LiDAR Project Report
FY14 Suwannee River FL

Prepared For:

United States Geological Survey

Prepared By:

Digital Aerial Solutions, LLC

CONTRACT: #G10PC00093
CONTRACTOR: DIGITAL AERIAL SOLUTIONS
TASK ORDER: # G14PD00206

Project Report
LiDAR Collection, Processing, and QA/QC

2014 Suwannee River FL QL2
Task Order G14PD00206

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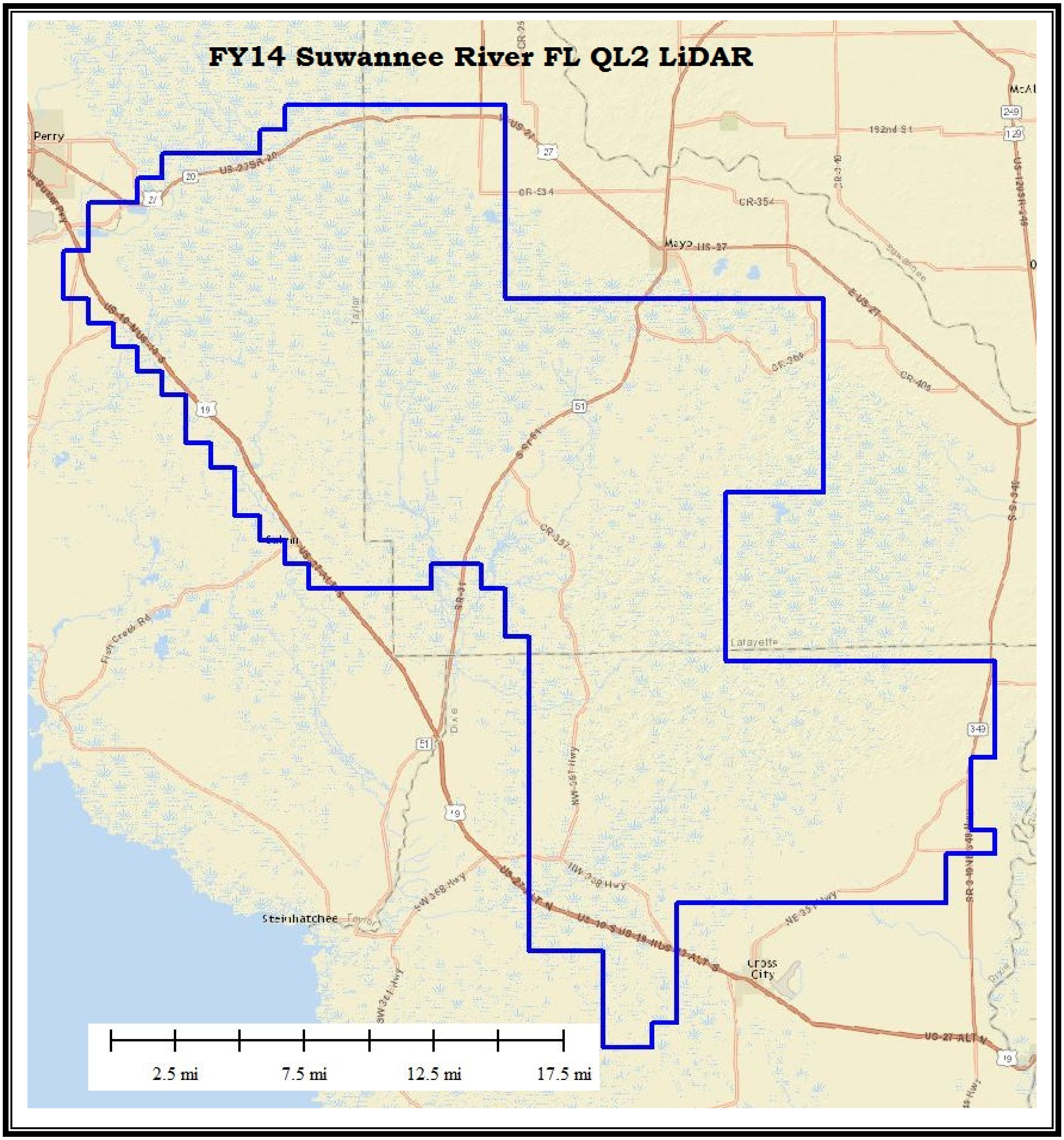
FY14 Suwannee River FL QL2 LiDAR
Perry
Mayo
Lafayette
Steinhatchee
Cross City
2.5 mi
7.5 mi
12.5 mi
17.5 mi

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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 Suwannee River, FL with QL2 Specification. The FY14 Suwannee River survey area encompasses approximately 571 square miles Aerial LiDAR data was collected utilizing an ALS60. The ALS60 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems. LiDAR data collected for the Suwannee River Management survey has a nominal pulse spacing of 0.7 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, and bare-earth DEM tiles. Point cloud deliverables are stored in the LAS version 1.2 format, point data record format 1. The tiling scheme for tiled deliverables is a 5000 feet x 5000 feet grid. Tile number is the appropriate cell number values found in the 2007 Florida state grid index. All deliverables were generated in conformance with the *U.S. Geological Survey National Geospatial Program Guidelines and Base Specifications, Version 1.*

2 Spatial Reference System

The spatial reference of the data is as follows.

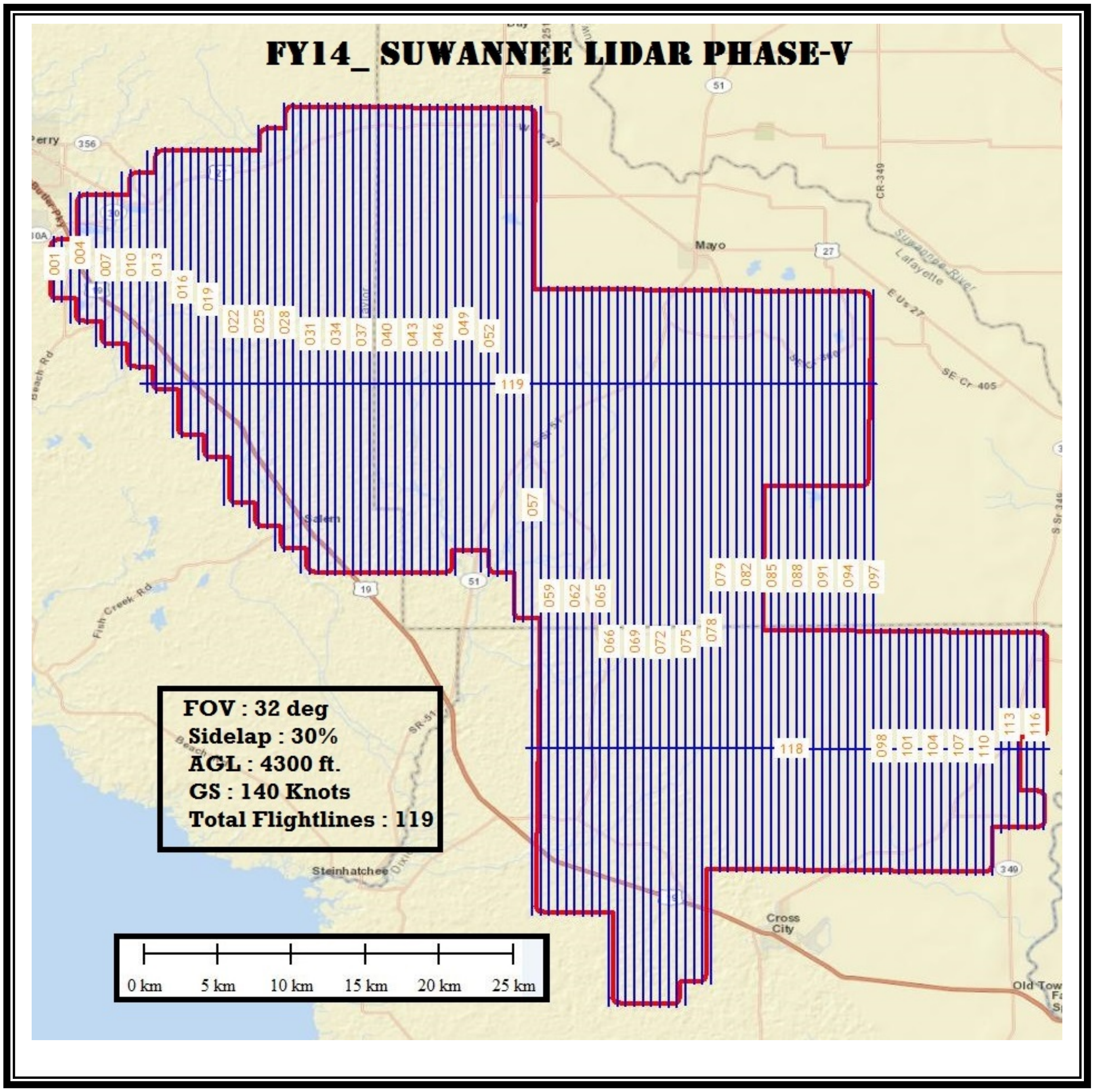
Horizontal Spatial Reference
- Datum: North American Datum of 1983 (National Spatial Reference System 2007)
- Coordinates: Florida State Plane North, U.S. Survey Feet

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 1988 (GEOID09)

3 LiDAR Acquisition

3.1 Survey Area

The FY14 Suwannee River LiDAR survey covers approximately 571 square miles located in north central Florida affecting Taylor, Lafayette and Dixie counties. The flight plan consisted of 119 survey lines and 2 control lines.



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 FY 13 Suwannee River water Management Area 1 LiDAR project are summarized below.

Parameter	Value
Flying Height Above Ground Level	4,300 feet
Nominal Sidelap	30%
Nominal Speed Over Ground	140 knots
Field of View	32°
Laser Rate	132 kHz
Scan Rate	66.2 hz
Maximum Cross Track Spacing	0.96 meters
Maximum Along Track Spacing	1.09 meters
Average Spacing	0.6 meters

3.3 Acquisition Mission

The acquisition mission for the FY 14 Suwannee River LiDAR survey was coordinated to be acquired in 2 week. Collection began on February 19th 2014 and was completed on March 1st, 2014, a complete flight log for the acquisition mission may be found in Appendix A.

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)
C421 – N112MJ	ALS60 – SN6130	x: -0.210, y: -0.060, z: -1.370	x: -0.450, y: -0.159, z: -0.169

In addition, GPS data was collected with ground base stations during the acquisition mission, providing corrections to support differential post-processing of the airborne GPS. One ground base station was setup at an NGS Benchmark (Keyport) as the base of operation. The additional ground base station were selected and place threw the project to ensure complete coverage. Ground GPS observations were collected at a frequency of 2Hz.

4 LiDAR Processing

4.1 Acquisition Post-Processing

Once the acquisition was completed, initial post-processing was performed to generate geo-referenced LiDAR elevation point clouds.

The airborne GPS dataset was differentially corrected using the ground base station GPS datasets collected by DAS in Lecia's IPAS software. IPAS computes the GPS dataset corrections in both forward and reverse chronological sequence, obtaining two solutions for the GPS trajectory. The differences between these two solutions were reviewed to ensure a consistent result, and agree within +/- 3cm. The forward and reverse solutions also show good fit between the two different base stations used in the post-processing.

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 flightline, 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. The LiDAR data collected for the Suwannee Management survey area2 passed these quality control checks.

Swath point clouds were assigned a unique File Source ID within the LAS file format before further processing. Swath files for the FY 14 Suwannee River 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 ALS60 sensor system. Terrasolid's Terramatch software was used to calculate the IMU bore-site and mirror scale parameters for the FY14 Suwannee River LiDAR data. 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. The FY14 Suwannee River survey did not support this requirement, due to the large water area within the survey and control lines. 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. 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. 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 the FY 14 Suwannee River LiDAR project, the control lines were used to determine relative z offset corrections in areas of discernible ground. The base station operated by DAS in the survey area provided for minimal baseline lengths, resulting in generally good z agreement between the survey lines and control lines.

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 maybe found in section 5.1.

4.3 Point Cloud Classification

Georeference information was applied to the swath point could LAS files. Geometrically calibrated swath point clouds were cut into 2007 Florida state grid index, State Plane Zone 5000 feet x 5000 LAS format tiles for point cloud classification and derived product creation. It is important to note that Florida state grid index tiles are non- orthogonal when stored and displayed in a geographic coordinate system. As a result, tiled vector data does not have overlap, but tiled raster data does have overlap to permit seamless display of the data products.

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 – Noise
- Class 9 – Water
- Class 10 – Ignored Ground
- Class 11 – Withheld
- Class 17 – Reserve
- Class 18 – Reserve

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 Terrasolids'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 Florida state grid index State Plane North.

The data collected for the FY14 Suwannee River 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 and the NGP version 13 guidelines. 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 32 bit raster ERDAS .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 Suwannee Management 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.

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.

Horizontal accuracy assessments of LiDAR data require the presence of vertical targets such as buildings within in the survey area. Field check points are surveyed at the corners of the building roofs, and the surveyed locations compared to the estimated corner locations in the LiDAR point cloud. The FY 14 Suwannee Management survey did not present any accessible buildings for use as vertical targets.From the manufacturer's specifications, the estimated horizontal accuracy at one sigma, based on flying height for the project, is between 10cm and 20cm.

Absolute vertical accuracy assessments for the point cloud data are made against ground check point data. For the FY14 Suwannee Management survey, 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 were 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 fundamental vertical accuracy (FVA) of the swath point clouds as described in NDEP Elevation Guidelines Version 1. The FVA of the TIN tested RMSEz 0.089 meters and 0.175 meters at the 95% confidence level in open terrain. FVA of the DEM tested at an RMSEz of 0.083 and 0.170 meters at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix B.

FVA of TIN

$RMSE_Z$ =	0.089	meters
NSSDA=	0.175	meters

FVA of DEM

$RMSE_Z$ =	0.083	meters
NSSDA=	0.170	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 NGP version 1 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 Florida state grid index, State Plane Zone.

Appendix A. Flight Logs

ALS60 LiDAR Flight Log														
Project	FY14_Suwannee_Lidar_PhaseV				ALS60	N6130_090724							Sensor Operator/s	
											-		Bertin Evina-Ze	
Date/Julian:	2/19/2014					Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)				Base PID:	Pilot/s	
Hobbs End	525.4					2-600059224		140				BD2735	MWAZ	
Hobbs ST	521.5			LIFT				TAR ALT AGL (ft):			Flight Plan(s):	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.9							10,010			Seneca	1.500	421C 13RF	KPEO
Lift		Flight Line	Mission Line	UTC time: B:	E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	HDOP	Comments and Conditions:	
C							-	-	149				Static Alignment	
	1	45	140220_014758	1:48	1:55	4,190	180	131	146	10	1.6	1.0	CLEAR	
	2	46	140220_020102	2:00	2:08		0	140	144	11	1.6	0.9	CLEAR	
	3	47	140220_021349	2:13	2:21		180	134	142	14	1.3	0.7	CLEAR	
	4	48	140220_022646	2:26	2:34		0	142	140	14	1.3	0.7	CLEAR	
	5	49	140220_023927	2:39	2:46		180	134	137	14	1.4	0.7	CLEAR	
	6	50	140220_025130	2:51	2:58		0	144	135	14	1.5	0.7	CLEAR	
	7	51	140220_030313	3:03	3:10		180	136	133	14	1.5	0.7	CLEAR	
	8	52	140220_031541	3:15	3:23		0	139	131	14	1.5	0.7	CLEAR	
	9	53	140220_032858	3:29	3:36		180	135	128	15	1.2	0.7	CLEAR	
	10	54	140220_034127	3:41	3:48		0	143	126	14	1.2	0.7	CLEAR	
	11	55	140220_035413	3:54	4:02		180	138	124	13	1.3	0.7	CLEAR	
	12	56	140220_040720	4:07	4:15		0	139	121	11	1.4	0.8	CLEAR	
	13	UL001	140220_042331	4:23	4:26		270	133	120	12	1.3	0.8	X-Strip	
	14	UL002	140220_043136	4:31	4:35		90	140	119	12	1.3	0.8	X-strip	

ALS60 LiDAR Flight Log														
Project	FY14_Suwannee_Lidar_PhaseV				ALS60	N6130_090724							Sensor Operator/s	
											-		Bertin Evina-Ze	
Date/Julian:	2/19/2014					Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)				Base PID:	Pilot/s	
Hobbs End	525.4					2-600059224		140				BD2735	MWAZ	
Hobbs ST	521.5			LIFT B				TAR ALT AGL (ft):			Flight Plan(s):	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.9							10,010			Seneca	1.500	421C 13RF	KPEO
Lift		Flight Line	Mission Line	UTC time: B:	E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	HDOP	Comments and Conditions:	
B							-	-	120				Static Alignment	
	1	24	140219_133549	13:35	13:41	4,215	0	142	117	11	1.4	0.8	CLEAR	
	2	25	140219_134730	13:47	13:54		180	135	115	11	1.4	0.8	CLEAR	
	3	26	140219_135833	13:58	14:04		0	144	113	11	1.4	0.8	CLEAR	
	4	27	140219_140954	14:09	14:16		180	129	111	11	1.5	0.8	CLEAR	
	5	28	140219_142059	14:20	14:28		0	147	109	11	1.6	0.9	CLEAR	
	6	29	140219_143240	14:32	14:40		180	124	107	12	2	1.0	CLEAR	
	7	30	140219_144436	14:44	14:52		0	143	105	11	1.5	0.8	CLEAR	
	8	31	140219_145626	14:56	15:04		180	133	102	11	1.5	0.8	CLEAR	
	9	32	140219_151002	15:09	15:17		0	145	100	11	1.4	0.8	CLEAR	
	10	33	140219_152144	15:21	15:29		180	132	97	12	1.4	0.8	CLEAR	
	11	34	140219_153346	15:33	15:41		0	141	95	13	1.2	0.7	CLEAR	
	12	35	140219_154556	15:46	15:53		180	131	92	13	1.2	0.7	CLEAR	
	13	36	140219_155744	15:57	16:05		0	139	90	12	1.4	0.8	CLEAR	
	14	37	140219_161003	16:10	16:17		180	132	88	11	1.3	0.8	CLEAR	
	15	38	140219_162239	16:22	16:30		0	141	85	10	1.8	1.0	CLEAR	
	16	39	140219_163513	16:35	16:44		180	129	83	10	2.4	1.0	CLEAR	
	17	40	140219_164724	16:47	16:55		0	143	81	9	2.4	1.4	CLEAR	
	18	41	140219_165951	16:59	17:07		180	133	78	9	2.2	1.4	CLEAR	
	19	42	140219_171146	17:11	17:19		0	143	76	10	1.5	1.0	CLEAR	
	20	43	140219_172402	17:24	17:31		180	131	74	10	1.5	1.0	CLEAR	
	21	44	140219_173549	17:35	17:43		0	138	71	10	1.4	0.9	CLEAR	
	22	UL001	140219_174945	17:49	17:56		270	134	69	10	1.4	0.8	X-Strip	

ALS60 LiDAR Flight Log

Project	FY14_Suwannee_Lidar_PhaseV	ALS60	N6130_090724			Sensor Operator/s
					-	Bertin Evina-Ze
Date/Julian:	2/20/2014	Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	535.4	2-600059224		140	BD2735	MWAZ
Hobbs ST	533.5	LIFT A		TAR ALT AGL (ft):	Flight Plan(s): / Base Height:	Aircraft / Airport Idnt:
Flight Time	1.9			4,190	Suwannee / 1.500	421C 13RF / KPEO

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A							-	-	149				Static Alignment
	1	57	140220_143604	14:36	14:48	4,193	0	140	145	10	1.6	0.9	CLEAR
	2	58	140220_145341	14:53	15:06		180	134	141	10	1.6	0.9	CLEAR
	3	59	140220_151152	15:11	15:21		0	141	138	11	1.5	0.9	CLEAR
	4	60	140220_152729	15:27	15:36		180	134	135	12	1.3	0.7	CLEAR
	5	61	140220_154122	15:41	15:51		0	142	132	13	1.3	0.7	CLEAR
	6	UL001	140220_155644	15:56	15:58		90	141	131	12	1.3	0.8	X-Strip
	7	UL002	140220_160126	16:01	16:04		270	142	130	12	1.4	0.8	X-Strip

ALS60 LiDAR Flight Log

Project	FY14_Suwannee_Lidar_PhaseV	ALS60	N6130_090724			Sensor Operator/s
					-	Bertin Evina-Ze
Date/Julian:	2/20/2014	Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	540.2	2-600059224		140	BD2735	MWAZ
Hobbs ST	535.9	LIFT B		TAR ALT AGL (ft):	Flight Plan(s): / Base Height:	Aircraft / Airport Idnt:
Flight Time	4.3			4,190	Suwannee / 1.500	421C 13RF / KPEO

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
B							-	-	130				Static Alignment
	1	62	140221_005216	:52	1:02	4,160	0	144	127	15	1.2	0.8	CLEAR
	2	63	140221_010741	1:07	1:18		180	131	124	15	1.1	0.7	CLEAR
	3	64	140221_012304	1:23	1:32		0	140	121	15	1.3	0.8	CLEAR
	4	65	140221_013855	1:39	1:50		180	124	118	13	1.6	0.9	CLEAR
	5	66	140221_015615	1:56	2:07		0	143	114	14	1.6	0.9	CLEAR
	6	67	140221_021250	2:12	2:24		180	128	110	16	1.3	0.7	CLEAR
	7	68	140221_022945	2:29	2:40		0	140	107	14	1.6	0.7	CLEAR
	8	69	140221_024604	2:45	2:57		180	129	104	15	1.5	0.7	CLEAR
	9	70	140221_030227	3:02	3:13		0	141	100	14	1.5	0.7	CLEAR
	10	71	140221_031854	3:18	3:30		180	133	96	14	1.4	0.7	CLEAR
	11	72	140221_033510	3:35	3:46		0	142	93	13	1.4	0.8	CLEAR
	12	73	140221_035150	3:51	4:03		180	134	89	12	1.7	0.9	CLEAR
	13	74	140221_040753	4:08	4:19		0	141	86	12	1.2	0.8	CLEAR
	14	75	140221_042329	4:23	4:34		180	137	83	12	1.2	0.8	CLEAR
	15	UL001	140221_044013	4:40	4:44		270	141	81	11	1.4	0.9	X-Strip
	16	UL002	140221_044859	4:49	4:53		90	141	78	11	1.4	0.9	X-Strip

ALS60 LiDAR Flight Log

Project	FY14_Suwannee_Lidar_PhaseV		ALS60	N6130_090724					Sensor Operator/s	
							-		Bertin Evina-Ze	
Date/Julian:	3/1/2014		Mem Drive MM60		Int. Time:	TAR AIRSPD (KNTS)		Base PID:	Pilot/s	
Hobbs End	525.4		2-600059224			140		BD2735	MWAZ	
Hobbs ST	521.5	LIFT A				TAR ALT AGL (ft):	Flight Plan(s):	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.9					10,010	Seneca	1.500	421C 13RF	KPEO

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A							-	-	139				Static Alignment
	1	~~76~~	~~140301_191353~~	~~19:14~~	~~19:24~~	~~4,215~~	~~0~~	~~140~~	~~136~~	~~11~~	~~1.7~~	~~1.0~~	~~CLEAR(DO NOT USE)~~
	2	77	140301_192901	19:29	19:39		180	142	133	11	1.4	0.8	CLEAR
	3	78	140301_194405	19:44	19:55		0	137	130	11	1.5	0.9	CLEAR
	4	79	140301_195901	19:59	20:08		180	139	127	11	1.2	0.8	CLEAR
	5	80	140301_201221	20:12	20:21		0	142	124	11	1.9	1.0	CLEAR
	6	81	140301_202454	20:24	20:34		180	142	121	12	1.9	1.0	CLEAR
	7	82	140301_203803	20:38	20:47		0	138	119	11	1.6	0.8	CLEAR
	8	83	140301_205051	20:50	21:00		180	140	116	11	1.4	0.8	CLEAR
	9	84	140301_210358	21:04	21:13		0	138	113	11	1.4	0.8	CLEAR
	10	85	140301_211644	21:16	21:25		180	143	110	12	1.3	0.8	CLEAR
	11	86	140301_213018	21:30	21:39		0	138	107	13	2.2	1.1	CLEAR
	12	87	140301_214257	21:43	21:52		180	144	105	13	1.7	1.0	CLEAR
	13	88	140301_215551	21:55	22:05		0	135	102	12	1.8	0.9	CLEAR
	14	89	140301_220848	22:08	22:18		180	141	99	11	1.8	0.9	CLEAR
	15	90	140301_222128	22:21	22:30		0	138	96	10	1.5	0.7	CLEAR
	16	91	140301_223432	22:34	22:43		180	138	93	10	1.8	0.7	CLEAR
	17	92	140301_224731	22:47	22:56		0	142	91	9	1.4	0.7	CLEAR
	18	93	140301_230010	23:00	23:09		180	143	88	9	1.5	0.7	CLEAR
	19	94	140301_231230	23:12	23:21		0	140	85	10	1.7	0.7	CLEAR
	20	119	140301_232620	23:26	23:30		270	138	84	10	1.7	0.7	X-Strip
	21	119	140301_233228	23:32	23:36		90	136	82	10	1.4	0.7	X-Strip
	22	76	140301_234409	23:44	23:55		180	140	79	10	1.4	0.7	REFLY

ALS60 LiDAR Flight Log

Project	FY14_Suwannee_Lidar_PhaseV		ALS60	N6130_090724					Sensor Operator/s	
							-		Bertin Evina-Ze	
Date/Julian:	3/1/2014		Mem Drive MM60		Int. Time:	TAR AIRSPD (KNTS)		Base PID:	Pilot/s	
Hobbs End	525.4		2-600059224			140		BD2735	MWAZ	
Hobbs ST	521.5	LIFT B				TAR ALT AGL (ft):	Flight Plan(s):	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.9					4,190	Suwannee	1.500	421C 13RF	KPEO

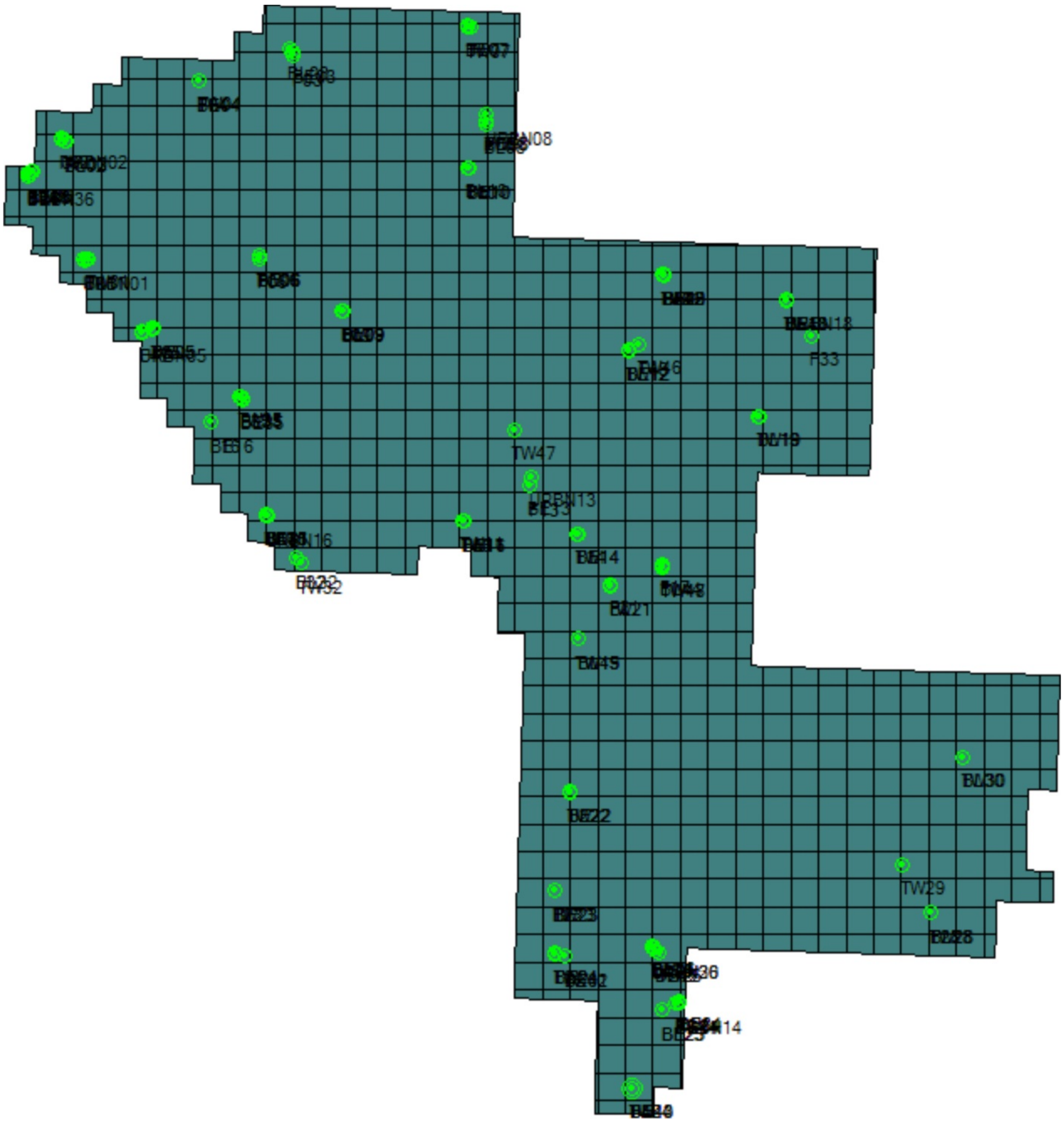
Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
B							-	-	146				Static Alignment
	1	95	140302_011301	1:13	1:22	4,190	0	140	143	13	1.3	0.8	CLEAR
	2	96	140302_012559	1:26	1:35		180	141	142	13	1.6	0.8	CLEAR
	3	97	140302_013847	1:38	1:47		0	144	137	14	1.3	0.8	CLEAR
	4	98	140302_015433	1:54	1:58		180	137	135	13	1.4	0.7	CLEAR
	5	99	140302_020220	2:02	2:06		0	138	134	13	1.5	0.7	CLEAR
	6	100	140302_020958	2:10	2:13		180	139	133	13	1.5	0.7	CLEAR
	7	101	140302_021727	2:17	2:21		0	139	132	14	1.4	0.8	CLEAR
	8	102	140302_022449	2:24	2:28		180	136	131	14	1.6	0.8	CLEAR
	9	103	140302_023217	2:32	2:36		0	138	130	14	1.4	0.8	CLEAR
	10	104	140302_023933	2:39	2:43		180	140	129	14	1.4	0.7	CLEAR
	11	105	140302_024646	2:46	2:50		0	139	128	15	1.5	0.6	CLEAR
	12	106	140302_025420	2:54	2:58		180	140	127	15	1.2	0.6	CLEAR
	13	107	140302_030136	3:01	3:05		0	138	126	14	1.2	0.6	CLEAR
	14	108	140302_030846	3:08	3:11		180	134	125	13	1.3	0.7	CLEAR
	15	109	140302_031558	3:16	3:20		0	142	124	13	1.5	0.7	CLEAR
	16	110	140302_032308	3:23	3:27		180	143	123	13	1.4	0.7	CLEAR
	17	111	140302_033019	3:30	3:34		0	141	122	12	1.4	0.8	CLEAR
	18	112	140302_033724	3:37	3:40		180	139	121	13	1.3	0.8	CLEAR
	19	113	140302_034404	3:44	3:47		0	140	120	12	1.3	0.8	CLEAR
	20	114	140302_035028	3:50	3:53		180	141	119	12	1.5	0.8	CLEAR
	21	115	140302_035700	3:57	4:00		0	139	118	11	1.5	0.9	CLEAR
	22	116	140302_040337	4:03	4:06		180	142	117	12	1.3	0.8	CLEAR
	23	117	140302_041035	4:10	4:13		0	140	116	11	1.4	0.9	CLEAR
	24	118	140302_041843	4:18	4:22		270	141	115	11	1.4	0.9	X-Strip
	25	118	140302_042507	4:25	4:29		90	135	114	11	1.4	0.9	X-Strip

ALS60 LiDAR Flight Log

Project	FY14_Suwannee_Lidar_PhaseV		ALS60 N6130_090724					Sensor Operator/s	
						-		Bertin Evina-Ze	
Date/Julian:	2/19/2014		Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)		Base PID:	Pilot/s	
Hobbs End	525.4		2-600059224		140		BD2735	MWAZ	
Hobbs ST	521.5	LIFT A			TAR ALT AGL (ft):	Flight Plan(s):	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.9				4,210	Suwannee	1.500	421C 13RF	KPEO

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A							-	-	148				Static Alignment
	1	1	140219_080740	8:07	8:08	4,215	0	136	147	9	1.8	0.9	CLEAR
	2	2	140219_081300	8:13	8:14		180	124	146	10	1.8	1.0	CLEAR
	3	3	140219_081905	8:19	8:21		0	138	145	10	1.8	1.0	CLEAR
	4	4	140219_082542	8:25	8:28		180	125	144	9	1.8	0.9	CLEAR
	5	5	140219_083202	8:32	8:34		0	135	143	9	1.8	0.9	CLEAR
	6	6	140219_083910	8:39	8:42		180	122	142	9	1.5	0.9	CLEAR
	7	7	140219_084551	8:45	8:48		0	139	141	10	1.5	0.8	CLEAR
	8	8	140219_085327	8:53	8:56		180	122	140	10	2.2	0.8	CLEAR
	9	9	140219_090041	9:00	9:03		0	135	139	8	2.2	1.1	CLEAR
	10	10	140219_090833	9:08	9:12		180	123	138	9	1.6	1.2	CLEAR
	11	11	140219_093726	9:37	9:40		0	138	137	9	1.4	1.0	CLEAR
	12	12	140219_094514	9:45	9:44		180	122	136	9	1.5	0.9	CLEAR
	13	13	140219_095338	9:53	9:57		0	139	135	10	1.8	0.8	CLEAR
	14	14	140219_100256	10:02	10:07		180	123	134	9	1.9	0.8	CLEAR
	15	15	140219_101141	10:11	10:16		0	137	133	9	1.5	1.1	CLEAR
	16	16	140219_102059	10:20	19:26		180	128	132	10	1.5	1.0	CLEAR
	17	17	140219_103012	10:30	19:26		0	144	131	10	1.6	1.1	CLEAR
	18	18	140219_103954	10:39	10:46		180	130	130	10	1.2	0.8	CLEAR
	19	19	140219_104928	10:49	10:54		0	139	129	12	1.4	0.8	CLEAR
	20	20	140219_105950	10:59	11:05		180	122	128	12	1.5	0.8	CLEAR
	21	21	140219_111037	11:10	11:16		0	139	127	12	1.5	0.8	CLEAR
	22	22	140219_112122	11:21	11:27		180	126	126	12	1.4	0.8	CLEAR
	23	23	140219_113243	11:32	11:38		0	143	125	12	1.4	0.8	CLEAR
	24	UL001	140219_114511	11:45	11:48		90	135	120	11	1.5	0.8	X-Strip

Appendix B. Vertical Accuracy Calculations



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LiDAR Accuracy Assessment Summary

LC Type	# of Points	FVA	SVA	C
LAS				
ALL	140			0.214
Bare Earth	31	0.175		
Brush Land	30		0.213	
Forested	30		0.255	
Tall Weed	38		0.213	
Urban	11		0.119	
Total	140			
DEM				
ALL	140			0.218
Bare Earth	31	0.170		
Brush Land	30		0.211	
Forested	30		0.243	
Tall Weed	38		0.201	
Urban	11		0.124	
Total	140			

Units: Meters

PID	Survey X	Survey Y	Survey Z	Z DEM	Z LAS	ΔZ DEM	ΔZ LAS	LC Type
BE02	283225.207	3284820.669	10.615	10.710	10.714	0.095	0.099	Bare Earth
BE03	268444.540	3333948.562	27.243	27.199	27.194	-0.044	-0.049	Bare Earth
BE04	263288.693	3332402.429	23.992	24.050	24.055	0.058	0.063	Bare Earth
BE05	260783.346	3318961.042	17.118	17.110	17.117	-0.008	-0.001	Bare Earth
BE06	266571.146	3322894.732	20.474	20.458	20.476	-0.016	0.002	Bare Earth
BE07	277898.344	3335412.835	25.191	25.272	25.258	0.081	0.067	Bare Earth
BE08	278916.906	3330225.971	24.559	24.602	24.591	0.043	0.032	Bare Earth
BE09	271146.118	3319904.199	20.947	20.979	20.944	0.032	-0.003	Bare Earth
BE10	277955.284	3327653.936	25.746	25.681	25.687	-0.065	-0.059	Bare Earth
BE11	277656.091	3308486.376	10.877	10.837	10.829	-0.040	-0.048	Bare Earth
BE12	286659.128	3317746.122	22.759	22.767	22.767	0.008	0.008	Bare Earth
BE13	281290.909	3310440.163	15.291	15.222	15.225	-0.069	-0.066	Bare Earth
BE14	283903.673	3307790.946	15.468	15.367	15.326	-0.101	-0.142	Bare Earth
BE16	263983.297	3313848.000	15.858	15.864	15.851	0.006	-0.007	Bare Earth
BE18	295241.383	3320463.432	24.428	24.516	24.524	0.088	0.096	Bare Earth
BE20	288552.267	3321841.304	24.272	24.135	24.134	-0.137	-0.138	Bare Earth
BE22	283468.137	3293762.624	11.833	11.719	11.715	-0.114	-0.118	Bare Earth
BE23	282667.662	3288368.398	11.688	11.544	11.542	-0.144	-0.146	Bare Earth
BE24	282695.913	3284999.636	11.741	11.652	11.669	-0.089	-0.072	Bare Earth
BE25	288510.815	3281896.585	12.068	11.937	11.933	-0.131	-0.135	Bare Earth
BE26	287994.520	3285413.941	12.979	12.839	12.849	-0.140	-0.130	Bare Earth
BE31	266938.067	3308829.431	12.222	12.138	12.139	-0.084	-0.083	Bare Earth
BE34	289417.999	3282394.787	13.105	13.259	13.270	0.154	0.165	Bare Earth
BE35	265637.988	3315082.563	15.946	15.997	15.989	0.051	0.043	Bare Earth
BE36	254014.075	3327350.839	13.191	13.121	13.103	-0.070	-0.088	Bare Earth
BE40	286854.371	3277654.420	10.449	10.323	10.333	-0.126	-0.116	Bare Earth
BE41	289272.331	3282266.195	12.354	12.377	12.393	0.023	0.039	Bare Earth
BE42	288170.710	3285082.674	12.896	12.770	12.782	-0.126	-0.114	Bare Earth
BE43	254014.077	3327350.836	13.200	13.121	13.104	-0.079	-0.096	Bare Earth
BE44	289242.052	3282281.823	12.169	12.239	12.254	0.070	0.085	Bare Earth
BE45	266939.058	3308844.358	12.295	12.250	12.250	-0.045	-0.045	Bare Earth
BL01	257132.578	3322649.870	16.201	16.348	16.366	0.147	0.165	Brush Land
BL02	256067.644	3329101.021	16.159	16.274	16.289	0.115	0.130	Brush Land
BL03	268222.368	3334126.427	27.074	27.074	27.062	0.000	-0.012	Brush Land
BL05	288609.985	3321864.472	24.293	24.340	24.335	0.047	0.042	Brush Land
BL06	266581.246	3322891.839	20.643	20.686	20.637	0.043	-0.006	Brush Land
BL08	278915.139	3330058.668	25.374	25.329	25.324	-0.045	-0.050	Brush Land
BL09	271174.880	3319868.699	21.183	21.104	21.080	-0.079	-0.103	Brush Land
BL10	277909.134	3327666.441	25.692	25.754	25.774	0.062	0.082	Brush Land

BL11	277702.693	3308488.402	10.149	10.241	10.246	0.092	0.097	Brush Land
BL12	286665.841	3317763.953	22.440	22.405	22.415	-0.035	-0.025	Brush Land
BL15	283972.379	3302085.160	13.527	13.476	13.467	-0.051	-0.060	Brush Land
BL16	267011.842	3308772.267	12.426	12.395	12.389	-0.031	-0.037	Brush Land
BL18	295285.164	3320497.870	23.401	23.464	23.437	0.063	0.036	Brush Land
BL19	293773.113	3314186.522	20.816	20.949	20.926	0.133	0.110	Brush Land
BL20	288615.168	3321874.744	24.387	24.176	24.181	-0.211	-0.206	Brush Land
BL21	285681.421	3305005.585	17.069	16.974	16.953	-0.095	-0.116	Brush Land
BL22	283470.723	3293766.604	11.686	11.566	11.577	-0.120	-0.109	Brush Land
BL23	282633.189	3288367.305	11.230	11.050	11.090	-0.180	-0.140	Brush Land
BL24	286838.615	3277667.831	9.912	10.156	10.140	0.244	0.228	Brush Land
BL25	288525.510	3281885.690	11.220	11.144	11.120	-0.076	-0.100	Brush Land
BL26	287971.270	3285344.092	12.264	12.176	12.113	-0.088	-0.151	Brush Land
BL28	303119.739	3287193.744	14.044	14.243	14.233	0.199	0.189	Brush Land
BL30	304882.878	3295626.380	16.252	16.463	16.470	0.211	0.218	Brush Land
BL31	266973.237	3308851.897	12.136	12.032	12.038	-0.104	-0.098	Brush Land
BL32	268630.244	3306457.817	10.319	10.432	10.386	0.113	0.067	Brush Land
BL35	265636.651	3315153.056	16.255	16.172	16.183	-0.083	-0.072	Brush Land
BL36	254226.311	3327432.374	13.278	13.396	13.416	0.118	0.138	Brush Land
BL41	254005.281	3327236.873	14.067	14.185	14.188	0.118	0.121	Brush Land
BL42	288538.042	3321897.601	24.730	24.660	24.663	-0.070	-0.067	Brush Land
BL44	288480.615	3306047.542	17.992	17.893	17.886	-0.099	-0.106	Brush Land
F01	257271.077	3322710.484	14.993	15.148	15.133	0.155	0.140	Forested
F02	255814.377	3329275.761	16.118	16.011	16.016	-0.107	-0.102	Forested
F03	268442.362	3333753.804	27.280	27.045	27.053	-0.235	-0.227	Forested
F04	263330.396	3332374.143	24.350	24.244	24.235	-0.106	-0.115	Forested
F05	260815.411	3318952.774	17.418	17.245	17.272	-0.173	-0.146	Forested
F06	266578.346	3322760.469	19.548	19.618	19.626	0.070	0.078	Forested
F07	278106.547	3335350.614	25.619	25.693	25.706	0.074	0.087	Forested
F08	278930.935	3330232.785	24.683	24.763	24.738	0.080	0.055	Forested
F09	271139.618	3319895.109	20.823	21.031	21.016	0.208	0.193	Forested
F10	277941.947	3327642.125	25.702	25.603	25.572	-0.099	-0.130	Forested
F13	281316.648	3310400.253	12.853	12.988	12.967	0.135	0.114	Forested
F14	283870.334	3307762.326	15.511	15.445	15.442	-0.066	-0.069	Forested
F16	263948.736	3313840.340	15.456	15.464	15.445	0.008	-0.011	Forested
F17	288484.431	3306116.514	17.665	17.635	17.635	-0.030	-0.030	Forested
F21	285690.830	3305044.030	16.754	17.098	17.106	0.344	0.352	Forested
F22	283509.458	3293730.541	11.937	11.771	11.771	-0.166	-0.166	Forested
F23	282649.124	3288362.421	11.389	11.358	11.353	-0.031	-0.036	Forested
F24	282702.155	3284974.746	10.853	10.733	10.736	-0.120	-0.117	Forested
F28	303128.056	3287214.000	14.035	14.252	14.228	0.217	0.193	Forested

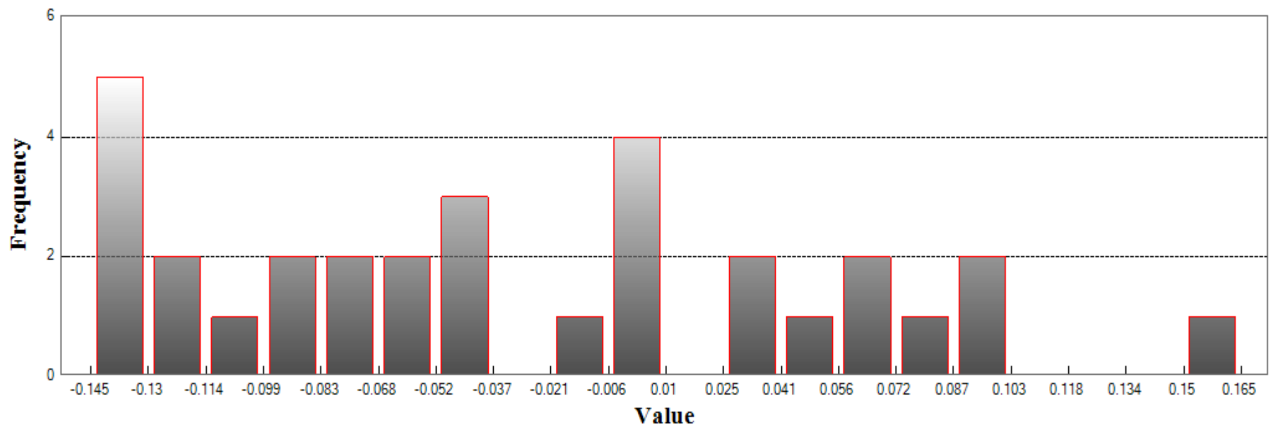
F31	266963.673	3308821.347	12.234	12.198	12.199	-0.036	-0.035	Forested
F32	268624.048	3306452.402	10.692	10.444	10.446	-0.248	-0.246	Forested
F33	296590.684	3318550.944	22.893	22.949	22.952	0.056	0.059	Forested
F34	289394.265	3282341.805	12.710	12.865	12.848	0.155	0.138	Forested
F35	265617.737	3315226.301	15.968	16.063	16.091	0.095	0.123	Forested
F36	254128.668	3327333.265	13.095	13.147	13.147	0.052	0.052	Forested
F40	288553.688	3321824.338	23.957	23.910	23.923	-0.047	-0.034	Forested
F42	286881.593	3277653.798	10.291	10.053	10.028	-0.238	-0.263	Forested
F46	277718.594	3308486.520	10.275	10.410	10.408	0.135	0.133	Forested
F47	260164.927	3318756.106	16.578	16.490	16.542	-0.088	-0.036	Forested
F48	287243.641	3318064.299	22.464	22.383	22.372	-0.081	-0.092	Forested
TW01	257207.953	3322752.292	15.085	15.170	15.144	0.085	0.059	Tall Weed
TW02	256006.067	3329129.674	16.190	16.276	16.268	0.086	0.078	Tall Weed
TW04	263336.078	3332440.435	24.038	24.201	24.163	0.163	0.125	Tall Weed
TW05	260764.031	3318927.833	16.848	16.864	16.864	0.016	0.016	Tall Weed
TW06	266551.355	3322877.996	20.450	20.417	20.420	-0.033	-0.030	Tall Weed
TW07	277922.196	3335323.537	24.873	24.952	24.933	0.079	0.060	Tall Weed
TW08	278919.227	3330218.902	24.716	24.848	24.772	0.132	0.056	Tall Weed
TW09	271098.836	3319922.557	20.676	20.756	20.728	0.080	0.052	Tall Weed
TW10	277960.190	3327658.762	25.296	25.470	25.510	0.174	0.214	Tall Weed
TW11	277634.852	3308490.648	10.216	10.397	10.414	0.181	0.198	Tall Weed
TW12	286640.518	3317784.977	22.632	22.513	22.440	-0.119	-0.192	Tall Weed
TW14	283903.207	3307761.786	15.365	15.277	15.275	-0.088	-0.090	Tall Weed
TW15	283908.318	3302064.710	13.656	13.519	13.500	-0.137	-0.156	Tall Weed
TW16	277687.208	3308487.702	10.376	10.492	10.497	0.116	0.121	Tall Weed
TW17	288506.364	3305944.411	17.820	17.832	17.809	0.012	-0.011	Tall Weed
TW19	293722.786	3314192.452	20.562	20.759	20.744	0.197	0.182	Tall Weed
TW21	285661.581	3304972.325	17.207	17.080	17.096	-0.127	-0.111	Tall Weed
TW22	283480.966	3293745.570	12.263	12.115	12.153	-0.148	-0.110	Tall Weed
TW23	282678.278	3288371.949	11.454	11.444	11.409	-0.010	-0.045	Tall Weed
TW24	282679.634	3284960.148	10.915	10.788	10.818	-0.127	-0.097	Tall Weed
TW26	288344.791	3285073.117	12.601	12.458	12.452	-0.143	-0.149	Tall Weed
TW28	303146.854	3287191.107	13.998	14.224	14.214	0.226	0.216	Tall Weed
TW29	301560.398	3289777.281	14.624	14.810	14.808	0.186	0.184	Tall Weed
TW30	304863.457	3295650.916	16.489	16.740	16.702	0.251	0.213	Tall Weed
TW31	266970.817	3308797.512	12.177	12.276	12.256	0.099	0.079	Tall Weed
TW32	268844.584	3306177.072	10.453	10.552	10.577	0.099	0.124	Tall Weed
TW34	289388.470	3282325.339	12.642	12.819	12.824	0.177	0.182	Tall Weed
TW35	265542.498	3315280.708	16.397	16.314	16.320	-0.083	-0.077	Tall Weed
TW36	254184.638	3327435.812	13.459	13.619	13.631	0.160	0.172	Tall Weed
TW40	295250.862	3320450.403	24.458	24.586	24.568	0.128	0.110	Tall Weed

TW41	283227.218	3284827.956	10.468	10.562	10.581	0.094	0.113	Tall Weed
TW42	288558.617	3321839.925	24.101	24.062	24.035	-0.039	-0.066	Tall Weed
TW43	286829.758	3277650.998	10.086	9.997	10.050	-0.089	-0.036	Tall Weed
TW44	287991.422	3285326.652	12.521	12.364	12.355	-0.157	-0.166	Tall Weed
TW46	287232.882	3318101.923	23.057	23.052	23.050	-0.005	-0.007	Tall Weed
TW47	280438.324	3313439.365	17.956	17.990	17.989	0.034	0.033	Tall Weed
TW48	288506.394	3305944.414	17.803	17.832	17.813	0.029	0.010	Tall Weed
TW49	283908.554	3302064.831	13.444	13.519	13.474	0.075	0.030	Tall Weed
URBN01	257024.513	3322705.316	16.742	16.842	16.845	0.100	0.103	Urban
URBN02	255835.271	3329246.137	15.856	15.934	15.927	0.078	0.071	Urban
URBN05	260185.699	3318763.694	16.516	16.599	16.600	0.083	0.084	Urban
URBN08	278932.536	3330557.386	25.295	25.377	25.387	0.082	0.092	Urban
URBN13	281343.202	3310894.072	15.591	15.520	15.543	-0.071	-0.048	Urban
URBN14	289241.112	3282280.847	12.151	12.229	12.235	0.078	0.084	Urban
URBN16	266981.107	3308725.844	12.411	12.341	12.329	-0.070	-0.082	Urban
URBN18	295281.530	3320512.889	23.570	23.548	23.558	-0.022	-0.012	Urban
URBN26	288009.092	3285297.927	13.044	12.963	12.962	-0.081	-0.082	Urban
URBN30	288010.595	3285289.089	12.998	12.889	12.899	-0.109	-0.099	Urban
URBN36	254000.206	3327246.257	14.110	14.248	14.245	0.138	0.135	Urban

Fundamental Vertical Accuracy - LAS

LandCover Type: Bare Earth
Minimum DZ: -0.146
Maximum DZ: 0.165
Mean DZ: -0.031
Mean Magnitude DZ: 0.276
Number Observations: 31
Standard Deviation DZ: 0.085
RMSE Z: 0.089
95% Confidence Level Z: 0.175
Units: Meters

Histogram



Min: -0.146
Max: 0.165
Number Of Bins: 20
Bin Interval: 0.016

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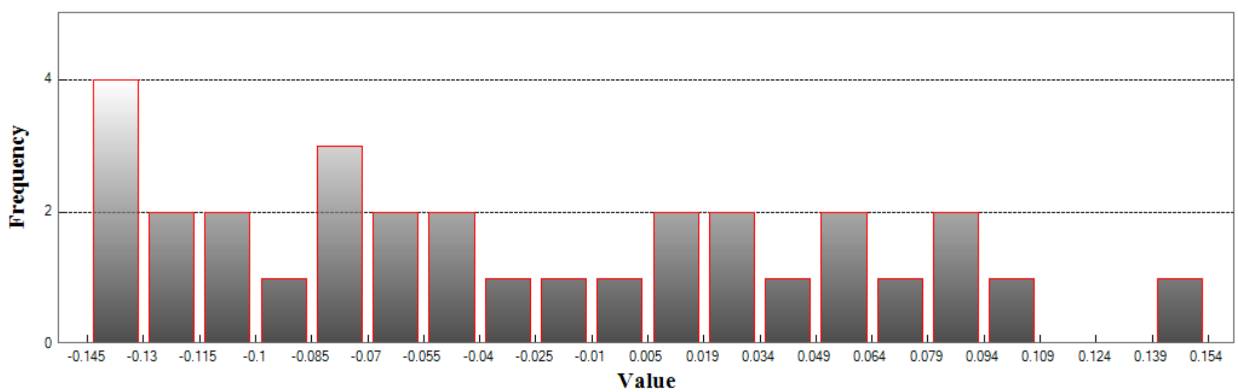
Fundamental Vertical Accuracy – DEM

Land Cover Type: Bare Earth
Minimum DZ: -0. 144
Maximum DZ: 0. 154
Mean DZ: -0.03
Mean Magnitude DZ: 0.275
Number Observations: 31
Standard Deviation DZ: 0.083
RMSE Z: 0.087
95% Confidence Level Z: 0.17
Units: Meters



Min: -0.144
Max: 0.154
Number Of Bins: 20
Bin Interval: 0.015

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Supplemental Vertical Accuracy - Brush land	
LAS	DEM
Land Cover Type: Brush land Minimum DZ: -0.206 Maximum DZ: 0.228 Mean DZ: 0.006 Mean Magnitude DZ: 0.32 Number Observations: 30 Standard Deviation DZ: 0.12 RMSE Z: 0.118 95th Percentile: 0.213 Units: Meters	Land Cover Type: Brush land Minimum DZ: -0.211 Maximum DZ: 0.244 Mean DZ: 0.011 Mean Magnitude DZ: 0.32 Number Observations: 30 Standard Deviation DZ: 0.119 RMSE Z: 0.118 95th Percentile: 0.211 Units: Meters

Supplemental Vertical Accuracy - Forested	
LAS	DEM
Land Cover Type: Forested Minimum DZ: -0.263 Maximum DZ: 0.352 Mean DZ: 0.005 Mean Magnitude DZ: 0.345 Number Observations: 30 Standard Deviation DZ: 0.145 RMSE Z: 0.143 95th Percentile: 0.255 Units: Meters	Land Cover Type: Forested Minimum DZ: -0.248 Maximum DZ: 0.344 Mean DZ: -0.003 Mean Magnitude DZ: 0.349 Number Observations: 30 Standard Deviation DZ: 0.147 RMSE Z: 0.145 95th Percentile: 0.243 Units: Meters

Supplemental Vertical Accuracy - Tall weeds	
LAS	DEM
Land Cover Type: Tall weeds Minimum DZ: -0.192 Maximum DZ: 0.216 Mean DZ: 0.034 Mean Magnitude DZ: 0.323 Number Observations: 38 Standard Deviation DZ: 0.12 RMSE Z: 0.123 95th Percentile: 0.213 Units: Meters	Land Cover Type: Tall weeds Minimum DZ: -0.157 Maximum DZ: 0.251 Mean DZ: 0.041 Mean Magnitude DZ: 0.332 Number Observations: 38 Standard Deviation DZ: 0.121 RMSE Z: 0.126 95th Percentile: 0.201 Units: Meters

Supplemental Vertical Accuracy - URBAN	
LAS	DEM
LandCover Type: URBAN Minimum DZ: -0.099 Maximum DZ: 0.135 Mean DZ: 0.022 Mean Magnitude DZ: 0.285 Number Observations: 11 Standard Deviation DZ: 0.088 RMSE Z: 0.086 95th Percentile: 0.119 Units: Meters	LandCover Type: URBAN Minimum DZ: -0.109 Maximum DZ: 0.138 Mean DZ: 0.019 Mean Magnitude DZ: 0.288 Number Observations: 11 Standard Deviation DZ: 0.089 RMSE Z: 0.089 95th Percentile: 0.124 Units: Meters

Consolidated Vertical Accuracy	
LAS	DEM
LandCover Type: URBAN Minimum DZ: -0.263 Maximum DZ: 0.352 Mean DZ: 0.004 Mean Magnitude DZ: 0.315 Number Observations: 140 Standard Deviation DZ: 0.118 RMSE Z: 0.117 95th Percentile: 0.214 Units: Meters	LandCover Type: ALL Minimum DZ: -0.248 Maximum DZ: 0.344 Mean DZ: 0.008 Mean Magnitude DZ: 0.318 Number Observations: 140 Standard Deviation DZ: 0.119 RMSE Z: 0.118 95th Percentile: 0.218 Units: Meters