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Olympic Peninsula LiDAR

Technical Data Report

WOOLPERT
DESIGN | GEOSPATIAL | INFRASTRUCTURE

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Cover Photo: A view looking at an oxbow in Bogachiel River. The gridded, bare earth model is colored by elevation and overlaid by the vegetation LiDAR point cloud colored by intensity

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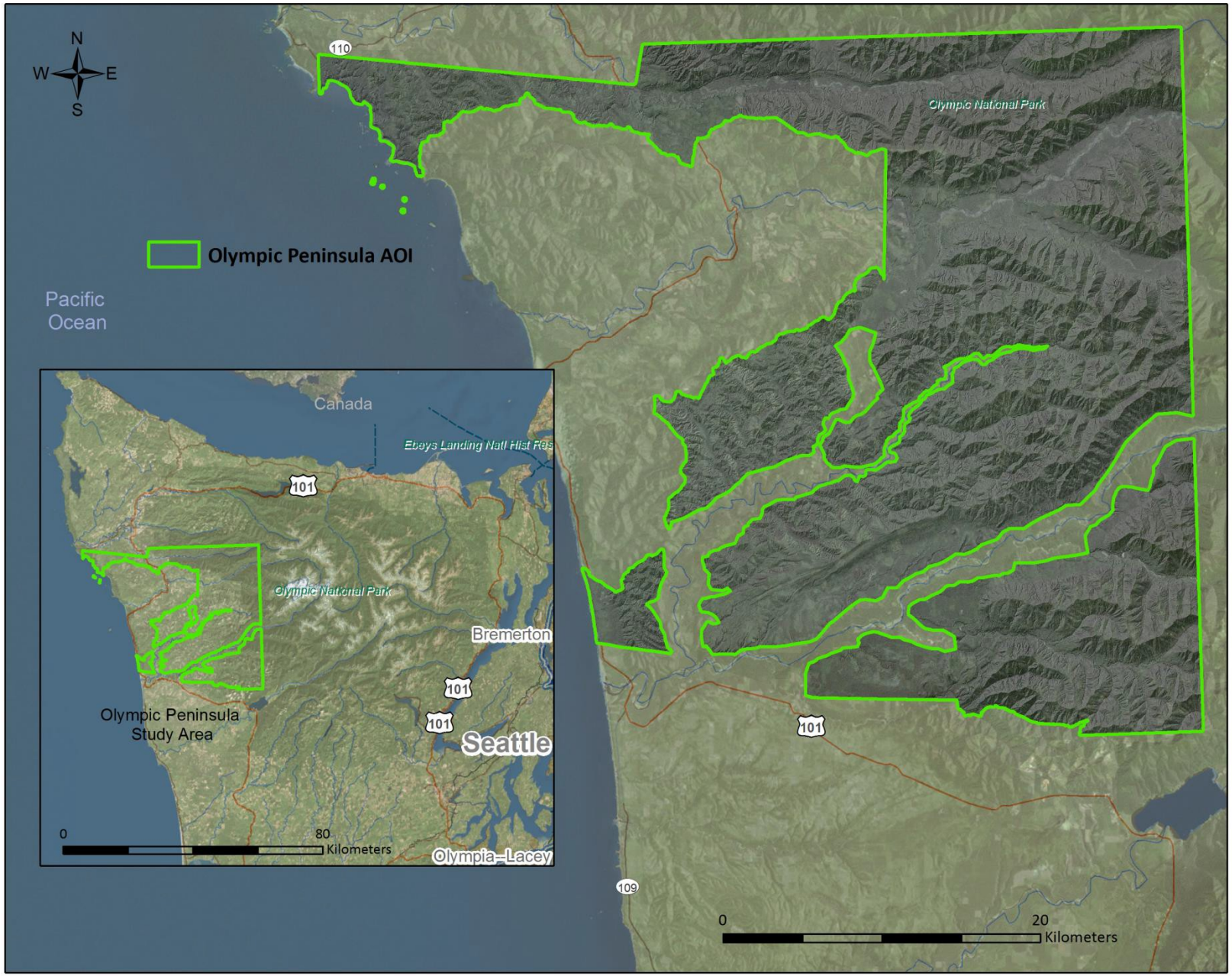

Figure 1: Location map of the Olympic Peninsula site in Washington

Ground Survey

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

Existing NGS Monument

Monumentation

The spatial configuration of ground survey monuments provided redundant control within 13 nautical miles of the mission areas for LiDAR flights. Monuments were also used for collection of ground survey points using real time kinematic (RTK) survey techniques.

QSI-Established Monument

Monument locations were selected with consideration for satellite visibility, field crew safety, and optimal location for GSP coverage. QSI utilized five existing monuments and established ten new monuments for the Olympic Peninsula LiDAR project (Table 4, Table 5, Figure 2). New monumentation was set using 5/8" x 30" rebar topped with stamped 2" aluminum caps. QSI's professional land surveyor, Chris Brown (WAPLS#46328LS) oversaw and certified the establishment of all monuments.

To correct the continuously recorded onboard measurements of the aircraft position, QSI concurrently conducted multiple static Global Navigation Satellite 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[1]) for precise positioning. Multiple independent sessions over the same monument were processed to confirm antenna height measurements and to refine position accuracy.

[1] OPUS is a free service provided by the National Geodetic Survey to process corrected monument positions. http://www.ngs.noaa.gov/OPUS.

Table 4: Monuments established for the Olympic Peninsula acquisition. Coordinates are on the NAD83 (2011) datum, epoch 2010.00.

Monument ID	Latitude	Longitude	Ellipsoid (meters)
HOH_02	47° 45' 50.77725"	-124° 06' 40.55543"	211.134
HOH_05_RESET	47° 50' 58.32165"	-124° 17' 06.70065"	161.800
HOH_06	47° 48' 29.88898"	-123° 59' 30.04899"	194.881
OLYMPIC_02	47° 36' 16.63611"	-124° 07' 53.59317"	97.573
OLYMPIC_03	47° 36' 35.23073"	-124° 06' 29.22167"	119.057
OLYMPIC_04	47° 27' 32.31022"	-123° 54' 34.44647"	77.010
OLYMPIC_05	47° 34' 11.31169"	-124° 20' 13.74136"	96.633
OLYMPIC_06	47° 36' 50.24028"	-124° 15' 40.93355"	157.734
OLYMPIC_07	47° 56' 12.54053"	-124° 33' 40.92884"	32.736
OLYMPIC_08	47° 52' 54.70111"	-124° 28' 23.01269"	150.492
OLYMPIC_09	47° 51' 32.42677"	-124° 20' 44.50812"	206.190
OLYMPIC_10	47° 41' 22.68978"	-124° 09' 02.32720"	256.697
QUIN_02	47° 38' 09.76938"	-124° 15' 29.37893"	58.535
QUIN_09	47° 31' 13.25781"	-123° 55' 21.49634"	747.380
SD0880	47° 56' 12.19144"	-124° 23' 44.16522"	65.302

Table 5: Monuments established for the Olympic Peninsula acquisition. Coordinates are on the NAD83 (HARN) datum.

Monument ID	Latitude	Longitude	Ellipsoid (meters)
HOH_02	47° 45' 50.77437"	-124° 06' 40.56044"	211.146
HOH_05_RESET	47° 50' 58.31853"	-124° 17' 06.70593"	161.812
HOH_06	47° 48' 29.88640"	-123° 59' 30.05362"	194.893
OLYMPIC_02	47° 36' 16.63296"	-124° 07' 53.59856"	97.585
OLYMPIC_03	47° 36' 35.22765"	-124° 06' 29.22697"	119.069
OLYMPIC_04	47° 27' 32.30751"	-123° 54' 34.45130"	77.022
OLYMPIC_05	47° 34' 11.30787"	-124° 20' 13.74757"	96.645
OLYMPIC_06	47° 36' 50.23678"	-124° 15' 40.93937"	157.746
OLYMPIC_07	47° 56' 12.53708"	-124° 33' 40.93452"	32.748
OLYMPIC_08	47° 52' 54.69768"	-124° 28' 23.01834"	150.504
OLYMPIC_09	47° 51' 32.42354"	-124° 20' 44.51353"	206.202
OLYMPIC_10	47° 41' 22.68671"	-124° 09' 02.33248"	256.709
QUIN_02	47° 38' 09.76593"	-124° 15' 29.38468"	58.547
QUIN_09	47° 31' 13.25510"	-123° 55' 21.50113"	747.392
SD0880	47° 56' 12.18828"	-124° 23' 44.17051"	65.314

Monuments were established according to the national standard for geodetic control networks, as specified in the Federal Geographic Data Committee (FGDC) Geospatial Positioning Accuracy Standards for geodetic networks.[2] This standard provides guidelines for classification of monument quality at the 95% confidence interval as a basis for comparing the quality of one control network to another. The monument rating for this project is shown in Table 6.

Table 6: Federal Geographic Data Committee monument rating for network accuracy

Direction	Rating
1.96 * St Dev $_{NE}$:	0.020 m
1.96 * St Dev $_{z}$:	0.020 m

For the Olympic Peninsula LiDAR project, the monument coordinates contributed no more than 2.8 cm of positional error to the geolocation of the final ground survey points and LiDAR, with 95% confidence.

Ground Survey Points (GSP)

Ground survey points (GSP) were collected using real time kinematic (RTK), and post-processed kinematic (PPK) survey techniques. A Trimble R7 base unit was positioned at a nearby monument to broadcast a kinematic correction to a roving Trimble R10 receiver. All GSP measurements were made during periods with a Position Dilution of Precision (PDOP) of ≤ 3.0 with at least six satellites in view of the stationary and roving receivers. When collecting RTK and PPK data, the rover records data while stationary for five seconds, then calculates the pseudorange position using at least three one-second epochs. Relative errors for the position must be less than 1.5 cm horizontal and 2.0 cm vertical in order to be accepted. See Table 7 for Trimble unit specifications.

GSP were collected in areas where good satellite visibility was achieved on paved roads and other hard surfaces such as gravel or packed dirt roads. GSP measurements were not taken on highly reflective surfaces such as center line stripes or lane markings on roads due to the increased noise seen in the laser returns over these surfaces. GSP were collected within as many flightlines as possible, however the distribution of GSP depended on ground access constraints and monument locations and may not be equitably distributed throughout the study area (Figure 2).

Table 7: Trimble equipment identification

Receiver Model	Antenna	OPUS Antenna ID	Use
Trimble R7 GNSS	Zephyr GNSS Geodetic Model 2	TRM57971.00	Static

[2] Federal Geographic Data Committee, Geospatial Positioning Accuracy Standards (FGDC-STD-007.2-1998). Part 2: Standards for Geodetic Networks, Table 2.1, page 2-3. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part2/chapter2

Receiver Model	Antenna	OPUS Antenna ID	Use
Trimble R10	Integrated Antenna R10	TRMR10	Rover

Land Cover Classes

Land cover class check points were collected throughout the study area. Individual accuracies were calculated for each land cover type to assess confidence in the LiDAR derived ground models across land cover classes. Land cover types and descriptions are shown in Table 8.

Table 8: Land cover descriptions of check points taken for the Olympic Peninsula site

Land cover type	Land cover code	Example	Description
Bare Earth/Open Terrain	BARE, QUARRY		Bare ground, gravel, or quarry sites
Urban	PARK, URBAN, REC	*Picture Unavailable*	Urban developed areas, or parks and recreational sites
Tall Weeds and Crops	TALL_GRASS, SH_GRASS		Grasses or herbaceous ground cover
Brushlands	SHRUB, CLEARCUT		Clear cut areas or herbaceous shrubland
Forested and Fully Grown	DEC_FOR, EVERGREEN_1, MX_FOREST		Deciduous, evergreen, or mixed mature forest

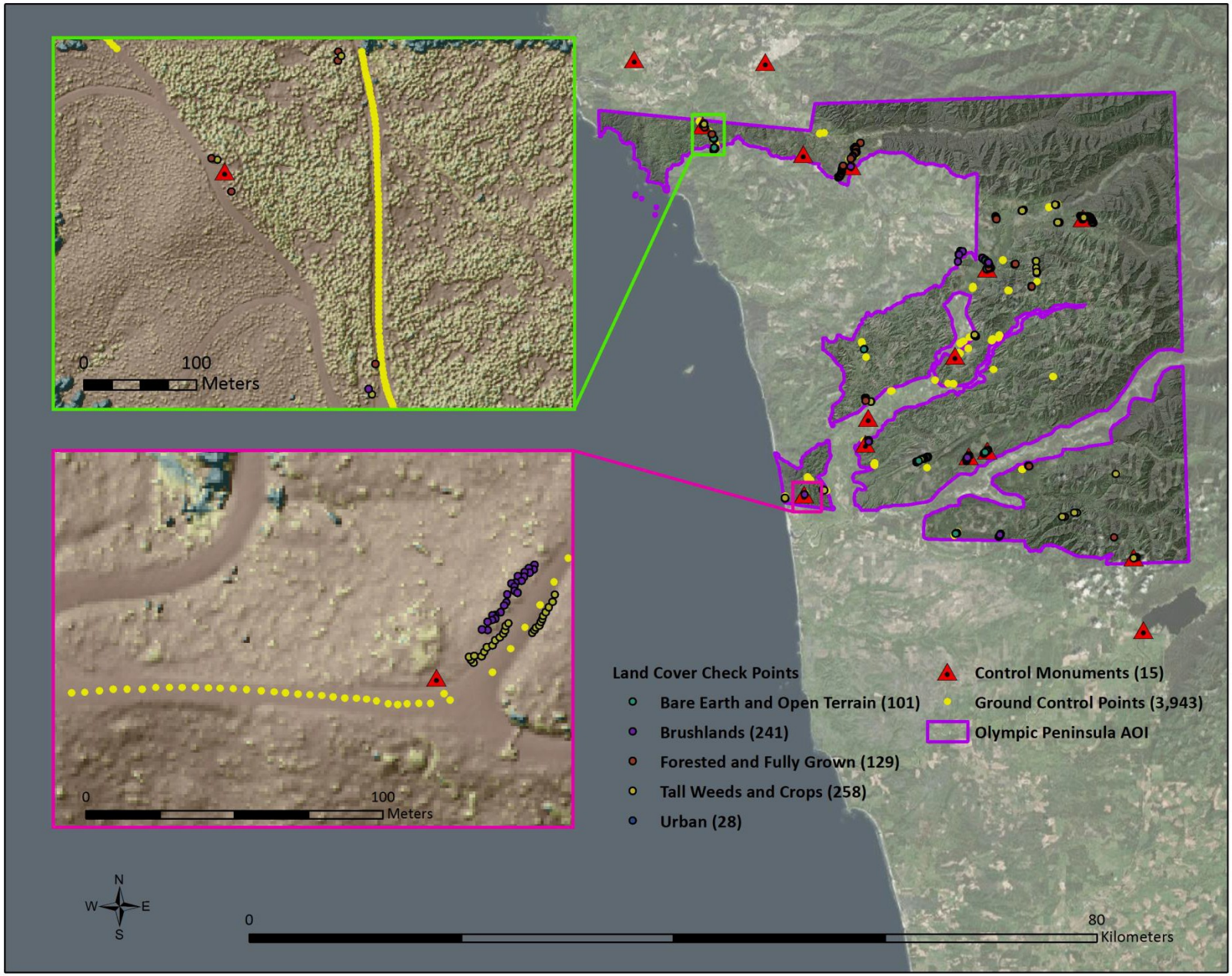

Figure 2: Ground control location map

CERTIFICATIONS

Watershed Sciences provided LiDAR services for the Olympic Peninsula LiDAR project as described in this report.

I, Kris Fausti, have reviewed the attached report for completeness and hereby state that it is a complete and accurate report of this project.

Kris Fausti, PMP
Operations Manager
WSI, a Quantum Spatial Company

I, Christopher W. Brown, being duly registered as a Professional Land Surveyor in and by the state of Washington, say that I hereby certify the methodologies, LiDAR project, Static GNSS occupations on the Base Stations used during airborne flights and RTK survey on hard surface and land classification, were performed using commonly accepted Standard Practices. Field work conducted for this report was conducted between October 13, 2013 and January 25, 2014.

Accuracy statistics shown in the Accuracy Section of this Report have been reviewed by me and found to meet the "National Standard for Spatial Data Accuracy".

6/13/2014

Christopher W. Brown, PLS Oregon & Washington
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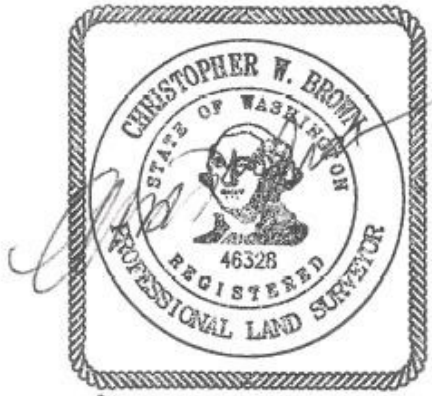
Portland, OR 97204



Renews: 12/21/14