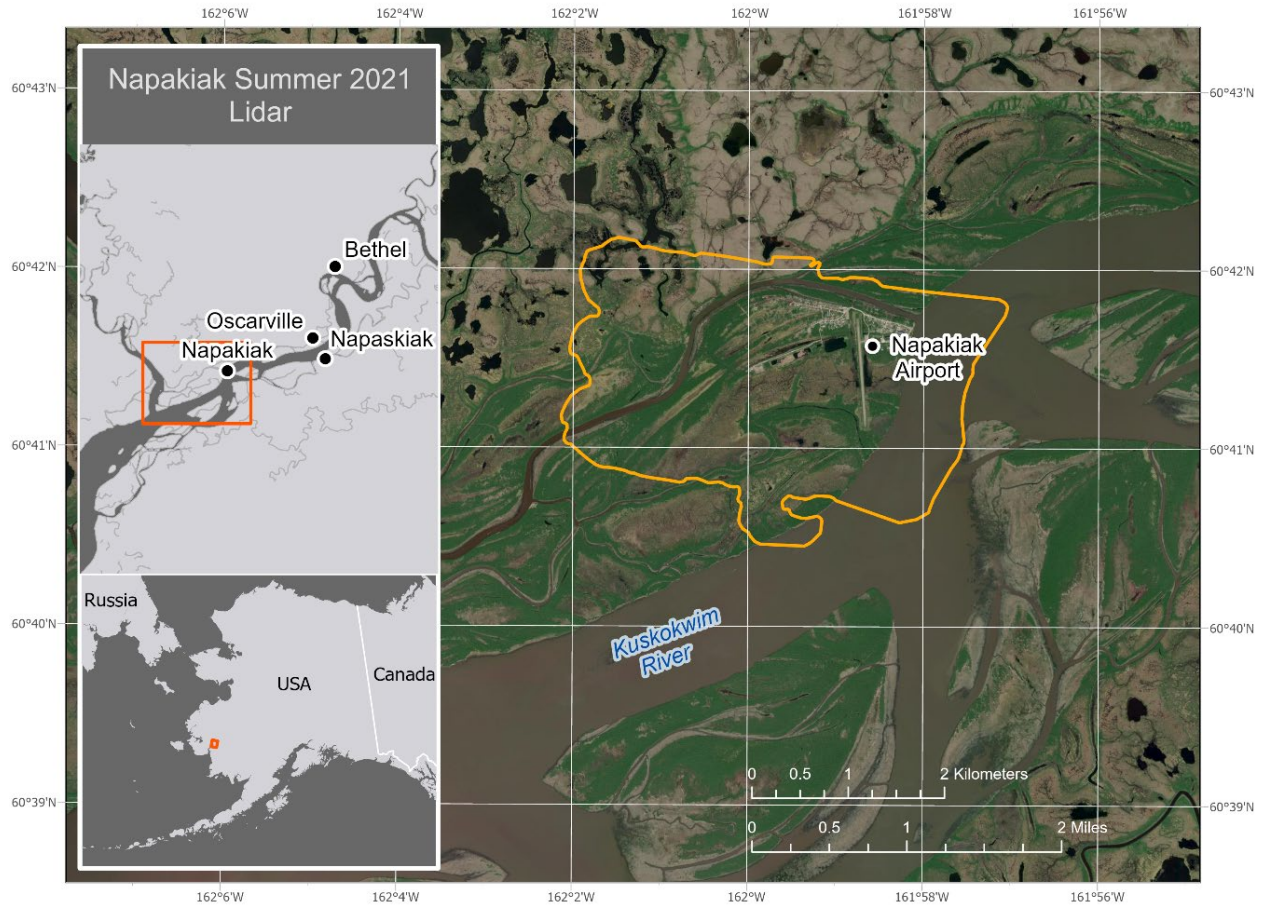


# Lidar-derived elevation data for Napakiak, southwest Alaska, collected August 20, 2022

Jenna M. Zechmann, Andrew M. Herbst, Richard M. Buzard, Katreen M. Wikstrom Jones, and Gabriel J. Wolken

## Raw Data File 2024-12 v. 2



Location map of the survey area.

Raw Data Files provide elevation data, field observations, or analytical data. They are reviewed for clarity and consistency but do not undergo technical peer review.

State of Alaska  
Department of Natural Resources  
Division of Geological & Geophysical Surveys



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# **Lidar-derived elevation data for Napakiak, southwest Alaska, collected August 20, 2022**

Jenna M. Zechmann<sup>1</sup>, Andrew M. Herbst<sup>1\*</sup>, Richard M. Buzard<sup>1\*</sup>, Katreen M. Wikstrom Jones<sup>1</sup>, Gabriel J. Wolken<sup>1</sup>

## **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 an intensity model of Napakiak, Southwest Alaska, during leaf-on conditions (cover figure). The survey provides snow-free surface elevations for flooding hazard assessment and coastal erosion studies. Ground control data were collected on October 8, 2020, and aerial lidar data were collected on August 20, 2021, and were subsequently merged and processed using a suite of geospatial processing software. Version 2 provides data reprocessed to correct a 60-cm vertical offset error identified post-publication. These data and accompanying documentation are released as a DGGS Raw Data File and are available from the DGGS website at <https://doi.org/10.14509/31258>.

## **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) designed by Phoenix LiDAR Systems. The sensor can collect a maximum of 820,000 points per second at a range of 215 m, or a minimum of 50,000 points per second at a range of 820 m (ranges assume  $\geq 20\%$  natural reflectance). The scanner operated with a pulse refresh rate of 400,000 pulses per second, with a scan rate of 200 revolutions per second. We used a Cessna 180 Skywagon fixed-wing platform to survey from an elevation of approximately 180–230 m above ground level, at a ground speed of approximately 40 m/s, and with a scan angle set from 80 to 280 degrees. The total survey area covers approximately 9.9 km<sup>2</sup>.

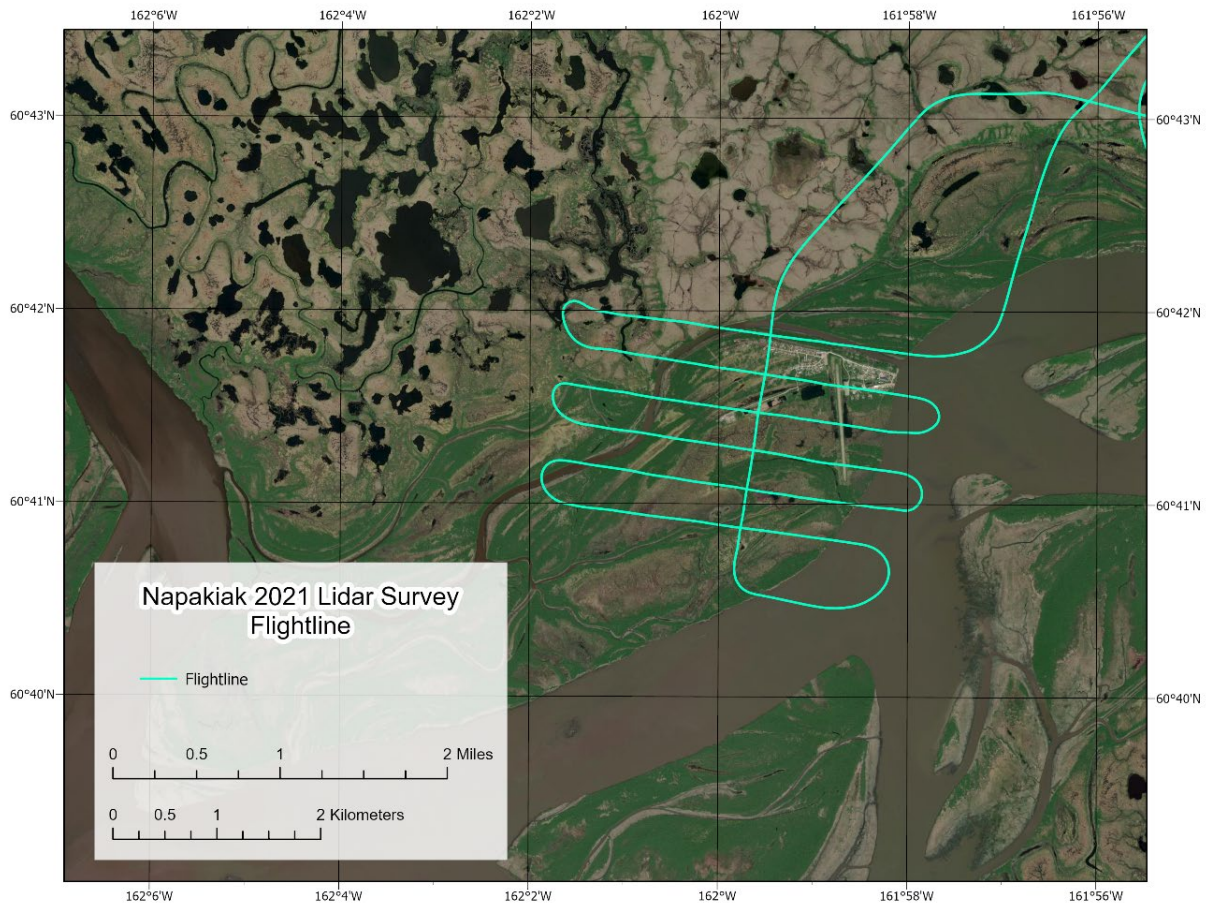
### **Weather Conditions and Flight Times**

The survey area was accessed by air (fig. 1) from Bethel Airport. Data collection occurred between 10:40 am and 11:00 am (AST), and the weather was partly cloudy throughout the survey.

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**Figure 1.** Lidar data collection flightline.

## PROCESSING REPORT

### Lidar Dataset Processing

We processed point data in Spatial Explorer for initial filtering and multiple-time-around (MTA) disambiguation. MTA errors, corrected in this process, result from ambiguous interpretations of received pulse time intervals and occur more frequently with higher pulse refresh rates. IMU and 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 pulse density is 8.95 pulses/m<sup>2</sup>, and the average pulse spacing is 33.4 cm.

We created macros in Terrasolid software and classified points in accordance with the American Society for Photogrammetry & Remote Sensing (ASPRS) 2019 guidelines (ASPRS, 2019). 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. A 50-cm DSM was interpolated from maximum return values from ground, vegetation, bridge deck, wire, and

building classes using a binning method. A 50-cm DTM was interpolated from all ground-classified returns using a binning method and minimum values. We also produced a 50-cm intensity image for the entire area using average binning in ArcGIS Pro, with no normalization or corrections applied.

### Classified Point Cloud

Classified point cloud data are provided in LAZ format. Data are classified following ASPRS 2019 guidelines (table 2) and contain return and intensity information. For classified ground points, the average point density (fig. 2) is 1.83 pts/m<sup>2</sup>, and the average spacing is 74.0 cm.

**Table 2.** Point cloud class code definitions.

CLASS CODE	DESCRIPTION
1	UNCLASSIFIED
2	GROUND
3	LOW VEGETATION, $\geq 0.0M$ , $< 0.5M$
4	MEDIUM VEGETATION, $\geq 0.5M$ , $< 3M$
5	HIGH VEGETATION, $\geq 3M$ , $\leq 60M$
6	BUILDING
7	LOW NOISE
14	WIRE (CONDUCTOR)
17	BRIDGE DECK
18	HIGH NOISE
30	NOISE (MANUALLY CLASSIFIED)

### Digital Surface Model

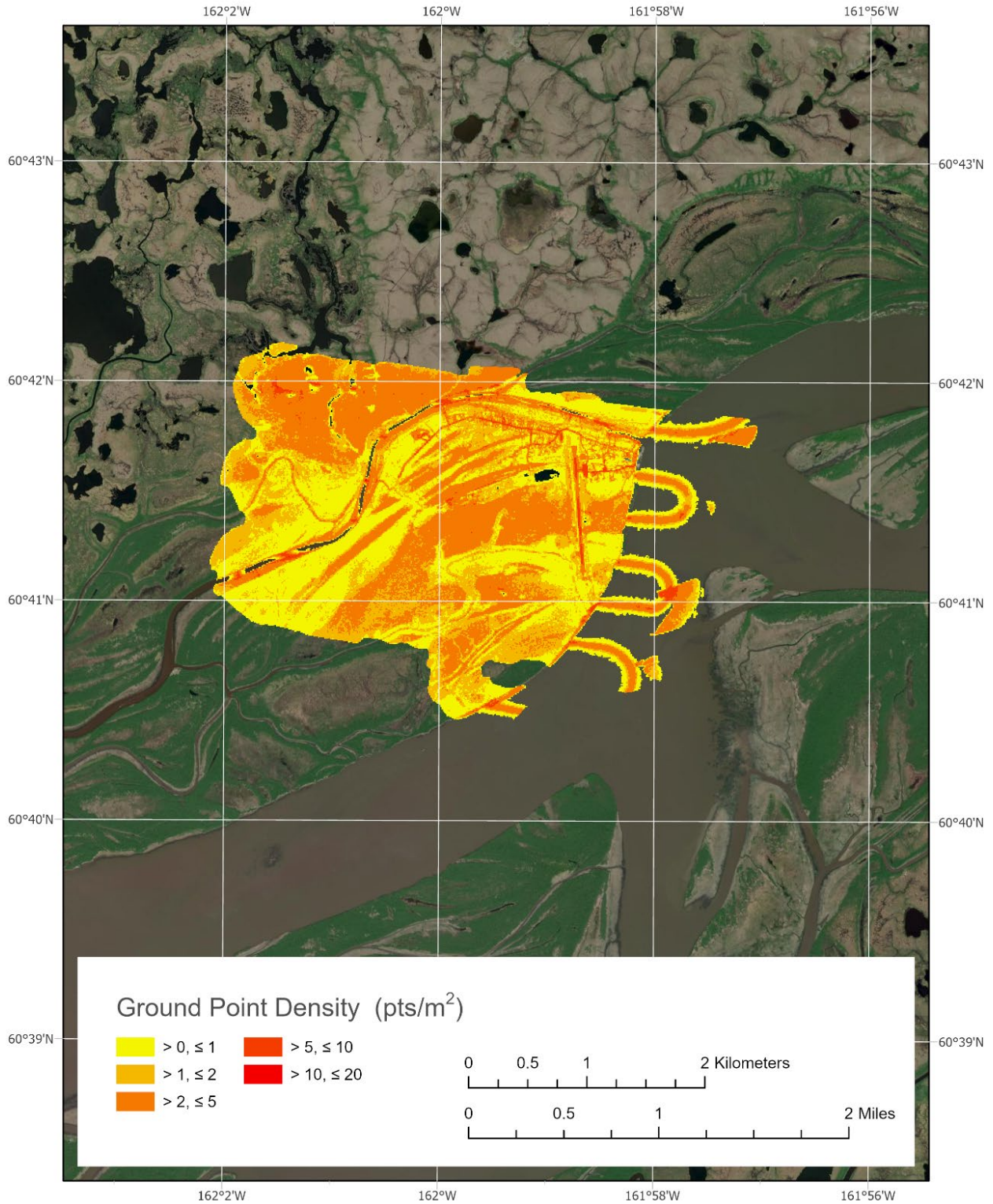
The DSM represents surface elevations, including heights of vegetation, buildings, powerlines, bridge decks, etc. The DSM is a single-band, 32-bit GeoTIFF file of 50-cm resolution. No Data value is set to -3.40282306074e+38 (32-bit, floating-point minimum).

### Digital Terrain Model

The DTM represents bare earth elevations, excluding vegetation, bridge decks, wires, buildings, etc. The DTM is a single-band, 32-bit GeoTIFF file of 50-cm 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 (1) primarily a function of scanned object reflectance in relation to the signal frequency, (2) dependent on ambient conditions, and (3) not necessarily consistent between separate scans. The intensity image is a single-band, 32-bit GeoTIFF file of 50-cm resolution. No Data value is set to -3.40282306074e+38.



**Figure 2.** Ground point density for the survey displayed as a raster.

## **SURVEY REPORT**

### **Ground Survey Details**

Ground control points were collected on October 8, 2020. We deployed a base Trimble R10 GNSS receiver to provide a base station occupation and real-time kinematic (RTK) corrections to points we surveyed with a rover Trimble R10 GNSS receiver/Mesa3 controller. Napakiak Airport served as the base station location (cover figure). We collected 92 ground control points and checkpoints to use for calibration and to assess the vertical accuracy of the point cloud. Checkpoints were collected on bare earth and in vegetation.

### **Coordinate System and Datum**

We processed and delivered all data in NAD83 (2011) UTM4N and vertical datum NAVD88 GEOID12B.

### **Horizontal Accuracy**

Horizontal accuracy was not measured for this collection.

### **Vertical Accuracy**

We measured a mean offset of -2.02 m between 62 control points and the point cloud (app. 1). This offset was reduced to -0.6 cm in non-vegetated areas (app. 2) and +19.2 cm in vegetated areas (app. 3) by applying a constant vertical correction to the lidar point data. We used 17 checkpoints to determine the non-vegetated vertical accuracy of the point cloud ground class using a Triangulated Irregular Network (TIN) approach. The project's non-vegetated vertical accuracy has a root mean square error (RMSE) of 3.8 cm (app. 2). Thirteen additional checkpoints were used to calculate the vegetated vertical accuracy, which has an RMSE of 23.5 cm (app. 3). We evaluated the relative accuracy for this dataset as the interswath overlap consistency and measured it at 5.8 cm RMSE.

Version 2, released May 2026, provides data reprocessed to correct a ground control point datum conversion error identified post-publication.

### **Data Consistency and Completeness**

This is a full-release dataset. There was no over-collect. Data quality is consistent throughout the survey.

## **ACKNOWLEDGMENTS**

This survey area is on the traditional homelands of the Yup'ik people. This work was funded by the National Coastal Resilience Fund and collected and processed by DGGS. We thank Clearwater Air for their aviation expertise and contribution to these data products. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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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](https://www.asprs.org/wp-content/uploads/2019/07/LAS_1_4_r15.pdf)

**APPENDIX 1: GROUND CONTROL POINTS**

<b>GCP</b>	<b>Easting (m)</b>	<b>Northing (m)</b>	<b>GCP Z (m)</b>	<b>Pointcloud Z (m)</b>	<b>Elevation Difference (Pointcloud Z – GCP Z) (m)</b>
1	337455.957	6732336.518	5.336	3.324	-2.012
2	337460.642	6732343.488	5.220	3.224	-1.996
3	337462.514	6732351.058	5.114	3.105	-2.009
4	337471.032	6732394.144	4.875	2.846	-2.029
5	337474.270	6732439.438	4.572	2.515	-2.057
6	337458.614	6732478.332	4.434	2.379	-2.055
7	337425.968	6732540.598	4.896	2.832	-2.064
8	337370.268	6732641.738	4.236	2.207	-2.029
9	337260.142	6732648.528	4.444	2.416	-2.028
10	337207.653	6732594.908	4.883	2.834	-2.049
11	337190.397	6732576.437	5.012	2.977	-2.035
12	337069.627	6732546.464	5.346	3.309	-2.037
13	337027.784	6732548.423	5.310	3.277	-2.033
14	336966.850	6732535.434	5.140	3.129	-2.011
15	336904.418	6732509.919	4.986	2.950	-2.036
16	337001.296	6732620.309	5.100	3.048	-2.052
17	337004.868	6732680.450	5.046	3.011	-2.035
18	336940.792	6732689.066	5.148	3.149	-1.999
19	336894.600	6732699.313	5.258	3.252	-2.006
20	336648.765	6732768.353	4.975	2.932	-2.043
21	336546.976	6732797.603	5.111	3.084	-2.027
22	336387.633	6732770.197	4.906	2.885	-2.021
23	336313.026	6732743.801	4.746	2.736	-2.010
24	336268.804	6732908.820	2.265	0.288	-1.977
25	336264.098	6732848.034	3.921	1.927	-1.994
26	336240.816	6732717.529	4.755	2.718	-2.037
27	336160.203	6732643.655	4.673	2.668	-2.005
28	336094.282	6732672.507	4.869	2.859	-2.010
29	336096.913	6732629.360	4.706	2.734	-1.972
30	336124.834	6732610.890	4.737	2.728	-2.009
31	335958.267	6732459.463	4.782	2.856	-1.926
32	337072.699	6732669.971	4.848	2.812	-2.036
33	337154.599	6732645.713	4.770	2.712	-2.058
34	337230.415	6732650.213	4.521	2.500	-2.021
35	337557.361	6732550.175	5.077	3.042	-2.035
36	337596.966	6732532.202	5.000	2.936	-2.064
37	337660.623	6732511.573	4.531	2.483	-2.048
38	337781.131	6732482.521	4.688	2.640	-2.048

39	337467.659	6732308.450	5.141	3.126	-2.015
40	337496.827	6732298.442	4.646	2.645	-2.001
41	337536.018	6732298.473	4.573	2.554	-2.019
42	337569.071	6732298.575	4.571	2.559	-2.012
43	337642.411	6732297.823	4.287	2.298	-1.989
44	337670.198	6732300.554	4.123	2.104	-2.019
45	337696.834	6732299.252	4.209	2.200	-2.009
46	337735.518	6732308.194	4.229	2.190	-2.039
47	337818.469	6732333.026	4.306	2.271	-2.035
48	337863.951	6732339.185	4.324	2.088	-2.236
49	337788.912	6732456.570	4.790	2.754	-2.036
50	337620.213	6732441.618	4.448	2.395	-2.053
51	337612.147	6732389.997	4.734	2.700	-2.034
52	337619.629	6732328.555	4.678	2.663	-2.015
53	337461.107	6732277.875	5.270	3.280	-1.990
54	337405.771	6732308.175	5.066	3.077	-1.989
55	337379.313	6732264.196	5.486	3.533	-1.953
56	337379.888	6732198.708	5.486	3.579	-1.907
57	337383.188	6732082.025	5.324	3.369	-1.955
58	337386.721	6731893.631	5.000	2.966	-2.034
59	337385.977	6731818.578	5.218	3.166	-2.052
60	337389.354	6731734.264	5.278	3.233	-2.045
61	337393.254	6731618.319	5.402	3.382	-2.020
62	337399.486	6731402.563	3.659	1.777	-1.882
<b>Average elevation difference (dZ) (m)</b>	-2.020				
<b>Minimum dZ (m)</b>	-2.236				
<b>Maximum dZ (m)</b>	-1.882				
<b>Average magnitude error (m)</b>	2.020				
<b>Root mean square error (m)</b>	2.021				
<b>Standard deviation (m)</b>	0.045				

**APPENDIX 2: NON-VEGETATED CHECK POINTS**

Check Point	Easting (m)	Northing (m)	Checkpoint Z (m)	Corrected Pointcloud Z (m)	Elevation Difference (Corrected Pointcloud Z -- Checkpoint Z) (m)
1	337469.499	6732333.203	5.219	5.204	-0.015
2	337464.016	6732367.246	5.011	5.015	0.004
3	337429.515	6732591.895	4.321	4.409	0.088
4	337151.948	6732552.949	5.271	5.251	-0.020
5	337005.351	6732555.522	5.060	5.020	-0.040
6	336774.748	6732732.681	5.131	5.085	-0.046
7	336293.413	6732813.836	4.748	4.756	0.008
8	336119.724	6732674.450	4.774	4.789	0.015
9	336044.039	6732538.111	4.717	4.780	0.063
10	337458.388	6732588.927	4.546	4.536	-0.010
11	337871.493	6732446.857	4.663	4.625	-0.038
12	337621.392	6732298.759	4.584	4.591	0.007
13	337780.535	6732322.026	4.157	4.154	-0.003
14	337651.485	6732474.273	4.369	4.333	-0.036
15	337436.643	6732281.702	5.243	5.287	0.044
16	337384.918	6731979.967	5.189	5.217	0.028
17	337392.980	6731474.602	5.242	5.296	0.054
<b>Average elevation difference (dZ) (m)</b>	0.006				
<b>Minimum dZ (m)</b>	-0.046				
<b>Maximum dZ (m)</b>	0.088				
<b>Average magnitude error (m)</b>	0.031				
<b>Root mean square error (m)</b>	0.038				
<b>Standard deviation (m)</b>	0.039				

**APPENDIX 3: VEGETATED CHECK POINTS**

<b>Check Point</b>	<b>Easting (m)</b>	<b>Northing (m)</b>	<b>Checkpoint Z (m)</b>	<b>Corrected Pointcloud Z (m)</b>	<b>Elevation Difference (Corrected Pointcloud Z --Checkpoint Z) (m)</b>
1	337450.211	6731383.470	3.513	3.646	0.133
2	337458.276	6731358.185	3.509	3.869	0.360
3	337473.319	6731334.932	3.426	3.694	0.268
4	337470.628	6731255.153	3.381	3.854	0.473
5	337506.186	6731225.646	3.225	3.367	0.142
6	337520.731	6731212.111	3.370	3.477	0.107
7	337463.522	6731286.769	3.500	3.542	0.042
8	337465.460	6731329.621	3.641	3.705	0.064
9	337443.579	6731464.376	3.540	3.714	0.174
10	337453.310	6731537.856	3.497	3.570	0.073
11	337448.157	6731567.276	3.672	3.803	0.131
12	337445.518	6731631.657	3.900	4.079	0.179
13	337432.587	6731782.064	3.379	3.470	0.091
14	337440.436	6731689.004	3.459	3.905	0.446
<b>Average elevation difference (dZ) (m)</b>	0.192				
<b>Minimum dZ (m)</b>	0.042				
<b>Maximum dZ (m)</b>	0.473				
<b>Average magnitude error (m)</b>	0.192				
<b>Root mean square error (m)</b>	0.235				
<b>Standard deviation (m)</b>	0.141				