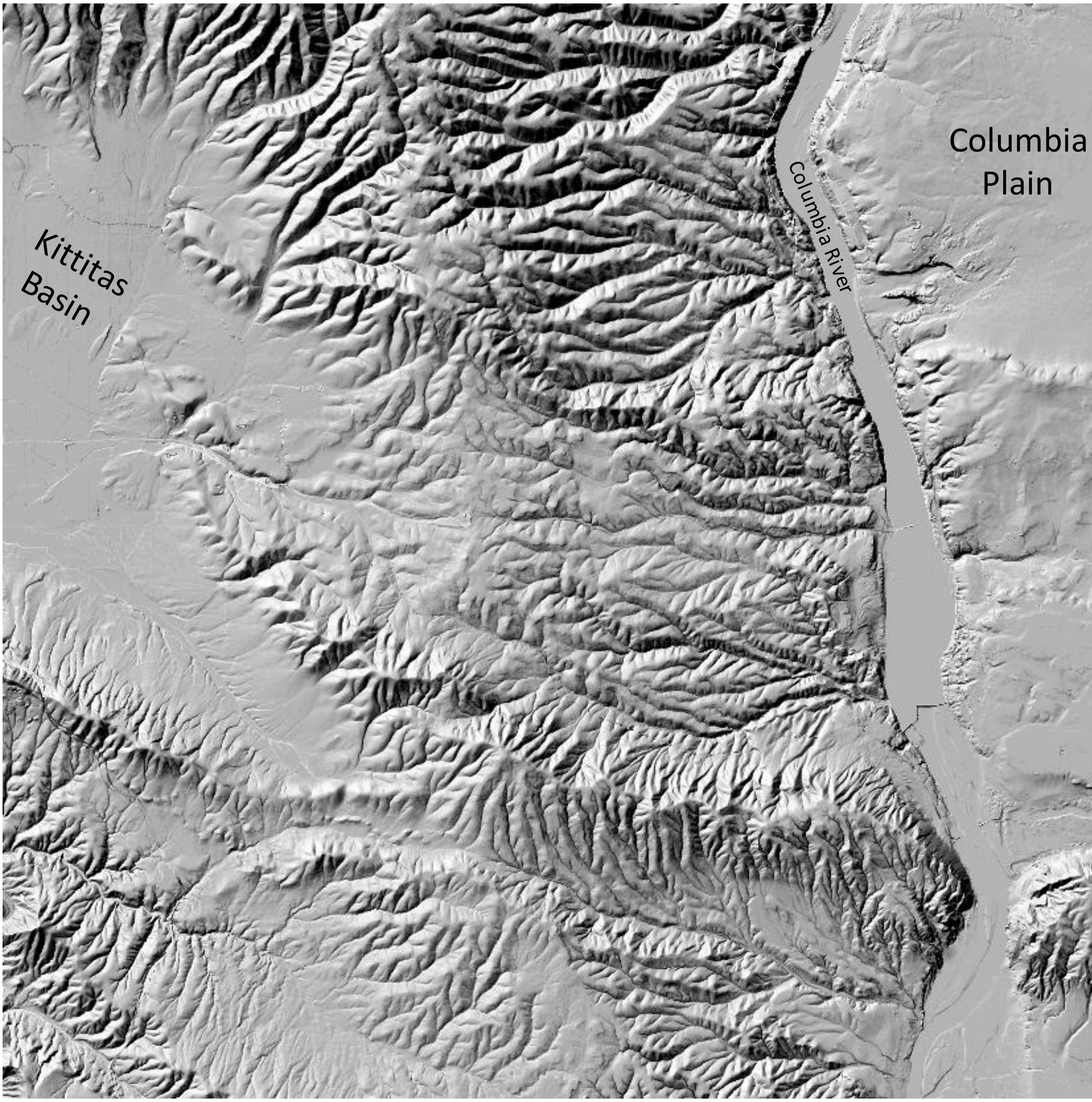
Ellensburg Chapter Ice Age Floods Institute

East of Ellensburg Field Trip



Field Trip Leader:
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May 18, 2024

Field Trip Overview

Welcome to the area between Ellensburg and Ginkgo State Petrified Forest! We will examine the geology and geography at several stops in the old Vantage Highway corridor. The trip will include stops at: 1) Wild Horse Wind and Solar Facility and Renewable Energy Center for a big picture view of geology and physical geography of the Whiskey Dick area; 2) Pumphouse Road to see impacts of past and current erosion (including that from the 2022 Vantage Highway Fire); 3) Trees of Stone Interpretive Trailhead for evidence of Ice Age Flooding; and 4) Ginkgo Petrified Forest State Park Interpretive Center to discuss the ancient petrified wood found near here plus historic land use changes in the Vantage area. Throughout, we will be immersed in the Columbia River Basalts and the aridity of the region.

Tentative Schedule

11:00am	**Stop 1—Wild Horse Wind & Solar Facility**
	(inc. restrooms)
12:00pm	Depart
12:15	**Stop 2—Pumphouse Road**
1:30	Depart
1:45	**Stop 3—Ginkgo Petrified Forest State Park--Trees of Stone Interpretive Trailhead)**
	(inc. restroom)
3:00	Depart
3:15	**Stop 4—Ginkgo Petrified Forest State Park Interpretive Center**
	(inc. restrooms)
4:00	**Depart**

Getting to Stop 1

You can drive to Stop 1—Wild Horse Wind & Solar Facility from several directions. From Ellensburg, you can follow Vantage Highway eastward to the Beacon Hill Road. From the east, take Vantage Highway to the Beacon Hill Road. In either case, follow the Beacon Hill Road 3 miles to Stop 1.

Stop 1—Wild Horse Wind & Solar Facility

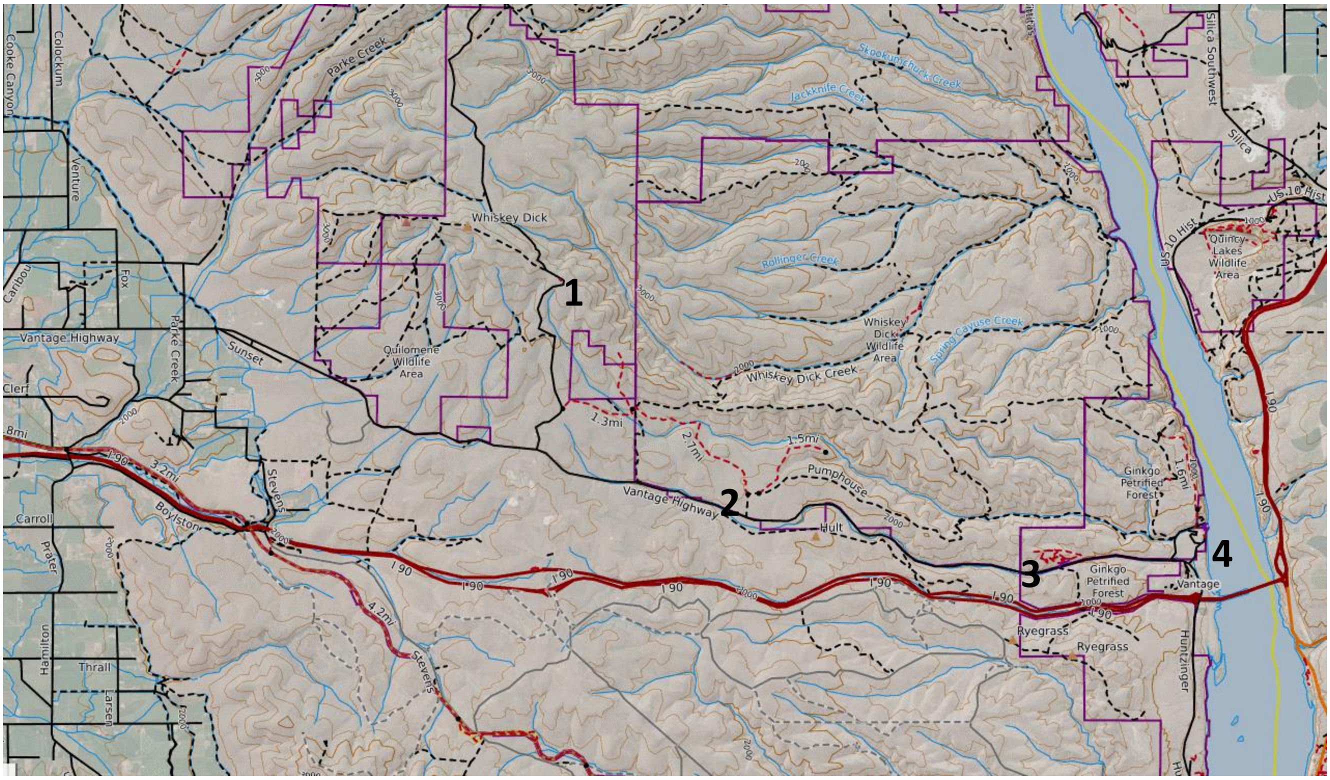


Figure 1. The approximate locations of field stops between Ellensburg and Vantage noted with bold, black numbers. Source: Google Maps.

Location: We are located at the Wild Horse Wind & Solar Facility Renewable Energy Center. GPS coordinates for the site are 47.011879°N, 120.200681°W. The interpretative center sits near the top of Whiskey Dick Mountain (Figure 1) at an elevation of ~3,500 ft which is ~500 ft higher than Snoqualmie Pass! This is an information and restroom stop.

Getting our bearings: On a clear day, the view from the Renewable Energy Center is spectacular. We can see two *physiographic* (i.e., topographic) *provinces* from here—the Cascades and the Columbia Plateau. Ellensburg is situated near the boundary of these two provinces. The Cascades lie to the west and include two prominent volcanoes—Mt. Rainier to the west-southwest and Mt. Adams to the southwest. Were Mt. St. Helens still 9,677 ft high rather than its 8,363 ft post-1980 eruption height, I think we could also see it from here between Mt. Rainier and Mt. Adams. East of Mt. Adams, we can see the ridges of the Yakima Fold Belt within the Columbia Plateau. And looking east, we can see the Columbia Plateau including (from south to north), the Saddle Mountains, Frenchman Hills, Beezley Hills, and Badger Mountain. To the north, we can see the forested slopes of the Wenatchee Range.

Stop 1—Wild Horse Wind & Solar Facility

Bedrock Geology: The bedrock geology of our field day is the Columbia River Basalt Group (CRBG) and associated interbeds. These dark, dense, volcanic rocks characterize much of central and eastern Washington (Figure 2). More specifically, much of our day will be spent in the Grande Ronde Basalts and the overlying Frenchman Springs member of the Wanapum Basalts (Figures 2 & 3) (Schuster, 1994). The Vantage sandstone interbed separates the Grande Ronde and Wanapum basalts, and suggests a lengthy hiatus in volcanism (Carson, & others, 1987). The Grande Ronde Basalts originated from fissure eruptions in the eastern and southeastern portion of the Columbia River flood basalt province (Figure 2) (Reidel & Tolan, 2013). The Frenchman Springs member originated in dikes in southeast Washington, and northeast Oregon (Martin & others, 2013). Each member is a different basalt flow, and as you can see in Table 1, there are many flows composing the entire Columbia River Basalt Group. How old are these basalts? Most (~95%) erupted between 16.7 and 15.9 million years ago (Ma) (Kasbohm and Schoene, 2018). We are on the Grande Ronde basalts here (Tabor & others, 1982)

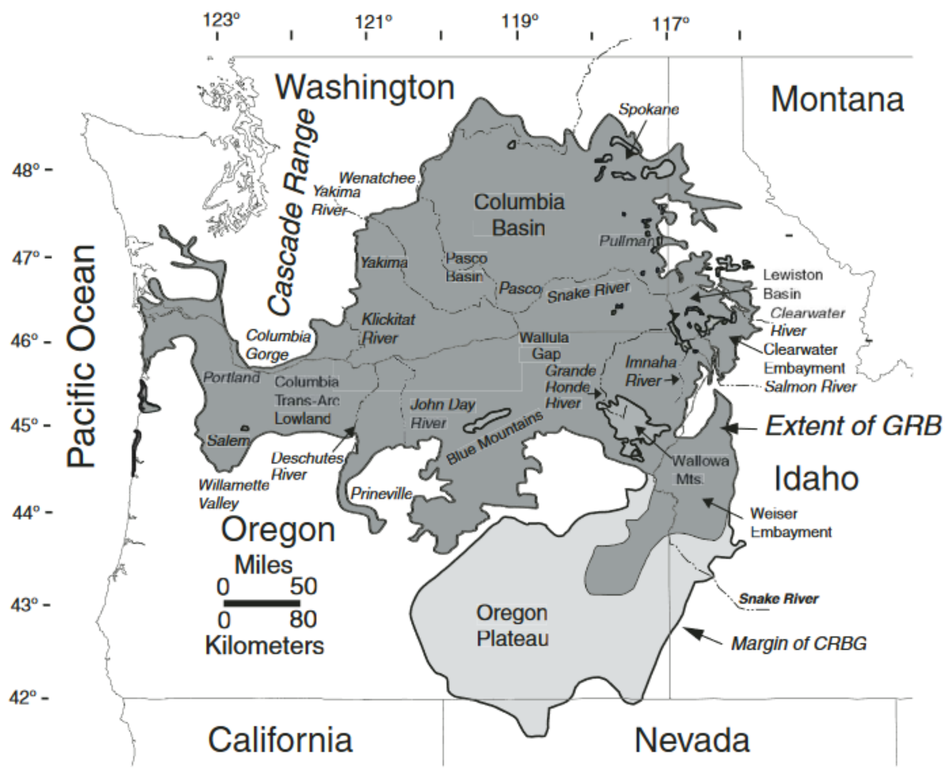


Figure 2. The extent of the Grande Ronde Basalts (GRB) within the Columbia River Basalt Group (CRBG) in Washington, Oregon, Idaho, and northern Nevada. Source: Reidel & Tolan (2013).

Stop 1—Wild Horse Wind & Solar Facility

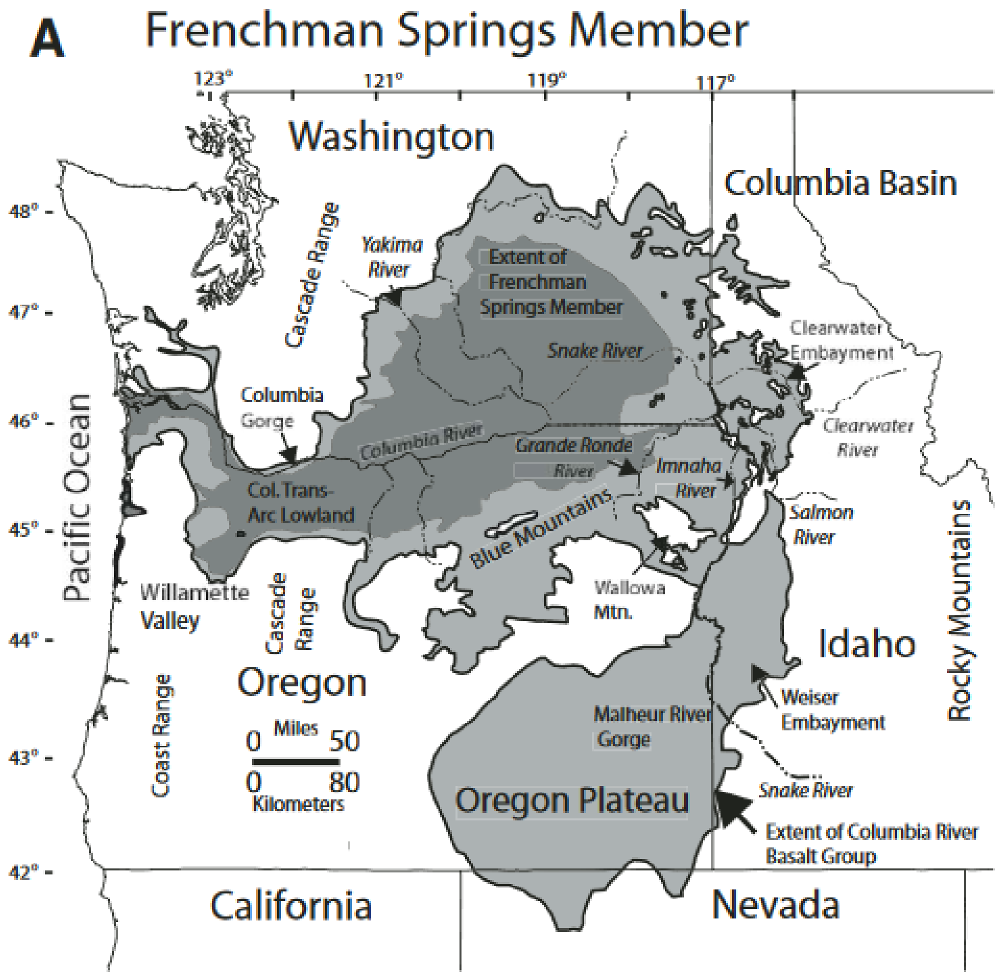


Figure 3. The extent of the Frenchman Springs Member of the Wanapum Basalt Formation within the Columbia River Basalt Group (CRBG) in Washington, Oregon, Idaho, and northern Nevada. Source: Martin & others (2013).

Stop 1—Wild Horse Wind & Solar Facility

Series		Group	Formation	Member	Isotopic Age (m. y.)	Magnetic Polarity
Miocene	Upper	Columbia River Basalt Group	Saddle Mountains Basalt	Lower Monumental Member	6	N
				Ice Harbor Member	8.5	
				Basalt of Goose Island		N
				Basalt of Martindale		R
				Basalt of Basin City		N
				Buford Member		R
	Middle			Elephant Mountain Member	10.5	R,T
				Pomona Member	12	R
				Esquatzel Member		N
				Weissenfels Ridge Member		
				Basalt of Slippery Rock		N
				Basalt of Tenmile Creek		N
				Basalt of Lewiston Orchards		N
				Basalt of Cloverland		N
				Asotin Member	13	
				Basalt of Huntzinger		N
				Wilber Creek Member		
				Basalt of Lapwai		N
				Basalt of Wahluke		N
				Umatilla Member	13.5	N
				Basalt of Sillusi		N
				Basalt of Umatilla Member		N
			Wanapum Basalt	Priest Rapids Member	14.5	
				Basalt of Lolo		R
				Basalt of Rosalia		R
				Roza Member		T,R
				Shumaker Creek Member		N
				Frenchman Springs Member		
				Basalt of Lyons Ferry		N
				Basalt of Sentinel Gap		N
				Basalt of Sand Hollow	15.3	N
				Basalt of Silver Falls		N,E
				Basalt of Ginkgo		E
				Basalt of Palouse Falls		E
				Eckler Mountain Member		
				Basalt of Dodge		N
				Basalt of Robinette Mountain		N
				Vantage Horizon		
			Grande Ronde Basalt	Member of Sentinel Bluffs	15.6	N_2
				Member of Slack Canyon		
				Member of Field Springs		
				Member of Winter Water		
	Lower			Member of Umtanum		
			Prineville Basalt	Member of Ortley		
				Member of Armstrong Canyon		
				Member of Meyer Ridge		R_2
				Member of Grouse Creek		
				Member of Wapshilla Ridge		
			Picture Gorge Basalt	Member of Mt. Horrible		
				Member of China Creek		N_1
				Member of Downey Gulch		
				Member of Center Creek		R_1
				Member of Rogersburg		
				Member of Teepee Butte		
				Member of Buckhorn Springs	16.5	
			Imnaha Basalt			R_1
						T
						N_0
					17.5	R_0

Table 1. Stratigraphy of the Columbia River Basalt Group. Bold arrows indicate general basalt formations present in study area. Source: https://or.water.usgs.gov/projs_dir/crbg/nomenclature.pdf

Stop 1—Wild Horse Wind & Solar Facility

Structural Geology: The Renewable Energy Center sits atop the broad Naneum *Anticline*, a ~north-south trending structure that extends from Mission Ridge in the north to the Horse Heaven Hills near the Columbia River (Reidel & others, 2013) (Figure 4). This anticline forms the drainage divide separating streams that flow east into the Columbia River from those that flow west into the Yakima River. It is somewhat anomalous in the Yakima Fold and Thrust Belt region in its north-south orientation. Recent research by Staisch & Sadowski (2021) indicates that uplift of the Naneum Anticline occurred before 3.7 Ma resulting in isolation of the Upper Yakima River Basin from the Columbia River Basin. This age of uplift is also significant in that it is older than the 3.0-2.5 Ma age of several Yakima Folds (Kelsey and others, 2017). In the big picture, the combination of the Naneum anticline, Naneum fault, and Yakima folds appears to have accommodated the strain resulting from the back arc tectonic setting of the Northern Cascadia Subduction Zone (Kelsey and others, 2017) (Figure 5).

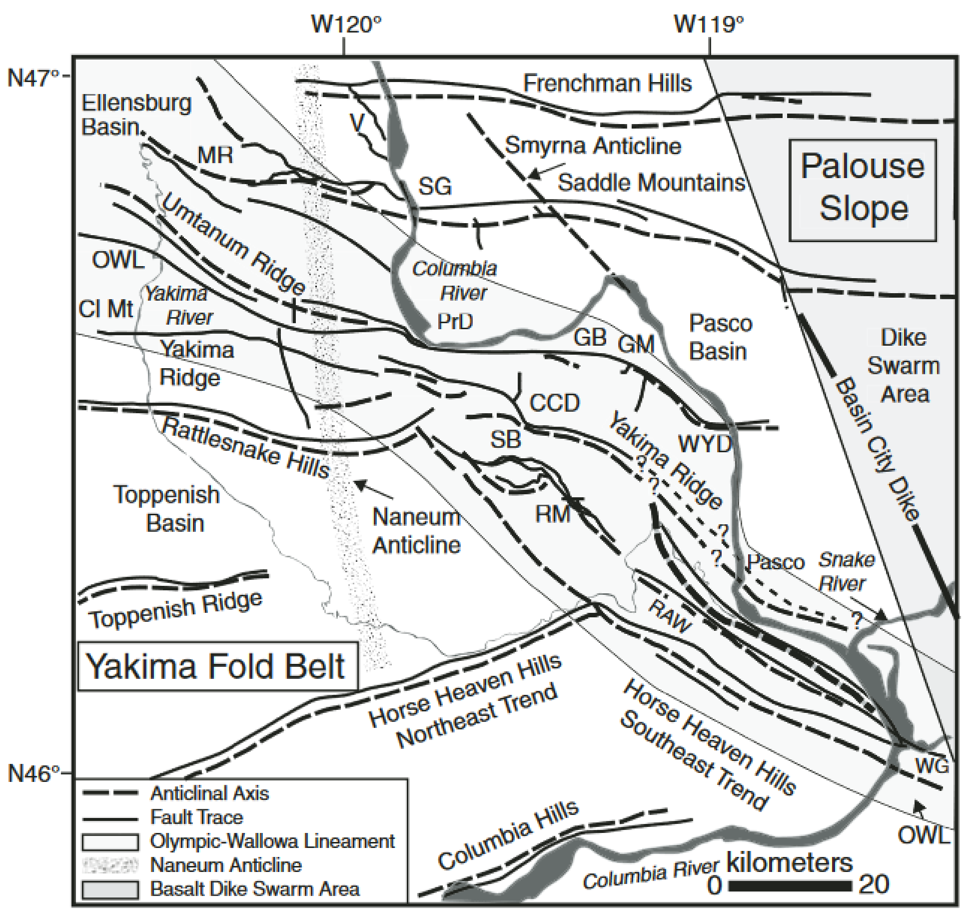


Figure 4. Major folds in south central Washington. Note the location and somewhat anomalous orientation of the Naneum Anticline. Source: Reidel and others (2013)

Stop 1—Wild Horse Wind & Solar Facility

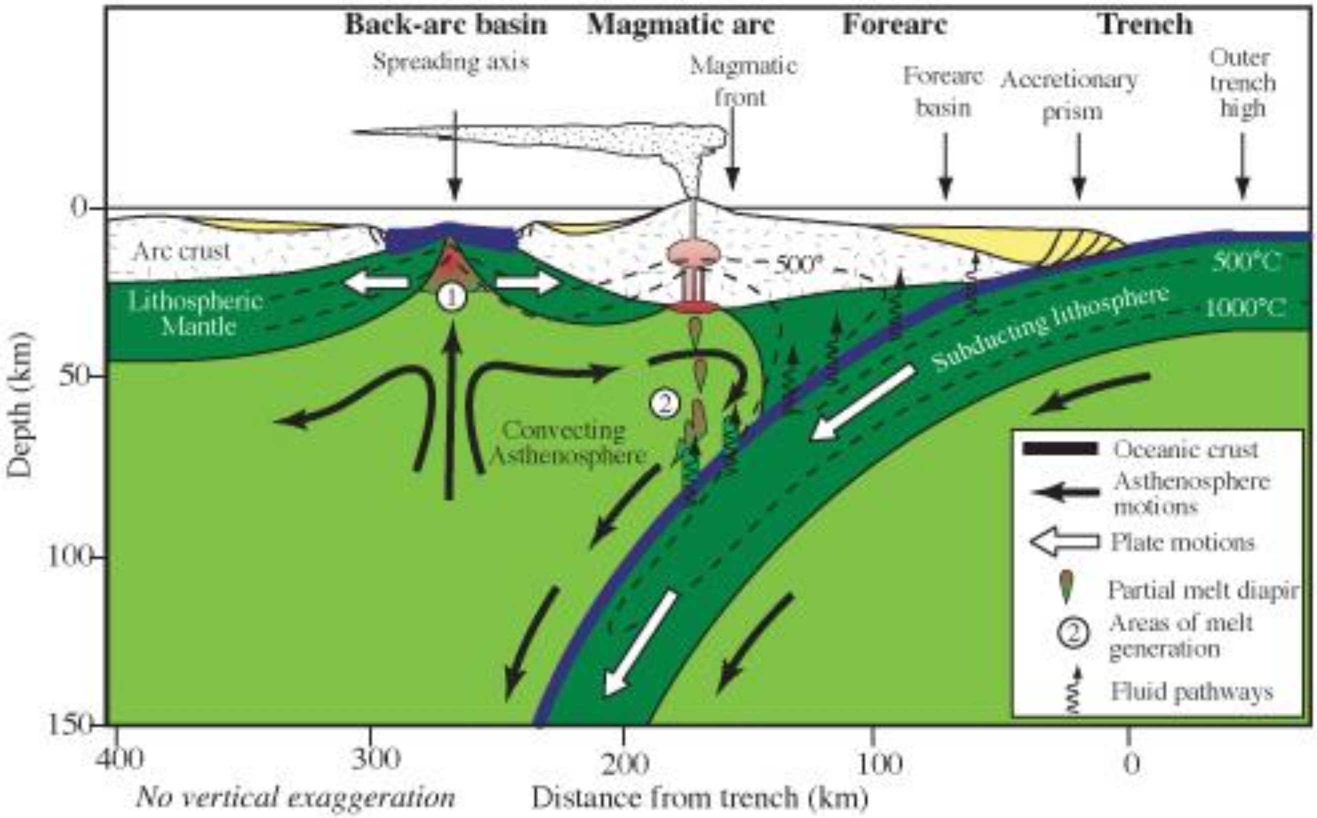


Figure 5. Subduction zone model including back arc zone somewhat akin to that east of the Cascade Range. Source: Robert Stern, Wikipedia.

A Deep Well in the Basalts: In 1981, Shell Oil Company drilled a well (BISSA 1-29) on this anticline in search of natural gas and petroleum. They suspected that the basalts were underlain by pre-Miocene sedimentary rocks (e.g., Roslyn Formation) that contained natural gas and petroleum. This was not such a far-fetched idea in that the Roslyn Formation contained extensive deposits of coal that were mined in the 19th and 20th centuries. The first nearly ~4,600 ft drilled was in thrust faulted basalt and associated interbeds. Below that was ~10,300 ft of sedimentary rock. At 14,966 ft below the ground surface, the well ended in granite. Some natural gas was located but no petroleum was found (Shell Oil BISSA 1-29; Andrew Sadowski, written communication, 4/22/2024).

Stop 1—Wild Horse Wind & Solar Facility

A Dissected Landscape: A look at the Lidar image shows that we are amidst a stream-dissected landscape (Figure 6). That may come as a surprise when considering the dry climate here. Keep in mind, though, that landscapes are accumulations of their varied pasts. Present-day streams may only flow for a few days or weeks here, or may be very small in relation to their valleys. However, in the past, strea had over 3.7 million years to develop! Our high elevation (~3500 ft) relative m flow may have been much more significant here. And this landscape has to the Columbia River (nearly 600 ft) means east-flowing streams had high gradients that were effective in eroding hard basalts. Dissected landscapes are often composed of ridges and intervening valleys. That’s the case here, and the ridges are the sites of the wind turbines.

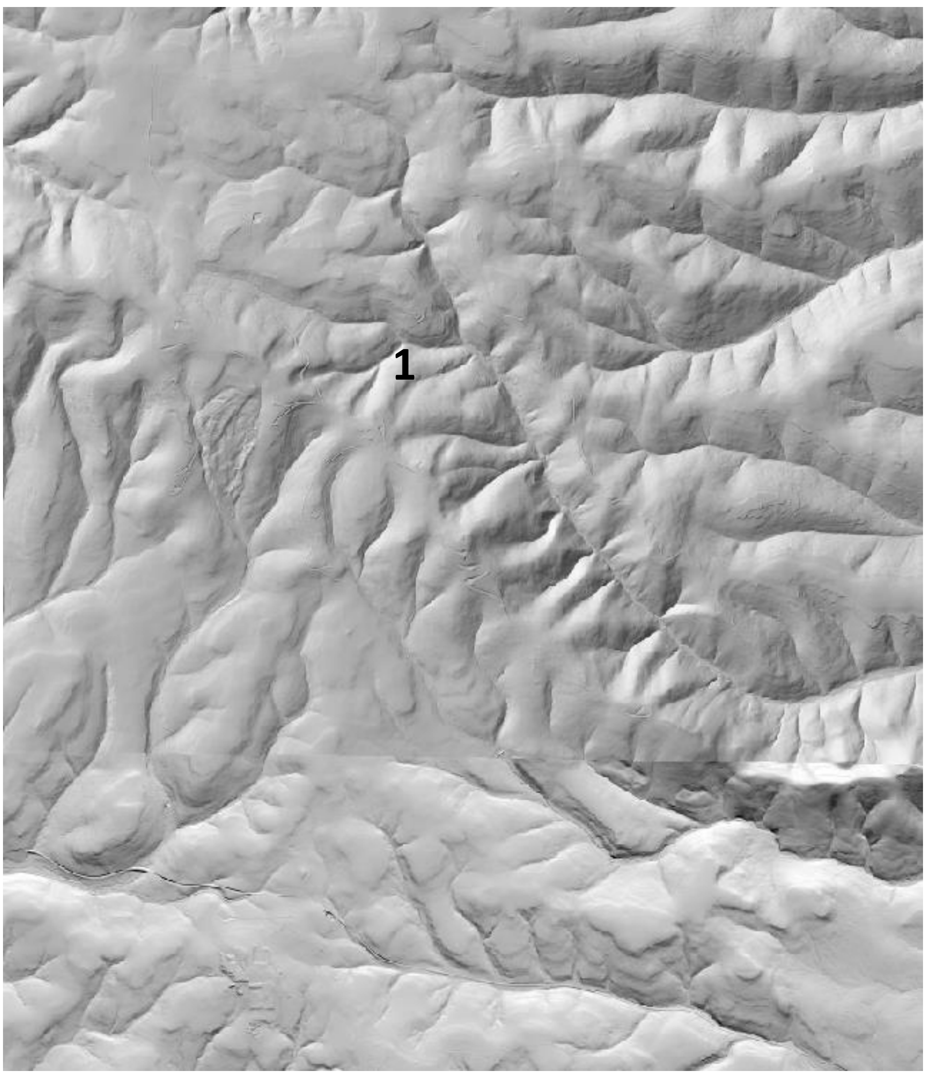


Figure 6. Stream dissected landscape surrounding the Renewable Energy Center (note bold 1). Source: Washington Lidar Portal.

Stop 1—Wild Horse Wind & Solar Facility

Mass wasting: Mass wasting is the downslope movement of earth materials due to gravity. The Lidar image in Figure 7 reveals a large irregular area to the west of the Renewable Energy Center (**1**). This area is a large landslide. Because it lacks large, backtilted blocks I suspect it is a *translational slide*. A good analogy for a translational slide is a snow sled on a slope—i.e., the slide just follows the topography. These are typically shallow slides. This is unlike a rotational slide that involves a thicker substrate as it rotationally slides down a slope. Translational slides may break apart as they descend because of increases in velocity or water content. This may cause the slide to transition to a flow. So…this is likely a complex earth slide-earth flow (Cruden and Varnes, 1996). I suspect that happened here as the slide pinched down into a narrow valley (Figure 7). This is a prominent feature measuring about 115 acres (~0.2mi^2). And this might actually be two slides (see the dividing line I placed within). Why did it form? Water was likely involved in the slide-flow and very possibly associated with a wetter climate in the past or perhaps the event was triggered by a past earthquake.

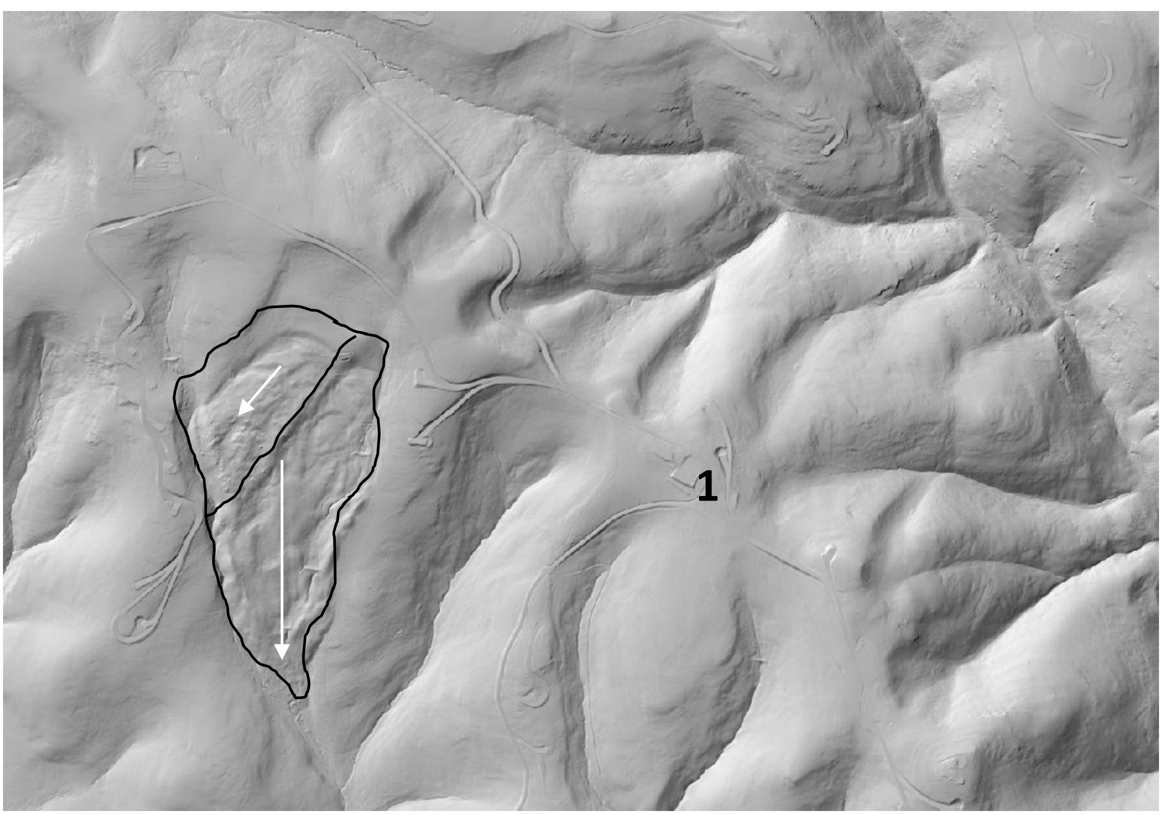


Figure 7. Complex earth slide-flows near the Renewable Energy Center. Source: Washington Lidar Portal.

Stop 1—Wild Horse Wind & Solar Facility

Why are wind turbines located here? Winds form in response to pressure gradients which, in turn, are often associated with temperature gradients. In general, winds blow from areas of high barometric pressure toward areas of low pressure. Topography tends to block, divert or funnel these general *pressure gradient winds*. In the Pacific Northwest, two types of settings favor wind power production—the coasts and inland areas in or downwind of mountain passes (Mass, 2008) (Figure 8). Here, we are downwind of the "Stampede Gap", a broad low area near Snoqualmie Pass. In spring and summer, a strong pressure gradient forms from areas west of the Cascade crest to areas east. High pressure forms over the cold Pacific Ocean. This air is drawn toward the low pressure that forms east of the Cascades as the landscape warms. The stronger the temperature difference, the stronger the winds. The Stampede Gap and downwind of that, the upper Yakima River Valley, funnels the winds. Residents of the Kittitas Basin experience this wind regularly in spring and summer in what is termed the "Kittitas Breezeway". Whiskey Dick Mountain is even more windy because it is about 2000 feet above the floor of the Kittitas Basin where there is less friction to slow the wind. It also lies above the cold, stagnant air that often characterizes the Kittitas Basin floor during winter *inversions*. Therefore, upland sites such as this should experience windy conditions all year while the Kittitas Basin floor typically experiences its lowest wind speeds in the winter months. I often see this pattern in the adjacent Wenatchee Range which shows evidence of ample, frequent winter winds. Therefore, it is the uplands around the Kittitas Basin that are prime for wind energy development (Figure 9).

How do these winds shape the semi-arid environment we are in today? This will be a topic for our next stop.

Stop 1—Wild Horse Wind & Solar Facility

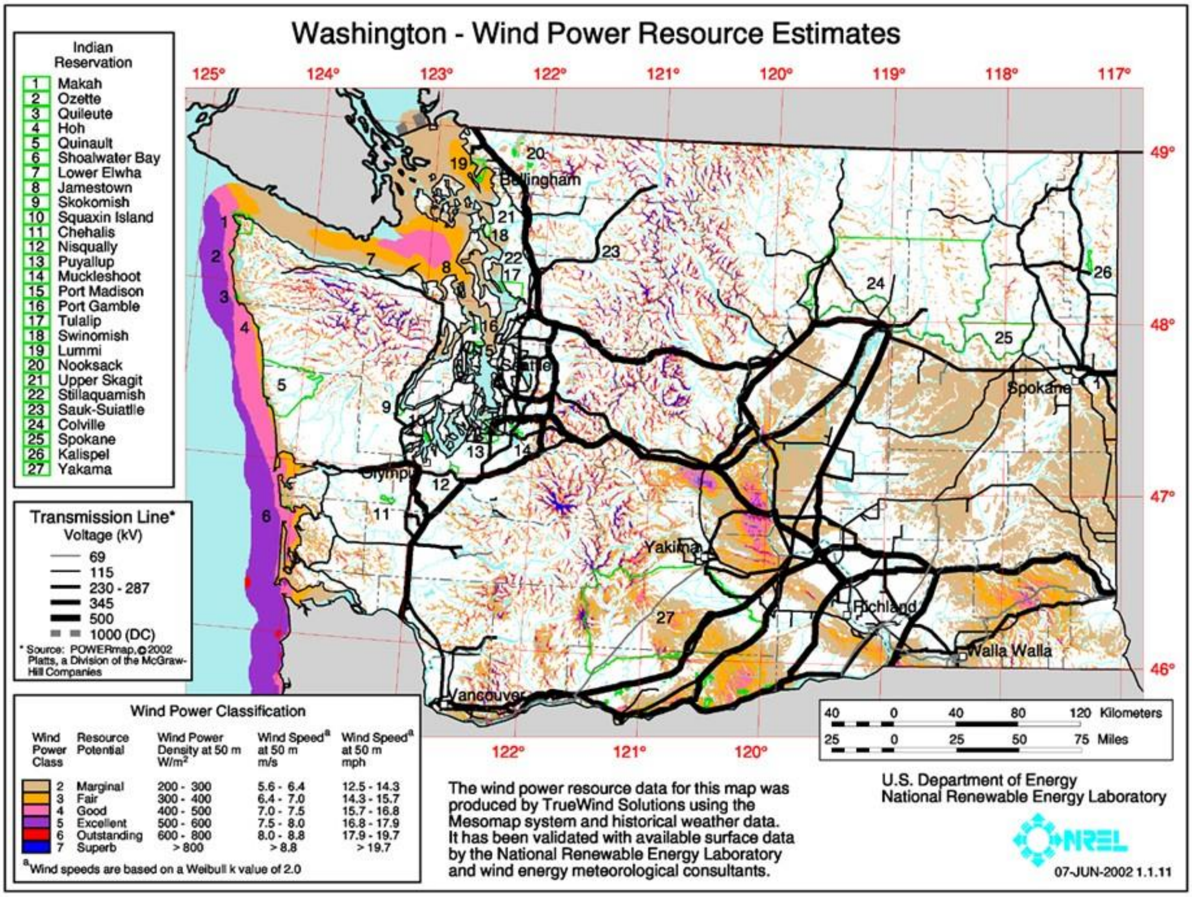


Figure 8. Estimates of wind power density at 50 m above the ground. Depicts the resource that could be used for community-scale wind development using wind turbines at 50-60-m hub heights. Source: Windhttps://windexchange.energy.gov/maps-data/134.

Stop 1—Wild Horse Wind & Solar Facility

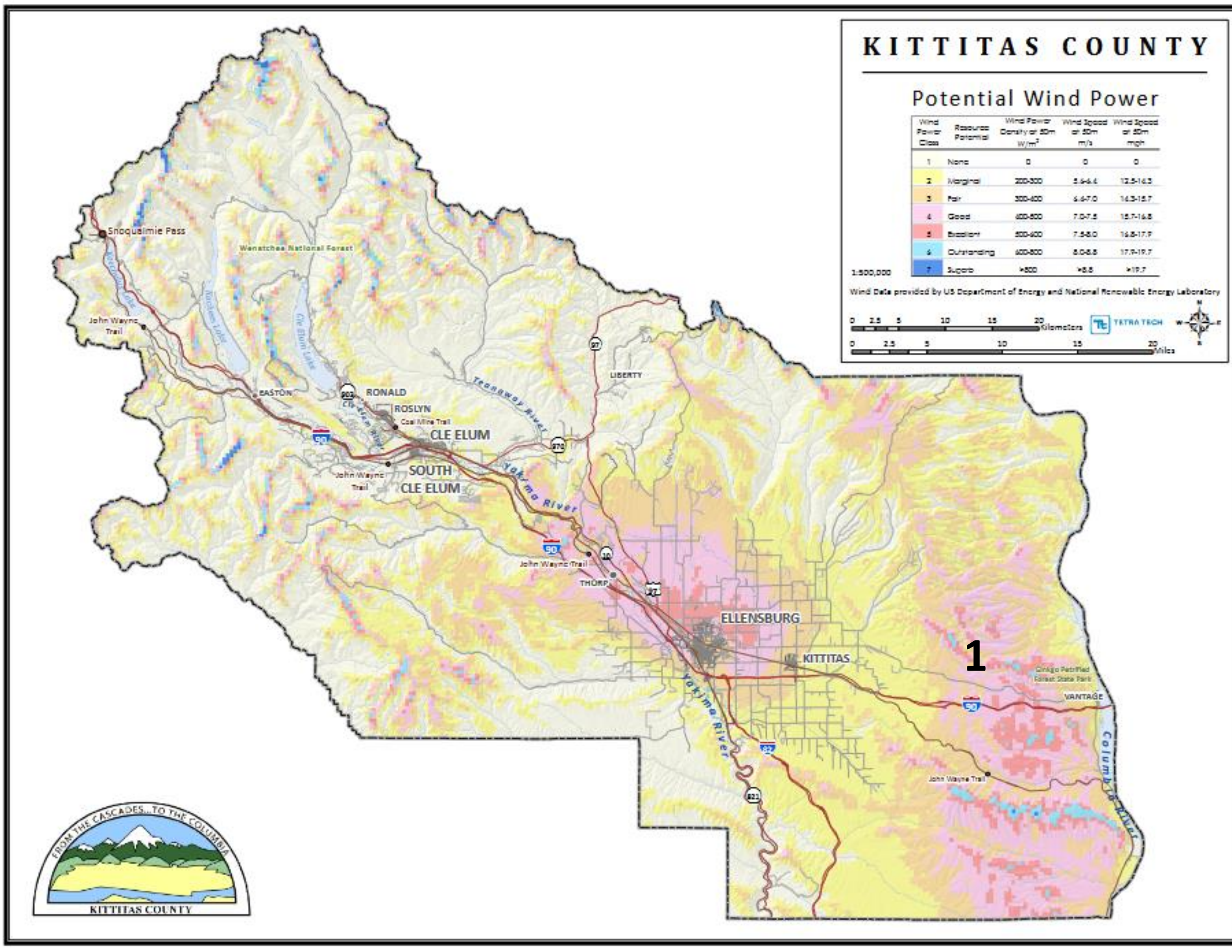


Figure 9. Potential wind power in Kittitas County. Reds and blues are areas of highest wind power potential. Note the approximate location of Stop 1 on map. Source: https://www.co.kittitas.wa.us/uploads/public-works/hazard-mitigation-plan/hazard-maps//KittitasCo%20-%20Wind.pdf

Enroute to Stop 2

Route: Return to Vantage Highway on the Beacon Ridge Road. Turn left onto Vantage Highway and head east down Schnebly Coulee toward Vantage. You will be travelling the 1915-1922 version of the Sunset Highway for part of this drive (Anonymous, n.d.). Schnebly Coulee drains into the Columbia River just north of Vantage. In about 3.5 miles from the junction of Beacon Ridge Road and Vantage Highway, you will reach a road on the left, Pumphouse Road. Take this road and immediately park in the parking lot. The GPS coordinates here are 46.959175°N, 120.139872°W. You will need a Washington state Discover Pass or Wildlife Pass to park here. If the parking lot is full, park alongside Vantage Highway but make sure that your car is parked outside the white line.

Stop 2—Pumphouse Road

Location: We are located at the Pumphouse Road Washington Division of Fish and Wildlife public lands access (Figure 1). This area lies in the Whiskey Dick Unit of the L.T. Murray Wildlife Area.

Shrub Steppe: We are located in a semiarid portion of Central Washington characterized by *shrub steppe* vegetation (Figure 10). Shrub steppe naturally consists of several varieties of sagebrush and various bunchgrasses (Taylor, 1992). To the uninitiated eye, it may seem a dry wasteland. However, once you start looking at the shrub steppe you realize that it is teeming with life, especially in the moist spring months. Shrub steppe environments consist of at least four "life layers" within—below ground (where many animals live because of cooler summer and warmer winter temperatures, a surface microbiotic crust that stabilizes the surface, a bunchgrass layer, and a shrub layer. Shrub steppe is home to variety of wildlife including burrowing owls, bighorn sheep, mule deer, sagebrush sparrows, and the iconic greater sage grouse. Much (~80%) of the historic extent of shrub steppe in the western U.S. is degraded or has been lost to various forms of land use; therefore, this ecosystem is in peril (Figure 11). Fire can be particularly harsh on shrub steppe when it burns sufficiently hot to destroy the shrub species. Weedy, non-native species such as cheatgrass (*Bromus tectorum*) often replace the native grass and shrub species following fire. Once cheatgrass is in the ecosystem, it makes that system much more fire-prone.

Figure 10. Shrub steppe vegetation at Stop 2. Source: Author photo, 05/2024.

Stop 2—Pumphouse Road

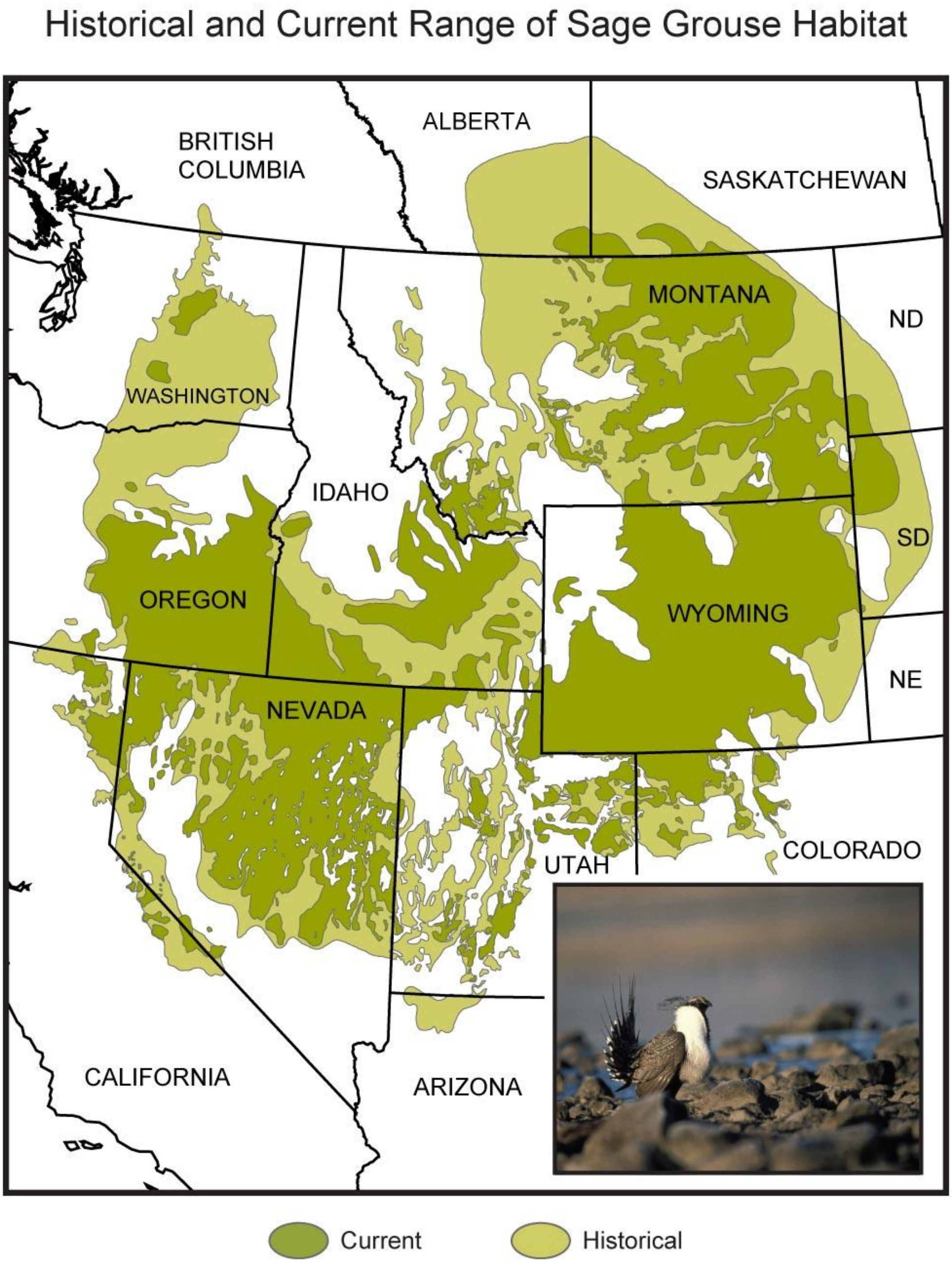


Figure 11. Current vs. historical ranges of sage grouse habitat (i.e., sagebrush shrub steppe). Source: https://earthlab.colorado.edu/blog/sage-advice

Stop 2—Pumphouse Road

Prehistoric & Historic Erosion, Lithosols, & Mounds: *Lithosols* are thin, rocky soils characteristic of ridgetops. They form here due to the weathering of the underlying basalts and the accumulation of small amounts of *loess* (i.e., windlblown silts) and volcanic ash. If you look and excavate carefully around the base of sagebrush plants, you can still find May 18, 1980 Mt. St. Helens ash here. Some of the ridgetop soils at this stop fit the lithosol definition really well. See how deeply you can dig here. About the best I can excavate is 6” deep. Note the type of vegetation that grows on these shallow lithosols--e.g., stiff sagebrush (*Artemisia rigida*), various forms of desert buckwheat (*Eriogonum spp*.), and dwarf goldenweed (*Happlopappas acaulis*) (Taylor, 1992). Interspersed with the lithosols are low mounds of deeper, loess-based soil (Figure 12). The mounds are often covered with taller and more robust vegetation cover including big sagebrush (*Artemisia tridentata*). With a bit of imagination, one could call these soil mounds *patterned ground*. However, they differ in appearance from the classic patterned ground on Manastash Ridge that consists of tall soil mounds surrounded by stone rings (Kaatz, 1959). I interpret these mounds as remnants of a once more universal loess cover that has since been partially eroded by water. What sparked this erosion—was it previous fires? Droughts? Overgrazing? And when did it occur? Despite years of research on patterned ground dating back to Central Washington University Geographer Martin Kaatz, we still have lots of questions to answer.

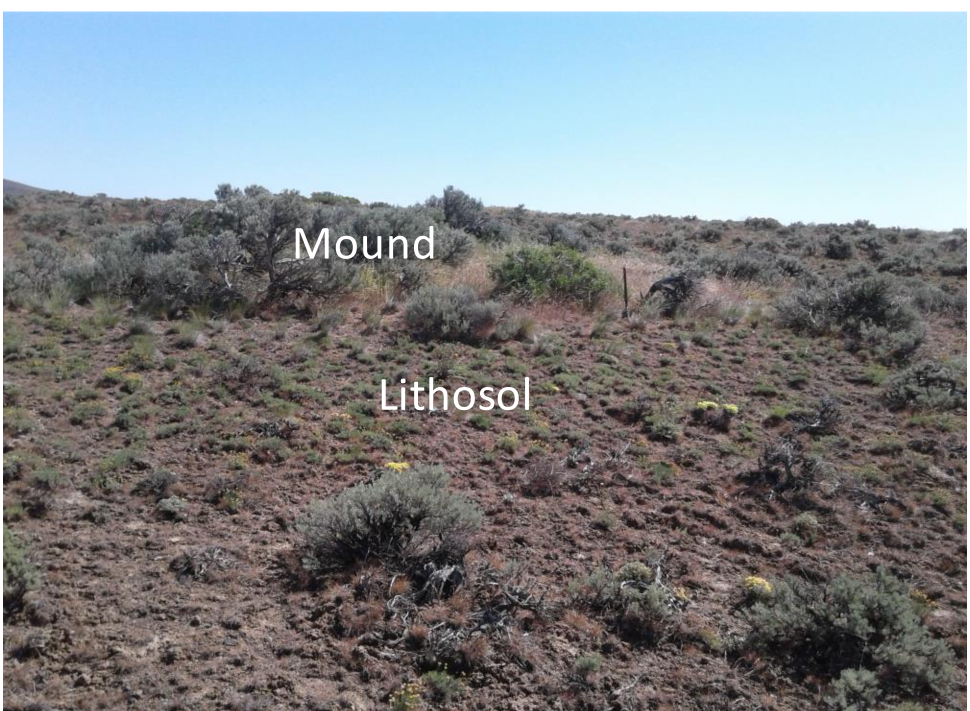


Figure 12. Lithosols and mounds in unburned area, Pumphouse Road. Source: Author photo, 05/2024.

Stop 2—Pumphouse Road

Historic Erosion Mitigation: Gully erosion has been an issue of concern for the U.S. Department of Agriculture since at least the early 1920s (Ramser, 1922). A common solution to gully erosion was the construction of "soil-saving dams" from a variety of materials. Such dams were also effective in water storage for stock watering and flood irrigation (Soil Conservation Service, 1937). Soil-saving dams provided storage of thunderstorm or snowmelt waters and associated sediments. Water remaining in ponds behind the dams had the added benefit for wildlife and cattle. By 1937, the Soil Conservation Service and the Civilian Conservation Corps (CCC) had been involved in the construction of nearly 300,000 such structures in the U.S.! One such dam was constructed near Stop 2 (see Figures 13 & 14). We know the dam near here was built prior to 1954 because it is shown on a 1954 Kittitas County airphoto in the CWU Geography Department's Central Washington Historical Aerial Photograph Project website. Numerous such dams are present throughout this landscape. I count 30 in the vicinity of Stops 1 and 2 (Figure 15). Perhaps these too were constructed by the CCC in the 1930's.

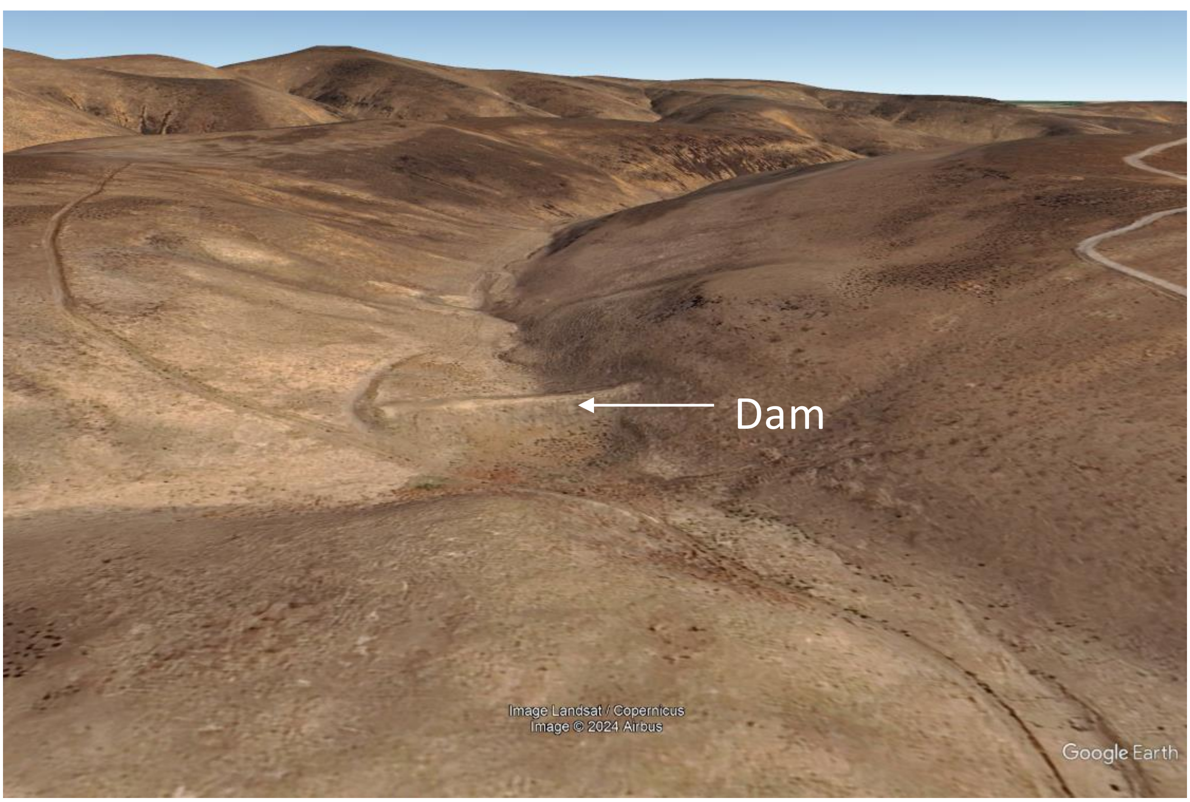


Figure 13. Oblique aerial view of upstream side of soil-saving dam in the headwaters of Rocky Coulee approximately 1 mile from the Pumphouse Road parking area. Source: Google Earth Pro, 7/20/2023.

Stop 2—Pumphouse Road

Figure 14. On-the-ground view of the downstream side of the soil-saving dam in the headwaters of Rocky Coulee. Author standing atop dam for scale. Source: Nancy Lillquist, 03/2024.

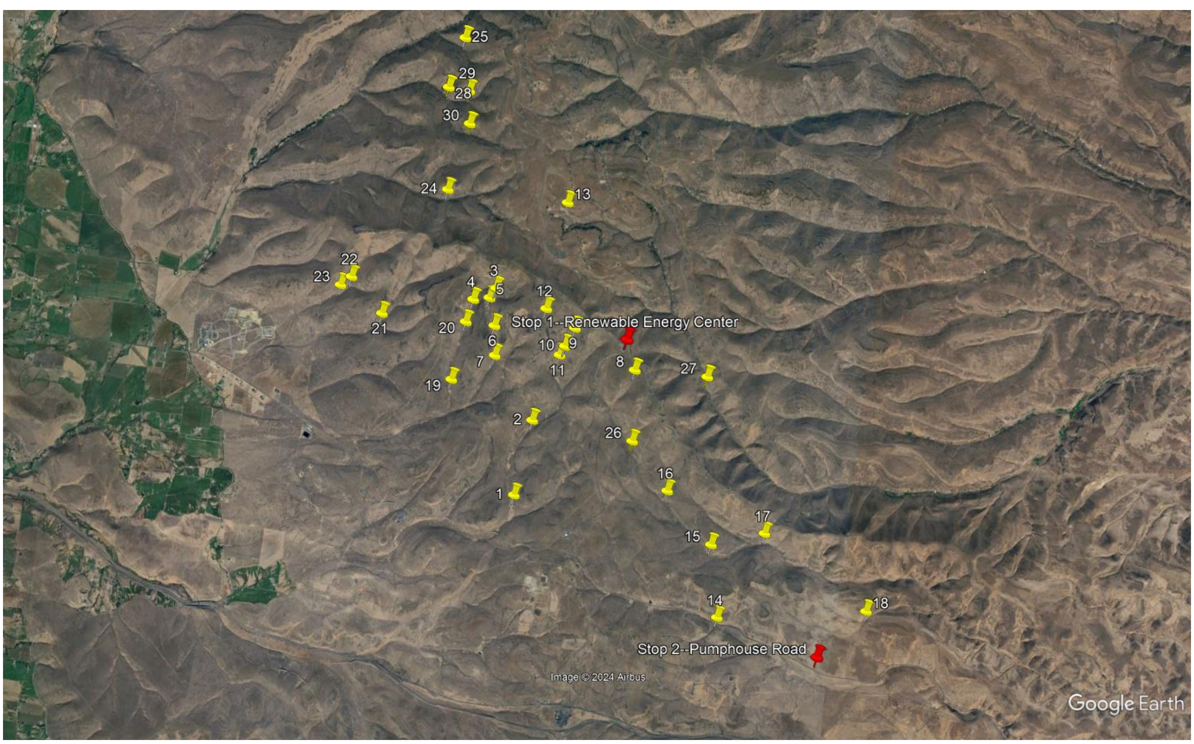


Figure 15. Distribution of US Department of Agriculture Soil Conservation Service soil-saving dams in the vicinity of Stop 1 and Stop 2 (shown with red pins). Dams identified from Google Earth Pro and Lidar (from the Washington Lidar Portal). Source of image: Google Earth Pro.

Stop 2—Pumphouse Road

Vantage Highway Fire: We are located within the perimeter of the August 2022 Vantage Highway Fire (Figure 16 & 17). This largest Washington state fire of 2022 burned over 30,000 acres (nearly 47mi^2), most of which was state-managed (Washington Department of Natural Resources, 2022; Inciweb, n.d.) shrub steppe land. It formed under *red flag conditions*—i.e., high temperatures, low humidity, and strong winds. This fire must have burned hot as it completely burned the shrub steppe vegetation cover in its path. However, as is common with most wildfires, the Vantage Highway Fire resulted in a burned and unburned vegetation mosaic (Figure 16). Post-fire invasive species growth has been phenomenal, especially between March and May 2024.

Figure 16. Note the light colored burned area of the Vantage Highway Fire. The darker area to the east is shrub steppe vegetation that was not burned. The while splotches with the unburned area are soil mounds. Parking area noted with bold 2. Source: Google Earth Pro, 9/12/2023 image.

Stop 2—Pumphouse Road

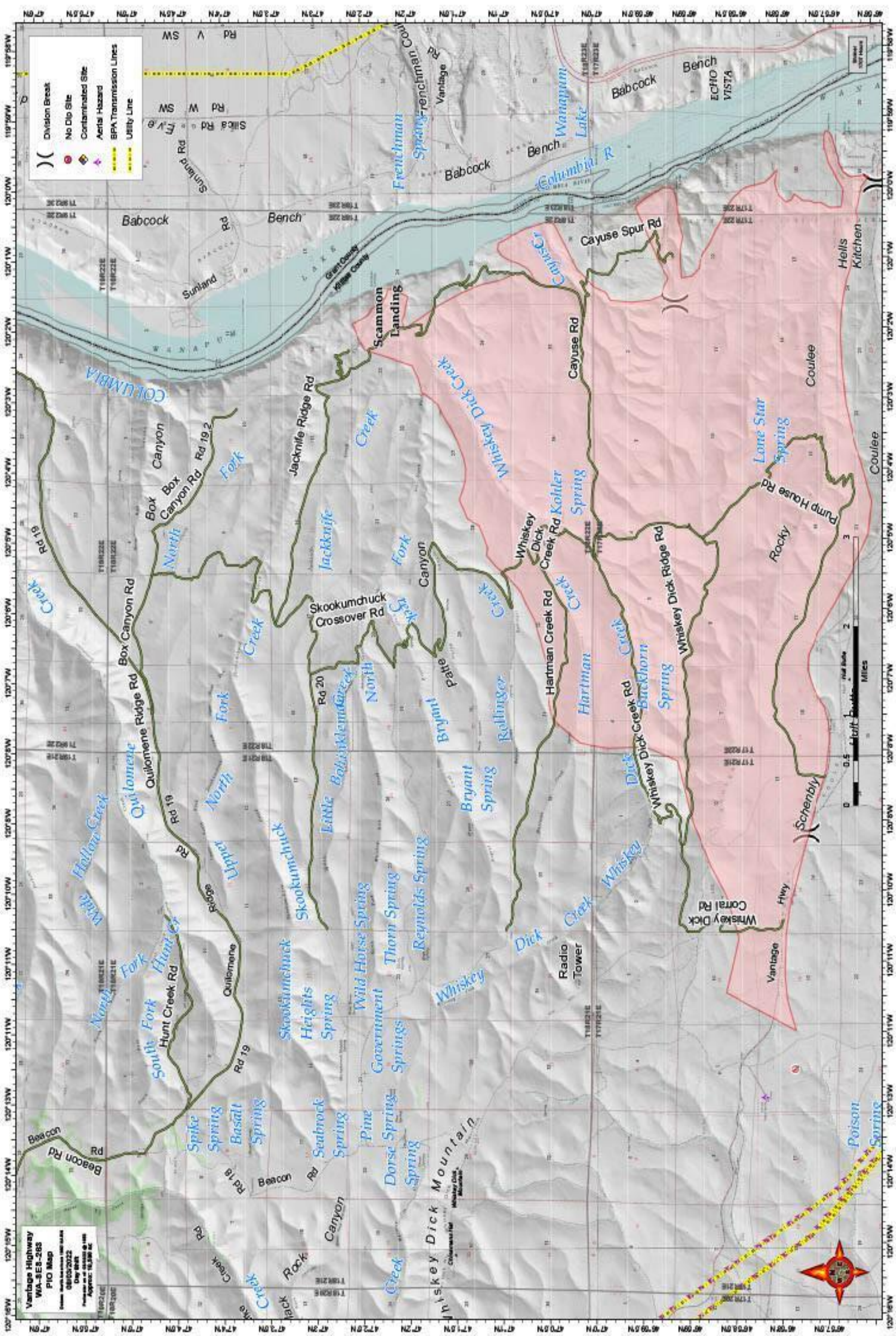


Figure 17. Extent of August 2022 Vantage Highway Fire (pink area). Note the locations of field trip stops shown with bold numbers. Source: Washington Department of Fish and Wildlife, 2022).

Stop 2—Pumphouse Road

Fire-related, Recent Soil Erosion: Wildfires often increase the potential for post-fire erosion because of the loss of soil binding roots, the loss of rainfall-shielding vegetation canopy, and the creation of *hydrophobic soils*. The 2022 Vantage Highway Fire also increased erosion, likely because of the removal of the native shrub steppe vegetation cover (Figures 16 & 18). In addition to the effects of the fire, the burned area soils in the vicinity of the parking lot are also considered to be erodible because of their lack of organic matter and the presence of volcanic ash *parent material* (Web Soil Survey, n.d.) . This erosion was sufficiently significant for Washington Division of Fish and Wildlife to install erosion structures (i.e., straw wattles) and plant (via broadcast seeding and vegetation plugs) shrub steppe obligate species in Fall 2023 (Shaun Morrison, oral communication, 5/9/2024). Erosion here is occurring primary because of water in the form of *sheetflow* (i.e., like a smooth sheet of water) on the more even surfaces and as *rill erosion* where that sheetflow has coalesced into channels. The straw wattles are being used to slow the movement of water and sediment on the slopes of the small drainage just northwest of the parking lot. Wind also plays a role in current erosion here, especially when the soil surface is disturbed by wildlife or human acitivity. Wind erosion is more difficult to mitigate.

Figure 18. Straw wattles on the margins of shallow gullies on burned area on Pumphouse Road. Wattles have been partially destroyed by elk. Also, note the scant, late winter vegetation in the burned area. Source: Author photo, March 2024.

Enroute to Stop 3

Route: From the Pumphouse Road parking lot, turn left onto Vantage Highway and proceed east about 5.5 miles down Schnebly Coulee to the Ginkgo Petrified Forest State Park Trees of Stone Interpretive Trailhead. Turn left into the parking area and park. The GPS coordinates for this parking area are 46.947690°N, 120.035789°W. You will need a Discover Pass to legally park here.

Stop 3—Trees of Stone Trailhead

Location: We are located at the Washington State Parks Ginkgo Petrified Forest Trees of Stone Trailhead (Figure 19). Central Washington College of Education (CWCE) professor George Beck discovered petrified logs during road construction in the vicinity in 1927. The Ginkgo Petrified Forest became a state park in 1935 after an unsuccessful first attempt at establishing it as a National Monument (Karlson, 2006). The CCC built the Trees of Stone Interpretive Trail and associated Vista House here (Figure 20) in the late 1930's. The interpretive trail includes 22 petrified logs representing nine different genera. We will wait to discuss the petrified forest until Stop 4. Here, we will walk south across Vantage Highway and ascend an old road to a place informally called "Iceberg Pass" to discuss Ice Age flood deposits.

Ice Age Floods & Slackwater: This may seem an odd place to talk about Ice Age floods, especially in this now-dry landscape. However, Ice Age floods inundated this area one or more times in the past. These floods came from Glacial Lake Missoula in northwest Montana (Bretz, 1969) and from the Okanogan Lobe of the Cordilleran Icesheet in the Okanogan Valley (Gombiner and Lesemann, 2024) (Figure 21). Waters from these sources entered the mainstem Columbia River upstream (via Moses Coulee and the western Quincy Basin cataracts) and downstream (via Crab Creek, the Koontz Channels, and the Snake River).

So how did floodwaters make it up here? The answer is *slackwater*. Floodwaters entering the Pasco Basin to the south were slowed by the relatively small Wallula Gap in the Horse Heaven Hills (Figure 22). This resulted in water backing up to form Glacial Lake Lewis. At its higher levels, this temporary lake backed up through Sentinel Gap (Figure 22). Floodwaters entering the basin above the Saddle Mountains were impounded by relatively low flow through Sentinel Gap and the presence of Lake Lewis. Therefore, floodwaters backed up into side channels such as Schnebly Coulee, and into this pass ("Iceberg Pass") connecting Schnebly Coulee with Ryegrass Coulee to the south.

Stop 3—Trees of Stone Trailhead

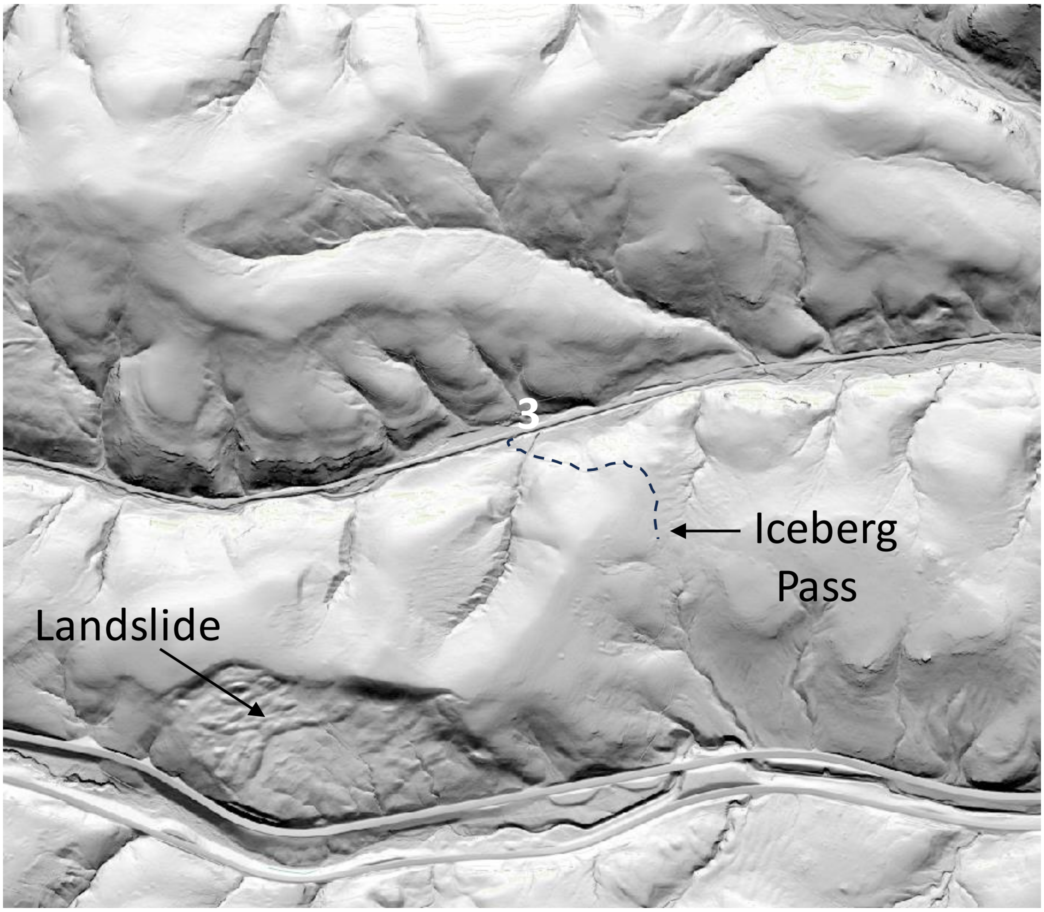


Figure 19. Trees of Stone Interpretive Trailhead (3) and vicinity. Note Iceberg Pass and large landslide to the south. The elevation of the floor of Iceberg Pass is about 1,150 ft. Source: Washington Lidar Portal.

Figure 20. The Ginkgo Petrified Forest State Park Trees of Stone Interpretive Trailhead (including Vista House) as of 1938. Image courtesy of the University of Washington, Lindsley Collection, September 5, 1938.

Stop 3—Trees of Stone Trailhead

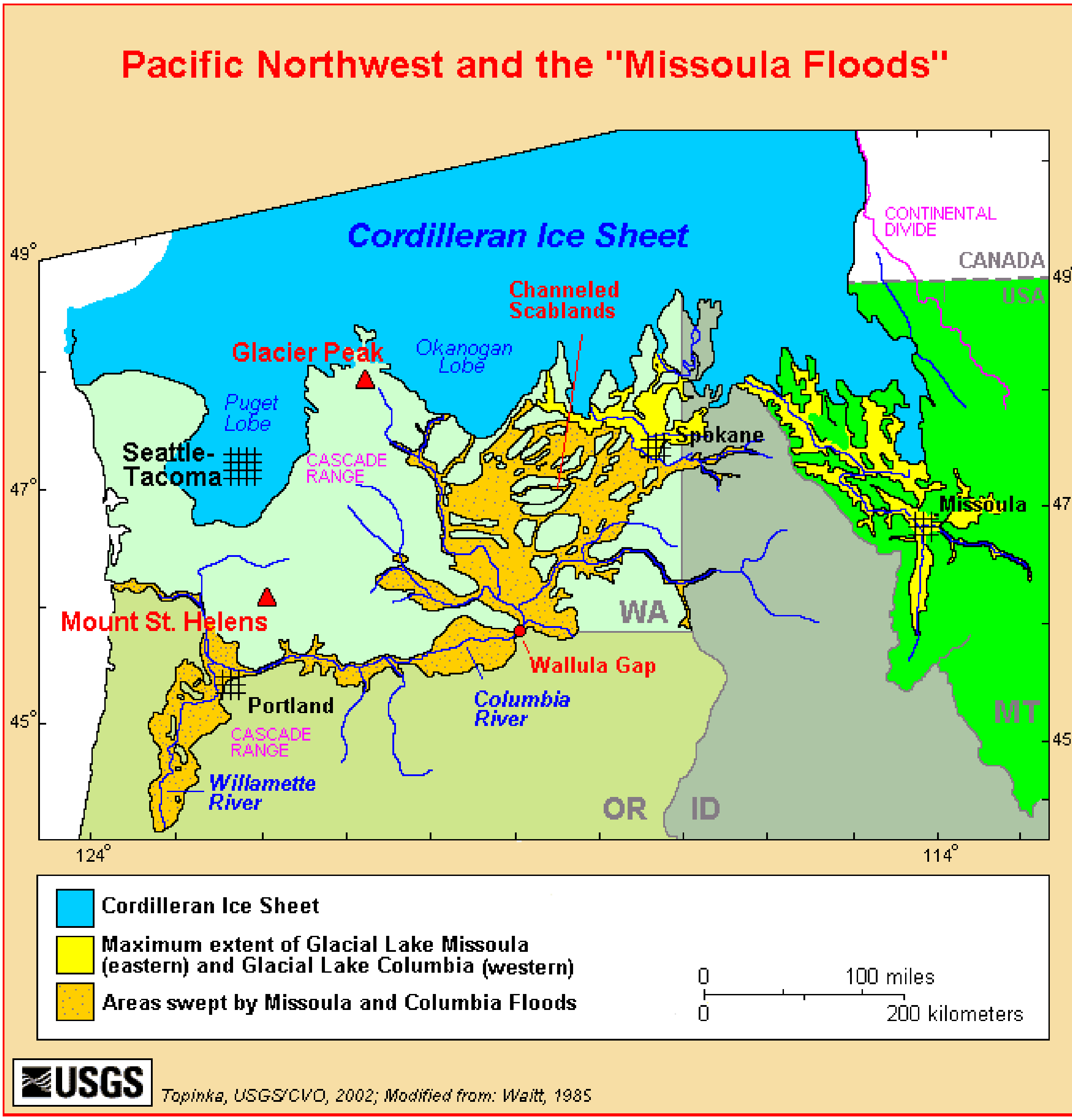


Figure 21. Missoula Flood and Cordilleran Icesheet extents in the Pacific Northwest. Source: Cascade Volcano Observatory.

Stop 3—Trees of Stone Trailhead

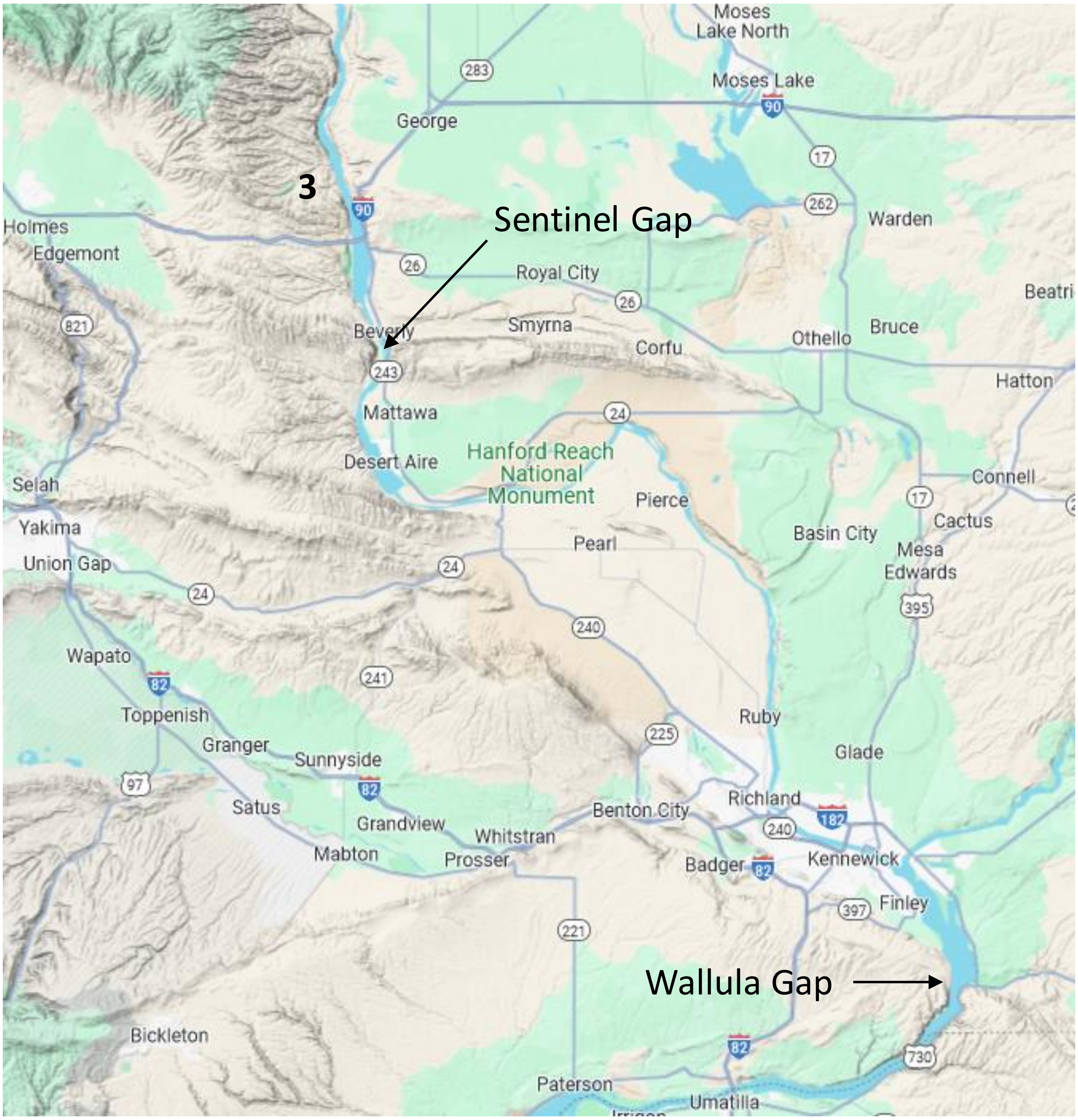


Figure 22. Wallula Gap, Pasco Basin, and Sentinel Gap in relation to the Trees of Stone Interpretive Trailhead, Ginkgo Petrified Forest State Park (3). Source: Google Maps.

Stop 3—Trees of Stone Trailhead

Individual Erratics, Clusters, and Bergmounds: We know slackwater was here based on the fieldwork of Ryan Karlson who mapped flood erratics as part of his M.S. thesis research in the Resource Management Program at Central Washington University (Karlson, 2006). He based his work on research done in the Lake Lewis basin (e.g., Fecht and Tallman , 1978; Bjornstad and others (2006). The key to locating flood-borne erratics in this basalt terrain is finding non-basalt rocks. Karlson found a variety of crystalline rocks including granite, granodiorite, diorite, gneiss, and quartzite here. Most of the individual erratics were less than 3 ft^2 in exposed area; however, the largest had an area of 85 ft^2 (Karlson, 2006)!

Slackwater flows do not have the velocity to transport large boulders or even cobbles. However, icebergs within slackwater can transport large erratics. Karlson interpreted the individual boulders as well as clusters and bergmounds (larger, taller clusters) of erratics as evidence of places where icebergs grounded on the slopes of Schnebly Coulee as the slackwater receded (Figures 23 & 24). Earlier, glacial till containing "foreign" rocks such as granite and gneiss was deposited atop icebergs (Figure 25). As the icebergs melted, individual erratics, clusters, and bergmounds were left behind. One erratic deposited in the Ginkgo Petrified Forest State Park indicates that slackwater reached an elevation of 1,263 feet near here and that slackwater had to travel up Schnebly Coulee about 3.5 miles to do so (Figure 26). This means that Ice Age floodwaters reached ~780 feet deep over the paleo-Columbia River channel at Vantage (Karlson, 2006)!

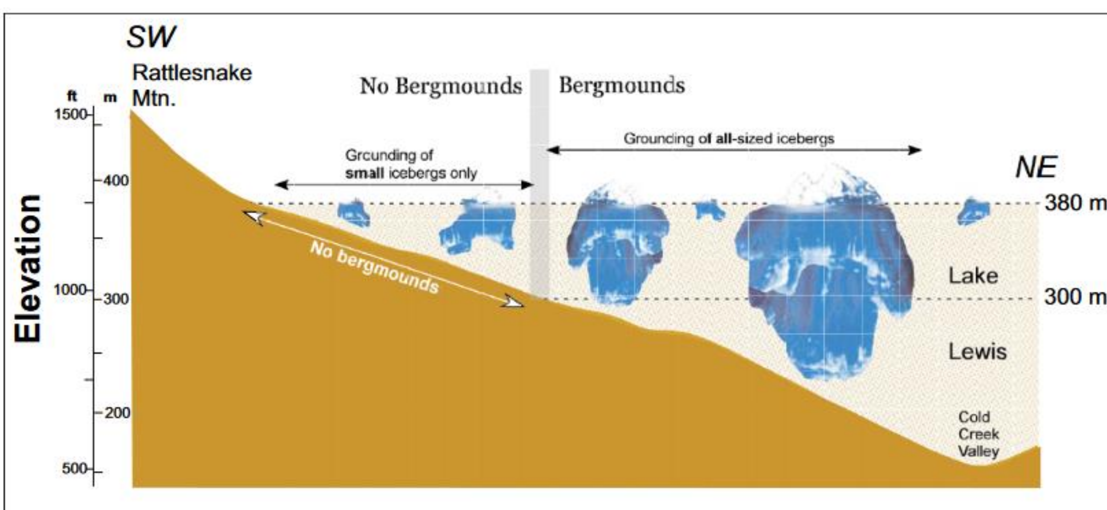


Figure 23. Elevation- and slope angle-driven impacts on the distribution of icebergs, hence bergmounds in the Lake Lewis basin south of Sentinel Gap. Source: Bjornstad (2014).

Stop 3—Trees of Stone Trailhead

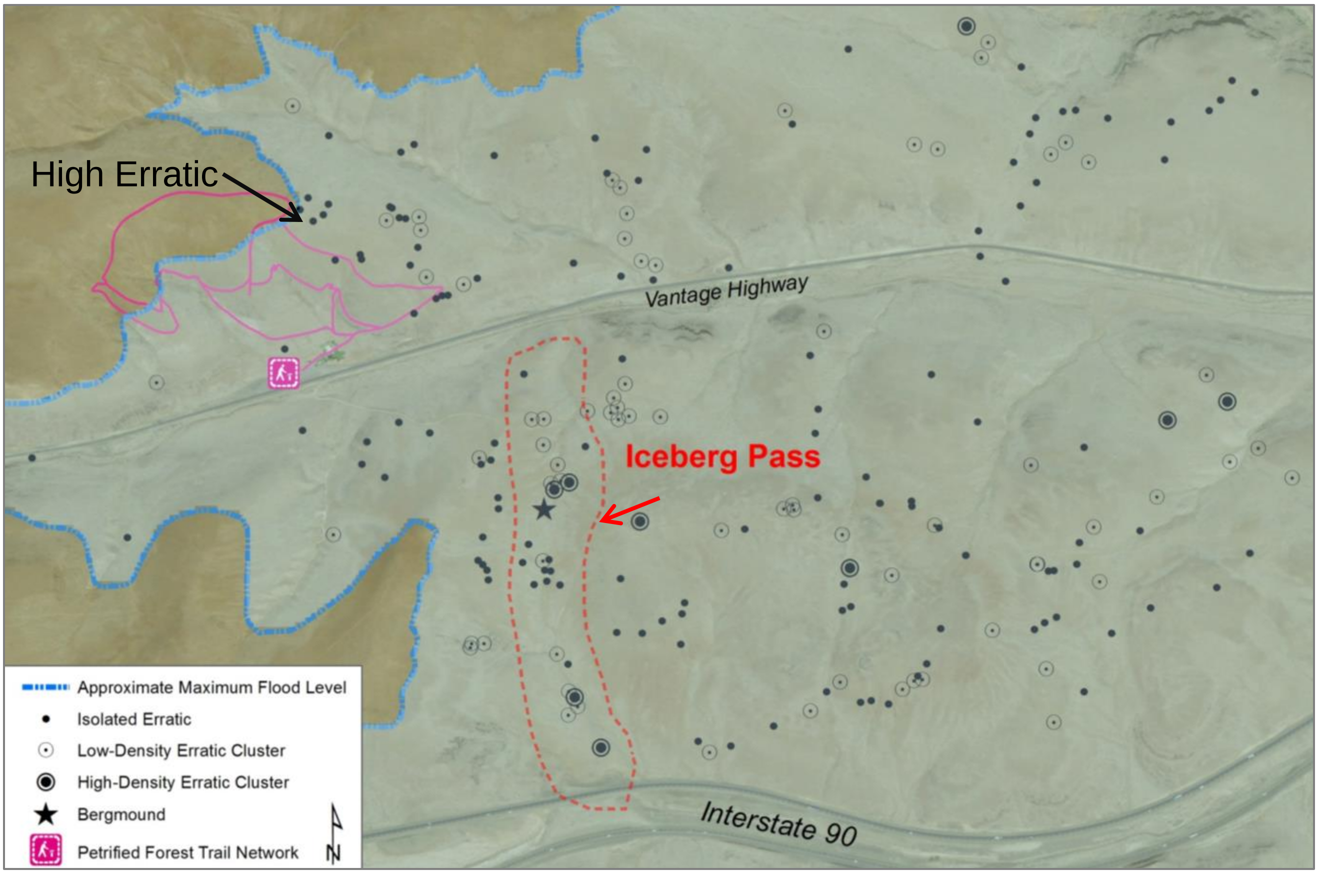
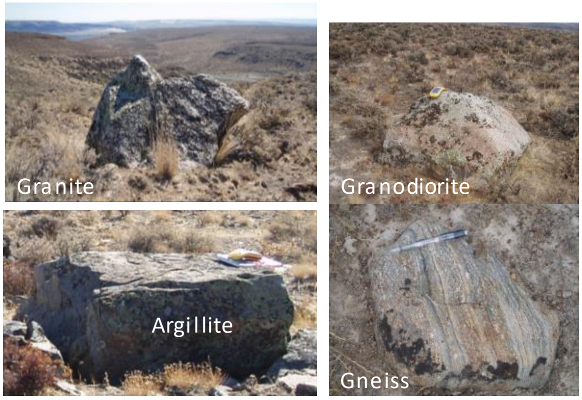


Figure 24. "Iceberg Pass" served as an Ice Age slackwater connection between Schnebly Coulee and Ryegrass Coulee. Iceberg Pass is so named because it contains iceberg deposited isolated erratics, low density clusters, high density clusters, and a bergmound. Source: Ryan Karlson.

Erratic Distribution: Erratics are found from near river level at 641 feet elevation up to 1,263 feet elevation. Forty-four percent were found between 1,100 feet and 1,200 feet elevation suggesting that a significant portion of all erratics were deposited by high-magnitude floods. Generally, erratic size declined with increasing elevation in the area. Isolated erratics are the most common iceberg-rafted deposits here (Figure 24) followed by low density clusters, high density clusters, and finally, bergmounds. Based on the deposit elevations relative to maximum water depth, Karlson (2006) determined that high density clusters required at least 45 feet of water depth while bergmounds needed at >100 feet.

Stop 3—Trees of Stone Trailhead



Isolated Erratic

Low-Density Erratic Cluster

High-Density Erratic Cluster

Bergmound

Figure 25. Examples of ice-rafted erratic deposit types in Ginkgo Ginkgo Petrified Forest State Park. Source: Ryan Karlson.

Timing of Floods: We know from research elsewhere in the Channeled Scablands that pre-Glacial Lake Columbia, Grand Coulee, and post-Glacial Lake Columbia floods would have passed through this reach of the Columbia River during the late Pleistocene (O'Conner & others, 2020). Karlson (2006) identified 37 rhythmites suggesting as many floods impacted the lower elevation of the park.

Stop 3—Trees of Stone Trailhead

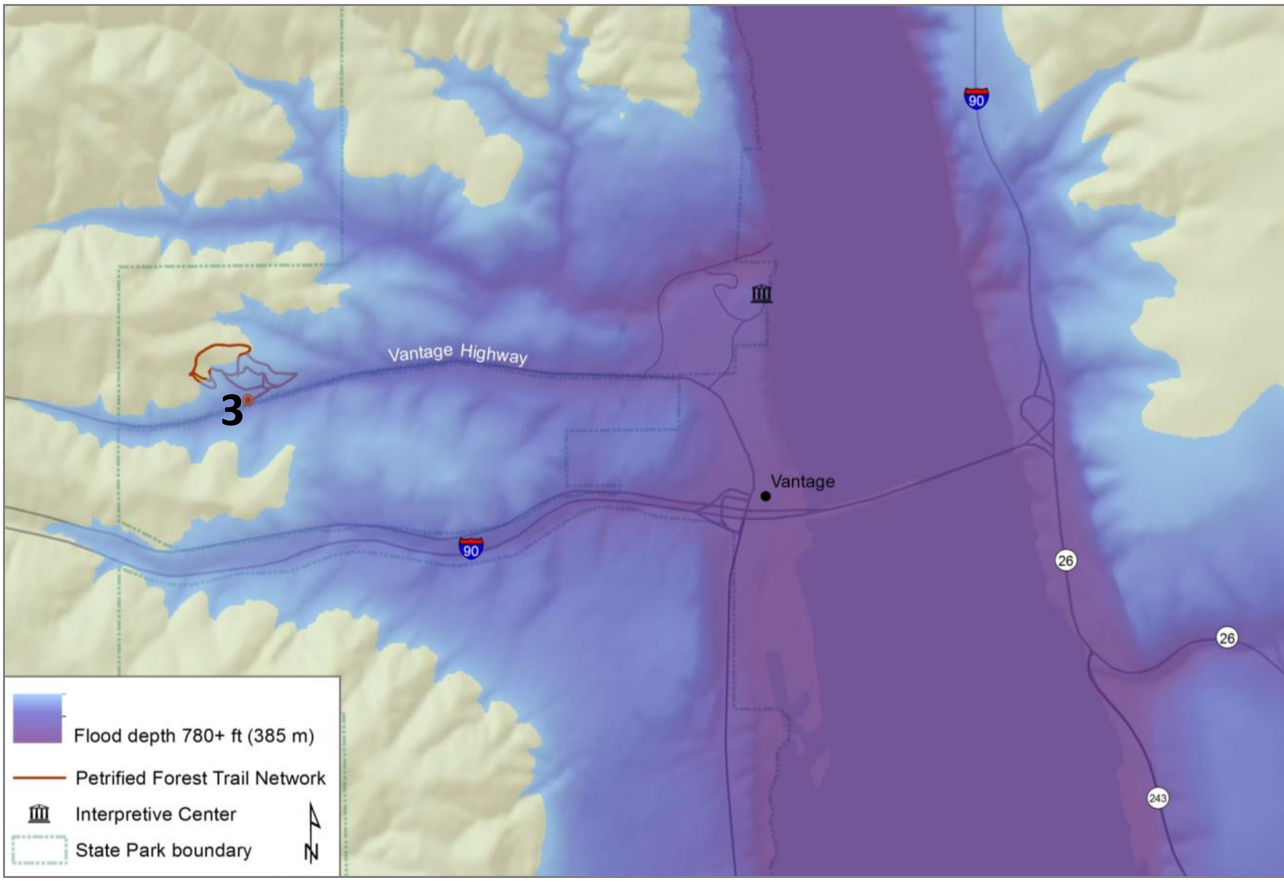


Figure 26. Estimated maximum Pleistocene flood inundation levels in Ginkgo Petrified Forest State Park. The 780+ ft (239 m) maximum depth is based on an ice-rafted erratic surveyed at 1,263 ft (385 m). Source: Ryan Karlson.

Enroute to Stop 4

Route: Our next stop is the interpretive center at Ginkgo Petrified Forest State Park in Vantage. From the parking lot at Stop 3, turn left onto Vantage Highway and head east down Schnebly Coulee toward Vantage. Follow the Vantage Highway for just over 2 miles. Turn left onto Ginkgo Avenue just after the road into Rocky Coulee (i.e., Recreation Drive) and just as you enter Vantage. Follow Ginkgo Avenue for about 0.5 miles to the interpretive center. GPS coordinates are 46.954441°N, 119.988109°W. A Discover Pass is required to park here.

Stop 4—Ginkgo Interpretive Center

Location: We are located at the Ginkgo Petrified Forest State Park Interpretive Center (Figure 27). The elevation here is about 720 feet. We have dropped nearly 2800 feet from Stop 1 on Whiskey Dick Mountain! The CCC built the north half of the interpretive center here (Karlson, 2006). This is an information and restroom stop.

Getting Our Bearings: We are located atop a Grande Ronde basalt flow (Table 1) (Carson & others, 1987). Ice Age floods played a big role in eroding the gorge in which we are located. Immediately to our west is a large eddy bar associated with the passage of those Ice Age floodwaters. Upriver, we can see the mouth of Frenchman Coulee, the southwesternmost cataract in the Quincy Basin. Across Wanapum Lake, we see Babcock Bench, a *stripped structural surface* formed at the interface of the Wanapum and Grande Ronde flows (Carson & others, 1987). Tan sand dunes which originated on the Columbia River floodplain pre-Wanapum Dam blanket parts of the basalt bedrock and *talus* slopes. Sentinel Gap is a *water gap* through the Saddle Mountains.

Petrified Wood in Central Washington: Petrified wood forms when silica replaces organic material over a very long period. The source of the silica was likely devitrified volcanic glass (Mustoe & Dillhoff, 2022). The petrified wood present here formed after the mid-Miocene, beginning about 15.5 million years ago (Table 1). This is but one of several petrified wood localities in Central Washington. U.S. Geological Survey geologist I.C. Russell was the first to mention fossil trees in Central Washington (Russell, 1893). CWCE geologist George Beck (Figure 28) subsequently identified the Vantage-area petrified forest deposits as one of 12 petrified "Russell forests" (named after I.C. Russell) in Central Washington (Beck, 1945). The Ginkgo Petrified Forest is one of three Central Washington localities known with ample petrified wood within Columbia River Basalt flows. The others are the Umtanum Petrified Forest of Umtanum Creek and Umtanum Ridge, and the Saddle Mountains Petrified Forest (Orsen and Reidel, 2003).

Ginkgo Petrified Forest: Most of the petrified wood here is found in the Ginkgo unit of the Frenchman Springs member of the Wanapum Basalts (Carson and others, 1987) (Table 1). Much of the petrified wood within the Ginkgo is found in a pillow basalt complex at the base of the flow indicating that the lava flow cooled in water. The Ginkgo petrified forest consists of at least 32 different genera of coniferous and deciduous trees (Figure 29; Table 2) (Prakesh, 1968). These include trees that are: 1) currently extinct in North America but found at present in Eastern Asia, Africa, and Australia (e.g., *Ginkgo*) ; 2) currently extinct from Western North America but present in Eastern North America (e.g., *Fagus*) ; and 3) currently growing near Vantage or at other sites in Western North America (e.g., *Abies*) (Prakesh, 1968).

Stop 4—Ginkgo Interpretive Center

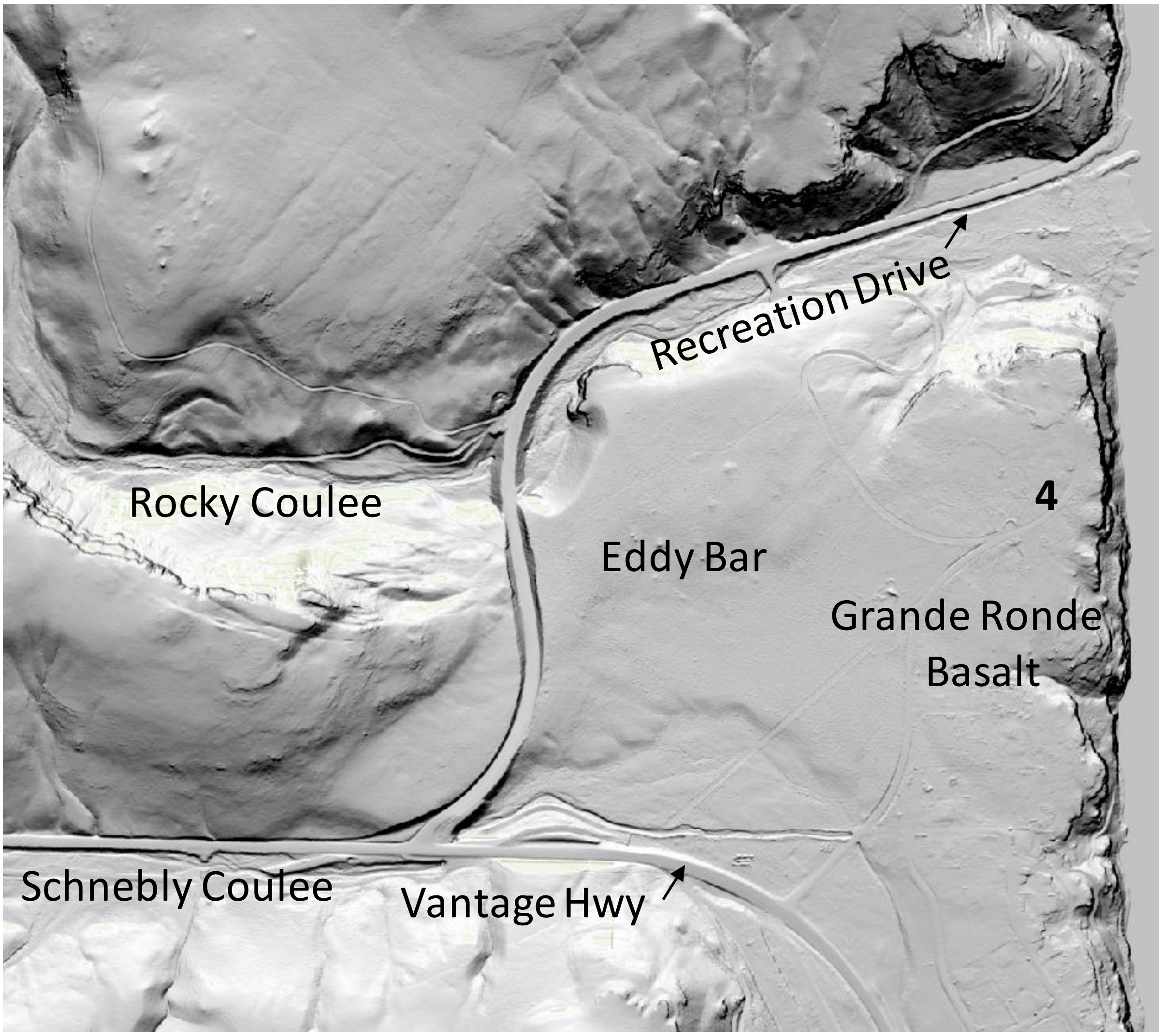


Figure 27. Interpretive Center (4) atop Grande Ronde basalt flow adjacent to Schnebly Coulee and Rocky Coulee eddy bar. Source: Washington Lidar Portal.

Ginkgo Petrified Forest (continued): The logs of the Ginkgo petrified forest were well preserved because they were deposited in wet places. Most were missing their root wads, were found in horizontal positions, and missing limbs and bark (Mustoe & Dillhoff, 2022). These characteristics suggest that a *lahar (*i.e., volcanic mudflow) transported logs into Lake Vantage, a lake formed by the advance of the Ginkgo flow into the area (Tolan & Reidel, 1991. Logs in the lahar floated free of the lahar and were subsequently entombed by the Ginkgo flow. The ample moisture combined with rapid inundation of the wet places by lava flow protected them from burning. The association between the petrified logs and basalts is seen in the pillow lava nature of the flow (Beck, 1945).

Stop 4—Ginkgo Interpretive Center

Figure 28. CWCE Professor George Beck. Source: Central Washington University, "George Beck" (1935). *Washington State Normal School Photographs*. 55. https://digitalcommons.cwu.edu/wsns_photographs/55

Figure 29. Examples of petrified wood located at Ginkgo Petrified Forest State Park Interrpretive Center. Source: Author photo, May 2024.

Stop 4—Ginkgo Interpretative Center

Table 2. Present distribution of the Vantage-area genera. From Prakash (1968, p. 196).

Genera	Eastern North America	Eastern Asia	Western North America
Ginkgo	—	+	—
Abies	+	+	+
Picea	+	+	+
Larix	+	+	+
Pseudotsuga	—	+	+
Taxus	+	+	+
Taxodium	+	—	—
Sequoia	—	—	+
Callitris	—	—	—
Carya	+	+	—
Juglans	+	+	+
Pterocarya	—	+	—
Betula	+	+	+
Quercus	+	+	+
Fagus	+	+	—
Ulmus	+	+	—
Hamamelis	+	+	—
Liquidambar	+	+	—
Plantanus	+	+	+
Malus (Pyrus)	+	+	+
Prunus	+	+	+
Gleditsia	+	+	—
Albizzia	—	+	—
Robinia	+	—	+
Acacia	—	+	—
Sophora	—	+	+
Acer	+	+	+
Aesculus	+	+	+
Gordonia	+	+	—
Sapindus	+	+	+
Nyssa	+	+	—
Diospyros	+	+	—
Fraxinus	+	+	+

Stop 4—Ginkgo Interpretive Center

Ginkgo Petrified Forest (continued): The petrified logs suggest a "warm temperate mesophytic" climate (Prakesh & Barghoorn, 1961). This essentially means a warmer, more moist climate than is present in the Vantage area today. A large portion of the precipitation that fell here likely occurred in the summer. Subsequent changes toward more continental temperatures, increased overall aridity, and drier summers may have been related to changes in oceanic and atmospheric circulation, and to the rise of the Cascade Range (Mustoe, 2001).

"Old" Vantage. Ferries were common early ways of conveying passengers across Washington state rivers. This was true up and down the Columbia River (Ruby and Brown, 1974). The first ferryboat owned and operated by W.D. Van Slyke began operating at Vantage in 1914. Earlier, he had platted 120 lots and a large road easement through the middle on an 80 acre parcel and named it "Vantage" (Clarke, 2013). Grant and Kittitas counties took over the ferryboat service in 1917 (Figure 30) when Van Slyke could no longer afford to operate it. Traffic rapidly increased on the route. By 1922, the Vantage ferry transported 15,464 cars and 45,660 passengers. The combination of increasing traffic and public safety (e.g. wind and ice) led to the completion of the Vantage Bridge in 1927 (Figures 31 & 32) (Ruby and Brown, 1974). By 1941, Vantage included 6 occupants and a gas station, store, and one house (Washington Writers Project, 1941).

Wanapum Dam, Lake Wanapum & Present-Day Vantage. In 1959, Grant County Public Utility District began construction on Wanapum Dam, a primarily hydroelectric facility. This dam impounds the Columbia River to form Lake Wanapum. In anticipation of the completion of the dam, and the flooding of Old Vantage and the Vantage Bridge, the town of Vantage was moved upslope to its present-day location. The new bridge was completed 1.2 miles downstream of the original bridge in 1962. The original Vantage bridge was dismantled, and later reassembled to span the Snake River at Lyons Ferry in southeastern Washington (Dorpat & McCoy, 1998).

Stop 4—Ginkgo Interpretive Center

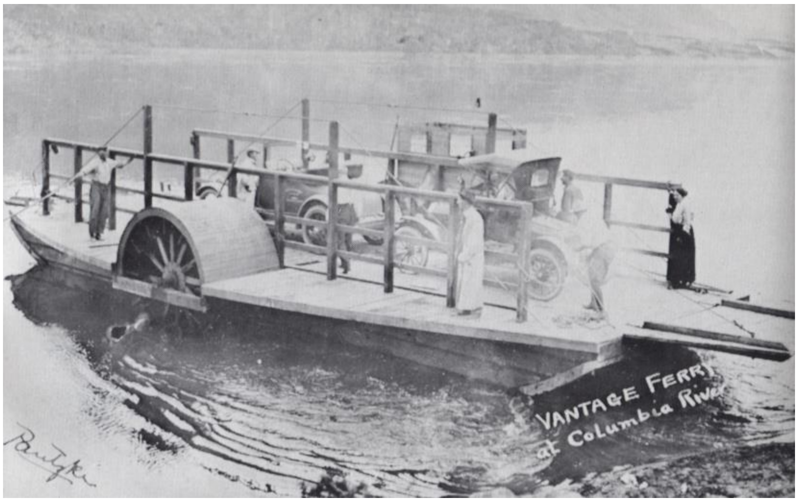


Figure 30. The Kittitas-Grant county operated ferry at Vantage. Date unknown. Source: Ruby and Brown (1974, p. 98-99).

Figure 31. View east of first Vantage Bridge located at the mouth of Rocky Coulee. Completion of this bridge in 1927 eliminated the need for the Vantage ferry. In 1940, it became a key link in the U.S. Department of Defense' establishment of US 10 as Washington state's primary military route. Source: Ruby and Brown (1974, p. 101).

Stop 4—Ginkgo Interpretive Center

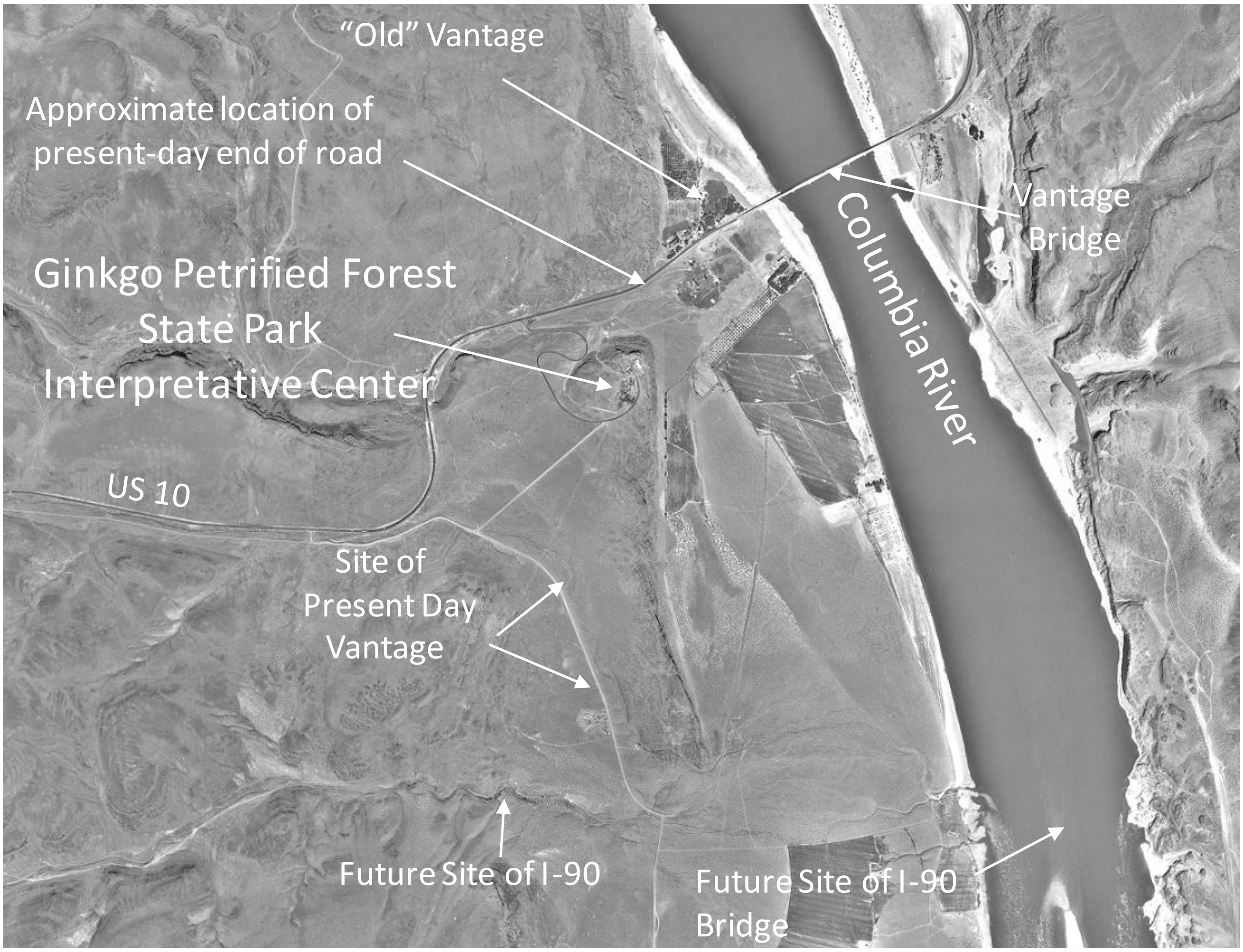


Figure 32. Vantage, Washington as of August 1954. Note the location of "old" Vantage and the first Vantage Bridge at the mouth of Rocky Coulee. The water of Lake Wanapum now covers both. Also note the approximate future locations of present-day Vantage, I-90 in Ryegrass Coulee, and the I-90 bridge at the mouth of Ryegrass Coulee. The dark areas just west of the Columbia River are irrigated farms. Source: Kittitas County airphoto NJ-4N-68, 8-11-54, Central Washington Historical Aerial Photograph Project, Geography Department, Central Washington University.

Stop 4—Ginkgo Petrified Forest State Park Interpretive Center

Wrap-up: The area between Ellensburg and Vantage has common themes. Our story began with basalt flows covering a warm, humid environment. Lahars transported logs to the Vantage area where they were encased by one of these flows. Since the changes in oceanic and atmospheric circulation, and uplift of the Cascades Range, a more continental climate characterized by aridity and temperature extremes has become the norm. And with the separation of climates between western and eastern Washington, pervasive winds characterize the area. Huge floods impacted the lower portions of the area during the late Pleistocene, leaving erratics high on slopes in side drainages. All of this is bisected by historical Vantage highway, an early version of the Sunset Highway.

Thanks for participating today. These trips don't happen without your continued interest. Feel free to contact me at lillquis@cwu.edu or (509) 963 1184 if you have further questions/comments. I hope to see you on the next trip in late summer/early fall 2024.

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