

2018 Coastal Texas LiDAR Final QA/QC Report

STATEMENT OF WORK #580-18-SOW0051

TEXAS WATER DEVELOPMENT BOARD

December 21, 2018

Prepared for:
TEXAS WATER DEVELOPMENT BOARD

Prepared by:
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Table of Contents

1.	Overview	1
	Independent QA/QC Scope of Work.....	2
	Project Area and Deliverables Received.....	3
	Applicable Specifications and Guidelines.....	4
2.	Phase I: Pre-flight Planning Review	5
	Aerial Acquisition Pre-flight Planning Review	5
	QA/QC Checkpoint Survey Plan Review	6
3.	Phase II: Data Acquisition Review.....	7
	Post-flight: Aerial Acquisition Review.....	7
	Post-flight: Ground Control Review	8
	Review and Delivery of QA/QC Checkpoint Survey	9
4.	Phase III: Data Processing.....	17
	Quality Assessment	17
	Software Used.....	17
	Quality Assessment Process.....	17
	UTM Zones 14 and 15 Macro and Micro Review Quality Assessment Results	18
	Vertical Accuracy Assessment.....	21
	Horizontal Accuracy Assessment.....	29
	Point Density and Spatial Distribution Analysis.....	30
5.	Phase IV: Product Development	31
	Zone 14 and 15 AOI DEM Macro and Micro Quality Assessment Results.....	31
	Vertical Accuracy Assessment.....	32
	Credits	41
6.	Conclusions.....	41

1. Overview

Independent quality assurance and control for Texas Water Development Board (TWDB) Project 580-18-SOW0051 (Quality Assurance / Quality Control of the Acquisition and Production of LiDAR Elevation Data for 2018 Coastal Texas) was performed by AECOM to validate the LiDAR data, and various derivative products, meet project specifications, client expectations, and quality standards.

Project stakeholders included the Texas Natural Resources Information System (TNRIS), a part of the Texas Water Development Board (TWDB), and the Houston-Galveston Area Council (H-GAC).

“The project AOI (~9,758 DO4Q tiles) is on the Texas coast covering much of Orange to Matagorda County along with Harris County and the surrounding area. This region is strongly dominated by coastal ecology in addition to the large metropolitan area of Houston and the surrounding urban sprawl.

The data acquired will be used for floodplain management and planning, feature extraction, water quality modeling, stream restoration potential analysis, change detection and emergency management services. The data acquired will become part of an ongoing geospatial data collection program by the State of Texas to support regional and local mapping needs.

The products acquired by this Contract will be available in the public domain through the Texas Natural Resources Information System (TNRIS) for use by government entities and the public”.

- from TWDB Project Solicitation # 580-18-SOW0051

The adjusted project area of interest (AOI) is ~9,163 mi² in size.

Fundamental project requirements were to meet, or exceed, TNRIS, ASPRS, and USGS QL2 specifications having a point density ≥ 4 pts/m² and an RMSE vertical accuracy ≤ 10 cm in Non-Vegetated Areas. Specific QA/QC requirements and the results obtained are outlined in the following report for the primary TNRIS data deliverables developed in the UTM projection. These primary LiDAR data derivative products include Hydro Breaklines, Hydro-flattened DEM Rasters, Intensity Rasters, and Metadata.

At the time of this report the reprojected Houston-Galveston Area Council (H-GAC) AOI data have not yet been produced. The H-GAC AOI is a subset of the overall project AOI – see Figure 1. H-GAC LiDAR data derivative products will include Hydro Breaklines, Hydro-flattened DEM Rasters, Intensity Rasters, and Metadata. These additional data will be developed in the Texas State Plane projection and submitted to AECOM for macro level QA/QC checks in late February 2019.

All LiDAR data and derivative products were acquired and processed by Fugro.

The findings of this report encompass data deliverables received January 2018 to December 2018.

Listed below are the QA/QC elements considered during this project, some of which were reported upon in preliminary reports during the course of the project and have been incorporated into this final report for completeness:

- Overview of independent QA/QC scope of work
- Pre-acquisition planning assessment
- Post-acquisition data assessment
- Vendor production reviews
- Quality control checkpoint survey data
- Assessment practices and methodologies
- Data accuracy assessment
- Conclusions and lessons learned

For convenience, this report is organized by the major phases of project work as outlined in Table 1 below.

Independent QA/QC Scope of Work

The following scope of work (SOW) tasks were completed during the project:

Table 1: AECOM – Independent QA/QC Tasks	
Phase	Tasks
Phase I Pre-flight Planning	<ol style="list-style-type: none"> 1. Participate in Kick-Off Meeting 2. Review timeline and projected milestones 3. Review Fugro's LiDAR flight plans and survey maps 4. Review sensor calibration reports 5. Prepare and submit QA/QC reports
Phase II Data Acquisition	<ol style="list-style-type: none"> 1. Collect QA/QC checkpoints 2. Review Flight Trajectories and associated data acquisition reporting files 3. Review Fugro's Survey Report and associated reporting files 4. Prepare and submit QA/QC reports
Phase III Data Processing	<ol style="list-style-type: none"> 1. Review LiDAR and derivative datasets including <ol style="list-style-type: none"> a. Classified point cloud tiles b. Hydro-flattened breaklines c. Intensity rasters d. Metadata 3. Review revised data 4. Prepare and submit QA/QC reports
Phase IV Final Product Development	<ol style="list-style-type: none"> 1. Review Hydro-flattened DEM rasters and metadata 2. Review revised datasets 3. Prepare and submit QA/QC reports 4. Prepare and submit Final QA/QC Report

Project Area and Deliverables Received

The 2018 Coastal Texas project AOI covering ~9,163 mi².

Zone 14 (Yellow) AOI - 922 mi²
Zone 15 (Red) AOI - 8,241 mi²
H-GAC (Blue) AOI - 3,744 mi²

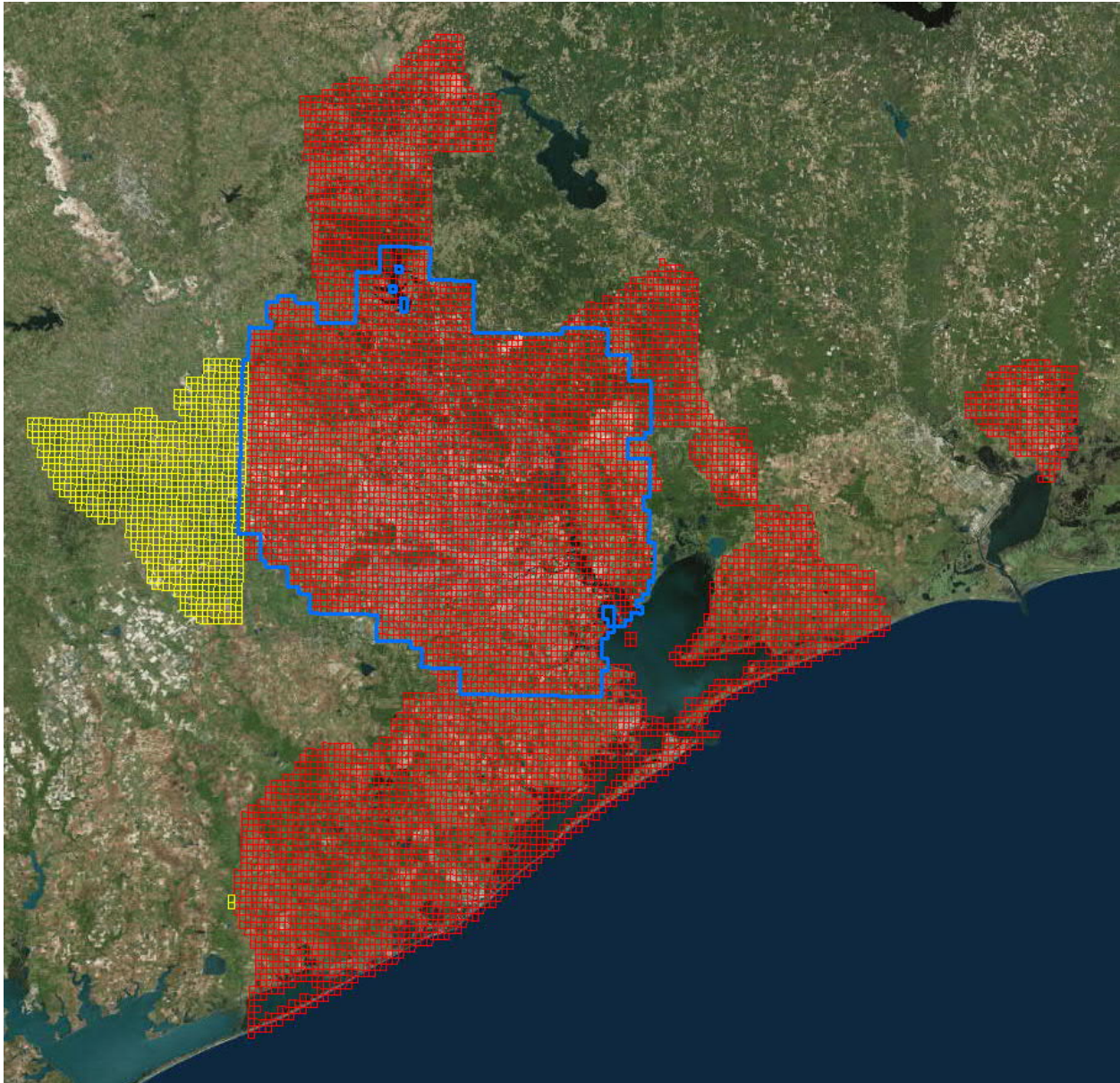


Figure 1 – TNRIS 2018 Coastal Texas Project AOI

TNRIS data deliverables were received in the following formats in UTM Zone 14 and 15, NAD83 (2011), NAVD88 (Geoid 12B), Meters.

Table 2: Data Deliverables Received		
Deliverable	Zone 14 AOI	Zone 15 AOI
LiDAR files in .LAS v1.4 format	Y	Y
Hydro-flattened bare earth DEM files in .IMG format	Y	Y
LiDAR intensity images in GeoTIF/TFW format	Y	Y
LiDAR, DEM-intensity tile layouts in ESRI SHP format	Y	Y
3D breaklines in ESRI geodatabase format	Y	Y
Project and tile level metadata in XML format	Y	Y

Applicable Specifications and Guidelines

The following guidelines, specifications, and standards are applicable to this report:

- A. TWDB/TNRIS SOW - SM_58017SOW0040_QAQC_Coastal_Texas .pdf
- B. American Society for Photogrammetry and Remote Sensing. 2013. ASPRS Accuracy Standards for Digital Geospatial Data. Photogrammetric Engineering & Remote Sensing 79, no. 12: 1073-1085.
- C. American Society for Photogrammetry & Remote Sensing. ASPRS Guidelines Vertical Accuracy Reporting for Lidar Data. 24 May 2004.
http://www.asprs.org/a/society/committees/lidar/Downloads/Vertical_Accuracy_Reporting_for_Lidar_Data.pdf
- D. American Society for Photogrammetry & Remote Sensing. LAS Specification Version 1.4-R6. 10 June 2012.
http://www.asprs.org/a/society/committees/standards/LAS_1_4_r12.pdf
- E. Federal Geographic Data Committee. Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy. 1998. <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3>
- F. Maune, David F. Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition. 2007.
- G. Maune, David F. FEMA's Mapping and Surveying Guidelines and Specifications. 2003.
http://w.psadewberry.com/Libraries/Documents/FEMAs_Mapping_and_Surveying_Guidelines_and_Specifications_ASPRSFall2003.pdf
- H. National Digital Elevation Program. Guidelines for Digital Elevations Data (Version 1.0). 10 May 2004.
http://www.ndep.gov/NDEP_Elevation_Guidelines_Ver1_10May2004.pdf
- I. The National Geodetic Survey. The NGS Geoid Page. 11 September 2012.
<http://www.ngs.noaa.gov/GEOID/>

2. Phase I: Pre-flight Planning Review

During the project kickoff meeting AECOM reviewed project QA/QC specifications that would be employed and responded to questions. AECOM applied previous established Phase I review procedures to provide reporting on QA/QC tasks.

For Phase I (Pre-flight Planning Phase), AECOM conducted a review of the proposed flight operations and plan files submitted by Fugro prior to the mobilization of data collection flights. These files included, but were not limited to:

- Planned flight lines
- Planned GPS base stations
- Planned airport location
- Calibration plans
- Schedule
- Terrain consideration
- Quality procedures
- Planned scan set (sensor settings)
- Type of aircraft
- Procedure for re-flights
- Land cover considerations

All files and planning documents generated for this phase were reviewed against the project specifications and guidelines provided. Planning documents further facilitated the QA/QC process during the subsequent acquisition and processing tasks of the project.

Aerial Acquisition Pre-flight Planning Review

For the purpose of this review, Fugro provided AECOM with planned flight lines and ground control locations, base station locations, sensor settings, and field calibration plans.

A review was conducted to validate aerial acquisition flight planning and reporting requirements in accordance with SOW# 580-18-SOW0051 SOW. AECOM sent clarifying questions to Fugro, the responses to which were deemed acceptable.

The overall control layout, including any QA/QC checkpoints, acquisition base stations, and nearest CORS stations was reviewed by AECOM to ensure adequate project coverage and distribution of points.

The following table reports the results of the AECOM review for the planning phase of the aerial acquisition effort:

Table 3: Pre-flight Planning Review	
Items Reviewed	Meets Specifications
Planned lines – sufficient coverage, spacing, and length	Yes
Planned GPS basestations – collecting at 1 Hz, at least 2 in range of all missions (baseline 40 km or less)	Yes
Planned ground control – sufficient to control and boresight	Yes
Planned airports – within reasonable distance of AOI	Yes
Schedule	Yes
Quality procedures	Yes
Aircraft utilizes ABGPS at 2 Hz	Yes
Sensor parameters support project design pulse density	Yes
Type of aircraft – supports project design parameters	Yes
Re-flight procedure – tracking, documenting, processing	Yes
Project design supports accuracy requirements of project	Yes
Project design accounts for land cover and terrain types	Yes
Aerial Acquisition Report	Yes

QA/QC Checkpoint Survey Plan Review

The ground survey layout for the QA/QC checkpoints was developed by AECOM referencing USGS and ASPRS specifications with respect to distribution and vegetative cover. A vertical accuracy requirement of 3.3 cm RMSE_z was required.

Publicly available imagery was referenced to confirm that control point locations were accessible and to ensure that the locations chosen conformed to project specifications and guidelines.

Gorrondona & Associates, Inc. (Gorrondona), working as a subcontractor to AECOM, executed the field survey.

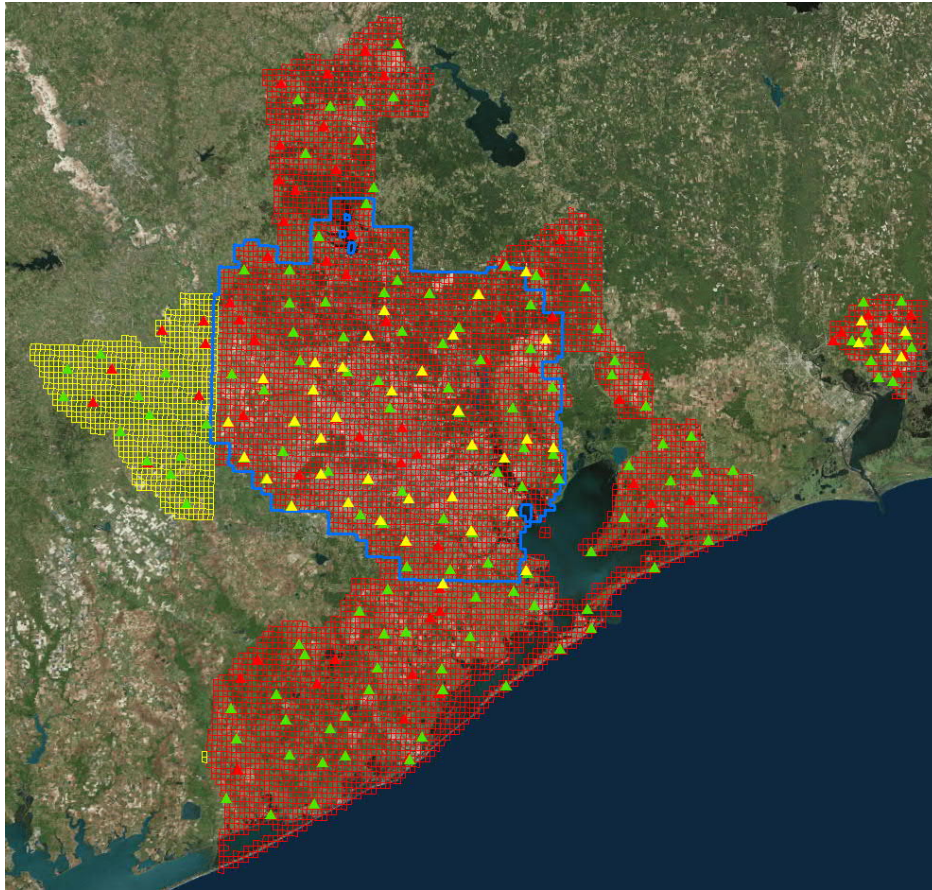


Figure 2 – AECOM QA Checkpoint Plan

A total of **239 NVA** (including 40 horizontal check points (yellow above)) and **137 VVA**, checkpoints were established across the project AOI.

- NVA and VVA checkpoints supported the vertical accuracy assessments of the LiDAR and DEM datasets.
- Horizontal checkpoints supported horizontal accuracy assessments of the LiDAR data via the intensity imagery.

3. Phase II: Data Acquisition Review

The following QA/QC actions were performed after the aerial acquisition of the LiDAR data.

Post-flight: Aerial Acquisition Review

Following the aerial acquisition of the LiDAR data Fugro provided AECOM with trajectory files as well as a variety of other related data files associated with the LiDAR acquisition effort.

The trajectory data captured from the aircraft's GPS, collected at 0.5 second intervals, were compared against the planned flight plans. A comparison of the planned flight lines and trajectories as they were flown is included below. The as-flown data aligned well with the planned datasets.

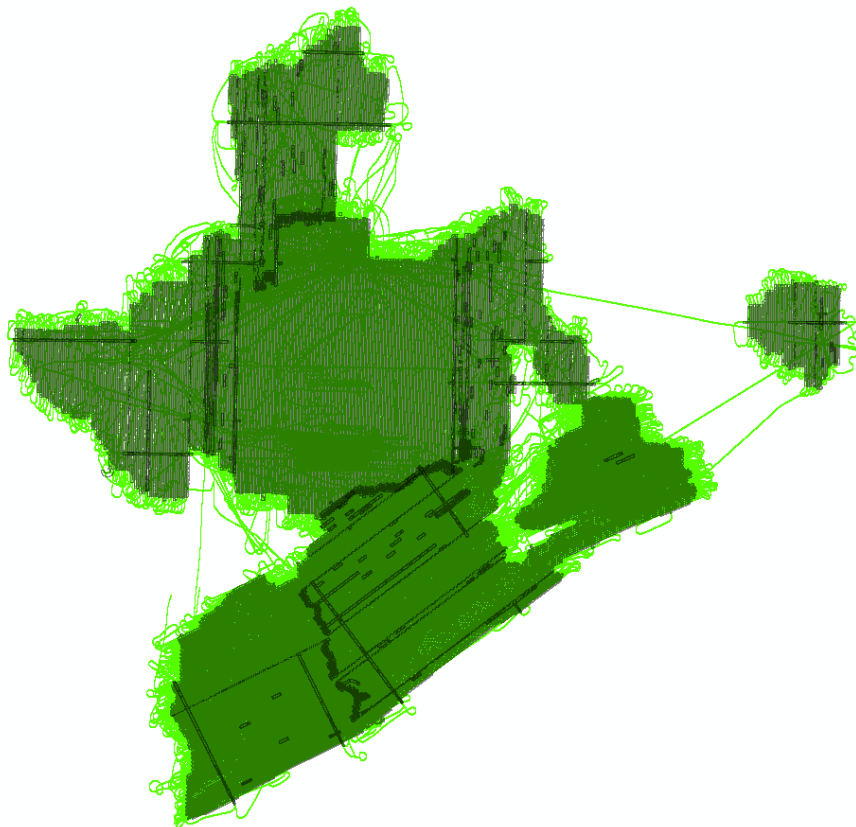


Figure 3 – LiDAR Planned Flight Lines (Black) Overlaid As-Flown Trajectories (Green)

GNSS Plot Reviews

- Number of satellites tracked during acquisition altitude exceeded 6 satellites.
- There were instances where PDOP exceeded 4.0 however these instances were instantaneous/spurious noise or outside the on-line data acquisition window.
- Supporting flight logs and ancillary documentation suggested data acquisition met specifications.

Data acquisition status updates

- Fugro provided daily acquisition updates via the TNRIS project email thread system from acquisition commencement to completion.

Post-flight: Ground Control Review

Fugro provided a detailed survey report identifying the control network used and the spatial parameters associated with the network. The description of survey processes and methodology provided suggests the ground control data meets the horizontal and vertical accuracy specifications.

The control report included tabular data in XLS, CSV, and SHP format containing coordinate and elevation information to 3 decimal places in the project spatial reference framework. Land cover type descriptions were also included for each point, as were images of each survey point.

Survey points were evenly spaced, well dispersed, and for the most part closely mimic the planned control point locations, as can be seen in the graphic below.

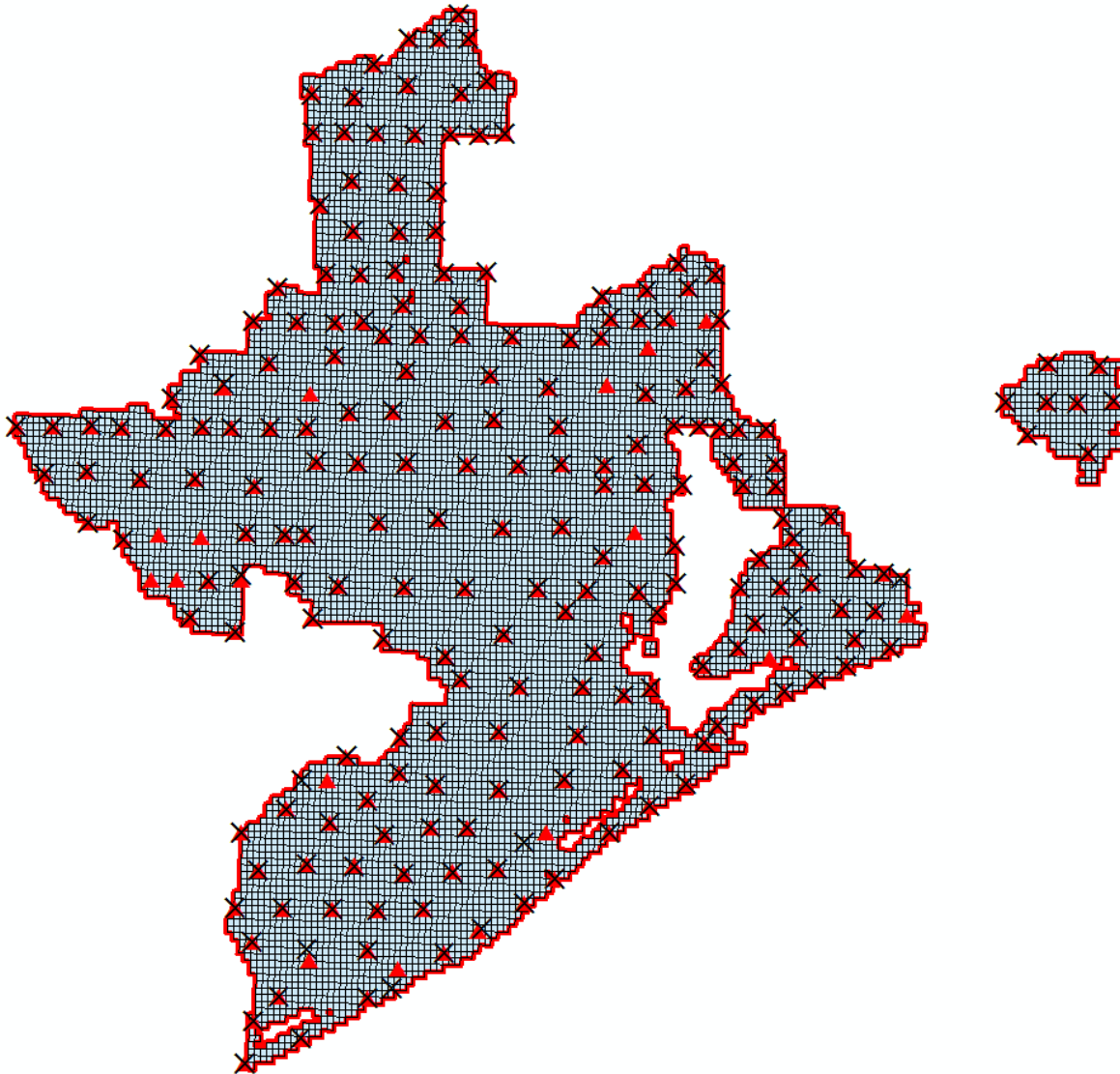


Figure 4 - Fugro LiDAR Planned Control Locations (X) and Actual Control Locations (▲)

Review and Delivery of QA/QC Checkpoint Survey

During the planning and establishment of QA/QC checkpoints, AECOM and Gorrondona frequently coordinated regarding status. Gorrondona completed survey field work and data processing on March 19, 2018.

239 NVA (including 40 horizontal check points) and 137 VVA checkpoints were established across the project AOI.

- NVA and VVA checkpoints supported the vertical accuracy assessments of the LiDAR and DEM datasets.
- Horizontal checkpoints supported horizontal accuracy assessments of the LiDAR data via the Intensity imagery.

AECOM reviewed all pertinent documentation submitted by Gorrondona at the conclusion of the checkpoint collection. The control report included tabular data in XLS, CSV, and SHP format containing coordinate and elevation information to 3 decimal places in the project spatial reference framework. Land cover type descriptions were also included for each point, as were images of each survey point. Reported QA/QC point locations were verified against project specifications and control plan layouts. All survey related documentation were delivered to TNRIS April 2018.

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
NVA	NVA_0	426994.831	3329635.017	2.793	1005478.644	3341009.199	2.793	3625760.669	13983119.96	9.163
NVA	NVA_1	429537.095	3332027.152	2.708	1007899.051	3343539.589	2.708	3633689.017	13991389.16	8.886
NVA	NVA_2	404631.847	3334012.246	6.325	982850.293	3344213.23	6.325	3551729.801	13993689.02	20.751
NVA	NVA_3	407338.178	3336728.706	6.21	985416.968	3347076.37	6.21	3560140.283	14003049.01	20.373
NVA	NVA_4	415869.206	3342162.752	7.632	993673.247	3352969.39	7.632	3587181.587	14022299.95	25.04
NVA	NVA_5	429122.78	3342226.465	6.727	1006944.913	3353734.585	6.727	3630609.215	14024747.39	22.07
NVA	NVA_6	415747.692	3334010.103	5.102	993982.431	3344797.846	5.102	3588160.541	13995559.86	16.739
NVA	NVA_7	423576.64	3321212.644	2.428	1002498.431	3332392.565	2.428	3615979.431	13954939.66	7.966
NVA	NVA_8	424961.363	3324409.466	1.672	1003717.17	3335667.633	1.672	3619978.161	13965650.51	5.486
NVA	NVA_9	419075.696	3322399.466	2.935	997927.684	3333344.45	2.935	3601027.994	13958069.62	9.629
NVA	NVA_10	416674.672	3327740.127	3.864	995241.584	3338567.076	3.864	3592257.418	13975167.42	12.676
NVA	NVA_11	428007.715	3335856.697	3.219	1006164.797	3347294.954	3.219	3628030.067	14003682.2	10.562
NVA	NVA_12	414406.002	3346220.545	9.059	991993.019	3356955.858	9.059	3581700.336	14035351.91	29.721
NVA	NVA_13	415357.72	3336743.932	5.344	993447.48	3347515.263	5.344	3586420.68	14004453.81	17.532
NVA	NVA_14	420814.228	3331804.9	3.355	999173.328	3342856.595	3.355	3605137.957	13989188.15	11.008
NVA	NVA_15	422662.469	3341138.466	6.73	1000531.397	3352302.907	6.73	3609619.26	14020090.46	22.08
NVA	NVA_16	427286.07	3336931.794	3.684	1005385.111	3348333.745	3.684	3625483.383	14007083.97	12.086
NVA	NVA_17	418951.472	3337427.561	5.541	997010.682	3348389.844	5.541	3598083.413	14007301.36	18.18
NVA	NVA_18	410674.028	3334240.482	3.712	988889.002	3344760.722	3.712	3571493.394	13995457.87	12.179
NVA	NVA_19	426229.285	3346657.179	9.345	1003811.88	3358019.55	9.345	3620377.41	14038780.56	30.66
NVA	NVA_20	268117.117	3427409.832	76.048	841305.649	3430359.893	76.048	3088492.848	14276514.55	249.501
NVA	NVA_21	245528.763	3418111.085	67.079	819236.821	3419852.626	67.079	3016089.17	14242172.25	220.075
NVA	NVA_22	230945.833	3415038.154	74.56	804834.891	3415999.414	74.56	2968849.79	14229600.72	244.62
NVA	NVA_23	246465.158	3407957.645	89.167	820717.492	3409759.364	89.167	3020899.52	14209073.39	292.543
NVA	NVA_24	263405.967	3417413.485	63.792	837136.145	3420116.916	63.792	3074773.496	14242955.76	209.291
NVA	NVA_25	266328.236	3410866.143	79.085	840408.148	3413731.245	79.085	3085469.721	14222007.02	259.466
NVA	NVA_26	255225.632	3397330.661	131.307	830039.251	3399611.04	131.307	3051417.337	14175764.26	430.798
NVA	NVA_27	244314.414	3401749.937	87.997	818901.444	3403442.466	87.997	3014919.176	14188370.66	288.704
NVA	NVA_28	230554.154	3395845.702	118.468	805471.813	3396808.65	118.468	2970861.906	14166673	388.673
NVA	NVA_29	230306.769	3384693.678	106.384	805819.735	3385656.453	106.384	2971962.478	14130106.67	349.027
NVA	NVA_30	238678.329	3392924.932	106.913	813742.963	3394325.111	106.913	2997971.056	14158499.18	350.763
NVA	NVA_31	260051.714	3382474.897	100.294	835654.587	3385024.531	100.294	3069767.079	14127927.04	329.048
NVA	NVA_32	248355.853	3387898.92	85.62	823679.222	3389820.555	85.62	3030529.169	14143693.91	280.905

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
NVA	NVA_33	235385.041	3381470.381	108.002	811063.952	3382707.235	108.002	2989145.888	14120419.28	354.338
NVA	NVA_34	231788.172	3371622.527	76.022	807994.625	3372679.061	76.022	2979050.007	14087552.19	249.415
NVA	NVA_35	242862.483	3366775.051	68.747	819314.583	3368424.313	68.747	3016146.873	14073568.01	225.547
NVA	NVA_36	257803.014	3377124.763	96.61	833692.423	3379558.702	96.61	3063315.187	14110017.98	316.96
NVA	NVA_37	253205.781	3367317.502	69.666	829619.883	3369514.961	69.666	3049931.284	14077109.91	228.561
NVA	NVA_38	266230.182	3362143.822	75.035	842909.212	3365035.681	75.035	3093474.657	14062384.5	246.178
NVA	NVA_39	267688.591	3353196.088	53.323	844840.391	3356170.628	53.323	3099775.729	14033324	174.943
NVA	NVA_40	251631.221	3354994.92	80.494	828699.327	3357119.114	80.494	3046875.177	14036481.25	264.089
NVA	NVA_41	245397.328	3359138.796	84.207	822251.642	3360929.56	84.207	3025751.679	14048990.65	276.27
NVA	NVA_42	233535.671	3356471.128	79.934	810543.01	3357637.015	79.934	2987359.681	14038231.19	262.249
NVA	NVA_43	226969.98	3360690.517	95.622	803761.533	3361504.254	95.622	2965138.399	14050928.58	313.721
NVA	NVA_44	219539.596	3356527.312	126.909	796560.54	3356953.126	126.909	2941517.112	14036027.34	416.369
NVA	NVA_45	214790.939	3345902.526	90.151	792378.958	3346091.606	90.151	2927779.98	14000427.14	295.769
NVA	NVA_46	206537.391	3340388.789	84.908	784427.298	3340150.885	84.908	2901695.47	13980967.39	278.569
NVA	NVA_47	193653.116	3337406.059	53.021	771719.733	3336495.128	53.021	2860021.108	13969006.99	173.952
NVA	NVA_48	207077.878	3333315.89	60.971	785338.836	3333116.601	60.971	2904669.446	13957901.99	200.036
NVA	NVA_49	217937.322	3340653.784	95.896	795797.675	3341015.488	95.896	2938976.66	13983776.84	314.618
NVA	NVA_50	222614.521	3334462.881	81.445	800794.639	3335078.337	81.445	2955345.611	13964301.29	267.208
NVA	NVA_51	233521.86	3346056.873	82.967	811079.151	3347233.268	82.967	2989089.435	14004124.01	272.171
NVA	NVA_52	234813.931	3336773.123	65.572	812858.803	3338027.395	65.572	2994900.913	13973941.8	215.132
NVA	NVA_53	244949.079	3346203.373	70.064	822487.307	3347982.293	70.064	3026487.602	14006549.67	229.869
NVA	NVA_54	250287.244	3334982.179	51.313	828411.879	3337051.989	51.313	3045879.235	13970707.75	168.349
NVA	NVA_55	263538.793	3349373.82	37.751	840895.165	3352131.45	37.751	3086833.664	14020097.88	123.853
NVA	NVA_56	268958.124	3337160.307	34.489	846955.251	3340211.093	34.489	3106661.217	13981014.69	113.152
NVA	NVA_57	277543.523	3349192.639	45.777	854901.747	3352690.124	45.777	3132737.979	14021887.01	150.185
NVA	NVA_58	286894.366	3338372.689	27.814	864819.886	3342367.6	27.814	3165207.783	13988032.67	91.253
NVA	NVA_59	300970.558	3358261.939	46.22	877842.132	3362996.258	46.22	3207941.333	14055581.75	151.639
NVA	NVA_60	319140.144	3366067.853	21.867	895597.477	3371766.084	21.867	3266144.256	14084246.35	71.741
NVA	NVA_61	325219.271	3368321.975	19.762	901557.789	3374343.613	19.762	3285679.902	14092665.73	64.835
NVA	NVA_62	326799.276	3350988.618	17.904	904057.477	3357090.18	17.904	3293801.301	14036139.77	58.741
NVA	NVA_63	312537.021	3355565.852	39.885	889550.884	3360913.026	39.885	3246294.491	14048714.75	130.858
NVA	NVA_64	309413.591	3345584.162	34.212	886955.318	3350765.922	34.212	3237756.608	14015481.33	112.244
NVA	NVA_65	299641.343	3341563.162	33.193	877395.907	3346229.366	33.193	3206424.116	14000648.84	108.902
NVA	NVA_66	309590.455	3331878.532	27.648	887854.742	3337069.403	27.648	3240661.498	13970609.21	90.709
NVA	NVA_67	330632.767	3337862.241	15.556	908585.45	3344162.611	15.556	3308588.333	13993781.29	51.038
NVA	NVA_68	336079.607	3327984.199	20.447	914554.517	3334567.859	20.447	3328108.54	13962338.74	67.084
NVA	NVA_69	335255.551	3323450.051	19.542	913968.478	3329988.557	19.542	3326176.235	13947343.13	64.115
NVA	NVA_70	345730.415	3323011.371	18.426	924471.383	3330100.004	18.426	3360571.781	13947678.71	60.452
NVA	NVA_71	345659.452	3313581.874	13.597	924895.193	3320661.528	13.597	3361934.38	13916770.19	44.609
NVA	NVA_72	316291.125	3319586.794	17.853	895201.752	3325128.717	17.853	3264696.726	13931474.96	58.571
NVA	NVA_73	310414.18	3325541.609	23.71	889011.678	3330775.565	23.71	3244434.294	13949988.28	77.788
NVA	NVA_74	295410.712	3328012.67	22.815	873879.326	3332458.167	22.815	3194864.038	13955540.1	74.854
NVA	NVA_75	283625.853	3319288.349	24.295	862555.269	3323117.554	24.295	3157738.812	13924963.35	79.709
NVA	NVA_76	275223.747	3324708.075	21.822	853872.22	3328094.513	21.822	3129298.155	13941291.35	71.595
NVA	NVA_77	262013.652	3321138.088	34.512	840856.576	3323833.68	34.512	3086635.798	13927357.42	113.229
NVA	NVA_78	251466.586	3323969.924	42.278	830168.597	3326110.558	42.278	3051612.195	13934842.35	138.708
NVA	NVA_79	241085.969	3318681.064	44.349	820074.051	3320282.366	44.349	3018514.155	13915760.04	145.501
NVA	NVA_80	236503.432	3328166.167	60.773	814998.791	3329518.049	60.773	3001896.871	13946043.43	199.386
NVA	NVA_81	225658.523	3318813.589	54.311	804655.77	3319607.221	54.311	2967972.56	13913575.64	178.186
NVA	NVA_82	215447.092	3324019.906	74.738	794184.252	3324272.395	74.738	2933652.515	13928888.62	245.201

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
NVA	NVA_83	205210.184	3316900.31	52.611	784334.061	3316626.76	52.611	2901345.171	13903839.41	172.607
NVA	NVA_84	194785.605	3324067.12	52.584	773550.29	3323237.144	52.584	2865998.865	13925531.23	172.52
NVA	NVA_85	186177.393	3317004.121	82.148	765325.88	3315735.453	82.148	2839019.286	13900946.65	269.513
NVA	NVA_86	177653.321	3325140.782	96.661	756391.263	3323411.667	96.661	2809733.286	13926132	317.13
NVA	NVA_87	171755.229	3314696.411	101.344	751050.451	3312678.49	101.344	2792203.285	13890942.72	332.491
NVA	NVA_88	163863.158	3325341.006	98.127	742617.394	3322889.357	98.127	2764562.356	13924440.66	321.94
NVA	NVA_89	180440.972	3305717.971	86.042	760188.429	3304169.693	86.042	2822157.539	13863028.85	282.288
NVA	NVA_90	189186.472	3295698.137	60.339	769440.285	3294622.097	60.339	2852483.127	13831712.04	197.961
NVA	NVA_91	189561.816	3311009.777	44.859	769017.652	3309927.969	44.859	2851116.124	13881898.7	147.175
NVA	NVA_92	199585.877	3297762.545	47.316	779715.994	3297223.881	47.316	2886177.354	13840231.22	155.234
NVA	NVA_93	207415.18	3308059.309	49.028	786997.632	3307913.485	49.028	2910064.519	13875268.36	160.852
NVA	NVA_94	219450.584	3296777.493	46.583	799604.932	3297273.344	46.583	2951381.209	13840369.59	152.83
NVA	NVA_95	219218.157	3310532.127	56.052	798655.998	3310998.995	56.052	2948289.639	13885366.34	183.897
NVA	NVA_96	231714.064	3299445.305	40.446	811715.704	3300576.34	40.446	2991084.808	13851181.11	132.697
NVA	NVA_97	235034.968	3308759.529	43.748	814547.6	3310054.134	43.748	3000381.506	13882243.73	143.529
NVA	NVA_98	236651.986	3292028.703	28.674	817034.446	3293424.051	28.674	3008509.329	13827730.58	94.076
NVA	NVA_99	248598.529	3309888.349	35.167	828039.837	3311890.204	35.167	3044607.707	13888239.13	115.377
NVA	NVA_100	245953.473	3292966.305	25.202	826278.823	3294844.288	25.202	3038810.37	13832374.07	82.683
NVA	NVA_101	255569.367	3304221.485	27.489	835301.156	3306591.536	27.489	3068396.958	13870861.13	90.188
NVA	NVA_102	258418.228	3290663.427	19.207	838854.009	3293191.062	19.207	3080020.92	13826939.92	63.016
NVA	NVA_103	255895.66	3279265.057	20.265	836924.575	3281669.377	20.265	3073685.075	13789183.97	66.488
NVA	NVA_104	263136.343	3276750.071	18.466	844291.004	3279530.977	18.466	3097823.167	13782169.46	60.585
NVA	NVA_105	269024.006	3286934.141	13.492	849647.422	3290014.917	13.492	3115386.656	13816518.31	44.263
NVA	NVA_106	273930.984	3298423.086	14.024	853954.477	3301753.709	14.024	3129516.295	13854977.66	46.011
NVA	NVA_107	269097.929	3306822.911	23.495	848685.624	3309897.405	23.495	3112264.836	13881671.99	77.083
NVA	NVA_108	265263.805	3312972.09	27.053	844532.275	3315842.831	27.053	3098665.365	13901162.82	88.757
NVA	NVA_109	287307.439	3311500.685	15.563	866643.504	3315524.968	15.563	3171117.726	13900077.44	51.061
NVA	NVA_110	303796.521	3313118.879	16.949	883045.436	3318005.73	16.949	3224858.752	13908170.18	55.607
NVA	NVA_111	337625.285	3315696.59	13.474	916746.128	3322356.178	13.474	3335252.688	13922340.22	44.205
NVA	NVA_112	307977.769	3301079.582	12.023	887855.928	3306184.919	12.023	3240593.204	13869437.41	39.444
NVA	NVA_113	316683.891	3298385.794	8.991	896703.493	3303945.025	8.991	3269570.067	13862084.21	29.497
NVA	NVA_114	318511.588	3290569.212	9.09	898938.767	3296222.206	9.09	3276878.356	13836785.17	29.822
NVA	NVA_115	307019.942	3288646.426	2.992	887545.729	3293701.347	2.992	3239556.439	13828545.33	9.816
NVA	NVA_116	303845.453	3280202.585	4.011	884809.734	3285092.407	4.011	3230582.734	13800348.43	13.158
NVA	NVA_117	298995.67	3292845.313	4.195	879303.136	3297482.678	4.195	3212560.789	13840944.7	13.762
NVA	NVA_118	291167.094	3301039.945	10.61	871048.648	3305268.262	10.61	3185531.049	13866464.69	34.811
NVA	NVA_119	284393.872	3285123.03	9.613	865105.386	3289002.634	9.613	3166034.828	13813182.43	31.539
NVA	NVA_120	282149.282	3278195.451	12.597	863220.801	3281960.616	12.597	3159852.221	13790112.24	41.328
NVA	NVA_121	270136.189	3271193.852	17.155	851574.732	3274339.826	17.155	3121686.292	13765152.78	56.283
NVA	NVA_122	270668.189	3263116.391	16.572	852523.695	3266293.516	16.572	3124790.387	13738786.81	54.369
NVA	NVA_123	264821.203	3256023.286	15.382	847045.108	3258902.496	15.382	3106835.112	13714570.7	50.464
NVA	NVA_124	255077.01	3248882.708	13.403	838303.45	3251297.354	13.403	3078187.402	13689651.07	43.972
NVA	NVA_125	281007.881	3256158.44	12.641	863218.261	3259871.131	12.641	3159828.371	13717738.73	41.474
NVA	NVA_126	280371.122	3269720.899	13.766	861881.838	3273396.631	13.766	3155457.518	13762054.32	45.164
NVA	NVA_127	291551.949	3273820.704	7.235	872847.904	3278073.905	7.235	3191389.219	13777368.94	23.738
NVA	NVA_128	296278.953	3264129.34	6.839	878075.431	3268628.117	6.839	3208507.157	13746420.24	22.438
NVA	NVA_129	308602.831	3260999.842	2.634	890560.984	3266134.792	2.634	3249404.93	13738244.95	8.641
NVA	NVA_130	340514.406	3294783.388	6.003	920729.98	3301583.989	6.003	3348253.51	13854307.81	19.694
NVA	NVA_131	353539.957	3290138.718	5.459	934005.499	3297615.221	5.459	3391715.743	13841288.68	17.911
NVA	NVA_132	351172.715	3301668.699	10.769	931035.193	3309029.575	10.769	3382012.439	13878667.72	35.33

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
NVA	NVA_133	359992.591	3304162.187	9.171	939731.075	3311985.857	9.171	3410490.715	13888327.87	30.09
NVA	NVA_134	367023.753	3284302.833	1.642	947803.926	3292476.466	1.642	3436881.874	13824441.69	5.386
NVA	NVA_135	373171.32	3293518.655	3.373	953477.27	3302021.203	3.373	3455471.048	13855676.81	11.066
NVA	NVA_136	365470.314	3271365.074	7.378	946920.861	3279446.351	7.378	3433973.131	13781786.87	24.206
NVA	NVA_137	359922.512	3283766.949	2.611	940724.476	3291570.796	2.611	3413703.898	13821487.93	8.566
NVA	NVA_138	347714.429	3282903.708	2.495	928552.494	3290072.282	2.495	3373849.157	13816600.02	8.184
NVA	NVA_139	339081.051	3278599.441	2.353	920137.714	3285317.167	2.353	3346288.725	13801041.12	7.721
NVA	NVA_140	350928.412	3277044.713	1.909	932072.866	3284376.336	1.909	3385367.941	13797945.19	6.262
NVA	NVA_141	348510.004	3262833.253	2.103	930388.818	3270029.998	2.103	3379839.306	13750974.11	6.899
NVA	NVA_142	327360.899	3249563.292	1.206	909913.005	3255662.245	1.206	3312782.521	13703936.61	3.957
NVA	NVA_143	328115.231	3243268.029	1.523	910991.358	3249403.302	1.523	3316312.961	13683439.12	4.995
NVA	NVA_144	318646.923	3237163.648	2.527	901833.184	3242810.859	2.527	3286320.056	13661848.34	8.292
NVA	NVA_145	310591.958	3250784.471	2.828	893076.819	3256020.704	2.828	3257641.11	13705115.23	9.317
NVA	NVA_146	303953.523	3255197.48	4.837	886210.545	3260092.285	4.837	3235151.617	13718454.27	15.869
NVA	NVA_147	292136.261	3253638.99	9.77	874474.06	3257925.255	9.77	3196703.887	13711359.68	32.054
NVA	NVA_148	280914.276	3249138.472	8.519	863485.899	3252848.355	8.519	3160703.313	13694729.53	27.949
NVA	NVA_149	277991.663	3247116.984	7.082	860668.051	3250677.288	7.082	3151470.626	13687616.65	23.227
NVA	NVA_150	263260.741	3241850.087	12.18	846213.712	3244656.549	12.18	3104108.779	13667889.17	39.961
NVA	NVA_151	247910.416	3233762.277	10.93	831287.293	3235787.726	10.93	3055195.615	13638822.88	35.86
NVA	NVA_152	236595.563	3239060.916	18.31	819710.575	3240502.947	18.31	3017252.852	13654274.04	60.073
NVA	NVA_153	223681.973	3233767.693	17.458	807080.666	3234554.295	17.458	2975856.795	13634773.11	57.277
NVA	NVA_154	218209.621	3227944.874	18.126	801911.842	3228458.516	18.126	2958915.843	13614789.52	59.47
NVA	NVA_155	215167.212	3218287.064	15.354	799365.142	3218657.013	15.354	2950573.025	13582658.14	50.374
NVA	NVA_156	217022.108	3209028.842	12.39	801688.373	3209503.911	12.39	2958195.964	13552655.25	40.649
NVA	NVA_157	217368.023	3199426.495	7.583	802520.6	3199930.101	7.583	2960933.802	13521272.35	24.88
NVA	NVA_158	213801.838	3190154.581	8.872	799427.231	3190488.664	8.872	2950805.011	13490318.08	29.107
NVA	NVA_159	227907.51	3185139.025	0.912	813770.784	3186190.154	0.912	2997829.944	13476248	2.992
NVA	NVA_160	241406.204	3188399.705	1.447	827093.152	3190129.052	1.447	3041490.634	13489178.6	4.749
NVA	NVA_161	251227.775	3203414.348	2.654	836147.945	3205629.889	2.654	3071146.21	13539992.17	8.706
NVA	NVA_162	244166.757	3201623.571	3.906	829182.691	3203482.408	3.906	3048321.398	13532946.36	12.816
NVA	NVA_163	233809.966	3203946.55	6.772	818716.751	3205278.471	6.772	3014016.956	13538821.46	22.218
NVA	NVA_164	232512.208	3214750.88	9.588	816871.568	3216006.942	9.588	3007959.175	13573984.16	31.458
NVA	NVA_165	242282.254	3226224.065	10.066	826048.601	3227967.815	10.066	3038029.704	13613192.33	33.025
NVA	NVA_166	261325.56	3231098.516	9.561	844830.059	3233811.642	9.561	3099577.014	13632351.51	31.368
NVA	NVA_167	281459.621	3231281.919	5.211	864946.732	3235024.55	5.211	3165491.095	13636332.92	17.096
NVA	NVA_168	280665.922	3223236.338	2.168	864564.293	3226940.463	2.168	3164241.907	13609846.6	7.112
NVA	NVA_169	275312.142	3209507.033	6.352	859911.287	3212942.404	6.352	3149007.72	13563979.29	20.841
NVA	NVA_170	271063.17	3202970.881	0.989	855995.672	3206192.73	0.989	3136185.168	13541859.21	3.244
NVA	NVA_171	269655.521	3215020.172	3.729	853976.274	3218165.834	3.729	3129556.385	13581088.98	12.233
NVA	NVA_172	272464.187	3229049.536	3.599	856068.283	3232332.956	3.599	3136402.33	13627510.62	11.809
NVA	NVA_173	258532.375	3224387.727	8.889	842381.174	3226961.945	8.889	3091555.289	13609904.37	29.164
NVA	NVA_174	251276.752	3216031.367	7.394	835555.895	3218241.042	7.394	3069194.066	13581320.78	24.258
NVA	NVA_175	246369.831	3212168.341	5.409	830848.909	3214131.142	5.409	3053771.461	13567847.75	17.748
NVA	NVA_176	201216.978	3282939.671	41.307	782114.013	3282507.628	41.307	2894024.817	13791980.53	135.522
NVA	NVA_177	196270.413	3292160.725	45.559	776696.674	3291458.3	45.559	2876271.803	13821331.18	149.47
NVA	NVA_178	361960.777	3292754.51	5.069	942296.454	3300671.8	5.069	3418866.048	13851280.91	16.632
NVA	NVA_179	316431.113	3341493.187	29.978	894189.222	3347045.182	29.978	3261442.227	14003269.25	98.352
NVA	NVA_180	234413.889	3282036.745	26.645	815317.058	3283325.707	26.645	3002869.398	13794632.94	87.419
NVA	NVA_181	226315.629	3290750.848	39.466	806775.219	3291610.535	39.466	2974879.162	13821798.1	129.48
NVA	NVA_182	243571.374	3303436.885	32.641	823353.626	3305181.866	32.641	3029237.474	13866259.91	107.088

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
NVA	NVA_183	264122.394	3340272.88	43.155	841958.47	3343067.131	43.155	3090293.172	13990387.84	141.583
NVA	NVA_184	257499.283	3425457.809	46.335	830801.041	3427836.996	46.335	3054041.68	14268295.9	152.026
NVA	NVA_185	256073.073	3409270.269	83.118	830246.398	3411586.17	83.118	3052147.582	14215021.07	272.666
NVA	NVA_186	236272.129	3409958.148	91.042	810427.725	3411211.123	91.042	2987168.414	14213876.67	298.695
NVA	NVA_187	162630.237	3316651.556	110.841	741841.437	3314153.19	110.841	2762005.116	13895791.29	363.652
NVA	NVA_188	174036.975	3330033.498	81.496	752525.282	3328105.707	81.496	2797063.224	13941531.63	267.374
NVA	NVA_189	229858.26	3222692.495	13.293	813815.86	3223805.811	13.293	2997938.17	13599544.51	43.612
NVA	NVA_190	238228.831	3235059.894	12.063	821547.16	3236589.088	12.063	3023273.151	13641446.58	39.576
NVA	NVA_191	328465.514	3267830.354	1.679	910075.458	3273993.238	1.679	3313325.061	13763968.82	5.508
NVA	NVA_192	342062.235	3289337.341	5.147	922562.337	3296215.698	5.147	3354244.354	13836725.63	16.885
NVA	NVA_193	290570.408	3240985.776	4.711	873558.678	3245193.223	4.711	3193703.34	13669649.17	15.455
NVA	NVA_194	301782.419	3225556.246	2.522	885560.119	3230338.384	2.522	3233022.884	13620990	8.276
NVA	NVA_195	284396.793	3262151.307	10.912	866297.325	3266037.086	10.912	3169919.274	13737938.93	35.802
NVA	NVA_196	292918.924	3348574.088	37.081	870304.569	3352884.128	37.081	3183210.499	14022474.76	121.657
NVA	NVA_197	281969.981	3333243.388	31.648	860167.206	3336980.774	31.648	3149947.664	13970394.34	103.831
NVA	NVA_198	268680.862	3295848.917	16.717	848840.926	3298907.342	16.717	3112755.873	13845658.46	54.846
Horizontal	NVA_199H	426266.761	3329194.821	2.94	1004772.556	3340529.855	2.94	3623448.777	13981554.36	9.646
Horizontal	NVA_200H	421130.681	3331736.424	3.317	999493.904	3342804.709	3.317	3606186.659	13989017.16	10.881
Horizontal	NVA_201H	412755.219	3333685.426	4.819	991002.568	3344314.707	4.819	3578407.947	13993990.32	15.812
Horizontal	NVA_202H	413752.239	3340504.461	7.12	991640.8	3351196.612	7.12	3580523.568	14016507.35	23.36
Horizontal	NVA_203H	427300.637	3337208.16	4.972	1005385.095	3348611.349	4.972	3625484.463	14007992.21	16.311
Horizontal	NVA_204H	316695.409	3300466.289	8.424	896606.476	3306026.47	8.424	3269256.144	13868902.05	27.638
Horizontal	NVA_205H	308271.792	3303095.697	11.621	888044.731	3308216.466	11.621	3241215.496	13876091.86	38.127
Horizontal	NVA_206H	301056.103	3297236.349	9.836	881134.727	3301980.748	9.836	3218568.255	13855677.16	32.271
Horizontal	NVA_207H	290936.632	3301524.959	10.66	870792.932	3305741.157	10.66	3184694.091	13868014.46	34.975
Horizontal	NVA_208H	284732.155	3284946.257	8.561	865452.756	3288843.474	8.561	3167172.738	13812660.54	28.087
Horizontal	NVA_209H	303543.654	3280204.202	3.488	884507.849	3285078.368	3.488	3229593.817	13800302.8	11.445
Horizontal	NVA_210H	290901.327	3274325.7	7.788	872171.243	3278545.132	7.788	3189172.845	13778913.37	25.55
Horizontal	NVA_211H	307955.849	3261884.601	3.097	889868.274	3266986.241	3.097	3247136.445	13741034.33	10.16
Horizontal	NVA_212H	281858.489	3257781.407	12.729	863985.016	3261537.458	12.729	3162341.201	13723197.9	41.761
Horizontal	NVA_213H	270167.354	3271159.239	17.387	851607.672	3274306.841	17.387	3121794.202	13765044.68	57.043
Horizontal	NVA_214H	271228.533	3284516.124	12.794	851976.423	3287712.512	12.794	3123015.529	13808971.06	41.974
Horizontal	NVA_215H	262255.096	3277650.793	17.568	843363.621	3280385.545	17.568	3094784.969	13784970.69	57.637
Horizontal	NVA_216H	252127.8	3283280.389	22.029	832951.247	3285486.578	22.029	3060667.486	13801697.68	72.273
Horizontal	NVA_217H	258477.657	3290671.314	19.494	838912.989	3293202.032	19.494	3080214.219	13826975.8	63.956
Horizontal	NVA_218H	234394.718	3282017.352	27.083	815298.911	3283305.339	27.083	3002809.899	13794566.19	88.854
Horizontal	NVA_219H	226513.977	3290736.837	38.828	806974.075	3291606.841	38.828	2975530.998	13821785.77	127.387
Horizontal	NVA_220H	243490.457	3292160.089	26.71	823859.815	3293910.722	26.71	3030880.89	13829317.35	87.63
Horizontal	NVA_221H	219489.305	3297411.047	47.331	799610.648	3297908.142	47.331	2951400.737	13842450.55	155.285
Horizontal	NVA_222H	243558.327	3303485.09	33.208	823338.078	3305229.348	33.208	3029186.586	13866415.56	108.951
Horizontal	NVA_223H	235300.617	3308817.888	42.957	814809.935	3310126.302	42.957	3001241.514	13882479.86	140.935
Horizontal	NVA_224H	214210.582	3308509.543	56.802	793760.351	3308717.619	56.802	2932236.777	13877894.78	186.356
Horizontal	NVA_225H	225326.81	3322101.738	62.856	804152.277	3322874.195	62.856	2966328.065	13924286.23	206.221
Horizontal	NVA_226H	241090.764	3318785.458	44.091	820073.376	3320386.913	44.091	3018512.146	13916102.72	144.657
Horizontal	NVA_227H	248350.169	3310015.75	35.593	827785.025	3312004.527	35.593	3043772.759	13888614.27	116.775
Horizontal	NVA_228H	241613.248	3327444.762	49.458	820141.492	3329065.505	49.458	3018753.028	13944549.09	162.263
Horizontal	NVA_229H	250405.592	3325705.323	46.6	829017.43	3327788.917	46.6	3047842.798	13940345.71	152.888
Horizontal	NVA_230H	258265.149	3335568.318	38.442	836352.843	3338057.343	38.442	3071908.502	13973983.37	126.122
Horizontal	NVA_231H	265730.614	3318329.381	29.309	844718.427	3321221.432	29.309	3099286.177	13918788.55	96.157
Horizontal	NVA_232H	275243.358	3324719.069	22.556	853891.246	3328106.531	22.556	3129360.528	13941330.68	74.002

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
Horizontal	NVA_233H	286557.461	3312013.888	15.847	865866.886	3315998.802	15.847	3168574.15	13901631.52	51.992
Horizontal	NVA_234H	285232.294	3336012.711	32.29	863282.636	3339920.829	32.29	3160163.93	13980019.7	105.938
Horizontal	NVA_235H	308026.548	3355849.736	40.798	885025.352	3360958.028	40.798	3231468.503	14048878.35	133.852
Horizontal	NVA_236H	314270.753	3334848.486	28.996	892378.95	3340285.927	28.996	3255491.404	13981132.97	95.13
Horizontal	NVA_237H	263374.731	3343761.231	38.808	841027.413	3346513.843	38.808	3087251.144	14001686.42	127.324
Horizontal	NVA_238H	293161.367	3348845.243	37.675	870532.628	3353168.032	37.675	3183958.654	14023404.26	123.604
VVA	VVA_0	429502.831	3332066.16	2.591	1007862.669	3343576.855	2.591	3633570.136	13991511.23	8.5
VVA	VVA_1	415682.087	3334028.966	4.656	993915.729	3344813.275	4.656	3587942.341	13995610.6	15.277
VVA	VVA_2	423580.777	3321235.707	2.405	1002501.362	3332415.885	2.405	3615989.099	13955015.94	7.891
VVA	VVA_3	419075.149	3322417.264	3.093	997926.2	3333362.247	3.093	3601023.197	13958127.86	10.148
VVA	VVA_4	416640.095	3327937.751	4.107	995196.537	3338763.185	4.107	3592110.728	13975809.27	13.473
VVA	VVA_5	427786.029	3335849.522	3.144	1005943.112	3347276.053	3.144	3627304.709	14003621.25	10.314
VVA	VVA_6	414249.835	3346206.28	9.522	991837.374	3356933.301	9.522	3581190.915	14035278.77	31.239
VVA	VVA_7	415350.87	3336728.305	4.998	993441.446	3347499.25	4.998	3586400.872	14004401.44	16.397
VVA	VVA_8	410637.612	3334199.812	3.825	988854.68	3344718.07	3.825	3571380.917	13995318.43	12.55
VVA	VVA_9	426170.723	3346625.621	8.78	1003754.892	3357984.836	8.78	3620190.8	14038667.23	28.807
VVA	VVA_10	267437.259	3427500.341	47.786	840621.376	3430413.678	47.786	3086249.865	14276694.36	156.778
VVA	VVA_11	266295.095	3410935.859	78.77	840371.287	3413799.134	78.77	3085349.217	14222229.76	258.446
VVA	VVA_12	255457.911	3397267.982	139.034	830274.692	3399560.835	139.034	3052188.949	14175598.71	456.146
VVA	VVA_13	238685.057	3392907.925	106.546	813750.592	3394308.482	106.546	2997996.007	14158444.64	349.561
VVA	VVA_14	260036.326	3382402.911	101.077	835643.045	3384951.779	101.077	3069728.973	14127688.61	331.618
VVA	VVA_15	266609.72	3361411.297	79.255	843327.333	3364323.727	79.255	3094842.693	14060049.73	260.024
VVA	VVA_16	233549.056	3356333.028	76.714	810563.684	3357499.772	76.714	2987427.07	14037781.21	251.687
VVA	VVA_17	219514.131	3356519.005	128.169	796535.547	3356943.483	128.169	2941435.144	14035995.79	420.502
VVA	VVA_18	250508.157	3335418.467	47.81	828609.663	3337499.539	47.81	3046528.581	13972174.18	156.856
VVA	VVA_19	263489.481	3349381.154	38.598	840845.498	3352136.175	38.598	3086670.9	14020113.51	126.633
VVA	VVA_20	268925.358	3337150.005	34.584	846923.045	3340199.072	34.584	3106555.642	13980975.38	113.463
VVA	VVA_21	286895.498	3338339.275	27.497	864822.778	3342334.256	27.497	3165217.165	13987923.4	90.212
VVA	VVA_22	301686.914	3357751.459	45.398	878585.446	3362523.796	45.398	3210375.056	14054031.13	148.944
VVA	VVA_23	326826.447	3351012.122	14.734	904083.411	3357115.128	14.734	3293886.337	14036221.39	48.341
VVA	VVA_24	311253.826	3354744.975	39.614	888311.123	3360024.173	39.614	3242229.788	14045807.25	129.967
VVA	VVA_25	309408.507	3345538.542	34.064	886952.644	3350720.033	34.064	3237747.696	14015331.01	111.759
VVA	VVA_26	309599.097	3331874.092	27.45	887863.619	3337065.417	27.45	3240690.567	13970596.13	90.057
VVA	VVA_27	330564.386	3337878.667	14.988	908516.182	3344175.436	14.988	3308361.501	13993823.51	49.174
VVA	VVA_28	336085.831	3327940.481	19.944	914563.043	3334524.451	19.944	3328136.337	13962196.55	65.433
VVA	VVA_29	335226.024	3323443.083	19.246	913939.305	3329980.035	19.246	3326080.669	13947315.31	63.143
VVA	VVA_30	345684.35	3313589.971	13.237	924919.681	3320670.935	13.237	3362014.591	13916800.93	43.429
VVA	VVA_31	316262.629	3319596.758	17.552	895172.73	3325137.188	17.552	3264601.682	13931502.78	57.586
VVA	VVA_32	293762.892	3328175.9	16.589	872223.231	3332534.774	16.589	3189438.314	13955795.37	54.427
VVA	VVA_33	283611.179	3319275.64	24.465	862541.266	3323104.081	24.465	3157692.899	13924919.24	80.265
VVA	VVA_34	261697.768	3321579.683	34.923	840517.749	3324258.435	34.923	3085526.292	13928750.16	114.577
VVA	VVA_35	251678.595	3324265.324	43.236	830364.947	3326416.842	43.236	3052256.388	13935845.78	141.851
VVA	VVA_36	194795.914	3324060.262	52.521	773560.942	3323230.837	52.521	2866033.782	13925510.53	172.312
VVA	VVA_37	186170.282	3317012.975	82.018	765318.317	3315743.92	82.018	2838994.502	13900974.42	269.086
VVA	VVA_38	163852.608	3325354.053	99.09	742606.183	3322901.824	99.09	2764525.608	13924481.57	325.097
VVA	VVA_39	180394.59	3305727.699	85.737	760141.623	3304176.987	85.737	2822004.067	13863052.83	281.288
VVA	VVA_40	188678.379	3296239.86	61.552	768904.878	3295136.52	61.552	2850728.153	13833399.32	201.943
VVA	VVA_41	189556.51	3310994.578	44.328	769013.148	3309912.519	44.328	2851101.334	13881848.05	145.431
VVA	VVA_42	199456.435	3297960.996	47.009	779576.425	3297415.302	47.009	2885719.981	13840858.98	154.228
VVA	VVA_43	219460.43	3297350.056	46.988	799584.981	3297845.723	46.988	2951316.503	13842245.98	154.184

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
VVA	VVA_44	231708.556	3299424.89	40.489	811711.265	3300555.659	40.489	2991070.229	13851113.33	132.839
VVA	VVA_45	235322.76	3308625.35	43.263	814842.107	3309935.114	43.263	3001346.657	13881853.12	141.938
VVA	VVA_46	248458.331	3310020.688	35.504	827892.841	3312015.111	35.504	3044126.143	13888648.77	116.482
VVA	VVA_47	245973.628	3292963.973	26.664	826299.083	3294843.006	26.664	3038876.769	13832369.85	87.479
VVA	VVA_48	225643.949	3318811.956	54.158	804641.299	3319604.827	54.158	2967925.116	13913567.82	177.682
VVA	VVA_49	236793.286	3327912.448	59.933	815301.668	3329279.797	59.933	3002889.176	13945261.82	196.631
VVA	VVA_50	258414.698	3290522.608	19.313	838857.8	3293050.152	19.313	3080033.163	13826478.14	63.361
VVA	VVA_51	255932.725	3279265.599	20.913	836961.587	3281671.841	20.913	3073806.37	13789192	68.611
VVA	VVA_52	263185.853	3276755.484	18.485	844340.205	3279538.95	18.485	3097984.402	13782195.55	60.645
VVA	VVA_53	269047.324	3286887.163	14.018	849673.168	3289969.173	14.018	3115470.966	13816368.38	45.992
VVA	VVA_54	265347.632	3312993.154	27.282	844614.952	3315868.267	27.282	3098936.351	13901246.01	89.507
VVA	VVA_55	287320.412	3311512.131	15.887	866655.874	3315537.09	15.887	3171158.281	13900117.13	52.124
VVA	VVA_56	303766.389	3313139.881	16.342	883014.206	3318025.154	16.342	3224756.486	13908233.88	53.615
VVA	VVA_57	307553.749	3300568.415	11.558	887458.564	3305651.609	11.558	3239290.562	13867691.15	37.919
VVA	VVA_58	316705.706	3298361.422	8.454	896726.582	3303921.788	8.454	3269645.653	13862008.06	27.737
VVA	VVA_59	318539.385	3290603.657	8.597	898964.778	3296258.105	8.597	3276963.606	13836902.71	28.206
VVA	VVA_60	306978.102	3288379.023	2.928	887517.792	3293431.756	2.928	3239464.535	13827662.27	9.605
VVA	VVA_61	303867.262	3280229.031	3.685	884830.171	3285119.985	3.685	3230649.714	13800438.74	12.09
VVA	VVA_62	299017.413	3292855.109	3.186	879324.367	3297493.606	3.186	3212630.36	13840980.46	10.454
VVA	VVA_63	291198.848	3301044.83	10.471	871080.141	3305274.802	10.471	3185634.24	13866486.06	34.354
VVA	VVA_64	282264.22	3278236.975	12.918	863333.552	3282008.083	12.918	3160221.689	13790267.64	42.383
VVA	VVA_65	270179.016	3271196.967	17.472	851617.378	3274345.155	17.472	3121826.035	13765170.21	57.323
VVA	VVA_66	270653.925	3263083.257	16.292	852511.147	3266259.662	16.292	3124749.252	13738675.89	53.451
VVA	VVA_67	264742.758	3256005.836	14.909	846967.602	3258881.017	14.909	3106581.132	13714500.35	48.915
VVA	VVA_68	255665.083	3248921.951	13.379	838259.535	3251334.417	13.379	3078043.494	13689772.54	43.893
VVA	VVA_69	296271.505	3264154.406	7.16	878066.689	3268652.797	7.16	3208478.534	13746501.09	23.491
VVA	VVA_70	308638.253	3260999.357	2.383	890596.434	3266136.135	2.383	3249521.051	13738249.33	7.819
VVA	VVA_71	340496.857	3294764.047	5.715	920713.43	3301563.723	5.715	3348199.279	13854241.48	18.75
VVA	VVA_72	353532.807	3290124.973	5.263	933999.06	3297601.094	5.263	3391694.635	13841242.43	17.266
VVA	VVA_73	351205.455	3301646.513	9.053	931069.113	3309009.086	9.053	3382123.461	13878600.56	29.702
VVA	VVA_74	360011.14	3304189.367	8.692	939748.217	3312014.028	8.692	3410546.903	13888420.07	28.517
VVA	VVA_75	367054.322	3284309.534	1.247	947834.174	3292484.764	1.247	3436980.909	13824468.8	4.092
VVA	VVA_76	373186.645	3293528.767	3.053	953492.084	3302032.125	3.053	3455519.561	13855712.54	10.015
VVA	VVA_77	365483.958	3271313.865	7.329	946937.172	3279395.804	7.329	3434026.47	13781621.38	24.044
VVA	VVA_78	339035.993	3278596.484	2.373	920092.786	3285311.87	2.373	3346141.596	13801023.83	7.786
VVA	VVA_79	350875.722	3277058.32	0.359	932019.433	3284387.218	0.359	3385193.005	13797980.89	1.178
VVA	VVA_80	348485.467	3262824.081	2.21	930364.738	3270019.552	2.21	3379760.455	13750939.92	7.252
VVA	VVA_81	327336.746	3249572.841	0.941	909888.351	3255670.554	0.941	3312701.785	13703963.83	3.086
VVA	VVA_82	328609.262	3243690.552	1.429	911463.879	3249851.38	1.429	3317860.432	13684906.48	4.688
VVA	VVA_83	318640.053	3237223.713	1.376	901823.233	3242870.587	1.376	3286287.453	13662043.96	4.513
VVA	VVA_84	310612.826	3250778.12	2.46	893098.017	3256015.427	2.46	3257710.546	13705097.95	8.07
VVA	VVA_85	304180.729	3255392.056	4.405	886427.735	3260298.575	4.405	3235863.144	13719129.92	14.452
VVA	VVA_86	292151.702	3253660.682	9.406	874488.382	3257947.74	9.406	3196750.814	13711433.34	30.858
VVA	VVA_87	270361.379	3242423.204	8.83	853281.572	3245593.569	8.83	3127268.34	13670959.9	28.971
VVA	VVA_88	263284.911	3241812.21	11.687	846239.812	3244619.931	11.687	3104194.307	13667769.18	38.343
VVA	VVA_89	236707.852	3238649.821	17.053	819843.812	3240097.974	17.053	3017689.611	13652946.74	55.949
VVA	VVA_90	215148.993	3218273.176	15.146	799347.651	3218642.215	15.146	2950515.697	13582609.61	49.692
VVA	VVA_91	216907.971	3209013.555	12.05	801575.143	3209482.849	12.05	2957824.808	13552586.1	39.536
VVA	VVA_92	213853.379	3190151.683	8.488	799478.857	3190488.371	8.488	2950974.253	13490317.19	27.848
VVA	VVA_93	227858.219	3185130.978	0.468	813721.948	3186179.629	0.468	2997669.88	13476213.43	1.534

Table 4: Checkpoint Types and Coordinates

		UTM Z15N, NAVD88 (Geoid12B), NAD83(2011), Meters			UTM Z14N, NAVD88 (Geoid12B), NAD83(2011), Meters			TX SPCS South Central Zone - NAVD88 (Geoid 99 with a bias of 0.253' up applied), NAD83(2011), US Survey Feet		
Check Point Type	Point ID	X	Y	Z	X	Y	Z	X	Y	Z
VVA	VVA_94	241384.61	3188416.024	1.401	827070.75	3190144.267	1.401	3041417.191	13489228.43	4.597
VVA	VVA_95	251258.024	3203444.615	2.306	836176.639	3205661.671	2.306	3071240.211	13540096.36	7.565
VVA	VVA_96	244118.341	3201532.938	3.247	829138.905	3203389.389	3.247	3048178	13532641.45	10.653
VVA	VVA_97	233812.587	3203928.315	6.787	818720.295	3205260.385	6.787	3014028.59	13538762.19	22.268
VVA	VVA_98	232523.087	3214733.125	8.953	816883.34	3215989.756	8.953	3007997.773	13573927.84	29.372
VVA	VVA_99	261269	3231123.024	9.104	844772.277	3233833.246	9.104	3099387.659	13632422.28	29.868
VVA	VVA_100	281459.894	3230978.471	4.895	864962.525	3234721.193	4.895	3165542.947	13635339.03	16.06
VVA	VVA_101	281779.626	3224261.412	1.143	865625.4	3228022.128	1.143	3167717.82	13613391.09	3.751
VVA	VVA_102	275351.836	3209491.691	1.461	859951.749	3212929.084	1.461	3149140.307	13563935.69	4.795
VVA	VVA_103	271301.031	3202271.455	1.39	856268.925	3205505.626	1.39	3137081.33	13539608.14	4.56
VVA	VVA_104	258543.053	3224368.046	8.473	842392.851	3226942.819	8.473	3091593.561	13609841.7	27.799
VVA	VVA_105	251282.582	3216012.959	6.894	835562.658	3218222.943	6.894	3069216.241	13581261.47	22.619
VVA	VVA_106	246426.979	3212183.441	4.773	830905.247	3214149.136	4.773	3053956.084	13567906.77	15.659
VVA	VVA_107	201234.302	3283000.016	40.559	782128.186	3282568.782	40.559	2894071.333	13792181.01	133.066
VVA	VVA_108	196299.875	3292173.922	45.255	776725.406	3291473.006	45.255	2876366.019	13821379.36	148.474
VVA	VVA_109	362004.031	3292760.819	5.105	942339.416	3300680.369	5.105	3419006.715	13851308.88	16.749
VVA	VVA_110	234311.267	3282328.387	26.586	815199.424	3283611.743	26.586	3002484.097	13795570.59	87.223
VVA	VVA_111	226336.081	3290761.326	39.595	806795.104	3291622.063	39.595	2974944.356	13821835.87	129.903
VVA	VVA_112	243585.969	3303457.317	32.927	823367.144	3305203.041	32.927	3029281.811	13866329.29	108.029
VVA	VVA_113	256048.368	3409258.204	82.807	830222.361	3411572.79	82.807	3052068.722	14214977.3	271.676
VVA	VVA_114	236311.587	3409928.895	91.586	810468.708	3411184.019	91.586	2987302.679	14213787.63	300.478
VVA	VVA_115	162623.004	3316636.389	111.065	741835.012	3314137.676	111.065	2761984.023	13895740.42	364.387
VVA	VVA_116	174055.762	3330045.415	82.123	752543.409	3328118.586	82.123	2797122.69	13941573.84	269.43
VVA	VVA_117	229635.647	3223008.82	12.823	813577.344	3224110.478	12.823	2997156.204	13600543	42.071
VVA	VVA_118	238337.585	3235250.404	11.709	821646.073	3236784.994	11.709	3023597.291	13642088.69	38.415
VVA	VVA_119	328459.212	3267812.087	1.587	910070.099	3273974.638	1.587	3313307.494	13763907.91	5.207
VVA	VVA_120	290552.023	3240972.348	4.481	873540.985	3245178.853	4.481	3193645.378	13669602.09	14.701
VVA	VVA_121	301919.215	3225704.054	3.005	885689.369	3230493.188	3.005	3233446.187	13621497.16	9.859
VVA	VVA_122	284375.396	3262207.307	10.335	866273.044	3266091.969	10.335	3169839.755	13738118.75	33.907
VVA	VVA_123	292985.084	3348622.37	36.568	870368.163	3352935.894	36.568	3183419.033	14022644.17	119.973
VVA	VVA_124	281963.075	3333261.176	31.717	860159.366	3336998.193	31.717	3149922.023	13970451.44	104.058
VVA	VVA_125	234825.571	3336692.545	66.313	812874.668	3337947.514	66.313	2994952.736	13973679.91	217.561
VVA	VVA_126	244955.171	3346250.415	71.748	822490.912	3348029.613	71.748	3026499.545	14006704.77	235.394
VVA	VVA_127	215426.462	3323610.927	73.58	794185.078	3323862.869	73.58	2933654.461	13927546.02	241.403
VVA	VVA_128	242864.597	3366740.338	68.311	819318.536	3368389.746	68.311	3016159.721	14073454.68	224.119
VVA	VVA_129	246391.817	3408000.99	89.511	820641.897	3409798.734	89.511	3020651.845	14209202.79	293.67
VVA	VVA_130	257787.683	3377129.775	96.095	833676.836	3379562.895	96.095	3063264.112	14110031.78	315.272
VVA	VVA_131	267673.151	3353182.297	53.092	844825.689	3356156.028	53.092	3099727.504	14033276.2	174.186
VVA	VVA_132	233532.149	3346060.215	83.131	811089.253	3347237.149	83.131	2989122.561	14004136.7	272.738
VVA	VVA_133	277617.758	3349161.714	45.909	854977.582	3352663.135	45.909	3132986.408	14021798.34	150.62
VVA	VVA_134	241025.458	3318704.848	44.4	820012.351	3320302.959	44.4	3018311.958	13915827.66	145.67
VVA	VVA_135	207481.907	3308045.311	48.338	787064.996	3307902.986	48.338	2910285.356	13875233.84	158.587
VVA	VVA_136	291514.234	3273814.937	7.673	872810.493	3278066.186	7.673	3191266.651	13777343.69	25.173

4. Phase III: Data Processing

The following quality control reviews were conducted during the Data Processing and Final Product Development phases.

Quality Assessment

This section describes the specifications checked, the methods and tools used, and the results of the quality assessment of the AOI deliverables.

Software Used

Primary software programs used by AECOM in performing the quality assessment were as follows:

- *TerraSolid TerraScan* - used for point classification checks and point file generation as needed
- *ESRI ArcMap/ArcCatalog* - general GIS analysis software used to run automated QA models and support manual data review
- *QCoherent LP360 standalone and ArcGIS extension* – LiDAR specific software used to run automated QA processes and support manual data review
- *FugroViewer* – used for data visualization and manual data assessments
- *Proprietary tools* - developed in-house to conduct statistical analyses and data extractions of LAS files

Quality Assessment Process

The following systematic Macro and Micro QA/QC review approach was used for performing quantitative and qualitative assessments. A full list of checks for each dataset type is presented in the following sections.

Macro Reviews

- Deliveries were reviewed for completeness of content
- Performed coverage/gap check to ensure proper coverage of the tiles submitted
 - Verified that tile naming conventions were followed
 - Verified that deliverable formats were correct
 - Created a spatial distribution raster to check that delivery meets data distribution requirements
 - Conducted a statistical analysis of delivery to check point classifications, variable-length record values, and maximum/minimum x,y,z ranges
 - QA/QC processing models were run on the DEM files to isolate data voids, pits and spikes
 - QA/QC processing of breaklines to ensure closed polygon vertices were consistent and direction of flow was accurate

Micro Reviews

- Performed tile-by-tile analysis
 - ArcGIS to review LAS bare earth surface as a raster
 - Using FugroViewer and LP360, checked for errors in profile mode (noise, high and low points)
 - Conducted measurements to determine if delivery met applicable specifications outlined in acquisition specifications (overlap, gaps, etc.)
 - Reviewed hydro breakline data for accuracy and completeness
 - Reviewed each tile for anomalies; if problems were found, the areas were identified using polygons in ESRI SHP format and accompanied by comments and relevant screenshots in the report.
- Reports prepared and submitted to TNRIIS and Fugro

UTM Zones 14 and 15 Macro and Micro Review Quality Assessment Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for review.

Classified LiDAR Point Cloud

Macro QA/QC Checks		
	Review Status	Comments to Fugro and TNRIS
Inventory Assessment		
Conduct file inventory	Meets project specifications	
Verify readability of media	Meets project specifications	
Coverage/Gap check	Meets project specifications	
No tile/data overlap	Meets project specifications	
Tile Naming Convention		
Tile name match index	Meets project specifications	
Metadata Review		
Project Level metadata - Content check	Meets project specifications	
USGS metadata parser check	Meets project specifications	
USGS LiDAR tags present	Meets project specifications	
Tile Level metadata - Content check	Meets project specifications	
USGS metadata parser check	Meets project specifications	
USGS Lidar tags present	Meets project specifications	
LAS Header Check		
LAS format (LAS 1.4)	Meets project specifications	
GPS Times is Adjusted GPS time	Meets project specifications	
GPS times (0.01 m)	Meets project specifications	
LAS X,Y,Z scale factors 0.01 precision	Meets project specifications	
LAS Number Variable Length Records Present	Meets project specifications	
Point Source ID assigned	Meets project specifications	
LAS Point Data Record Format - 6	Meets project specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z 14 or Z15 meters	Meets project specifications	
At least 3 returns per pulse	Meets project specifications	
Acceptable classes - 1,2,3,4,5,6,7,9,10,13,14	Meets project specifications	
Analysis		
LAS Overlap Flag - Overage points flagged as Overlap in Classified point clouds. Class 12 should NOT be used	Meets project specifications	
LAS Withheld Flag - Geometrically unreliable points flagged as Withheld in Classified point clouds	Meets project specifications	
Horizontal Accuracy Check - RMSE \leq 0.20 m	Meets project specifications	
Vertical Accuracy Check - NVA (RMSE \leq 0.1 m, 95% CI \leq 0.194 m)	Meets project specifications	
Vertical Accuracy Check - VVA (\leq 0.196 m @ 95th Percentile)	Meets project specifications	
Intra-swath Accuracy (\leq 0.06 m)	Meets project specifications	
Inter-swath Accuracy (\leq 0.08 m, MAX +/- 0.16m)	Meets project specifications	
ANPS \leq 0.35 m OR ANPD \geq 8.0 pts/m ²	Meets project specifications	
Spatial Distribution and Uniformity (At least 90 percent of the cells in a 0.7 m grid contain at least one single swath, FR lidar point)	Meets project specifications	
Duplicate Points (X, Y, Z, AND TIME)	Meets project specifications	
Gross Anomaly Check		
Extreme intensity values	Meets project specifications	

Systematic data dropouts	Meets project specifications	
Micro QA/QC Checks		
	Review Status	Comments to Fugro and TNRIS
Classification Review (1=unclassified, 2=bare earth ground, 3=low vegetation, 4=medium vegetation, 5=high vegetation, 6=buildings, 7=low point/noise, 9=water, 10=ignored ground (near BL), 13=bridges, 14=culverts)		
Consistency in filtering	Meets project specifications	
Classification accuracy (misclassification)	Meets project specifications	
Building sides are C6 not veg	Meets project specifications	
Data voids/gaps $\geq (4x ANPS)^2 = 1.96 m^2$	Meets project specifications	
Ridges/steps	Meets project specifications	
Cornrows	Meets project specifications	
Spikes/Divots (noise)	Meets project specifications	
No LiDAR shadowing (sliver gaps) around taller structures	Meets project specifications	

Intensity Rasters

Macro QA/QC Checks		
	Review Status	Comments to Fugro and TNRIS
Inventory Assessment		
Conduct file inventory	Meets project specifications	
Verify readability of media	Meets project specifications	
Coverage/Gap check	Meets project specifications	
50 meter tile overlap with 90 degree corners	Meets project specifications	
Tile Naming Convention		
Tile name match index	Meets project specifications	
Metadata Review		
Project Level metadata - Content check	Meets project specifications	
USGS metadata parser check	Meets project specifications	
Tile Level metadata - Content check	Meets project specifications	
USGS metadata parser check	Meets project specifications	
INTENSITY Header Check		
GeoTIFF format, 8, 16, or 32bit U	Meets project specifications	
Resolution $\leq 0.5 m$	Meets project specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z 14 or Z15 meters	Meets project specifications	
Analysis		
NODATA set to 256	Meets project specifications	
Micro QA/QC Checks		
	Review Status	Comments to Fugro and TNRIS
Micro Review		
Uniformity/consistency across swath	Meets project specifications	
No over or under saturation/Extreme intensity values	Meets project specifications	

Hydro-flattened Breaklines

Macro QA/QC Checks		
	Review Status	Comments to Fugro and TNIRIS
Inventory Assessment		
Conduct file inventory	Meets project specifications	
Verify readability of media	Meets project specifications	
Coverage/Gap check	Meets project specifications	
Breaklines can extend just beyond AOI limits	Meets project specifications	
Metadata Review		
Project Level metadata - Content check	Meets project specifications	
USGS metadata parser check	Meets project specifications	
Tile Level metadata - Content check	Meets project specifications	
USGS metadata parser check	Meets project specifications	
Breakline Header Checks		
Seamless or Tile based PolylineZ or PolygonZ GDB format v10.3	Meets project specifications	
.PRJ file present	N/A. GDB provided	
NAVD88, Geoid 12B, NAD83(2011), UTM Z 14 or Z15 meters	Meets project specifications	
Analysis		
No duplicate features	Meets project specifications	
No topology issues (overlapping features, snapping issues, or open polygons)	Meets project specifications	
Expresses monotonicity	Meets project specifications	
Relative Vertical Accuracy Check	Meets project specifications	
Micro QA/QC Checks		
	Review Status	Comments to Fugro and TNIRIS
Micro Review		
Streams/Rivers break at culverts	Meets project specifications	
Streams/Rivers continuous at bridges	Meets project specifications	
All inland streams and rivers should have been captured and flattened that have a 15.25 m nominal width	Meets project specifications	
Water bodies greater than 10,000 m ² collected	Meets project specifications	
Islands greater than 5,000 m ² collected	Meets project specifications	

Vertical Accuracy Assessment

Relative Vertical Accuracy

Intrawath Relative Accuracy – Intrawath vertical relative accuracy was tested using 137,910 points on a 1m grid residing on two dispersed airport tarmacs. All but 4,105 First Return, Single Swath points (3%) have Z difference of less than 6 cm and are deemed ignored. For the sake of brevity a table has not be included in this report.

Interswath Relative Accuracy – Measuring 1,746,350 interswath points, and excluding 8,330 points that exceeded 0.16 m that resided in vegetation areas, an RMSEz = 0.04m was calculated. For the sake of brevity a table has not be included in this report.

Absolute Vertical Accuracy

Vertical accuracy of LiDAR data will be achieved by comparing the elevation of Class 2 Bare Earth points against the QA/QC checkpoint elevation values. Deviations were reported as an RMSE and @95% confidence for NVA assessments and @95th Percentile for VVA assessments.

NVA Accuracy Assessment

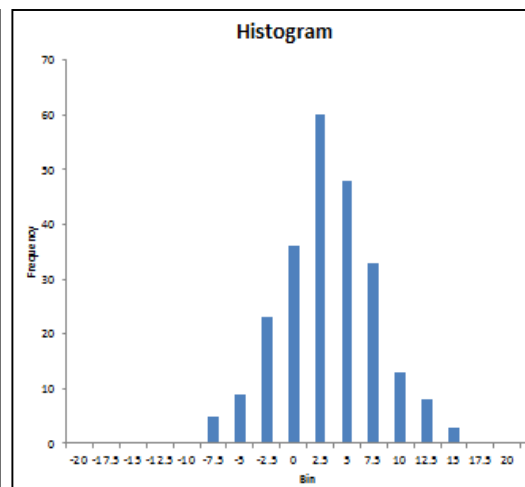
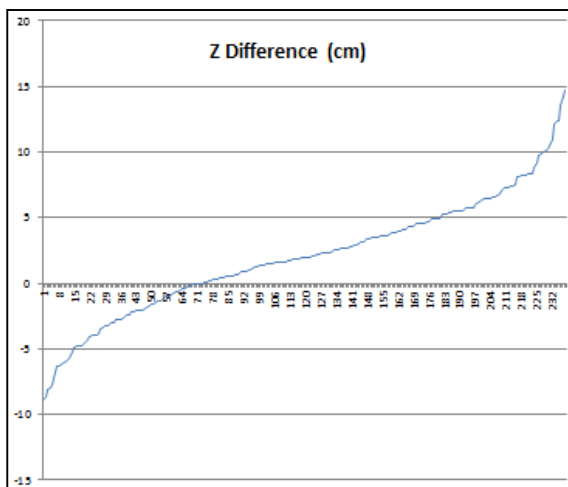
Table 5: LiDAR NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_61	19.762	19.662	0.100
NVA_68	20.447	20.377	0.070
NVA_73	23.710	23.642	0.069
NVA_140	1.909	1.844	0.065
NVA_201H	4.819	4.761	0.058
NVA_136	7.378	7.326	0.052
NVA_69	19.542	19.493	0.049
NVA_1	2.708	2.659	0.049
NVA_138	2.495	2.450	0.045
NVA_191	1.679	1.634	0.045
NVA_139	2.353	2.310	0.043
NVA_203H	4.972	4.930	0.042
NVA_5	6.727	6.687	0.040
NVA_2	6.325	6.286	0.039
NVA_15	6.730	6.694	0.036
NVA_64	34.212	34.178	0.035
NVA_130	6.003	5.969	0.034
NVA_141	2.103	2.069	0.034
NVA_111	13.474	13.442	0.032
NVA_66	27.648	27.617	0.031
NVA_67	15.556	15.526	0.030
NVA_71	13.597	13.570	0.027
NVA_192	5.147	5.120	0.027
NVA_10	3.864	3.837	0.027
NVA_205H	11.621	11.594	0.027
NVA_63	39.885	39.860	0.025
NVA_137	2.611	2.588	0.023
NVA_135	3.373	3.350	0.023
NVA_60	21.867	21.844	0.023
NVA_8	1.672	1.650	0.023
NVA_17	5.541	5.521	0.020
NVA_3	6.210	6.191	0.019
NVA_200H	3.317	3.298	0.019
NVA_131	5.459	5.440	0.019
NVA_132	10.769	10.751	0.018
NVA_236H	28.996	28.978	0.018
NVA_235H	40.798	40.780	0.018

Table 5: LiDAR NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_11	3.219	3.201	0.018
NVA_178	5.069	5.053	0.016
NVA_179	29.978	29.963	0.016
NVA_199H	2.940	2.925	0.015
NVA_14	3.355	3.340	0.015
NVA_202H	7.120	7.107	0.013
NVA_6	5.102	5.090	0.012
NVA_16	3.684	3.675	0.009
NVA_72	17.853	17.846	0.007
NVA_134	1.642	1.636	0.006
NVA_70	18.426	18.421	0.005
NVA_13	5.344	5.340	0.004
NVA_18	3.712	3.708	0.004
NVA_0	2.793	2.790	0.003
NVA_112	12.023	12.020	0.003
NVA_4	7.632	7.630	0.002
NVA_12	9.059	9.059	0.000
NVA_19	9.345	9.346	-0.001
NVA_7	2.428	2.430	-0.002
NVA_204H	8.424	8.430	-0.006
NVA_62	17.904	17.911	-0.007
NVA_113	8.991	9.008	-0.017
NVA_114	9.090	9.133	-0.043
NVA_133	9.171	9.219	-0.048
NVA_228H	49.458	49.310	0.148
NVA_79	44.349	44.225	0.124
NVA_38	75.035	74.914	0.121
NVA_37	69.666	69.557	0.109
NVA_223H	42.957	42.854	0.103
NVA_207H	10.660	10.559	0.101
NVA_108	27.053	26.955	0.098
NVA_226H	44.091	44.000	0.091
NVA_40	80.494	80.411	0.083
NVA_227H	35.593	35.510	0.083
NVA_102	19.207	19.124	0.083
NVA_197	31.648	31.566	0.082
NVA_96	40.446	40.364	0.082
NVA_230H	38.442	38.361	0.081
NVA_196	37.081	37.000	0.081
NVA_39	53.323	53.248	0.075
NVA_54	51.313	51.239	0.074
NVA_52	65.572	65.498	0.074
NVA_98	28.674	28.601	0.073
NVA_56	34.489	34.424	0.066
NVA_99	35.167	35.102	0.065
NVA_198	16.717	16.6531	0.0639
NVA_229H	46.6	46.5362	0.0638
NVA_76	21.822	21.7595	0.0625
NVA_97	43.748	43.6906	0.0574
NVA_41	84.207	84.1506	0.0564
NVA_222H	33.208	33.1528	0.0552
NVA_208H	8.561	8.50598	0.05502
NVA_183	43.155	43.1	0.055
NVA_78	42.278	42.2238	0.0542
NVA_80	60.773	60.72	0.053
NVA_100	25.202	25.1528	0.0492
NVA_59	46.22	46.173	0.047

Table 5: LiDAR NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_53	70.064	70.0176	0.0464
NVA_55	37.751	37.7051	0.0459
NVA_106	14.024	13.9782	0.0458
NVA_77	34.512	34.469	0.043
NVA_238H	37.675	37.6322	0.0428
NVA_231H	29.309	29.2684	0.0406
NVA_218H	27.083	27.0458	0.0372
NVA_57	45.777	45.7408	0.0362
NVA_216H	22.029	21.9941	0.0349
NVA_220H	26.71	26.6815	0.0285
NVA_74	22.815	22.7867	0.0283
NVA_101	27.489	27.4615	0.0275
NVA_180	26.645	26.619	0.026
NVA_107	23.495	23.4723	0.0227
NVA_75	24.295	24.2745	0.0205
NVA_217H	19.494	19.474	0.02
NVA_237H	38.808	38.7903	0.0177
NVA_103	20.265	20.2491	0.0159
NVA_232H	22.556	22.5409	0.0151
NVA_214H	12.794	12.7847	0.0093
NVA_206H	9.836	9.82896	0.00704
NVA_119	9.613	9.60741	0.00559
NVA_182	32.641	32.6388	0.0022
NVA_65	33.193	33.1927	0.0003
NVA_234H	32.29	32.2907	-0.0007
NVA_117	4.195	4.19972	-0.00472
NVA_105	13.492	13.5119	-0.0199
NVA_233H	15.847	15.8753	-0.0283
NVA_58	27.814	27.8552	-0.0412
NVA_109	15.563	15.6087	-0.0457
NVA_110	16.949	16.9965	-0.0475
NVA_118	10.61	10.6624	-0.0524
NVA_211H	3.097	3.03004	0.06696
NVA_212H	12.729	12.68	0.049
NVA_194	2.522	2.48366	0.03834
NVA_142	1.206	1.17003	0.03597
NVA_164	9.588	9.55352	0.03448
NVA_189	13.293	13.2676	0.0254
NVA_149	7.082	7.05716	0.02484
NVA_146	4.837	4.82025	0.01675
NVA_213H	17.387	17.3706	0.0164
NVA_162	3.906	3.88962	0.01638
NVA_215H	17.568	17.557	0.011
NVA_193	4.711	4.70166	0.00934
NVA_104	18.466	18.46	0.006
NVA_169	6.352	6.34667	0.00533
NVA_121	17.155	17.1503	0.0047
NVA_175	5.409	5.40589	0.00311
NVA_170	0.989	0.99	-0.001
NVA_120	12.597	12.6002	-0.0032
NVA_167	5.211	5.2147	-0.0037
NVA_126	13.766	13.7737	-0.0077
NVA_150	12.18	12.19	-0.01
NVA_125	12.641	12.6514	-0.0104
NVA_174	7.394	7.40616	-0.01216
NVA_143	1.523	1.53688	-0.01388
NVA_123	15.382	15.396	-0.014

Table 5: LiDAR NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_153	17.458	17.4732	-0.0152
NVA_168	2.168	2.18658	-0.01858
NVA_190	12.063	12.0832	-0.0202
NVA_147	9.77	9.791	-0.021
NVA_148	8.519	8.54114	-0.02214
NVA_163	6.772	6.79425	-0.02225
NVA_128	6.839	6.86271	-0.02371
NVA_171	3.729	3.75386	-0.02486
NVA_166	9.561	9.58724	-0.02624
NVA_158	8.872	8.89919	-0.02719
NVA_127	7.235	7.26317	-0.02817
NVA_155	15.354	15.3847	-0.0307
NVA_210H	7.788	7.81983	-0.03183
NVA_144	2.527	2.56	-0.033
NVA_161	2.654	2.68718	-0.03318
NVA_151	10.93	10.9644	-0.0344
NVA_145	2.828	2.86637	-0.03837
NVA_195	10.912	10.9513	-0.0393
NVA_154	18.126	18.1656	-0.0396
NVA_129	2.634	2.68105	-0.04705
NVA_156	12.39	12.4374	-0.0474
NVA_157	7.583	7.63183	-0.04883
NVA_173	8.889	8.94773	-0.05873
NVA_122	16.572	16.6324	-0.0604
NVA_209H	3.488	3.55	-0.062
NVA_160	1.447	1.51	-0.063
NVA_116	4.011	4.07425	-0.06325
NVA_172	3.599	3.66668	-0.06768
NVA_115	2.992	3.07	-0.078
NVA_152	18.31	18.39	-0.08
NVA_159	0.912	0.993426	-0.081426
NVA_165	10.066	10.1525	-0.0865
NVA_124	13.403	13.4922	-0.0892
NVA_46	84.908	84.7649	0.1431
NVA_92	47.316	47.1811	0.1349
NVA_177	45.559	45.4547	0.1043
NVA_93	49.028	48.9633	0.0647
NVA_89	86.042	85.9841	0.0579
NVA_84	52.584	52.5284	0.0556
NVA_47	53.021	52.9673	0.0537
NVA_48	60.971	60.9321	0.0389
NVA_187	110.841	110.802	0.039
NVA_87	101.344	101.308	0.036
NVA_83	52.611	52.5759	0.0351
NVA_90	60.339	60.3065	0.0325
NVA_85	82.148	82.127	0.021
NVA_176	41.307	41.2932	0.0138
NVA_188	81.496	81.4864	0.0096
NVA_91	44.859	44.8602	-0.0012
NVA_86	96.661	96.6699	-0.0089
NVA_88	98.127	98.1368	-0.0098
NVA_35	68.747	68.6236	0.1234
NVA_50	81.445	81.346	0.099
NVA_45	90.151	90.0632	0.0878
NVA_95	56.052	55.9702	0.0818
NVA_44	126.909	126.836	0.073
NVA_82	74.738	74.6657	0.0723

Table 5: LiDAR NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_26	131.307	131.242	0.065
NVA_51	82.967	82.906	0.061
NVA_221H	47.331	47.2718	0.0592
NVA_181	39.466	39.4091	0.0569
NVA_94	46.583	46.5283	0.0547
NVA_43	95.622	95.5697	0.0523
NVA_219H	38.828	38.779	0.049
NVA_25	79.085	79.0393	0.0457
NVA_184	46.335	46.2939	0.0411
NVA_42	79.934	79.9055	0.0285
NVA_36	96.61	96.5877	0.0223
NVA_34	76.022	75.9997	0.0223
NVA_32	85.62	85.6036	0.0164
NVA_224H	56.802	56.7871	0.0149
NVA_81	54.311	54.2974	0.0136
NVA_21	67.079	67.0656	0.0134
NVA_27	87.997	87.9866	0.0104
NVA_20	76.048	76.0475	0.0005
NVA_23	89.167	89.168	-0.001
NVA_30	106.913	106.917	-0.004
NVA_33	108.002	108.018	-0.016
NVA_49	95.896	95.9125	-0.0165
NVA_185	83.118	83.139	-0.021
NVA_225H	62.856	62.877	-0.021
NVA_29	106.384	106.408	-0.024
NVA_28	118.468	118.498	-0.03
NVA_24	63.792	63.825	-0.033
NVA_31	100.294	100.334	-0.04
NVA_186	91.042	91.0992	-0.0572
NVA_22	74.56	74.62	-0.06



Vertical Accuracy Statistics - NSSDA									
# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew	Min (cm)	Max (cm)	95% CI (cm) (RMSE * 1.96)	95TH (cm) Percentile
239	4.910	4.484	2.021	-1.924	0.084	-8.920	14.770	9.623	9.798

NVA Accuracy Assessment Results

PASS

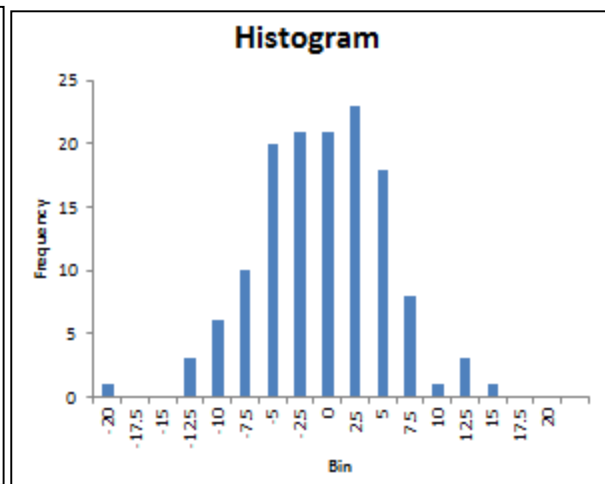
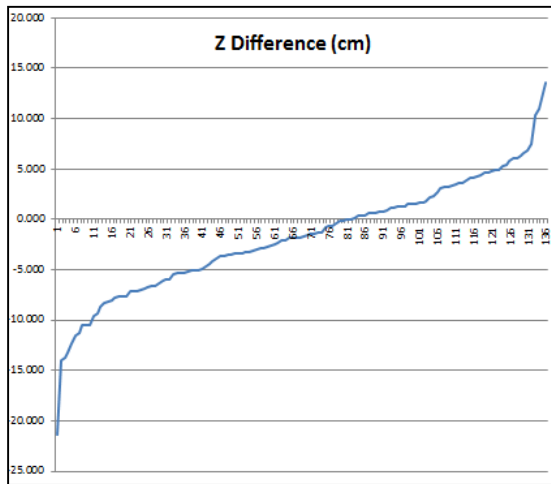
Tested 9.80 cm vertical accuracy at 95% confidence level in bare earth using RMSEz x 1.9600.

VVA Accuracy Assessment

Table 6: LiDAR VVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
VVA_109	5.105	5.062	0.043
VVA_77	7.329	7.290	0.039
VVA_76	3.053	3.017	0.036
VVA_71	5.715	5.688	0.027
VVA_24	39.614	39.592	0.022
VVA_29	19.246	19.230	0.016
VVA_73	9.053	9.040	0.013
VVA_0	2.591	2.578	0.013
VVA_25	34.064	34.051	0.013
VVA_5	3.144	3.132	0.012
VVA_9	8.780	8.768	0.012
VVA_4	4.107	4.100	0.007
VVA_119	1.587	1.583	0.004
VVA_28	19.944	19.941	0.003
VVA_58	8.454	8.455	-0.001
VVA_75	1.247	1.248	-0.001
VVA_78	2.373	2.380	-0.007
VVA_27	14.988	14.995	-0.007
VVA_26	27.450	27.463	-0.013
VVA_57	11.558	11.572	-0.014
VVA_31	17.552	17.570	-0.018
VVA_72	5.263	5.287	-0.024
VVA_8	3.825	3.850	-0.025
VVA_1	4.656	4.684	-0.028
VVA_23	14.734	14.762	-0.028
VVA_80	2.210	2.238	-0.028
VVA_7	4.998	5.034	-0.036
VVA_2	2.405	2.447	-0.042
VVA_30	13.237	13.288	-0.051
VVA_79	0.359	0.423	-0.064
VVA_6	9.522	9.588	-0.066
VVA_59	8.597	8.693	-0.096
VVA_74	8.692	8.816	-0.124
VVA_15	79.255	79.119	0.136
VVA_131	53.092	52.982	0.110
VVA_125	66.313	66.210	0.103
VVA_54	27.282	27.207	0.075
VVA_20	34.584	34.516	0.068
VVA_44	40.489	40.423	0.066
VVA_50	19.313	19.252	0.061
VVA_46	35.504	35.446	0.058
VVA_134	44.400	44.351	0.049
VVA_45	43.263	43.215	0.048
VVA_22	45.398	45.351	0.047
VVA_34	34.923	34.877	0.046
VVA_133	45.909	45.868	0.041
VVA_123	36.568	36.533	0.035
VVA_35	43.236	43.202	0.034

Table 6: LiDAR VVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
VVA_126	71.748	71.716	0.032
VVA_18	47.810	47.791	0.019
VVA_55	15.887	15.870	0.017
VVA_47	26.664	26.647	0.017
VVA_33	24.465	24.449	0.016
VVA_32	16.589	16.583	0.006
VVA_53	14.018	14.017	0.001
VVA_51	20.913	20.913	0.000
VVA_124	31.717	31.731	-0.014
VVA_49	59.933	59.954	-0.021
VVA_112	32.927	32.961	-0.034
VVA_19	38.598	38.634	-0.035
VVA_21	27.497	27.536	-0.039
VVA_110	26.586	26.652	-0.066
VVA_56	16.342	16.413	-0.071
VVA_63	10.471	10.553	-0.082
VVA_62	3.186	3.400	-0.214
VVA_52	18.485	18.449	0.036
VVA_85	4.405	4.373	0.032
VVA_64	12.918	12.888	0.031
VVA_96	3.247	3.243	0.004
VVA_120	4.481	4.486	-0.005
VVA_81	0.941	0.949	-0.008
VVA_117	12.823	12.836	-0.013
VVA_87	8.830	8.849	-0.019
VVA_98	8.953	8.979	-0.026
VVA_91	12.050	12.079	-0.029
VVA_121	3.005	3.038	-0.033
VVA_102	1.461	1.494	-0.033
VVA_97	6.787	6.820	-0.033
VVA_66	16.292	16.326	-0.034
VVA_65	17.472	17.507	-0.035
VVA_136	7.673	7.718	-0.045
VVA_105	6.894	6.94115	-0.04715
VVA_101	1.143	1.19245	-0.04945
VVA_95	2.306	2.35624	-0.05024
VVA_92	8.488	8.53972	-0.05172
VVA_83	1.376	1.42909	-0.05309
VVA_84	2.46	2.51317	-0.05317
VVA_69	7.16	7.21338	-0.05338
VVA_100	4.895	4.95	-0.055
VVA_104	8.473	8.5321	-0.0591
VVA_70	2.383	2.4426	-0.0596
VVA_67	14.909	14.9703	-0.0613
VVA_90	15.146	15.2132	-0.0672
VVA_118	11.709	11.78	-0.071
VVA_99	9.104	9.17508	-0.07108
VVA_106	4.773	4.84999	-0.07699
VVA_103	1.39	1.47081	-0.08081
VVA_88	11.687	11.7688	-0.0818
VVA_61	3.685	3.77132	-0.08632
VVA_68	13.379	13.4718	-0.0928
VVA_86	9.406	9.51077	-0.10477
VVA_122	10.335	10.4398	-0.1048
VVA_82	1.429	1.53436	-0.10536
VVA_89	17.053	17.1652	-0.1122
VVA_93	0.468	0.583257	-0.115257

Table 6: LiDAR VVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
VVA_60	2.928	3.06522	-0.13722
VVA_94	1.401	1.54143	-0.14043
VVA_135	48.338	48.2773	0.0607
VVA_108	45.255	45.2019	0.0531
VVA_42	47.009	46.9648	0.0442
VVA_107	40.559	40.5501	0.0089
VVA_115	111.065	111.057	0.008
VVA_37	82.018	82.0106	0.0074
VVA_39	85.737	85.7307	0.0063
VVA_38	99.09	99.0904	-0.0004
VVA_36	52.521	52.5369	-0.0159
VVA_116	82.123	82.1407	-0.0177
VVA_40	61.552	61.5699	-0.0179
VVA_41	44.328	44.4053	-0.0773
VVA_128	68.311	68.1911	0.1199
VVA_43	46.988	46.9246	0.0634
VVA_111	39.595	39.5403	0.0547
VVA_132	83.131	83.0851	0.0459
VVA_17	128.169	128.128	0.041
VVA_48	54.158	54.1355	0.0225
VVA_127	73.58	73.5641	0.0159
VVA_130	96.095	96.1132	-0.0182
VVA_129	89.511	89.5321	-0.0211
VVA_12	139.034	139.065	-0.031
VVA_13	106.546	106.583	-0.037
VVA_113	82.807	82.8577	-0.0507
VVA_11	78.77	78.8383	-0.0683
VVA_114	91.586	91.6575	-0.0715
VVA_16	76.714	76.79	-0.076
VVA_10	47.786	47.8625	-0.0765
VVA_14	101.077	101.209	-0.132



Vertical Accuracy Statistics - NSSDA									
# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew	Min (cm)	Max (cm)	95% CI (cm) (RMSE * 1.96)	95TH (cm) Percentile
137	5.899	5.669	-1.702	1.765	-0.177	-21.407	13.600	11.562	11.642

VVA Accuracy Assessment Results

PASS Tested 11.64 cm vertical accuracy at 95th percentile in vegetated areas.

Horizontal Accuracy Assessment

Horizontal accuracy of LiDAR data will be achieved by identifying coincident locations between the Intensity rasters and the horizontal checkpoints. Deviations exhibited by the LiDAR Intensity rasters relative to the checkpoints were reported as an RMSE. The RMSE reported below reflects an accuracy assessment for both UTM zones. Shaded points below reside in Zone 14.

Table 7: NSSDA Horizontal Accuracy Results
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters

Point ID	Ground Control Report Values		Orthoimage Coordinates		Residuals (Errors)	
	X	Y	X	Y	Delta X	Delta Y
NVA_201H	316695.409	3300466.289	316695.353	3300466.718	0.05556	-0.22863
NVA_202H	314270.753	3334848.486	314271.205	3334848.470	-0.25243	0.01588
NVA_203H	308271.792	3303095.697	308271.593	3303095.538	0.19844	0.15875
NVA_204H	427300.637	3337208.160	427300.375	3337208.239	0.16193	-0.0793
NVA_205H	413752.239	3340504.461	413752.183	3340504.398	0.05556	0.06350
NVA_235H	412755.219	3333685.426	412755.088	3333685.259	0.13097	0.16669
NVA_236H	308026.548	3355849.736	308026.528	3355849.379	0.01984	0.15719
NVA_206H	301056.103	3297236.349	301056.103	3297236.349	0.00000	0.00000
NVA_208H	284732.155	3284946.257	284732.221	3284946.555	-0.06615	-0.29766
NVA_214H	271228.533	3284516.124	271228.599	3284515.793	-0.06615	0.33073
NVA_216H	252127.800	3283280.389	252127.403	3283280.819	0.39688	-0.12995
NVA_223H	235300.617	3308817.888	235300.418	3308817.822	0.19844	0.06615
NVA_226H	241090.764	3318785.458	241090.664	3318786.252	0.09922	-0.29375
NVA_227H	248350.169	3310015.750	248349.937	3310015.915	0.13151	-0.16536
NVA_228H	241613.248	3327444.762	241613.611	3327444.894	-0.16380	-0.13229
NVA_229H	250405.592	3325705.323	250405.525	3325705.753	0.06615	-0.12995
NVA_230H	258265.149	3335568.318	258265.149	3335568.318	0.00000	0.00000
NVA_231H	265730.614	3318329.381	265730.614	3318329.381	0.00000	0.00000
NVA_232H	275243.358	3324719.069	275242.961	3324719.036	0.19687	0.03307
NVA_233H	286557.461	3312013.888	286557.461	3312013.888	0.00000	0.00000
NVA_234H	285232.294	3336012.711	285232.194	3336012.380	0.09922	0.33073
NVA_237H	263374.731	3343761.231	263374.731	3343761.231	0.00000	0.00000
NVA_238H	293161.367	3348845.243	293161.168	3348845.772	0.19844	-0.5291
NVA_209H	303543.654	3280204.202	303543.548	3280204.123	0.10600	0.07900
NVA_210H	290901.327	3274325.700	290901.195	3274325.700	0.13200	0.00000
NVA_211H	307955.849	3261884.601	307955.796	3261884.601	0.05300	0.00000
NVA_212H	281858.489	3257781.407	281858.648	3257781.407	-0.15900	0.00000
NVA_213H	270167.354	3271159.239	270167.354	3271159.239	0.00000	0.00000
NVA_215H	262255.096	3277650.793	262254.990	3277651.137	0.10600	-0.34400
NVA_219H	226513.977	3290736.837	226513.754	3290736.562	0.22300	0.27500
NVA_221H	219489.305	3297411.047	219488.7807	3297410.996	0.4243	0.05100
NVA_224H	214210.582	3308509.543	214210.4818	3308510.122	0.10020	-0.57900
NVA_225H	225326.810	3322101.738	225326.9003	3322101.968	-0.09030	-0.23000
	Number of Check Points				33	33
	Mean Error (M)				0.071	-0.043
	Standard Deviation (M)				0.143	0.211
	RMSE (M)				0.158	0.212
	RMSEr (M)				0.265	
	NSSDA Horizontal Accuracy (ACCr) at 95% Confidence Level (M)				0.458	

Point Density and Spatial Distribution Analysis

Table 8: Aggregated Nominal Point Density (ANPD) / Aggregated Nominal Point Spacing (ANPS) Check		
Project AOI M ²	22,844,285,911	
Number of First Return(FR), Single Swath(SS) Points	99,812,284,456	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
Number of FR, SS Points/m ² ≥ 4.00	4.37 pts/m ²	PASS

ANPD = 4.37 pts/m² or ANPS = 0.48 m

Table 9: Spatial Distribution of Points (Uniformity Grid Analysis)		
Project AOI M ²	22,844,285,911	
# 1m X 1m cells in project AOI with ≥ 1 FR, SS point	22,533,754,549	
Specification Acceptance		
Specification Threshold	Calculated Result	Status
≥90% of 1m X 1m cells contain at least one single swath, FR point	98.64%	PASS

5. Phase IV: Product Development

Zone 14 and 15 AOI DEM Macro and Micro Quality Assessment Results

A 100% review of the data was performed using automated, semi-automated, and manual review processes. Below is a tabular summary of the review which includes the review status as well as any pertinent notes associated with each QA/QC check. Reporting reflects the status of the final data deliverables after all revised data had been submitted for review.

Macro QA/QC Checks		
	Review Status	Comments to Fugro and TNRIS
Inventory Assessment		
Conduct file inventory	Meets Specifications	
Verify readability of media	Meets Specifications	
Coverage/Gap check	Meets Specifications	
50 meter tile overlap with 90 degree corners	Meets Specifications	
Tile Naming Convention		
Tile name match index	Meets Specifications	
Metadata Review		
Project Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
Tile Level metadata - Content check	Meets Specifications	
USGS metadata parser check	Meets Specifications	
DEM Header Check		
.IMG format, 32bit U	Meets Specifications	
Resolution = 0.5 m	Meets Specifications	
X,Y,Z 0.01 meter precision	Meets Specifications	
NAVD88, Geoid 12B, NAD83(2011), UTM Z15 meters	Meets Specifications	
Analysis		
NODATA value = -9999	Meets Specifications	
Vertical Accuracy Check - NVA (RMSEz ≤ 0.10 m, 95% CI ≤ 0.196 m)	Meets Specifications	
Vertical Accuracy Check - VVA (≤ 0.294 m 95th Percentile)	Meets Specifications	
Micro QA/QC Checks		
	Review Status	Comments to Fugro and TNRIS
Micro Review		
Bridges not in DEM (Culverts in DEM bare earth surface)	Meets Specifications	
Extreme elevation values	Meets Specifications	
No floating or sunken waterbodies	Meets Specifications	
Water bodies greater than 10,000m ² flattened	Meets Specifications	
Islands greater than 5,000 m ² collected	Meets Specifications	
Data voids/gaps	Meets Specifications	
Ridges/steps between tiles	Meets Specifications	
Over or Under aggressive filtering anomalies	Meets Specifications	
Spikes/Divots (noise)	Meets Specifications	

Vertical Accuracy Assessment

Absolute Vertical Accuracy

Vertical accuracy of DEM raster data will be achieved by comparing the rasterized version of Class 2 Bare Earth points against the QA checkpoint elevation values. Deviations were reported as an RMSE and @ 95% confidence for NVA assessments and @ 95th Percentile for VVA assessments.

NVA Accuracy Assessment

Mimicking the checkpoints used as part of the LiDAR NVA checks 238 evenly distributed checkpoints were utilized to calculate the NVA RMSEz.

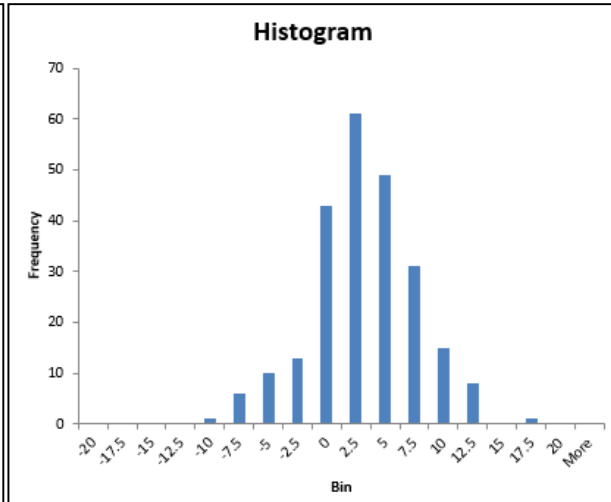
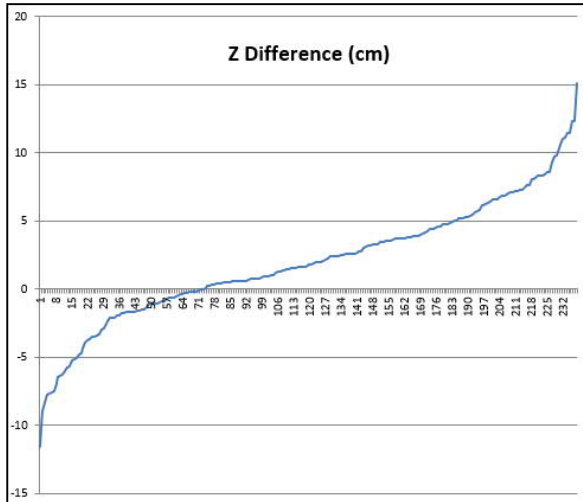
Table 10: DEM NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_0	2.793	2.796	-0.003
NVA_1	2.708	2.653	0.055
NVA_2	6.325	6.283	0.042
NVA_3	6.210	6.189	0.021
NVA_4	7.632	7.627	0.005
NVA_5	6.727	6.693	0.034
NVA_6	5.102	5.096	0.006
NVA_7	2.428	2.439	-0.011
NVA_8	1.672	1.645	0.027
NVA_10	3.864	3.837	0.027
NVA_11	3.219	3.199	0.020
NVA_12	9.059	9.061	-0.002
NVA_13	5.344	5.336	0.008
NVA_14	3.355	3.348	0.007
NVA_15	6.730	6.700	0.030
NVA_16	3.684	3.680	0.004
NVA_17	5.541	5.515	0.026
NVA_18	3.712	3.722	-0.010
NVA_19	9.345	9.347	-0.002
NVA_60	21.867	21.858	0.009
NVA_61	19.762	19.670	0.093
NVA_62	17.904	17.910	-0.006
NVA_63	39.885	39.903	-0.018
NVA_64	34.212	34.173	0.039
NVA_66	27.648	27.616	0.032
NVA_67	15.556	15.525	0.031
NVA_68	20.447	20.375	0.072
NVA_69	19.542	19.490	0.052
NVA_70	18.426	18.420	0.006
NVA_71	13.597	13.563	0.034
NVA_72	17.853	17.844	0.009
NVA_73	23.710	23.641	0.069
NVA_111	13.474	13.469	0.005
NVA_112	12.023	12.025	-0.002
NVA_113	8.991	9.005	-0.014
NVA_114	9.090	9.147	-0.057
NVA_130	6.003	5.966	0.037
NVA_131	5.459	5.438	0.021
NVA_132	10.769	10.743	0.026
NVA_133	9.171	9.222	-0.051
NVA_134	1.642	1.628	0.014
NVA_135	3.373	3.347	0.027
NVA_136	7.378	7.328	0.050

Table 10: DEM NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_137	2.611	2.587	0.024
NVA_138	2.495	2.451	0.044
NVA_139	2.353	2.312	0.041
NVA_140	1.909	1.840	0.069
NVA_141	2.103	2.068	0.035
NVA_178	5.069	5.056	0.013
NVA_179	29.978	29.959	0.019
NVA_191	1.679	1.635	0.044
NVA_192	5.147	5.115	0.032
NVA_199H	2.940	2.934	0.006
NVA_200H	3.317	3.301	0.017
NVA_201H	4.819	4.771	0.048
NVA_202H	7.120	7.111	0.009
NVA_203H	4.972	4.937	0.035
NVA_204H	8.424	8.429	-0.005
NVA_205H	11.621	11.584	0.037
NVA_235H	40.798	40.774	0.024
NVA_236H	28.996	28.974	0.022
NVA_37	69.666	69.568	0.098
NVA_38	75.035	74.925	0.110
NVA_39	53.323	53.208	0.115
NVA_40	80.494	80.410	0.084
NVA_41	84.207	84.161	0.046
NVA_52	65.572	65.491	0.081
NVA_53	70.064	70.020	0.044
NVA_54	51.313	51.242	0.071
NVA_55	37.751	37.704	0.047
NVA_56	34.489	34.440	0.049
NVA_57	45.777	45.739	0.038
NVA_58	27.814	27.820	-0.006
NVA_59	46.220	46.163	0.057
NVA_65	33.193	33.194	-0.001
NVA_74	22.815	22.780	0.035
NVA_75	24.295	24.271	0.024
NVA_76	21.822	21.776	0.046
NVA_77	34.512	34.446	0.066
NVA_78	42.278	42.225	0.053
NVA_79	44.349	44.226	0.123
NVA_80	60.773	60.719	0.054
NVA_96	40.446	40.3622	0.0838
NVA_97	43.748	43.6793	0.0687
NVA_98	28.674	28.606	0.068
NVA_99	35.167	35.0937	0.0733
NVA_100	25.202	25.1568	0.0452
NVA_101	27.489	27.4635	0.0255
NVA_102	19.207	19.151	0.056
NVA_103	20.265	20.245	0.02
NVA_105	13.492	13.522	-0.03
NVA_106	14.024	13.9852	0.0388
NVA_107	23.495	23.4887	0.0063
NVA_108	27.053	26.9871	0.0659
NVA_109	15.563	15.6025	-0.039
NVA_110	16.949	16.9512	-0.002
NVA_117	4.195	4.1847	0.0103
NVA_118	10.61	10.6628	-0.053
NVA_119	9.613	9.6053	0.0077
NVA_180	26.645	26.6332	0.0118

Table 10: DEM NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_182	32.641	32.639	0.002
NVA_183	43.155	43.0829	0.0721
NVA_196	37.081	37.0096	0.0714
NVA_197	31.648	31.572	0.076
NVA_198	16.717	16.6337	0.0833
NVA_206H	9.836	9.8351	0.0009
NVA_207H	10.66	10.5624	0.0976
NVA_208H	8.561	8.5093	0.0517
NVA_214H	12.794	12.778	0.016
NVA_216H	22.029	22.0031	0.0259
NVA_217H	19.494	19.4788	0.0152
NVA_218H	27.083	27.0692	0.0138
NVA_220H	26.71	26.6854	0.0246
NVA_222H	33.208	33.1691	0.0389
NVA_223H	42.957	42.8562	0.1008
NVA_226H	44.091	43.9851	0.1059
NVA_227H	35.593	35.5298	0.0632
NVA_228H	49.458	49.343	0.115
NVA_229H	46.6	46.5373	0.0627
NVA_230H	38.442	38.3659	0.0761
NVA_231H	29.309	29.2995	0.0095
NVA_232H	22.556	22.5144	0.0416
NVA_233H	15.847	15.8664	-0.019
NVA_234H	32.29	32.2855	0.0045
NVA_237H	38.808	38.808	0
NVA_238H	37.675	37.6392	0.0358
NVA_104	18.466	18.451	0.015
NVA_152	18.31	18.385	-0.075
NVA_154	18.126	18.135	-0.009
NVA_215H	17.568	17.573	-0.005
NVA_153	17.458	17.46	-0.002
NVA_213H	17.387	17.384	0.003
NVA_121	17.155	17.166	-0.011
NVA_122	16.572	16.619	-0.047
NVA_123	15.382	15.398	-0.016
NVA_155	15.354	15.389	-0.035
NVA_126	13.766	13.776	-0.01
NVA_124	13.403	13.519	-0.116
NVA_189	13.293	13.26	0.033
NVA_212H	12.729	12.68	0.049
NVA_125	12.641	12.658	-0.017
NVA_120	12.597	12.592	0.005
NVA_156	12.39	12.407	-0.017
NVA_150	12.18	12.189	-0.009
NVA_190	12.063	12.08	-0.017
NVA_151	10.93	10.965	-0.035
NVA_195	10.912	10.96	-0.048
NVA_165	10.066	10.15	-0.084
NVA_147	9.77	9.787	-0.017
NVA_166	9.561	9.586	-0.025
NVA_164	9.588	9.564	0.024
NVA_173	8.889	8.913	-0.024
NVA_158	8.872	8.887	-0.015
NVA_148	8.519	8.596	-0.077
NVA_210H	7.788	7.782	0.006
NVA_157	7.583	7.616	-0.033
NVA_174	7.394	7.388	0.006

Table 10: DEM NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_127	7.235	7.242	-0.007
NVA_149	7.082	7.045	0.037
NVA_128	6.839	6.876	-0.037
NVA_163	6.772	6.79	-0.018
NVA_169	6.352	6.334	0.018
NVA_175	5.409	5.407	0.002
NVA_167	5.211	5.203	0.008
NVA_146	4.837	4.82	0.017
NVA_193	4.711	4.712	-1E-03
NVA_116	4.011	4.071	-0.06
NVA_162	3.906	3.888	0.018
NVA_171	3.729	3.767	-0.038
NVA_172	3.599	3.656	-0.057
NVA_209H	3.488	3.553	-0.065
NVA_115	2.992	3.07	-0.078
NVA_211H	3.097	3.033	0.064
NVA_145	2.828	2.845	-0.017
NVA_129	2.634	2.685	-0.051
NVA_161	2.654	2.66	-0.006
NVA_144	2.527	2.556	-0.029
NVA_194	2.522	2.485	0.037
NVA_168	2.168	2.184	-0.016
NVA_143	1.523	1.51	0.013
NVA_160	1.447	1.51	-0.063
NVA_142	1.206	1.202	0.004
NVA_170	0.989	0.983	0.006
NVA_159	0.912	0.976	-0.064
NVA_46	84.908	84.756687	0.1513
NVA_47	53.021	52.970355	0.0506
NVA_48	60.971	60.931598	0.0394
NVA_83	52.611	52.578441	0.0326
NVA_84	52.584	52.546213	0.0378
NVA_85	82.148	82.150661	-0.003
NVA_86	96.661	96.664718	-0.004
NVA_87	101.344	101.30675	0.0373
NVA_88	98.127	98.161399	-0.034
NVA_89	86.042	85.980749	0.0613
NVA_90	60.339	60.300579	0.0384
NVA_91	44.859	44.85103	0.008
NVA_92	47.316	47.192485	0.1235
NVA_93	49.028	48.966446	0.0616
NVA_176	41.307	41.291863	0.0151
NVA_177	45.559	45.475315	0.0837
NVA_187	110.841	110.815142	0.0259
NVA_188	81.496	81.48093	0.0151
NVA_26	131.307	131.2409973	0.066
NVA_44	126.909	126.8339996	0.075
NVA_28	118.468	118.4889984	-0.021
NVA_33	108.002	108.0210037	-0.019
NVA_30	106.913	106.8970032	0.016
NVA_29	106.384	106.4049988	-0.021
NVA_31	100.294	100.3700027	-0.076
NVA_36	96.61	96.58499908	0.025
NVA_49	95.896	95.91699982	-0.021
NVA_43	95.622	95.5739975	0.048
NVA_186	91.042	91.13200378	-0.09
NVA_45	90.151	90.06999969	0.081

Table 10: DEM NVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
NVA_23	89.167	89.1780014	-0.011
NVA_27	87.997	87.9940033	0.003
NVA_32	85.62	85.58300018	0.037
NVA_185	83.118	83.1289978	-0.011
NVA_51	82.967	82.8809967	0.086
NVA_50	81.445	81.35900116	0.086
NVA_42	79.934	79.9240036	0.01
NVA_25	79.085	79.08000183	0.005
NVA_20	76.048	76.02799988	0.02
NVA_34	76.022	75.9980011	0.024
NVA_82	74.738	74.68599701	0.052
NVA_22	74.56	74.62999725	-0.07
NVA_35	68.747	68.63600159	0.111
NVA_21	67.079	67.06300354	0.016
NVA_24	63.792	63.83599854	-0.044
NVA_225H	62.856	62.87099838	-0.015
NVA_224H	56.802	56.76900101	0.033
NVA_95	56.052	55.97000122	0.082
NVA_81	54.311	54.29600143	0.015
NVA_221H	47.331	47.27299881	0.058
NVA_94	46.583	46.52999878	0.053
NVA_184	46.335	46.32899857	0.006
NVA_181	39.466	39.39300156	0.073
NVA_219H	38.828	38.75799942	0.07



NVA Vertical Accuracy Statistics - NSSDA									
# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew	Min (cm)	Max (cm)	95% CI (RMSE * 1.96) (cm)	95 TH Percentile (cm)
238	4.796	4.388	1.957	-1.750	-0.055	-11.600	15.131	9.400	9.327

NVA Accuracy Assessment Results

PASS

Tested 9.40 cm vertical accuracy at 95% confidence level in bare earth using RMSEz x 1.9600

VVA Accuracy Assessment

Mimicking the checkpoints used as part of the LiDAR VVA checks 136 evenly distributed checkpoints were utilized to report VVA RMSEz.

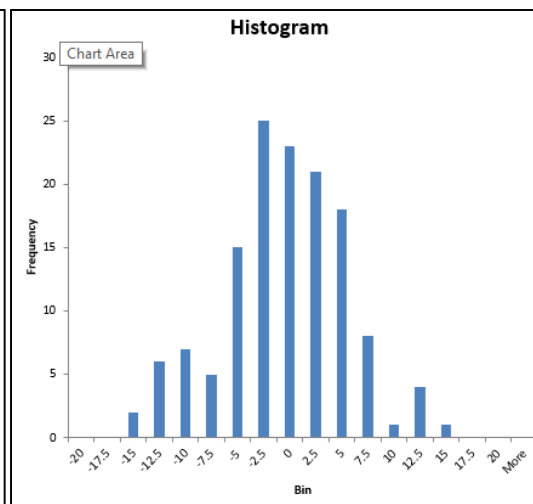
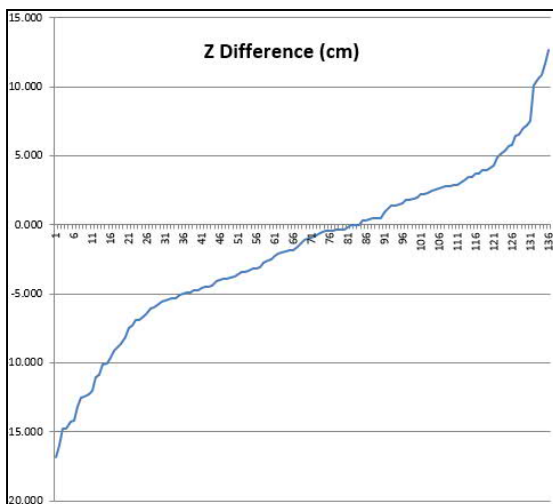
Table 11: DEM VVA Assessment

UTM, NAVD88, Geoid 12B, NAD83(2011), Meters

GPS Point Name	Survey Elevation	DEM Elevation	Difference
VVA_0	2.59	2.59	0.00
VVA_1	4.66	4.69	-0.04
VVA_2	2.41	2.44	-0.04
VVA_4	4.11	4.09	0.02
VVA_5	3.14	3.14	0.00
VVA_6	9.52	9.58	-0.06
VVA_7	5.00	5.04	-0.04
VVA_8	3.83	3.85	-0.02
VVA_9	8.78	8.77	0.01
VVA_23	14.73	14.76	-0.03
VVA_24	39.61	39.59	0.02
VVA_25	34.06	34.02	0.04
VVA_26	27.45	27.47	-0.02
VVA_27	14.99	14.99	-0.01
VVA_28	19.94	19.94	0.00
VVA_29	19.25	19.24	0.00
VVA_30	13.24	13.27	-0.03
VVA_31	17.55	17.57	-0.02
VVA_57	11.56	11.61	-0.05
VVA_58	8.45	8.46	0.00
VVA_59	8.60	8.70	-0.10
VVA_71	5.72	5.69	0.03
VVA_72	5.26	5.31	-0.04
VVA_73	9.05	9.04	0.01
VVA_74	8.69	8.82	-0.12
VVA_75	1.25	1.26	-0.01
VVA_76	3.05	3.01	0.04
VVA_77	7.33	7.29	0.04
VVA_78	2.37	2.37	0.00
VVA_79	0.36	0.53	-0.17
VVA_80	2.21	2.24	-0.03
VVA_109	5.11	5.07	0.03
VVA_119	1.59	1.59	0.00
VVA_15	79.26	79.14	0.12
VVA_18	47.81	47.79	0.02
VVA_19	38.60	38.62	-0.03
VVA_20	34.58	34.54	0.04
VVA_21	27.50	27.54	-0.05
VVA_22	45.40	45.37	0.03
VVA_32	16.59	16.58	0.00
VVA_33	24.47	24.44	0.03
VVA_34	34.92	34.89	0.03

Table 11: DEM VVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
VVA_35	43.24	43.20	0.04
VVA_44	40.49	40.46	0.03
VVA_45	43.26	43.20	0.06
VVA_46	35.50	35.45	0.05
VVA_47	26.66	26.65	0.02
VVA_49	59.93	59.94	0.00
VVA_50	19.31	19.28	0.04
VVA_51	20.91	20.90	0.02
VVA_53	14.02	14.05	-0.03
VVA_54	27.28	27.18	0.10
VVA_55	15.89	15.86	0.03
VVA_56	16.34	16.46	-0.12
VVA_62	3.19	3.33	-0.15
VVA_63	10.47	10.53	-0.06
VVA_110	26.59	26.65	-0.06
VVA_112	32.93	32.95	-0.02
VVA_123	36.57	36.54	0.03
VVA_124	31.72	31.71	0.01
VVA_125	66.31	66.20	0.11
VVA_126	71.75	71.71	0.04
VVA_131	53.09	52.99	0.11
VVA_133	45.91	45.83	0.08
VVA_134	44.40	44.33	0.07
VVA_52	18.49	18.46	0.02
VVA_65	17.47	17.47	0.00
VVA_89	17.05	17.18	-0.12
VVA_66	16.29	16.30	-0.01
VVA_90	15.15	15.22	-0.07
VVA_67	14.91	14.96	-0.05
VVA_68	13.38	13.53	-0.15
VVA_64	12.92	12.90	0.02
VVA_117	12.82	12.83	-0.01
VVA_91	12.05	12.05	0.00
VVA_88	11.69	11.77	-0.08
VVA_118	11.71	11.75	-0.04
VVA_122	10.34	10.43	-0.09
VVA_86	9.41	9.52	-0.11
VVA_99	9.10	9.19	-0.09
VVA_98	8.95	8.99	-0.04
VVA_87	8.83	8.85	-0.02
VVA_104	8.47	8.62	-0.14
VVA_92	8.49	8.55	-0.06
VVA_136	7.67	7.72	-0.05
VVA_69	7.16	7.21	-0.05
VVA_105	6.89	6.94	-0.05
VVA_97	6.79	6.82	-0.03
VVA_100	4.90	4.96	-0.06
VVA_106	4.77	4.82	-0.05
VVA_120	4.48	4.49	-0.01
VVA_85	4.41	4.39	0.02
VVA_61	3.69	3.79	-0.10
VVA_96	3.25	3.23	0.02
VVA_60	2.93	3.05	-0.13
VVA_121	3.01	3.04	-0.03
VVA_84	2.46	2.52	-0.06
VVA_70	2.38	2.45	-0.07
VVA_95	2.31	2.36	-0.05

Table 11: DEM VVA Assessment			
UTM, NAVD88, Geoid 12B, NAD83(2011), Meters			
GPS Point Name	Survey Elevation	DEM Elevation	Difference
VVA_82	1.43	1.56	-0.13
VVA_94	1.40	1.54	-0.14
VVA_102	1.46	1.50	-0.04
VVA_103	1.39	1.46	-0.07
VVA_83	1.38	1.41	-0.03
VVA_101	1.14	1.19	-0.04
VVA_81	0.94	0.97	-0.03
VVA_93	0.47	0.58	-0.11
VVA_36	52.52	52.51	0.01
VVA_37	82.02	82.03	-0.01
VVA_38	99.09	99.09	0.00
VVA_39	85.74	85.74	0.00
VVA_40	61.55	61.57	-0.02
VVA_41	44.33	44.42	-0.10
VVA_42	47.01	46.98	0.03
VVA_107	40.56	40.53	0.03
VVA_108	45.26	45.21	0.05
VVA_115	111.07	111.08	-0.01
VVA_116	82.12	82.14	-0.02
VVA_135	48.34	48.27	0.07
VVA_12	139.03	139.04	0.00
VVA_17	128.17	128.12	0.05
VVA_13	106.55	106.60	-0.05
VVA_14	101.08	101.24	-0.16
VVA_130	96.10	96.09	0.01
VVA_114	91.59	91.65	-0.07
VVA_129	89.51	89.55	-0.04
VVA_132	83.13	83.06	0.07
VVA_113	82.81	82.86	-0.05
VVA_11	78.77	78.84	-0.07
VVA_16	76.71	76.75	-0.04
VVA_127	73.58	73.57	0.01
VVA_128	68.31	68.18	0.13
VVA_48	54.16	54.14	0.01
VVA_10	47.79	47.88	-0.09
VVA_43	46.99	46.93	0.06
VVA_111	39.60	39.54	0.06



VVA Vertical Accuracy Statistics - NSSDA									
# of Pts	RMSEz (cm)	Std Dev (cm)	Mean (cm)	Median (cm)	Skew	Min (cm)	Max (cm)	95% CI (RMSE * 1.96) (cm)	95 TH Percentile (cm)
136	6.210	5.955	-1.836	1.265	-0.240	-16.830	12.700	12.172	12.825

VVA Accuracy Assessment Results	
PASS	Tested 12.82 cm vertical accuracy at 95 th percentile in vegetated areas

Credits

Organizations involved in the procurement, acquisition, processing, and QA/QC of this project are identified below.

Table 12: Project Participants	
Project Function	Participant
LiDAR procurement	Texas Natural Resources Information System (TNRIS) Texas Water Development Board (TWDB) Houston-Galveston Area Council (H-GAC)
LiDAR acquisition and processing	Fugro USA Land, Inc.
QA/QC checkpoint ground surveys	AECOM subcontractor - Gorrondona & Associates, Inc.
Accuracy assessment, QA/QC review, and reporting	AECOM Technical Services, Inc.

6. Conclusions

By TNRIS standards the 2018 Coastal Texas Project was a large scale project having standard TNRIS and USGS specifications and deliverable requirements.

The overarching challenge associated with any geospatial data acquisition and data processing project is the narrow window within which to acquire, process, deliver, validate, and ultimately accept the data within the funding dependent project window.

Specific challenges encountered and addressed in the project were the following:

- Initial uncertainty regarding deliverable parameters for the H-GAC data products was eventually overcome
- Fugro PM change subsequent to data acquisition
- Fugro delivery delays translated into QA/QC review scheduling complexities for AECOM
- LAS classification of some areas deviated from pilot datasets, but were successfully addressed
- Overlap assignment of LAS points resulting in density anomalies in the delivered data. Data structure had a secondary impact of the calculated ANPS and ANPD. The classification structure was eventually addressed by Fugro and ANPS and ANPD accurately reported for each AOI.

Despite the laborious flight planning steps utilizing the LiDAR manufacturer's planning software, and the numerous subsequent internal checks performed by Fugro and AECOM, unanticipated anomalies sometimes present themselves. AECOM's recommends elevating the communication regarding these types of anomalies as part of the Planning Reviews in the future.

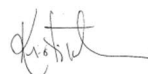
All QA/QC issues reported were satisfactorily addressed by Fugro or deemed insignificant and acceptable by TNRIS. Fugro was responsible to prepare and deliver the completed accepted datasets to TNRIS via mobile drive directly.

The final data sets reviewed by AECOM meet all contractual expectations and will be a valuable resource for all project stakeholders.

Geospatial Quality Assessment Conducted by:



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