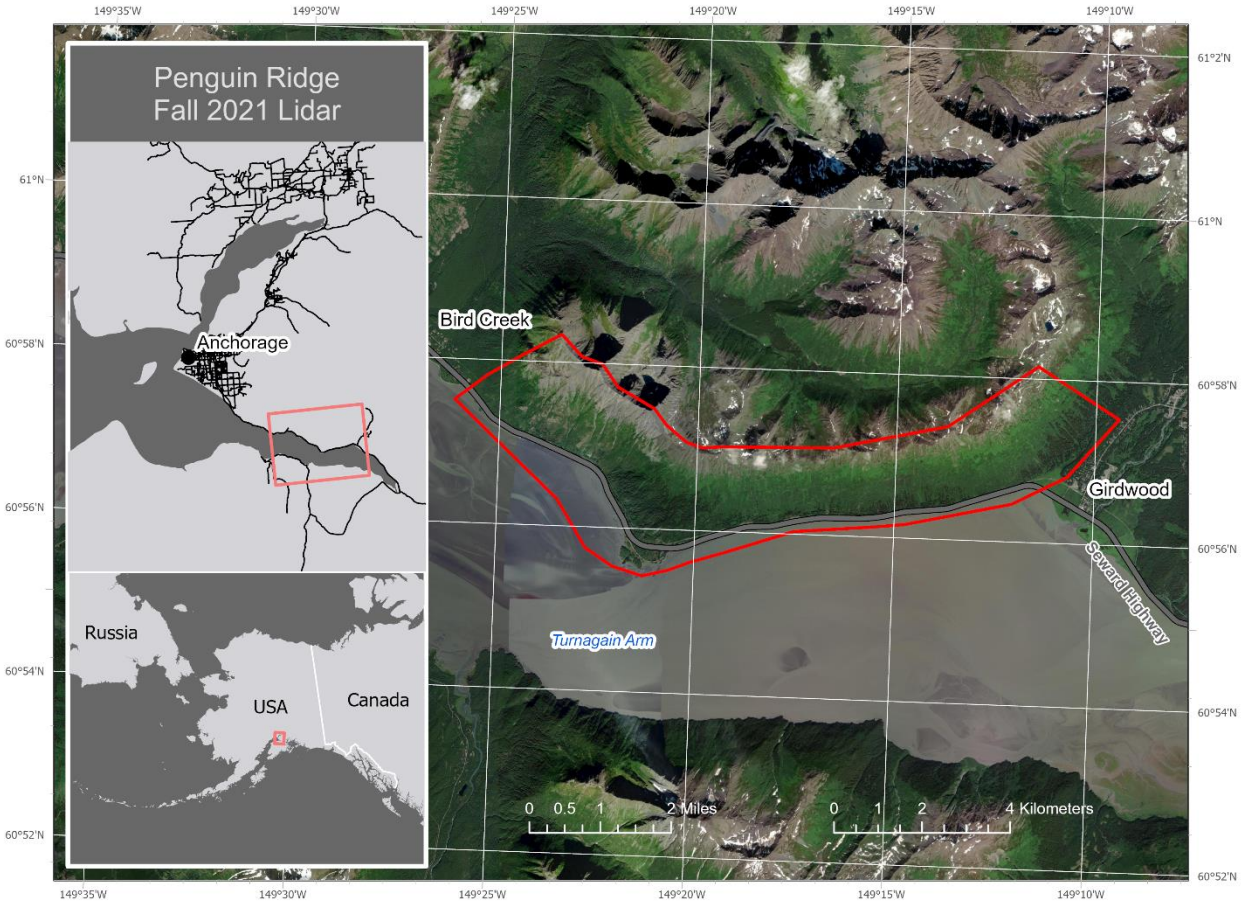
LIDAR-DERIVED ELEVATION DATA FOR PENGUIN RIDGE, SOUTHCENTRAL ALASKA, COLLECTED SEPTEMBER 22, 2021

Katreen M. Wikstrom Jones and Gabriel Wolken

Raw Data File 2024-5



Location map of survey area with orthometric image.

This report has not been reviewed for technical content or for conformity to the editorial standards of DGGS.

2024
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

STATE OF ALASKA
Mike Dunleavy, Governor

DEPARTMENT OF NATURAL RESOURCES
John Boyle, Commissioner

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
Melanie Werdon, State Geologist & Director

Publications produced by the Division of Geological & Geophysical Surveys are available to download from the DGGS website (dggs.alaska.gov). Publications on hard-copy or digital media can be examined or purchased in the Fairbanks office:

Alaska Division of Geological & Geophysical Surveys (DGGS)
3354 College Road | Fairbanks, Alaska 99709-3707
Phone: 907.451.5010 | Fax 907.451.5050
dggspubs@alaska.gov | dggs.alaska.gov

DGGS publications are also available at:

Alaska State Library, Historical
Collections & Talking Book Center
395 Whittier Street
Juneau, Alaska 99801

Alaska Resource Library and
Information Services (ARLIS)
3150 C Street, Suite 100
Anchorage, Alaska 99503

Suggested citation:
Wikstrom Jones, K.M., and Wolken, G.J., 2024, Lidar-derived elevation data for Penguin Ridge, Southcentral Alaska, collected September 22, 2021: Alaska Division of Geological & Geophysical Surveys Raw Data File 2024-5, 11 p. https://doi.org/10.14509/31158

LIDAR-DERIVED ELEVATION DATA FOR PENGUIN RIDGE, SOUTHCENTRAL ALASKA, COLLECTED SEPTEMBER 22, 2021

Katreen M. Wikstrom Jones[1] and Gabriel Wolken[1]

INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) used aerial lidar to produce a classified point cloud, digital surface model (DSM), digital terrain model (DTM), and intensity model of Penguin Ridge, Southcentral Alaska, during near snow-free ground conditions on September 22, 2021. The survey provides snow-free surface elevations for deriving snow depth distribution models with repeat surveys during snow-covered conditions. Aerial lidar data were collected on September 22, 2021, and ground control data were collected on September 27, 2021, and subsequently processed in a suite of geospatial processing software. This data collection is released as a Raw Data File with an open end-user license. All files are available at https://doi.org/10.14509/31158.

LIST OF DELIVERABLES

Classified Points

DSM and DTM

Intensity Image

Metadata

MISSION PLAN

Aerial Lidar Survey Details

DGGS used a Riegl VUX1-LR laser scanner integrated with a global navigation satellite system (GNSS) and Northrop Grumman LN-200C inertial measurement unit (IMU). The lidar integration system was designed by Phoenix LiDAR Systems. The sensor can collect up to 820,000 points per second at a range of up to 150 m. The scanner operated with a pulse refresh rate of 200,000 pulses per second in the alpine areas and 400,000 pulses per second over forested areas at a scan rate of 160 lines per second. We used a Cessna 180 fixed-wing aircraft to survey from an elevation of approximately 200 m above ground level, at a ground speed of approximately 37 m/s, and with a scan angle set from 80 to 280 degrees. The total survey area covered approximately 14.5 km^2 (fig. 1).

Weather Conditions and Flight Times

We flew the aerial survey on September 22, 2021, with departure at 11:50 am from Merrill Field Airport, Anchorage, Alaska, and landed back at the airport at 2:45 pm. The weather throughout the survey was clear with no wind. There was a dusting of snow in the alpine areas on Penguin Ridge prior to the survey.

[1] Alaska Division of Geological & Geophysical Surveys, 3354 College Road, Fairbanks, AK 99709

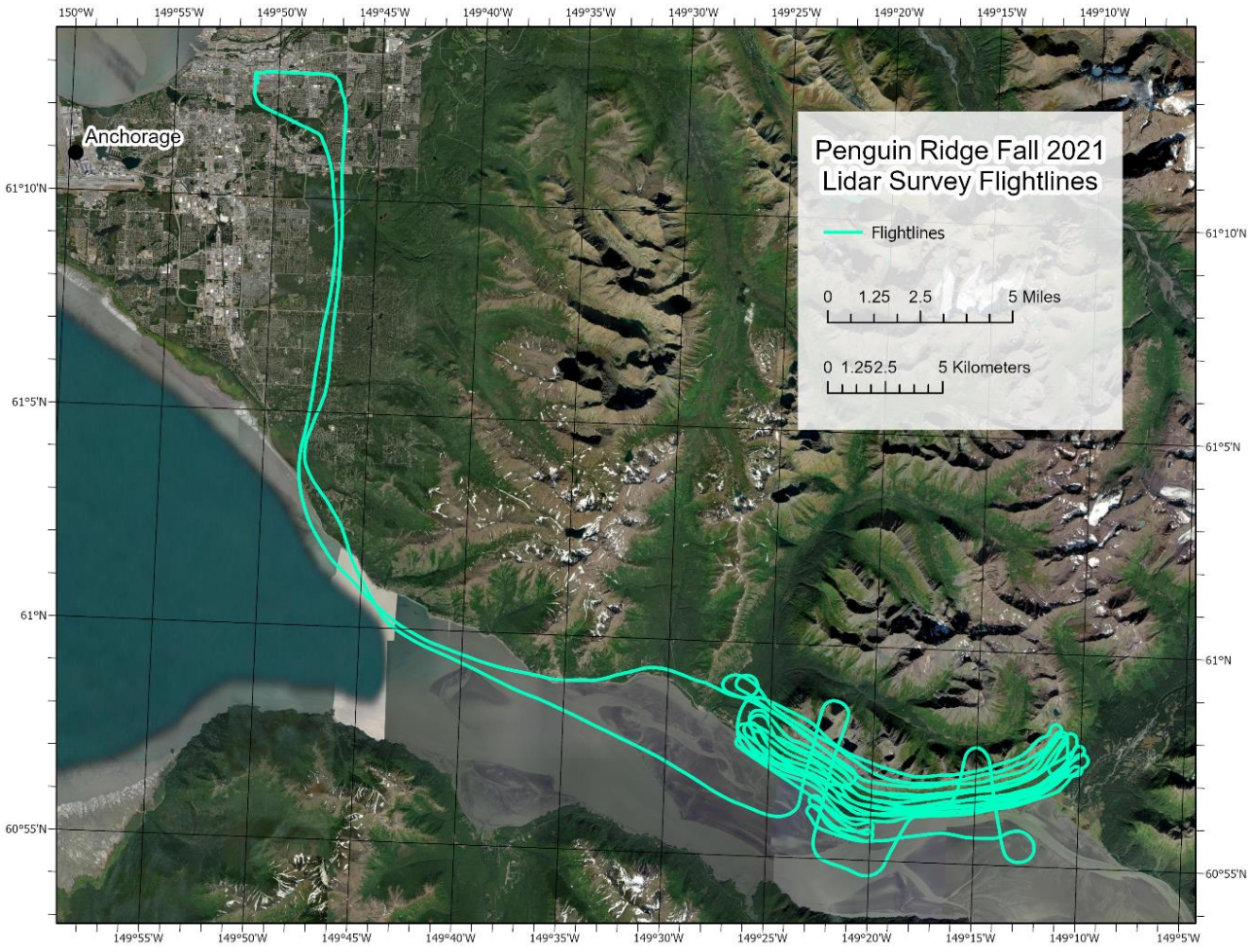


Figure 1. Project flightlines.

PROCESSING REPORT

Lidar Dataset Processing

We processed point data in SDCimport software for initial filtering and multiple-time-around (MTA) disambiguation. MTA errors, corrected in this process, are the result of ambiguous interpretations of received pulse time intervals and occur more frequently with higher pulse refresh rates. Inertial Measurement Unit (IMU) and Global Navigation Satellite System (GNSS) data were processed in Inertial Explorer, and flightline information was integrated with the point cloud in Spatial Explorer. We calibrated the point data at an incrementally precise scale of sensor movement and behavior, incorporating sensor velocity, roll, pitch, and yaw fluctuations throughout the survey. For the lidar data collection, the average nominal pulse density is 17.1 pts/m^2 and the average nominal pulse spacing is 24.2 cm.

We created macros in Terrasolid software and classified points in accordance with American Society for Photogrammetry and Remote Sensing (ASPRS) 2019 guidelines. Once classified, we applied a geometric transformation and converted the points from ellipsoidal heights to GEOID12B (Alaska) orthometric heights.

Raster products were derived from the point cloud in ArcGIS Pro. The DSM was interpolated from maximum return values from the ground, vegetation, wire, and vehicle classes using a Triangulated Irregular Network (TIN) method. The DTM was interpolated from all ground class returns also using a TIN method and minimum values. In ArcMap we produced an intensity image using closest-to-mean binning.

Classified Point Cloud

Classified point cloud data are provided in compressed LAZ format. Data are classified in accordance with ASPRS 2019 guidelines and contain return and intensity information. Class 14 (Wire [conductor]) comprises both transmission lines and towers. For classified ground points, the average point density is 3.24 pts/m^2 (fig. 2).

Table 2. Point cloud class code definitions.

Class Code	Description
1	Unclassified
2	Ground
3	Low Vegetation, ≥0.0m, <0.5m
4	Medium Vegetation, ≥0.5m, <3m
5	High Vegetation, ≥3m, ≤60m
6	Building
7	Low Noise
14	Wire (conductor)
18	High Noise
31	Vehicle (manually classified)

Digital Surface Model

The DSM represents surface elevations, including heights of vegetation, buildings, powerlines, etc. The DSM is a single-band, 32-bit float GeoTIFF file of 50-centimeter resolution. No Data value is set to -3.40282306074e+38.

Digital Terrain Model

The DTM represents bare earth elevations, excluding vegetation, bridges, buildings, etc. The DTM is a single-band, 32-bit float GeoTIFF file of 50-centimeter resolution. No Data value is set to -3.40282306074e+38.

Lidar Intensity Image

The lidar intensity image describes the relative amplitude of reflected signals contributing to the point cloud. Lidar intensity is largely a function of scanned object reflectance in relation to

the signal frequency, is dependent on ambient conditions, and is not necessarily consistent between separate scans. The intensity image is a single-band, 32-bit float GeoTIFF file of 1-meter resolution. No Data value is set to -3.40282306074e+38.

SURVEY REPORT

Ground Survey Details

We collected ground control and check points on September 27, 2021. We deployed a Trimble R10-2 GNSS receiver (internal antenna) at Bird Point, located in the center of the survey area. It provided a base station occupation and real-time kinematic (RTK) corrections to points that we surveyed with a rover Trimble R10-2 GNSS receiver (internal antenna). We collected a total of 170 ground control points and check points to use for calibration and to assess the vertical accuracy of the point cloud. All points were collected on paved surfaces.

Coordinate System and Datum

We processed and delivered all data in NAD83 (2011) UTM8N and vertical datum NAVD88 GEOID12B.

Horizontal Accuracy

We did not measure horizontal accuracy for this collection.

Vertical Accuracy

We measured a mean offset of +42.1 cm between 132 control points and the point cloud (appendix 1). We reduced this offset to +0.3 cm by performing a vertical transformation of the lidar point data. We used 35 check points to determine the non-vegetated vertical accuracy (NVA) of the point cloud ground class using a TIN approach. We calculated the project NVA to have a root mean square error (RMSE) of 3.3 cm (appendix 2). We evaluated the relative accuracy for this dataset as the interswath overlap consistency and measured it at 0.7 cm RMSE.

Data Consistency and Completeness

This is a complete release dataset. There was no over collect except for aircraft turns that were eliminated from the dataset. The data quality is consistent throughout the survey.

ACKNOWLEDGMENTS

These data products were funded by Alaska Department of Transportation & Public Facilities and the State of Alaska, and they were collected and processed by DGGS. We thank Clearwater Air for their aviation expertise and contribution to these data products.

REFERENCES

The American Society for Photogrammetry & Remote Sensing (ASPRS), 2019, LAS Specification 1.4 - R15. https://www.asprs.org/wp-content/uploads/2019/07/LAS_1_4_r15.pdf

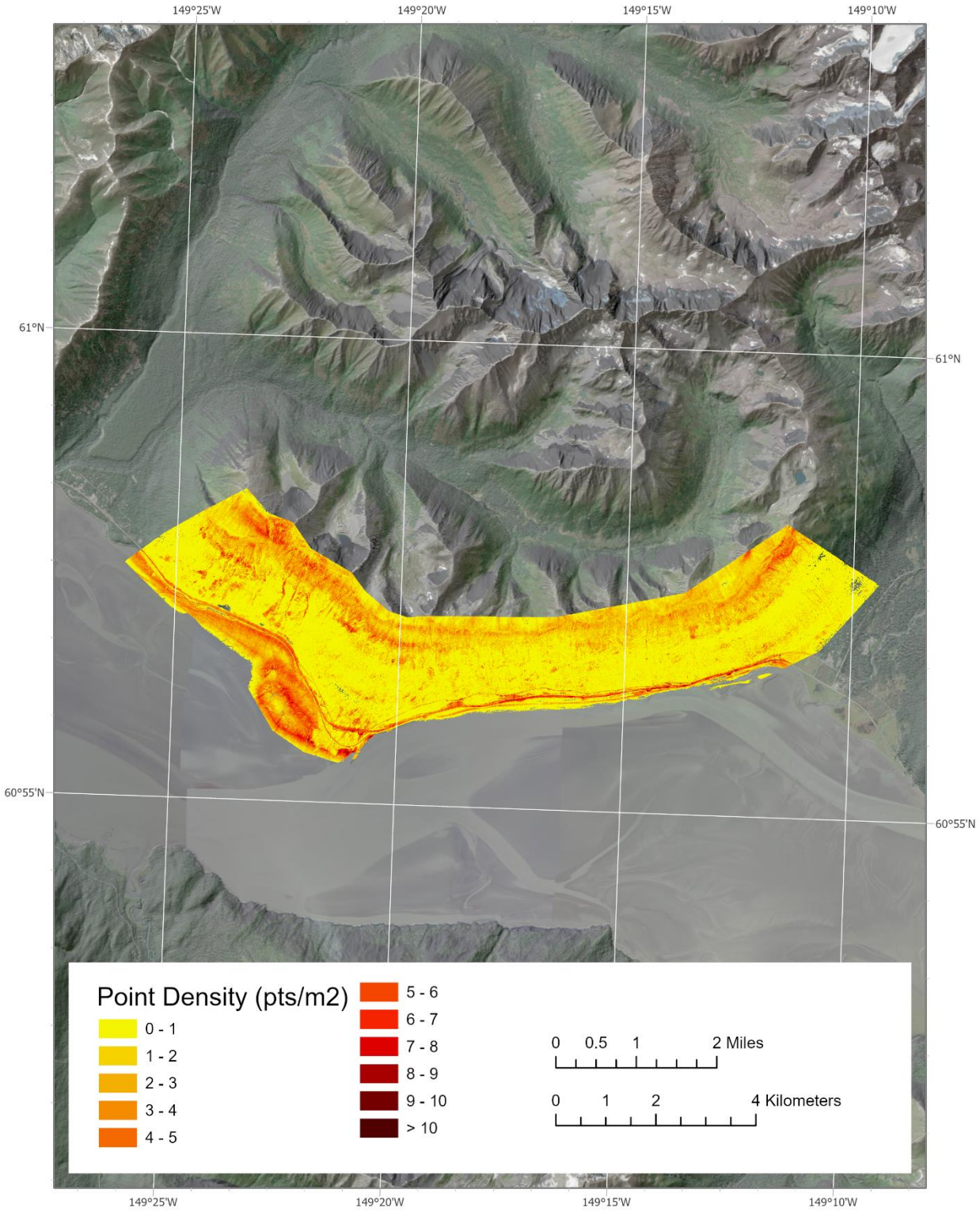


Figure 2. Ground point density for the survey displayed as a 1-meter raster.

APPENDIX 1: GROUND CONTROL POINTS

Ground Control Point	Easting (m)	Northing (m)	GCP Z (m)	Point Cloud Z (m)	Elevation Difference dZ (Point Cloud Z – GCP Z) (m)
1	372835.900	6757169.396	19.96	20.37	0.41
2	372827.526	6757164.423	20.21	20.58	0.37
3	372830.253	6757156.427	20.55	20.97	0.42
4	372817.648	6757153.734	22.09	22.51	0.42
5	372785.848	6757165.028	23.77	24.14	0.37
6	372797.435	6757147.544	24.67	25.04	0.37
7	372803.996	6757138.109	24.71	25.11	0.40
8	372792.082	6757111.425	23.93	24.35	0.42
9	372783.970	6757095.949	23.32	23.72	0.40
10	372775.189	6757069.532	23.17	23.57	0.40
11	372820.395	6757166.982	20.25	20.63	0.39
12	372802.399	6757167.173	20.33	20.72	0.39
13	372784.769	6757181.563	20.18	20.56	0.38
14	372803.185	6757183.169	20.16	20.57	0.41
15	372822.212	6757181.226	20.01	20.41	0.40
16	372851.041	6757178.675	19.90	20.28	0.38
17	372869.949	6757190.182	19.77	20.14	0.38
18	372900.697	6757213.812	19.27	19.64	0.37
19	372871.202	6757217.116	20.01	20.43	0.42
20	372849.378	6757216.202	19.93	20.34	0.41
21	372825.455	6757217.881	20.00	20.40	0.40
22	374087.199	6757492.881	9.30	9.72	0.42
23	374084.039	6757508.139	9.45	9.86	0.41
24	374078.507	6757521.538	9.69	10.07	0.38
25	374099.059	6757511.749	9.52	9.96	0.44
26	374135.402	6757521.788	9.46	9.91	0.45
27	374158.632	6757530.074	9.53	9.97	0.44
28	374142.361	6757513.905	9.39	9.82	0.43
29	374126.645	6757509.583	9.35	9.80	0.45
30	375966.300	6757837.455	9.69	10.12	0.43
31	375965.577	6757846.729	9.78	10.21	0.43
32	375977.091	6757845.414	9.76	10.22	0.46
33	375988.089	6757846.431	9.82	10.24	0.42
34	376024.134	6757851.609	9.83	10.24	0.41
35	376039.621	6757853.579	9.78	10.16	0.38
36	376054.150	6757856.165	9.75	10.13	0.38

Ground Control Point	Easting (m)	Northing (m)	GCP Z (m)	Point Cloud Z (m)	Elevation Difference dZ (Point Cloud Z – GCP Z) (m)
37	376067.552	6757862.952	9.81	10.20	0.39
38	376071.626	6757852.135	9.65	10.04	0.39
39	376041.338	6757848.431	9.68	10.09	0.41
40	376017.088	6757845.062	9.76	10.17	0.41
41	376003.393	6757842.776	9.76	10.18	0.42
42	377282.370	6757873.310	9.54	10.00	0.46
43	377263.319	6757875.837	9.57	10.03	0.46
44	377249.629	6757886.540	9.67	10.14	0.47
45	377253.922	6757897.603	9.89	10.33	0.44
46	377279.859	6757880.826	9.72	10.16	0.44
47	377294.990	6757880.627	9.73	10.16	0.44
48	377316.849	6757880.908	9.71	10.16	0.45
49	377336.261	6757894.984	9.98	10.40	0.42
50	377321.005	6757874.605	9.61	10.04	0.44
51	377306.670	6757875.031	9.62	10.06	0.44
52	377294.441	6757874.899	9.60	10.03	0.43
53	377288.164	6757878.747	9.67	10.12	0.45
54	378586.376	6758037.110	9.52	9.93	0.41
55	378569.185	6758036.563	9.51	9.92	0.41
56	378551.672	6758043.133	9.61	10.04	0.43
57	378555.228	6758059.089	9.74	10.13	0.39
58	378572.625	6758046.725	9.75	10.14	0.39
59	378580.010	6758042.413	9.66	10.05	0.39
60	378590.298	6758047.750	9.77	10.17	0.40
61	378598.570	6758043.684	9.71	10.08	0.38
62	378624.664	6758048.536	9.75	10.13	0.38
63	378635.415	6758061.68	9.82	10.18	0.37
64	378625.811	6758041.718	9.58	9.97	0.39
65	378613.816	6758039.877	9.61	9.98	0.37
66	380200.391	6758361.818	9.50	9.91	0.41
67	380183.831	6758359.828	9.55	9.97	0.42
68	380169.525	6758355.705	9.54	9.94	0.40
69	380154.405	6758357.511	9.55	9.99	0.44
70	380163.606	6758360.314	9.56	10.00	0.44
71	380174.805	6758365.396	9.66	10.09	0.43
72	380185.616	6758368.628	9.68	10.11	0.43
73	380195.426	6758367.256	9.62	10.03	0.41

Ground Control Point	Easting (m)	Northing (m)	GCP Z (m)	Point Cloud Z (m)	Elevation Difference dZ (Point Cloud Z – GCP Z) (m)
74	380224.303	6758376.344	9.61	10.02	0.41
75	380233.892	6758394.885	9.77	10.19	0.42
76	380234.540	6758382.888	9.56	9.97	0.41
77	380224.717	6758370.926	9.53	9.94	0.41
78	371448.565	6758911.493	11.38	11.86	0.48
79	371460.771	6758892.609	12.14	12.59	0.46
80	371469.110	6758879.861	12.26	12.69	0.43
81	371478.400	6758863.999	12.39	12.82	0.43
82	371495.075	6758832.096	12.51	12.92	0.41
83	371502.082	6758817.682	12.43	12.84	0.41
84	371512.456	6758796.857	12.79	13.20	0.41
85	371544.458	6758727.149	16.02	16.47	0.45
86	371566.817	6758663.344	18.20	18.61	0.41
87	371583.194	6758613.950	19.87	20.31	0.44
88	371599.026	6758585.675	20.54	20.96	0.42
89	371604.937	6758563.685	21.01	21.39	0.38
90	371441.341	6758921.183	11.45	11.86	0.41
91	371429.449	6758937.142	12.05	12.43	0.38
92	371411.119	6758959.686	12.63	13.02	0.39
93	371397.709	6758975.417	13.16	13.54	0.38
94	371368.165	6759008.846	13.68	14.07	0.39
95	371353.210	6759024.924	13.59	14.00	0.41
96	371340.859	6759037.521	13.65	14.06	0.41
97	371328.756	6759049.079	13.67	14.07	0.40
98	371303.183	6759072.331	13.80	14.18	0.38
99	371291.279	6759081.839	13.76	14.16	0.40
100	371278.472	6759091.050	13.62	14.02	0.40
101	371266.584	6759099.112	13.59	13.99	0.40
102	371242.990	6759115.503	13.39	13.81	0.42
103	371232.581	6759122.469	13.34	13.76	0.43
104	371221.669	6759129.684	13.25	13.68	0.43
105	371210.029	6759137.000	13.10	13.53	0.43
106	371185.714	6759151.752	12.88	13.31	0.43
107	371172.893	6759158.841	12.75	13.19	0.44
108	371157.530	6759166.751	12.70	13.14	0.44
109	371137.607	6759176.126	12.78	13.24	0.46
110	371109.572	6759188.090	12.43	12.92	0.49

Ground Control Point	Easting (m)	Northing (m)	GCP Z (m)	Point Cloud Z (m)	Elevation Difference dZ (Point Cloud Z – GCP Z) (m)
111	371053.873	6759206.803	9.70	10.21	0.51
112	371046.932	6759211.608	9.53	10.01	0.48
113	371034.567	6759219.839	9.85	10.25	0.41
114	370969.544	6759257.715	12.37	12.85	0.48
115	370915.063	6759281.924	11.05	11.55	0.50
116	370902.036	6759287.861	10.89	11.39	0.50
117	369430.827	6759881.872	22.28	22.72	0.44
118	369418.500	6759887.823	22.38	22.82	0.44
119	369411.870	6759892.154	22.41	22.86	0.45
120	369404.812	6759897.219	22.41	22.89	0.48
121	369394.058	6759907.131	22.40	22.87	0.48
122	369406.441	6759901.691	22.51	22.98	0.47
123	369423.631	6759905.250	22.81	23.24	0.43
124	369415.493	6759897.668	22.55	23.00	0.46
125	369425.937	6759890.748	22.47	22.91	0.45
126	369431.668	6759887.704	22.40	22.84	0.44
127	369437.057	6759884.677	22.33	22.77	0.44
128	369442.919	6759881.472	22.24	22.65	0.41
129	369449.409	6759891.564	22.35	22.76	0.41
130	369461.513	6759882.545	22.10	22.56	0.46
131	369451.544	6759875.712	22.11	22.53	0.42
132	369443.719	6759874.711	22.13	22.57	0.44
Average elevation difference(dZ) (m)	0.421				
Minimum dZ (m)	0.365				
Maximum dZ (m)	0.506				
Average magnitude error (m)	0.421				
Root mean square error (RMSE)	0.422				
Standard deviation	0.03				

APPENDIX 2: CHECK POINTS

Check Point	Easting (m)	Northing (m)	Check Point Z (m)	Point Cloud Z (m)	Elevation Difference dZ (Point Cloud Z – GCP Z) (m)
1	372845.197	6757159.667	20.23	20.21	-0.02
2	372835.291	6757144.241	21.19	21.10	-0.09
3	372794.174	6757128.074	24.15	24.14	-0.01
4	372770.596	6757066.086	23.15	23.13	-0.02
5	372790.306	6757198.370	20.29	20.25	-0.04
6	372878.706	6757207.404	19.96	19.93	-0.03
7	372779.585	6757215.184	20.24	20.24	0.00
8	374116.713	6757516.562	9.53	9.57	0.04
9	374107.697	6757504.837	9.40	9.42	0.02
10	376004.924	6757848.517	9.86	9.88	0.02
11	376081.859	6757860.620	9.68	9.65	-0.03
12	375985.007	6757839.664	9.73	9.75	0.02
13	377263.479	6757881.631	9.66	9.70	0.04
14	377331.033	6757879.108	9.66	9.68	0.02
15	377300.164	6757879.826	9.71	9.72	0.01
16	378560.217	6758043.148	9.62	9.62	0.00
17	378608.908	6758048.268	9.78	9.74	-0.04
18	378597.138	6758038.282	9.61	9.59	-0.02
19	380154.519	6758371.772	9.77	9.75	-0.02
20	380204.244	6758374.134	9.68	9.68	0.00
21	380209.440	6758365.431	9.51	9.51	0.00
22	371487.609	6758847.318	12.49	12.49	0.00
23	371556.015	6758694.617	17.15	17.16	0.01
24	371615.924	6758547.614	21.43	21.45	0.02
25	371381.573	6758993.642	13.58	13.54	-0.04
26	371317.207	6759060.130	13.73	13.69	-0.04
27	371254.037	6759107.934	13.50	13.51	0.01
28	371196.846	6759145.320	12.92	12.93	0.01
29	371122.640	6759182.737	12.68	12.74	0.06
30	370982.095	6759251.133	12.36	12.41	0.05
31	370885.427	6759295.802	10.76	10.83	0.07
32	369397.602	6759903.437	22.43	22.47	0.04
33	369420.293	6759893.905	22.50	22.53	0.03

Check Point	Easting (m)	Northing (m)	Check Point Z (m)	Point Cloud Z (m)	Elevation Difference dZ (Point Cloud Z – GCP Z) (m)
34	369447.902	6759883.108	22.22	22.23	0.01
35	369436.938	6759878.776	22.22	22.24	0.02
Average elevation difference dZ (m)	0.003				
Minimum dZ (m)	-0.088				
Maximum dZ (m)	0.072				
Average magnitude error (m)	0.026				
Root mean square error (m)	0.033				
Standard deviation (m)	0.033				