

LiDAR Acquisition Report

City of Nanaimo

Data collected and prepared for:

Aeroquest Mapcon

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EML Project # 15-073

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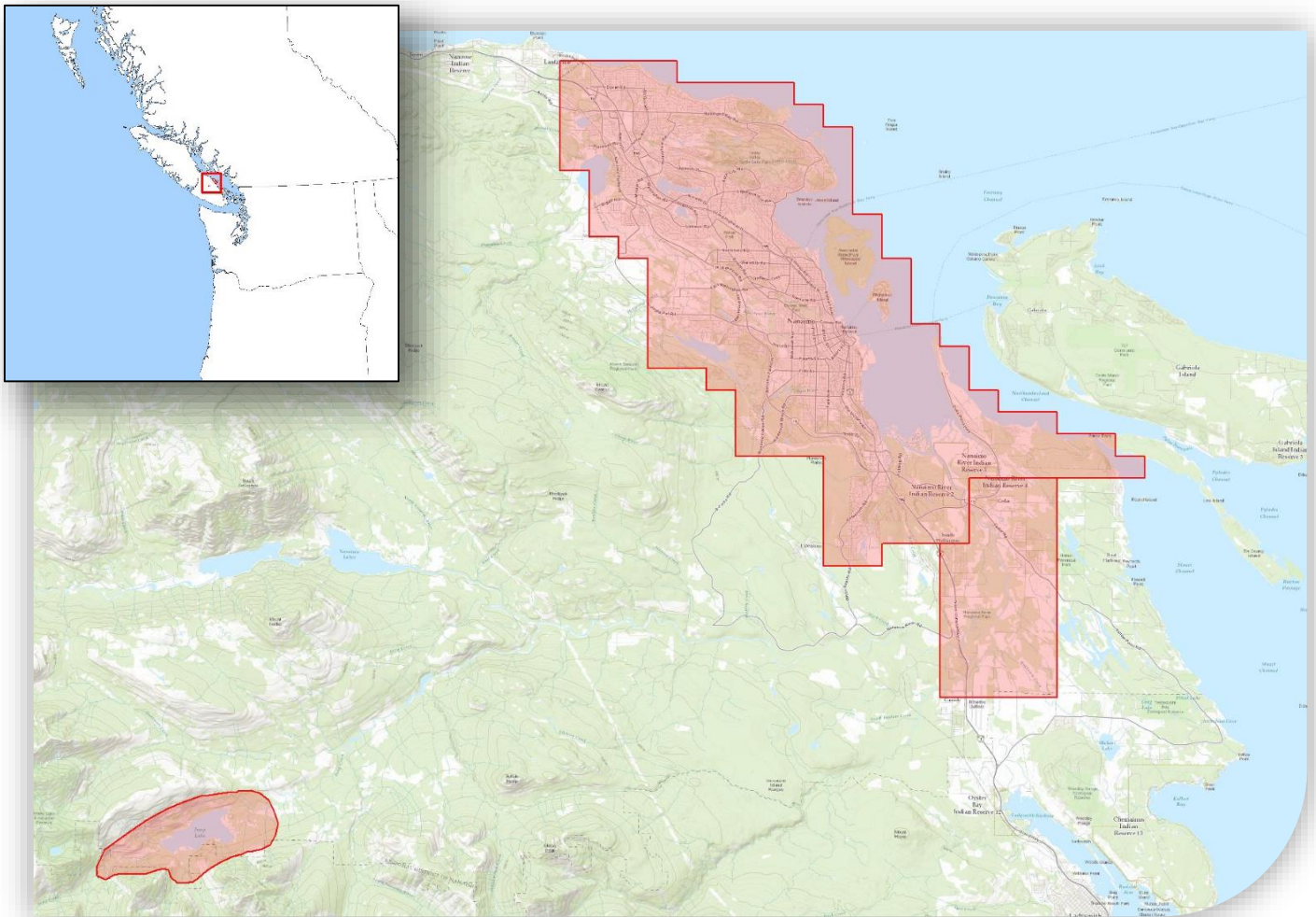
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1. Project Overview

1.1 Area of Interest

Eagle Mapping Ltd. collected aerial LiDAR over the Nanaimo, BC in a single lift occurring on February 9, 2016. The three Areas of Interest (AOIs) for this project cover a total of 186 sq km. LiDAR acquisition included the City of Nanaimo plus additional regions extending into neighbouring lands under the jurisdiction of the Regional District of Nanaimo. All areas were collected with a minimum 100m buffer to ensure adequate coverage for classification.



1.2 File Formats, Units, and Projection

Project deliverables include the following:

LAS Data

- Calibrated, raw unclassified LiDAR files in LAS format (v 1.4)
- Contains 16-bit intensity values, OGC WKT projection, return count, etc.
- Delivered as one file per laser channel per flight line

LiDAR Waveform

- Waveform data packets matching each flight line in .wdp format
- To be delivered at a future date

Flight Line Trajectories

- 200Hz position and attitude information in ASCII format
- Delivered as one file per laser channel per flight line

Survey Control Points

- Comprehensive ground survey delivered in Excel .xlsx and .txt formats

LiDAR Data Report

- Overview of project specifications, methodology and accuracies achieved
- PDF format

Map Projection Information	
Projection	UTM zone 10N
Horizontal Datum	NAD83 (CSRS)
Vertical Datum	CGVD28
Geoid	HTv2.0
Units	Meters
EPSG Code	3157

2. Acquisition & Calibration

2.1 Airborne LiDAR Collection

A Riegl Q1560 dual-channel LiDAR system was used for acquisition of the LiDAR data. This system was installed in Eagle Mapping's Cessna 206 aircraft, which is based in Pitt Meadows, BC. In total, 28 flight lines were required to cover the AOI. Nominal flying height was 1250m above ground level (AGL) over the city, and 1700m over the watershed. The lower altitude over the city was to provide higher point density over this area. Flight speed was approximately 115kts. The scan field of view for the Riegl Q1560 is 29° either side of nadir, for a total scan field of view of 58°. The scan rate used for this project was 800 kHz. However, due to the nature of the 4-sided rotating mirror in Riegl scanners only 2/3 of pulses are recorded (533 kHz useable). This yields an average pulse density of 3 pulses per channel per swath (6 pulses per dual-channel flight line) for the city acquisition, and 2 pulses per channel – 4 per flight line over the watershed area. Note, each pulse may result in one or more returned points as the pulse filters through vegetation, etc. All areas were captured with at least 60% side overlap, so expected pulse density would be twice the per-line densities listed above.



Along the coastline and tidal areas, LiDAR was collected within an hour on either side of the daily low tide posted by Fisheries and Oceans Canada.

LiDAR Acquisition Specifications	
Flight Altitude	1250m & 1700m AGL
Flying Speed	115kts nominal
Scan Rate	800khz (533khz usable)
Scan Field of View	58°
Line Spacing	550m & 750m
Minimum Overlap	60% (double coverage + 10%)

2016-02-09 (Tuesday)		
Time	Height	
PST	(m)	(ft)
06:37	4.7	15.4
12:21	2.7	8.9
17:36	4.3	14.1

2.2 Aircraft GNSS Trajectory Processing

GNSS post-processing determines the position and attitude of the aircraft at a rate of 200 observations/second along the entire flight path. This data is logged on the Q1560 via an Applanix POS AV510. Post-processing requires data from the onboard GNSS and Inertial Measurement Unit (IMU) as well as data from one or more static GNSS base station(s) with known coordinates.

Processing is performed with Applanix PosPAC v7.1 software. Here the aircraft GNSS / IMU data is referenced to the base station data to provide adjusted positions for the aircraft in latitude, longitude, and height, roll, pitch, and yaw / heading. The final trajectory is then smoothed, and exported in .pos format for use in RiProcess for LiDAR processing. The resulting flight path is commonly referred to as a Smoothed Best Estimate of Trajectory (SBET).

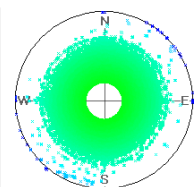
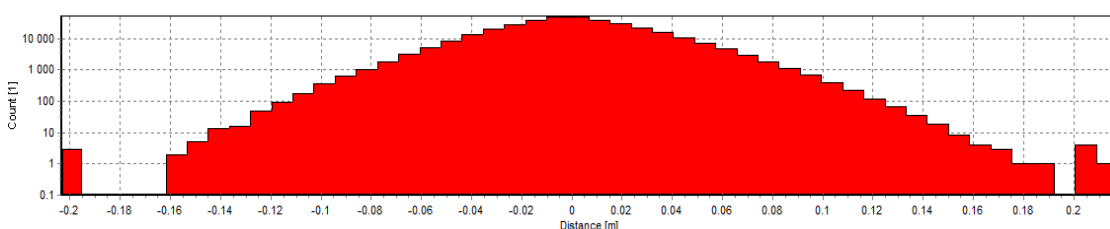
Mission planning ensures the project is flown during a period of good satellite visibility, resulting here in an average PDOP of 1.5 and maximum of 2.0. Statistical accuracy (RMS) of the SBET trajectory is < 2cm.

The base station used for this project is a continually-operating station operated which is part the Can-Net reference station network. This particular station (Station ID - NANA) is located outside the Nanaimo City Hall building.

Trajectory Processing Results	
Min. # of Satellites	11
Max. # of Satellites	17
Minimum PDOP	1.2
Maximum PDOP	2.2
RMSE	1.9 cm

2.3 LiDAR Calibration

LiDAR data was calibrated using Riegl RiProcess software. A quality check was performed using matching tie planes which are calculated automatically and analyzed via a least-squares adjustment. Manual cross section checks were also performed to verify the automatic results. Internal accuracy of the LiDAR data was calculated at ± 0.029 . Once deemed properly calibrated, the LAS data is exported along with individual 'trajectories' for each scan line. All data is projected into UTM and adjusted to the proper vertical datum (CGVD28) at this time.



3. Ground Control Measurement

Our survey technicians use dual-frequency Trimble R6 and R8 GNSS receivers to measure ground control points. These receivers are capable of establishing and measuring points to a high degree of accuracy (usually in the 1-2cm range). Survey processing is done with Trimble Business Center software.

For this project, 193 points were measured throughout the 3 project areas (57 at Jump Lake and 136 in the City of Nanaimo). Most points are located in open terrain where it is likely to receive a LiDAR return. Several others were measured under tree cover in order to verify LiDAR accuracy in vegetation. Generally, the control points are used for vertical accuracy verification only, but when possible, features are surveyed for horizontal assessment as well. Horizontal check points would include large paint lines, pavement edges, grass / gravel interface, etc and in some cases were features not suitable for vertical accuracy assessment (ie. bridge deck). These points as well as several significant outliers were removed from vertical accuracy reporting.

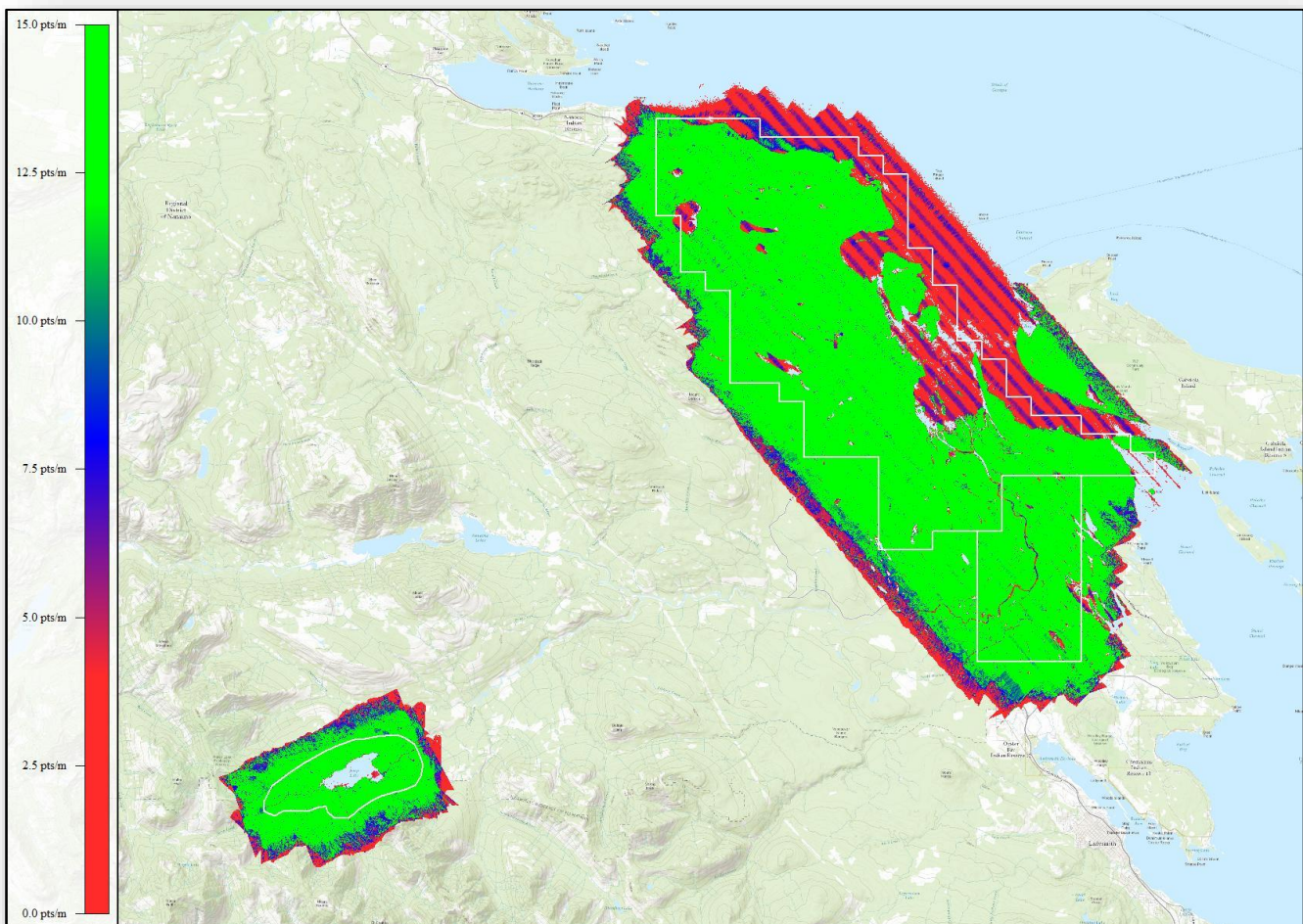


4. Results and Conclusions

4.1 Point Density and Coverage

LiDAR data was collected over the city with an average density of 15-20 points / sq. meter for all returns, and 12-14 points / sq. meter counting only first-returns. Over the Jump Lake watershed the average density is 12-15 points for all returns and 8-10 counting only first returns. Density is much greater for all returns vs first-returns due to the full waveform analysis performed by the Q1560 laser. By analyzing the full LiDAR waveform, the Q1560 is able to extract many additional points in vegetation, or other terrain where the laser pulse is 'filtered' through many objects in close proximity to each other.

A coverage / density plot is shown below. Water bodies will indicate a very low return density which is due to the absorption on the laser pulse by water.

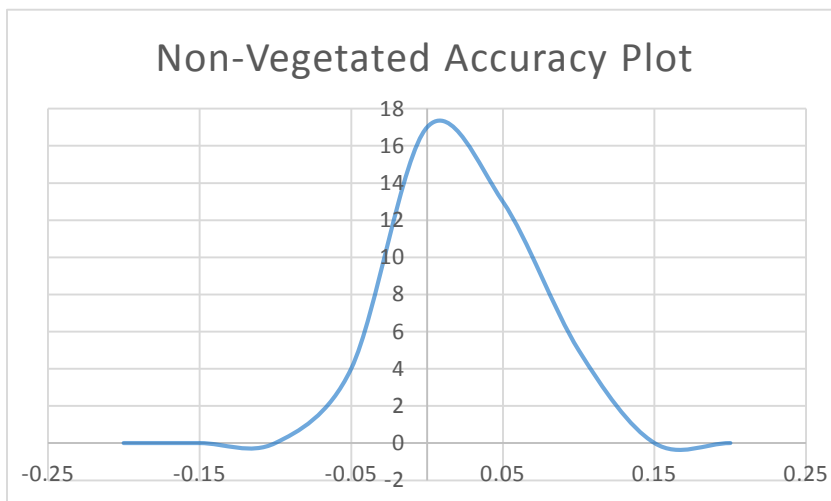


4.2 Accuracy

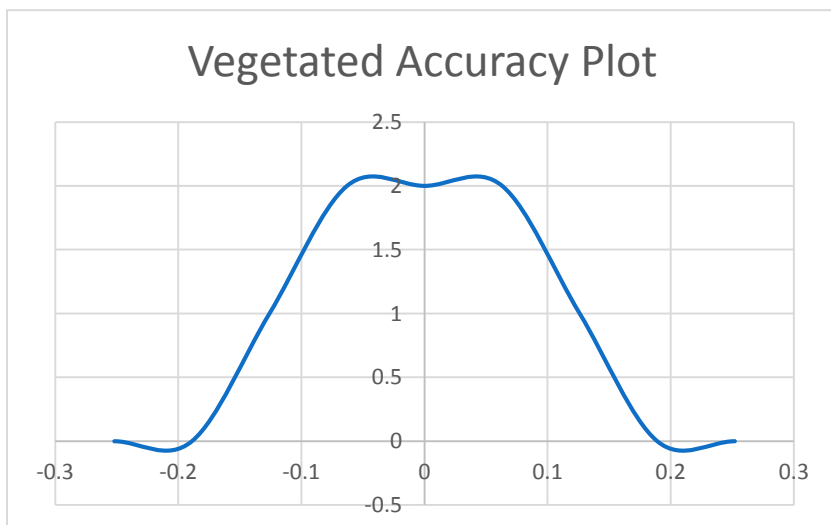
LiDAR Accuracy

Accuracy of the LiDAR data was determined via comparison to a set of ground control points measured by an Eagle Mapping surveyor. LiDAR data was measured to fit these control points very well but a slight vertical bias was observed. The Jump Lake LiDAR data was adjusted by -7.5cm in order to best fit the control points.

This dataset was tested to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a <10.0cm RMSEz Vertical Accuracy Class. Actual Non-Vegetated Accuracy (NVA) was found to be RMSEz = 4.0cm, equating to ± 7.8 cm at 95% confidence level. Vegetated Vertical Accuracy (VVA) was found to be ± 14.5 cm at the 95th percentile. Relative accuracy was observed to meet USGS Quality Level 1 standards: Smooth Surface Repeatability <6cm, Swath Overlap Difference RMSD_z <8cm, and Swath Overlap Difference Maximum <16cm.



LiDAR Accuracy (NVA)	
Average dZ	+0.001
Minimum dZ	-0.074
Maximum dZ	+0.092
Average magnitude	0.000
Root mean square	0.040
Std deviation	0.040



LiDAR Accuracy (VVA)	
Average dZ	-0.028
Minimum dZ	-0.139
Maximum dZ	+0.107
Average magnitude	0.063
Root mean square	0.076
Std deviation	0.076

Appendix A – Survey Control List (Jump Lake)

Point ID	Easting	Northing	Elevation	PDOP	RMS	H. Precision (95%)	V. Precision (95%)	Feature Code	Comments
1	410863.808	5429263.421	377.483					base	Processed through Trimble TRX post processing solution
3000	410871.825	5429244.352	377.737	1.470	0.002	0.015	0.019	mon	
3006	406462.977	5428245.465	437.418	1.560	0.004	0.024	0.026	rd profile	
3007	406455.362	5428240.054	437.744	1.560	0.004	0.024	0.026	rd profile	
3008	406465.192	5428250.440	437.285	1.560	0.004	0.024	0.026	rd split middle	
3009	406494.869	5428290.137	438.694	2.590	0.004	0.029	0.045	chk28 placed nail	6" spike with pink flagging placed in stump
3019	408980.345	5428637.936	378.001	3.910	0.015	0.040	0.063	rd split middle	
3020	410645.862	5430175.130	376.643	1.760	0.002	0.019	0.022	face of dam top crn	
3021	410652.230	5430161.198	376.659	1.760	0.003	0.019	0.022	face of dam top	
3022	410662.952	5430137.737	376.648	1.750	0.003	0.019	0.022	face of dam top	
3023	410676.171	5430108.604	376.660	1.750	0.003	0.019	0.022	face of dam top crn	
3024	410678.302	5430109.217	377.874	1.740	0.003	0.020	0.023	chk28 end of barrier rebar	
3025	410675.917	5430116.034	376.649	1.730	0.003	0.020	0.022	dam topo	
3026	410669.489	5430130.112	376.637	1.730	0.002	0.024	0.027	dam topo	
3027	410662.481	5430145.489	376.649	1.720	0.003	0.021	0.023	dam topo	
3028	410650.834	5430171.060	376.659	1.720	0.003	0.021	0.023	dam topo	
3029	411218.440	5430502.229	363.587	2.170	0.003	0.059	0.063	rd profile	
3030	411209.719	5430500.711	363.823	2.270	0.006	0.037	0.048	rd profile	
3031	411199.153	5430498.841	363.950	1.950	0.004	0.029	0.037	rd profile	
3032	411189.829	5430497.084	364.057	1.950	0.003	0.024	0.030	rd profile	
3033	411179.892	5430495.710	364.146	1.950	0.004	0.025	0.032	rd profile	
3034	411209.535	5430493.426	364.956	1.950	0.005	0.032	0.040	chk29 placed nail	6" spike with pink flagging placed in stump
3035	411217.641	5430502.574	363.546	2.170	0.007	0.034	0.045	rd split middle	
3036	410687.580	5429459.777	377.669	1.410	0.003	0.017	0.017	NNE blue pole	taken at base of blue pole on the North -Northeast face
3037	410690.227	5429462.413	377.590	1.410	0.003	0.017	0.017	dam curve	
3038	410696.199	5429449.443	377.598	2.060	0.002	0.037	0.027	dam curve	
3039	410699.898	5429441.460	377.599	1.410	0.004	0.022	0.022	dam curve	
3040	410702.659	5429436.991	377.595	1.410	0.004	0.022	0.021	dam curve	
3041	410706.227	5429432.506	377.577	2.320	0.001	0.033	0.025	dam curve	
3042	410712.254	5429425.676	377.599	2.070	0.003	0.036	0.027	dam curve	
3043	410747.541	5429383.815	377.742	1.500	0.002	0.023	0.019	top of T-rebar	centre of T-rebar monumentation
3044	410752.747	5429379.755	377.594	1.500	0.002	0.026	0.021	Lead plug-orange mrk	existing monumentation
3045	410858.155	5429273.469	376.962	1.520	0.003	0.022	0.019	topo	
3046	410853.820	5429283.192	375.857	1.520	0.003	0.020	0.017	topo	
3047	410847.973	5429293.735	374.823	1.530	0.002	0.020	0.017	topo	
3056	410868.173	5429239.517	377.793	1.550	0.003	0.020	0.017	crn of rail	taken at base of rail corner
3057	410871.815	5429244.360	377.735	1.560	0.003	0.020	0.018	chk mon	
3058	410871.820	5429244.356	377.736					Combined MON	Calculated with average of both Spillway monumnet observations

Appendix B – Survey Control Deviations (Jump Lake)

Point ID	Easting	Northing	KnownZ	LaserZ	Dz
3020	410645.86	5430175.1	376.643	376.81	0.167
3044	410752.75	5429379.8	377.594	377.74	0.146
3041	410706.23	5429432.5	377.577	377.72	0.143
3037	410690.23	5429462.4	377.59	377.72	0.13
3042	410712.25	5429425.7	377.599	377.72	0.121
3040	410702.66	5429437	377.595	377.71	0.115
3006	406462.98	5428245.5	437.418	437.52	0.102
3007	406455.36	5428240.1	437.744	437.84	0.096
3038	410696.2	5429449.4	377.598	377.69	0.092
3045	410858.16	5429273.5	376.962	377.05	0.088
3008	406465.19	5428250.4	437.285	437.37	0.085
3039	410699.9	5429441.5	377.599	377.68	0.081
3023	410676.17	5430108.6	376.66	376.74	0.08
3019	408980.35	5428637.9	378.001	378.08	0.079
3047	410847.97	5429293.7	374.823	374.9	0.077
3032	411189.83	5430497.1	364.057	364.13	0.073
3036	410687.58	5429459.8	377.669	377.74	0.071
3057	410871.82	5429244.4	377.735	377.8	0.065
3058	410871.82	5429244.4	377.736	377.8	0.064
3033	411179.89	5430495.7	364.146	364.21	0.064
3000	410871.83	5429244.4	377.737	377.8	0.063
3025	410675.92	5430116	376.649	376.71	0.061
3022	410662.95	5430137.7	376.648	376.7	0.052
3027	410662.48	5430145.5	376.649	376.7	0.051
3026	410669.49	5430130.1	376.637	376.68	0.043
3046	410853.82	5429283.2	375.857	375.9	0.043
3031	411199.15	5430498.8	363.95	363.99	0.04
3035	411217.64	5430502.6	363.546	363.58	0.034
3028	410650.83	5430171.1	376.659	376.69	0.031
3014	409027.99	5428655.9	378.771	378.79	0.019
3030	411209.72	5430500.7	363.823	363.83	0.007
3029	411218.44	5430502.2	363.587	363.59	0.003
3021	410652.23	5430161.2	376.659	376.66	0.001

Appendix C – Survey Control List (Nanaimo)

Point ID	Easting	Northing	Elevation	PDOP	RMS	H. Precision (95%)	V. Precision (95%)	Feature Code	Comments
1001	422879.021	5455392.458	53.289	1.770	0.003	0.021	0.022	chk20	6" spike with pink flagging placed in middle of log
1002	422879.480	5455387.369	52.721	1.630	0.003	0.020	0.024	end of log mid	taken at ground level middle of log ends
1003	422878.098	5455398.199	52.421	1.640	0.003	0.019	0.023	end of log mid	taken at ground level middle of log ends
1004	422855.131	5455392.393	52.821	2.000	0.002	0.021	0.027	topo rd	
1005	422846.133	5455392.443	52.626	1.810	0.003	0.026	0.035	topo rd	
1006	422836.606	5455392.449	52.448	2.000	0.004	0.025	0.032	topo rd	
1007	425140.884	5455007.638	57.361	1.420	0.003	0.019	0.022	cul de sac	
1008	425136.395	5455003.778	57.839	1.420	0.004	0.019	0.022	cul de sac	
1009	425134.317	5454997.681	58.261	1.310	0.004	0.019	0.022	cul de sac	
1010	425135.176	5454992.837	58.500	1.380	0.005	0.025	0.029	cul de sac	
1011	425135.583	5454991.936	58.562	1.380	0.005	0.024	0.029	cul de sac	
1012	425138.266	5454988.408	58.658	1.820	0.003	0.022	0.031	cul de sac	
1013	425141.669	5454986.278	58.645	1.670	0.004	0.023	0.029	cul de sac	
1014	425148.000	5454985.604	58.433	2.120	0.003	0.023	0.037	cul de sac	
1015	425153.248	5454988.010	57.986	2.120	0.004	0.022	0.036	cul de sac	
1016	425156.678	5454992.452	57.658	2.370	0.003	0.027	0.029	cul de sac	
1017	425146.172	5454995.602	57.850	1.910	0.004	0.028	0.034	cul de sac center	
1018	428015.767	5453944.063	38.909	2.990	0.011	0.062	0.095	chk26 va	Residuals for Vegetation shots should be taken into account
1020	428024.717	5453913.512	39.750	1.600	0.008	0.035	0.050	cross walk crn	Taken at outside corners of crosswalk
1021	428024.777	5453916.551	39.749	2.090	0.006	0.033	0.051	cross walk crn	
1022	428032.666	5453916.387	39.751	1.820	0.007	0.039	0.053	cross walk crn	
1023	428032.560	5453913.331	39.774	2.180	0.006	0.038	0.059	cross walk crn	
1024	430524.362	5452464.592	78.702	1.310	0.003	0.013	0.018	chk25 cnt water manhole	
1025	430516.907	5452437.612	79.107	1.310	0.004	0.017	0.023	rd topo	
1026	430516.550	5452431.460	79.269	1.310	0.004	0.017	0.024	rd topo	
1027	430516.248	5452422.899	79.473	1.380	0.004	0.019	0.025	rd topo	
1028	430464.533	5452482.092	86.138	1.180	0.004	0.016	0.021	79h9260	Offset 0.435m has been applied
1029	428993.096	5451598.862	71.146	2.930	0.005	0.043	0.050	rd topo	
1030	429011.897	5451486.808	71.864	1.630	0.006	0.036	0.045	92h0764	Offset of 0.490m has been applied
1031	428998.190	5451493.568	71.883	1.930	0.029	0.042	0.049	chk21 va	Residuals for Vegetation shots should be taken into account
1032	429326.242	5450486.181	3.656	1.850	0.003	0.023	0.026	crn yellow no-prk	Outside corner of yellow line
1033	429261.598	5450482.422	4.879	1.530	0.004	0.027	0.029	stop sign	
1034	429255.349	5450471.124	5.488	1.530	0.005	0.027	0.029	stop sign	
1035	426651.477	5452603.759	158.039	1.360	0.003	0.017	0.019	sidewalk end crn	taken at top corners (POV approaching stop sign)
1036	426650.697	5452602.488	157.985	1.360	0.003	0.017	0.019	sidewalk end crn	
1037	426646.946	5452598.844	158.230	1.360	0.003	0.018	0.020	rd topo	
1038	426638.797	5452603.593	159.347	1.360	0.003	0.017	0.019	rd topo	

1039	426632.150	5452607.786	160.305	1.360	0.004	0.018	0.020	rd topo	
1040	426647.400	5452597.064	158.024	1.440	0.004	0.024	0.023	middle yellow barrier ends	taken at ground level and middle of barriers
1041	426648.623	5452599.327	158.049	1.360	0.004	0.022	0.024	middle yellow barrier ends	
1042	426591.369	5452623.818	165.637	1.350	0.003	0.019	0.021	ne crn elec box	taken at ground level on Northeastern corner
1043	426657.142	5452591.820	156.554	1.350	0.004	0.023	0.025	va	Residuals for Vegetation shots should be taken into account
1044	426505.241	5452678.031	176.248	1.230	0.002	0.015	0.016	14h2754	Monument has zero offset
1045	424045.292	5451771.749	108.017	1.660	0.003	0.021	0.022	crosswalk	Taken at outside corners of crosswalk
1046	424048.364	5451771.671	108.217	1.800	0.003	0.027	0.032	crosswalk	
1047	424048.583	5451780.818	108.278	1.800	0.005	0.025	0.027	crosswalk	
1048	424045.552	5451780.864	108.057	1.800	0.004	0.028	0.033	crosswalk	
1049	424031.006	5451751.031	105.079	2.160	0.006	0.050	0.056	va	Residuals for Vegetation shots should be taken into account
1050	424235.570	5451758.999	117.750	1.650	0.006	0.052	0.056	stop sign	taken at top corners (POV approaching stop sign)
1051	424482.602	5450427.076	92.732	1.690	0.004	0.027	0.032	stop sign	
1052	424480.020	5450432.191	92.838	1.690	0.004	0.026	0.031	stop sign	
1053	424467.346	5450425.997	93.608	1.680	0.005	0.027	0.032	stop sign yellow line	taken at the end and middle of yellow line
1054	427753.932	5449063.523	111.963	1.290	0.004	0.022	0.024	79h9296	Offset of 0.475m has been applied
1055	427806.550	5449070.143	113.881	2.360	0.002	0.024	0.028	top of yellow arrows	Taken at tip of arrows
1056	427817.665	5449068.936	114.092	1.700	0.003	0.021	0.025	top of yellow arrows	
1057	427827.400	5449066.691	114.285	2.360	0.002	0.022	0.032	top of yellow arrows	
1058	427154.779	5447457.476	98.669	2.290	0.004	0.027	0.039	89h5636	Offset of 0.265m has been applied
1059	427154.599	5447449.332	99.235	1.840	0.002	0.020	0.025	topo rd over mon	
1060	427154.760	5447455.300	98.851	2.150	0.002	0.022	0.030	topo rd over mon	
1061	427154.852	5447461.285	98.432	2.140	0.002	0.027	0.039	topo rd over mon	
1062	427154.821	5447468.086	97.957	2.100	0.004	0.026	0.037	topo rd over mon	
1063	427162.672	5447466.209	97.654	2.480	0.002	0.033	0.031	telephone pole west	taken at ground level on west face
1064	427144.554	5447439.959	100.253	2.560	0.005	0.026	0.033	va	Residuals for Vegetation shots should be taken into account
1065	425523.865	5447132.948	139.730	1.700	0.002	0.017	0.022	stop sign	taken at top corners (POV approaching stop sign)
1066	425531.132	5447130.876	139.788	1.700	0.002	0.017	0.022	stop sign	
1067	425526.668	5447136.873	139.676	1.700	0.003	0.018	0.024	paint line curve	taken on the middle of white line
1068	425529.530	5447141.554	139.603	1.690	0.004	0.019	0.025	paint line curve	
1069	425533.029	5447145.963	139.536	1.690	0.003	0.019	0.024	paint line curve	
1070	425537.040	5447149.955	139.480	1.690	0.003	0.018	0.024	paint line curve	
1071	425541.648	5447153.495	139.410	1.690	0.003	0.019	0.025	paint line curve	
1072	425546.105	5447156.741	139.333	1.830	0.003	0.021	0.026	paint line curve	
1073	425249.854	5445956.636	248.251	3.210	0.004	0.060	0.060	va	Residuals for Vegetation shots should be taken into account
1074	425233.925	5445953.281	250.062	2.650	0.007	0.056	0.080	rd topo	
1075	425229.672	5445957.641	249.316	2.650	0.007	0.067	0.089	rd topo	
1076	425223.895	5445963.758	248.139	2.650	0.006	0.048	0.068	rd topo	
1077	429999.580	5448514.679	62.710	1.870	0.003	0.025	0.030	77h5321	Offset of 0.420m has been applied

1078	430000.818	5448514.530	62.746	1.950	0.003	0.026	0.029	rd topo	
1079	429998.342	5448514.699	62.765	1.950	0.003	0.023	0.025	rd topo	
1101	431766.034	5446503.485	13.999	1.820	0.004	0.023	0.027	stop sign	taken at top corners (POV approaching stop sign)
1102	431768.412	5446498.999	13.834	1.830	0.004	0.022	0.027	stop sign	
1103	428947.467	5446150.293	85.668	1.820	0.006	0.027	0.035	79h5585	Offset of 0.445m has been applied
1104	428948.053	5446149.793	85.692	1.830	0.004	0.024	0.031	rd topo	
1105	428946.936	5446150.790	85.603	2.000	0.004	0.028	0.032	rd topo	
1106	428950.419	5446162.581	84.763	1.930	0.004	0.028	0.033	telephone pole SSW	taken at ground level on South Southwest face
1107	428942.285	5446169.523	84.498	1.840	0.005	0.026	0.034	rd topo	
1108	428946.997	5446174.804	83.822	1.840	0.005	0.026	0.034	rd topo	
1109	428950.945	5446180.816	83.044	1.840	0.004	0.026	0.034	rd topo	
1110	428939.381	5446156.682	85.383	1.850	0.004	0.030	0.040	end cnrt barrier	taken at ground level and middle of barrier
1111	428974.754	5443786.156	112.191	1.400	0.004	0.018	0.023	crn cnrt	taken at transition from metal to concrete
1112	428976.012	5443785.860	112.151	1.400	0.004	0.018	0.023	crn cnrt	
1113	428975.283	5443782.990	112.155	1.400	0.004	0.018	0.023	crn cnrt	
1114	428974.033	5443783.313	112.191	1.400	0.003	0.018	0.023	crn cnrt	
1115	432031.552	5444345.456	22.159	1.570	0.003	0.020	0.026	stop sign	taken at top corners (POV approaching stop sign)
1116	432031.674	5444341.811	22.156	1.570	0.003	0.020	0.026	stop sign	
1117	432015.249	5444341.713	23.115	1.570	0.003	0.020	0.026	stop sign	
1118	432015.411	5444338.510	23.130	1.680	0.003	0.020	0.026	stop sign	
1119	435893.434	5434785.334	28.578	2.150	0.006	0.037	0.052	pull out	
1120	435893.122	5434788.025	28.595	2.570	0.006	0.040	0.048	pull out	
1121	435886.073	5434752.281	28.632	1.900	0.009	0.044	0.062	end of barrier	taken at ground level and middle of barrier
1122	439047.232	5434942.143	31.415	1.720	0.004	0.020	0.029	stop sign	taken at top corners (POV approaching stop sign)
1123	439045.392	5434939.224	31.480	1.720	0.003	0.019	0.028	stop sign	
1124	439049.608	5434936.347	31.339	1.710	0.003	0.020	0.030	topo	
1130	434186.658	5441218.312	19.361	1.270	0.007	0.027	0.033	va	Residuals for Vegetation shots should be taken into account
1131	434195.214	5441216.092	18.945	3.310	0.003	0.031	0.039	va	Residuals for Vegetation shots should be taken into account
1132	434214.113	5441236.997	19.439	1.800	0.006	0.043	0.048	rd topo	
1133	434199.569	5441236.127	19.717	1.460	0.006	0.035	0.045	rd topo	
1137	434141.288	5441252.572	20.923	1.680	0.005	0.029	0.037	telephone pole south	taken at ground level on South face
1138	434143.164	5441254.136	20.651	1.270	0.007	0.029	0.037	end of fence post	taken at ground level on West face
NANA	431609.271	5446091.413	33.299						

Appendix D – Survey Control Deviations (Nanaimo)

Point ID	Easting	Northing	Known Z	Laser Z	Dz
1004	422855.131	5455392.393	52.821	52.76	-0.061
1005	422846.133	5455392.443	52.626	52.59	-0.036
1006	422836.606	5455392.449	52.448	52.34	-0.108
1007	425140.884	5455007.638	57.361	57.42	0.059
1008	425136.395	5455003.778	57.839	57.85	0.011
1009	425134.317	5454997.681	58.261	58.31	0.049
1010	425135.176	5454992.837	58.5	58.51	0.01
1011	425135.583	5454991.936	58.562	58.59	0.028
1012	425138.266	5454988.408	58.658	58.67	0.012
1013	425141.669	5454986.278	58.645	58.61	-0.035
1014	425148	5454985.604	58.433	58.43	-0.003
1015	425153.248	5454988.01	57.986	57.99	0.004
1016	425156.678	5454992.452	57.658	57.64	-0.018
1017	425146.172	5454995.602	57.85	57.89	0.04
1020	428024.717	5453913.512	39.75	39.66	-0.09
1020	428024.717	5453913.512	39.75	39.66	-0.09
1021	428024.777	5453916.551	39.749	39.66	-0.089
1021	428024.777	5453916.551	39.749	39.66	-0.089
1022	428032.666	5453916.387	39.751	39.66	-0.091
1022	428032.666	5453916.387	39.751	39.66	-0.091
1023	428032.56	5453913.331	39.774	39.69	-0.084
1023	428032.56	5453913.331	39.774	39.69	-0.084
1025	430516.907	5452437.612	79.107	79.00	-0.107
1026	430516.55	5452431.46	79.269	79.16	-0.109
1027	430516.248	5452422.899	79.473	79.35	-0.123
1029	428993.096	5451598.862	71.146	71.04	-0.106
1032	429326.242	5450486.181	3.656	3.51	-0.146
1033	429261.598	5450482.422	4.879	4.84	-0.039
1034	429255.349	5450471.124	5.488	5.50	0.012
1037	426646.946	5452598.844	158.23	158.13	-0.1
1038	426638.797	5452603.593	159.347	159.31	-0.037
1039	426632.15	5452607.786	160.305	160.2	-0.105
1045	424045.292	5451771.749	108.017	107.92	-0.097
1046	424048.364	5451771.671	108.217	108.11	-0.107
1047	424048.583	5451780.818	108.278	108.16	-0.118
1048	424045.552	5451780.864	108.057	108.01	-0.047
1050	424235.57	5451758.999	117.75	117.71	-0.04
1051	424482.602	5450427.076	92.732	92.63	-0.102
1052	424480.02	5450432.191	92.838	92.82	-0.018
1053	424467.346	5450425.997	93.608	93.58	-0.028

1059	427154.599	5447449.332	99.235	99.15	-0.085
1060	427154.76	5447455.3	98.851	98.74	-0.111
1061	427154.852	5447461.285	98.432	98.32	-0.112
1062	427154.821	5447468.086	97.957	97.89	-0.067
1065	425523.865	5447132.948	139.73	139.73	0.000
1066	425531.132	5447130.876	139.788	139.76	-0.028
1067	425526.668	5447136.873	139.676	139.66	-0.016
1068	425529.53	5447141.554	139.603	139.58	-0.023
1069	425533.029	5447145.963	139.536	139.5	-0.036
1070	425537.04	5447149.955	139.48	139.46	-0.02
1071	425541.648	5447153.495	139.41	139.39	-0.02
1072	425546.105	5447156.741	139.333	139.33	-0.003
1074	425233.925	5445953.281	250.062	removed	*
1075	425229.672	5445957.641	249.316	removed	*
1076	425223.895	5445963.758	248.139	248.01	-0.129
1078	430000.818	5448514.53	62.746	62.7	-0.046
1079	429998.342	5448514.699	62.765	62.69	-0.075
1101	431766.034	5446503.485	13.999	13.95	-0.049
1102	431768.412	5446498.999	13.834	13.81	-0.024
1104	428948.053	5446149.793	85.692	85.53	-0.162
1105	428946.936	5446150.79	85.603	85.53	-0.073
1107	428942.285	5446169.523	84.498	84.47	-0.028
1108	428946.997	5446174.804	83.822	83.7	-0.122
1109	428950.945	5446180.816	83.044	82.96	-0.084
1115	432031.552	5444345.456	22.159	22.12	-0.039
1116	432031.674	5444341.811	22.156	22.13	-0.026
1117	432015.249	5444341.713	23.115	23.05	-0.065
1118	432015.411	5444338.51	23.13	23.09	-0.04
1119	435893.434	5434785.334	28.578	removed	*
1120	435893.122	5434788.025	28.595	28.5	-0.095
1122	439047.232	5434942.143	31.415	31.32	-0.095
1123	439045.392	5434939.224	31.48	31.38	-0.1
1124	439049.608	5434936.347	31.339	31.24	-0.099
1132	434214.113	5441236.997	19.439	19.37	-0.069
1133	434199.569	5441236.127	19.717	19.67	-0.047
1134	434182.05	5441235.962	20.019	19.97	-0.049
1135	434159.721	5441237.851	20.586	20.52	-0.066
1136	434141.261	5441240.97	21.278	21.22	-0.058