OLC Colville

WSI Applied Remote Sensing and Analysis

quantumspatial.com

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Data collected for:

Department of Geology and Mineral Industries

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Contents

Base station set up over a survey monument within the Colville study area.

Project Overview

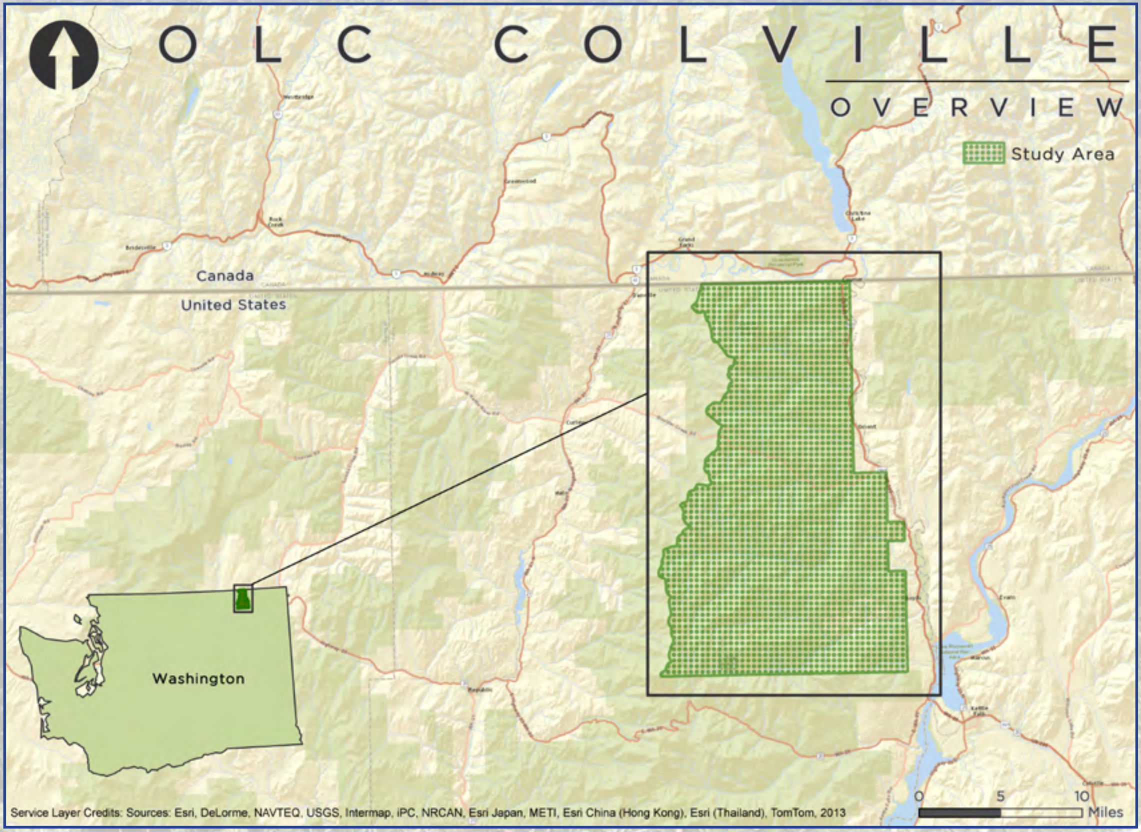
WSI, a Quantum Spatial company, has collected Light Detection and Ranging (LiDAR) data for the Oregon LiDAR Consortium (OLC) Colville study area. This study area is located in northeastern Washington, abutting Canada.

The collection of high resolution geographic data is part of an ongoing pursuit to amass a library of information accessible to government agencies as well as the general public.

In August 2014 WSI employed remote-sensing lasers in order to obtain a total area flown of 171,091 acres. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter.

Final products created include LiDAR point cloud data, one meter digital elevation models of bare earth ground models, ground density rasters, and highest-hit returns, one-half meter intensity rasters, study area vector shapes, and corresponding statistical data. Final deliverables are projected in United States Forest Service (USFS) Region 6 Albers.

Colville Data	
Acquisition Dates	August 3 - August 29, 2014
Area of Interest	168,083 acres
Total Area Flown	171,091 acres
Projection	USFS Region 6 Albers
Datum: horizontal & vertical	NAD83 (2011) NAVD88 (Geoid 12A)
Units	Meters



Aerial Acquisition

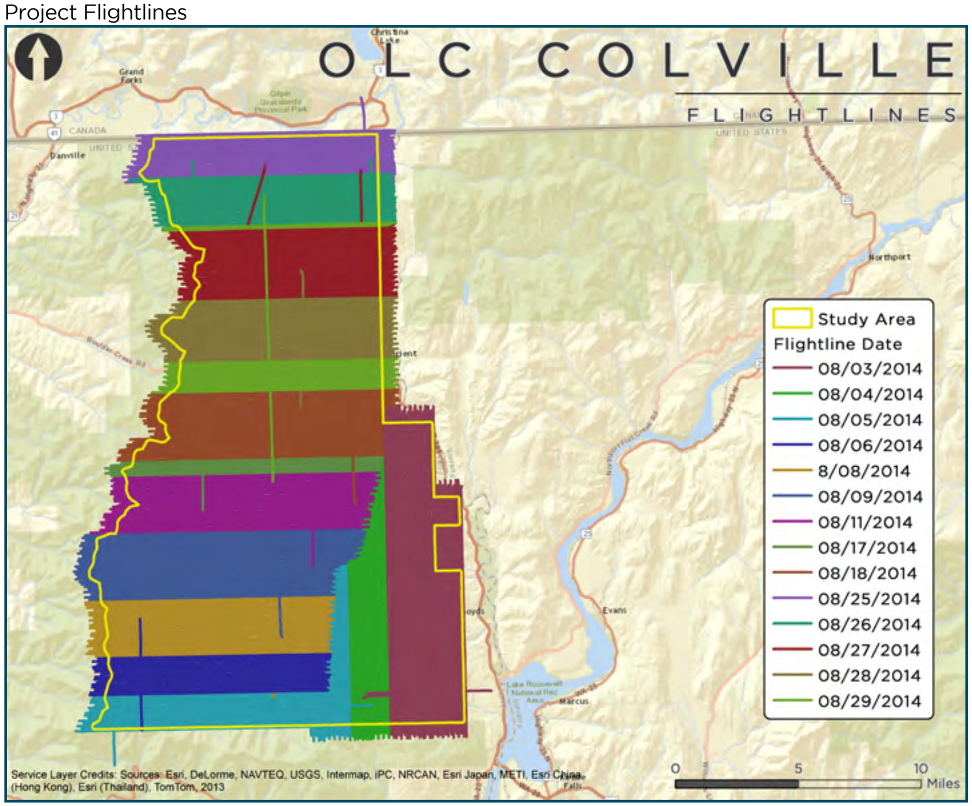
LiDAR Survey

The LiDAR survey occurred between August 3 and August 29, 2014 utilizing a Leica ALS 60 sensor mounted in a Partenavia P68. The system was programmed to emit single pulses at between 96 kHz and 105.9 kHz and were flown at 900 meters above ground level (AGL), capturing a scan angle of 15 degrees from nadir (field of view equal to 30 degrees). These settings were developed to yield points with an average native density of greater than eight pulses per square meter over terrestrial surfaces.

To solve for laser point position, an accurate description of aircraft position and attitude is vital. Aircraft position is described as x, y, and z and was measured twice per second (two hertz) by an onboard differential GPS unit. Aircraft attitude is described as pitch, roll, and yaw (heading) and was measured 200 times per second (200 hertz) from an onboard inertial measurement unit (IMU).

The LiDAR sensor operators constantly monitored the data collection settings during acquisition of the data, including pulse rate, power setting, scan rate, gain, field of view, and pulse mode. For each flight, the crew performed airborne calibration maneuvers designed to improve the calibration results during the data processing stage. They were also in constant communication with the ground crew to ensure proper ground GPS coverage for data quality. The LiDAR coverage was completed with no data gaps or voids, barring non-reflective surfaces (e.g., open water, wet asphalt). All necessary measures were taken to acquire data under good conditions (e.g., minimum cloud decks) and in a manner (e.g., adherence to flight plans) that prevented the possibility of data gaps. All WSI LiDAR systems are calibrated per the manufacturer and our own specifications, and tested by WSI for internal consistency for every mission using proprietary methods.

Project Flightlines



Colville LiDAR Acquisition Specs	
Aircraft	Partenavia P68
Sensor	Leica ALS 60
Coverage	100% Overlap with 65% Sidelap
Field of View (FOV)	30°
Targeted Pulse Density	≥ 8 pulses per square meter

Ground Survey

Ground control surveys, including monumentation, aerial targets, and ground survey points (GSPs) were conducted to support the airborne acquisition. Ground control data are used to geospatially correct the aircraft positional coordinate data and to perform quality assurance checks on final LiDAR data and orthoimagery products.

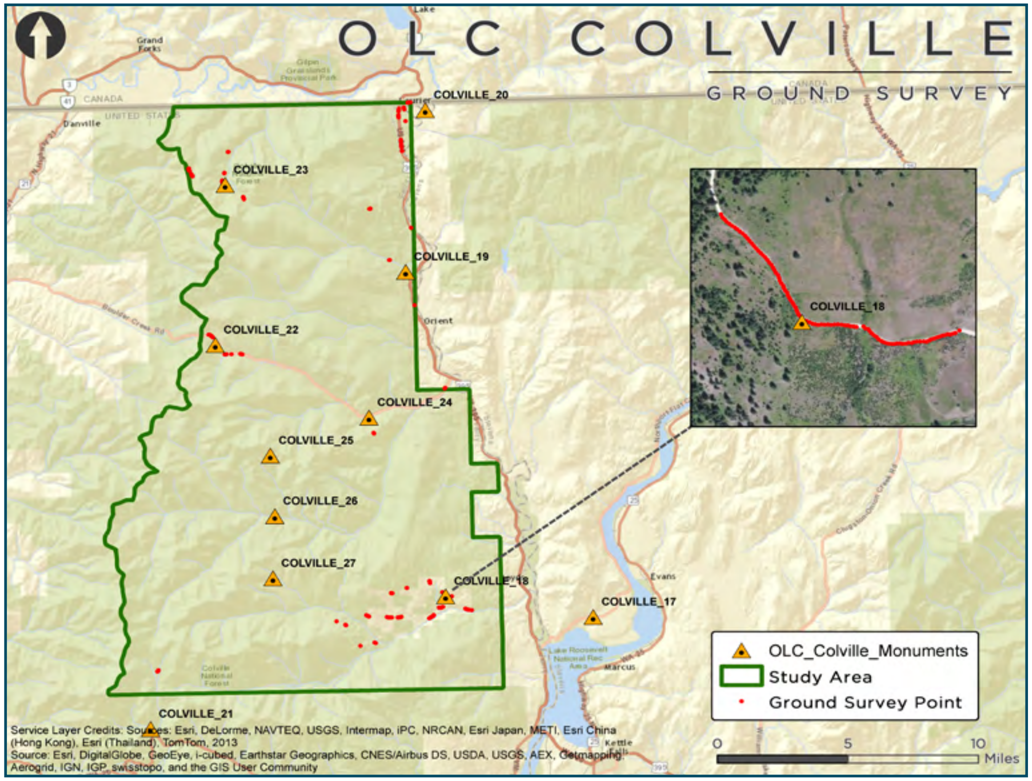
Instrumentation

All Global Navigation Satellite System (GNSS) static surveys utilized Trimble R7 GNSS receivers with Zephyr Geodetic Model 2 RoHS antennas and Trimble R8 GNSS receivers with internal antennas. Rover surveys for GSP collection were conducted with Trimble R8 and Trimble R10 GNSS receivers. See the table on the following page for specifications of equipment used.

Monumentation

Existing and newly established survey benchmarks serve as control points during LiDAR acquisition. Monument locations were selected with consideration for satellite visibility, field crew safety, and optimal location for GSP coverage. NGS benchmarks are preferred for control points; however, in the absence of NGS benchmarks, WSI produces our own monuments, and every effort is made to keep them within the public right of way or on public lands. If monuments are necessary on private property, consent from the owner is required. All monumentation is done with 5/8" x 30" rebar topped with a two-inch diameter aluminum cap stamped "Watershed Sciences, Inc. Control." The table at right provides the list of monuments used in the OLC Colville study area.

Monument Accuracy	
FGDC-STD-007.2-1998 Rating	
St Dev NE	0.05 m
St Dev z	0.05 m



Monuments				
	Datum NAD 83 (2011)			
Name	Latitude	Longitude	Ellipsoid Height (m)	NAVD88 Height (m)
COLVILLE_17	48° 41' 34.52290"	-118° 04' 20.22047"	464.91	482.34
COLVILLE_18	48° 42' 25.51520"	-118° 11' 43.04141"	874.71	891.76
COLVILLE_19	48° 53' 58.70507"	-118° 13' 20.69680"	542.43	1304.75
COLVILLE_20	48° 59' 42.53495"	-118° 12' 09.55838"	430.31	559.33
COLVILLE_21	48° 37' 54.61277"	-118° 26' 40.76614"	1288.03	1353.37
COLVILLE_22	48° 51' 30.72378"	-118° 23' 01.10949"	1336.77	447.15
COLVILLE_23	48° 57' 11.42919"	-118° 22' 20.82699"	1292.94	1309.59
COLVILLE_24	48° 48' 49.66725"	-118° 15' 21.81072"	754.82	771.72
COLVILLE_25	48° 47' 32.94538"	-118° 20' 22.01921"	1521.26	1537.88
COLVILLE_26	48° 45' 23.38491"	-118° 20' 12.89138"	1000.17	1016.86
COLVILLE_27	48° 43' 11.01785"	-118° 20' 22.18381"	1249.98	1266.65

Coordinates are on the NAD83 (2011) datum, epoch 2010.00. NAVD88 height referenced to Geoid12A.

Methodology

To correct the continuously recorded onboard measurement of the aircraft position, WSI concurrently conducts multiple static Global Navigation Satelite System (GNSS) ground surveys (1 Hz recording frequency) over each monument. During post-processing, the static GPS data were triangulated with nearby Continuously Operating Reference Stations (CORS) using the Online Positioning User Service (OPUS) for precise positioning. Multiple independant sessions over the same monument were processed to confirm antenna height measurements and to refine position accuracy.

Ground Survey Points (GSPs)

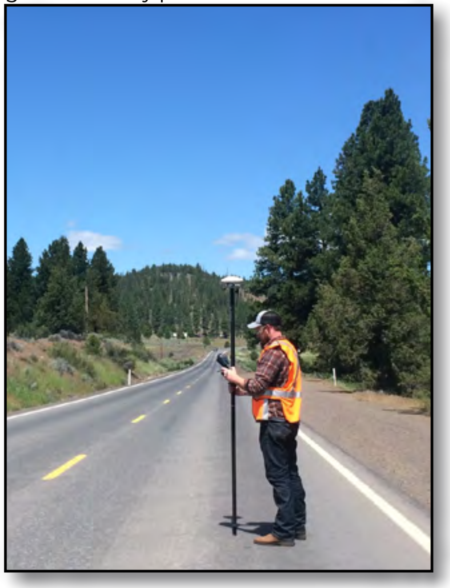
Ground Survey Points are collected using Real Time Kinematic (RTK) survey techniques. For RTK surveys, a base receiver is positioned at a nearby monument to broadcast a kinematic correction to a roving receiver.

All GSP measurements are made during periods with a Position Dilution of Precision (PDOP) no greater than 3.0 and in view of at least six satellites for both receivers. Relative errors for the position must be less than 1.5 centimeters horizontal and 2.0 centimeters vertical in order to be accepted.

In order to facilitate comparisons with high quality LiDAR data, GSP measurements are not taken on highly reflective surfaces such as center line stripes or lane markings on roads. GSPs are taken no closer than one meter to any nearby terrain breaks such as road edges or drop offs. GSPs were collected within as many flight lines as possible; however, the distribution depended on ground access constraints and may not be equitably distributed throughout the study area.

Below: R7 receivers in the Colville study area

Below: Ground professional collecting ground survey points.



Instrumentation			
Receiver Model	Antenna	OPUS Antenna ID	Use
Trimble R7 GNSS	Zephyr GNSS Geodetic Model 2 RoHS	TRM57971.00	Static
Trimble R8	Integrated Antenna R8 Model 2	TRM_R8_GNSS	Static, Rover
Trimble R10	Integrated Antenna R10	TRMR10	Rover

Accuracy

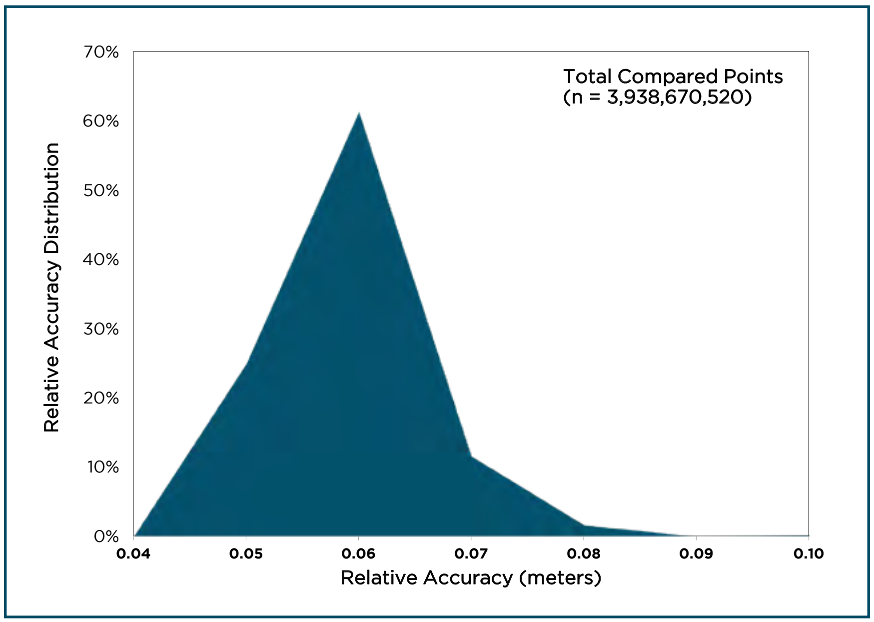
Relative Accuracy

Relative accuracy refers to the internal consistency of the data set and is measured as the divergence between points from different flightlines within an overlapping area. Divergence is most apparent when flightlines are opposing. When the LiDAR system is well calibrated the line to line divergence is low (<10 centimeters). Internal consistency is affected by system attitude offsets (pitch, roll, and heading), mirror flex (scale), and GPS/IMU drift.

Relative accuracy statistics are based on the comparison of 413 flightlines and over three billion LiDAR points. Relative accuracy is reported for the entire study area.

Relative Accuracy Calibration Results	
Project Average	0.05 m (0.18 ft)
Median Relative Accuracy	0.05 m (0.18 ft)
1σ Relative Accuracy	0.06 m (0.19 ft)
2σ Relative Accuracy	0.06 m (0.21 ft)

Relative Accuracy Distribution



Below: Survey monument COLVILLE_18

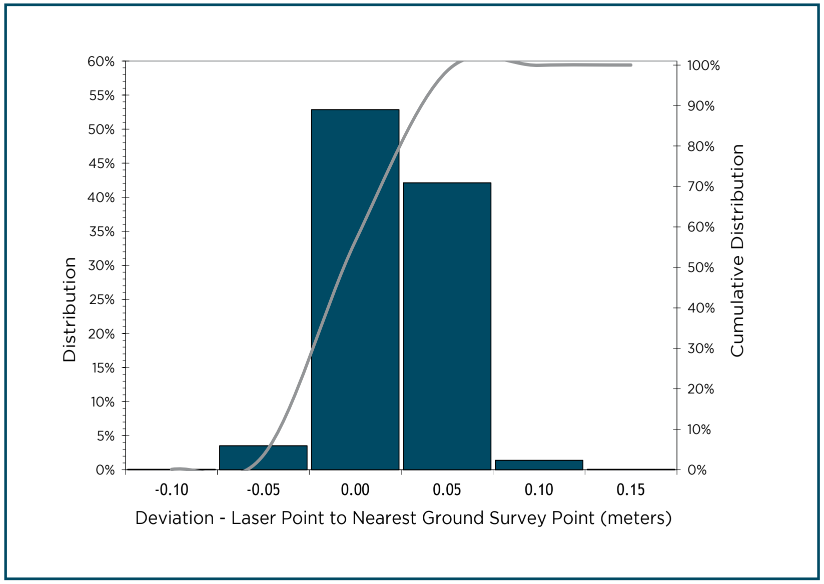
Vertical Accuracy

Vertical Accuracy reporting is designed to meet guidelines presented in the National Standard for Spatial Data Accuracy (NSSDA) (FGDC, 1998) and the ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data V1.0 (ASPRS, 2004). The statistical model compares known Ground Survey Points (GSPs) to the closest laser point. Vertical accuracy statistical analysis uses ground check points in open areas where the LiDAR system has a "very high probability" that the sensor will measure the ground surface and is evaluated at the 95th percentile.

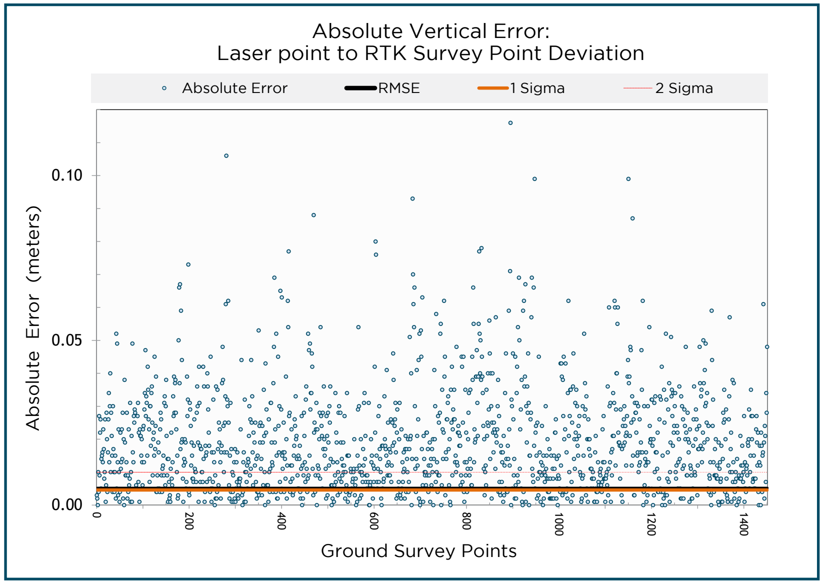
For the Colville study area, 1,451 GSPs were collected.

For this project, no independent survey data were collected, nor were reserved points collected for testing. As such, vertical accuracy statistics are reported as "Compiled to Meet." Vertical Accuracy is reported for the entire study area and reported in the table below. Histogram and absolute deviation statistics are displayed to the right.

Vertical Accuracy Distribution



Absolute Vertical Error



Vertical Accuracy Results	
Sample Size (n)	1,451 GSPs
FVA (RMSE*1.96)	0.05 m (0.16 ft)
Root Mean Square Error	0.02 m (0.08 ft)
1 Standard Deviation	0.02 m (0.08 ft)
2 Standard Deviations	0.05 m (0.16 ft)
Average Deviation	0.02 m (0.06 ft)
Minimum Deviation	-0.11 m (-0.35 ft)
Maximum Deviation	0.12 m (0.38 ft)

Density

Pulse Density

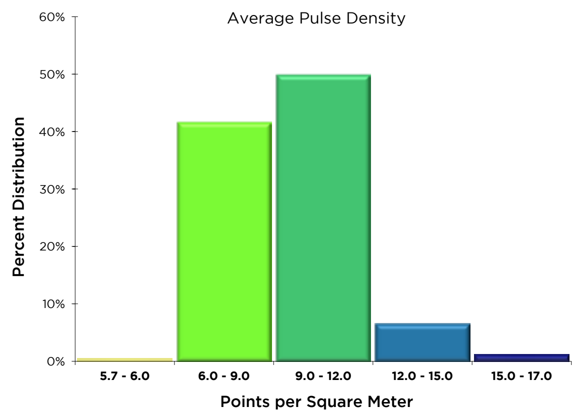
Some types of surfaces (e.g., dense vegetation, water) may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and vary according to terrain, land cover, and water bodies. Density histograms and maps have been calculated based on first return laser pulse density and ground-classified laser point density.

Average Point Densities			
Pulses per square foot	Pulses per square meter	Ground points per square foot	Ground points per square meter
0.92	9.90	0.08	0.91

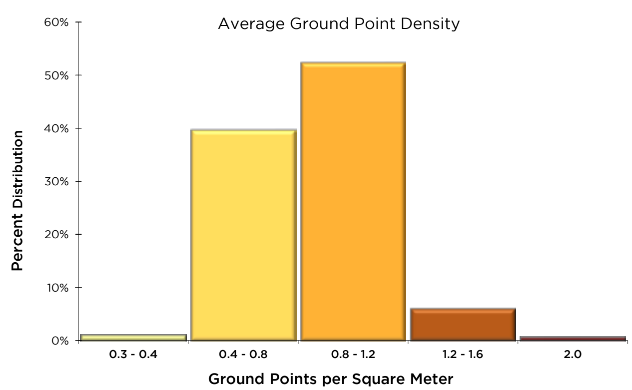
Ground Density

Ground classifications were derived from ground surface modeling. Further classifications were performed by reseeding of the ground model where it was determined that the ground model failed, usually under dense vegetation and/or at breaks in terrain, steep slopes, and at tile boundaries.

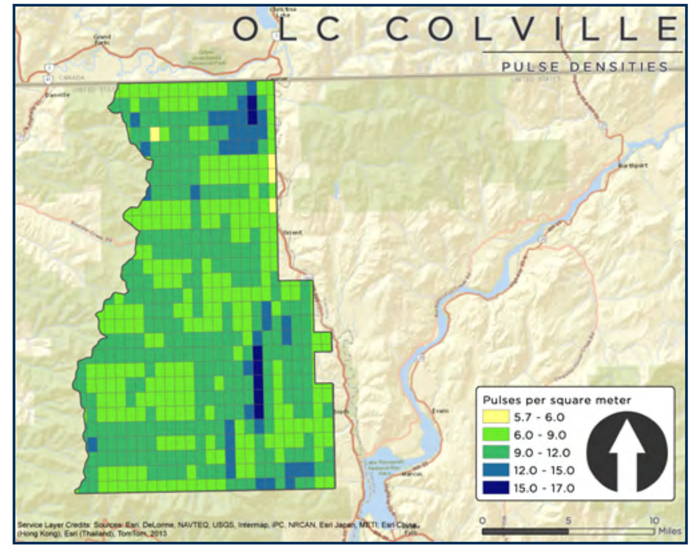
Pulse Density Distribution



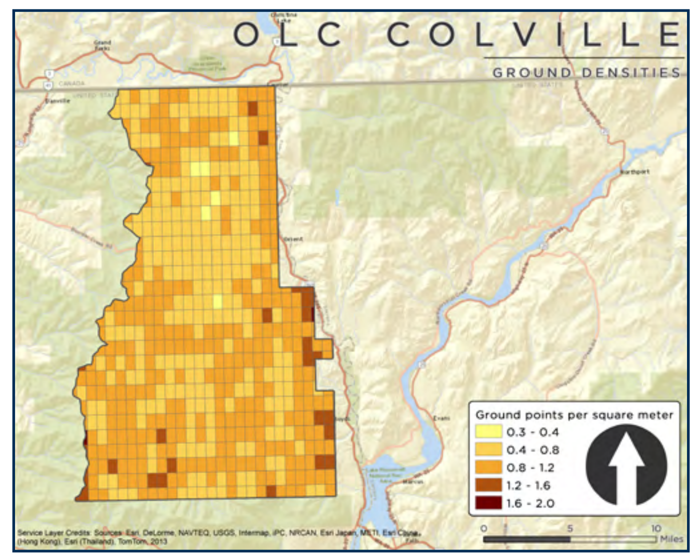
Ground Density Distribution



Average Pulse Density per 0.75' USGS Quad
(color scheme aligns with density chart)



Average Ground Point Density per 0.75' USGS Quad
(color scheme aligns with density chart)



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WSI, a Quantum Spatial company, provided LiDAR Services for OLC Colville LiDAR project as described in this report.

I, John English, have reviewed the attached report for completeness and herby state that it is a complete and accurate report of this project.

3/13/2015

John English
Project Manager
WSI, a Quantum Spatial Company

I, Christopher Glantz, being duly registered as a Professional Land Surveyor in the state of Washington, say that I hereby certify the methodologies and results of the attached LiDAR project, and that Static GNSS occupations on the Base Stations during airborne flights and RTK survey on hard-surface and GSP's were performed using commonly accepted Standard Practices. Field work conducted for this report was conducted between August 3, 2014 and August 29, 2014. Accuracy statistics shown in the Accuracy Section of this Report have been review by me and found to meet the "National Standard for Spatial Data Accuracy".

3/13/2015

Christopher Glantz, PLS
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