Olympic Coast Geodetic Control and Beach Profiles

Coastal and Marine Spatial Planning

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WA STATE DEPARTMENT OF ECOLOGY - COASTAL MONITORING AND ANALYSIS PROGRAM

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Summary

The Coastal Monitoring and Analysis Program (CMAP) is a research group, based out of the Washington State Department of Ecology. Since 1996, they have been studying beach morphology on the Southwest Washington coast. This project aimed to extend the previous monitoring project to the entire outer coast of Washington. Prior studies had reached as far north as Point Grenville, on the Quinault Indian Reservation. The installation of geodetic control networks is integral to accurate elevation surveying, as it allows for the use of real time kinematic GPS survey techniques.

In the July of 2012, CMAP worked with the Quinault Indians to install geodetic control monuments on the coasts of their reservation. Using the new network, beach profile data was collected on land by walking field crews and on water by jet skis in conjunction with the United States Geological Survey (USGS) and Oregon State University (OSU).

CMAP also worked with the National Parks Service throughout winter and spring of 2013 to install geodetic monuments on select beaches in the Olympic National Park, and in the spring, baseline beach profile data on those beaches.

In La Push, in June, 2012, the USGS, OSU, and CMAP coordinated with the Quileute tribe to collect bathymetric and topography profiles on Rialto, First, and Second Beaches.

Ultimately, this year's work left the coastal community with a continuous geodetic control network from the Columbia River to the Hoh River. North of the Hoh River, the coastal topography and beach geography presents a great challenge to a continuous network, but the new monuments installed in La Push and on pocket beaches in the National Park provide a great start for further monitoring efforts. Baseline beach profile data collected on 58 kilometers of previously unsurveyed coastline will aid coastal communities with beach and resource management and planning.

This report first details the installation of the new geodetic control networks: site planning, on site investigation, location selection, marker installation and GPS occupation. It then focuses on the collection of beach profile data at these new sites on the central and northern Washington coast, before making suggestions for further geodetic control and monitoring in the region.

Site Planning and Reconnaissance

Geodetic network installation began with planning in the office before departing to the study area. To start, boundaries are designated for each site. Areas north of the Hoh River had obvious start and end points, since the study areas are primarily pocket beaches. For Kalaloch and Ruby, boundaries of ongoing studies performed by NPS's Steve Fradkin were used as guides. The entire Quinalt Indian Reservation was surveyed, using tribal boundaries as survey end points. The specified boundaries were then used to search for existing monuments in the area. This search was focused on the Ruby and Kalaloch areas, where roads are close and development may have warranted monuments previously. A list was generated of possibly usable existing monuments, and field crews investigated the sites while installing monuments. Ultimately, no existing monuments were used for the project, as markers were

not occupied recently, had moved or could not be found, did not have good visibility for satellites, were too far from the coast, or were not close enough to the designated survey areas.

Aerial and oblique photos of the coastline and maps of roads and trails were used to establish potential locations for new monument installations. At this point, other individuals were contacted who might have insight on the area. Li Clinton, a ranger at the Kalaloch Ranger Station, was an indispensible resource for planning and installation in the Ruby Beach and Kalaloch study areas. Dave Bingaman and Joe Shumacker of the Quinault Indian Nation led CMAP field crews over rugged terrain and through thick vegetation to every corner of the Reservation, investigating possible installation sites. The entire Quinault community took a great interest in the survey, and field crews were greeted with excitement and helpfulness at every turn, even catching a ride across the river in a fisherman's tin boat.

A significant amount of time went in to researching the best materials for building and installing monuments, keeping in mind the stipulation that the markers be both low profile and lasting. Solid aluminum rods (a little lighter for our hiking crew), and marine epoxy were chosen and purchased. An extensive list of tools (sledge hammers, drills, saws, etc) would also be necessary for installation.

Before departing for the field, field crews planned access points and computed drive and hike times for general scheduling purposes and to make estimates for how many on site days would be necessary.

Choosing Monument Locations

The use of RTK GPS requires a base station; a GPS receiver set up on a known location (a geodetic monument) with a large radio. The base's function is to broadcast, via radio, GPS corrections to repeater radios and GPS rover backpacks taking data. Before starting the survey, crews tell the base station the coordinates of the monument over which its receiver sits. The receiver observes GPS satellites and uses their transmissions to guess its location. Comparing it to its known location, over a geodetic monument, the base station generates a correction, a vector of the difference between its observed location and its known location. Those corrections are transmitted once per second via radio signal to other gps receivers taking data on the beach or at other monuments, making their data measurements more accurate. Since the survey data will be referenced to the base station's monument, it is very important that the position of the monument be known with high accuracy. When performing an RTK survey, control points are often used as a quality check.

Generally, four monuments are necessary for each survey area: one for the base station and three for control points. The sites of the monuments are therefore very carefully chosen for their ability to receive not only GPS signal from satellites (requiring no overhead vegetation or especially close tall tree), but radio broadcasts from the base station. Since the radio signal does not travel well through trees or headlands, monuments, and especially the base station monument, should be located up high (on a bluff or headland, if possible) and close to the beach. The "line of sight" visualization tool for good base setup; from the base monument, one must be able to see direct lines to the edges of the survey area and the other three control monuments without interference from headlands or wooded areas. This is

relatively easy on small pocket beaches, like Shi Shi and Sand Point, but more difficult in the Ruby beach and Kalaloch area where small headlands attenuate radio signal and survey areas are longer.

The base station must be set up for the duration of a survey (5 hours at least), the base monument must located in a rather safe and protected area, not right on a road or in a tidal dependant area. The space needs to be large enough for two tripods to be set up and away from interference from tourists and wind (wind was one of our biggest concerns when using epoxy on rocks where tripod legs couldn't be sunk into the ground). When possible, base monuments should also be conveniently located, since the radio requires a deep-cycle car battery to transmit on high frequency for an extended period of time, making the equipment very heavy to carry long distances. The corrections transmitted by the base station are more accurate when the rovers are close to the base, so it should also be located in the middle of the survey when the survey area is long.

Control points should surround study sight, a more difficult task on the coast than in inland surveys. Therefore, one monument was located on each end of the survey (North and South) and one in the middle. Optimally, these three should be spread out somewhat evenly.

Perhaps most importantly, the survey monuments need to be stable - they cannot move once set. Rocks high up on the beach, where sand is less likely to cover seasonally, were used for epoxy monuments. And with rods, ground was designated far enough back on a cliff that it will not soon erode.

On-Site Reconnaissance and Monument Installation

Reaching the survey sites to install and occupy monuments became one of the largest challenges of the project. The southwest Washington beaches, where prior surveys took place, are relatively accessible by car, involving a half mile hike at most. Gear to install four monuments included a sledge hammer, solid aluminum rods, a drill, four large geodetic tripods, four GPS receivers, and batteries. At Shi Shi, Sand Point, and Cedar Creek, the excursion required four people each with a pack weighing more than 70 lbs. While most of the monument sites investigated on the Quinault Reservation are accessible by car, many of the drives require four wheel drive. Many of the navigation routes planned in the office were ultimately non-traversable. Without Joe Shumacker's guidance in the field, crews would likely could not have found beach and bluff access necessary to complete the geodetic control network and the survey.

Upon arrival at a survey site, the crew investigated all existing monument sites and site suggestions drafted in the office. On the remote northern beaches, base station monument locations were chosen close to the trailhead on the beach and control point monuments were usually put close to the headlands and in the middle of the pocket beach. At Ruby and Kalaloch beaches, the monuments were spaced out beyond the previously specified NPS survey areas, so monitoring can be extended beyond the current survey boundaries in the future. Also, only 7 monuments were installed (rather than 4 for each) in the Ruby/Kalaloch area, since the two sites are close in proximity and can use some of the same control points. Sites were evenly spread throughout the Quinault Reservation, with the largest factor being access.

Locations were generally selected with a type of monument in mind (epoxy with divot, divot in non-mobile metal (ex. guard rail, man hole, etc), or rods in the ground). Quickest to install are the divots in pre-existing metal structures. A titanium drill bit was used to put a divot in the edge of a manhole and on a support for a guard rail (at "Klodge" and "Seyk," respectively). The epoxy was also quick to install, but took days or weeks to set up, depending on the weather. A tripod tip was used to make a hole in the epoxy, usually pressing through to the hard surface beneath to ensure correct elevation, even if the marker was occupied before it was completely hardened.

Rod monuments were the most difficult to install. However, rods could be installed on tops of bluffs, where bedrock was rarely available for epoxy and no manmade structures were available for drilling. Since rod's could be installed up high, they often make great base monuments, and were the choice for the Quinault area, where fewer monument locations were accessible and radio transmissions would need to travel longer distances along jagged coastline.

At Shi Shi, Sand Point, and Cedar Creek survey areas, aluminum rods were used, while steel was used for Quinault, Ruby, and Kalaloch. Using a sledge, the section of steel or aluminum was driven into the ground; when the first rod was nearly flush with the ground, another length of rod would be added. This continued until complete refusal depth was reached and the stakes could not be driven any further. A hack saw was used to remove any remaining length of rod, leaving only ~1-2 cm above ground. A power drill was used to make a small divot for the tripod point in the center of the sawed off rod.

In each scenario (divot, epoxy, or rod), a geodetic tripod was set up with a GPS antenna to log satellite data. In each survey area, the logging receivers' occupations were overlapped by at least two hours. Two weeks after the observations were taken, they were processed using the Online Positioning User Service (OPUS) to get more accurate coordinates for the markers. The overlapping files meant the occupations to be processed as groups, allowing OPUS to return even smaller error margins.

In all cases, extensive notes were taken on the location and installation of these new markers. All of this information, as well as the final coordinates for the markers, can be found in Appendix A.

Baseline Profile Collection

Lines were generated running perpendicular to offshore bathymetric contours. North of the Queets river lines were spaced by 50 meters, while in the Quinault Indian Reservation, they were spaced at 250m. These files were imported to Trimble GPS controllers, where they could be staked out in the field.

A large field team of USGS, OSU, and CMAP collected beach profiles throughout the entire Quinault Reservation over just three days. They walked 250 m spaced lines in groups of two. As many as 5 people were walking the beaches at one time. Logistics of this survey were awesomely difficult. No cell service, coupled with heavily wooded coastlines that attenuated VHF radio signal meant little to no communication between separate field groups. Access was very rare, with high bluffs along most of the coast, so teams of two would be dropped at one access point and would hope to be picked up at another, hours later with little contact with the driver. In addition, the Raft River, running to the coast

about 8 km from the Queets River, is not traversable by car or by person, due to a downed bridge. Driving from one side of the river to the other was an almost 2 hour trip, complicating logistics further. Due to no signage, low accessibility, and the private nature of the tribe, it is imperative that field crews have someone who knows the area, as well as good topographic and logging maps, food provisions, and bear repellant.

Survey crews revisited the ONP sites in May and June, when they walked beach profiles to obtain baseline survey data of the sites. Two people surveyed each site. At the northern sites (Shi Shi, Sand Point, and Cedar Creek), two people hiked out to each site, carrying (amongst other things) a radio tripod and radio, a geodetic tripod, a large 35 amp hour battery, two GPS receivers, a control point rod, and a wetsuit and wading boots. The base monuments for the southern sites (Ruby and Kalaloch) are accessible by car, so much less equipment was carried on any necessary hikes.

Most sites were done with one rover GPS taking line data at about 100 meter spacing. Crews found that Shi Shi was rather too long for only one person walk (38 profiles), while Cedar Creek, Sand Point, and Second Beach were all manageable. Kalaloch was done with two rovers for convenience, but could have been done with one.

Ruby Beach presented some unforeseen obstacles. The base monument is north of the study area, and while the southern boundary of the study area is within the range of our 4 amp hour radio, a small headland blocked our radio reception. We were not prepared with repeater radios, and forfeited the last few intended lines of the survey area. For the future, we will set up a repeater at the car pullout off 101 where our monument/control point marker, “Saddle,” is located. The survey could be completed with the 4 amp hour base radio and one repeater, but using the 35 amp hour base radio may also help retain signal.

Full information about the profiles walked at each site is available in Appendix D.

Appendix A – Monument Locations and Descriptions

Beach/Survey Area	Name	Material/ Type	Installation Date	Access	State Plane N/S	Easting	Northing	Elevation	Location Description
Shi Shi	**Sarg**	Epoxy	4/19/2013	Hike	N	214551.1	149104.2	17.268	North of Shi Shi trail head on small headland with saddle. Monument is on a rock inland of the lowest point in the saddle. About 10 m. E and 5 m. above (elevation) the trail over the saddle at it's lowest point.
Shi Shi	**M-Kel**	Rod	4/19/2013	Hike	N	214627.1	148915.3	7.252	North of Shi Shi trail head about 50 m. In brush, about 3 m from wood line.
Shi Shi	**Petroleum**	Rod	4/19/2013	Hike	N	214200.3	146763.7	5.196	North side of Petroleum Creek (clearly marked on maps and aerial photos). There is a small trail from a campsite on the north bank of the creek (trail runs N/S). Monument is on west side of trail, ~5 m. west of large fir tree.
Shi Shi	**Mom**	Epoxy	4/19/2013	Hike	N	212971.6	145848.4	3.425	At the very southern end of Shi Shi, just north of a passageway through the taller rocks, on a rock approximately 2 feet above sand grade. The mark is in the center of a lighter spot on the rock (possibly a granite patch embedded in a sedimentary rock).
Sand Point	**Luna**	Epoxy	4/20/2013	Hike	N	211461	132408.6	4.003	On a rock just south of Sand Point. Stake this out, since there are so many small rocks.
Sand Point	**McNeill**	Rod	4/20/2013	Hike	N	211653.1	132340.8	4.546	When hiking out Sand Point trail, take the third beach access (first has a privy and is north of the point, second is very close to the point). Go through the camp site to access, and monument is north of the small beach access trail. On the east side of the driftwood, in a grassy area in the middle of three logs forming a rough triangle with ~1.5 m sides.
Sand Point	**Floyd**	Rod	4/20/2013	Hike	N	212387.3	131716.9	5.175	In the middle of the Sand Point pocket beach, there is a primitive trail heading back east to Lake Ozette. The trailhead for this trail is just north of a large creek (all clearly marked/seen on maps/aerials). Monument is about 0.75 m. SW of the target marking the trail in soil overgrown with brush and weeds.
Sand Point	**Reddog**	Epoxy	4/20/2013	Hike	N	212677.5	131044.2	2.881	At the south end of Sand Point, on a sedimentary rock that juts out of the sand.
Cedar Creek	**Redneck**	Epoxy	4/21/2013	Hike	N	213017.4	120691.1	3.725	on a rock at the base of the northern headland of this pocket beach. About 2 m. above beach level (must climb on rock to get control point). Rock is ~20 m SW of cave in the headland (follow the headland to the south). Best found by staking out, as it is not especially visible without climbing on the rock.
Cedar Creek	**Cedar**	Epoxy	4/21/2013	Hike	N	213123.4	120499.4	2.706	on large gray rock on north side of Cedar creek (northern-most creek on this pocket beach). Rock sticks up ~1.5 m above surrounding cobbles and water level.
Cedar Creek	**Starbuck**	Epoxy	4/21/2013	Hike	N	213279.5	120018.4	3.866	Hiking south from Norwegian Memorial trial, past headland and two monuments, cross Cedar Creek and continue south. Monument is on a large white rock ~500 m. north of second creek crossing. Near, but still north of, the Starbuck Mine site.
Cedar Creek	**Bliss**	Epoxy	4/21/2013	Hike	N	213287.1	119548.1	3.537	On top of a huge rock. South of where the tidelands become rocky. Likely, the area around this rock becomes innundated at high tide, but the top of the rock itself is unlikely to get wet. Definitely stake this out, since you cannot see it at all without climbing on top of the rock.

Beach/Survey Area	Name	Material/ Type	Installation Date	Access	State Plane N/S	Easting	Northing	Elevation	Location Description
Second Beach	**Miller**	Capped Rod	N/A	drive	N	215708.2	108050	8.367	In La Push, in front of the school house on Coast Guard Rd. There are two monument caps on a circular cement pad flush with grass. "Miller" is the one stamped with "Quilleyute R. CG Lot 1054 1069." Of the two monuments (about 5 feet apart), it is most SE. The divot is not in the geometric center of the brass cap.
Second Beach	**Stevens**	Epoxy	2/13/2013	Hike	N	216406.3	106004.7	2.354	On a rock pretty low on the beach (was innundated about two hours before an average high tide). Just south of the headland-type rock that is immediately south of the trail ending on Second Beach. When it was installed, monument sat about .5 m above beach (in winter), but in spring, we once saw this monument under about 10 cm of sand and once about 5 cm above ground.
Second Beach	**Kwalla**	Epoxy	2/13/2013	Hike	N	217688.9	104800.8	3.364	On a rock on the beach on the south end of second beach. Before the first "almost headland." Use GPS to stake this one out.
Ruby Beach	**Hoh**	Epoxy	2/12/2013	drive	N	230255.6	89499.93	4.475	At dead end of Lower Hoh Road, monument is in the middle of the turnaround circle. There is a fire hydrant, three red stacks, and a water line cover. Epoxy monument Is on the cement that surrounds the water line cover. RS spoke to David Hanna, public works director for the tribe. He was concerned about the hydrant being disturbed. Call before using as a control point to ensure integrity of position (360.374.6582 (office), 360.797.1797 (cell)). Stop by the tribal center before taking the point, just to check in.
Ruby Beach	**R-Sex**	Rod	2/11/2013	drive	N	231343.8	84917.57	34.797	When turning off 101, "driveway" to Ruby Beach bends right, with a picnic table on the left (water view). Monument is in the brush, about 8m w, 9 m west of picnic table. Follow a trail behind the table to the west, then south, then monument will be on your left (you're walking south). In winter, monument is situated in ~6-7 ft tall brush/twigs. This is a high bluff site. In spring, we found that the monument site had been completely overgrown. It required about an hour of machete work to attain satelite coverage.
Ruby Beach	**Saddle**	Epoxy	2/12/2013	drive	N	231597.4	82967.31	39.471	In center of pullout, monument is on cement pad, used to support a sign that has now been removed (two stumps of supports remain).
Kalaloch/Ruby	**H-Bar**	Rod	2/12/2013	drive	N	231931.1	81820.51	22.551	At unmarked parking lot, monument is down near viewing area (Destruction Island Overlook), 2 m E of southernmost fence post of guard rail (most seward rail). In the midst of vegetation that was cut down in winter, but rebounded in spring (meaning you might want a machete or clippers). High bluff.
Kalaloch	**Seyk**	Divot	2/11/2013	drive	N	233571.3	75517.62	20.313	On overlook, north of large yellow sign. Monument is a divot in the southern end post (I-beam?) of the guard rail.
Kalaloch	**Klodge**	Divot	2/12/2013	drive	N	233884.8	73319.63	12.758	From gazebo, monument is about 20 m east. Small divot in the westernmost edge of a rusty steel manhole cover on a sewer pipe.
Kalaloch	**Liandra**	Epoxy	2/12/2013	drive	N	234620.9	69057.09	12.491	Entering South Beach Campground, at the southern tip of the grassy island in the middle of two drives. Monument is on the NE corner of the cement pad.

Appendix B – Driving Directions

Monument/Trailhead	Time from ECY	Suggested lodging	Beach Access?	Directions
Shi Shi Trailhead	4:21	Sekiu	yes	West on 112 toward Neah Bay. Drive through Neah Bay on 112, following signs for Cape Flattery (you'll be on Cape Flattery Road). Approximately 2.5 miles after leaving town, turn left over a bridge on Hobuck Rd. Follow signs to fish hatchery. Shi Shi trail is marked, and is 2 driveways before hatchery.
Sand Point Trailhead	4:23	Sekiu	yes	West on 112, following signs for Ozette. Left onto Hoko-Ozette Road, follow until it ends at Ozette Ranger Station.
Cedar Creek Trailhead	4:05	Forks	yes	From 101, north of Forks, go west on La Push Rd. Right on Quillayute Rd. Right on Mina Smith Road, next to Quillayute Prarie Cemetary, go 0.7 miles. Left on gravel road (5000 line), travel 4.6 miles (at 0.9 mi: bridge over Dicky River, stay right; at 2.3 miles: another bridge; at 2.4 miles: junction with 5500 road, stay right). Left on 5600 road, travel 4.4 miles (at 1.4 miles: locked blue gate, stay right; at 3.0 miles: another locked blue gate, stay right; at 4.0 miles: an ungated dirt road, stay right; at 4.3 miles: bridge over Cedar Creek). Left at locked blue gate, travel 0.5 miles up rough gravel hill. Park at second parking aera on right. NOTE: bring GPS and topo/logging maps. 5600 road is often closed, but other logging roads can get you to the trailhead. 4wd and high clearance suggested.
Miller	3:23	Forks	yes	North of Forks on 101, go west on La Push Rd all the way into La Push. Continue straight onto Front Street, then straight on to Coast Guard. Monument is in front of the school house.
Second Beach Trailhead	3:21	Forks	yes	North of Forks on 101, go west on La Push Rd for ~11.7 mi. Second beach is the second trailhead on left (S).
Hoh	2:39	Forks/Queets	yes	On 101, follow signs to the Hoh Tribal Center (they will lead you west on Lower Hoh Rd). Follow Lower Hoh all the way to the beach, where there is a roundabout with monument in the center.
R-Sex	2:30	Forks/Queets	yes	Take 101 to Ruby Beach, but stop just after turning off highway. Monument is in bushes near picnic table near 101.
Saddle	2:27	Forks/Queets	no	N on 101, 0.8 mi north of H-Bar and Steamboat Creek, on a pullout west of the highway, overlooking Destruction Island.
H-Bar	2:27	Forks/Queets	no	S on 101, 0.4 mi after NPS Rd 1436, unmarked driveway to parking lot on west side of road. Lot is just north of a Steamboat Creek, and about 5.5 mi north of Kalaloch Lodge.
Seyk	2:23	Forks/Queets	no	N on 101, ~1.2 mi north of Kalaloch Lodge. Monument is on a pullout west of the highway. A big yellow sign facing north says "CAUTION, left turns for 1 mile."
Klodge	2:21	Forks/Queets	yes	On Kalaloch Lodge premises. Park at the gazebo near the beach.
Liandra	2:18	Forks/Queets	yes	N on 101, ~2.2 mi north of the Queets River, turn west (left) into "South Beach Campground"

Appendix C – Hiking Directions

Trailhead	Trail Length (1-way)	Beach Length	Hike Time	Description	Notes
Shi Shi	2 miles	2.5 miles	1:00	Trail is well marked. Trail head is signed with NPS signs, and has a drop pit at parking lot. Wide trail is easy to follow. Big hill climb directly off the beach. Trail drops you out at the north end of Shi Shi.	Super duper muddy. While we were on the beach, someone drove something wheeled and mechanized on the trail behind us. Investigate how this was done/where it came from??
Sand Point	3 miles	1.5 miles	1:15	From ranger station, follow signs to "beach trails." At ~0.3 miles, at the Y in the trail, choose south to Sand Point. Boardwalks make up most of the trail, with gravel and dirt for the last ~0.8 miles (?).	Boardwalk. Very slippery when wet, and rather rough on the body - lots of pounding.
Cedar Creek	1.5 miles	1 mile	1:00	Trail head is marked with striping on trees (from parking area, trailhead is located opposite side of the road, back toward where you came). Follow the trail for about 1 mile over mud and tree roots and down some hills (trail is very clear and easy to follow, well traveled). You will be dumped out in a big camp ground with privy and fire pits. Cedar Creek site is south on the beach, around the visible headland (about .3 miles ish). The headland has an over-head trail with ropes and ladders, but you can get around on the beach at anything lower than about a 5 foot tide.	Muddy. A bit of elevation gain to get back to trailhead. We saw a lot of cougar tracks and some warm cougar skat once while out there - carry a stick, make noise, and bring bear spray.
Second Beach	0.8 miles	1.3 miles	0:30	Trail is very easy to follow. A bit of a hill at the end, but not rigorous.	

Appendix D – Data Collection Statistics by Survey Site

Survey Area	Monuments placed	Coastline length (km)	Number of Profiles Walked	Spacing (m)
Shi Shi	4	3.93	38	100
Sand Point	4	2.74	18	100
Cedar Creek	4	1.85	19	100
Second Beach	2	2.22	32	100
Ruby Beach	4	2.08	17	100/150
Kalaloch	3	3.04	30	100

Appendix E – Maps

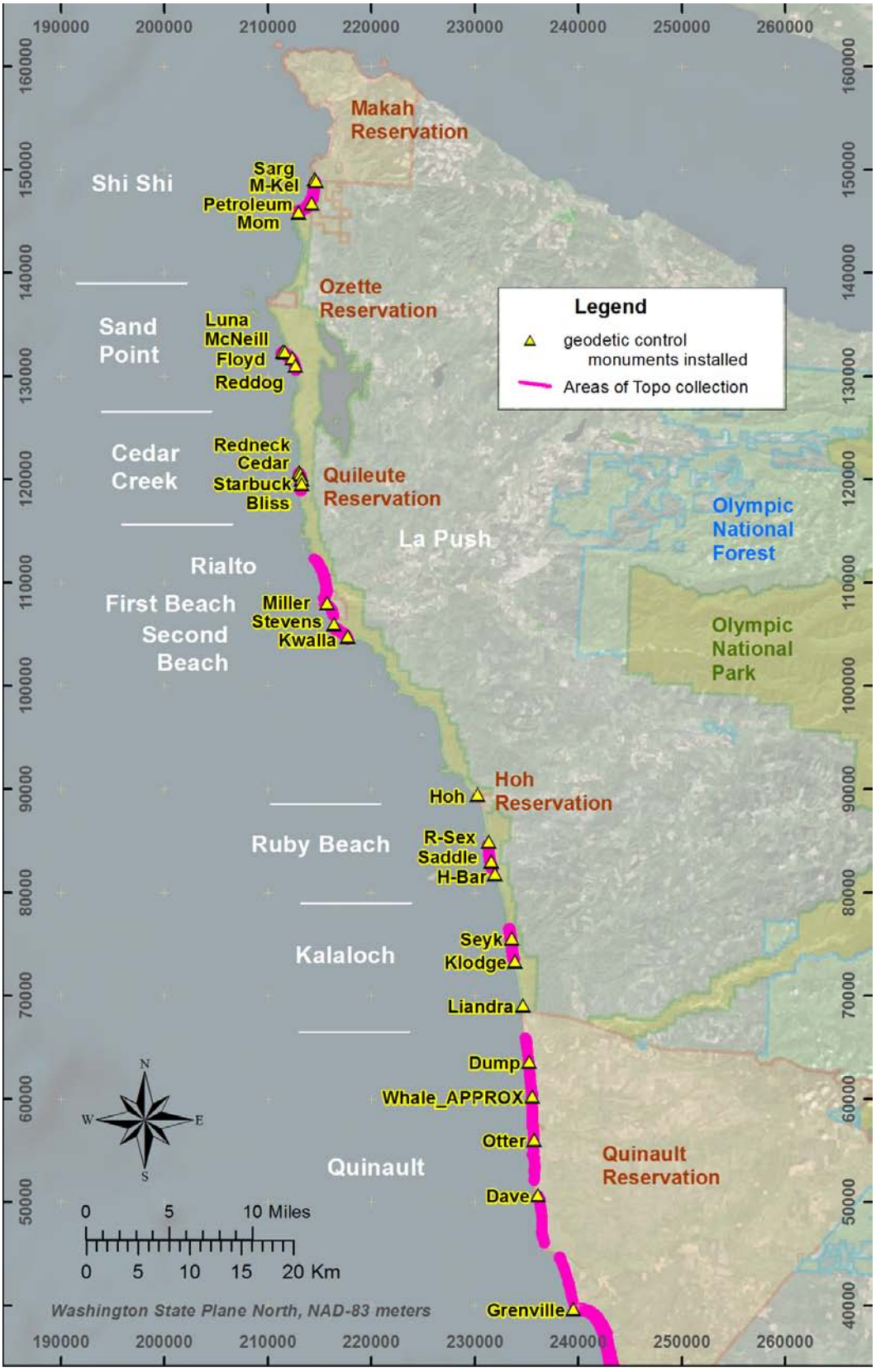

Figure 1. Overview of geodetic control and beach profiles walked north of Point Grenville.

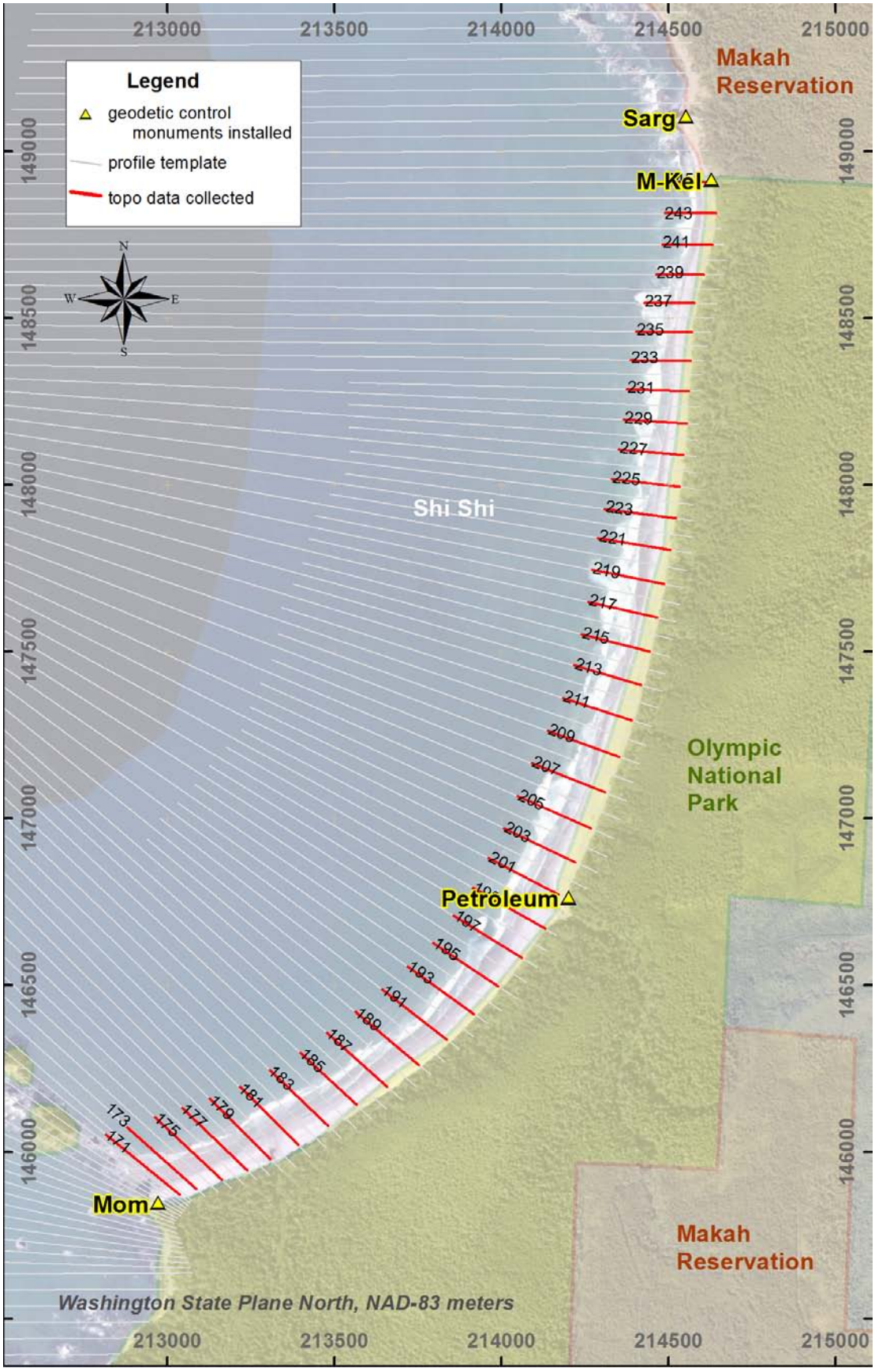

Figure 2. Monuments installed and beach profiles walked (in red) in the Shi Shi Beach study area.

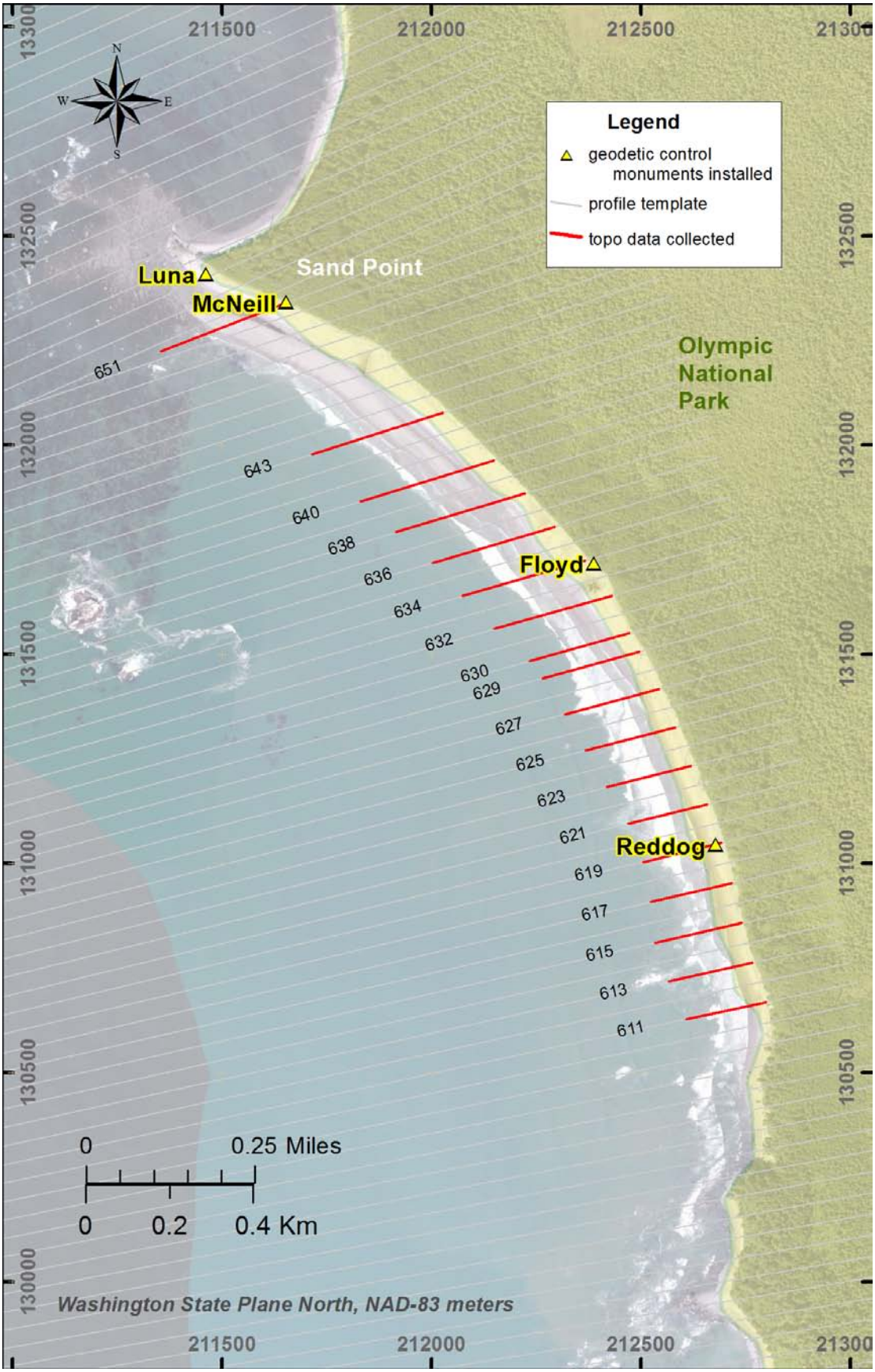

Figure 3. Monuments installed and beach profiles walked in the Sand Point survey area.

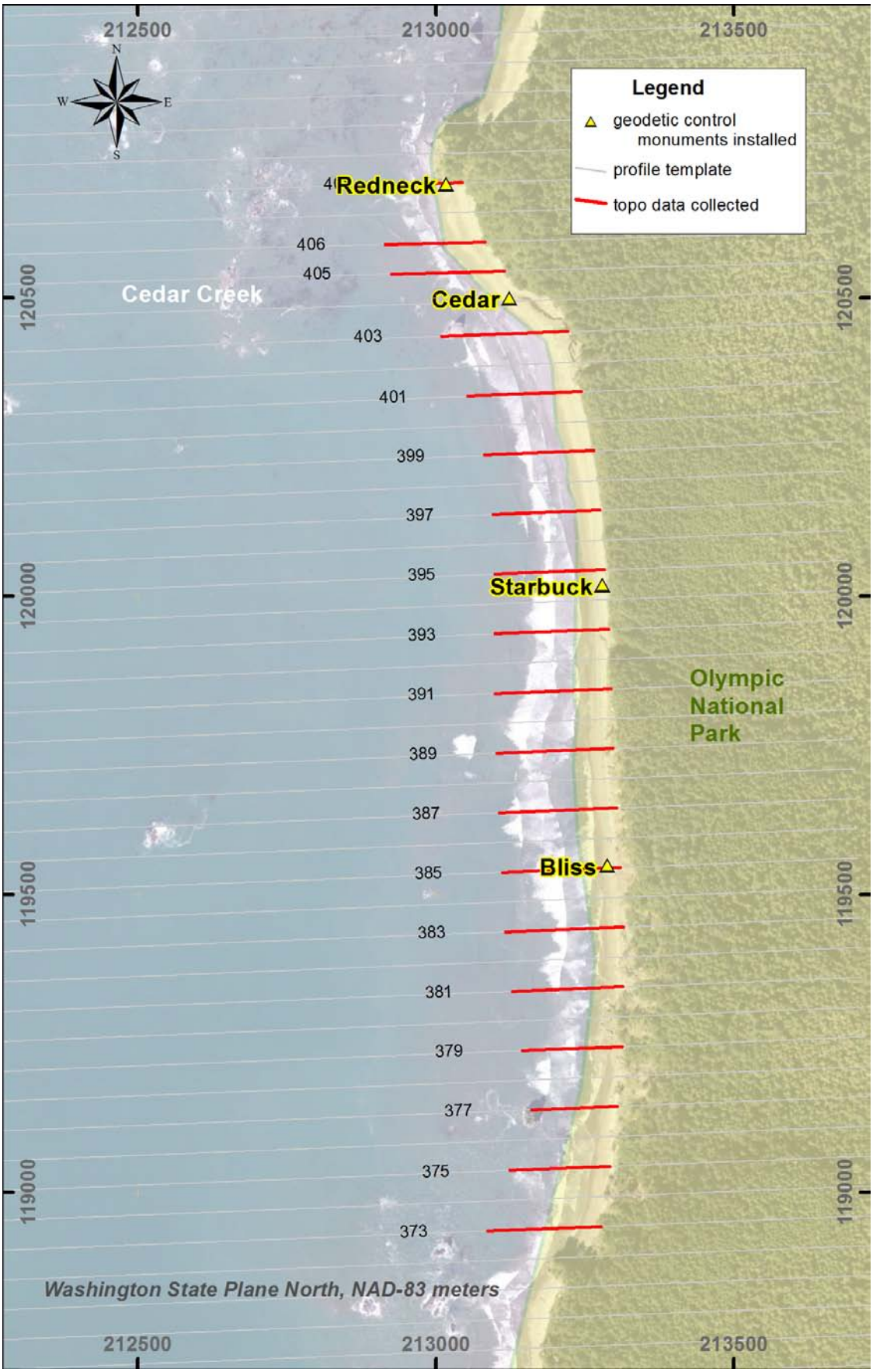

Figure 4. Installed monuments and beach profiles walked (in red) in the Cedar Creek survey area.

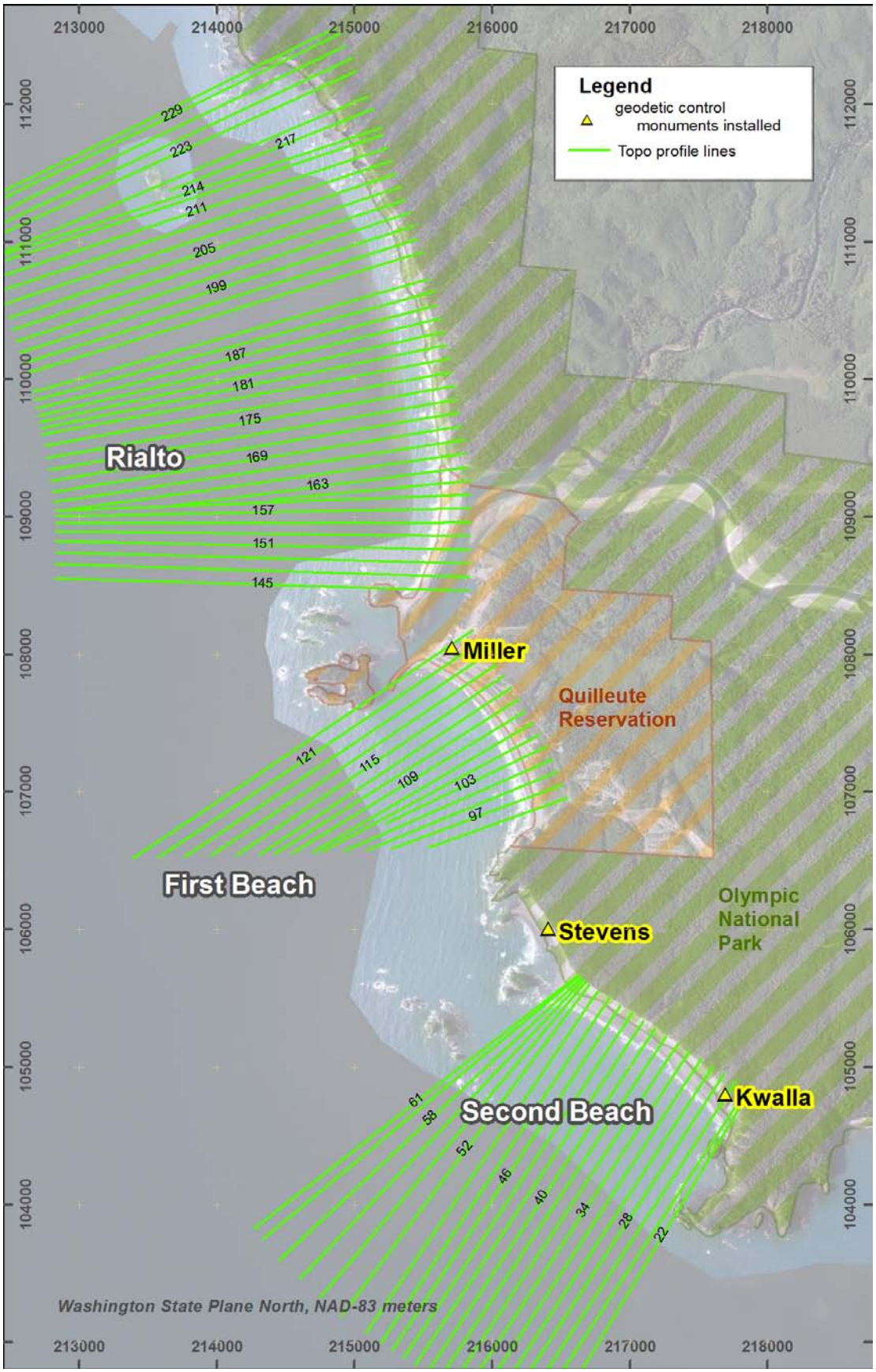

Figure 5. Monuments installed and beach profiles walked in the La Push area.

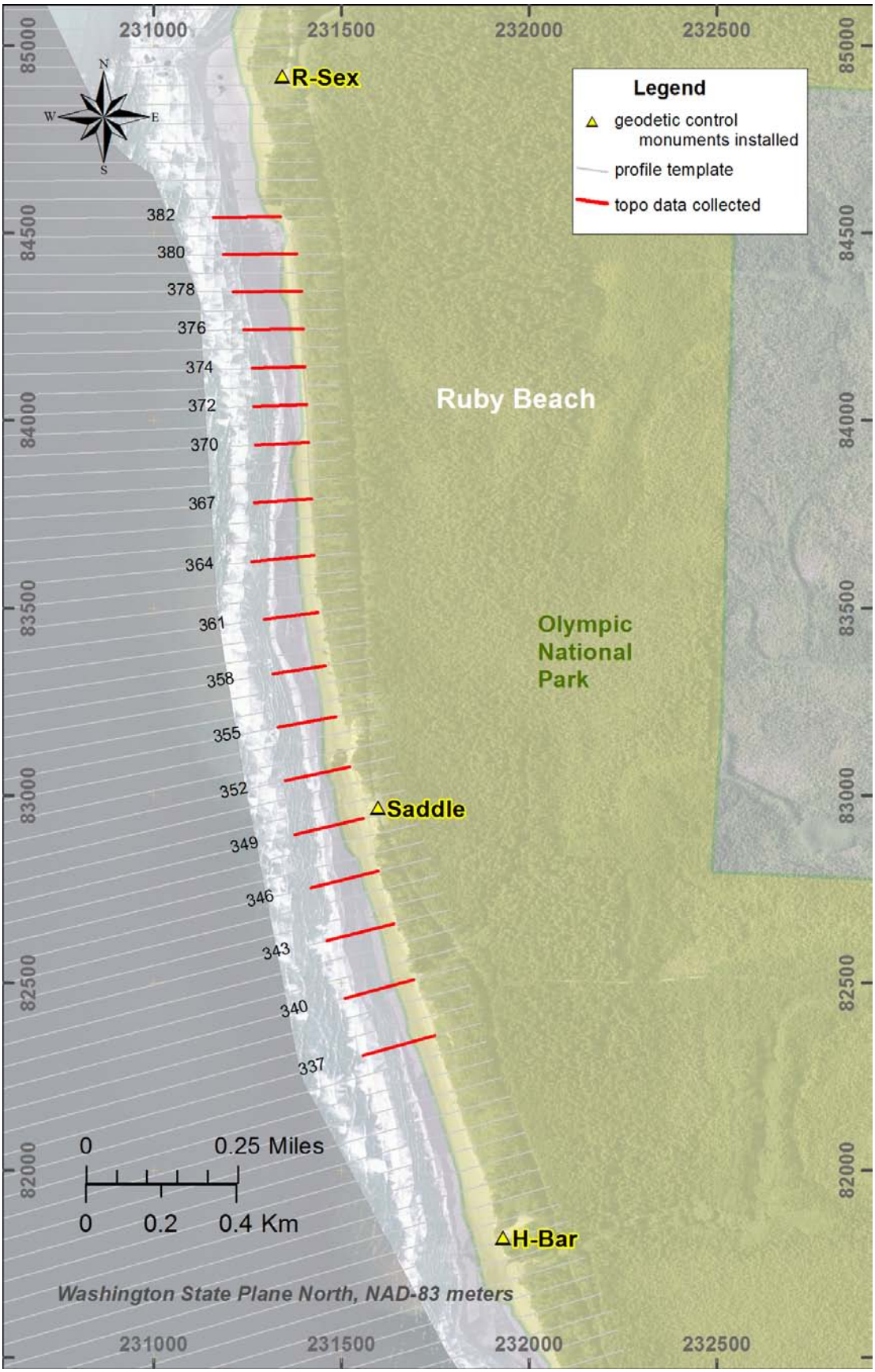

Figure 6. Monuments installed and profiles collected at the Ruby Beach survey site.

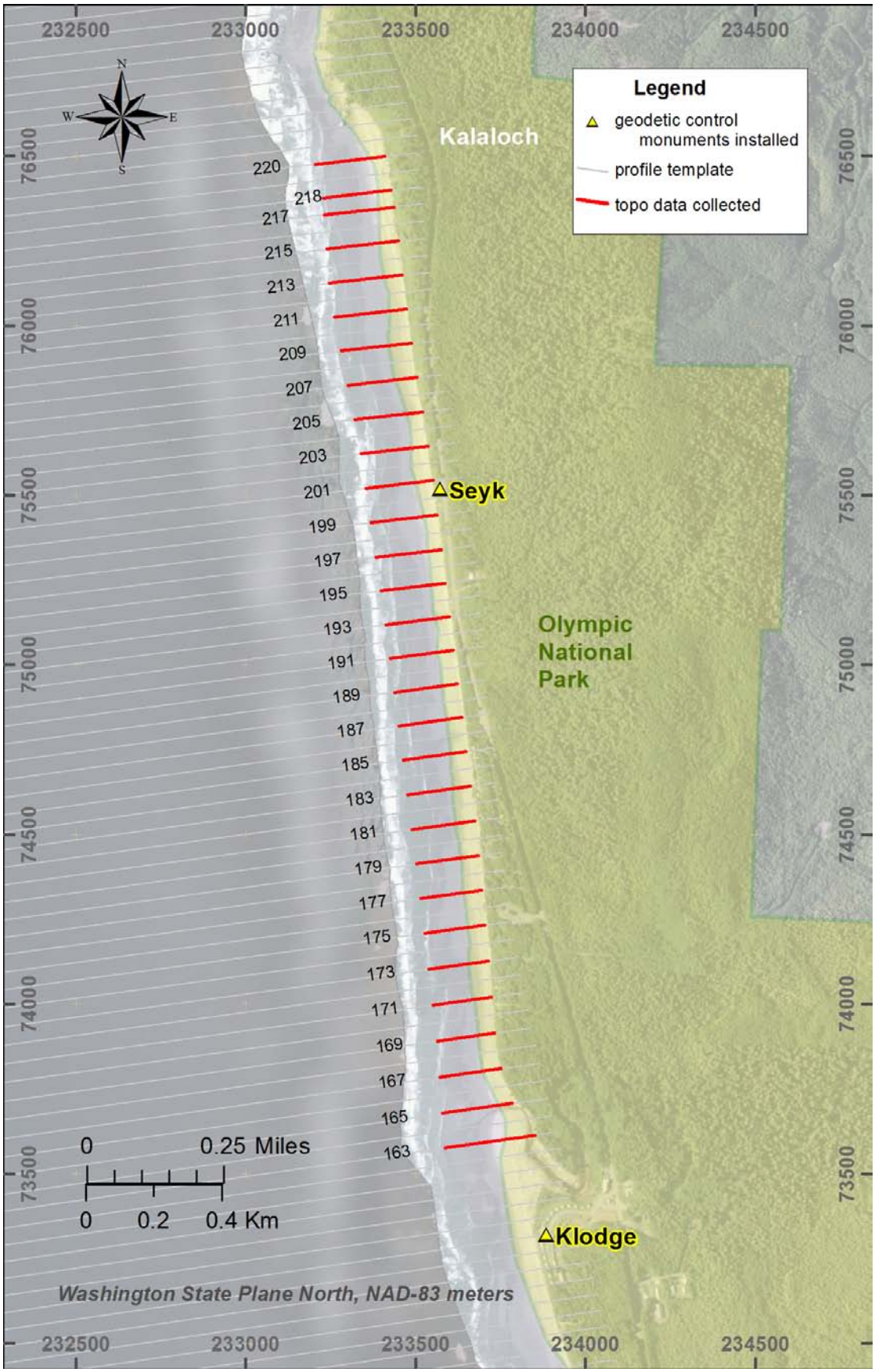

Figure 7. Monuments installed and beach profiles collected in the Kalaloch study area.

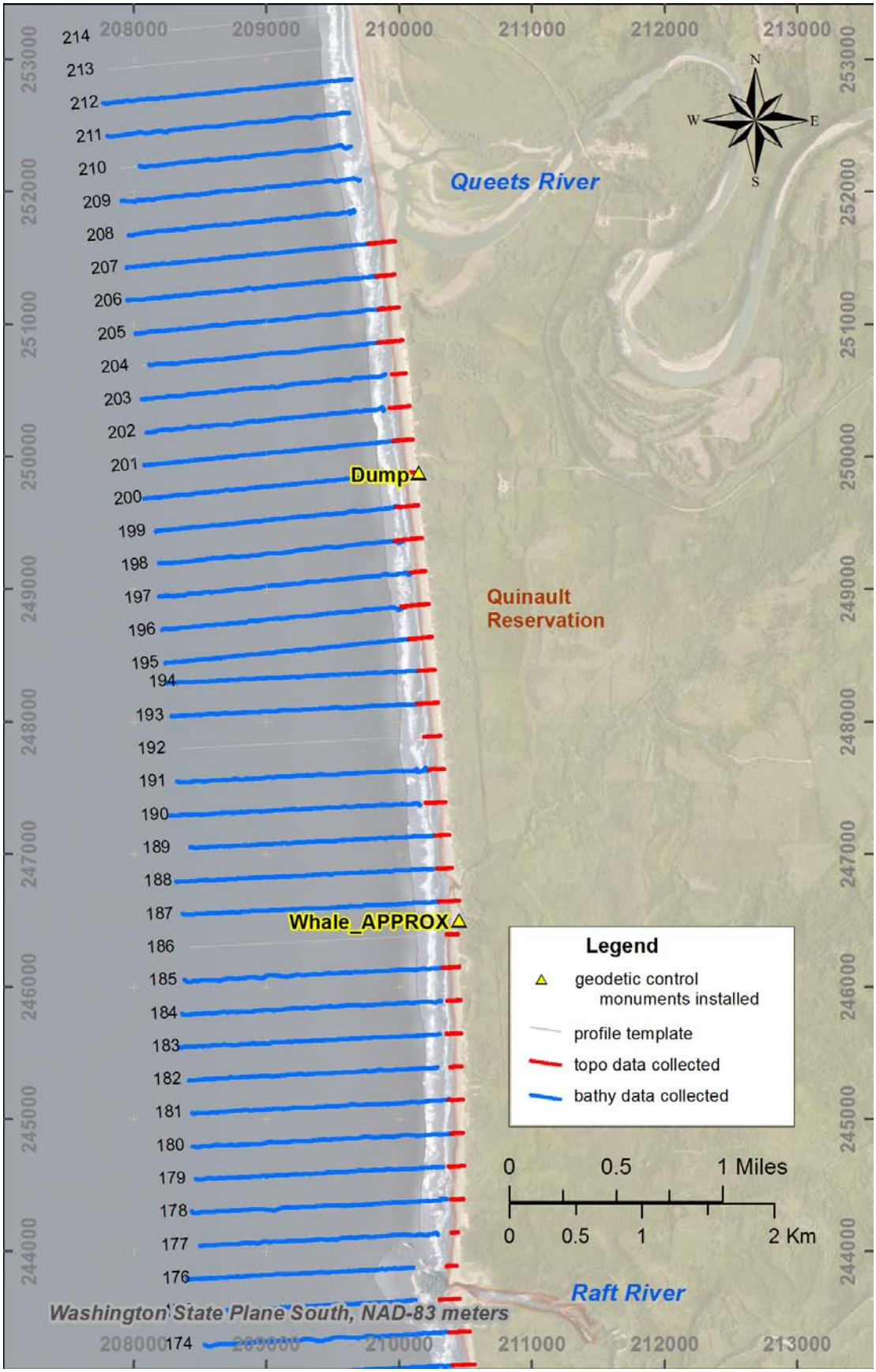

Figure 8. Monuments installed and beach profiles walked in the northern section of the Quinault Indian Reservation.

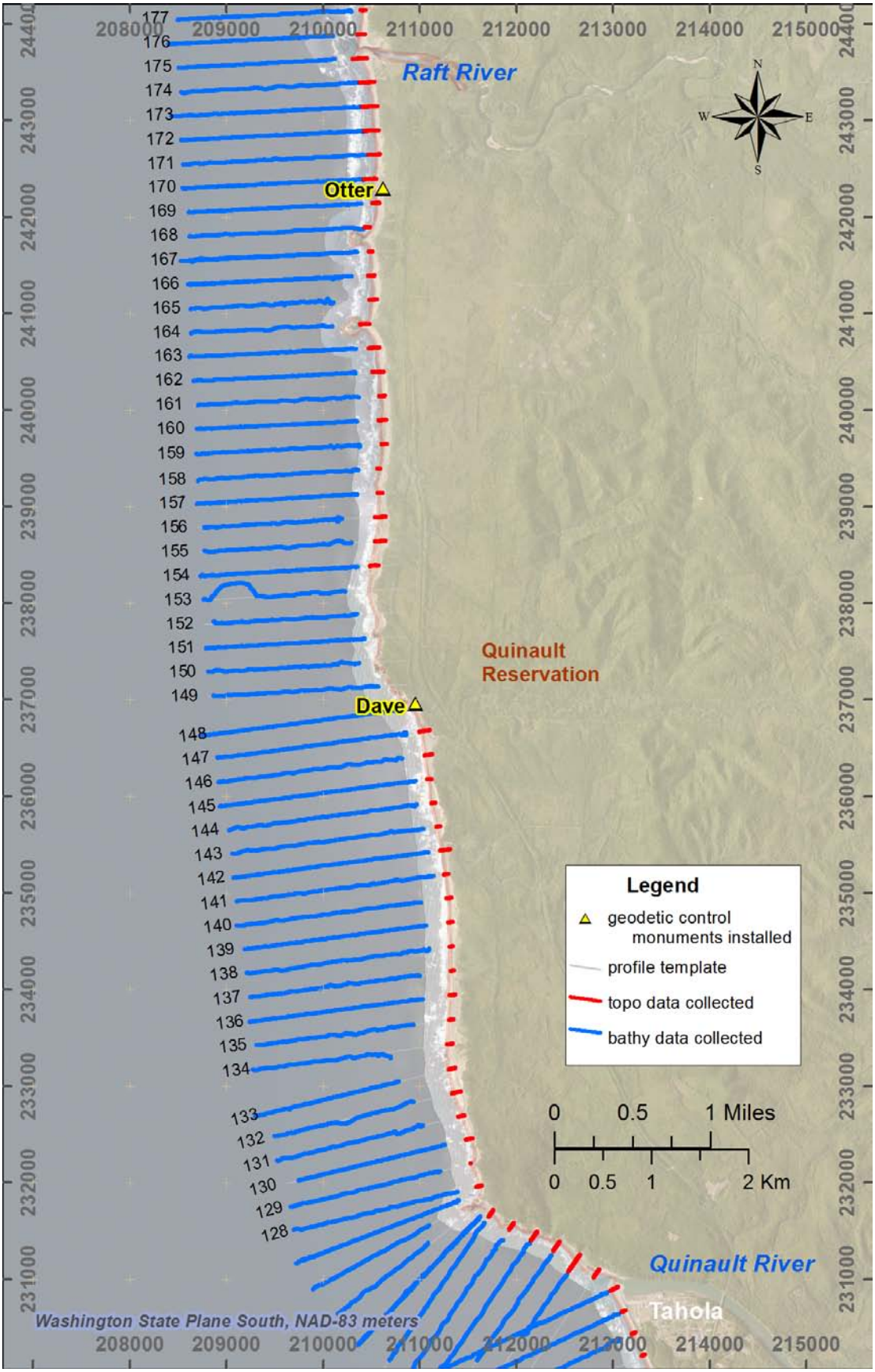

Figure 9. Geodetic monuments installed and beach profiles collected in the central Quinault Indian Reservation.

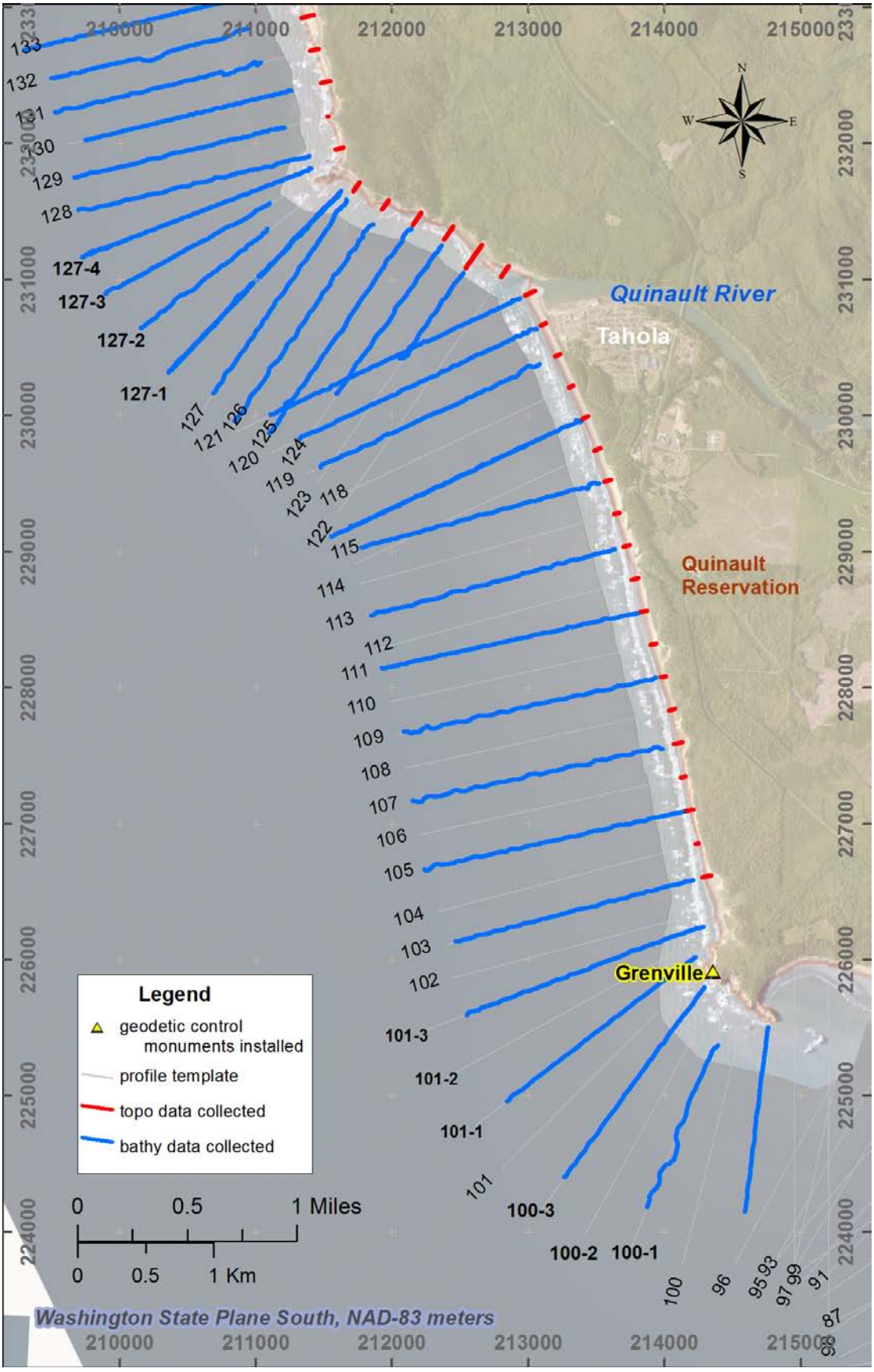

Figure 10. Monuments installed and profiles collected in the southern Quinault Indian Reservation.

Appendix F – Photos

Figure 11. In the field, we consulted our in-office plans and visited all possible installation sites to choose the best locations. This was most important in Kalaloch, where we counted on ranger Li Clinton for local knowledge (center).

Figure 12. A finished rod monument sits almost flush with the ground and has a small divot drilled in the center to hold a tripod tip. Each rod marker has feet of aluminum or steel rod beneath the surface.

Figure 13. Epoxy monuments installed quickly; we mixed the epoxy wearing wet rubber gloves and adhered it to a clean section of rock or concrete. Our epoxy was dark green/gray and blended in with the rocks, making it hard to spot for park visitors.

Figure 14. "Sarg," is on the saddle at the north end of Shi Shi beach. Photographed from the south.

Figure 15. "Sarg" viewed from above (east).

Figure 16. "M-Kel" is just north of the Shi Shi trailhead, at beach level, but behind the grass line.

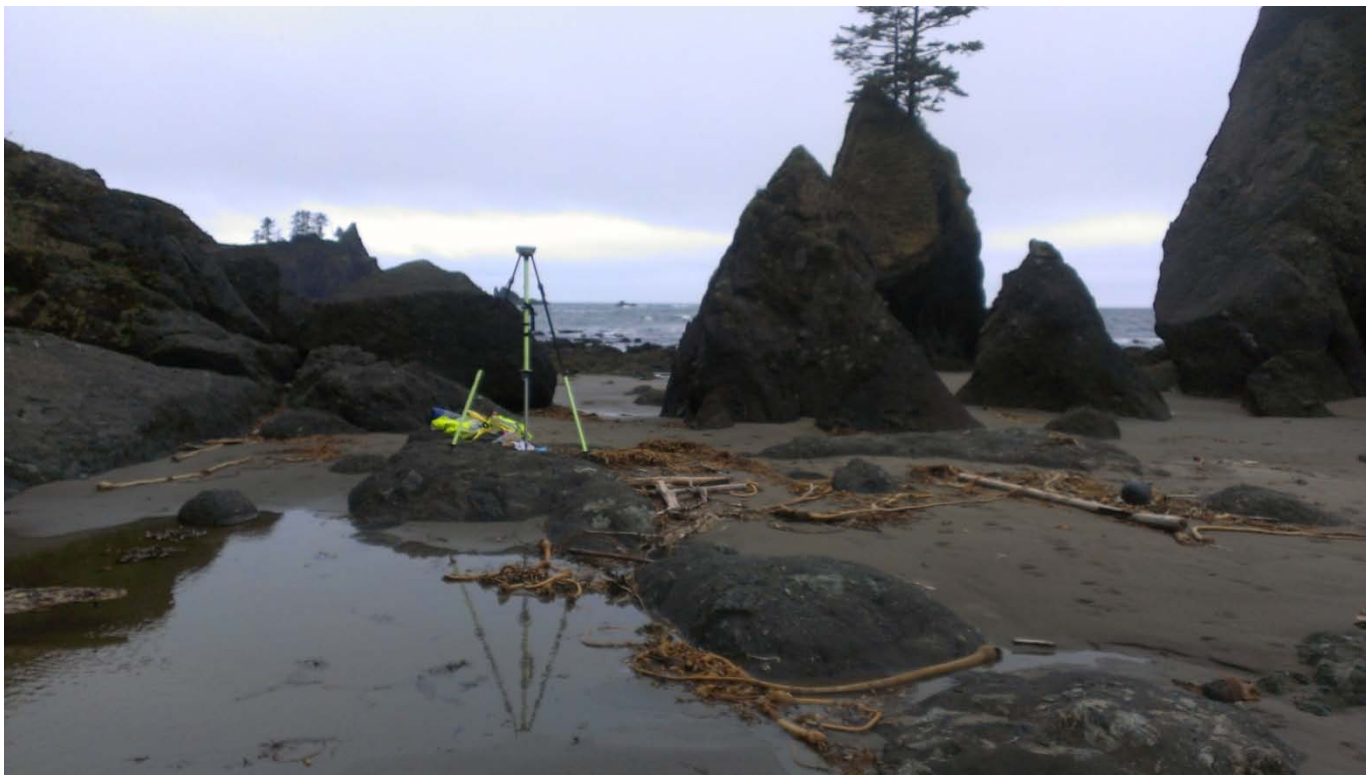

Figure 17. "Mom" is on the south end of Shi Shi beach. Viewed here from the north

Figure 18. "Luna" is just south of Sand Point. Viewed here from the south, the marker is near the large grassy knoll (visible in the background of the photo).

Figure 19. "McNeill" is behind the driftwood line, on the northern end of Sand Point survey area.

Figure 20. "Floyd" is in front of the trail marker for the primitive trail to Ericson's Bay on Lake Ozette.

Figure 21. "Reddog" is at the south end of the Sand Point survey area. It is viewed here from the north.

Figure 23. "Redneck" is on the headland marking the north end of the Cedar Creek survey area. Viewed here from the south.

Figure 22. "Redneck" viewed from the west; the over-headland trail, ending in a ladder, is visible just south of the monument.

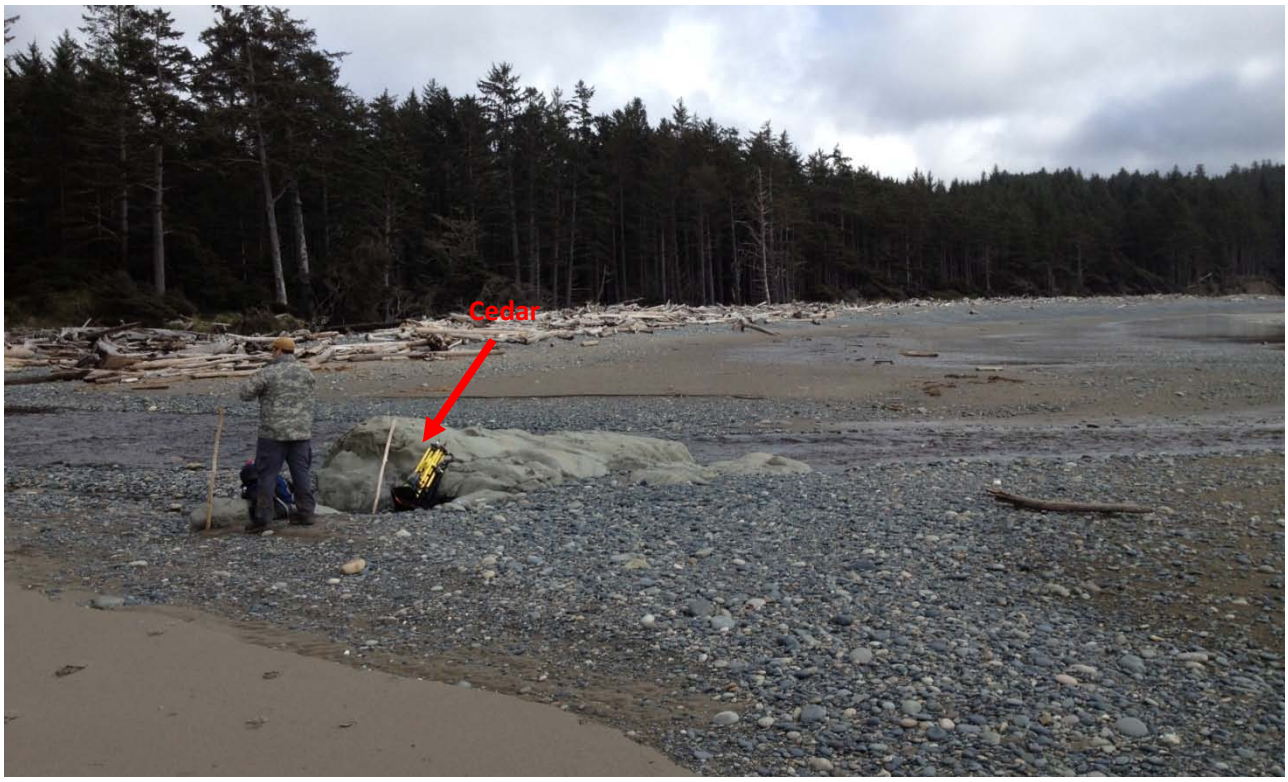

Figure 25. "Cedar" is on the large rock north of Cedar Creek. Shown here from the north.

Figure 24. "Starbuck" is just north of Starbuck Mine at the Cedar Creek survey area. Viewed here from the south.

Figure 26. "Bliss" viewed from the south.

Figure 27. "Bliss," viewed from above, an epoxy monument on top of a very large rock.

Figure 29. "Miller" is in front of the schoolhouse in La Push. There are two markers here, but we chose to use the one on the round concrete pad (the other is on the square shown behind the tripod in this photo).

Figure 28. "Stevens" is south of the trailhead on Second Beach. Viewed here from the south, it became inundated at high tide.

Figure 31. "Kwala" is on the south end of Second Beach, north of the first mini headland (passable at higher tides). It is viewed here from the south.

Figure 30. "Hoh;" next to a fire hydrant near the Hoh River mouth.

Figure 32. "R-Sex" is down this path and to the left. The path was very overgrown when the monument was revisited in Spring. Photo was taken in February.

Figure 33. "R-Sex" is not visible from the Ruby Beach driveway during Spring, but in February, we could glimpse safety-yellow rain jackets through the brush.

Figure 34. "R-Sex" is surrounded on all sides with brush, which was too thick to see or get good GPS signal through in Spring. We needed a machete to clear brush from the area.

Figure 35. "Saddle," on a pullout overlooking Destruction Island and the "saddle" landform, is epoxy on an old interpretive sign support.

Figure 36. "H-Bar" viewed from the east. The entire brown area on the left side of the photo was overgrown with blackberry bushes in Spring. Reaching the monument would require some extensive pruning.

Figure 37. "Seyk" viewed from the north. The monument is a divot in the last guard rail support, a metal I-beam.

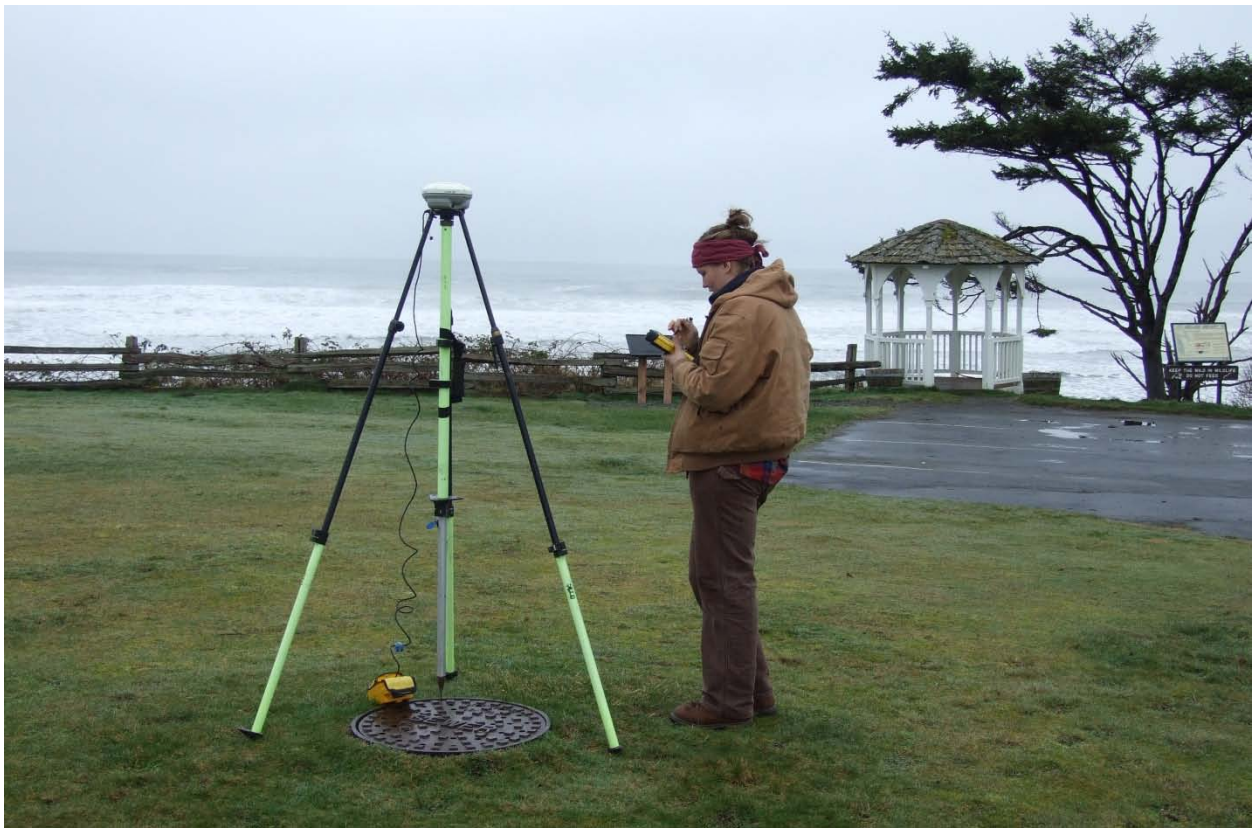

Figure 38. "Klodge," on the grounds of the Kalaloch Lodge, viewed from the east.

Figure 39. "Liandra," in South Beach Campground, viewed from the southeast.