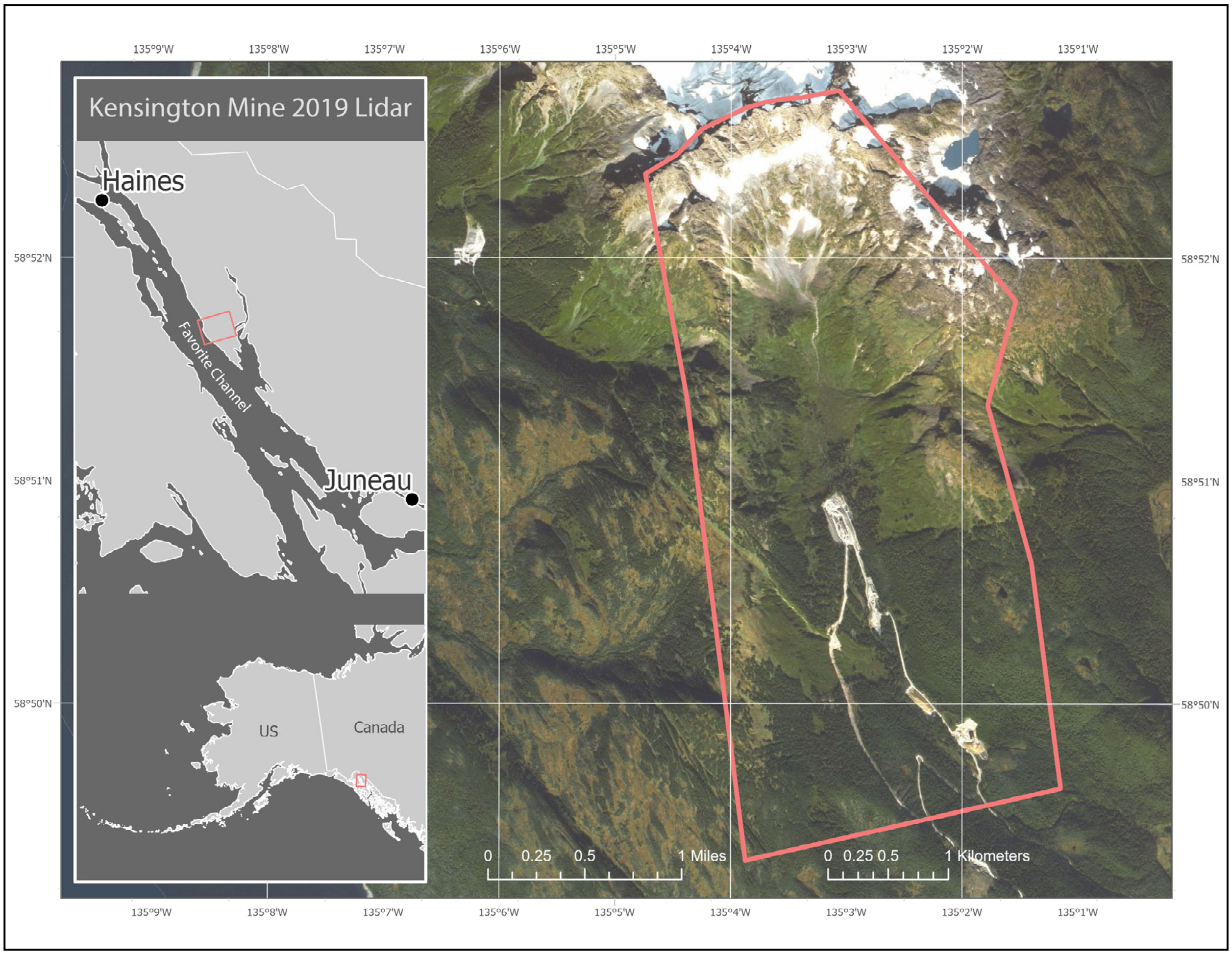
# LIDAR-DERIVED ELEVATION DATA FOR KENSINGTON MINE, SOUTHEAST ALASKA

Katreen Wikstrom Jones, Gabriel J. Wolken, Ronald P. Daanen, and Andrew M. Herbst

Raw Data File 2020-7




Location map of survey area with ortho-image base layer.

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

2020
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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# LIDAR-DERIVED ELEVATION DATA FOR KENSINGTON MINE, SOUTHEAST ALASKA

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## ABSTRACT

The State of Alaska Division of Geological & Geophysical Surveys (DGGS) used lidar to produce a digital terrain model (DTM) and digital surface model (DSM) of Kensington Mine, southeast Alaska, during snow-free ground conditions. The lidar and Global Navigation Satellite System (GNSS) data were collected on September 7, 2019, and processed using Terrasolid. The goal of the survey is to provide snow-free surface elevations for the purpose of deriving snow depth distribution models with repeat surveys during snow-covered surface conditions. This data release is one of a series of DGGS publications to present elevation data. This data collection is being released as a Raw Data File with an open end-user license. All files can be downloaded free of charge from the DGGS website at http://doi.org/10.14509/30470.

## LIST OF DELIVERABLES

Classified Points

DSM and DTM

Intensity Image

Metadata

## MISSION PLAN

### Airborne Survey Details

This dataset includes point cloud data, 32-bit digital terrain and digital surface models, and an intensity image covering Kensington Mine and surrounding area (approximately 60 mi$^2$ [155 km$^2$]) located southeast of Haines and northwest of Juneau in southeast Alaska. This lidar survey was flown at an average elevation of 130 m above ground level and a ground speed of approximately 30 m/s with a helicopter configuration, using a Bell 206 JetRanger. Elevation data were acquired with a Riegl VUX1-LR laser scanner integrated with a GNSS and Northrop Grumman IMU system. The integration was designed by Phoenix LiDAR systems. Lidar data were acquired at a pulse rate ranging from 50,000 pulses per second in the alpine areas to 400,000 pulses per second over forested areas, a scan rate of 200 revolutions per second, and a scan angle range of 80–**280** degrees. The total area surveyed was approximately 15 km$^2$.

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## Weather Conditions and Flight Times

The lidar data were collected on September 7, 2019. The sky was clear. No abnormalities were observed during the flights.

## Lidar Point Cloud Details

The ground-classified point cloud from which the DTM was derived has an average point spacing of 15 cm (11 cm on the ground in open alpine areas and 21 cm below dense vegetation in the valley) and an average point density of 6.5 points per square meter (fig. 2). The point cloud that was used to generate the DSM (which includes points classified as Grounds, and Low, Medium, and High Vegetation) has a point spacing of 3.7 cm and a point density of 27.1 points per square meter.

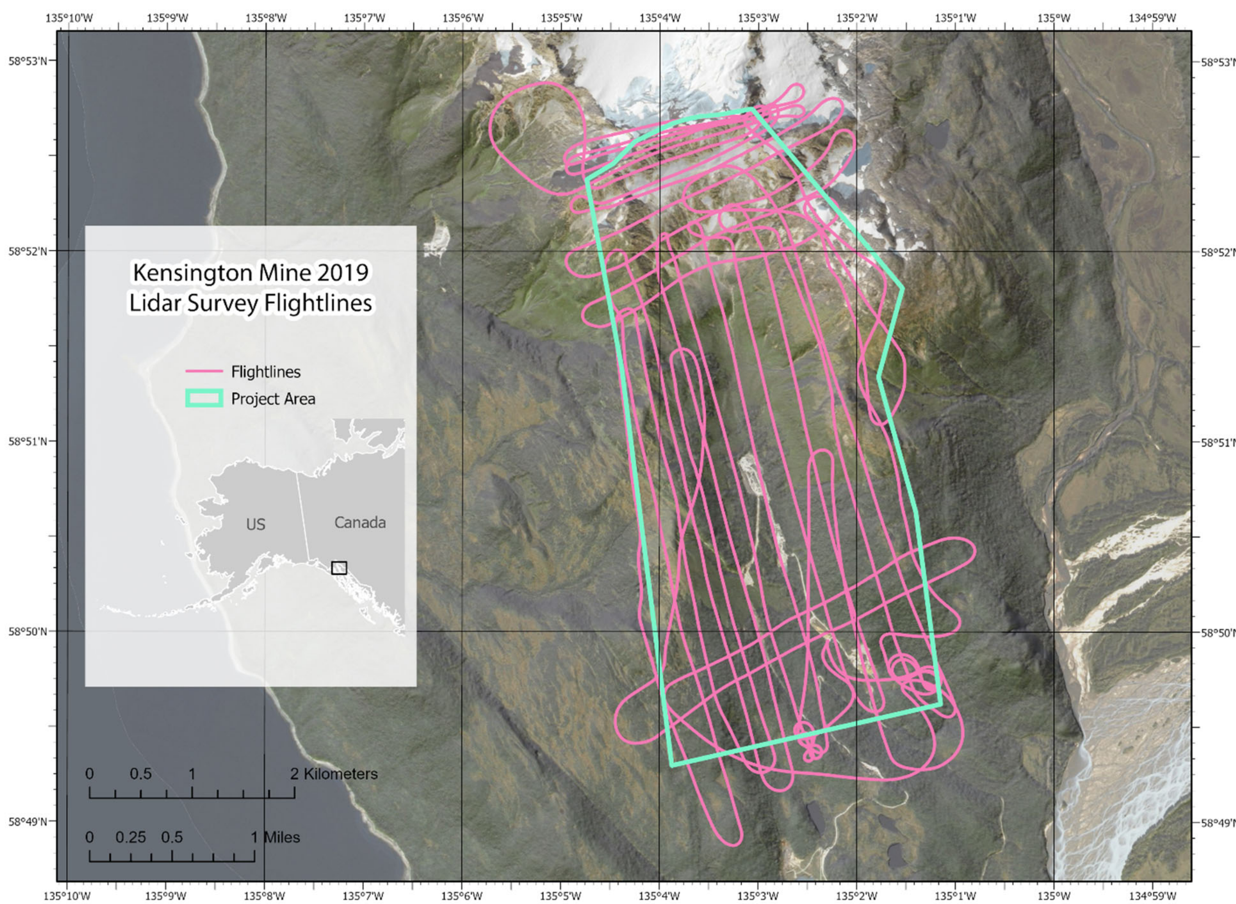


**Figure 1.** Project flightlines.

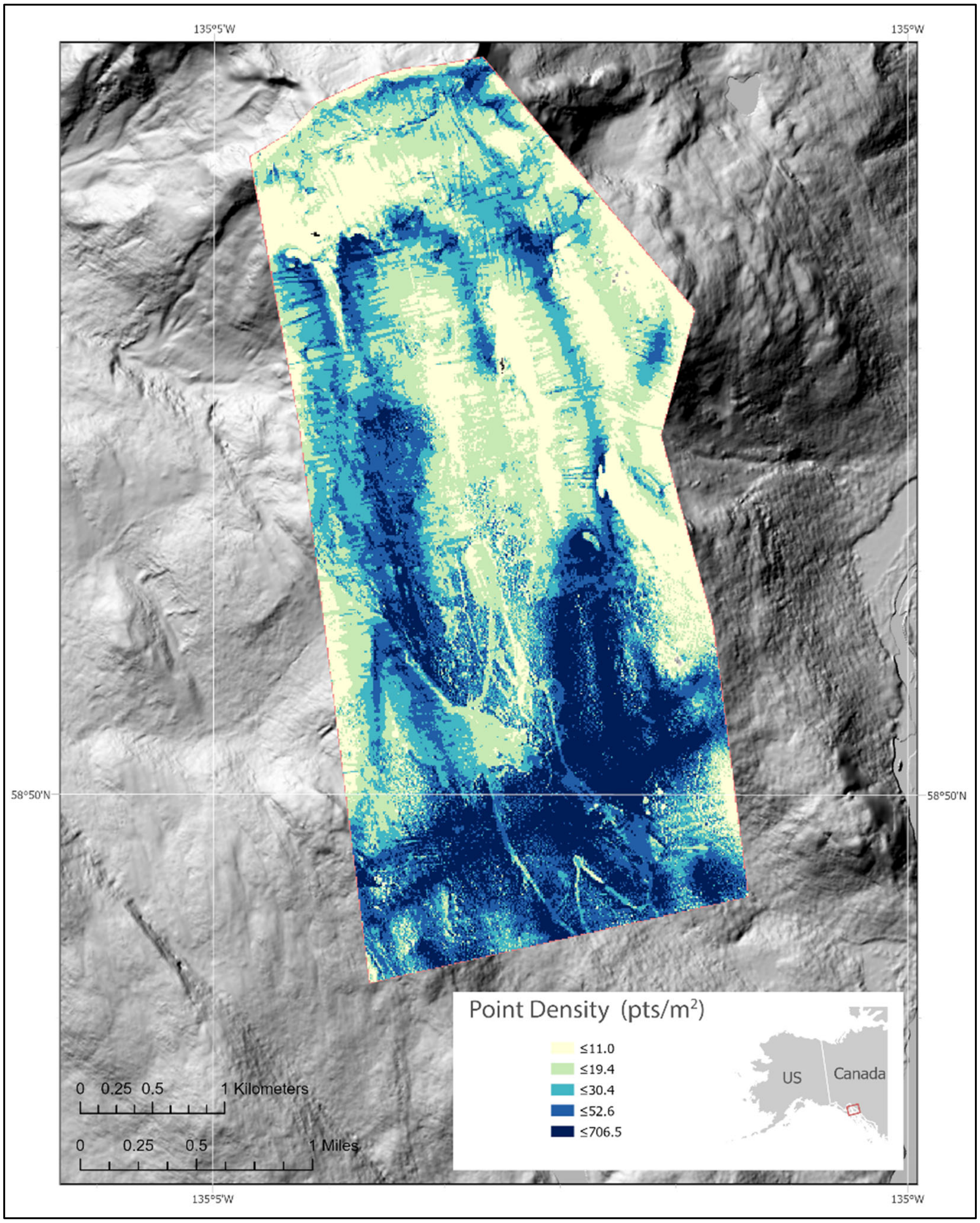


**Figure 2.** Ground point density displayed as 1-meter raster for the survey.

## PROCESSING REPORT

### Lidar Dataset Processing

Raw data were processed using Terrasolid software to produce integrated files for navigation correction and a point cloud for calibration. The navigation was corrected using Inertial Explorer software. The software integrates the GNSS and IMU data to establish the correct flight path and orientation of the lidar sensor.

Internal consistency within the dataset was improved by calibrating the point cloud data using global, flight line, and fluctuation (within individual flightlines) tielines in TerraSolid software. The point cloud data were classified for ground points as well as low, medium, and high vegetation (0.01–0.5 m, 0.5–3 m, and 3–60 m heights above the ground, respectively). Some manual processing was required to eliminate erratically placed points and misclassified ground points. All low points and air points were eliminated from the dataset.

A LAS dataset was created in ArcMap, from which a 50-cm DTM, 50-cm DSM, and 1-m intensity image were produced. The DTM was derived from elevation values of Ground-classified points only and built using the binning technique of minimum elevation and linear void fill. The DTM was derived from elevation values from first returns from the Grounds, Low Vegetation, Medium Vegetation, or High Vegetation classes, and built using the binning technique of average elevation values and linear void fill. The intensity image was derived from the intensity values of the first return points.

## DATA PRODUCTS

### Classified Point Cloud

Classified point cloud data is provided in this collection in compressed .laz format. Data are classified in accordance with ASPRS 2014 guidelines and contain return and intensity information.

### Digital Surface Model

The DSM represents surface elevations, for example, heights of vegetation, buildings, bridges, etc. The DSM is a single band, 32-bit GeoTIFF file, with a ground sample distance of 0.5 meters. No Data value is set to -3.40282306074e+038.

### Digital Terrain Model

The DTM represents surface elevations of ground surfaces, excluding vegetation, bridges, buildings, etc. The DTM is a single-band, 32-bit float GeoTIFF file, with a ground sample distance of 0.5 meter. No Data value is set to -3.40282306074e+038.

### 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 with a ground sample distance of 0.5 meters. No Data value is set to -3.40282306074e+038 (32-bit, floating-point minimum).

## SURVEY REPORT

### Ground Survey Details

Ground control and checkpoints were collected on October 24, 2019. A Trimble R7 GNSS receiver with Zephyr-2 antenna was deployed near the center of the study area. It provided a base station occupation and real-time kinematic (RTK) corrections to points surveyed with a rover Trimble R8-4 GNSS receiver (internal antenna). 76 ground control points and checkpoints were collected to be used for calibration and assessment of the vertical accuracy of the point cloud. All points were collected on a paved road surface.

### Coordinate system and Datum

All data were processed and delivered in NAD83 (2011) UTM8N and vertical datum NAVD88 with a geoid correction following the latest GEOID12B for Alaska.

### Vertical Accuracy

The elevation values of 59 ground control points were compared with the elevation values of the lidar points classified as Grounds. The average vertical offset was corrected with a z-transformation. 16 checkpoints were used to determine the final accuracy of the z-transformed lidar point cloud. The lidar point cloud had a vertical offset of +14.4 cm (Root mean squared error [RMSE] 18.7 cm) compared to ground control; therefore, a vertical transformation of -14.4 cm was applied to the lidar point cloud. The final accuracy assessment showed a mean vertical offset of -8.24 cm and RMSE of 17.6 cm (appendix 1). Relative accuracy for this dataset was evaluated as the interswath overlap consistency and was measured at 0.56 cm RMSE.

### Horizontal Accuracy

Horizontal accuracy was not measured for this collection.

### Data Consistency and Completeness

This data release is complete, and there is no over collect, except for the aircraft turns that were eliminated from the dataset. There are a few areas where data coverage is limited due to laser range exceedance, which is related to the slow response of the fixed-wing aircraft to the fast elevation change along the flight path (e.g., in canyons) (fig. 1).

## ACKNOWLEDGMENTS

These data products were funded by U.S. Geological Surveys, Kensington Mine (Coeur Mining) and Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys. We thank Coastal Helicopters for their aviation expertise and contribution to these data products.

## APPENDIX: CHECKPOINTS

| Checkpoint Number | Easting (m) | Northing (m) | Known Z (m) | Laser Z (m) | Elevation Difference Dz (m) |
|---|---|---|---|---|---|
| 1 | 497212.908 | 6522761.73 | 251.655 | 251.54 | -0.115 |
| 2 | 497226.718 | 6522785.366 | 251.742 | 251.66 | -0.082 |
| 3 | 497186.777 | 6522884 | 255.787 | 255.88 | 0.093 |
| 4 | 497165.448 | 6522961.772 | 257.17 | 257.23 | 0.06 |
| 5 | 497032.445 | 6523078.204 | 293.98 | 293.84 | -0.14 |
| 6 | 496992.087 | 6523052.164 | 294.078 | 293.6 | -0.478 |
| 7 | 497058.996 | 6522205.701 | 302.03 | 302.08 | 0.05 |
| 8 | 497105.606 | 6522507.878 | 300.245 | 300.32 | 0.075 |
| 9 | 497107.725 | 6522601.455 | 293.724 | 293.71 | -0.014 |
| 10 | 497108.553 | 6522651.03 | 290.145 | 290.1 | -0.045 |
| 11 | 497107.487 | 6522669.679 | 288.77 | 288.69 | -0.08 |
| 12 | 497287.828 | 6522543.993 | 231.361 | 231.14 | -0.221 |
| 13 | 497293.737 | 6522541.928 | 230.639 | 230.29 | -0.349 |
| 14 | 497794.914 | 6521399.844 | 156.074 | 156.11 | 0.036 |
| 15 | 497774.086 | 6521479.637 | 171.319 | 171.36 | 0.041 |
| 16 | 497763.239 | 6521499.911 | 173.189 | 173.04 | -0.149 |

| | |
|---|---|
| Average dz (m) | -0.082 |
| Minimum dz (m) | -0.478 |
| Maximum dz (m) | 0.093 |
| Average magnitude (m) | 0.127 |
| Root mean squared error (m) | 0.176 |
| Standard deviation (m) | 0.16 |