Appendix E: Geology of the Skamokawa Area

E.1 Bedrock

The Pacific Northwest has been dominated by plate convergence for at least 60 Ma.[1] The Willapa Hills, like the Siletzia terrane in general, is built of Tertiary marine sedimentary rocks deposited over submarine and oceanic-island basalts, which have been accreted by subduction of the Kula–Farallon and (lately) Juan de Fuca plates beneath the North American plate. Around the uplifted core of volcanics, the coastal mountains expose older Paleogene to Neogene sedimentary and volcanic rocks that have been deposited in the forearc. Uplift and crustal deformation created a complex mountain structure of these materials; hydroclimatic and geomorphic processes have carved it all into an intricate landscape over a long history of erosion by water and mass wasting.

Basalts of the Crescent Formation, erupted on mid-ocean ridges to oceanic islands, form the crustal foundations of the coast ranges. They date to the early Eocene epoch (regionally ~64–46 Ma, but in this area ~50 Ma). Along with associated marine sediments, this sea-floor or rifted-margin terrane was accreted to the continent ~46–42 Ma, causing reorganization of the plate margin. From then through the Miocene, a variety of sediments and volcanics were deposited on a generally shoaling forearc shelf.

Continent-derived sands and silts now designated as several local rock units[2], collectively called the Cowlitz sequence (Armentrout, 1987), were deposited around the Crescent highs through most of the Eocene (~43–38 Ma). During this period, local volcanoes were producing the basaltic flows, breccias, tuffs, and related intrusions of the Grays River Volcanics. The volumes and characteristics of the sediments varied with fluctuations of sea level, eruption locations and rates, and the delivery of sediments from the east. Regional deformation near the end of the Eocene, perhaps associated with the beginning of Cascade arc magmatism, caused uplift and erosion in the Willapas. Deposition of the extensive Lincoln Creek Formation accompanied marine transgression in the Oligocene, with sandstones and siltstones containing large proportions of tuffaceous materials derived from Cascade eruptions. Another period of structural deformation beginning ~23 Ma (earliest Miocene) folded and faulted the rocks, and brought much of the coast range province above sea level. From then on, marine waters were restricted to embayments around the lower Columbia and Grays Harbor, where sediments of the Astoria Formation were deposited.

Lava floods of the Columbia River Basalt Group arrived in the region ~17–12 Ma, erupting from vents far to the east and flowing through several valleys toward the sea. East of Skamokawa the CRBs are dominantly subaerial flows[3], but west to the coast they are chiefly dikes and sills formed when the dense lavas flowed into and through the unconsolidated marine sediments (invasive flows of Beeson and others, 1979); both kinds are found in the Skamokawa WAU. Miocene and later deformation further restricted marine deposition, and apparently no sedimentary units younger than Astoria are identified on land in this basin. Uplift in the late Pliocene and Quaternary (<5 Ma) raised the coast ranges into their present elevations.

---

[1] Various parts of the study area were mapped by Wolfe and McKee (1968) and Wells (1981), among others, with additional work for compilation of the 1:100,000 quads (Walsh, 1987). More detailed information can be found in these publications; a summary of regional geology is also contained in Armentrout (1987).
[2] Including the sandstone of Skamokawa and various unnamed or uncorrelated sedimentary units.
[3] Near Cathlamet, CRBG rocks include at least 10 flows of the Grande Ronde subgroup, at least two flows of the Wanapum (Frenchman Springs Member), and the Pomona Member of the Saddle Mountains subgroup (Wells and others, 1989).

E.2 Structure

Compression and folding have occurred mainly perpendicular to the major NE–SW direction of plate convergence. The bedded rock layers generally dip moderately away from the volcanic core of the Willapa Hills, meaning SW to SE in the basins on the southern flank. However, this regional dip is interrupted by several subparallel folds[4] and faults, commonly striking NW–SE. These trends can be seen as structural landforms, including many elongate ridges and valleys, and consequent dip- and scarp-slopes on cuestas. The area is cut by many mapped faults, principally parallel to the NW–SE grain but also conjugate to it.

Tectonism remains active in southwest Washington, due to continuing convergence of the Juan de Fuca and North American plates along the offshore Cascadia subduction zone. Great earthquakes (up to magnitude 9+) occur along the plate margin at average recurrence intervals of several centuries, most recently on 26 January 1700 (Atwater, 1997). The cycle of strain build-up and release causes differing amounts of uplift and subsidence in bands parallel to the subduction zone, evidence of which has been observed in tidal marshes along the Columbia River and Willapa Bay, but probably extending far inland. Besides these coseismic cycles, there appears to be some continuing long-term uplift in the Willapa Hills, as suggested by old beach and estuarine deposits along the Washington coast now raised several hundred feet above present sea level.

E.3 Surficial Geology

Multiple episodes of colder climate and glaciation affected western Washington during the Quaternary. Although not glaciated in any great extent, the Willapas were affected by these global ice ages. Climatic cooling changed atmospheric circulation patterns such that the regional climate was drier; in addition, depression of sea level widened the continental shelves, moving the hills about 25 mi farther from the ocean. The glacial-age Willapas may have experienced lower rates of weathering than they do during interglacial times.

During full glacial periods (such as the Fraser glaciation, ~30–15 ka), the Columbia River flowed through a narrow canyon ~300 ft below present sea level[5], and this lowering of base levels induced downcutting of its tributary streams such as Skamokawa Creek and the Grays River, particularly in their lower reaches. The increased relief along these incised valley walls almost certainly produced higher rates of landsliding (despite any changes in precipitation). Then, as sea levels rose after each glaciation (most recently, ~15–5 ka), fluvial, marsh, and tidewater deposits were built out at the new higher grades, eventually refilling most of the stream valleys, with just the Columbia estuary and Willapa Bay remaining open. The map patterns of recent alluvium suggest the probable extent of ice-age incised valleys in the lower Naselle, Grays and Deep rivers, and along Skamokawa Creek[6]. Terraces of older alluvium and estuarine deposits along the larger valleys, rising to ~100–200 ft elevation, are probably indicators of previous high stands of sea level, but tectonically raised since earlier interglacial stages.

The soils mantling the study basin reflect their parent materials, and a long history of subaerial weathering in a humid temperate climate. SCS soil mapping (Pringle, 1986; now NRCS) shows that they are mostly moderately to very deep; upland residual and colluvial soils are generally well drained, but those in the floodplains are poorly drained. Textures are typically silt loam, silty

[4] Such as the Wilson Creek anticline of Wells (1981).
[5] Thus, the surface of Missoula Flood waters was probably below current sea level in this area.
[6] With perhaps a bedrock sill and former waterfall in the gap at the mouth of Skamokawa Creek.

clay loam, silty clay, and loam, reflecting the common siltstone and sandstone parent materials, with gravelly subsoils in areas underlain by volcanic rocks.

E.4 References

Armentrout, J. M., 1987, Cenozoic stratigraphy, unconformity-bounded sequences, and tectonic history of southwestern Washington: p 291-320 *in* Schuster, J. E., ed, Selected papers on the geology of Washington: Washington Division of Geology and Earth Resources, Bulletin 77, 395 p

Atwater, B. F., 1997, Coastal evidence for great earthquakes in western Washington: U.S. Geological Survey, Professional Paper 1560, p 77-90

Beeson, M. H.; Perttu, R.; Perttu, J., 1979, The origin of the Miocene basalts of coastal Oregon and Washington; an alternative hypothesis: Oregon Geology, 41(10)159-166

Pringle, R. F., 1986, Soil survey of Grays Harbor County area, Pacific County, and Wahkiakum County, Washington: USDA Soil Conservation Service, 296 p + plates

Walsh, T. J., 1987, Geologic map of the Astoria and Ilwaco quadrangles, Washington: Washington Division of Geology and Earth Resources, Open File Report 87-2, 30 p, scale 1:100,000

Wells, R. E., 1981, Geologic map of the eastern Willapa Hills, Cowlitz, Lewis, Pacific, and Wahkiakum Counties, Washington: U.S. Geological Survey, Open File Report 81-674, scale 1:62,500

Wells, R.E.; Simpson, R.W.; Bentley, R. D.; Beeson, M. H.; Mangan, M. T.; Wright, T. L., 1989, Correlation of Miocene flows of the Columbia River Basalt Group from the Columbia River Plateau to the coast of Oregon and Washington: p 113-129 *in* Reidel, S. P., Hooper, P. R., eds, Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America, Special Paper 239, 386 p

Wolfe, E. W.; McKee, E. H., 1968, Geology of the Grays River quadrangle, Wahkiakum and Pacific Counties, Washington: Washington Division of Geology and Earth Resources, Geologic Map GM–4, 6 p, scale 1:62,500

Appendix F: Vegetation, Land-Use and Historic Considerations

F.1 Vegetation and Disturbance

The Willapa Hills region spans the *Picea sitchensis* Zone on the west and the *Tsuga heterophylla* Zone on the east (Franklin and Dyrness, 1973). Sitka spruce and western hemlock are the climax tree species in these vegetation zones, but Douglas-fir and western redcedar are codominant conifers in old forests as well as common plantation species. Angiosperm trees and shrubs (red alder, bigleaf and vine maple, huckleberry, salal, devil's club, etc.) are common in the understory and in younger stands (particularly in disturbed areas), as are a great variety of ferns, forbs, and herbs. Most sites would support conifer forests, but some tracts would naturally be hardwood stands, such as oak–madrone and riparian woodlands; or unforested, in the floodplains and marshes

Despite the wet climate, the Willapas have been susceptible to forest fires of various sizes and intensities, caused by agents both natural (lightning) and human, usually during the hotter and drier summers. However, the natural fire-return period is about 1000 yr in the coastal Sitka spruce zone, and many centuries in the hemlock zone (Agee, 1993). High winds seem to be more common disturbance agents on the coast, with regional blowdown frequency of about one to four centuries.

In the study area, forest survey mapping in 1900 (Gannett, 1902) showed areas of burned lands within about 3 mi of the Columbia from Grays Bay almost to Skamokawa, and smaller burns in upper Wilson Creek, on the Skamokawa–South Fork Grays divide, and around Grays Bay. However, the map also indicated many mature (uncut) stands having lower estimated timber volumes than the regional maximum, and it is likely that many of these were recovering from earlier fires. The forest map from the 1930s (Andrews and Cowlin, 1936) showed a few small burns scattered around the southwest Willapa Hills, none of them in the Skamokawa WAU[1] (although some areas mapped by Andrews and Cowlin as "nonrestocked cutovers" may have been old burns). In addition, we observed dozens (hundreds?) of small, scattered blowdown sites in those photos, certainly from the (then) recent Columbus Day storm of 1962.

F.2 Settlement and Land Use

This part of southwest Washington was originally occupied by members of two major native groups (Ruby and Brown, 1992). Bands of Chinookan Indians lived along the north side of the Columbia River from Baker Bay (Chinooks proper) past Grays Bay and upstream (the Wahkiakums[2] and Kathlamets); and northward along Willapa Bay (Nisal and Shoalwater bands). The Athabascan-speaking Kwalhioqua tribe lived in the Willapa Hills to the north, over into the basins of the upper Chehalis and Willapa rivers. Collectively they numbered a few thousand people in late pre-contact times, typically living in villages located near the larger rivers and utilizing the resources of the mountains as well as the waters. In the mid-1800s, epidemics of Old World diseases (smallpox, malaria, etc.) ravaged the Chinooks and Kwalhioquas, allowing other tribes (such as the Salishan Chehalis) to move into their lands around Willapa Bay and the middle Co-

[1] There seem to have been four fire lookouts around the Skamokawa WAU, most built by predecessors of the DNR and WFPA: Hull Ck, on the divide between the West Grays and the Naselle (2042 ft), much older site?; K.O. Point, nearby in the upper Grays basin (2632 ft); Blaney, on the ridge between Blaney Ck and the South Grays (2546 ft), 1960; and Incline, east of the Elochoman River (2291 ft), 1938 (see Spring and Fish, 1996).

[2] *Skamokawa* meant "smoke/fog on the waters" in Chinookan; it was also the name of a Wahkiakum chief (Hitchman, 1985).

lumbia.[3] Many of these tribes and bands participated in treaty negotiations with U.S. representatives, but some of those treaties were not ratified. As a result, there has been a long history of legal controversy between the tribes and the federal government (and among some tribes) for recognition, allotments, payment for lost lands, etc.

Early coastal exploration by Euro-Americans was focused on finding the Great River of the West (Johansen, 1967). Willapa Bay was a near miss, charted by the Spanish and English (Bruno Heceta, 1775; John Meares, 1788, who called it Shoalwater Bay). The mouth of the Columbia was discovered and named in 1792 by Robert Gray (American), and the river was explored shortly thereafter by William Broughton (British, under George Vancouver); trading ships followed quickly. The overland Lewis and Clark party canoed downriver in November 1805, and camped near Altoona before wintering at Fort Clatsop; they passed back upriver in March 1806. The U.S. Exploring Expedition charted the river up to Vancouver in 1841, naming several local features (such as Pillar Rock).

The first permanent trading post was established at Astoria in 1811, but the immigrant population grew slowly until the arrival of large numbers of Americans in the Oregon Country in the 1840s. Many of them settled around the Columbia estuary; at least two donation land claims (DLCs) were granted in the area, on the east side of Grays Bay and at Knappton. The village of Chinook was an important fishing port, and the original Pacific County seat, by 1851. Willapa Bay was another focus of early settlement (with dozens of DLCs between Chinook and Long Beach), chiefly because oysters were cultivated/harvested there beginning in the 1850s. Cathlamet was founded as a trading post in the 1860s. The army built Fort Cape Disappointment for coastal defense in 1864 (later renamed Fort Canby). A sawmill and cement plant were built at Knappton in 1868; in 1899, an old cannery was converted into the Knappton Cove Quarantine Station, one of four immigration pesthouse sites on the west coast, operating until 1938. By 1900, all townships had been surveyed in the area, and other village or town sites established at Deep River, Oneida, Rosburg, Grays River, Frankfort, Brookfield (cannery), and Skamokawa (Gannett, 1902; Hitchman, 1985).

F.3 Logging and Roading

Because of the relatively early white settlement around the lower Columbia and Willapa Bay, logging had occurred over much of the region even by 1900 (Gannett, 1902). Some may have been clearing for farms, but the presence of local sawmills at Knappton, Astoria, and South Bend would have stimulated commercial harvests. This was particularly true where river transport for logs was easy: either by splash damming, which was common in the Willapas, with several dams in this area[4] (see Sedell and Luchessa, 1981); and by rafting in deeper rivers and bays. Thus, older cuts were concentrated in the lowlands of the Skamokawa basin, inland about 3 mi from the river.

The USFS vegetation map (Andrews and Cowlin, 1936) shows that a majority of the southwest Willapa Hills had been logged or burned by the mid-1930s, especially in the parts near the big rivers. However, significant stands of old-growth and mature trees remained, chiefly in the central highlands from the upper Skamokawa to the upper Naselle basins, and in the hills between the Grays and Columbia rivers. The oldest topographic maps published of the area, the Ft. Columbia (1938) and Brookfield (1940, later called Grays Bay) 15' quadrangles, indicate the presence of logging railroads.

---

[3] It is uncertain whether the original "Willapas" were Chinooks or Kwalhioquas. The latter merged with the Chehalis.

[4] Map in Sedell and Luchessa (1981) shows one splash dam in the Skomakawa WAU, plus several others in the Naselle, Deep and Grays watersheds.

Topographic maps (15' and 7.5') made in the 1940s and '50s (and later) reveal the extension of harvest areas away from those available to the old river and rail routes, although those were still in use. These maps show many newer roads in the hills, including logging railroads (some already abandoned): lines from the Elochoman through Skamokawa Pass and over into the upper Grays basin; in the upper Naselle basin, lines on the west divide, south toward Knappton, upstream past an old logging camp, and over into the Nemah drainage. However, many more truck roads were being built in the steeper country inaccessible to trains (and some railroad lines were being converted). The 1940s–'50s maps indicated then-recent harvest NW from Skamokawa Pass, and in patches farther south. The 1982 7.5' topographic maps show the region to be thoroughly roaded.

F.4 References

Agee, J. K., 1993, *Fire Ecology of Pacific Northwest Forests*: Island Press, Washington D.C., 493 p

Andrews, H. J.; Cowlin, R. W., 1936, Forest type map, state of Washington (southwest quarter): U.S. Forest Service, Pacific Northwest Forest Experiment Station, Portland; scale 1"= 4 mi

Franklin, J. F.; Dyrness, C. T., 1973, Natural vegetation of Oregon and Washington: U.S. Forest Service, General Technical Report PNW-8, 417 p

Gannett, Henry, 1902, The forests of Washington – a revision of estimates: U.S. Geological Survey, Professional Paper 5, 38 p (including a map showing classification of lands, by G.H. Plummer, F.G. Plummer, and J.H. Rankine)

Hitchman, Robert, 1985, *Place Names of Washington*: Washington State Historical Society, Tacoma, 340 p (with 1986 addendum)

Johansen, D. O., 1967, *Empire of the Columbia*: Harper & Row, New York, second edition, 654 p

Ruby, R. H.; Brown, J. A., 1992, *A Guide to the Indian Tribes of the Pacific Northwest*: University of Oklahoma Press, Norman, 289 p

Sedell, J. R.; Luchessa, K. J., 1981, Using the historical record as an aid to salmonid habitat enhancement: p 210-223 *in* Proceedings, Symposium on Acquisition and Utilization of Aquatic Habitat Inventory Information; American Fisheries Society; Portland, Oreg.

Spring, Ira; Fish, Byron, 1996, *Lookouts – Firewatchers of the Cascades and Olympics*: The Mountaineers, Seattle, 224 p