

**LIDAR REMOTE SENSING DATA COLLECTION
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
OREGON NORTH COAST**

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LIDAR REMOTE SENSING DATA COLLECTION:

DOGAMI, OREGON NORTH COAST STUDY AREA

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1. Overview

1.1 Study Area (Oregon North Coast)

Watershed Sciences, Inc. has collected Light Detection and Ranging (LiDAR) data of the Oregon North Coast Study Area for the Oregon Department of Geology and Mineral Industries (DOGAMI). The complete area of interest (AOI) totals 1,553 square miles (994,440 acres) and the total area to fly (TAF) covers 1,597 square miles (1,022,401 acres). The TAF acreage is greater than the original AOI acreage due to buffering and flight planning optimization (**Figure 1.1** below). DOGAMI data are *delivered* in OGIC(HARN): Projection: Oregon Statewide Lambert Conformal Conic; horizontal and vertical datums: NAD83 (HARN)/NAVD88(Geoid03); Units: International Feet.

Figure 1.1. DOGAMI Oregon North Coast Study Area.



1.2 Area Delivered to Date

Total delivered acreage to date is detailed below.

DOGAMI Oregon North Coast Study Area				
	Delivery Date	Acquisition Date	AOI Acres	TAF Acres
Delivery Area 1	August 21, 2009	Apr. 5, 2009 - May 10, 2009	96,383	97,176
Delivery Area 2	September 4, 2009	Apr. 16, 2009 - Jun. 15, 2009	115,458	117,731
Delivery Area 3	September 18, 2009	Oct. 23, 2008 - Jun. 15, 2009	78,033	80,334
Delivery Area 4	October 2, 2009	Oct. 25, 2008 - Nov. 16, 2008	53,279	55,604
Delivery Area 5	October 29, 2009	Apr. 26, 2009 - June 28, 2009	74,477	77,127
Delivery Area 6	October 29, 2009	May 31, 2009 - June 23, 2009	101,056	103,406
Delivery Area 7	November 17, 2009	May 31, 2009 - Jun. 28, 2009	99,438	101,785
Delivery Area 8	November 17, 2009	May 20, 2009 - Jun. 16, 2009	71,734	73,877
Delivery Area 9	December 4, 2009	Apr. 21, 2009 - Jul. 16, 2009	101,033	104,190
Delivery Area 10	December 18, 2009	Jul. 10, 2009 - Jul. 19, 2009	133,920	137,467
Delivery Area 11	December 18, 2009	July 14, 2009 - Aug. 9, 2009	69,629	73,704
Total Acres			994,440	1,022,401

**Delivery areas 7 and 8 adjoin Willamette Valley Phase 1 area 14 (see image below). All stats for Willamette Valley Phase 1 area 14 are included in the north coast data report.*

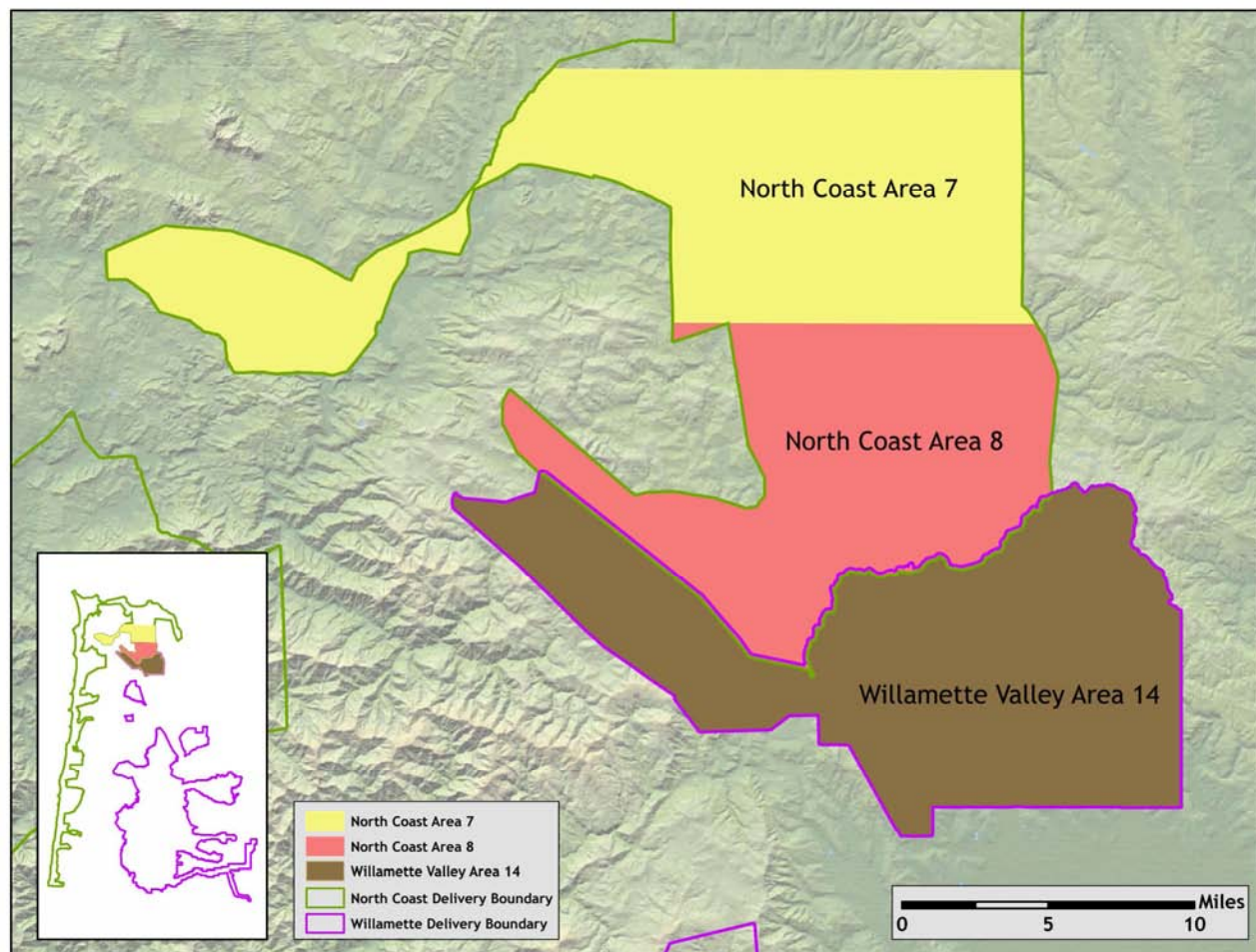


Figure 1.2. Oregon North Coast Study Area, illustrating the entire portion of the TAF.

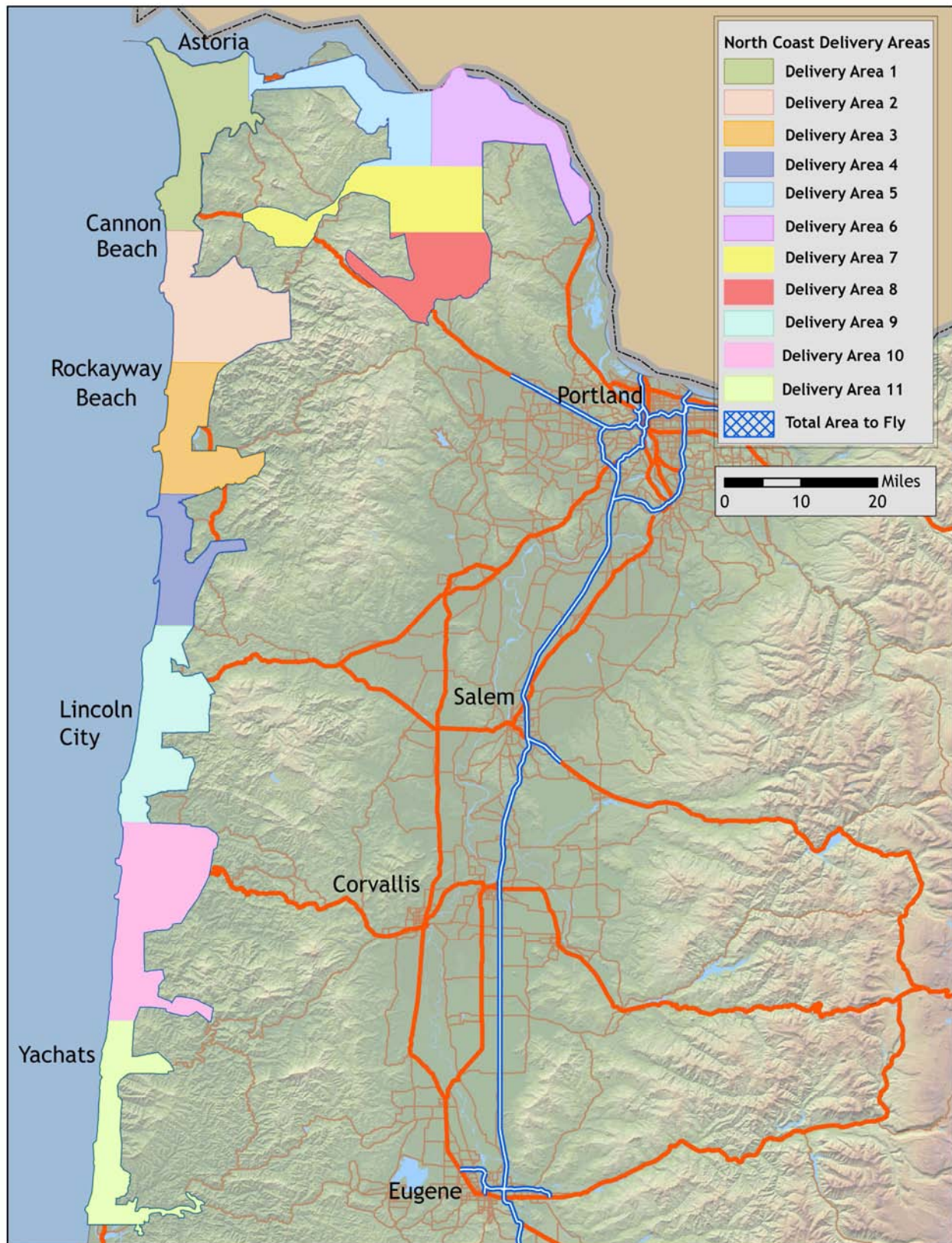
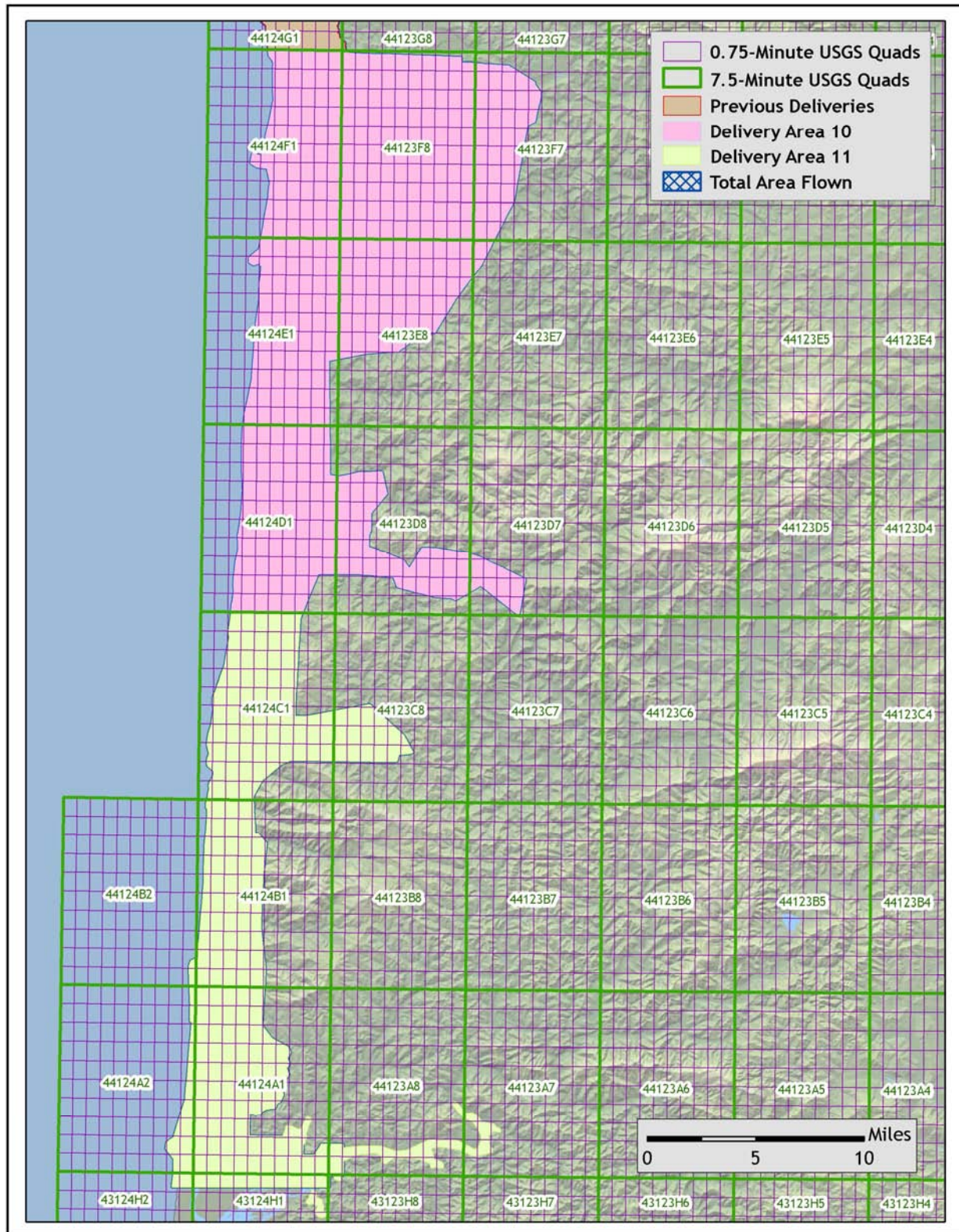


Figure 1.3. Oregon North Coast Study Area, illustrating the delivered 0.75 and 7.5 minute USGS quads.



1.3 Acquisition and Ground Survey

LiDAR acquisition for delivery areas 1 through 11 occurred from October 23, 2008 through August 9, 2009 for the Oregon North Coast Study Area.

Figure 1.4. Actual flightlines for the Oregon North Coast Study Area illustrating the dates flown (based on GPS week, $n = 1770$).

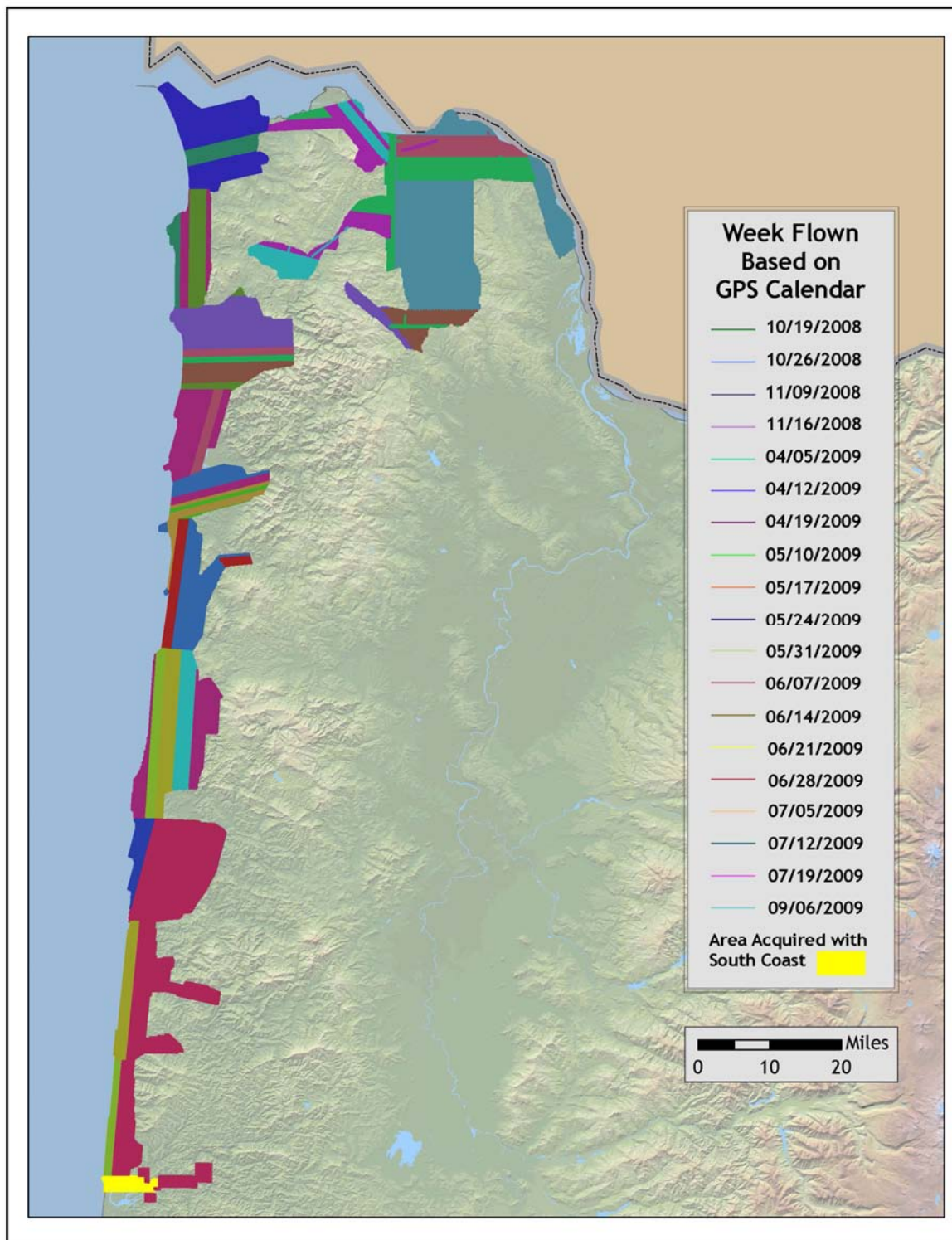


Figure 1.5. Base stations for the Oregon North Coast Study Area.

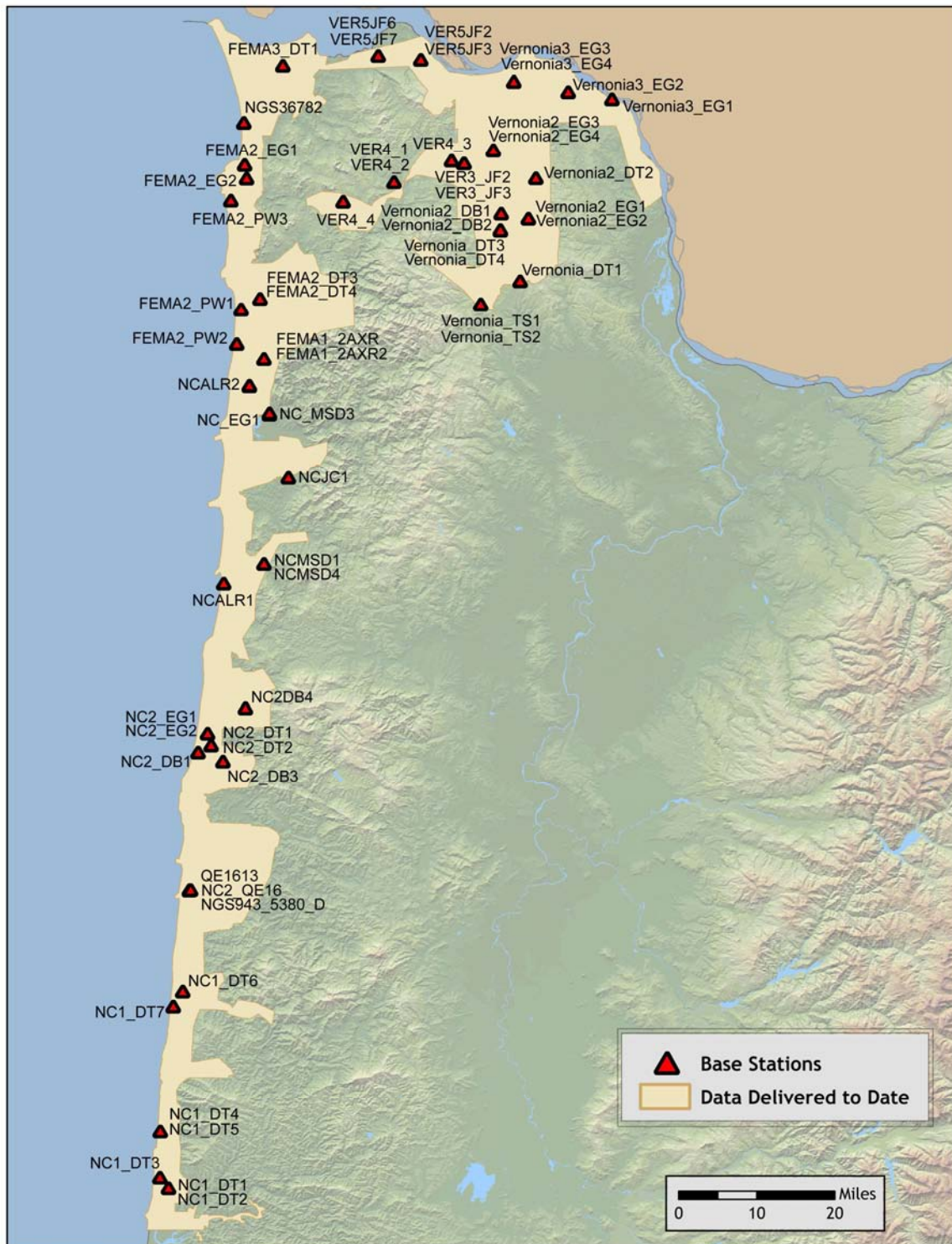


Table 1.1. Base Station Surveyed Coordinates, (NAD83/NAVD88, OPUS corrected) used for kinematic post-processing of the aircraft GPS data for the Oregon North Coast Study Area.

Base Stations ID	Datum NAD83 (HARN)		GRS80
	Latitude (North)	Longitude (West)	Ellipsoid Height (m)
FEMA1_2AXR	45 36 33.78932	123 52 06.78765	2.817
FEMA1_2AXR2	45 36 33.72568	123 52 06.89677	2.594
FEMA2_DT3	45 43 17.64550	123 52 49.87197	-20.064
FEMA2_DT4	45 43 17.56643	123 52 49.93792	-20.082
FEMA2_EG1	45 58 10.08067	123 55 31.64065	-16.968
FEMA2_EG2	45 56 36.95271	123 55 12.49635	-9.967
FEMA2_PW1	45 42 05.48306	123 55 50.56503	-13.774
FEMA2_PW2	45 38 11.22812	123 56 27.52835	-15.968
FEMA2_PW3	45 54 09.83331	123 57 37.87951	-19.263
FEMA3_DT1	46 09 14.05280	123 49 35.34525	-21.44
NC_EG1	45 30 25.51114	123 51 07.23801	-14.2525
NC_MSD3	45 30 34.04375	123 51 08.48898	-10.965
NC2_DB1	44 52 42.54178	124 01 44.86638	-7.1345
NC2_DB3	44 51 43.38710	123 57 51.14830	-6.981
NC2_DT1	44 53 31.03163	123 59 41.70682	-19.145
NC2_DT2	44 53 31.15941	123 59 41.83700	-19.135
NC2_EG1	44 54 50.63644	124 00 17.18346	-18.2165
NC2_EG2	44 54 50.76157	124 00 17.23799	-18.252
NC2DB4	44 57 41.05711	123 54 25.27841	224.812
NCALR1	45 11 32.67738	123 58 3.02370	-16
NCALR2	45 33 34.06040	123 54 20.71671	-17.509
NCJC1	45 23 22.82613	123 48 02.33580	8.7495
NCMSD1	45 13 49.73742	123 51 43.52409	-5.427
NCMSD3	45 30 34.04371	123 51 08.48879	-10.9575
NCMSD4	45 13 49.70222	123 51 43.52997	-5.4395
NGS36782	46 02 52.93571	123 55 41.56993	-11.811
VER3_JF2	45 58 31.94132	123 20 34.59815	135.2715
VER3_JF3	45 58 32.31860	123 20 29.88209	135.343
VER4_1	45 56 22.99520	123 31 41.07982	151.278
VER4_2	45 56 22.97292	123 31 40.86257	151.4395
VER4_3	45 58 51.44944	123 22 30.80297	132.833
VER4_4	45 54 8.35447	123 39 45.43236	271.765
VER5JF2	46 10 0.64009	123 27 29.44865	163.381
VER5JF3	46 10 0.51689	123 27 29.46335	163.374

(Table 1.1 continued on next page)

(Table 1.1 continued from previous page)

Base Stations ID	Datum NAD83 (HARN)		GRS80
	Latitude (North)	Longitude (West)	Ellipsoid Height (m)
VER5JF6	46 10 24.26607	123 34 19.04442	5.537
VER5JF7	46 10 24.11271	123 34 19.00799	5.687
Vernonia_DT1	45 45 27.55697	123 11 31.15795	270.445
Vernonia_DT3	45 51 05.65003	123 14 40.66124	175.1645
Vernonia_DT4	45 51 05.62455	123 14 40.56072	175.1145
Vernonia_TS1	45 42 51.50971	123 17 43.86203	323.289
Vernonia_TS2	45 42 51.45486	123 17 43.77242	323.323
Vernonia2_DB1	45 52 55.58074	123 14 32.84830	208.719
Vernonia2_DB2	45 52 55.43503	123 14 32.89682	208.412
Vernonia2_DT2	45 56 54.63107	123 09 00.29551	166.529
Vernonia2_EG1	45 52 22.73780	123 10 14.49055	161.622
Vernonia2_EG2	45 52 22.82932	123 10 14.45386	161.701
Vernonia2_EG3	46 00 01.14445	123 15 51.95965	141.368
Vernonia2_EG4	46 00 01.06873	123 15 51.70366	141.459
Vernonia3_EG1	46 05 43.49038	122 56 53.24971	-13.099
Vernonia3_EG2	46 06 29.45960	123 03 51.93937	162.24
Vernonia3_EG3	46 07 37.83672	123 12 34.92158	-16.2765

For the North Coast Study Area, including Willamette Valley Phase 1 area 14, 23,935 RTK points were collected in the study area. Figures 1.6 – 1.13 show a detailed view of selected RTK locations.

Figure 1.6. RTK point locations in the study area for delivery area 1; images are NAIP orthoimages.

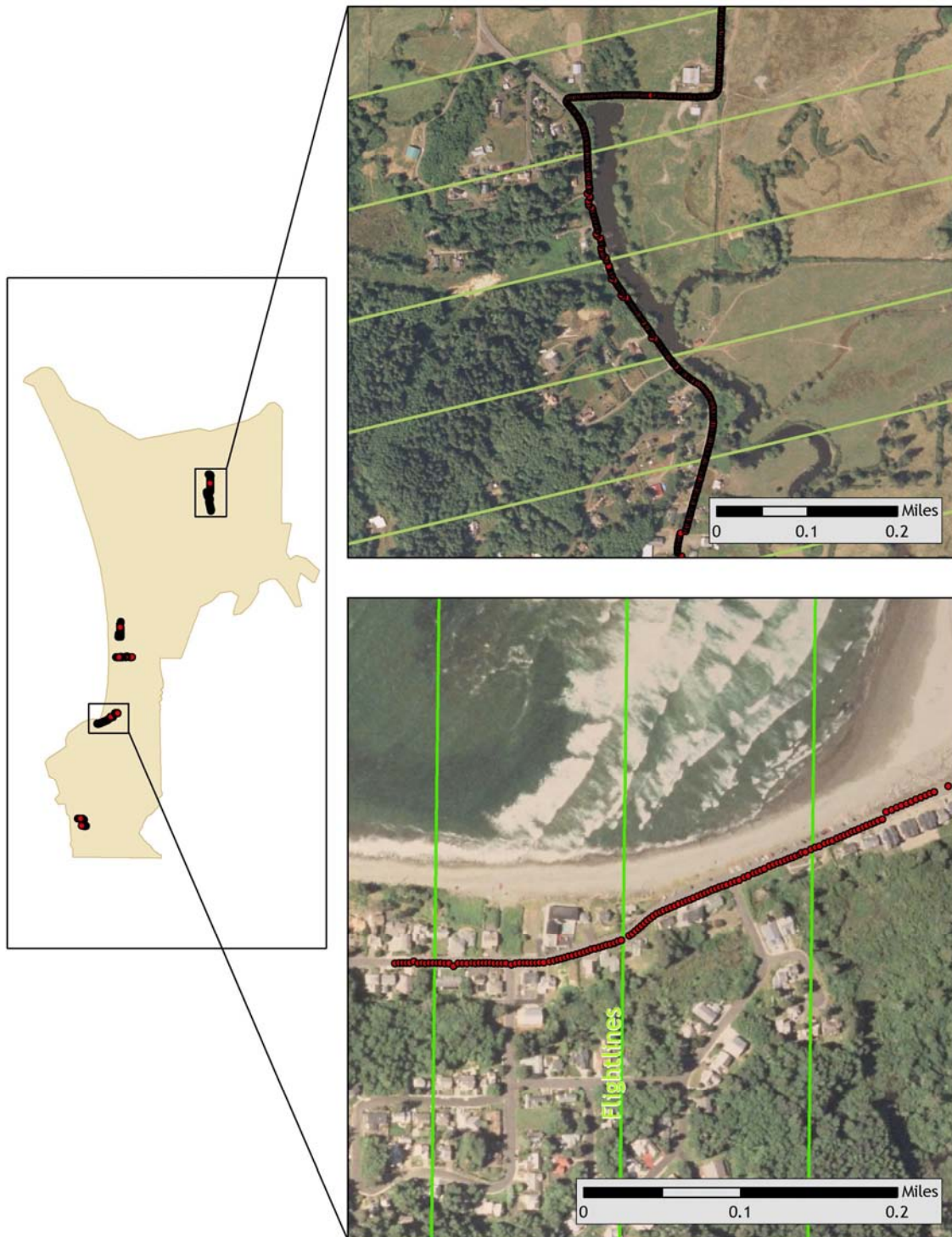


Figure 1.7. RTK point locations in the study area for delivery area 2; images are NAIP orthoimages.



Figure 1.8. RTK point locations in the study area for delivery area 3; images are NAIP orthoimages.

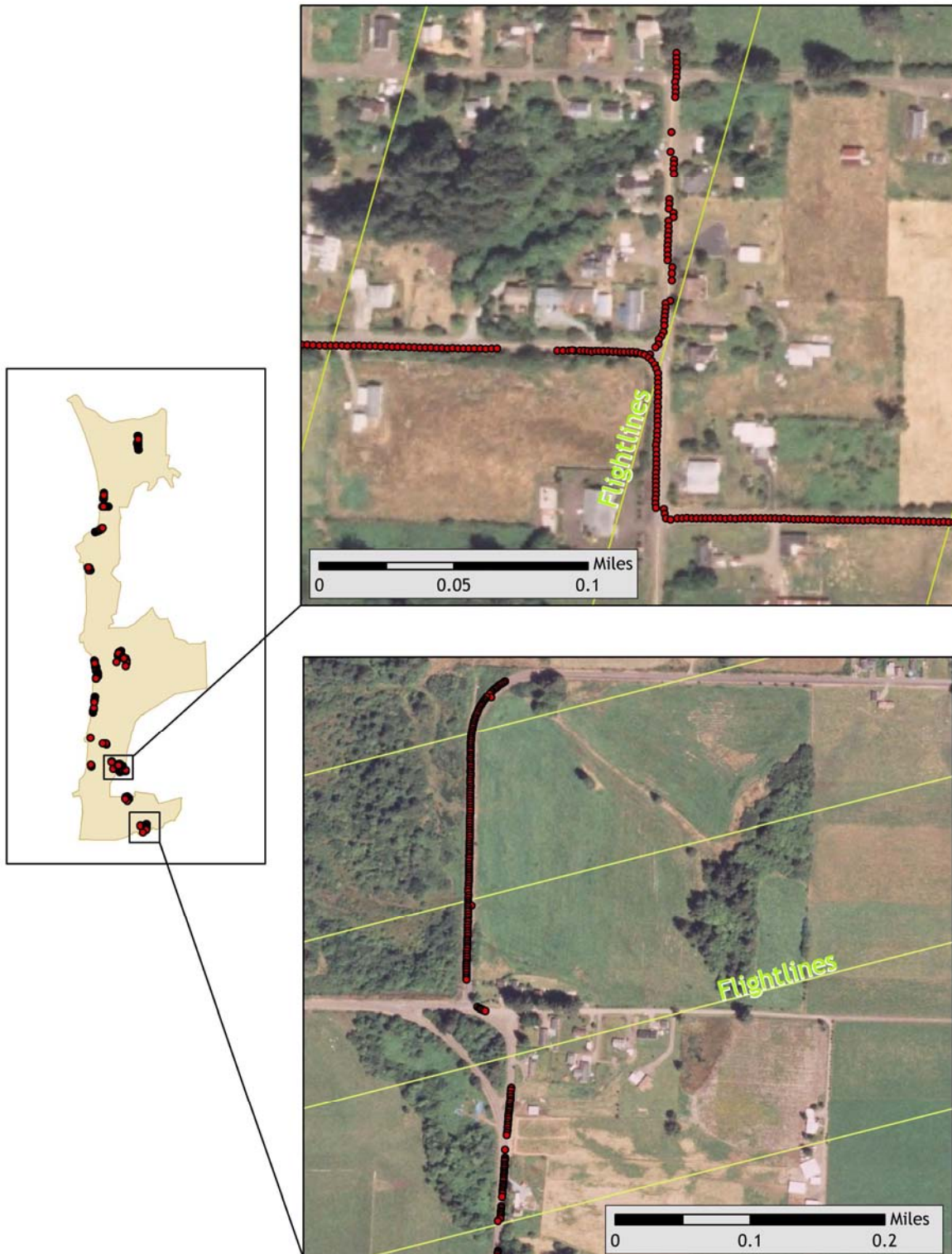


Figure 1.9. RTK point locations in the study area for delivery area 4; images are NAIP orthoimages.

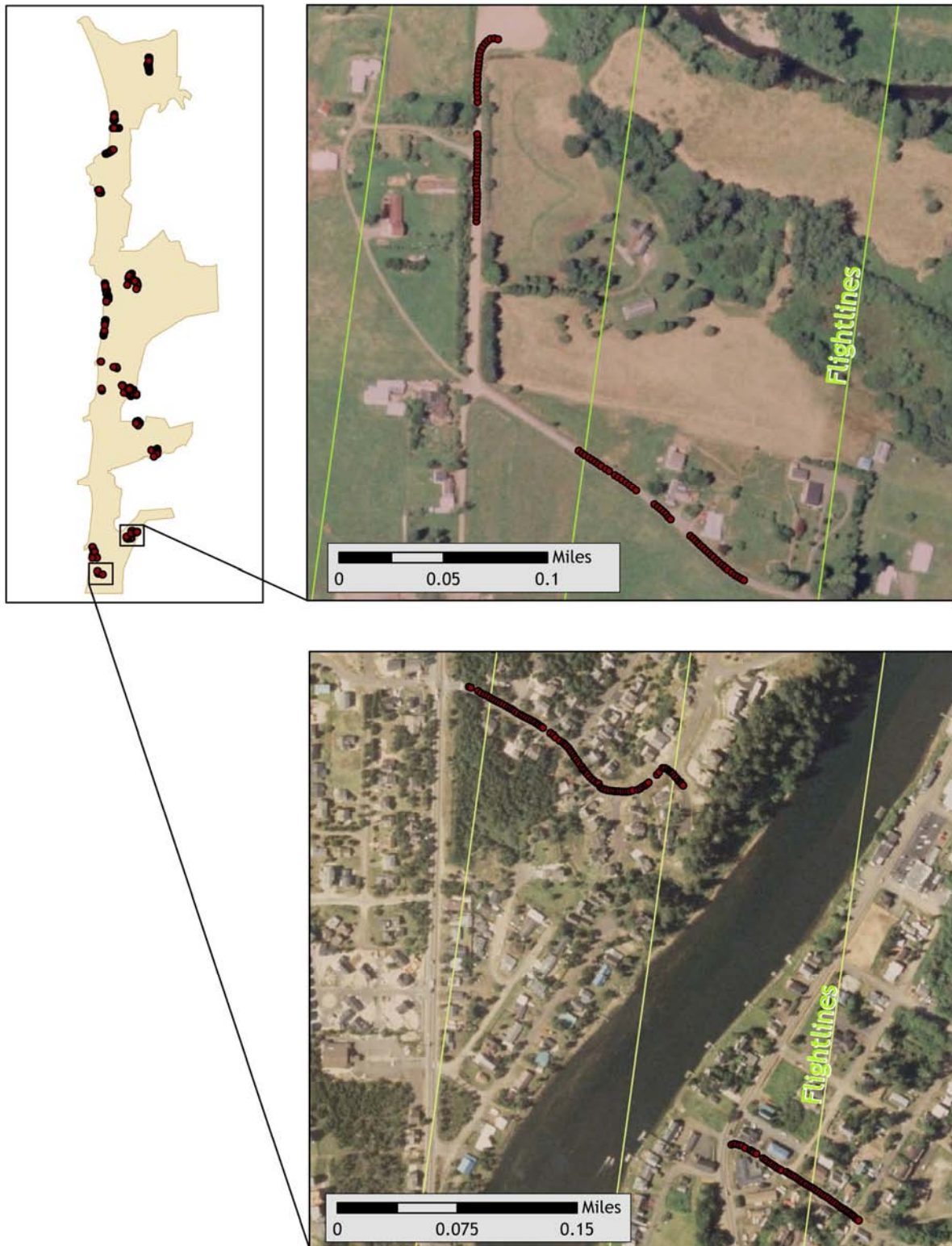


Figure 1.10. RTK point locations in the study area for delivery areas 5 and 6; images are NAIP orthoimages.

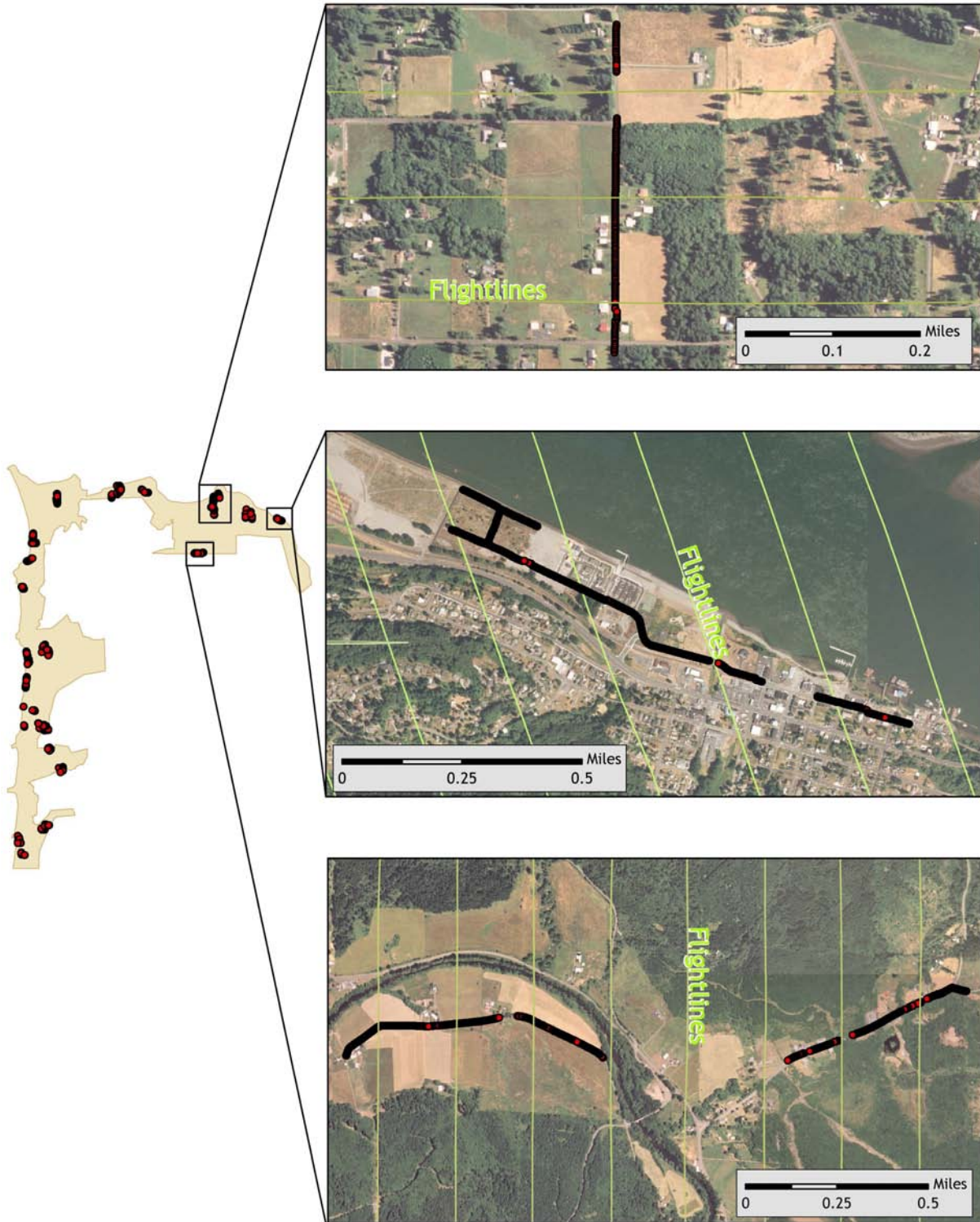


Figure 1.11. RTK point locations in the study area for delivery areas 7 and 8 and Willamette Valley Phase 1 area14; images are NAIP orthoimages.

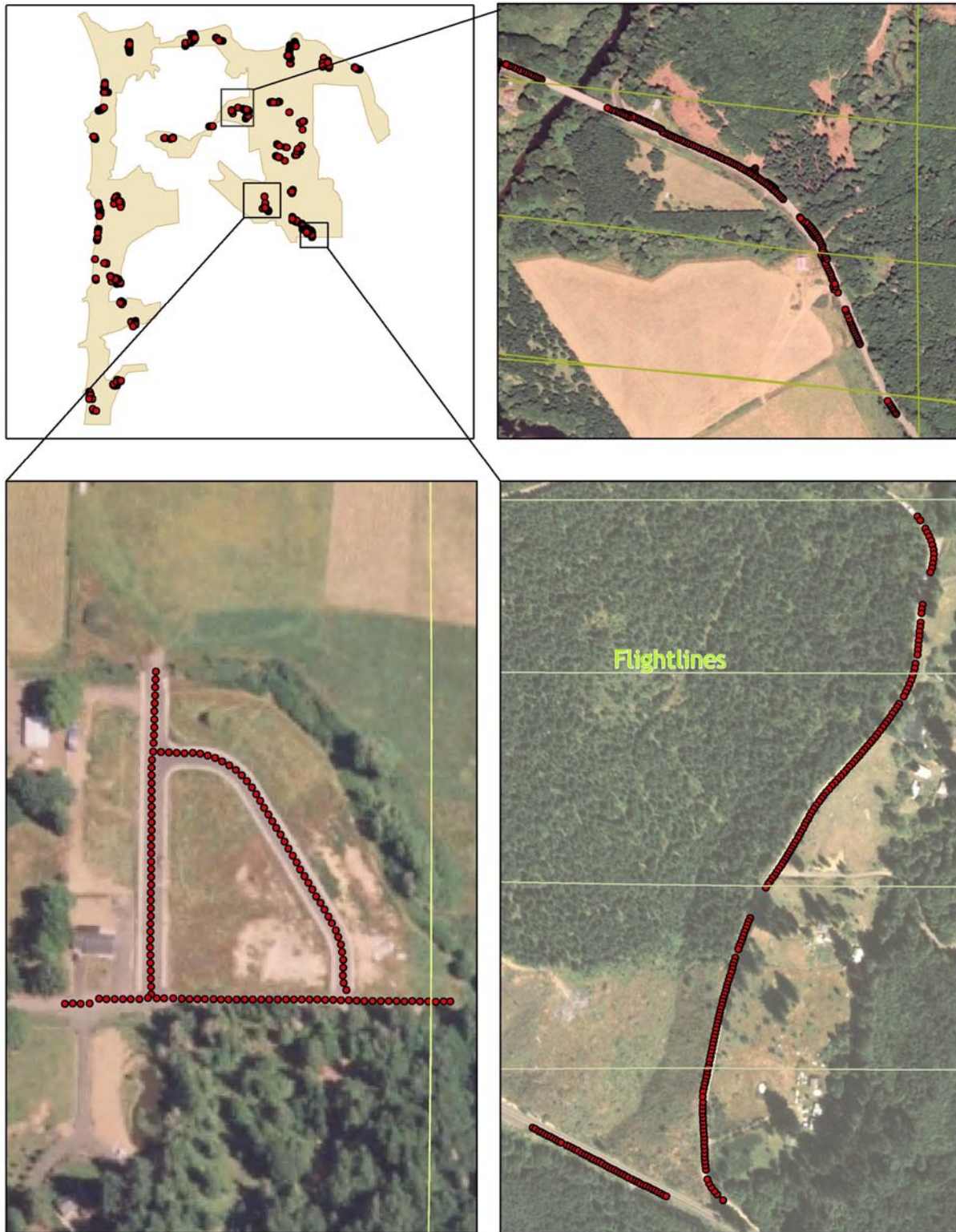


Figure 1.12. RTK point locations in the study area for delivery area 9; images are NAIP orthoimages.

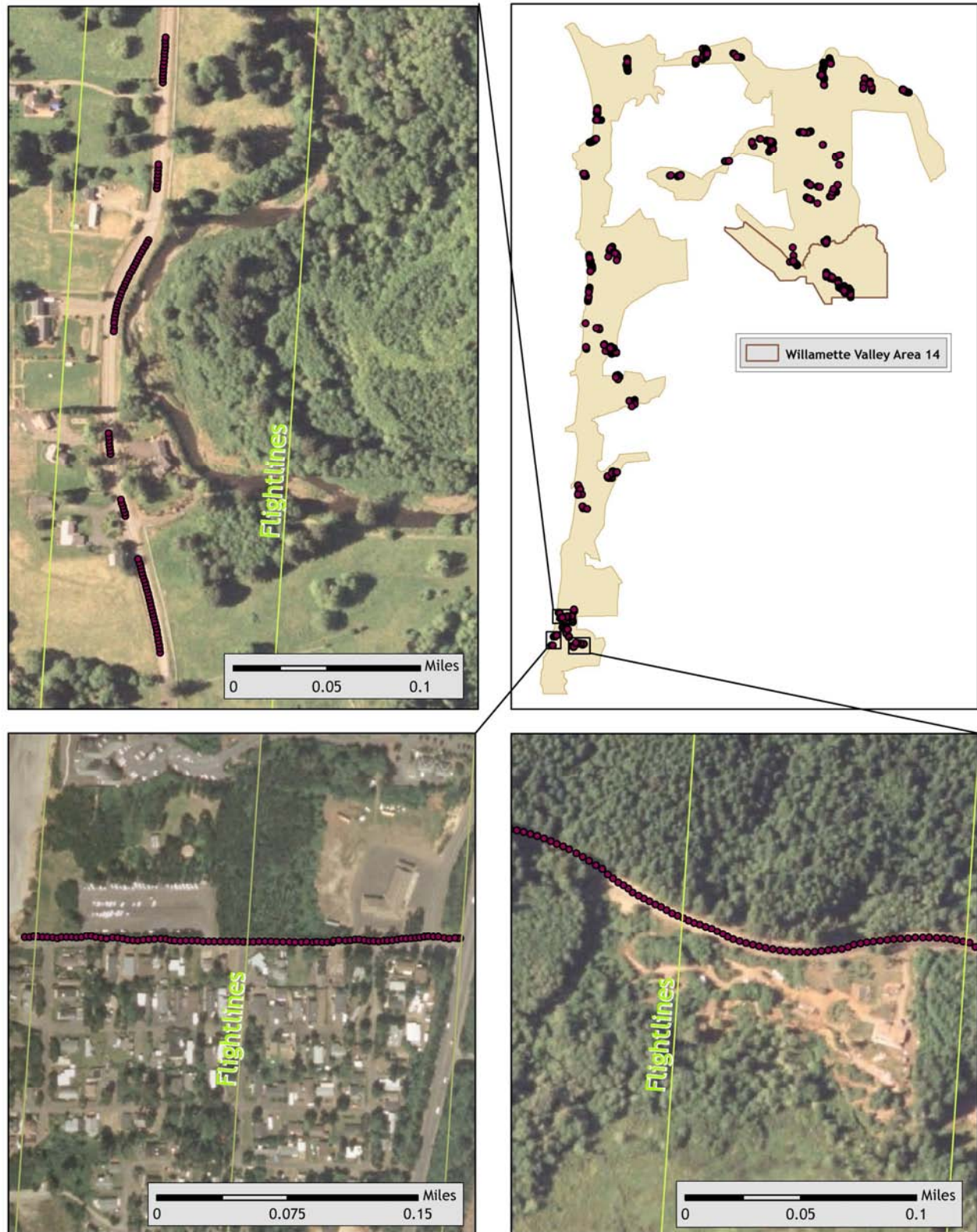
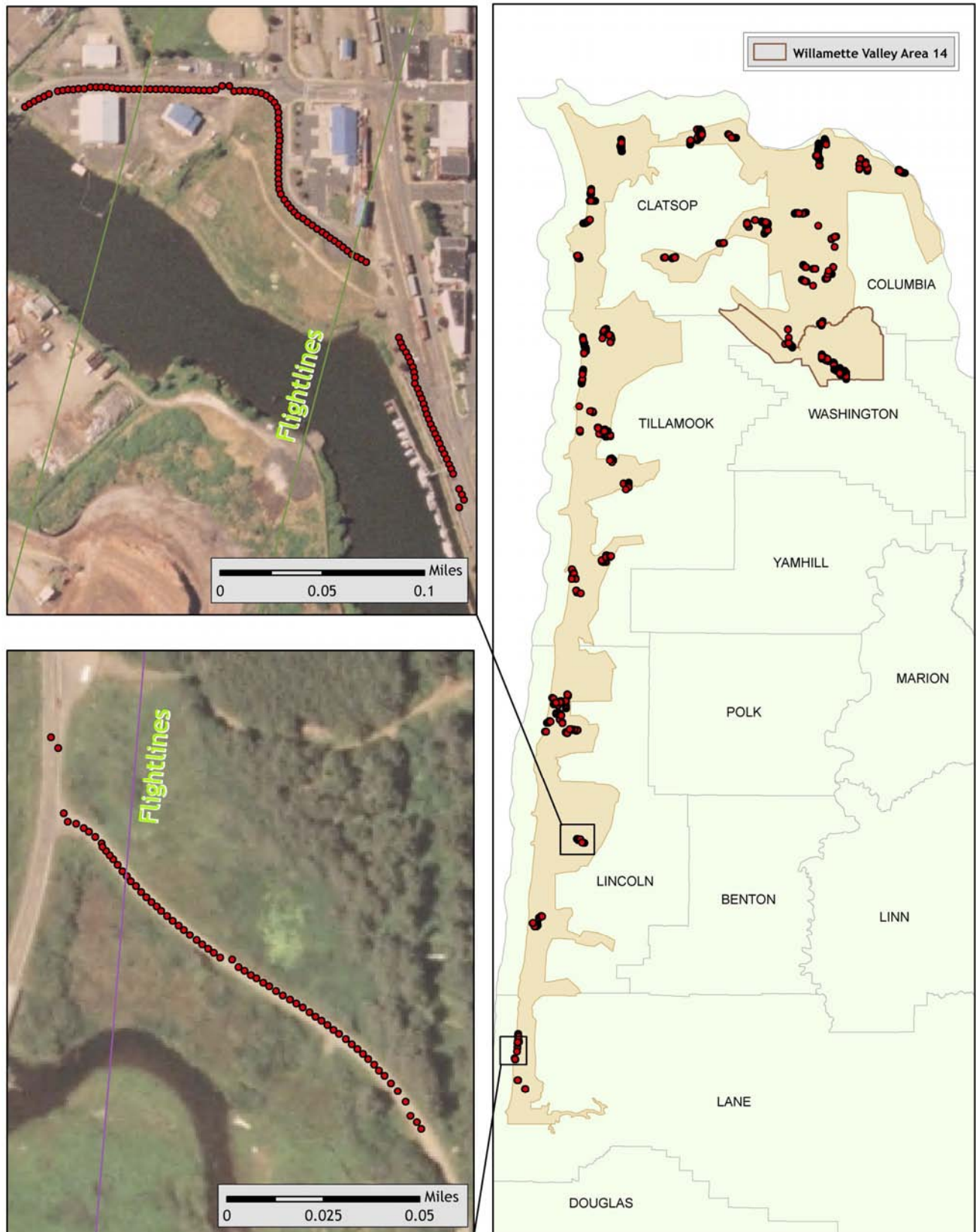


Figure 1.13. RTK point locations in the study area for delivery areas 10 and 11; images are NAIP orthoimages.



2. Accuracy

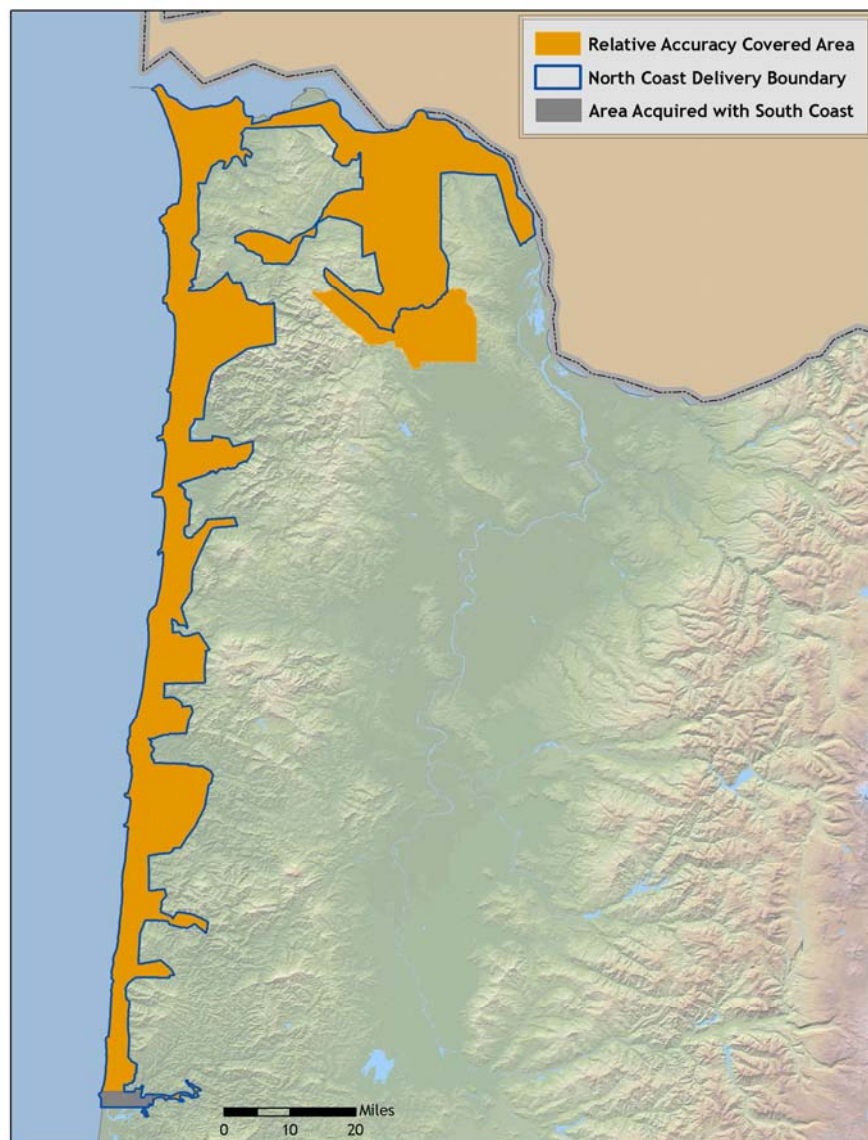
2.1 Relative Accuracy

Relative Accuracy Calibration Results

Relative accuracy statistics are based on the comparison of 1770 flightlines and over 16 billion points. Relative accuracy is reported for the portion of the study area listed in Figure 2.1 below.

- Project Average = 0.299 ft (0.091m)
- Median Relative Accuracy = 0.272 ft (0.083 m)
- 1 σ Relative Accuracy = 0.327 ft (0.100 m)
- 2 σ Relative Accuracy = 0.532 ft (0.162 m)

Figure 2.1. Relative Accuracy Covered Area.



* Relative accuracy includes Willamette Valley Study Area Phase I delivery area 14.

Figure 2.2. Statistical relative accuracies, non slope-adjusted.

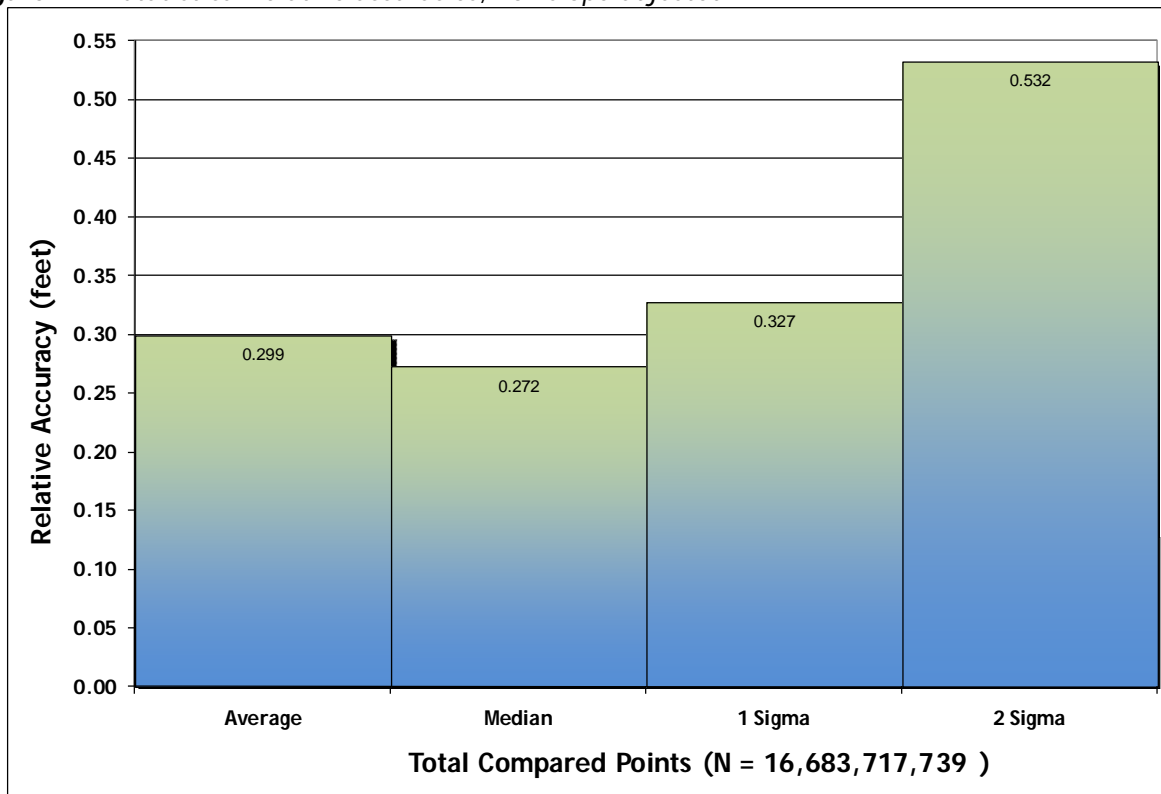
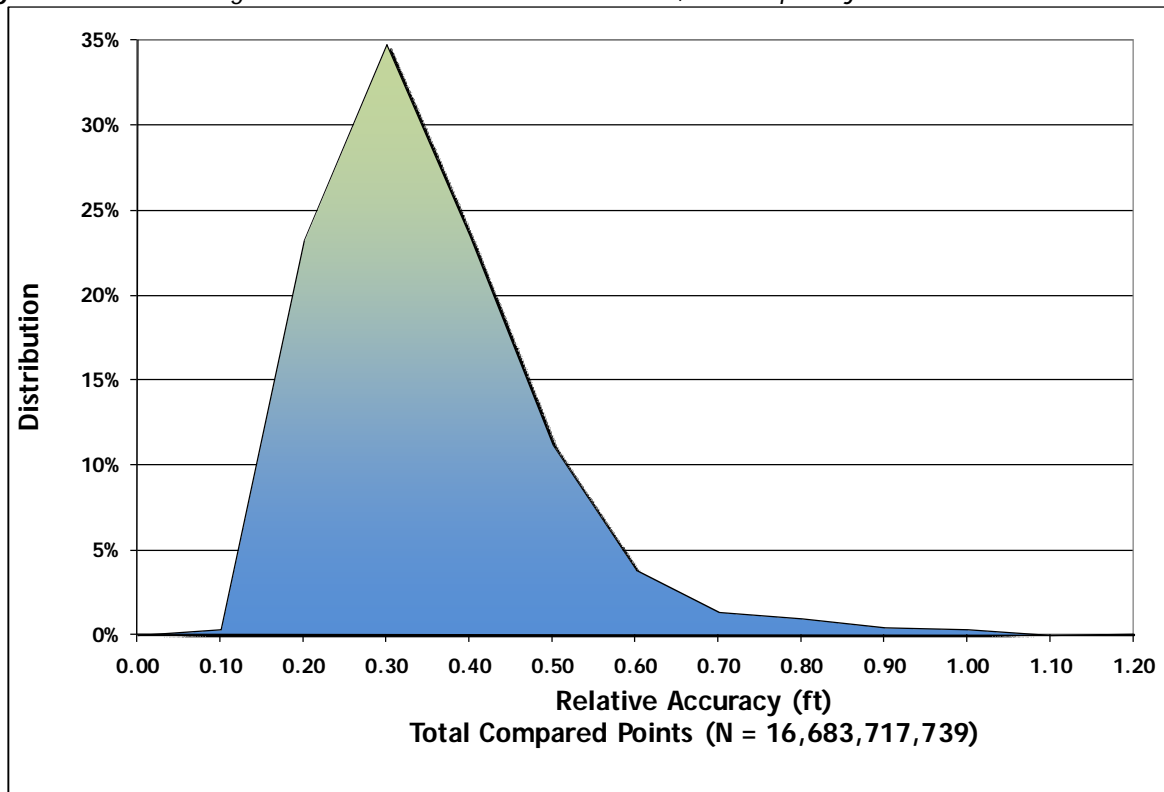


Figure 2.3. Percentage distribution of relative accuracies, non slope-adjusted.



2.2 Absolute Accuracy

Absolute accuracy compares known Real Time Kinematic (RTK) ground survey points to the closest laser point. For the Oregon North Coast Study Area, 23,935 RTK points were collected for data delivered to date. Absolute accuracy is reported for the portion of the study area shown, including Willamette Valley Phase 1 area 14 in **Figure 2.4** and reported in **Table 2.1** below. Histogram and absolute deviation statistics are reported in **Figures 2.5 and 2.6**.

Table 2.1. Absolute Accuracy - Deviation between laser points and RTK survey points.

Sample Size (n): 23,935	
Root Mean Square Error (RMSE): 0.11 ft (0.03m)	
Standard Deviations	Deviations
1 sigma (σ): 0.11 ft (0.03 m)	Minimum Δz : -0.51 ft (-0.15 m)
2 sigma (σ): 0.23 ft (0.07 m)	Maximum Δz : 0.53 ft (0.16 m)
	Average Δz : 0.09 ft (0.03 m)

Figure 2.4. Absolute Accuracy Covered Area.

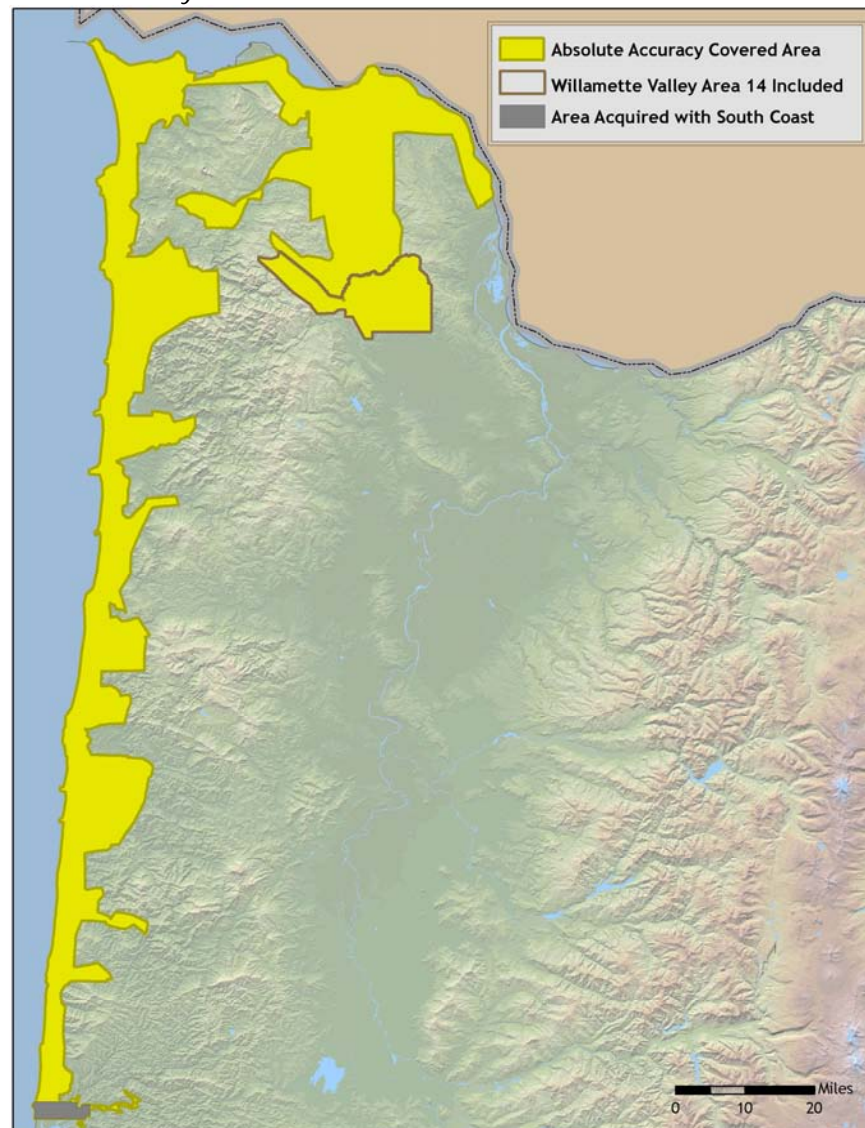


Figure 2.5. Oregon North Coast Study Area histogram statistics

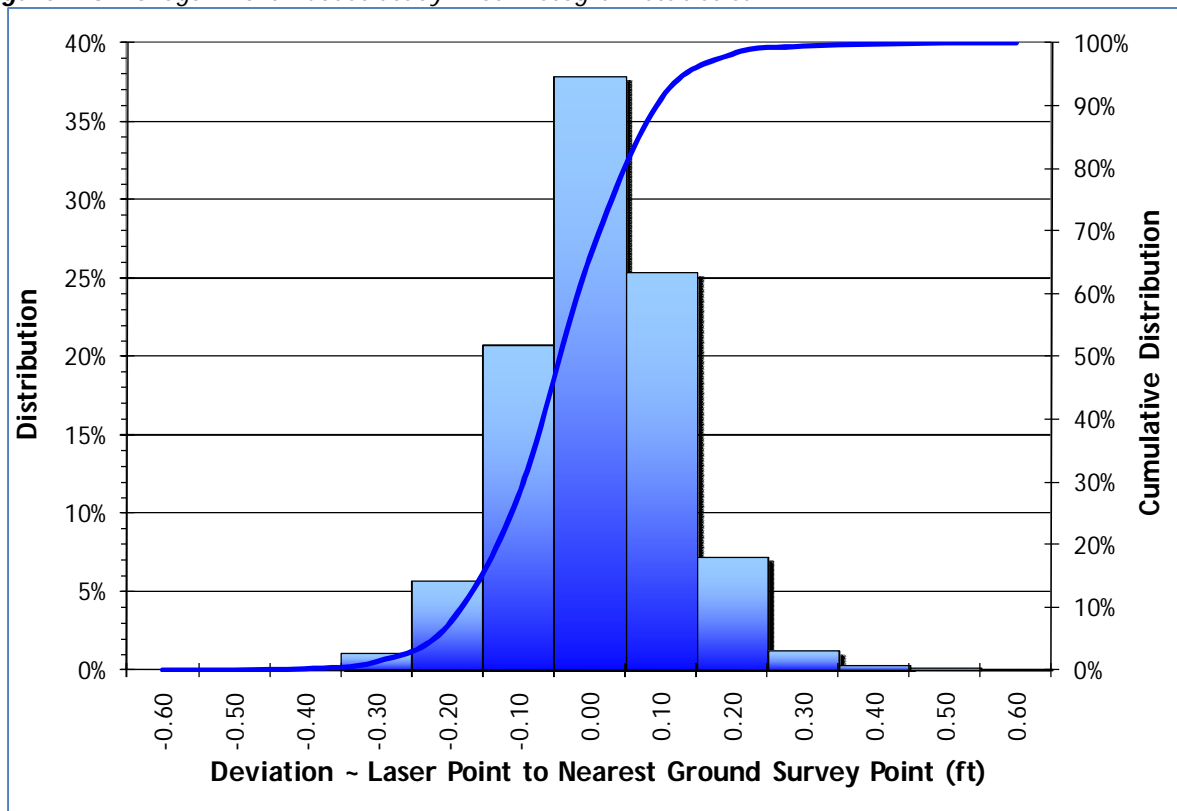
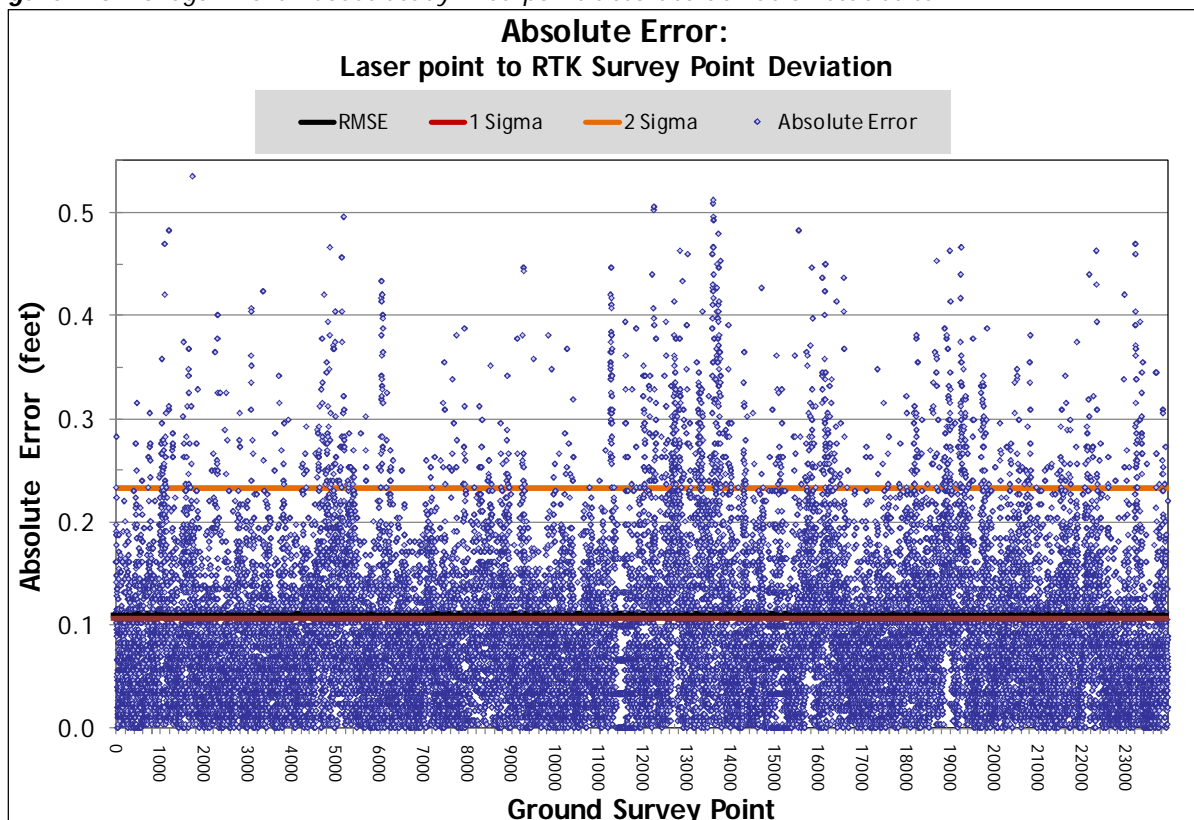


Figure 2.6. Oregon North Coast Study Area point absolute deviation statistics.



3. Data Density/Resolution

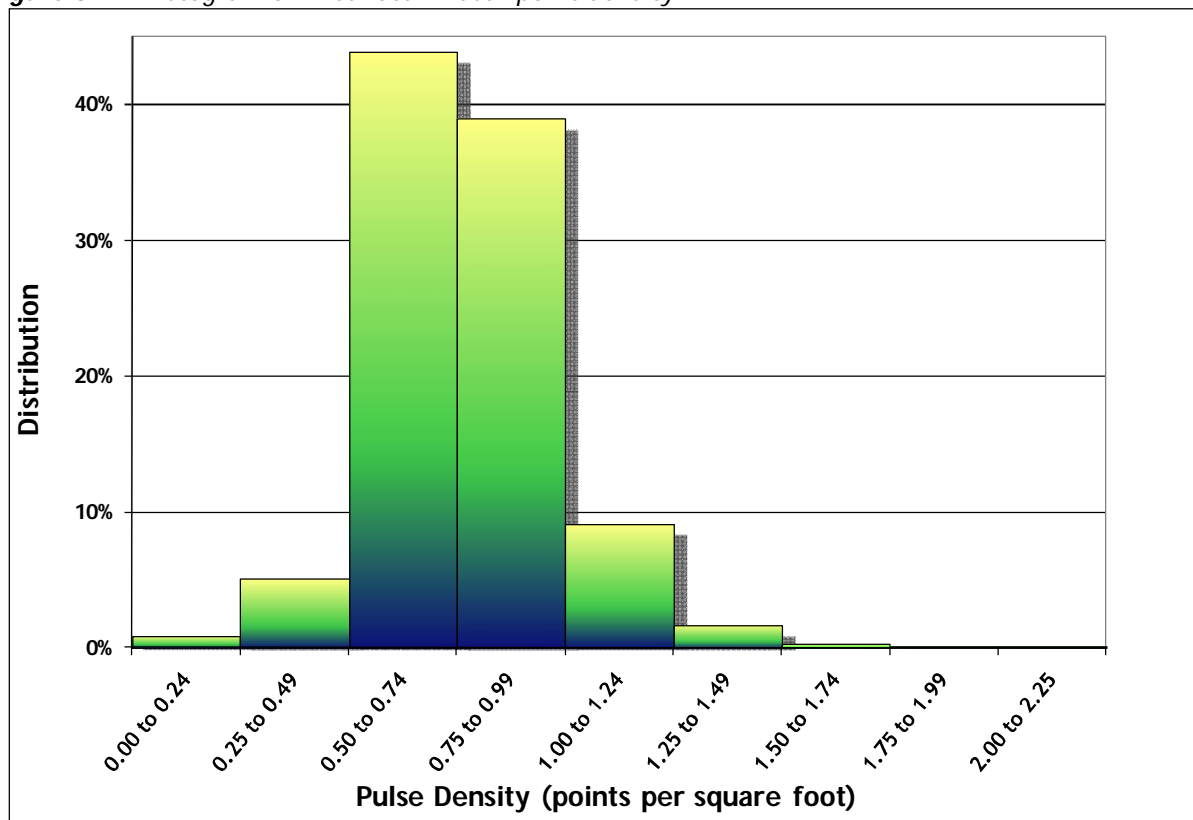
3.1 Density Statistics

Some types of surfaces (i.e., dense vegetation or 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 distributions of terrain, land cover and water bodies. Density histograms and maps (Figures 3.1 - 3.7) have been calculated based on first return laser point density and ground-classified laser point density.

Table 3.1. Average density statistics for Oregon North Coast Study Area data delivered to date, including Willamette Valley Phase 1 area 14.

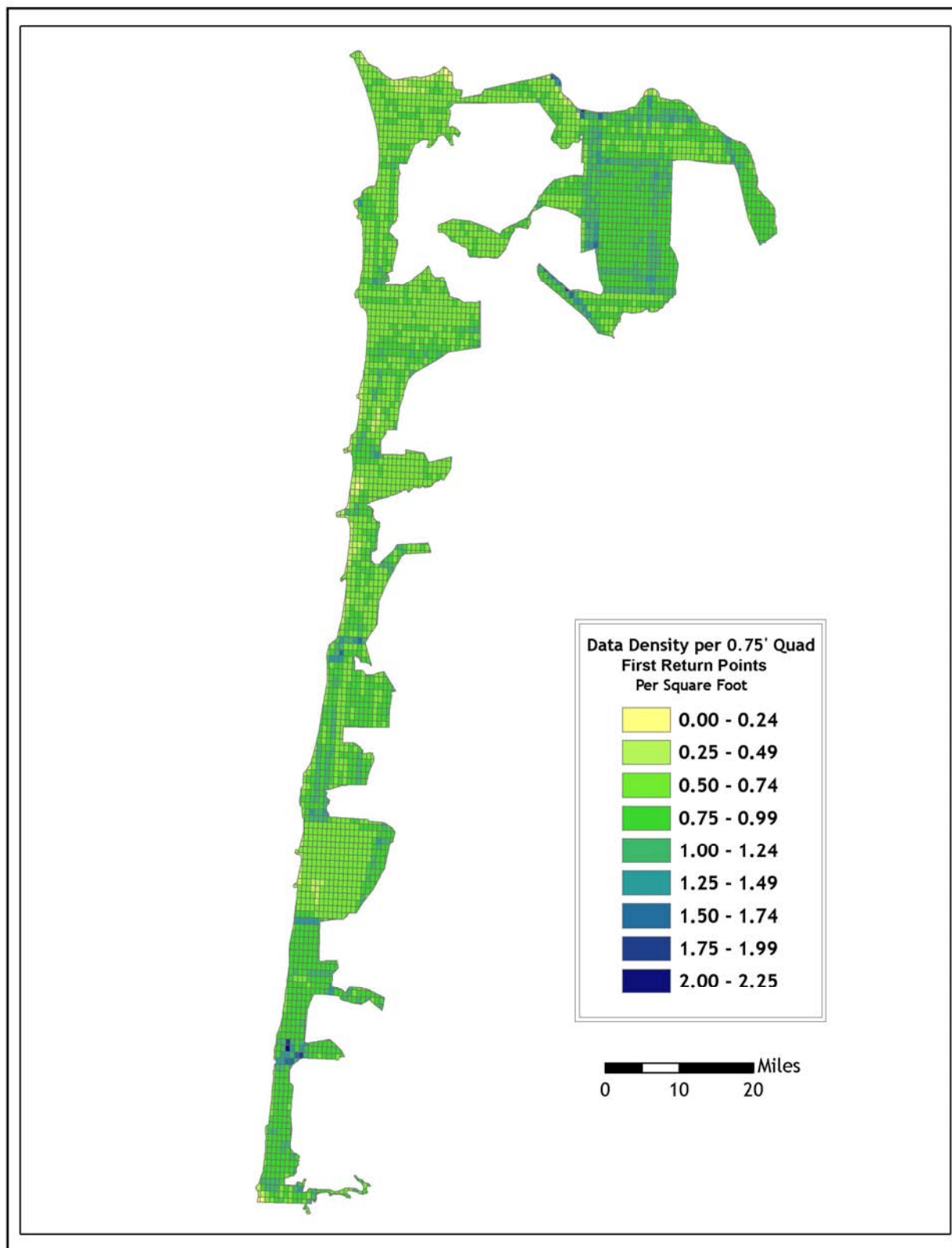
Average Pulse Density (per square ft)	Average Pulse Density (per square m)	Average Ground Density (per square ft)	Average Ground Density (per square m)
0.80	8.61	0.09	.96

Figure 3.1. Histogram of first return laser point density.



Pts ft²	Pts m²
0.00	0.00
0.05	0.54
0.10	1.08
0.15	1.61
0.20	2.15
0.25	2.69
0.30	3.23
0.35	3.77
0.40	4.31
0.45	4.84
0.50	5.38
0.55	5.92
0.60	6.46
0.65	7.00
0.70	7.53
0.75	8.07
0.80	8.61
0.85	9.15
0.90	9.69
0.95	10.23
1.00	10.76
1.05	11.30
1.10	11.84
1.15	12.38
1.20	12.92
1.25	13.45
1.30	13.99
1.35	14.53
1.40	15.07
1.45	15.61
1.50	16.15

Figure 3.2. Image shows first return laser point per 0.75' USGS Quad, including Willamette Valley Phase 1 area 14.



Pts ft ²	Pts m ²
0.00	0.00
0.05	0.54
0.10	1.08
0.15	1.61
0.20	2.15
0.25	2.69
0.30	3.23
0.35	3.77
0.40	4.31
0.45	4.84
0.50	5.38
0.55	5.92
0.60	6.46
0.65	7.00
0.70	7.53
0.75	8.07
0.80	8.61
0.85	9.15
0.90	9.69
0.95	10.23
1.00	10.76
1.05	11.30
1.10	11.84
1.15	12.38
1.20	12.92
1.25	13.45
1.30	13.99
1.35	14.53
1.40	15.07
1.45	15.61
1.50	16.15

↓

Ground classifications were derived from ground surface modeling. Supervised 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 bin boundaries.

Figure 3.3. Histogram of ground-classified laser point density, including Willamette Valley Phase 1 area 14.

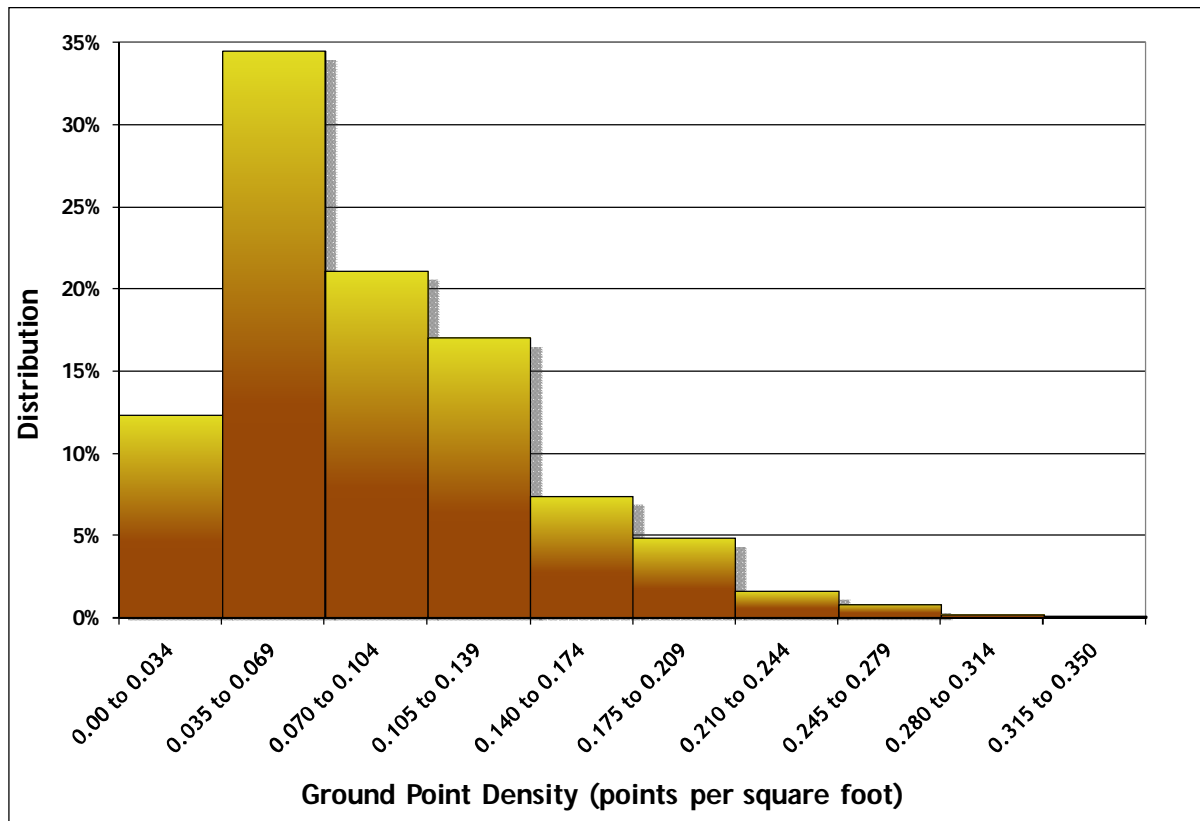
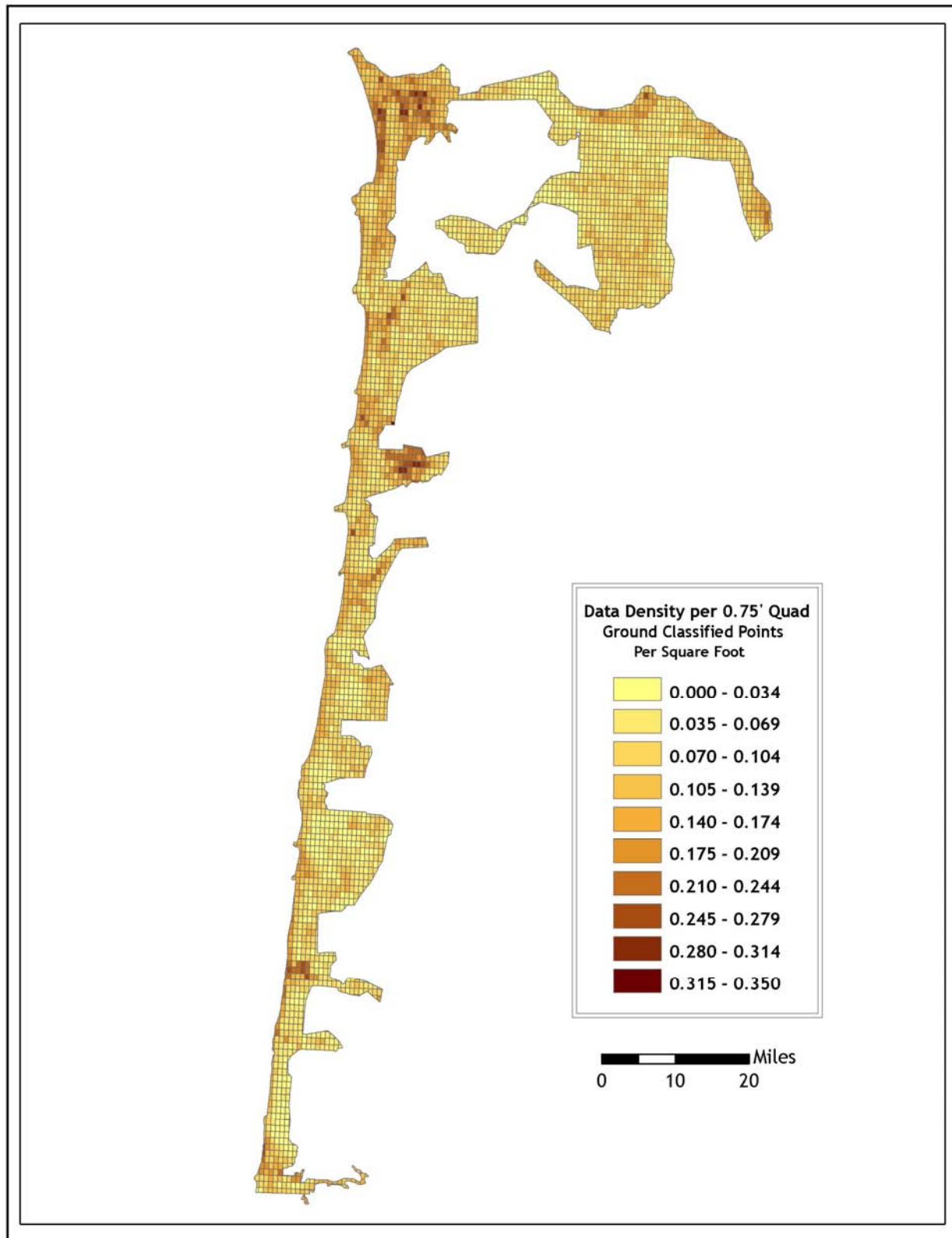


Figure 3.4. Ground-classified laser point density per 0.75' USGS Quad, including Willamette Valley Phase 1 area 14.



Pts ft ²	Pts m ²
0.00	0.00
0.05	0.54
0.10	1.08
0.15	1.61
0.20	2.15
0.25	2.69
0.30	3.23
0.35	3.77
0.40	4.31
0.45	4.84
0.50	5.38
0.55	5.92
0.60	6.46
0.65	7.00
0.70	7.53
0.75	8.07
0.80	8.61
0.85	9.15
0.90	9.69
0.95	10.23
1.00	10.76
1.05	11.30
1.10	11.84
1.15	12.38
1.20	12.92
1.25	13.45
1.30	13.99
1.35	14.53
1.40	15.07
1.45	15.61
1.50	16.15

3.2 Selected Samples of Data Density/Resolution

Figure 3.5. Quadrants containing low pulse density classified points include water bodies and shorelines.

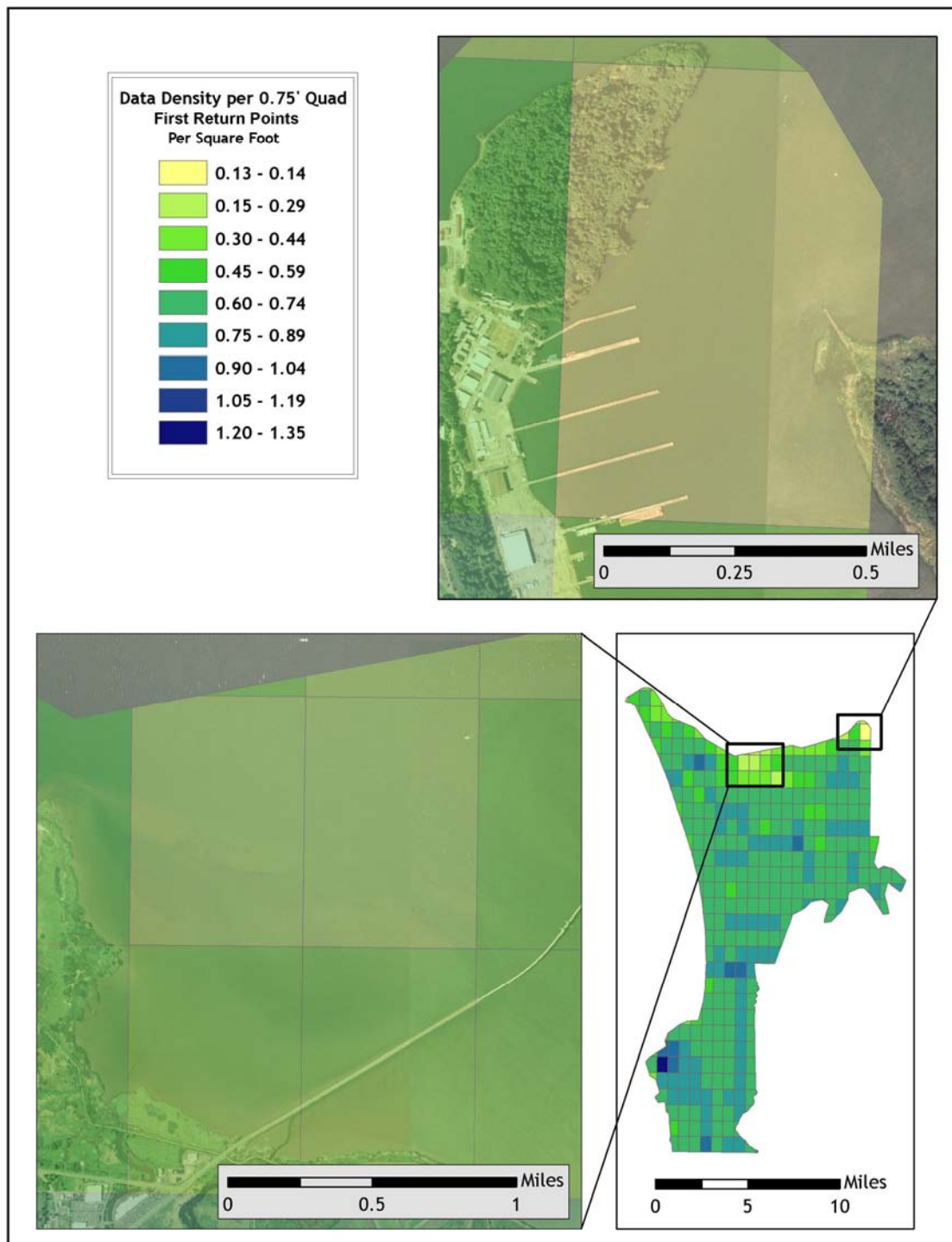


Figure 3.6. This quadrant illustrates a high number of ground classified points because of areas of little or no ground cover.

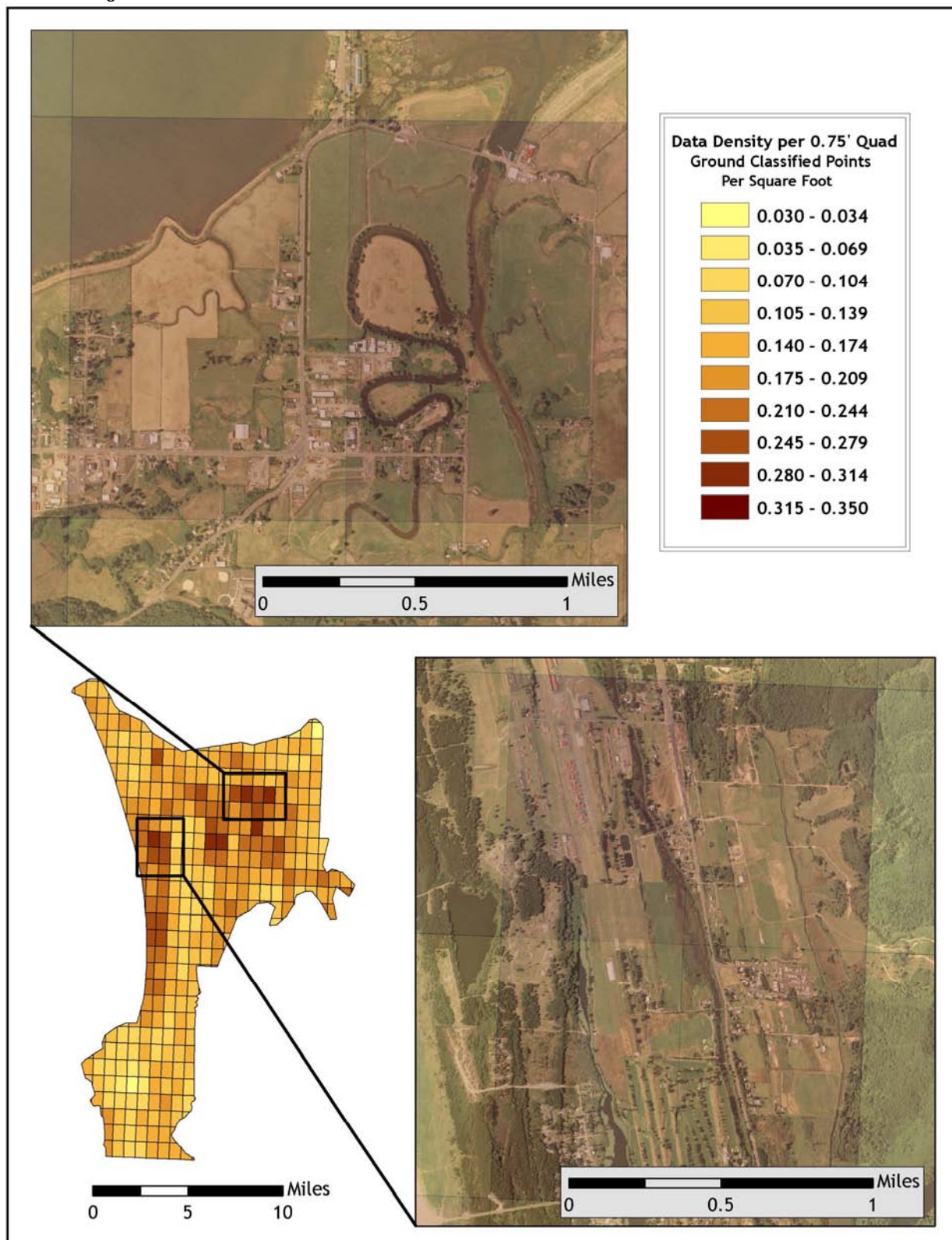


Figure 3.7. This quadrant illustrates a low ground density because of areas of dense vegetation.

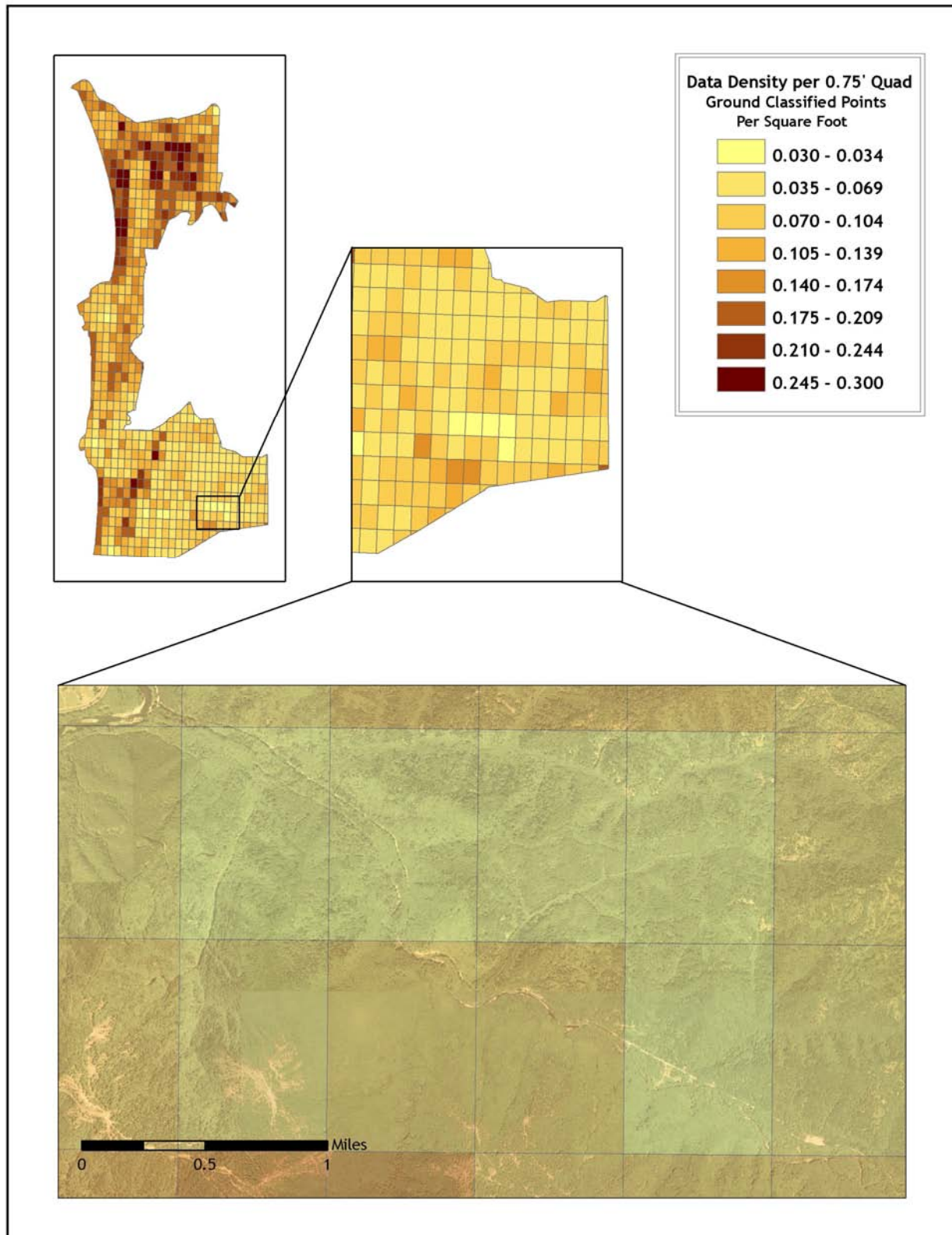
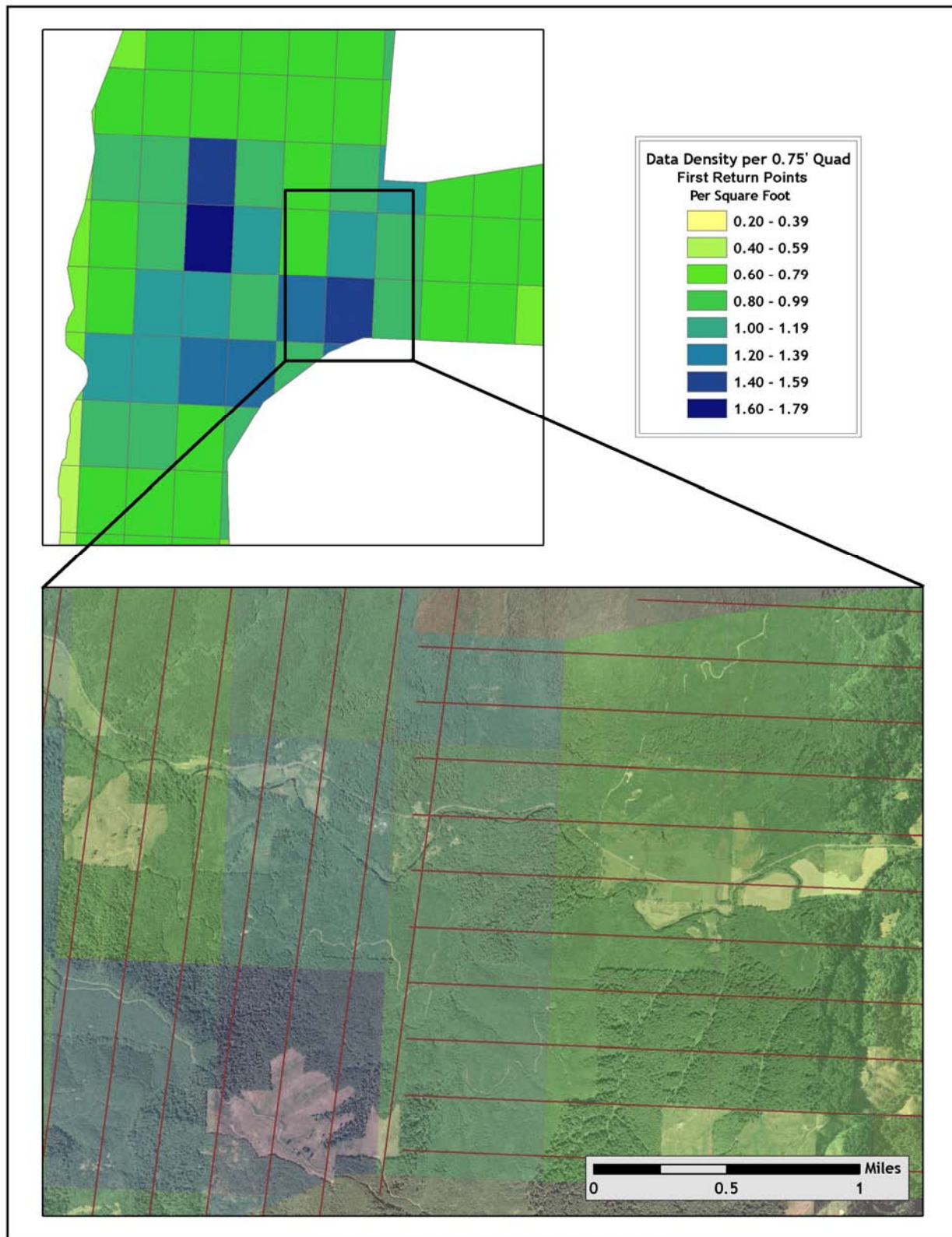


Figure 3.8. Quadrants containing high pulse density classified points include areas with overlapping flightlines.



4. Selected Imagery

Example areas are presented to show sample imagery (see **Figures 4.1 - 4.9**).

Figure 4.1. Section of the Tillamook River, located 1 mile south of the town of Tillamook, Oregon. (Quadrangles 45123D7).

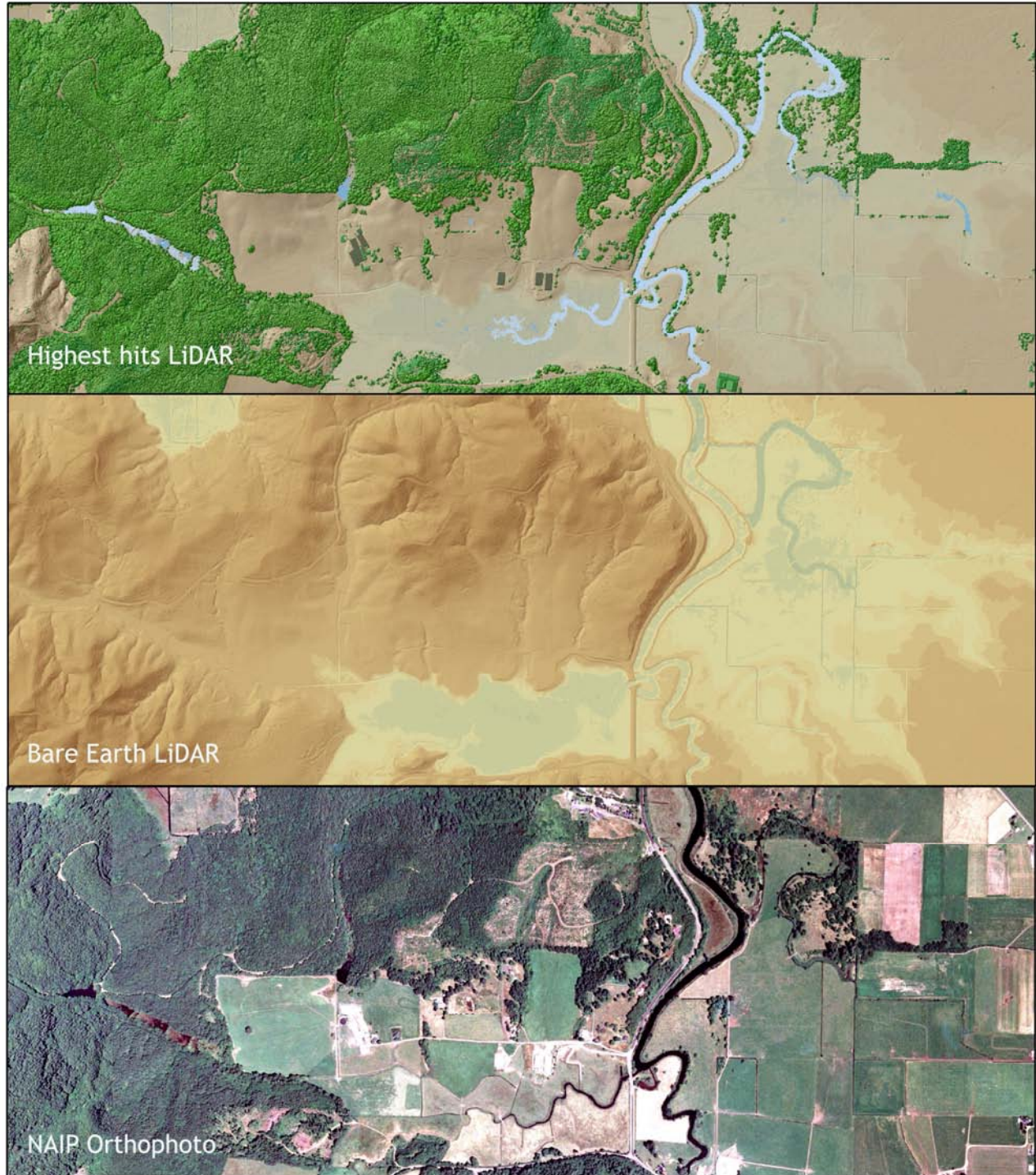


Figure 4.2. Section of the Nehalem River, located 1 mile northeast of the town of Nehalem, Oregon. (Quadrangles 45123F7 and 45123F8). Topmost image derived from NAIP orthophoto, center image from highest hit LiDAR, bottom image derived from bare earth LiDAR.

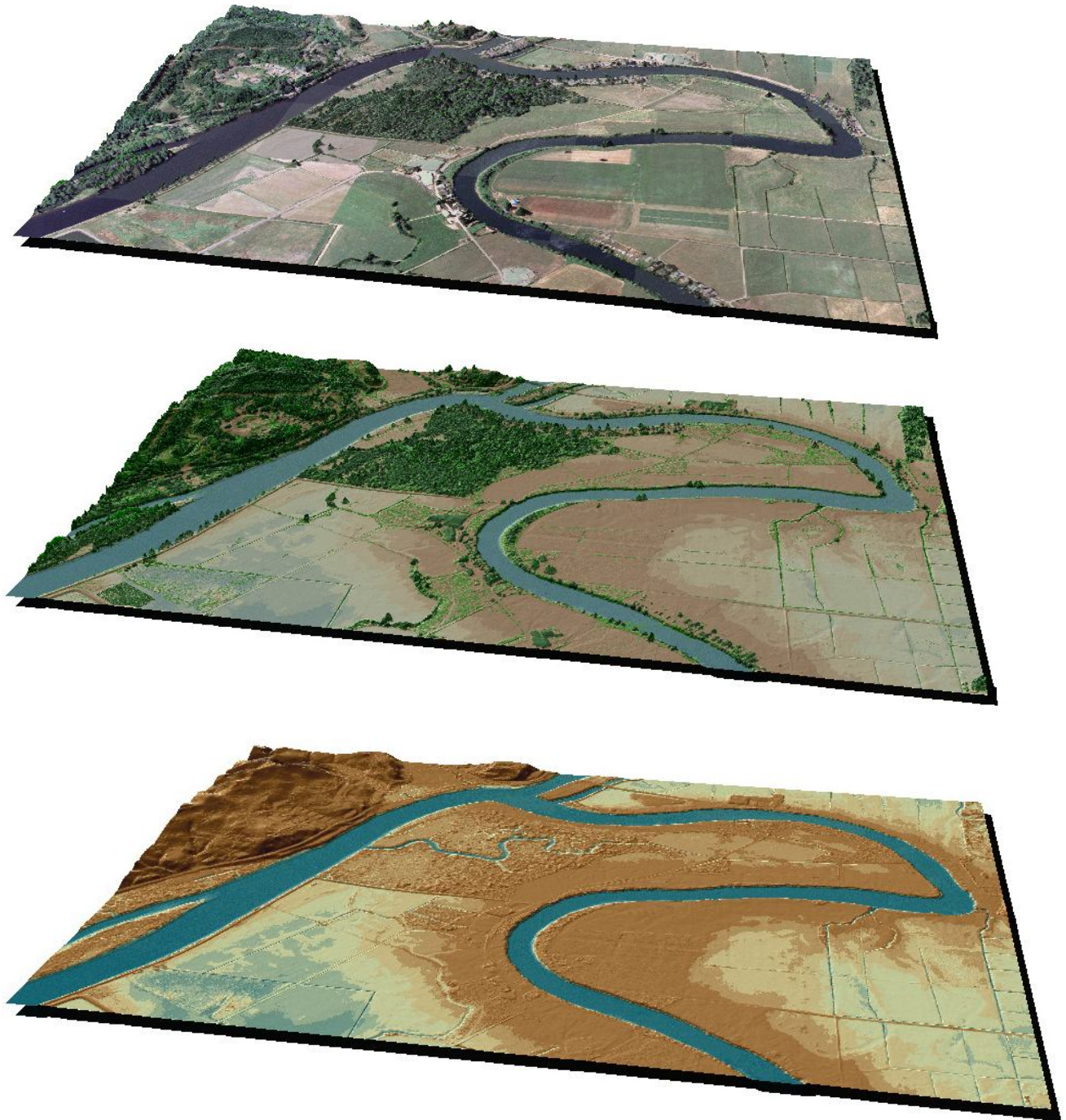


Figure 4.3. Section of the Lewis and Clark River, located along side Fort Clatsop National Memorial, two miles south of Youngs Bay (Quadrangles 46123B7 and 46123B8). Topmost image derived from NAIP orthophoto, bottom image derived from bare earth LiDAR.



Figure 4.4. Riverside Lake/Seaside Reservoir, located 3 miles south of the town of Seaside, Oregon (Quadrangle 45123H8) . Topmost image derived from NAIP orthophoto, bottom image from highest hit LiDAR.

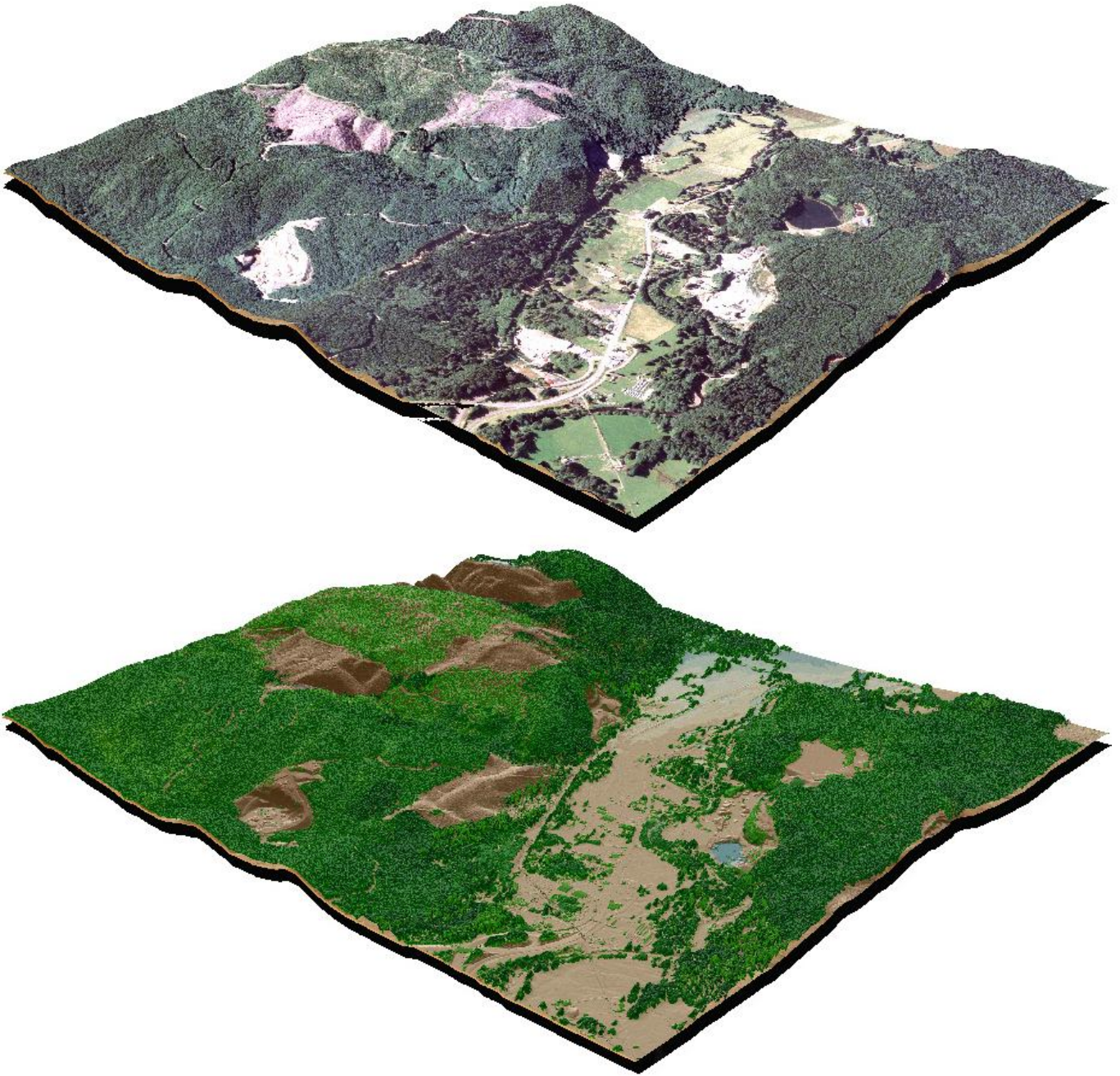


Figure 4.5 Mile Lake, located north of Pacific City, Oregon (Quadrangle 45123B8). Topmost image derived from highest hit LiDAR. Lower image derived from bare earth LiDAR.

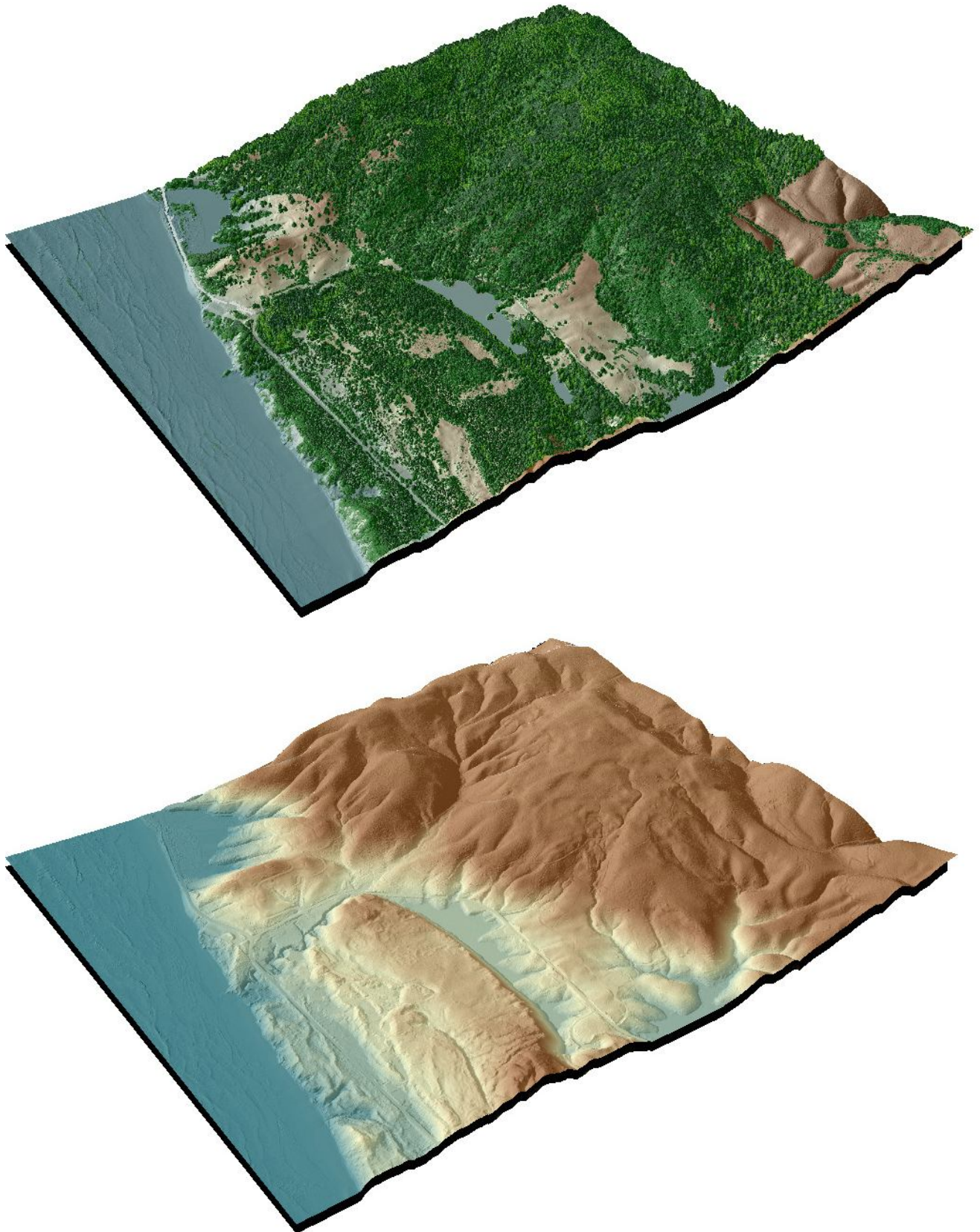


Figure 4.6. Portion of the Nestucca River located west of Cloverdale, Oregon (Quadrangle 45123B8). Topmost image derived from highest hit LiDAR. Lower image derived from bare earth LiDAR.

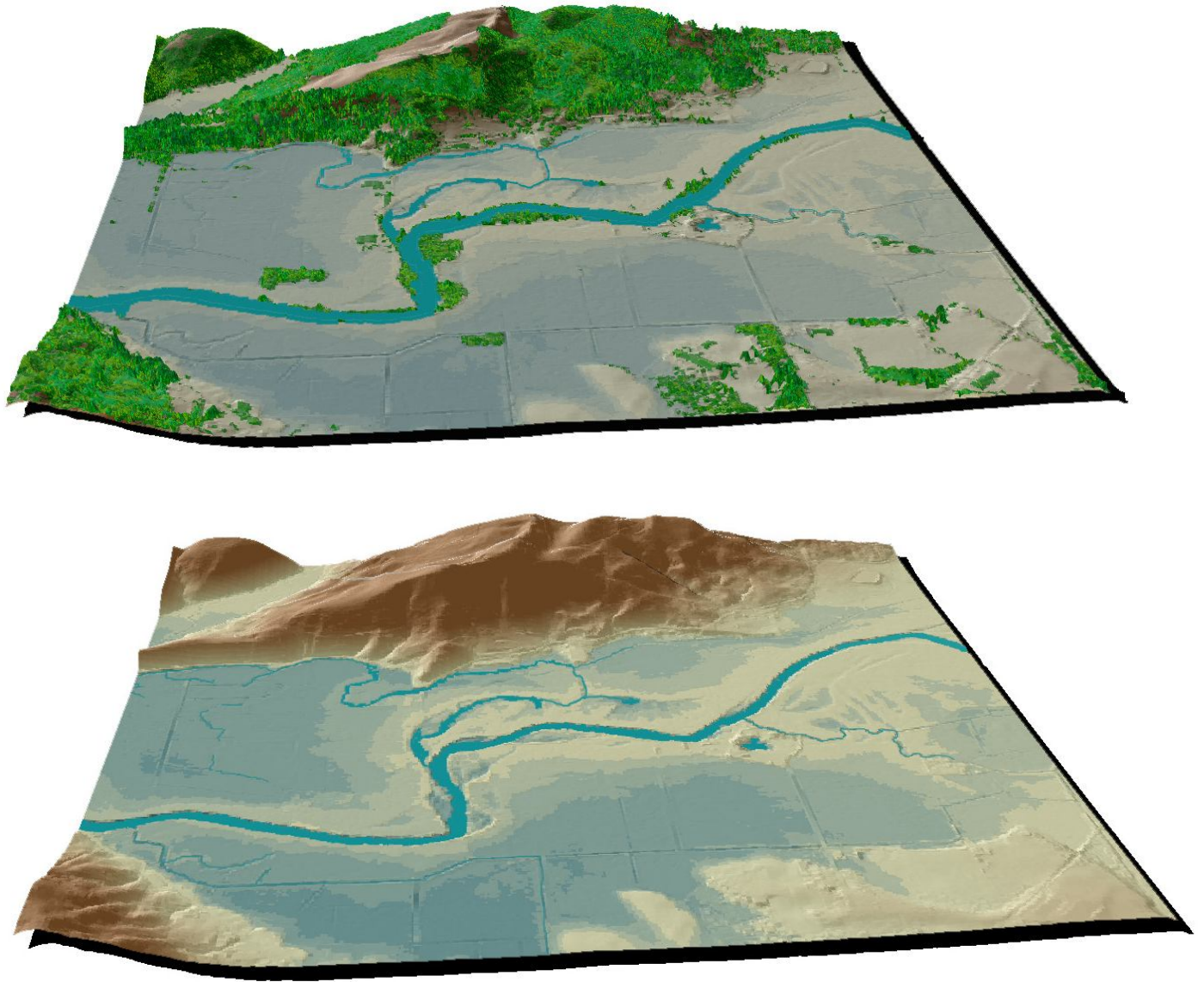


Figure 4.7. Vernonia, Oregon (Quadrangle 45123G2). Topmost image derived from highest hit LiDAR. Lower image derived from bare earth LiDAR.

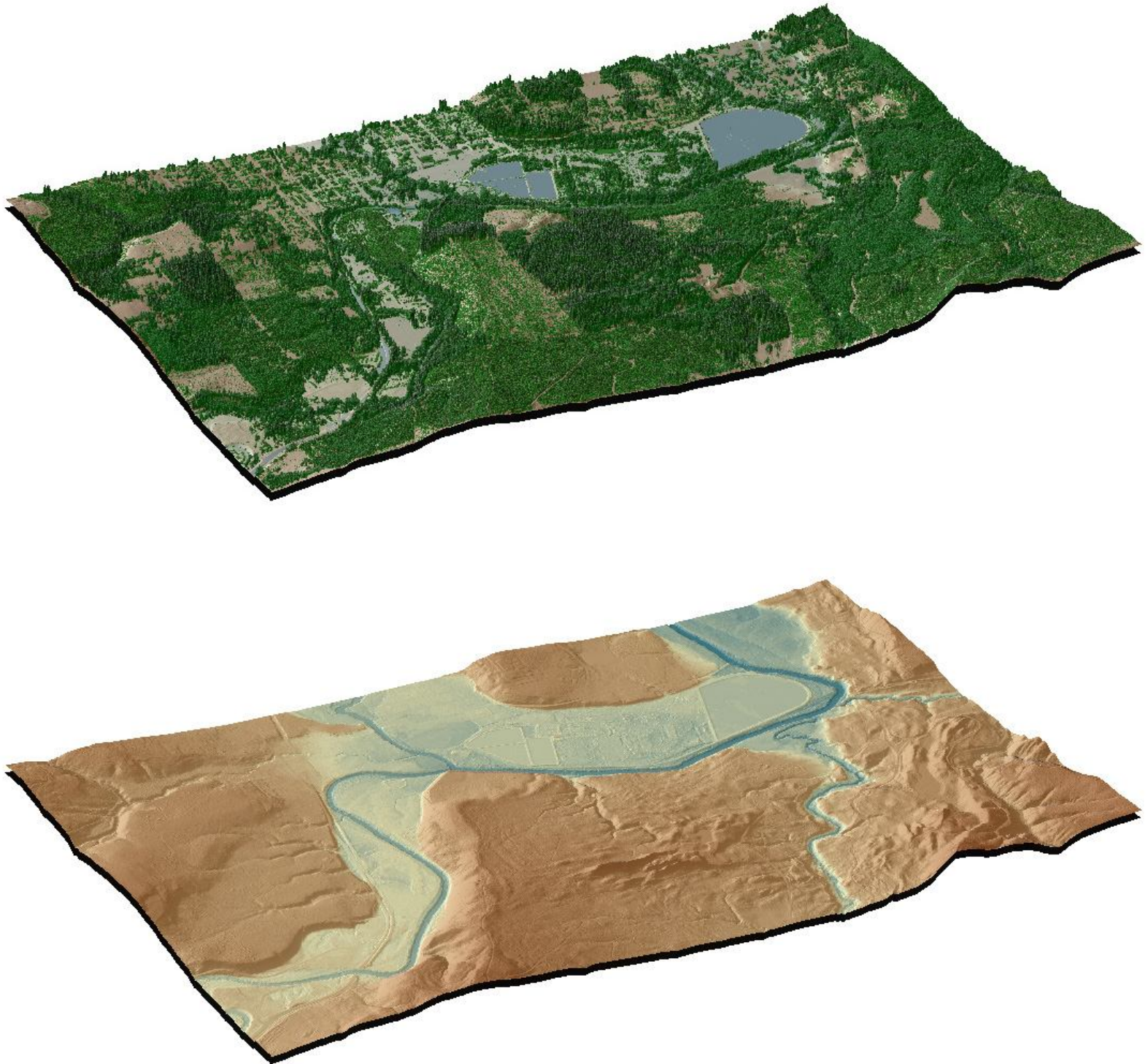


Figure 4.8. Big Creek Dam, located north of Newport, Oregon (Quadrangle 44124F1). Topmost image derived from highest hit LiDAR. Lower image derived from bare earth LiDAR.

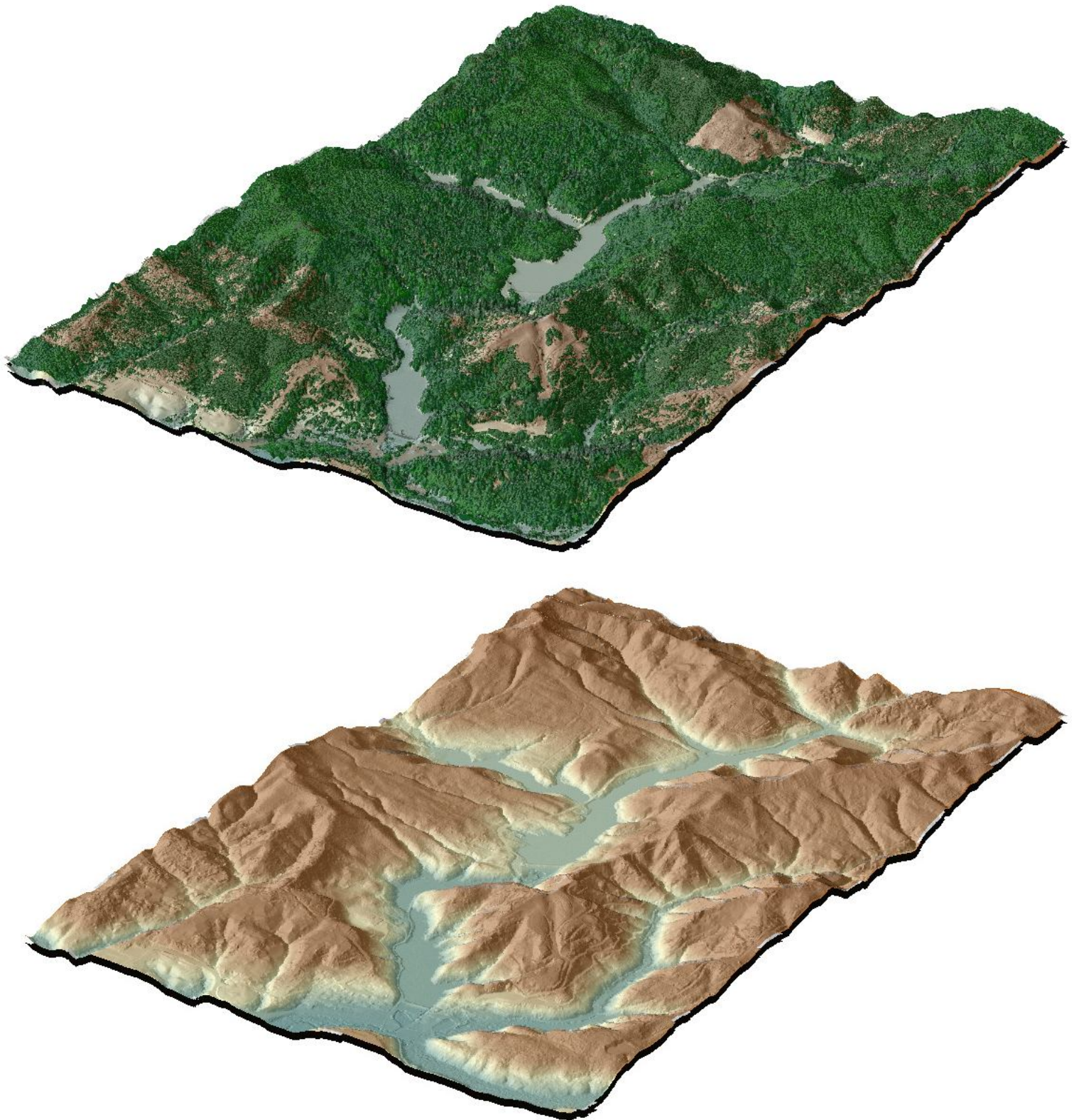


Figure 4.9. Chitwood Falls, located west of Tillamook, Oregon (Quadrangle 45123A) . Topmost image derived from highest hits LiDAR, bottom image from bare earth LiDAR.

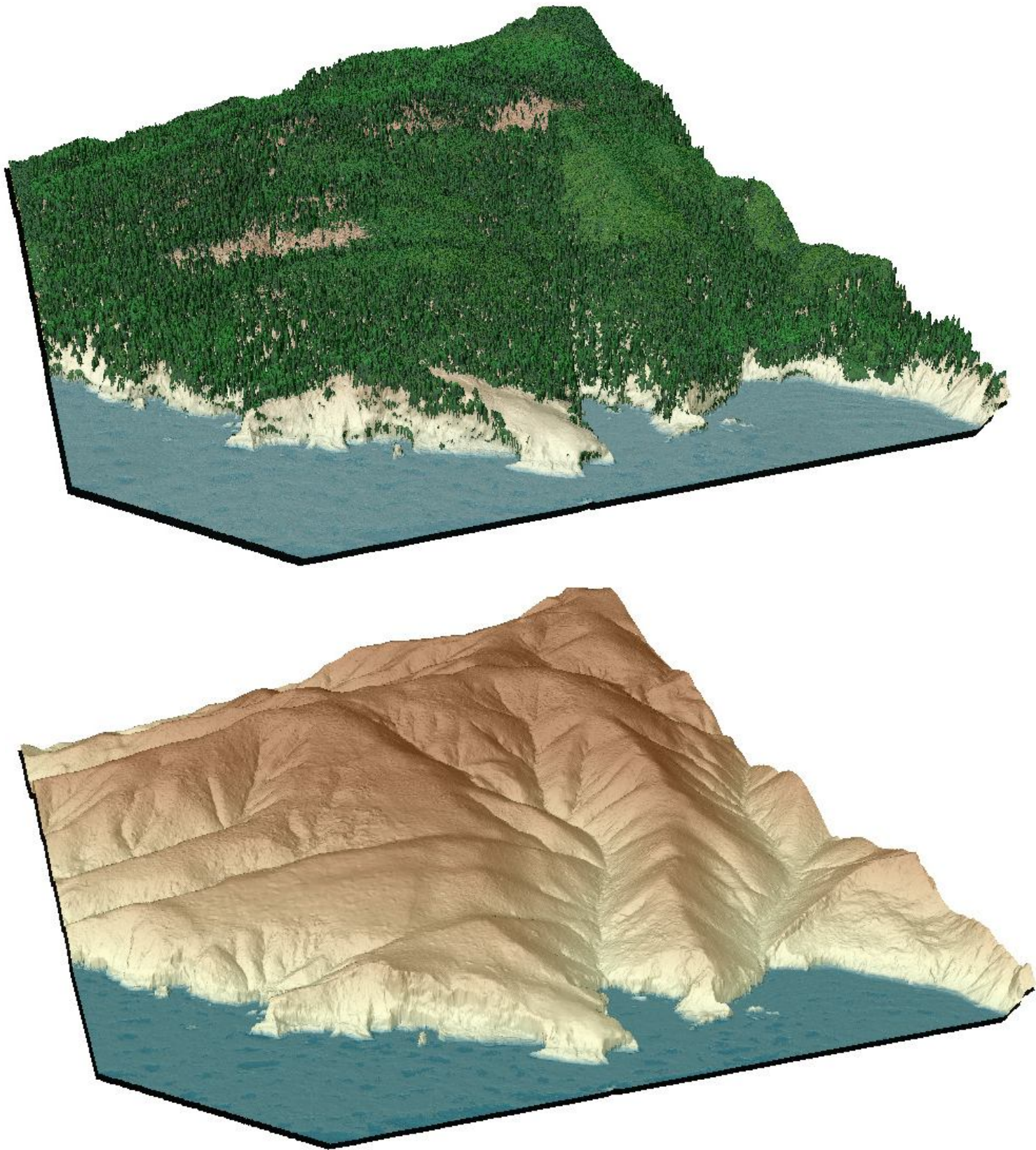


Figure 4.10. Trask River, located west of Tillamook, Oregon (Quadrangle 45123D7) . Topmost image derived from NAIP orthophoto, bottom image from highest hit LiDAR.

