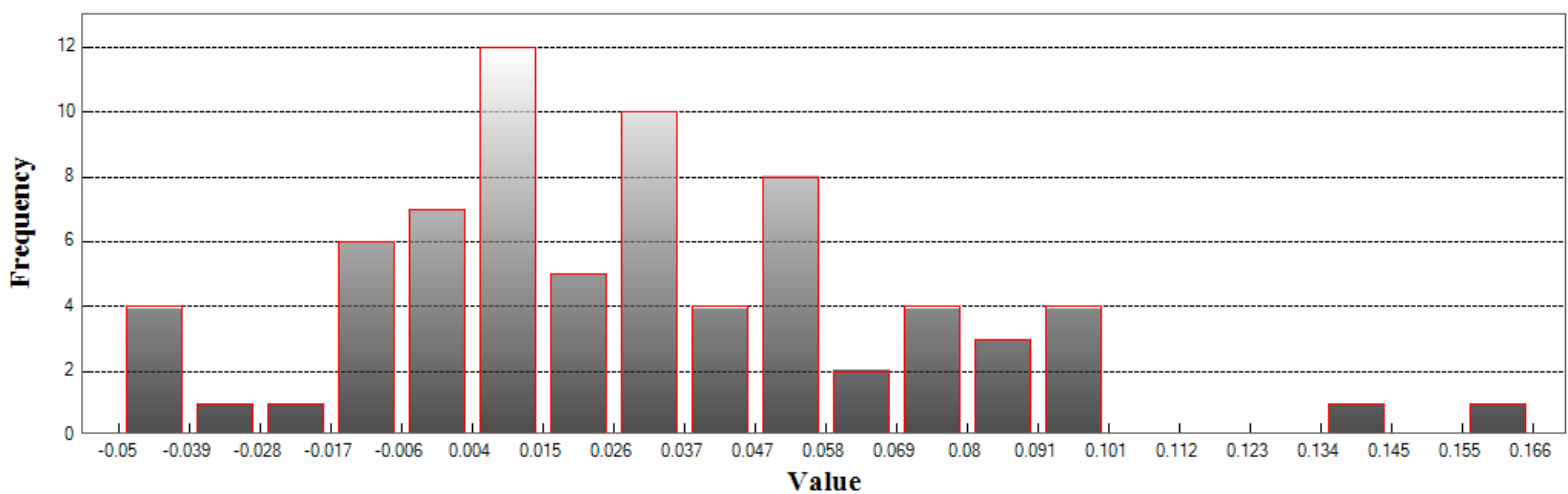
Standard Deviation DZ: 0.041

RMSE Z: 0.051

95th Percentile: 0.097

Units: Meters

Histogram



Min: -0.049

Max: 0.167

Number Of Bins: 20

Bin Interval: 0.011

LAS (Continued)

Vegetated Vertical Accuracy

LandCover Type: Medium Vegetation

Minimum DZ: -0.014

Maximum DZ: 0.205

Mean DZ: 0.075

Mean Magnitude DZ: 0.276

Number Observations: 36

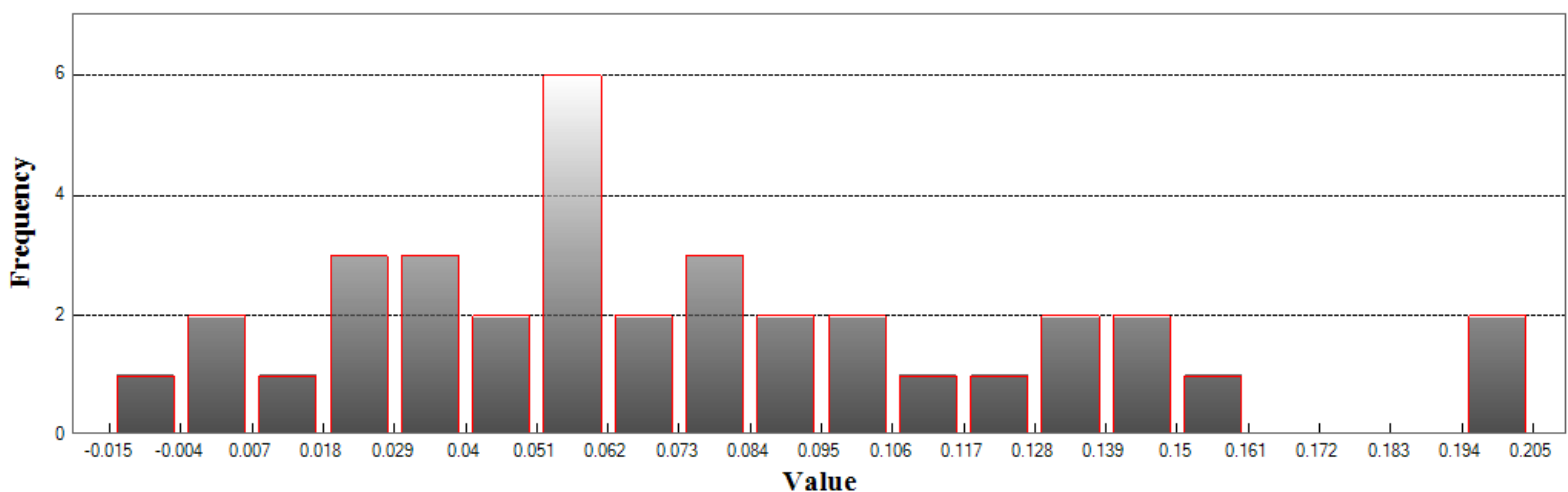
Standard Deviation DZ: 0.053

RMSE Z: 0.092

95th Percentile: 0.154

Units: Meters

Histogram



Min: -0.014

Max: 0.205

Number Of Bins: 20

Bin Interval: 0.011

DEM

Nonvegetated Vertical Accuracy

LandCover Type: Bare Ground, Hard Pavement, Packed Sand

Minimum DZ: -0.11

Maximum DZ: 0.07

Mean DZ: -0.003

Mean Magnitude DZ: 0.167

Number Observations: 130

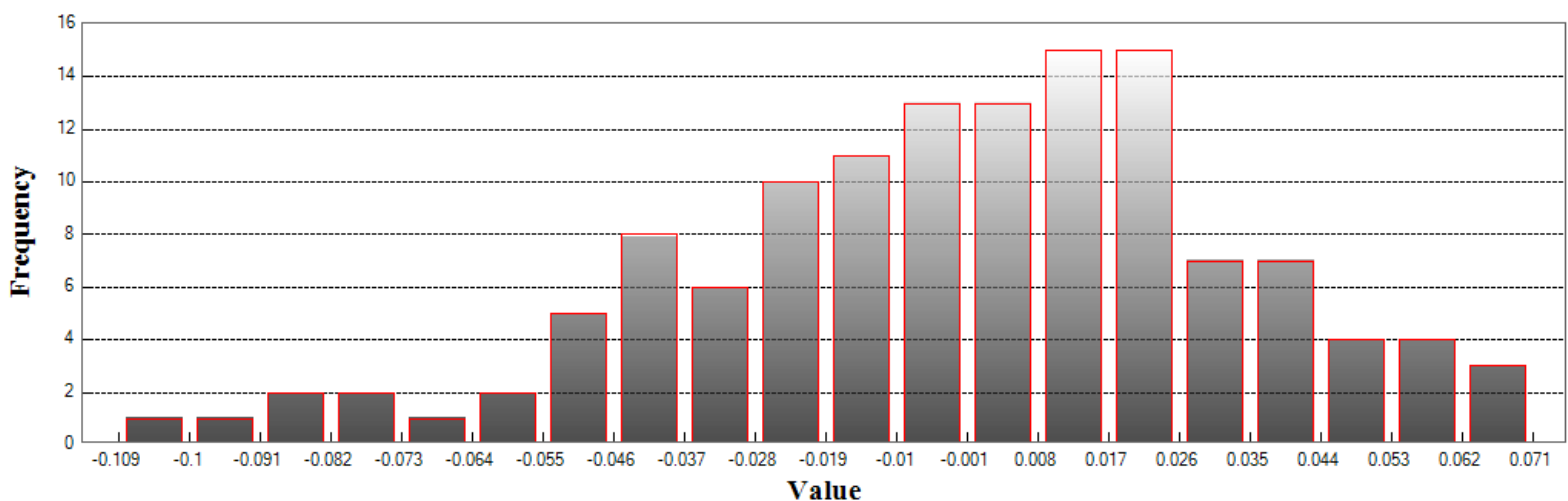
Standard Deviation DZ: 0.035

RMSE Z: 0.035

95% Confidence Level Z: 0.069

Units: Meters

Histogram



Min: -0.11

Max: 0.07

Number Of Bins: 20

Bin Interval: 0.009

DEM (Continued)

Vegetated Vertical Accuracy

LandCover Type: High Vegetation

Minimum DZ: -0.005

Maximum DZ: 0.311

Mean DZ: 0.109

Mean Magnitude DZ: 0.332

Number Observations: 10

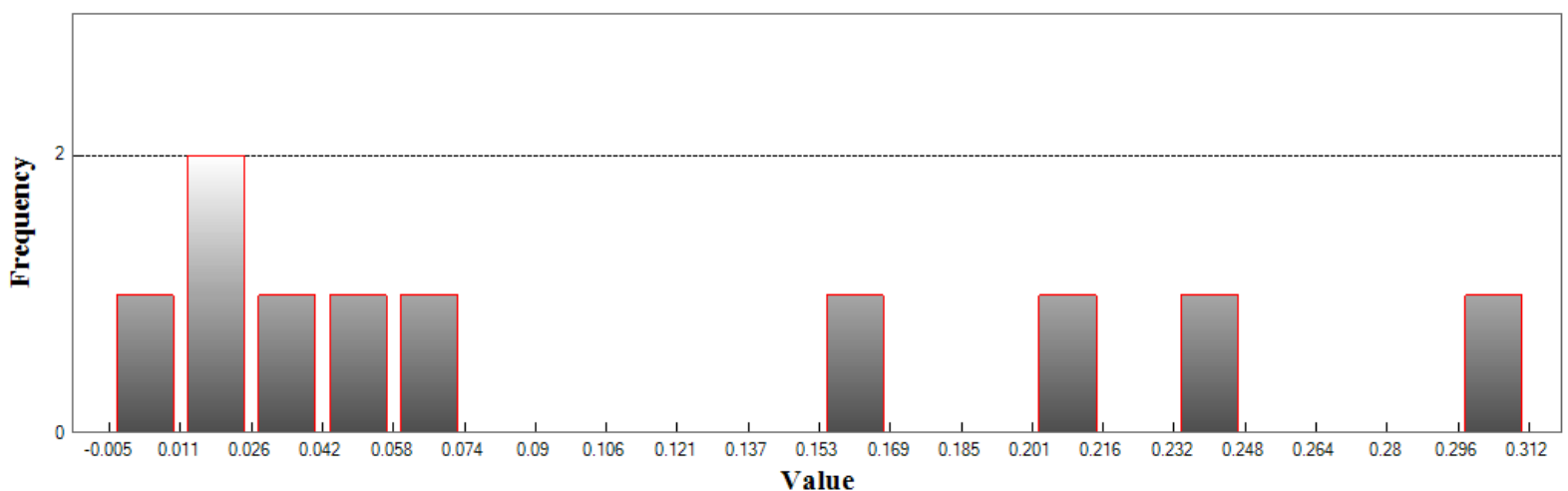
Standard Deviation DZ: 0.112

RMSE Z: 0.152

95th Percentile: 0.311

Units: Meters

Histogram



Min: -0.005

Max: 0.311

Number Of Bins: 20

Bin Interval: 0.016

DEM (Continued)

Vegetated Vertical Accuracy

LandCover Type: Low Vegetation

Minimum DZ: -0.041

Maximum DZ: 0.183

Mean DZ: 0.028

Mean Magnitude DZ: 0.193

Number Observations: 73

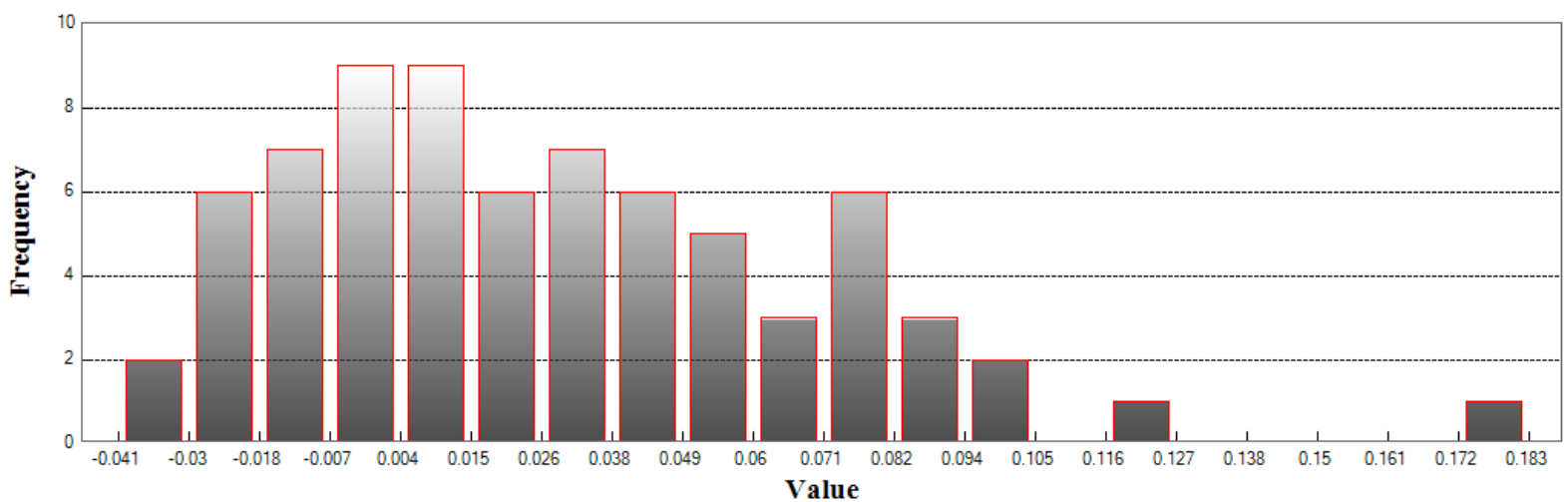
Standard Deviation DZ: 0.042

RMSE Z: 0.05

95th Percentile: 0.091

Units: Meters

Histogram



Min: -0.041

Max: 0.183

Number Of Bins: 20

Bin Interval: 0.011

DEM (Continued)

Vegetated Vertical Accuracy

LandCover Type: Medium Vegetation

Minimum DZ: -0.006

Maximum DZ: 0.239

Mean DZ: 0.072

Mean Magnitude DZ: 0.27

Number Observations: 36

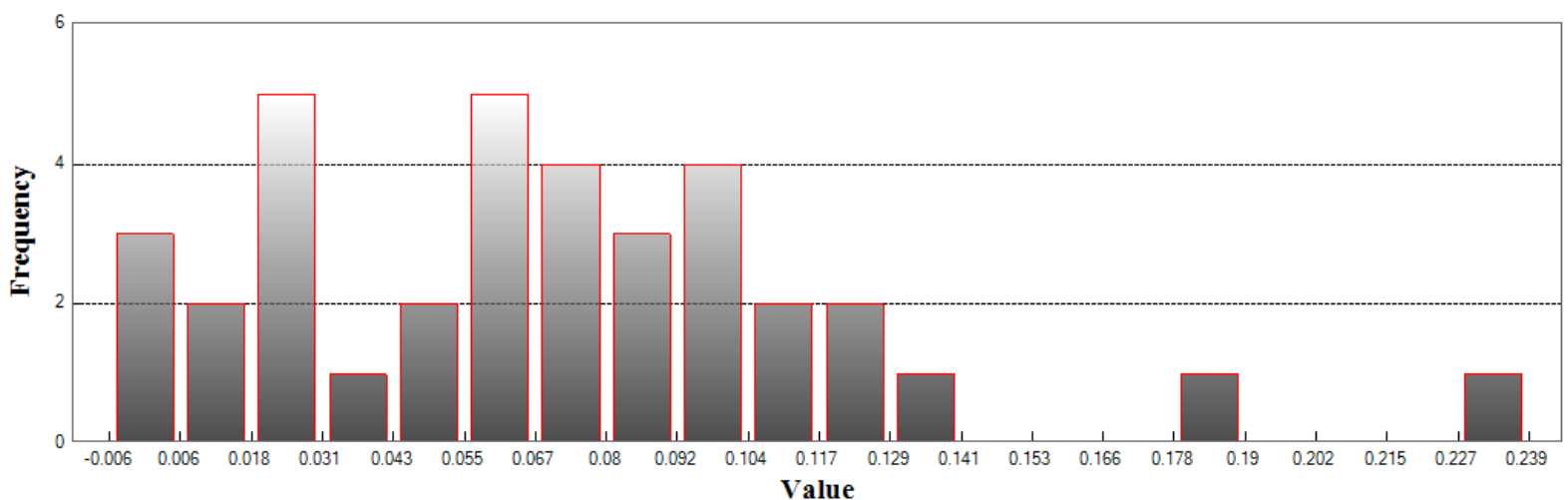
Standard Deviation DZ: 0.052

RMSE Z: 0.089

95th Percentile: 0.14

Units: Meters

Histogram



Min: -0.006

Max: 0.239

Number Of Bins: 20

Bin Interval: 0.012