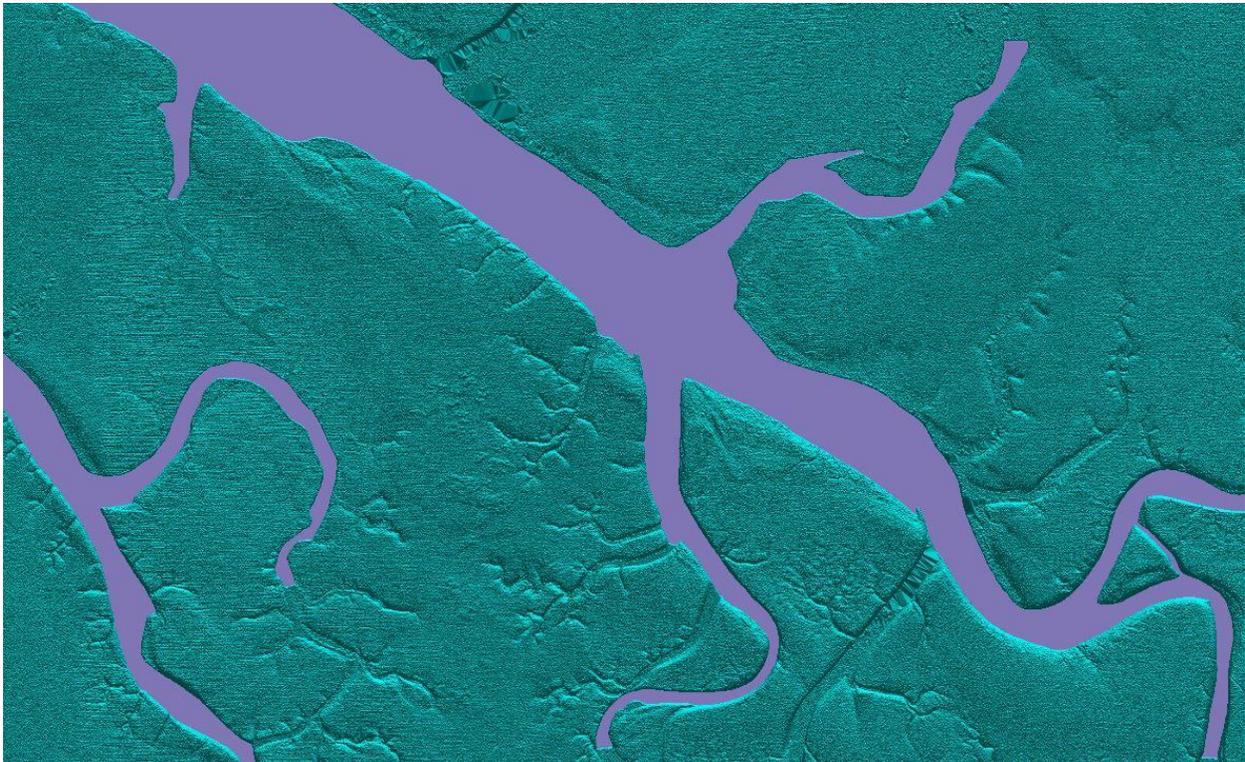


WA Topographic Elevation Data Skagit and Snohomish Counties NOS/OCM Project Report

February 24, 2020



PREPARED FOR

NOAA

Office for Coastal management
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Summary

Tetra Tech was contracted by National Oceanic and Atmospheric Administration's Office for Coastal Management to collect and deliver topographic elevation point data derived from multiple return light detection and ranging (LiDAR) measurements for portions of coastal Skagit and Snohomish County, WA. The project encompasses an area of about 186 square miles. Data was acquired within a 2 hour window of low tide. Deliverables included classified LiDAR point clouds, breaklines and digital elevation models (DEM). Details are provided in the following sections and in the metadata files.

Area of Interest (AOI)

The area of interest (AOI) or project boundary is defined in a boundary shapefile. The defined project area was buffered by 100 meters. All data (point clouds, breaklines and DEMs) were processed and delivered to the full extent of the 100 meter buffer. The buffered boundary is provided in the shapefile 'AOI-100m-extend'.

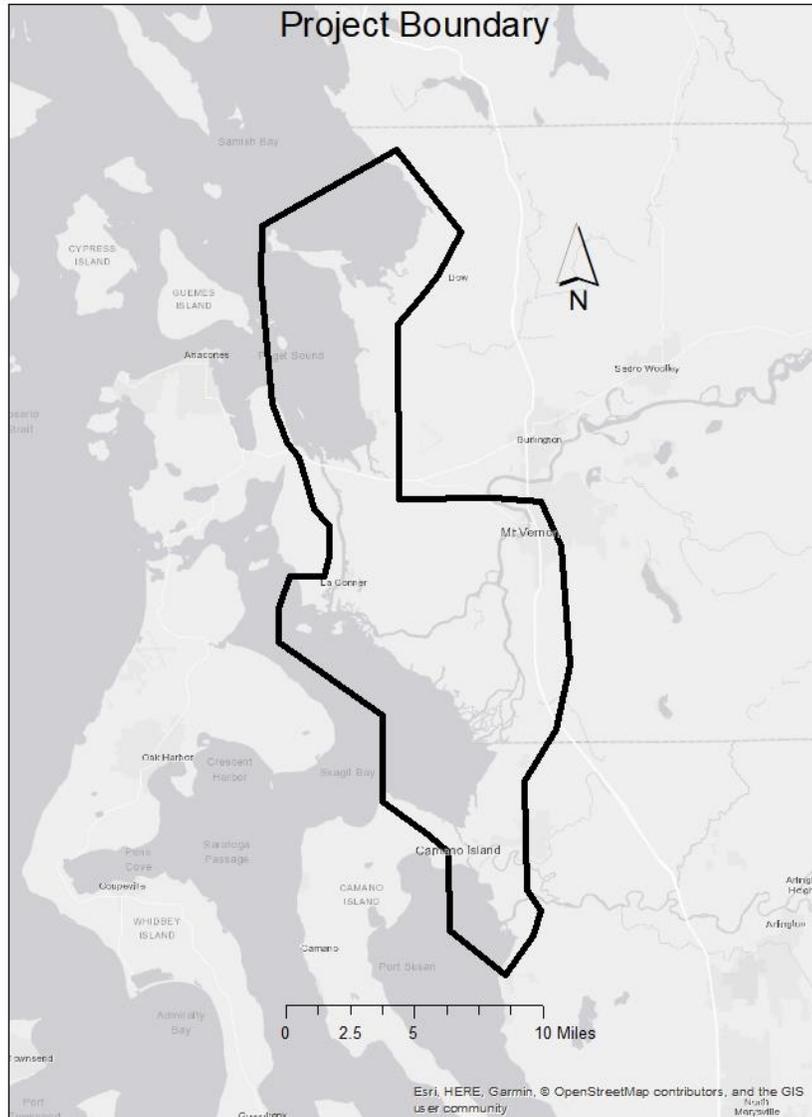


Figure 1: Area of Interest (AOI).

Acquisition

LiDAR data was acquired on 13 and 14 of August 2019. The coastal area was covered in one flight on August 14 while the inland area was covered on August 13. The coastal flight took place on August 14 with a tide window between -0.7 and +0.5 foot. For the airborne LiDAR flight Tetra Tech subcontracted with Eagle Mapping. The data was acquired with a Riegl LMS VQ780i sensor. Detailed flight logs are contained in pdf format in the flight-reports folder. The flight lines are contained in shp format in the shapefiles folder.

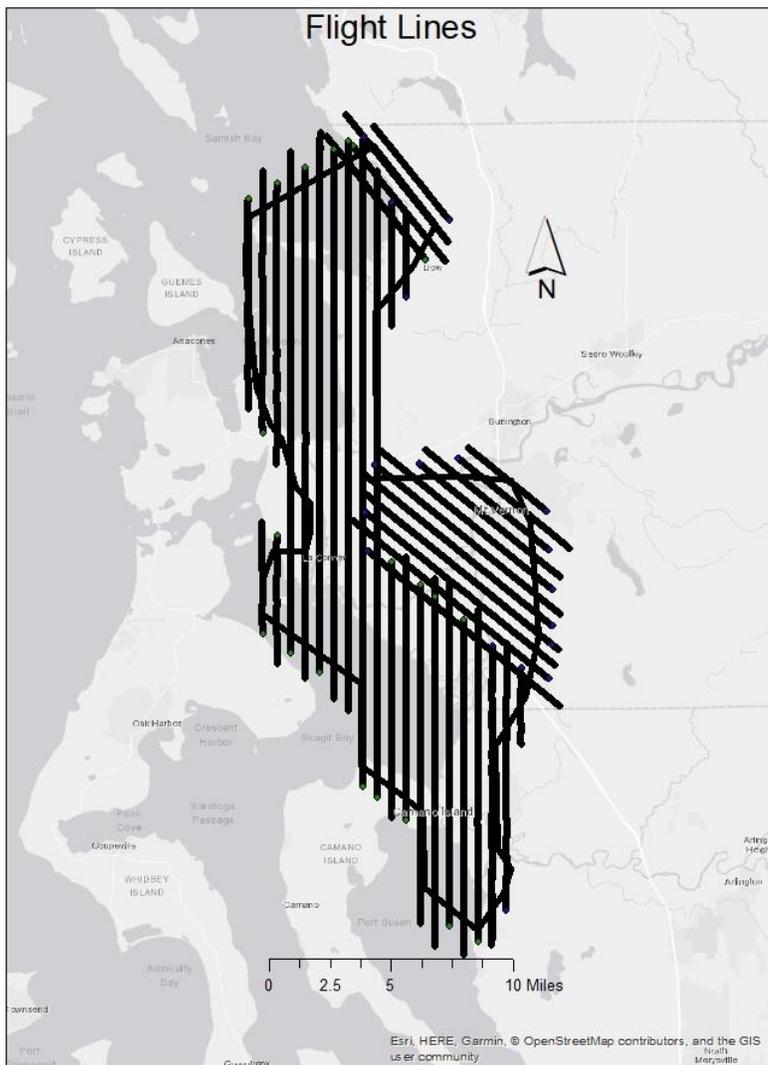


Figure 2: Flight Lines.

Project Coordinate System

Horizontal reference	UTM zone 10, meters, NAVD88
Vertical datum	NAVD88, meters, geoid12B

Ground Control Survey

Ground control survey was conducted by CompassData. CompassData collected 31 points in non-vegetated areas and 21 points in vegetated areas. Compassdata's survey report is contained in the subfolder 'CompassData survey'. Besides the point coordinates the data set contains the survey report and situation images. 7 of the NVA points were provide to Eagle Mapping for point cloud calibration. These points were not used in the absolute accuracy testing.

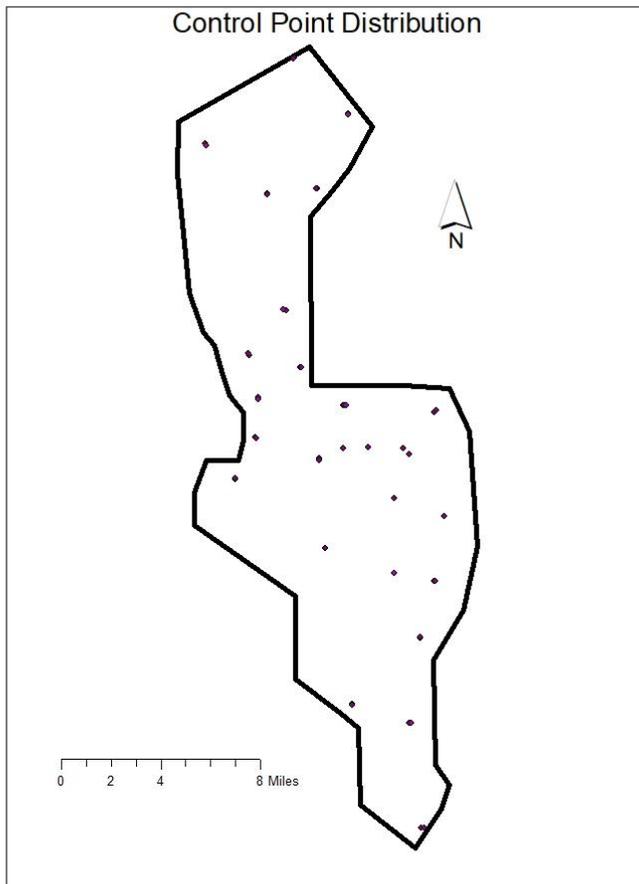


Figure 3: Control Point Distribution.

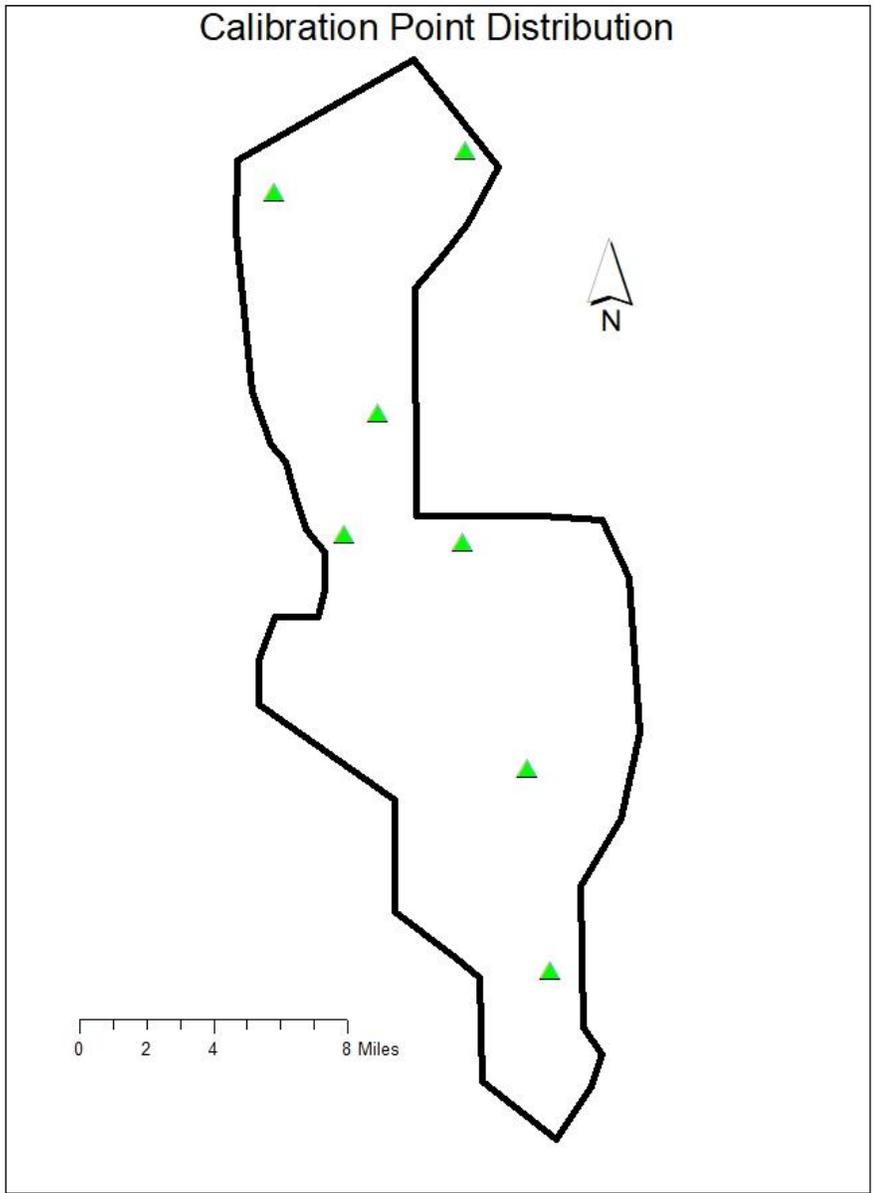


Figure 4: Calibration Points.

Data Quality Control

Prior to classification it was verified that the LiDAR meets data collection specifications as outlined in the scope of work. This included creation of 'dz-orthos' using the LP360 software. 'Dz-orthos' are based on an initial ground classification and flag offsets between overlapping strips that exceed the required threshold. An intensity map was created to confirm the required point density. The point cloud data is checked for data voids. No data voids exist except over water bodies. The point density exceeds the required aggregated point density of 8 points per square meter.

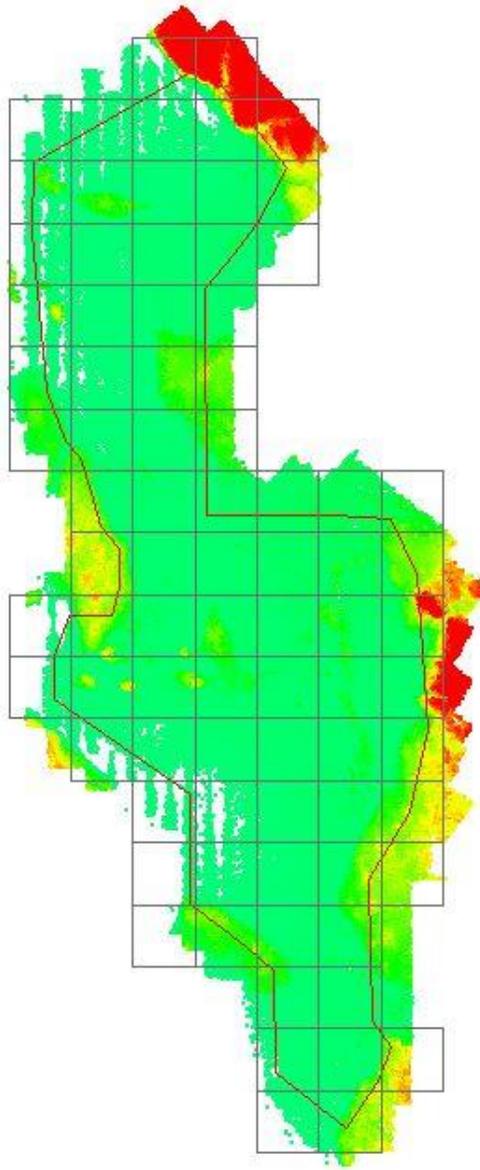


Figure 5: Coverage check. Void areas are over water bodies only.

Accuracy Reporting

Four control reports were prepared to document the absolute accuracy. The absolute accuracy was tested for:

- NVA assessment of the classified ground points
- VVA assessment of the classified ground points
- NVA assessment of the DEM
- VVA assessment of the DEM.

The results are summarized in Table 1

	LAS [m]	DEM [m]
NVA stdev	0.040	0.044
NVA rmse	0.040	0.044
NVA 95%	0.047	0.064
VVA stdev	0.079	0.089
VVA rmse	0.125	0.139
VVA 95%	0.194	0.223

Table 1: Control report summary.

The accuracies required per scope are summarized in Table 2

Required Specifications	LAS [m]	DEM [m]
NVA stdev		
NVA rmse	0.100	0.100
NVA 95%	0.196	0.196
VVA stdev		
VVA rmse		
VVA 95%		0.294

Table 2: Required accuracies per scope.

The complete reports (4) can be found in the Appendix. Calibration points were removed from the check points. Three VVA points were removed because they were located on slopes, one VVA point was removed automatically as being an outlier. The listings can also be found as text files and as pdf files in the control reports subdirectory. The 95% error has been determined by rank ordering the absolute values. All tested values in Table 1 meet or exceed the specifications listed in Table 2.

The relative vertical accuracy has been measured by assessing the swath overlap differences. The RMSE per flight line overlap is shown in Figure 7 and a summary in Figure 6. For 5 flightlines outside the clipped tiles the rmse is above 8 cm. 6797 sample points were evaluated to be within +/- 16 cm.

The relative swath repeatability has been tested to 4 cm.

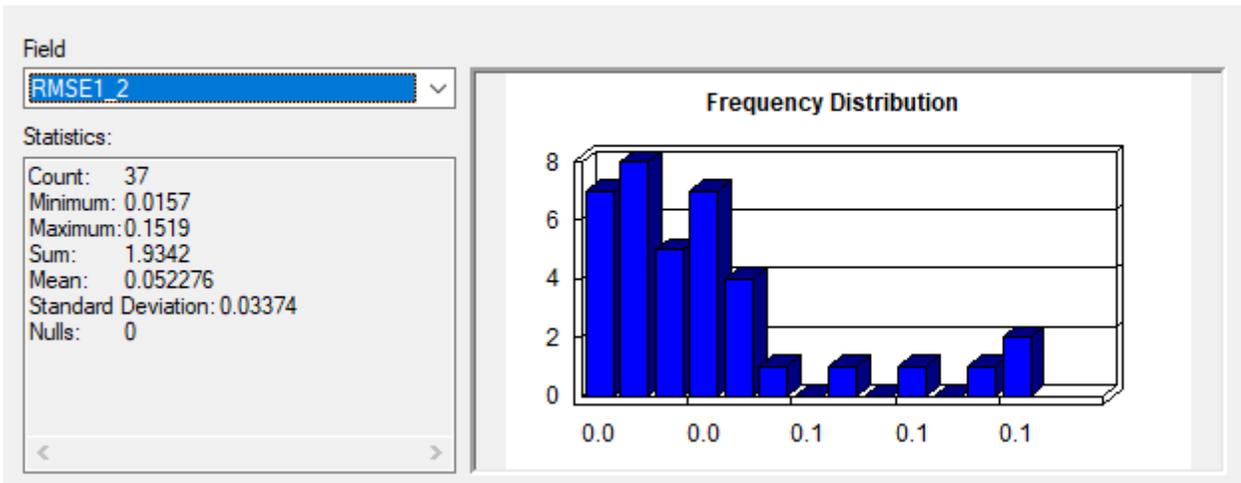


Figure 6: relative accuracy distribution.

FID	Shape	ID	IDSrc1	IDSrc2	RMSE1_2
20	Polyline ZM	22	9	8	0.0157
17	Polyline ZM	19	6	7	0.0163
4	Polyline ZM	5	23	4	0.0184
2	Polyline ZM	3	22	4	0.0218
21	Polyline ZM	23	10	11	0.0249
22	Polyline ZM	24	11	13	0.0249
15	Polyline ZM	17	40	39	0.025
25	Polyline ZM	27	15	14	0.0266
18	Polyline ZM	20	7	8	0.0278
24	Polyline ZM	26	14	15	0.0292
19	Polyline ZM	21	8	7	0.0323
26	Polyline ZM	28	19	15	0.0341
23	Polyline ZM	25	13	12	0.0346
8	Polyline ZM	9	36	37	0.0348
7	Polyline ZM	8	34	36	0.0349
33	Polyline ZM	35	29	30	0.0378
27	Polyline ZM	29	16	17	0.0406
31	Polyline ZM	33	31	32	0.0416
11	Polyline ZM	12	39	38	0.0424
6	Polyline ZM	7	35	34	0.0446
35	Polyline ZM	37	26	25	0.0478
5	Polyline ZM	6	24	35	0.0489
3	Polyline ZM	4	3	23	0.0511
10	Polyline ZM	11	38	37	0.0532
36	Polyline ZM	38	25	26	0.0532
16	Polyline ZM	18	5	6	0.0567
32	Polyline ZM	34	30	29	0.0567
30	Polyline ZM	32	32	31	0.0605
9	Polyline ZM	10	37	38	0.0616
1	Polyline ZM	2	21	22	0.065
34	Polyline ZM	36	27	26	0.0677
12	Polyline ZM	13	41	39	0.0712
29	Polyline ZM	31	33	18	0.0892
28	Polyline ZM	30	17	33	0.1121
14	Polyline ZM	16	43	40	0.136
0	Polyline ZM	1	2	20	0.1431
13	Polyline ZM	14	42	41	0.1519

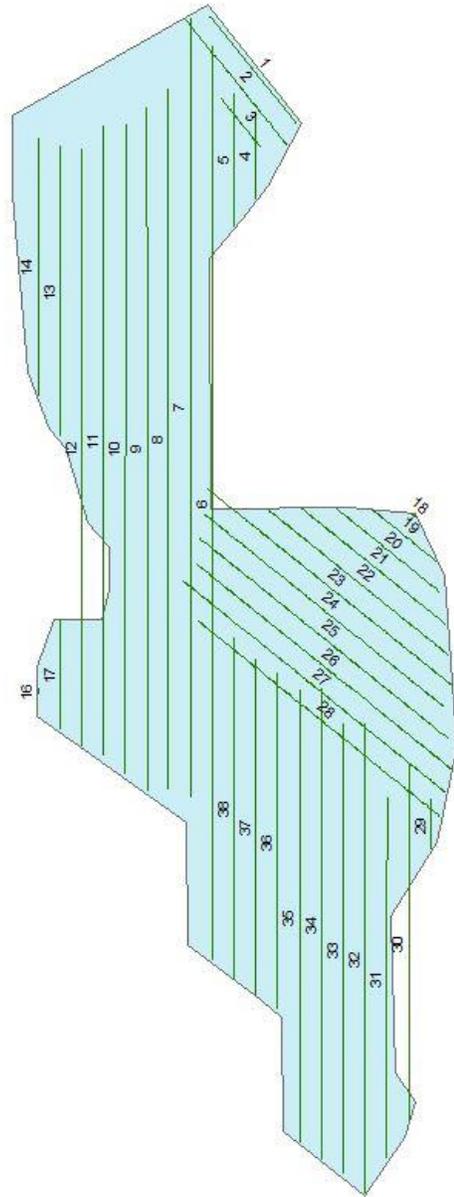


Figure 7: relative accuracy per line.

The data has been collected to meet or exceed a horizontal accuracy of $\leq 1m$.

Point Cloud Classification

The point cloud data was classified using the software tools Microstation, TerraScan and TerraModeler. Ground points were classified using a macro developed in-house. These points were then edited further manually to obtain the best bare earth representation. Water points were classified and edited using the hydro breaklines. Low, medium and high vegetation points were classified as per the following heights from the ground.

1. Low vegetation (<0.6m)
2. Medium vegetation (0.6 to 1.5m)
3. High vegetation (>1.5m)

“Ignored ground points” (class 20) were classified using 0.5m buffer distance from the hydro-breaklines. Bridge decks were identified using the surface file and classified accordingly. High and Low points were identified and classified into their respective classes. The point cloud data was finally tiled out in LP360 with the correct definition of the projected coordinate system

The point clouds have been classified using the following classes:

Class	Description	Point Count	Min	Average	Max
1	Default	11,419,873	-3.11	-0.55	469.75
2	Ground	2,607,438,873	-1.31	-0.41	475.65
3	Low_vegetation (0 – 0.6m)	1,631,352,621	-1.1	-0.28	476.01
4	Medium_vegetation (0.6 – 1.5 m)	151,567,537	-0.67	0.63	476.85
5	High_vegetation (above 1.5m)	1,039,793,650	-0.45	2.87	490.12
7	Low_point	840,222	-419.25	-0.61	476.38
9	Water	145,165,821	-1.42	-0.6	68.39
17	Bridge decks	870,198	-0.08	25.8	37.81
18	High_noise	13,400	-0.99	4.52	383.23
20	Ignored Ground	867,734	-1.25	-0.66	68.35

Table 3: Point classification count.

Breakline Collection

Breaklines were collected for the hydro-flattening of water bodies in the DEM. Breaklines were collected according to specification outlined in USGS Lidar Base Specifications for hydro-flattening of water bodies in the production of the DEM. Ponds/lakes with areas greater than 2 acres, streams/rivers with widths greater than 30.5 meters, non-tidal boundary waters and tidal waters were collected. Judgment calls were made when the width of streams is varying and narrowing around 30.5 meters, and in tidal areas, where detail of the exposed ground surface should be preserved and is of interest to the end user. Breakline collection in the tidal areas was based on feedback provided by NOAA on a pilot area. The intention was to preserve as much detail as possible in the tidal areas rather than flattening areas.

For the collection the software tools Microstation and TerraScan and TerraModel were used. First a ground surface was generated using the classified bare earth class. With the help of this surface and also

using the intensity imagery, breaklines were captured for all the hydro features such as rivers, ponds/ lakes, sea boundary line. While capturing the hydro breaklines for rivers, the downstream method was followed. Hydro breaklines for ponds and lakes were collected with a constant elevation. Hydro-flattening breaklines have finally been saved as closed polygons and are provided in shapefile format as PolygonZ and in Geopackage format.

Breaklines were also used for the classification of the point cloud. Points in proximity to the breaklines were classified as class 20 (ignored ground) and were excluded from the DEM generation process.

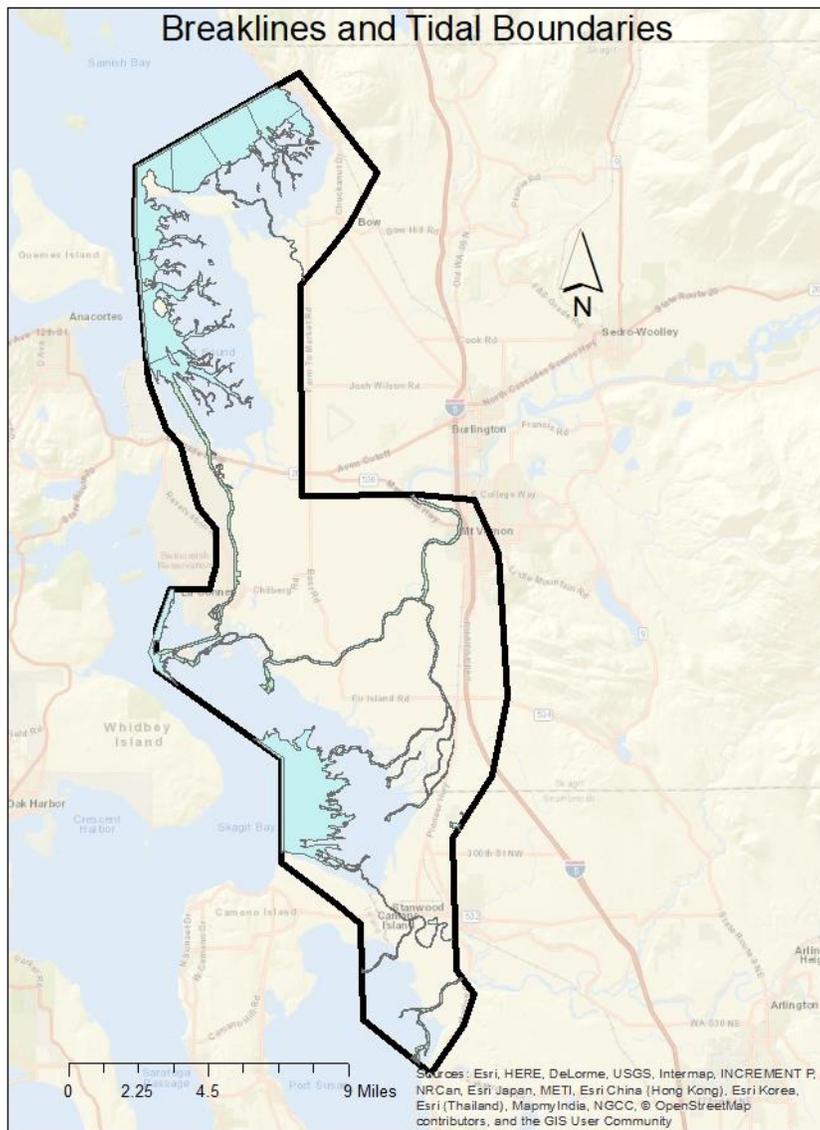


Figure 8: Breaklines.

Digital Elevation Model (DEM)

A bare earth DEM has been generated from the ground class and the breaklines. To generate the DEM tiles, the point clouds, the tiling scheme and the breaklines were loaded into terramodeler. A surface was generated using the triangulation method and exported to a grid with a 1 meter grid spacing and cut to tiles. The NoDATA value has been set to -32767. The 82 DEM tiles are provided as 32-bit rasters in geotiff format with associated tfw files.

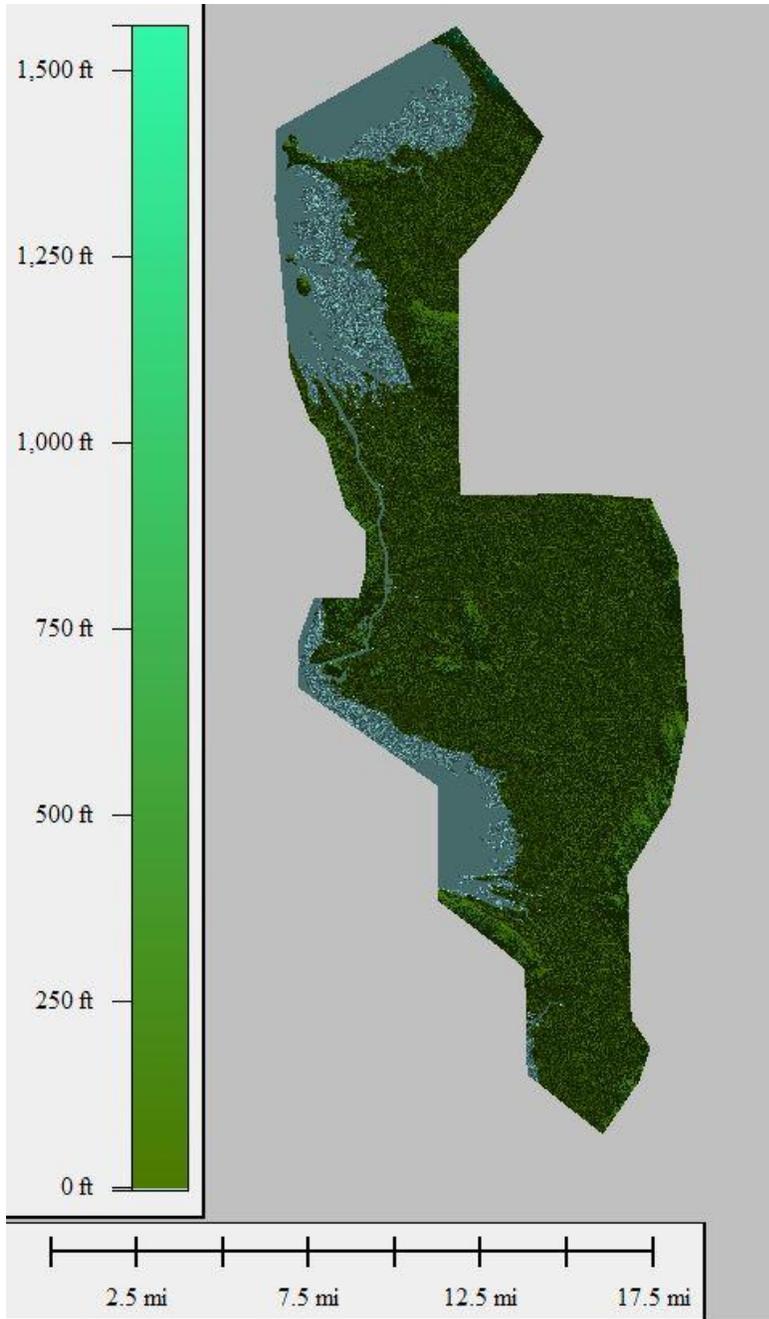


Figure 9: DEM.

Property	Value
Columns and Rows	3000, 3000
Number of Bands	1
Cell Size (X, Y)	1, 1
Uncompressed Size	34.33 MB
Format	TIFF
Source Type	Generic
Pixel Type	floating point
Pixel Depth	32 Bit
NoData Value	-32767

Figure 10: geotiff properties including pixel depth and NoDataValue.

Tiling Scheme

A tiling scheme was developed to cut the deliverables into manageable tiles. The tile size is 3,000 m by 3,000 m. This results in 82 tiles covering the extended (buffered by 100 meters) project boundary. Tiles are names by the lower left corner coordinates. The tiling scheme is provided as a shapefile in the deliverables folder in the shapefiles sub folder.

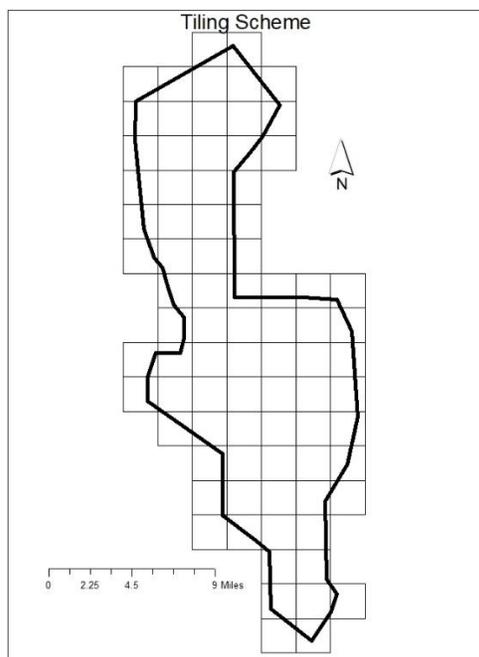


Figure 11: Tiling Scheme.

Deliverables

The deliverables are provided on a USB 3 external hard drive. Deliverables include the LiDAR point cloud, breaklines, DEM and accompanying files such as metadata, reports, and ground survey data. The following table lists the deliverables and the associated folders.

file folder	contents	format
LAZ	classified point cloud	82 LAZ files
LAS	classified point cloud	82 LAS files
DEM	digital elevation model	82 geotiff files with tfw
Breaklines	river	shp file, polygonZm
	tidal boundaries	shp file, polygonZm
	water bodies	shp file, polygonZm
	breaklines	GeoPackage
Shapefiles	AOI (project boundary)	shp file
	calibration points	shp file
	control points	shp, csv
	flight lines	2 shp files
	tiling scheme	shp file
Control Reports	4 reports	pdf and txt files
Reports and Metadata	Flight reports	3 pdf files
	Compass Data survey report	pdf, jpg, csv, other
	metadata	3 xml files

Table 4: Deliverables.

Appendix

1 Control Report NVA DEM

2						
3	Number	Easting	Northing	Known Z	Laser Z	Dz
4	-----					
5	NVA001	539579.650	5386071.463	59.362	59.352	-0.010
6	NVA003	543024.353	5382420.583	3.761	removed	*
7	NVA004	543018.124	5382455.594	3.417	3.388	-0.029
8	NVA005	533868.328	5380404.046	8.610	removed	*
9	NVA006	533841.234	5380569.204	11.695	11.651	-0.044
10	NVA008	541010.483	5377648.185	1.878	1.759	-0.119
11	NVA010	537821.414	5377296.925	2.482	2.453	-0.029
12	NVA011	538821.304	5369859.058	8.859	removed	*
13	NVA012	539022.645	5369771.897	3.585	3.621	+0.036
14	NVA014	536644.325	5366854.783	2.477	2.478	+0.001
15	NVA016	539942.547	5366096.697	3.164	3.185	+0.021
16	NVA017	537244.157	5364010.453	1.787	removed	*
17	NVA018	537255.450	5364165.623	2.067	2.059	-0.008
18	NVA019	544345.648	5360951.724	4.972	4.944	-0.028
19	NVA020	542910.566	5363643.835	3.948	removed	*
20	NVA022	537057.306	5361581.245	18.819	18.801	-0.018
21	NVA024	541192.514	5360248.463	2.625	2.592	-0.033
22	NVA025	542745.894	5363646.512	4.434	4.463	+0.029
23	NVA028	548574.339	5363187.440	10.747	10.629	-0.118
24	NVA029	535754.839	5358891.443	14.011	14.065	+0.054
25	NVA032	541548.715	5354383.612	2.669	2.642	-0.027
26	NVA034	547004.607	5360461.306	6.101	6.164	+0.063
27	NVA036	546008.053	5357620.299	4.603	4.577	-0.026
28	NVA037	549259.006	5356468.298	2.948	2.954	+0.006
29	NVA039	546030.359	5352819.746	1.930	removed	*
30	NVA041	548624.914	5352253.281	4.710	4.682	-0.028
31	NVA043	547673.923	5348595.276	2.805	2.836	+0.031
32	NVA045	547100.331	5343106.884	4.064	4.097	+0.033
33	NVA046	547010.657	5343121.076	3.154	3.166	+0.012
34	NVA047	543290.176	5344307.760	40.720	40.741	+0.021
35	NVA049	547753.580	5336341.998	27.930	27.949	+0.019
36	VVA002	539490.662	5386026.093	3.564	removed	*
37	VVA007	540984.376	5377640.918	1.354	removed	*
38	VVA009	537785.807	5377271.759	1.695	removed	*
39	VVA013	536581.633	5366972.794	1.367	removed	*
40	VVA015	540022.559	5366099.931	2.573	removed	*
41	VVA021	537102.106	5361522.608	6.764	removed	*
42	VVA023	541202.393	5360088.335	2.271	removed	*
43	VVA026	542764.944	5363651.212	3.645	removed	*
44	VVA027	548701.995	5363311.808	8.438	removed	*
45	VVA030	535772.049	5358911.597	12.830	removed	*
46	VVA031	541526.115	5354392.096	2.598	removed	*
47	VVA033	546597.917	5360845.226	6.566	removed	*
48	VVA035	546022.117	5357615.099	3.960	removed	*
49	VVA038	549267.223	5356457.847	2.149	removed	*
50	VVA040	546019.221	5352800.010	1.504	removed	*
51	VVA042	548675.006	5352255.954	2.114	removed	*
52	VVA044	547688.410	5348632.707	2.040	removed	*
53	VVA048	543269.016	5344304.512	40.519	removed	*
54	VVA050	547934.777	5336347.717	38.672	removed	*
55	VVA051	542740.666	5360836.953	2.013	removed	*
56	VVA052	547095.730	5343083.677	1.889	removed	*
57						
58	Average dz	-0.008				
59	Minimum dz	-0.119				
60	Maximum dz	+0.063				
61	Average magnitude	0.034				
62	Root mean square	0.044				
63	Std deviation	0.044				
64						
65						

1 Control Report NVA-LiDAR

2						
3	Number	Easting	Northing	Known Z	Laser Z	Dz
4	-----	-----	-----	-----	-----	-----
5	NVA001	539579.650	5386071.463	59.362	59.336	-0.026
6	NVA003	543024.353	5382420.583	3.761	removed	*
7	NVA004	543018.124	5382455.594	3.417	3.388	-0.029
8	NVA005	533868.328	5380404.046	8.610	removed	*
9	NVA006	533841.234	5380569.204	11.695	11.722	+0.027
10	NVA008	541010.483	5377648.185	1.878	1.791	-0.087
11	NVA010	537821.414	5377296.925	2.482	2.458	-0.024
12	NVA011	538821.304	5369859.058	8.859	removed	*
13	NVA012	539022.645	5369771.897	3.585	3.635	+0.050
14	NVA014	536644.325	5366854.783	2.477	2.482	+0.005
15	NVA016	539942.547	5366096.697	3.164	3.191	+0.027
16	NVA017	537244.157	5364010.453	1.787	removed	*
17	NVA018	537255.450	5364165.623	2.067	2.081	+0.014
18	NVA019	544345.648	5360951.724	4.972	4.933	-0.039
19	NVA020	542910.566	5363643.835	3.948	removed	*
20	NVA022	537057.306	5361581.245	18.819	18.806	-0.013
21	NVA024	541192.514	5360248.463	2.625	2.587	-0.038
22	NVA025	542745.894	5363646.512	4.434	4.462	+0.028
23	NVA028	548574.339	5363187.440	10.747	10.645	-0.102
24	NVA029	535754.839	5358891.443	14.011	14.057	+0.046
25	NVA032	541548.715	5354383.612	2.669	2.677	+0.008
26	NVA034	547004.607	5360461.306	6.101	6.164	+0.063
27	NVA036	546008.053	5357620.299	4.603	4.588	-0.015
28	NVA037	549259.006	5356468.298	2.948	2.929	-0.019
29	NVA039	546030.359	5352819.746	1.930	removed	*
30	NVA041	548624.914	5352253.281	4.710	4.693	-0.017
31	NVA043	547673.923	5348595.276	2.805	2.842	+0.037
32	NVA045	547100.331	5343106.884	4.064	4.108	+0.044
33	NVA046	547010.657	5343121.076	3.154	3.183	+0.029
34	NVA047	543290.176	5344307.760	40.720	40.719	-0.001
35	NVA049	547753.580	5336341.998	27.930	27.927	-0.003
36	VVA002	539490.662	5386026.093	3.564	slope	*
37	VVA007	540984.376	5377640.918	1.354	removed	*
38	VVA009	537785.807	5377271.759	1.695	removed	*
39	VVA013	536581.633	5366972.794	1.367	removed	*
40	VVA015	540022.559	5366099.931	2.573	removed	*
41	VVA021	537102.106	5361522.608	6.764	removed	*
42	VVA023	541202.393	5360088.335	2.271	removed	*
43	VVA026	542764.944	5363651.212	3.645	removed	*
44	VVA027	548701.995	5363311.808	8.438	removed	*
45	VVA030	535772.049	5358911.597	12.830	removed	*
46	VVA031	541526.115	5354392.096	2.598	removed	*
47	VVA033	546597.917	5360845.226	6.566	removed	*
48	VVA035	546022.117	5357615.099	3.960	removed	*
49	VVA038	549267.223	5356457.847	2.149	removed	*
50	VVA040	546019.221	5352800.010	1.504	removed	*
51	VVA042	548675.006	5352255.954	2.114	removed	*
52	VVA044	547688.410	5348632.707	2.040	removed	*
53	VVA048	543269.016	5344304.512	40.519	removed	*
54	VVA050	547934.777	5336347.717	38.672	removed	*
55	VVA051	542740.666	5360836.953	2.013	removed	*
56	VVA052	547095.730	5343083.677	1.889	removed	*
57						
58	Average dz	-0.001				
59	Minimum dz	-0.102				
60	Maximum dz	+0.063				
61	Average magnitude	0.032				
62	Root mean square	0.040				
63	Std deviation	0.040				
64						
65						

1 Control Report VVA DEM

2						
3	Number	Easting	Northing	Known Z	Laser Z	Dz
4	-----					
5	NVA001	539579.650	5386071.463	59.362	removed	*
6	NVA003	543024.353	5382420.583	3.761	removed	*
7	NVA004	543018.124	5382455.594	3.417	removed	*
8	NVA005	533868.328	5380404.046	8.610	removed	*
9	NVA006	533841.234	5380569.204	11.695	removed	*
10	NVA008	541010.483	5377648.185	1.878	removed	*
11	NVA010	537821.414	5377296.925	2.482	removed	*
12	NVA011	538821.304	5369859.058	8.859	removed	*
13	NVA012	539022.645	5369771.897	3.585	removed	*
14	NVA014	536644.325	5366854.783	2.477	removed	*
15	NVA016	539942.547	5366096.697	3.164	removed	*
16	NVA017	537244.157	5364010.453	1.787	removed	*
17	NVA018	537255.450	5364165.623	2.067	removed	*
18	NVA019	544345.648	5360951.724	4.972	removed	*
19	NVA020	542910.566	5363643.835	3.948	removed	*
20	NVA022	537057.306	5361581.245	18.819	removed	*
21	NVA024	541192.514	5360248.463	2.625	removed	*
22	NVA025	542745.894	5363646.512	4.434	removed	*
23	NVA028	548574.339	5363187.440	10.747	removed	*
24	NVA029	535754.839	5358891.443	14.011	removed	*
25	NVA032	541548.715	5354383.612	2.669	removed	*
26	NVA034	547004.607	5360461.306	6.101	removed	*
27	NVA036	546008.053	5357620.299	4.603	removed	*
28	NVA037	549259.006	5356468.298	2.948	removed	*
29	NVA039	546030.359	5352819.746	1.930	removed	*
30	NVA041	548624.914	5352253.281	4.710	removed	*
31	NVA043	547673.923	5348595.276	2.805	removed	*
32	NVA045	547100.331	5343106.884	4.064	removed	*
33	NVA046	547010.657	5343121.076	3.154	removed	*
34	NVA047	543290.176	5344307.760	40.720	removed	*
35	NVA049	547753.580	5336341.998	27.930	removed	*
36	VVA002	539490.662	5386026.093	3.564	removed	*
37	VVA007	540984.376	5377640.918	1.354	1.489	+0.135
38	VVA009	537785.807	5377271.759	1.695	1.770	+0.075
39	VVA013	536581.633	5366972.794	1.367	1.512	+0.145
40	VVA015	540022.559	5366099.931	2.573	2.610	+0.037
41	VVA021	537102.106	5361522.608	6.764	6.779	+0.015
42	VVA023	541202.393	5360088.335	2.271	removed	*
43	VVA026	542764.944	5363651.212	3.645	3.685	+0.040
44	VVA027	548701.995	5363311.808	8.438	8.356	-0.082
45	VVA030	535772.049	5358911.597	12.830	12.918	+0.088
46	VVA031	541526.115	5354392.096	2.598	removed	*
47	VVA033	546597.917	5360845.226	6.566	6.657	+0.091
48	VVA035	546022.117	5357615.099	3.960	4.068	+0.108
49	VVA038	549267.223	5356457.847	2.149	2.304	+0.155
50	VVA040	546019.221	5352800.010	1.504	1.723	+0.219
51	VVA042	548675.006	5352255.954	2.114	2.149	+0.035
52	VVA044	547688.410	5348632.707	2.040	2.262	+0.222
53	VVA048	543269.016	5344304.512	40.519	40.593	+0.074
54	VVA050	547934.777	5336347.717	38.672	38.975	+0.303
55	VVA051	542740.666	5360836.953	2.013	2.194	+0.181
56	VVA052	547095.730	5343083.677	1.889	1.998	+0.109
57						
58	Average dz	+0.108				
59	Minimum dz	-0.082				
60	Maximum dz	+0.303				
61	Average magnitude	0.117				
62	Root mean square	0.139				
63	Std deviation	0.089				
64						
65						

1 Control Report VVA-LiDAR

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3	Number	Easting	Northing	Known Z	Laser Z	Dz
4	-----	-----	-----	-----	-----	-----
5	NVA001	539579.650	5386071.463	59.362	removed	*
6	NVA003	543024.353	5382420.583	3.761	removed	*
7	NVA004	543018.124	5382455.594	3.417	removed	*
8	NVA005	533868.328	5380404.046	8.610	removed	*
9	NVA006	533841.234	5380569.204	11.695	removed	*
10	NVA008	541010.483	5377648.185	1.878	removed	*
11	NVA010	537821.414	5377296.925	2.482	removed	*
12	NVA011	538821.304	5369859.058	8.859	removed	*
13	NVA012	539022.645	5369771.897	3.585	removed	*
14	NVA014	536644.325	5366854.783	2.477	removed	*
15	NVA016	539942.547	5366096.697	3.164	removed	*
16	NVA017	537244.157	5364010.453	1.787	removed	*
17	NVA018	537255.450	5364165.623	2.067	removed	*
18	NVA019	544345.648	5360951.724	4.972	removed	*
19	NVA020	542910.566	5363643.835	3.948	removed	*
20	NVA022	537057.306	5361581.245	18.819	removed	*
21	NVA024	541192.514	5360248.463	2.625	removed	*
22	NVA025	542745.894	5363646.512	4.434	removed	*
23	NVA028	548574.339	5363187.440	10.747	removed	*
24	NVA029	535754.839	5358891.443	14.011	removed	*
25	NVA032	541548.715	5354383.612	2.669	removed	*
26	NVA034	547004.607	5360461.306	6.101	removed	*
27	NVA036	546008.053	5357620.299	4.603	removed	*
28	NVA037	549259.006	5356468.298	2.948	removed	*
29	NVA039	546030.359	5352819.746	1.930	removed	*
30	NVA041	548624.914	5352253.281	4.710	removed	*
31	NVA043	547673.923	5348595.276	2.805	removed	*
32	NVA045	547100.331	5343106.884	4.064	removed	*
33	NVA046	547010.657	5343121.076	3.154	removed	*
34	NVA047	543290.176	5344307.760	40.720	removed	*
35	NVA049	547753.580	5336341.998	27.930	removed	*
36	VVA002	539490.662	5386026.093	3.564	slope	*
37	VVA007	540984.376	5377640.918	1.354	1.497	+0.143
38	VVA009	537785.807	5377271.759	1.695	1.761	+0.066
39	VVA013	536581.633	5366972.794	1.367	1.472	+0.105
40	VVA015	540022.559	5366099.931	2.573	2.627	+0.054
41	VVA021	537102.106	5361522.608	6.764	6.767	+0.003
42	VVA023	541202.393	5360088.335	2.271	removed	*
43	VVA026	542764.944	5363651.212	3.645	3.667	+0.022
44	VVA027	548701.995	5363311.808	8.438	8.363	-0.075
45	VVA030	535772.049	5358911.597	12.830	12.935	+0.105
46	VVA031	541526.115	5354392.096	2.598	removed	*
47	VVA033	546597.917	5360845.226	6.566	6.657	+0.091
48	VVA035	546022.117	5357615.099	3.960	4.117	+0.157
49	VVA038	549267.223	5356457.847	2.149	2.301	+0.152
50	VVA040	546019.221	5352800.010	1.504	1.619	+0.115
51	VVA042	548675.006	5352255.954	2.114	2.147	+0.033
52	VVA044	547688.410	5348632.707	2.040	2.233	+0.193
53	VVA048	543269.016	5344304.512	40.519	40.575	+0.056
54	VVA050	547934.777	5336347.717	38.672	38.946	+0.274
55	VVA051	542740.666	5360836.953	2.013	2.163	+0.150
56	VVA052	547095.730	5343083.677	1.889	1.998	+0.109
57						
58	Average dz	+0.097				
59	Minimum dz	-0.075				
60	Maximum dz	+0.274				
61	Average magnitude	0.106				
62	Root mean square	0.124				
63	Std deviation	0.079				
64						
65						