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Wine and geology—The terroir of Washington State

Alan J. Busacca*
Department of Crop and Soil Sciences, Washington State University, Pullman, Washington 99164-6420, USA

Lawrence D. Meinert*
Department of Geology, Smith College, Northampton, Massachusetts 01063, USA

ABSTRACT

Washington State is second only to California in terms of wine produced in the United States, and some of its vineyards and wines are among the world's best. Most Washington vineyards are situated east of the Cascades on soils formed from Quaternary sediments that overlie Miocene basaltic rocks of the Columbia River Flood Basalt Province. Pleistocene fluvial sediments were deposited during cataclysmic glacial outburst floods that formed the spectacular Channeled Scabland. Late Pleistocene and Holocene sand sheets and loess form a variable mantle over outburst sediments. Rainfall for wine grape production ranges from ~6–18 in (150–450 mm) annually with a pronounced winter maximum and warm, dry summers. This field trip will examine the terroir of some of Washington's best vineyards. Terroir involves the complex interplay of climate, soil, geology, and other physical factors that influence the character and quality of wine. These factors underpin the substantial contribution of good viticultural practice and expert winemaking. We will travel by bus over the Cascade Mountains to the Yakima Valley appellation to see the effects of rain shadow, bedrock variation, sediment and soil characteristics, and air drainage on vineyard siting; we will visit the Red Mountain appellation to examine sites with warm mesoclimate and soils from back-eddy glacial flood and eolian sediments; the next stop will be the Walla Walla Valley appellation with excellent exposures of glacial slackwater sediments (which underlie the best vineyards) as well as the United States' largest wind energy facility. Finally, we will visit the very creatively sited Wallula Vineyard in the Columbia Valley appellation overlooking the Columbia River before returning to Seattle.

Keywords: wine, terroir, wine grapes, loess, soils, outburst floods.

INTRODUCTION

The purpose of this field trip is to examine the connection between wine and geology in Washington State, a connection that commonly is described by the word "terroir." Although the term originated in France, terroir increasingly is being used in other parts of the world to explore differences at the scale of appellations to individual vineyards to within-vineyard domains (Halliday, 1993, 1999; Wilson, 1998, 2001; Haynes, 1999, 2000). But the word "terroir" is mysterious to many people; there is confusion about what it is, how it is documented, and even how it is pronounced (tehr-wahr). Terroir involves the complex interplay of climate, soil, geology, and other physical factors that influence the character and quality of wine. These factors are in addition to, or perhaps underlie, the substantial contribution of good viticultural practice and expert winemaking. One common illustration of the importance of terroir is the occurrence of adjacent or nearby vineyards that produce strikingly different wines even though many of the measurable aspects of climate, viticulture, and winemaking technique are very similar. It is also common,

*E-mail: Busacca—busacca@wsu.edu; Meinert—Lmeinert@smith.edu.

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although usually incorrect, to point to a single factor as the explanation: "it's the soil"; "it's the water"; "it's the limestone"; etc. Terroir is the integration of individual factors that contribute to wine quality, and to make matters even more complicated there is the complexity of year-to-year variation in climate. What may be good terroir in one year may be less so in another.

The Merriam-Webster's dictionary defines "appellation" as a geographical name (as of a region, village, or vineyard) under which a winegrower is authorized to identify and market wine (from http://www.m-w.com/cgi-bin/dictionary?book=Dictionary&va=appellation; accessed on September 4, 2003). Washington State has five wine appellations called American Viticultural Areas (AVAs) by the Alcohol and Tobacco Tax and Trade Bureau (TTB; formerly Bureau of Alcohol, Tobacco, and Firearms), the chief regulatory agency of the wine industry in the United States. The current Washington State appellations (AVAs) are Columbia Valley, Puget Sound, Red Mountain, Walla Walla Valley, and Yakima Valley (Fig. 1). Sub-appellations that may someday become AVAs include Alder Ridge, Canoe Ridge, Cold Creek, Columbia River Gorge, Horse Heaven Hills, Wahluke Slope, Zephyr Ridge (Peterson-Nedry, 2000), and the Okanogan Valley-Lake Chelan area.

As with most other wine growing regions, Washington AVAs can be nested such that the Columbia Valley appellation, which produces more than 90% of the state's wine grapes, includes the Yakima Valley, Walla Walla Valley, and Red Mountain appellations (Fig. 1). The area available for future planting is very large. In the 10.7-million-acre Columbia Valley appellation, only ~16,000 acres are planted with wine grapes. Even the smallest appellation, Red Mountain, has room for expansion with ~710 acres out of the 4040 acres of the AVA planted with vines. In many cases the availability of water for irrigation is a larger limitation than the suitability of land for growing high-quality grapes.

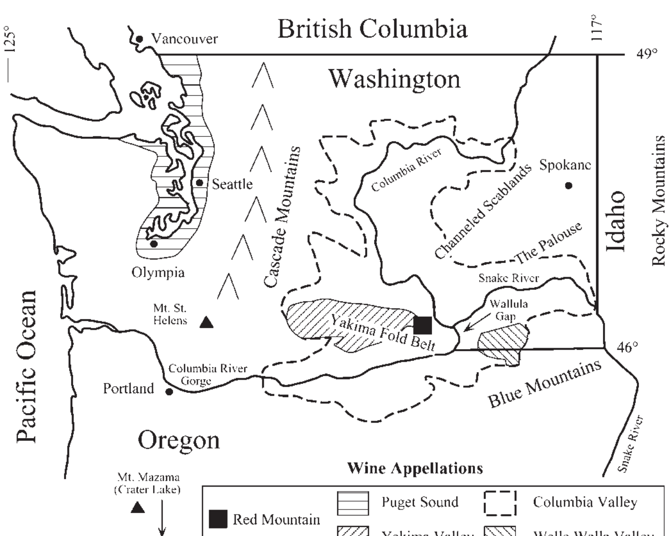

Figure 1. Location map of the Pacific Northwest showing wine appellations of Washington State and major geographical features described in the text.

Only ~18% of Washington's wine grapes are from vineyards more than 20 yr old, and of these older vineyards, white grapes (73%) predominate over red grapes (27%) (www.nass.usda.gov/wa/wine02.pdf). For example, Riesling was the most widely planted white wine grape prior to 1982 at 54% of its current (2002) acreage. In contrast, Cabernet Sauvignon, Merlot, and Syrah were the three most widely planted red grapes in 2002 and had only 12%, 5%, and 0%, respectively, of their current acreage planted prior to 1982.

Currently there are ~240 wineries in Washington State. Total wine grape production in 2001 was 100,000 tons from 24,000 acres of bearing vineyards. Wine grape production will continue to increase since there are an additional 6000 acres of wine grapes planted that were not yet bearing fruit in 2001. Most grape vines start producing commercial yields in their third year. Wine grape production in 2002 was 115,000 tons. Of the wine produced in Washington State in 2002, there was an equal split between white and red wine, down from a majority (62%) of white wine in 1998. For example, the production of Semillon and Chenin Blanc in this three-year period decreased 35%, whereas the production of Cabernet Sauvignon, Merlot, and Syrah increased 200%. This trend toward a predominance of red wine production in Washington State likely will continue in the future because of the increased plantings of red varietals and the higher prices realized from red grapes in general.

REGIONAL GEOLOGIC HISTORY

Most Washington vineyards lie in the geographic center of the Columbia Plateau, which is bordered on the north and east by the Rocky Mountains, on the south by the Blue Mountains, and on the west by the Cascade Mountains (Fig. 1). The area is underlain by the Columbia River Basalt Group, which covers an area of ~165,000 km^2. The Columbia River Basalt Group was erupted mostly between 17 and 11 Ma (early Miocene) from north-south fissures roughly paralleling the present-day Washington-Idaho border. The Columbia River Basalt Group has individual flows with estimated eruptive volumes of at least 3000 km^3, making them the largest documented lava flows on Earth (Baksi, 1989; Landon and Long, 1989; Tolan et al., 1989). This dwarfs the erupted volumes of typical Cascade volcanoes: even the explosive eruption of Mount St. Helens in 1980 yielded only ~1 km^3 of volcanic material (Pringle, 1993). The basalts are interstratified with volcaniclastic rocks of the Ellensburg Formation, mainly in the western part, including the Yakima fold belt through which we will be traveling.

The basalt bedrock is overlain by unconsolidated sediments deposited by glacial outburst floods and eolian processes described in some detail in Meinert and Busacca (2000). To briefly summarize: a lobe of the Cordilleran Ice Sheet blocked the Clark Fork River near the Canadian border in northern Idaho most recently ca. 18,000 ka and created glacial Lake Missoula (Fig. 2),

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which covered 7800 km^2 of western Montana (Pardee, 1910). At the ice dam the water was ~600 m deep (Weis and Newman, 1989). The ice dam failed repeatedly, releasing the largest floods documented on Earth (Baker and Nummedal, 1978). These floods overwhelmed the Columbia River drainage system and sent up to 2500 km^3 of water across the Columbia Plateau with each outburst (called jökulhlaups in Iceland, where similar, though orders of magnitude smaller, events occur today). The floods eroded a spectacular complex of anastomosing channels, locally called "coulees," into southwest-dipping basalt surfaces. They also eroded huge cataracts in the basalt, now seen as dry falls, and "loess islands" that are erosional remnants of an early thick loess cover on the plateau. The floods deposited immense gravel bars and ice-rafted erratic boulders at high elevations. Collectively these features make up the Channeled Scabland as detailed in the early work by Bretz (1923, 1925, 1928a, b, and c, 1932).

In south-central Washington State, the many paths of the onrushing floods converged on the Pasco Basin, where floodwaters were slowed by the hydrologic constriction of Wallula Gap (Fig. 2) before draining out through the Columbia River Gorge to the Pacific Ocean. This constriction caused back flooding of local river valleys and basins, which resulted in deposition of relatively fine-grained slackwater sediments characterized by rhythmically graded bedding; these graded rhythmites, locally called touchet beds and multiple sets, have been recognized and are indicative of multiple floods during the Last Glacial Maximum (Flint, 1938; Waitt, 1980, 1985).

Loess, sand dunes, and sand sheets have been accumulating on the Columbia Plateau throughout much or all of the Quaternary Period (Busacca, 1989). The loess is thickest, up to 75 m, in a 10,000 km^2 area northeast of the Columbia Valley appellation in an area called the Palouse (Fig. 2; Baker et al., 1991). A major source of sediment for the dunes and loess has been slackwater and other glacial sediments from older episodes of outburst flooding (McDonald and Busacca, 1988; Sweeney et al., 2002). Most recently during the last stages of the Pleistocene (from ca. 20 ka to 14 ka) and continuing through the Holocene, prevailing southwesterly winds eroded slackwater and other glacial sediments and redeposited them into the present sand dunes, sand sheets, and loess that mantle much of the Columbia Plateau. Soils formed from these windblown sediments are the backbone of agriculture in all of eastern Washington (Boling et al., 1998).

Two major units of loess that span approximately the past 70,000 yr have been informally named L1 and L2 (McDonald and Busacca, 1992). Many layers of distal tephra have been described and sampled from loess exposures and fingerprinted by electron microprobe (Busacca et al., 1992). Distal tephra layers in L1 loess have been correlated to Glacier Peak layers G and B (ca. 13,300 cal. yr B.P.) and to Mount St. Helens set S distal tephra (MSH S; ca. 15,300 cal. yr B.P.), and those in L2 loess to Mount St. Helens set C distal tephra (MSH C; ca. 50,000–55,000 thermoluminescence [TL] yr B.P.).

The L1 and L2 loess units thin and fine away from major slackwater sediment areas in the Umatilla and Pasco Basins (Busacca and McDonald, 1994) and Eureka Flat (Sweeney et al., 2003). The patterns are consistent with evidence that two major episodes of scabland flooding, one ca. 70,000–60,000 yr B.P. and the other the classic Spokane Floods ca. 20,000–15,000 TL yr B.P., triggered the last two major cycles of loess deposition on the Columbia Plateau and that they accumulated with only temporary slowing of deposition for much of the succeeding interglacial intervals.

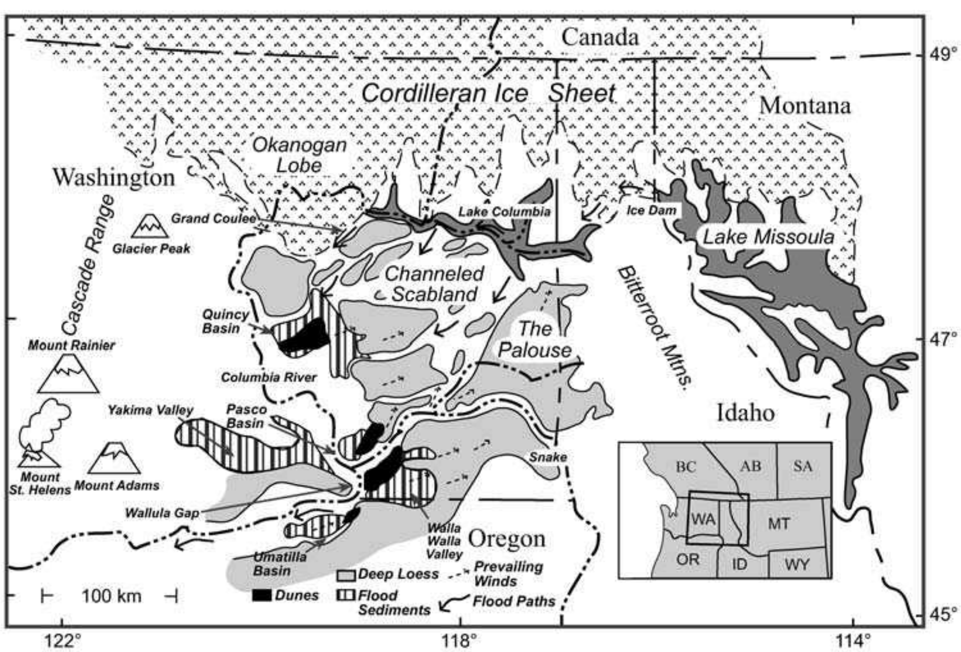

Figure 2. Schematic diagram showing the Pacific Northwest during the Last Glacial Maximum, the Lake Missoula–Channeled Scabland system, eolian sediments, and volcanoes of the Cascade Range.

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SOILS, NATIVE VEGETATION, AND CLIMATE

Surface soils on the Columbia Plateau are dominantly Mollisols, Aridisols, and Entisols (Boling et al., 1998; Soil Survey Staff, 1999). In the central part of the Columbia Plateau where mean annual precipitation (MAP) is less than ~9 in (230 mm), soils developed in loess under sagebrush steppe are Aridisols, whereas soils developed in sand dunes under similar vegetation and precipitation are Entisols. Soils developed in loess under perennial bunchgrass vegetation where MAP is greater than or equal to ~9 in are Mollisols. Around the margins of the plateau loess soils formed under conifers are Alfisols. Some forest soils have a mantle of tephra-rich loess from Mount Mazama and are Andisols. Soils used for wine grapes commonly are Aridisols in which the upper horizons are formed in loess or sheet sands and lower horizons are formed in stratified silty to gravelly outburst flood sediments. Some have a lime-silica indurated pan at the interface between materials. Some wine grape soils are formed in loess or sand to 5 ft (1.5 m) or more. Thus, there are major differences in rooting depth, texture, and resulting water-holding capacity, which are key properties for inducing controlled water stress to improve grape quality.

Pre-agricultural vegetation in southeastern Washington ranged from sagebrush-steppe in the driest areas, to meadow steppe in areas of intermediate precipitation, to coniferous forest (Daubenmire, 1970). Xerophytic (drought tolerant) shrubs include several species of *Artemisia*, *Purshia,* and *Crysothamnus*. Perennial grasses include the major species bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and Sandberg bluegrass (*Poa sandbergii*) and a host of less common annual and perennial grasses and forbs. Mesophytic (moisture-loving) shrubs include *rosa* spp., Serviceberry (*Amelanchier alnifolia*), and Snowberry (*Symphoricarpos albus*). Several zones of conifer vegetation have been recognized with increasing effective moisture and decreasing temperature (Daubenmire and Daubenmire, 1984).

Climate is one of the more important components of terroir. In some ways it is the most difficult to evaluate because it varies in both space and time. There are many weather variables and these can be measured at three different scales. Macroclimate is on a continental to regional scale and controls the length of the growing season and other long-term trends and extremes. Mesoclimate is on a regional to vineyard scale and is affected by topography, elevation, slope, aspect, and proximity to bodies of water or other moderating influences. Microclimate ranges from the scale of a vineyard down to individual vines, grape clusters, and even smaller domains if measurement permits. Macroclimate changes on a geologic time scale (thousands to millions of years), but both mesoclimate and microclimate can vary seasonally, daily, or even hourly. Both mesoclimate and microclimate can be affected by human activities such as urban development, wind machines, irrigation, and canopy management.

Although many climatic variables can be measured, four of the more important are temperature, humidity, wind, and sunlight (solar radiation). These and others are collected systematically by a variety of meteorological services, but in the state of Washington we are fortunate to have the Washington State University (WSU) Public Agricultural Weather System (PAWS) that automatically and continuously collects climatic data (http://frost.prosser.wsu.edu/). Such data can be used for regional and worldwide comparisons, e.g., the excellent analyses of Gladstones (1992, 2001).

The climate of the Columbia Plateau is influenced to a great extent by prevailing westerly winds and by the Cascade and Rocky Mountains. The Cascade Mountains create a rain shadow, and as a result the climate of the Columbia Plateau is arid to subhumid (15–100 cm of mean annual precipitation). The amount of precipitation is closely correlated with elevation, generally increasing from west to east and southeast. The Rocky Mountains protect this section of Washington from the coldest of the arctic storms that sweep down through Canada.

During the summer, high-pressure systems prevail, leading to dry, warm conditions and low relative humidity. Average afternoon temperatures in the summer range from 20 to over 35 °C. Most of the growing season is very dry and some vineyards experience no measurable precipitation during the summer months. The rainy season extends from October to late May or June, as frontal storms sweep across the area. In eastern Washington, most of the precipitation from mid-December to mid-February is in the form of snow.

As an example of climates of Washington appellations, Red Mountain is a warm vineyard site with 3409 degree days (50 °F) recorded in 1998 and an average of 3016 degree days for the years of record. For comparison, the Napa Valley in California and the Barossa Valley in Australia average 3280 and 3090 degree days, respectively (see the broader discussion by Meinert and Busacca [2000, 2002] of climatic measures in Washington and by Gladstones [1992, 2001] of general climatic measures relative to viticulture). Red Mountain also may be the driest viticultural area in Washington State, with an average annual precipitation of 17.8 cm and a low in 1999 of 8.4 cm. Typically, in most areas of the state, the time of year with lowest precipitation coincides with that of highest temperatures, and because of the low soil water-holding capacity and general absence of water tables, this creates a moisture deficit that requires irrigation in most vineyards. With the high evapotranspiration rates in such conditions, drip irrigation is the dominant method of supplying supplemental water.

Regional comparisons are possible using the above geologic history and climatic data. For example, more than 90% of Washington vineyards are located in areas affected by glacial outburst floods. In the Red Mountain appellation, these flood sediments were mostly deposited from the swirling back-eddies behind Red Mountain and include numerous lenses of relatively coarse gravel. In the Walla Walla Valley appellation, the flood sediments are generally finer grained due to deposition from ponded floodwaters, although there are some zones of coarse gravels in modern river channels.

The goal of this field trip is to examine the terroir of specific Washington vineyards and to attempt to correlate the observed features of soils, geology, climate, and other physical factors

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with variations in grape and wine quality. The specific field stops will include:

Day 1	
Stop 1	Yakima Valley appellation—Red Willow Vineyard
Stop 2	Hogue—lunch and winery tour
Stop 3	Red Mountain appellation—Ciel du Cheval and Klipsun Vineyards
Stop 4	Webber Canyon slackwater deposits with Mount St. Helens "S" ash and post-flood (L1) loess
Stop 5	Wallula Gap overlook (optional)
Stop 6	Holiday Inn Express, check in before dinner
Stop 7	Gourmet wine and dinner at L'Ecole No. 41 Winery

Day 2	
Stop 1	Walla Walla Valley appellation—Cailloux Vineyard
Stop 2	Walla Walla Valley appellation—Pepperbridge Vineyard
Stop 3	Walla Walla Valley appellation—Loess Vineyard: Leonetti Cellars
Stop 4	Burlingame Canyon exposure of slackwater sediments and L1 loess
Stop 5	Lunch and tour at FPL Energy's Stateline Wind Energy Center
Stop 6	Columbia Valley appellation—Wallula Vineyards; taste Stimson Lane wines sourced from Wallula and Canoe Ridge Vineyard grapes
Stop 7	Dinner at Grant's Brewpub in Yakima, return to Seattle Convention Center

ROAD LOG

Day 1. Seattle to Walla Walla (Fig. 3A)

Cumulative Miles	*(km)*	
0.0	(0.0)	Check in for field trip at main entrance to the Washington State Convention and Trade Center at 7:00 am to enable 7:30 am departure. Start out going southwest on Union St. Go three blocks and turn left onto 5th Ave. Go three blocks and turn left onto Spring St. Take the I-5 south ramp toward Portland.
1.3	(2.1)	Junction of I-5 with I-90 east. Immediately merge onto I-90 east via the exit—on the left—toward Bellevue/Spokane.
50.3	(80.9)	Snoqualmie Pass, elevation 3022 ft, on I-90, is the lowest and most heavily traveled east-west highway crossing in Washington State. It is one of the state's two east-west highways with mountain passes open year-round. It is the drainage divide between generally cool, rainy lands west of the Cascades and warm, dry lands east of the Cascades.
109.3	(175.9)	Take offramp from I-90 east to I-82 east toward Yakima.
146.8	(236.2)	Take offramp from I-82 onto State Highway 97 south.
147.4	(237.2)	Here the Yakima River passes through Union Gap, a water gap in Ahtanum Ridge, part of the Yakima fold belt (see Reidel et al., 1984). The Yakima fold belt formed when basalt flows and their interstratified sediments were folded and faulted by north-south compression. The Yakima fold belt is composed of sharp anticlinal ridges separated by wide synclinal valleys. Most of the folding is younger than ca. 10.5 Ma (Reidel and Hooper, 1989), or after the end of the major outpourings of Columbia River basalt. The steep north sides of most anticline ridges are faults that consist of imbricated thrust zones (Reidel, 1984; West et al., 1996).
149.4	(240.4)	Exit from Highway 97 by turning right (south) onto Lateral A.
154.2	(248.1)	Turn right onto West Wapato Road and travel west. Here the road travels across the Holocene fan of the Yakima River created as flood-stage flows expanded into the upper Yakima Valley after passing through the constriction of Union Gap. The low-lying fan and floodplain soils are not well suited for vinifera grapes but support hops, field crops, concord grapes (Washington is the United States' largest producer of concord grapes for juice and jellies), and various fruit crops such as apples and cherries.
156.9	(252.4)	The road rises 5–8 m over a dissected remnant of glacial slackwater sediments deposited by outburst floods that backflooded more than 70 mi (112 km) up the Yakima Valley from the Columbia-Yakima Rivers' confluence. The Horse Heaven Hills, the largest anticline in the fold belt, are visible on the left (to the south).
164.8	(265.2)	Turn right onto Stephenson Road (at 164.2 mi) and continue to the end of the road at Mike Sauer's Red Willow Vineyard.

Stop 1. Red Willow Vineyard

Red Willow Vineyard is on the south slope of Ahtanum Ridge and is within the Yakama Indian Reservation. Unlike almost all other vineyards in Washington State, Red Willow is entirely above/outside the influence of the Missoula floods and thus occurs on much older soils developed on Miocene-age volcaniclastic sediments of the Ellensburg Formation (Waters, 1961; Bingham and Grolier, 1966; Smith, 1988). At this stop we will examine soils formed from loess over volcaniclastic sediments (Fig. 4A) and discuss vineyard siting by grape varietal with owner Mike Sauer.

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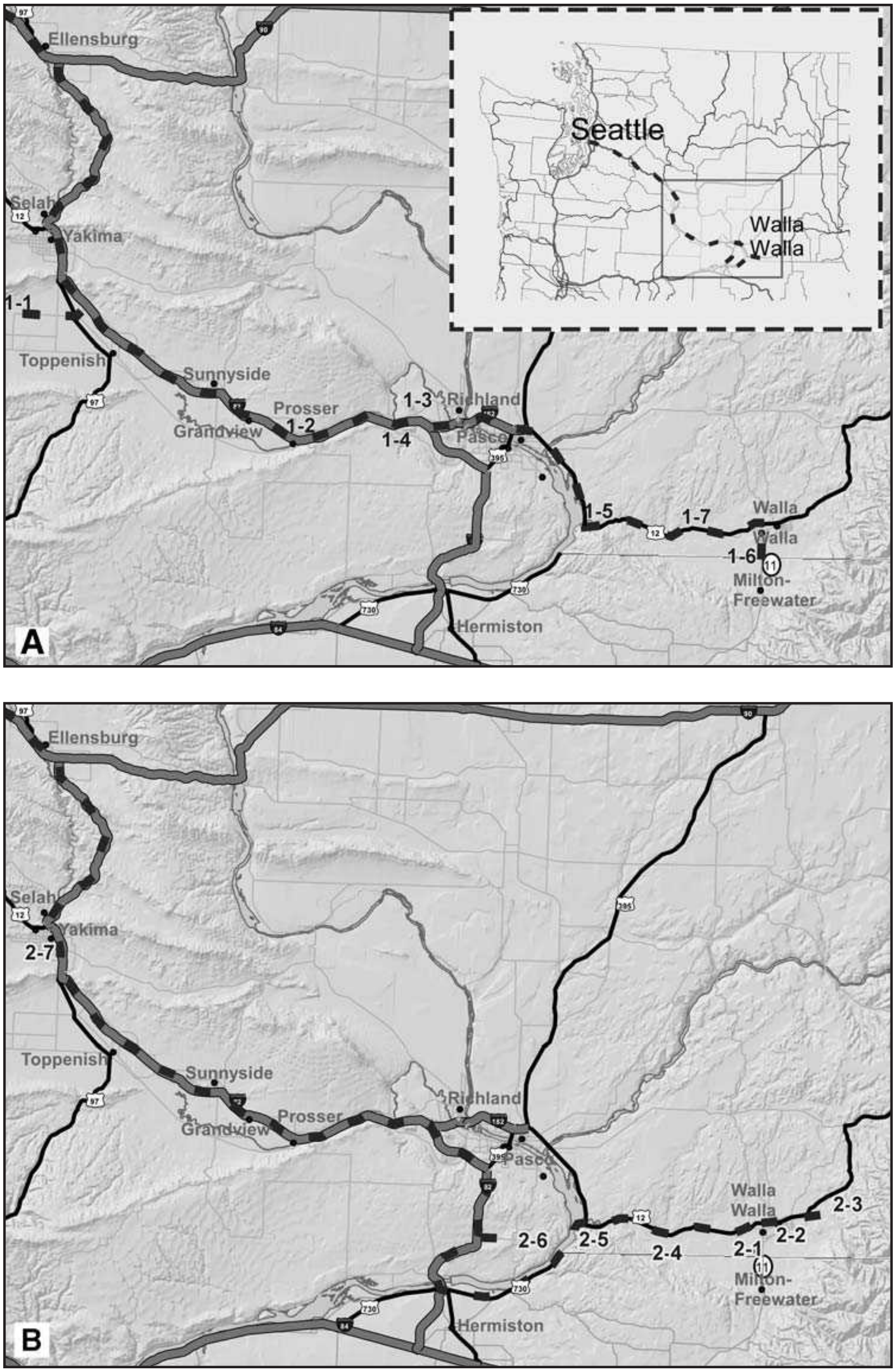

Figure 3. Maps of the routes and stops for Days 1 and 2 of the field trip.

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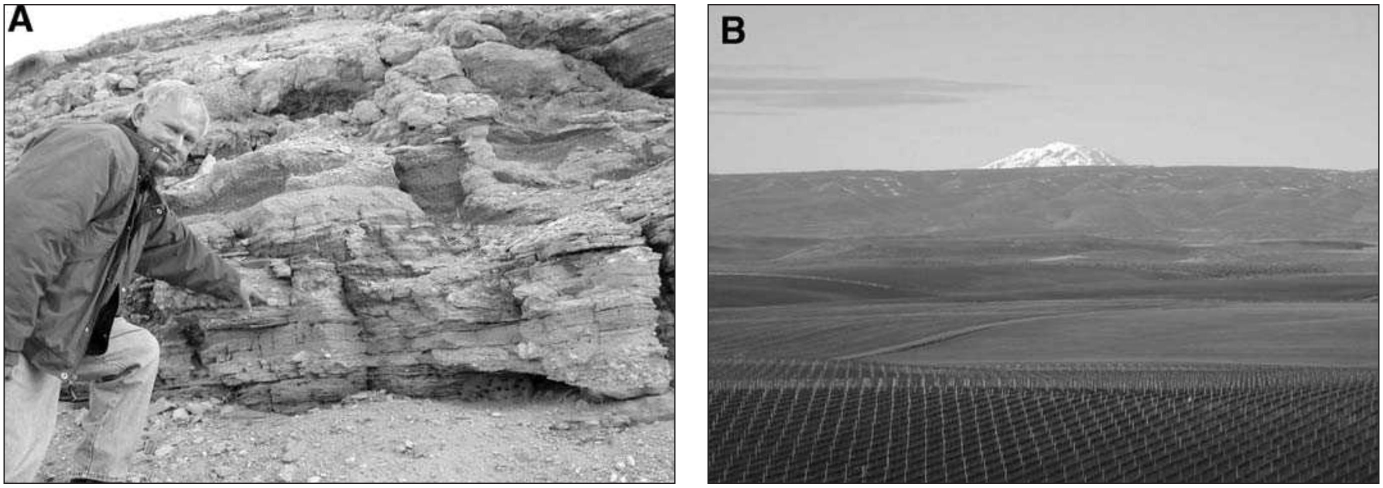

Figure 4. A: Outcrop of distinctive volcaniclastic sediments that form the soils at the Red Willow Vineyard in the Yakima Valley appellation. B: View to the south from Red Willow Vineyard showing Mount Adams (12276 ft/3472 m).

Known for being the inspiration for new varietals in the state, Red Willow has successfully pioneered varietals such as Syrah, Sangiovese, Malbec, Viognier and Cabernet Franc and has long produced award-winning Cabernet Sauvignon and Merlot.

At Red Willow Vineyard, the vines are planted on a peninsula of land jutting out from the south-facing Ahtanum Ridge. It is the only vinifera vineyard on the Ahtanum Ridge, and is the most westerly and the most northerly vineyard in the Yakima Valley appellation of Washington state. At 1300 feet above sea level, it is also the highest. To the west rise the foothills of the Cascades with Mt. Adams' snowcapped peak dominating the landscape.

While Red Willow itself is the highest vineyard in the Yakima Valley, it is also a relatively warm site—averaging 2700 degree days during the growing season. At 1300 feet above sea level, Red Willow stood above the cataclysmic Missoula floods at the end of the last ice age, floods that deposited silt and sand over the surrounding area. The ancient, well-drained, and nutritionally poor soil provides superb conditions for vinifera grapes.

Red Willow Vineyard first planted Cabernet Sauvignon in 1973 on the precipitous west-facing slope of the peninsula. In 1981, Columbia Winery released the first vineyard-designated wine from the vineyard with its Red Willow Cabernet Sauvignon. Cabernet Sauvignons from Red Willow are generally substantial, powerful wines with plum and blueberry fruit. Often the wine is blended with Cabernet Franc, which gives it an added finesse. Columbia Winery first produced Merlot from Red Willow grapes in 1987. This Merlot was the first in Washington to be blended with Cabernet Franc in the traditional Bordeaux manner.

With the release of Syrah from Red Willow Vineyard in 1988, Columbia Winery produced the first Syrah in the Pacific Northwest. In 1991, Columbia Winery released the first Red Willow Cabernet Franc and Columbia Winery's first vintage of Red Willow Sangiovese was 1995. (excerpted from http://www.columbiawinery.com/vineyards/redwillow.asp, accessed on August 5, 2003)

Cumulative Miles	*(km)*	
177.8	(286.1)	Retrace route on Stephenson Road, turning left and proceeding back to the east on West Wapato Road. Continue east on West Wapato Road across Lateral A to the intersection of State Highway 97. This is part of the Yakama Indian Nation. The reservation includes more than 1,300,000 acres, twice as large as Rhode Island. Its lands are used for agriculture, timber, range, and gathering of native plants.
178.3	(286.9)	Continue east across Highway 97 through the town of Wapato and angle left (NE) onto South Wapato (Donald Wapato) Road, crossing the railroad tracks.
179.3	(288.5)	Cross the Yakima River.
179.7	(289.1)	Enter onramp to I-82 east. There are good exposures of slackwater sediments on the left (north) side of the interstate.
186.7	(300.4)	On the left (north) side of the interstate are 10–20-m-high bluffs formed in slackwater sediments.
187.4	(301.5)	Slackwater sediment exposures on the left (north) side of the interstate have a distinctive white 2–5-cm-thick layer of 15 ka Mount St. Helens "S" ash near the top. This provides evidence for the timing of this emplacement of the slackwater sediments at the end of the Last Glacial Maximum.
198.3	(319.1)	On the right (south) side of the interstate is Snipes Mountain, a failed anticline.
217.6	(350.1)	Take exit 82 off of I-82 and turn right onto Wine Country Road.

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218.5	(351.6)	Continue east for ~0.9 mi on Wine Country Road, following signs to Hogue Cellars parking lot for lunch and tour.

Stop 2. The Hogue Cellars

Our stop here will provide a catered lunch, wine tasting, and tour of this state-of-the-art winery. The Prosser-based Hogue Cellars is Washington State's third largest winery, behind Stimson Lane (Château Ste. Michelle/Columbia Crest) and Constellation Brands (Columbia Winery/Covey Run), producing 450,000 cases of wine per year.

Mike and Gary Hogue's parents, Wayne and Shyla Hogue, began farming in the Yakima Valley in the 1940s, and eventually turned management of the business over to Mike. In 1974, he planted Hogue's first wine grapes, and in 1982, the first wine (2000 cases of Johannisberg Riesling) was produced by Hogue Cellars. Approximately 650 acres of the Hogue's 1600 acre farm is used to grow nine varieties of wine grapes. The additional acres produce hops, table grapes, apples, and vegetables, some of which are pickled and sold under the Hogue Farms label. In 2001, Vincor International bought Hogue Cellars, which continues to be run by Mike Hogue. Wade Wolfe is general manager and David Forsythe is director of winemaking.

Cumulative *Miles*	*(km)*	
219.4	(353.0)	Return to onramp of I-82 and enter freeway heading east.
221.3	(356.1)	To the south on the steep slopes of the Horse Heaven Hills are numerous landslide scarps and zones of hummocky ground indicative of the numerous mass failures on these oversteepened slopes. Landslides may have been set off by relatively recent earthquakes.
224.8	(361.7)	To the left (north) is a spectacular scabland landscape with scoured basalt on the valley floor where flood waters rushing into the Yakima Valley were constricted by the narrow valley walls. Rattlesnake Mountain is visible on the skyline to the north.
228.8	(368.1)	To the north is a breached anticline on the north side of the Yakima River. The anticline was cut by the backflooding of Missoula floodwaters upvalley into the Yakima Valley. The valley narrows here to less than four miles wide between the Rattlesnake Hills to the north and the Horse Heaven Hills to the south, concentrating the floodwaters and their erosive power. Upstream (toward Prosser and Yakima), the valley widens to more than twenty miles.
230.0	(370.1)	Red Mountain is visible in the distance on the north side of the highway.
233.7	(376.0)	Take exit 96 off of I-82 to Benton City. At the bottom of the offramp, turn left and go under the freeway toward Benton City.
234.1	(376.7)	Turn right onto 224 east.
234.6	(377.5)	Turn left onto Sunset Road.
235.0	(378.1)	On the right (east) is the tower of the Public Agricultural Weather Station (PAWS). This is one of many automated data collection sites operated by Washington State University.
235.5	(378.9)	Turn right into the driveway of the Ciel du Cheval Vineyard.

Stop 3. Red Mountain AVA: Ciel du Cheval and Klipsun Vineyards

The Ciel du Cheval and Klipsun Vineyards are two of about fifteen vineyards located in Red Mountain, the newest appellation in Washington State. Growing conditions include ~3000 degree days, with a 210 day growing season, which are similar to other great wine growing areas. Our stops here will include discussions with Jim Holmes of Ciel and Fred Artz and the Gelles family of Klipsun regarding the pioneering spirit and good fortune that led them to plant wine grapes at Red Mountain, the challenges posed by soil variability, extreme temperatures during veraison (ripening), and drying winds on grape quality.

Our discussion of these topics will draw on information and figures presented in Meinert and Busacca (2002) on the terroir of Red Mountain. Copies of this paper will be handed out at the beginning of the field trip. Diverse soils such as the Scooteney, Warden, and Hezel form the backbone of wine production at Red Mountain (Fig. 5; also see Figs. 11 and 14 in Meinert and Busacca, 2002).

Wines made from Ciel grapes have been described in the wine press as being among the best in the world. No wine is made at the vineyard; however, Ciel supplies grapes to more than 20 wineries in Washington and Oregon, such as Andrew Will, Quilceda Creek, and McCrea Cellars. Plantings on the 120 acre ranch include most Bordeaux types (Cabernet Sauvignon, Cabernet Franc, Merlot), several Rhone varieties (Syrah, Grenache), and two Italian varieties. Recent plantings have emphasized use of clones selected for their exceptional wine quality in France and Italy.

Klipsun Vineyards was founded in 1982. In 2002, *Wine and Spirits* magazine acclaimed Red Mountain's Klipsun Vineyard as one of the world's top 25 vineyards. The first 40 acres was planted with Cabernet Sauvignon, Chardonnay, and Sauvignon Blanc in 1984 and has now been expanded to 120 acres, including Cabernet Sauvignon, Merlot, Syrah, Sauvignon Blanc, Semillon, and Nebbiolo. Klipsun sells to ~25 different wineries in the Pacific Northwest. Vineyard rows are numbered so each winery knows which rows will be theirs.

Cumulative *Miles*	*(km)*	
238.3	(383.4)	Retrace route to and under the I-82 underpass.
238.4	(383.6)	Continue straight south, cross the railroad tracks, and curve left on Webber Canyon Road.

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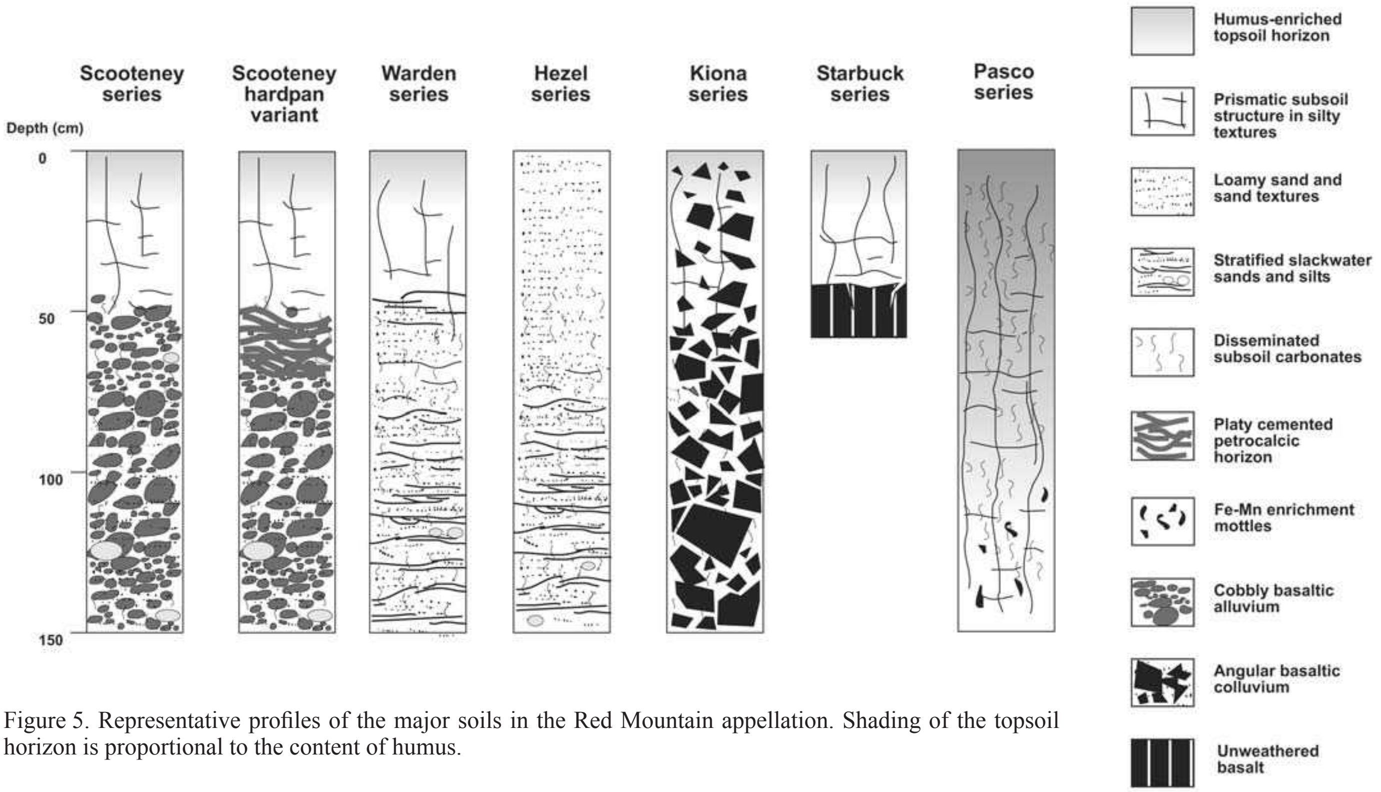

Figure 5. Representative profiles of the major soils in the Red Mountain appellation. Shading of the topsoil horizon is proportional to the content of humus.

239.0	(384.6)	Drive past the road cut and park in the wide section of Webber Canyon Road.

Stop 4. Exposure of Loess, Slackwater Sediments, and Tephra

On the left (north side) is a road cut that exposes slackwater sediments that contain a "doublet" of Mount St. Helens "S" ash that was deposited from an eruption that occurred simultaneously with an outburst flood slackwater ponding event. The Mount St. Helens S tephra layer is radiocarbon dated at 13,000 yr B.P. (ca. 15,300 cal. yr B.P.) at the volcano (Mullineaux, 1996). TL age dating of loess enclosing the same tephra (Busacca et al., 1992) yields a similar age estimate (Berger and Busacca, 1995). At this site, the slackwater sediments are covered by ~30 cm to 1 m of post-flood L1 loess (McDonald and Busacca, 1992).

Cumulative Miles	*(km)*	
239.7	(385.7)	Turn around and return to the onramp for I-82 and enter the interstate heading east.
244.7	(393.7)	Junction of I-82 and I-182. Take exit 12 on right onto I-182 toward Richland and Pasco.
257.6	(414.5)	At the intersection of State Highway 395 and State Highway 12, take Highway 12 east toward Walla Walla.
262.1	(421.7)	The Vaughan Hubbard Bridge crosses the Snake River, which flows in a channel cut into mega gravel bars deposited by outburst flood flows into the Pasco Basin. The force of the largest of these floods was great enough to travel more than 100 mi (160 km) upstream on the Snake River past Lewiston, Idaho.
272.7	(438.8)	Turn left at the town of Wallula, then left again on the frontage road, and park in front of the post office.

Stop 5. Wallula Gap Overlook (Optional)

Wallula Gap, the water gap where the Columbia River passes through the Horse Heaven Hills today, was one of the major flow constrictions along the lower Columbia River that was responsible for hydraulic damming and ponding of outburst floods that then backflooded axial valleys upstream from the constrictions. Elevations of high divide crossings eroded in basalt above Wallula Gap indicate that the maximum flood stage was at least 1150 ft (350 m). The floor of the original river channel beneath Lake Wallula was ~240 ft (80 m). Flood-cut scarps in the deep loess cover on the hills at the entrance to the constriction allow that the maximum stage could have been as high as 1200 ft (365 m; O'Connor and Baker, 1992). This is close to the highest elevations at which ice-rafted granitic erratic are found around the Pasco Basin.

Recent calculations of maximum flood discharges based on this high-water evidence suggest that ~10 million m^3s^{-1} passed

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through Wallula Gap (O'Connor and Baker, 1992). This is ~300 times the maximum flows of the 1993 Mississippi River flood! We are standing on a gravel bar deposited by giant floods; notice the mixed lithologies of the gravel. Today the Columbia River is dammed by a series of 10 dams from Bonneville Dam, 65 km (40 mi) east of Portland, Oregon, to Grand Coulee Dam in north-central Washington. The flat water in front of us is Lake Wallula ponded behind McNary Dam.

Cumulative Miles	*(km)*	
272.8	(438.9)	Rejoin Highway 12 toward Walla Walla. Nearby is a historical marker denoting former site of Fort Walla Walla (now underwater), originally a fur trading post of Hudson's Bay Company dating from 1818.
274.8	(442.2)	Intersection of Highways 12 and 730. At stop sign, turn left, continuing east on Highway 12 toward Walla Walla.
282.5	(454.5)	FPL Energy's Stateline Wind Energy Facility, which will be a stop on Day 2, is visible on the Horse Heaven Hills to the right (south).
283.8	(456.6)	Beginning of the Walla Walla appellation. The Blue Mountains form the skyline ridge straight ahead (east).
286.6	(461.1)	On right (south) are incised remnants of the very thick fill of bedded slackwater deposits that today form terrace remnants throughout the Walla Walla Valley.
287.7	(462.9)	The relatively flat Holocene flood plain of the Walla Walla River, which is bounded by terrace remnants, can be seen here.
291.8	(469.5)	On the left (north) are the Woodward Canyon and L'Ecole No. 41 Wineries. After checking in at the hotel in Walla Walla, we will return for dinner at L'Ecole Winery.
298.0	(479.5)	On the right (south) is the Three Rivers Winery.
302.5	(486.7)	Turn right onto West Pine Road.
302.7	(487.0)	Turn right into the Holiday Inn Express parking lot.

Stop 6. Holiday Inn Express

Check in, rest, and dress for dinner, then re-board the bus to drive to L'Ecole Winery for dinner. Retrace steps out of the Holiday Inn Express parking lot, left onto West Pine Road, and left again onto Highway 12 west.

Cumulative Miles	*(km)*	
313.6	(504.6)	Turn right into the L'Ecole No. 41 parking lot.

Stop 7. L'Ecole No. 41 Winery

Dinner will be provided through the hospitality of owner/winemaker Marty Clubb and executive chef Cristiana Fagioli, who will prepare an extraordinary dinner expertly pairing L'Ecole's new wine releases with five innovative courses.

L'Ecole No. 41 has been producing premium handcrafted varietal wines since 1983 in the historic Frenchtown School in Lowden, Washington. L'Ecole No. 41 is a family-owned business. Founded by Jean and Baker Ferguson, the winery is now owned and operated by their daughter and son-in-law, Megan and Marty Clubb. Marty has been the general manager and winemaker since 1989.

Built in 1915, the schoolhouse is located in historic Frenchtown, a small community just west of Walla Walla, Washington. Frenchtown derived its name from the many French-Canadians who settled the valley during the early 1800s. Legend has it, these men of French descent were raising grapes and producing wine. By the 1860s, nurseries, vineyards and winemaking had become a part of the region's growing economy. The name—L'Ecole No. 41, French for "the school" located in district number 41—was chosen to salute these pioneer viticulture efforts.

The winery currently produces ~20,000 cases annually. Semillon, Chardonnay, Merlot, and Cabernet Sauvignon at L'Ecole are all barrel aged, creating quite a demand for barrel storage. Today, L'Ecole has over 1,000 French and American oak barrels. In recent years, the winery has produced more single-vineyard and Walla Walla Valley appellation designated wines to take advantage of the exceptional fruit from the Walla Walla AVA. (excerpted from http://www.lecole.com/, accessed on August 5, 2003)

After dinner, drive east again to the Holiday Inn Express.

Cumulative Miles	*(km)*	
324.5	(522.1)	Turn right onto West Pine Road and into the parking lot of the Holiday Inn Express. End of Day 1.

Day 2. Walla Walla to Seattle (Fig. 3B)

Cumulative Miles	*(km)*	
0.0	(0.0)	From parking lot of Holiday Inn Express, turn right (east) onto West Pine St. and veer left to stay on West Pine to N 9th Ave. (Highway 125).
0.9	(1.4)	Turn right (south) onto N 9th Ave. (Highway 125) and continue on Highway 125 south.
6.6	(10.6)	Oregon-Washington state line. Washington Highway 125 becomes Oregon Highway 11 at the state line. The Walla Walla Valley appellation is one of the few to cross state lines and is, appropriately, bounded by natural rather than political features. Along the route the highway is alternately sited on higher elevation remnants of slackwater terraces and on

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lower alluvial surfaces of the Holocene and modern Walla Walla River and its tributaries.

9.3 (15.0) Turn right (west) onto Sunnyside Rd. This area around Milton-Freewater, Oregon, has been a highly productive center of production of orchard crops (cherries, peaches, apples, etc.) for more than 100 yr.

10.8 (17.4) On the right (north) side of the road is the Cailloux Vineyard, planted by vigneron Christophe Baron of Cayuse Vineyard on the cobbly former riverbed of the Walla Walla River.

Stop 1. Cailloux Vineyard

Discussion at Stops 1–3 today will draw heavily on information and figures presented in Meinert and Busacca (2000) on the terroirs of the Walla Walla Valley appellation. Copies of this paper will be handed out at the beginning of the field trip.

The soils of the Walla Walla Valley appellation have formed from four different types of surficial sediments or bedrock. Various combinations of soil parent materials and a strong gradient of mean annual precipitation across the appellation are key to determining vineyard potential performance. Soils formed from young alluvium vary tremendously in their properties, such as texture (cobbly to clayey), salt effects, and presence or absence of a water table within the rooting zone of vines. Soils formed from loess more than 150 cm deep are found around the margins of the Walla Walla Valley appellation and have dominantly silty, uniform soil profiles. Mean annual rainfall varies widely depending on location in the appellation, and this, along with slope steepness and aspect, determines suitability or potential for development of dryland or irrigated vineyards. Soils formed from thin to moderately thick loess overlying slackwater sediments (Fig. 6) have been the main focus of vineyard development up to the present time in the appellation. Soils located on steep slopes of the Blue Mountains that have bedrock at shallow depth have not been fully evaluated to determine their potential for vineyard development.

The objective of Stop 1 is to examine the Cailloux Vineyard, which is sited on one of the most unique agricultural soils in the Northwest, and to discuss the viticultural practices that have been tailored specifically to the stony, hot, droughty Freewater series soils (Figs. 6 and 7).

Christophe Baron was the first to envision the potential of these stony soils to produce grapes for fine wines. He planted the ten acres of this vineyard in 1996. Ten acres of En Cerise (French for cherry), and ten acres of Coccinelle (French for ladybug) followed in 1997. The ten acres of En Chamberlin were planted in spring of 2000. The majority of the vineyards are planted with Syrah alongside a few acres of Cabernet Sauvignon, Cabernet Franc, Merlot, Roussanne, Tempranillo, and Yiognier. A fifth vineyard, Armada, planted in 2001, contains 3 acres of Grenache, 3 acres of Syrah, and 1 acre of Mourvedre. Yields average 2–2.5 tons per acre, resulting in rich, highly-concentrated fruit.

Spacing is four feet between vines and five feet between rows, 2178 vines per acre. This is nearly double the standard vine quantity and easily marks it as the highest density vineyard in the Walla Walla Valley. The vines in all of the vineyards are trained

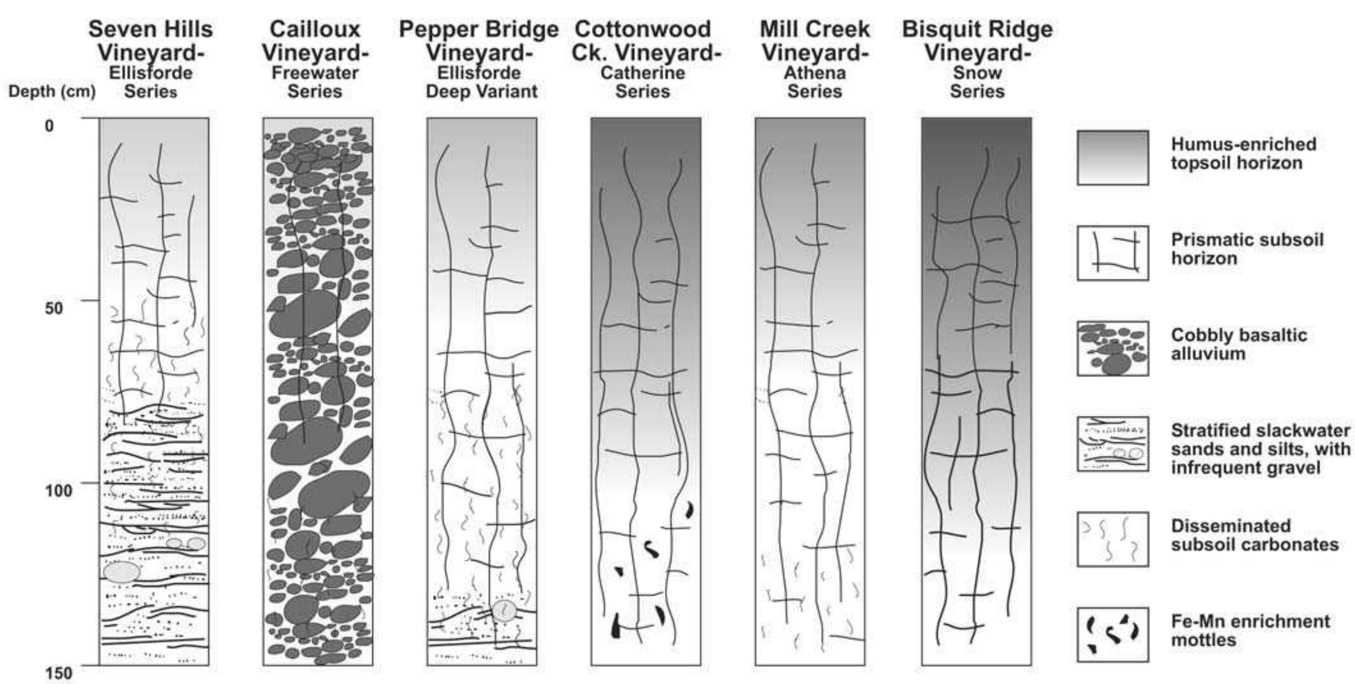

Figure 6. Representative profiles of the major soils in the Walla Walla Valley appellation. Shading of the topsoil horizons is proportional to the content of humus.

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Figure 7. Cobbly surface horizon of the Freewater series soil in the Cailloux Vineyard.

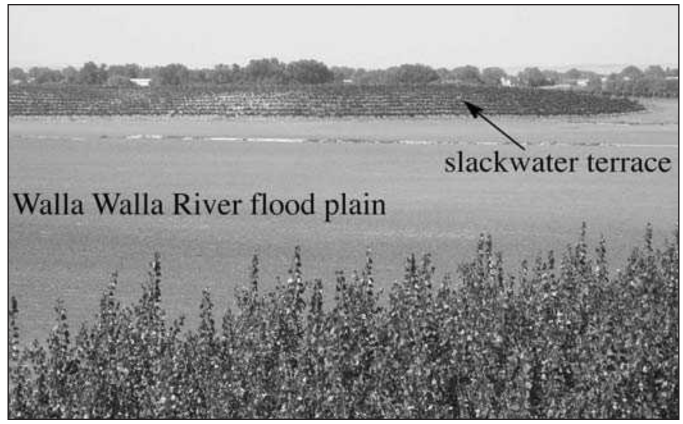

Figure 8. View across a part of the floodplain of the Walla Walla River showing dissected remnants of outburst flood slackwater terraces that make excellent vineyard sites.

low to the ground in the belief that re-radiation of heat at night from the exposed cobbly surface aids in the development of the fruit. An extra cane is maintained on the trunk close to the ground and is buried in the fall to provide a new starter trunk for each vine against a killing freeze in this low-lying valley site. Irrigation includes the application of scant quantities of water by drip irrigation, inducing water stress that concentrates fruit flavors, and the vines are organic.

Cumulative Miles	*(km)*	
12.3	(19.8)	Turn around and go back to Highway 11. Turn left (north) toward Walla Walla.
15.0	(24.1)	Turn right onto Stateline Road.
15.2	(24.4)	Turn left onto Pepper Road.
15.6	(25.1)	Turn right onto J.B. George Road.
16.3	(26.2)	Turn left onto Larson Road.
16.7	(26.9)	Pepper Bridge Winery is on the left and the Northstar Winery is on the right.

Stop 2. Pepper Bridge Vineyard

This stop will highlight the concept of terroir or optimal vineyard siting to produce fine wines. The best vineyards in the Walla Walla Valley occupy the tops of flood slackwater terraces (Fig. 8) with optimal soil characteristics and air drainage. Soils at Pepper Bridge Vineyard are dominantly a deep variant of the Ellisforde series with ~100–120 cm of loess over stratified slackwater sediments (Fig. 6). At this stop, there will be discussion about viticultural practices for wine grape production and we will relate these practices to the Pleistocene and Holocene geology.

The original 10 acres were planted in 1991 and have expanded to a total of 180 acres of wine grapes. Pepper Bridge Vineyard has gained an outstanding reputation with winemakers throughout the state of Washington, and especially the Walla Walla Valley. Tom Waliser has been the vineyard manager at Pepper Bridge Vineyard since its inception in 1991. All grapes are grown on split canopy trellises, in which the vines are trained both up and down off the cordon, or grape-bearing wire. With the exception of 5 acres of Merlot, which is on the Scott-Henry trellis system, all grapes are on the Smart-Dyson trellis system.

The vineyard uses cutting edge technology in its irrigation and weather systems. Weather data, temperature, humidity, wind, and sun energy units are recorded around the clock and the data are downloaded to computer by phone line. Over sixty moisture-measuring points are spread throughout the farm and moisture is data logged once an hour, 24 hours per day.

Cumulative Miles	*(km)*	
18.4	(29.6)	Return to the Pepper Road/J.B. George Road intersection, then turn left onto Pepper Road, right onto Stateline Road, and proceed to stoplight at Highway 125. Turn right onto Highway 125 and proceed toward Walla Walla (north).
23.6	(38.0)	Turn right onto W Poplar St.
24.1	(38.8)	Turn left onto S 2nd Ave.
24.7	(39.7)	Merge onto Highway12 east via the ramp on the left.
27.9	(44.9)	Take the offramp for Airport Road.
28.2	(45.4)	Turn right onto Airport Road, heading south, then left onto Isaacs Ave.
30.4	(48.9)	Isaacs Ave. becomes Mill Creek Road. Turn left at Walla Walla Vintners sign and drive up to Mill Creek Upland Vineyard of Leonetti Cellars and park opposite the vineyard.

Stop 3. Mill Creek Upland Vineyard of Leonetti Cellars

The purpose of this stop is to examine a state-of-the-art vineyard installation at Leonetti Cellars, one of the premier wineries

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in the Pacific Northwest. Chris Figgins, vineyard manager and assistant winemaker, will explain the use of the latest drip irrigation systems, virus-free rootstocks, new clones and varietals, and environmental monitors to take grape and wine quality to the next level. This vineyard receives ~16–18″ (400–460 mm) of annual precipitation, making it perhaps the vineyard with highest precipitation in eastern Washington. This and the very deep, organic matter–rich Athena soils in loess (Fig. 6) provide a new challenge for Leonetti Cellars to develop management strategies for this vineyard, which perhaps could be dry farmed because of the high rainfall and high water holding capacity of the silt-loam textured soils. This and the steep south-facing slope provide excellent sun exposure and air drainage.

Leonetti Cellars' owner and winemaker, Gary Figgins, honed his craft as a home winemaker and released his first commercial wine in 1978. Leonetti Cellars produces limited quantities of the highest quality Cabernet Sauvignon, Merlot, and Sangiovese.

Leonetti Cellars manages their vineyards very intensively, using a combination of the latest in technology, proven traditions, and sustainable agriculture. They draw their fruit increasingly only from vineyards in the Walla Walla Valley AVA. Yields are moderately low to very low, ranging from 1.5–4 tons per acre, depending on the vineyard and variety. Most vineyards are trellised to a vertically divided canopy, a method known as Smart-Dyson or Scott Henry. Deficit irrigation, monitored by neutron probes and a system called "enviroscan," is practiced in all of Leonetti's vineyards to control vegetative growth, reduce berry size, and intensify flavors in the berries. All grapes for Leonetti wines are handpicked at physiological maturity after a season of intensive hand pruning, hand leaf-plucking, shoot positioning, and cluster thinning.

Cumulative Miles	*(km)*	
32.9	(52.9)	Retrace route to Highway 12, enter Highway 12 west.
49.0	(78.8)	Continue on Highway 12 west through Walla Walla to the town of Lowden.

Stop 4. Burlingame Canyon, the "Little Grand Canyon"

The spectacular exposure of slackwater or touchet sediments from cataclysmic outburst flooding, which can be seen stopping at this site (Fig. 9), was created by a break in the irrigation canal a number of years ago. The purpose in stopping at this site is to discuss paleoflood dynamics, the "40-floods" hypothesis, and to show what underlies the terrace remnants in valleys like the Walla Walla and Yakima, forming the landscapes of some of the better vineyard sites in the Northwest.

Note: This exposure is on private property of the Gardena Farms Irrigation District and we are allowed to visit during this field trip only by special permission. Please do not return to this site at a later time on your own. Take any photos during this visit only. Please note the dangerous banks and stay clear of the edge. Our thanks to Stuart Durfee, manager.

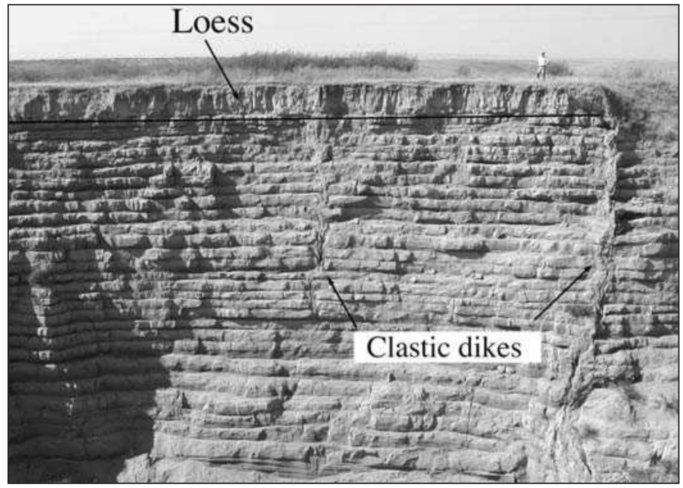

Figure 9. Exposure of a loess-covered terrace formed of rhythmically bedded outburst flood sediments.

The following are guidelines set by the land owner for our safety during our visit:

1. If a representative of Gardena Farms Irrigation District No. 13 accompanies you during your visit, you will abide by all instruction or be asked to leave immediately.
2. You will park along the main irrigation canal at the top of the hill near the house and walk down the west side of the channel leading south to the Little Grand Canyon.
3. You will not travel outside of the fenced area on the east side of the canyon or travel down the west side of the canyon unless instructed to do so.
4. There will be no ascent into the canyon past the first ascending down slope at the northern entrance to the canyon.
5. Visitors to the canyon must act in an orderly fashion so as not to endanger any of the participants.
6. The visitation privileges for your organization or any organization associated with the visit will be revoked for future visits if you fail to follow directions or if there are unauthorized repeat visits by persons in attendance on this site visit.

Exposures of fine sand-, silt-, and clay-dominated slackwater rhythmites at sites such as Burlingame Canyon formed the inspiration for Richard Waitt's hypothesis for multiple outburst floods during the last glaciation (Waitt, 1980, 1984, 1985). It also has been argued that some rhythmites, rather than signaling individual outburst floods separated by decades-long intervals of subaerial exposure, instead reflect multiple flood surge events during a few floods (Baker, 1973; Bjornstad, 1982; Bunker, 1982; Baker and Bunker, 1985). This alternate argument is supported by the scarcity of definitive sedimentary evidence for subaerial exposure of rhythmites, an impression one gets while viewing the parallel, amalgamated nature of the multiple, stacked rhythmites exposed in the canyon. However, the paleoaridity and attendant sparse vegetation of this region both during and after slackwater flood accumulation, the isolation of broad reaches of slackwater

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deposits from flanking valleys (and hence colluvial deposits), as well as compelling ecologic and sedimentary evidence elsewhere on the plateau (e.g., Smith, 1993) tend to support Waitt's (1985) contention for multiple floods. Regardless of the explanation you prefer, sites such as Burlingame Canyon provide clear evidence that the glacial outburst floods provided an abundance of raw sedimentary material from which winds have created sand sheets, sand dunes, and loess-covered landscapes.

Cumulative Miles	*(km)*	
65.9	(106.0)	From Lowden, continue west on Highway 12 to Hatch Grade Road. Rendezvous with representative of FPL Energy at Hatch Grade Road turnoff. Follow representative to FLP Energy's Stateline Wind Energy Center.

Stop 5. Stateline Wind Energy Center

The purpose of this stop is to recognize the incredible wind energy that has partnered with the incredible energy of the cataclysmic floods to redistribute huge amounts of fluvial sediment into the eolian mantle of soils, which provide the basis for the agricultural wealth of the inland Pacific Northwest. In addition, this impressive facility is the largest wind energy facility in the United States.

Developed, owned, and operated by FPL Energy, the 300 megawatt Stateline Wind Energy Center provides clean, renewable energy to PacificCorp Power Marketing (PPM) for customers throughout the Pacific Northwest.

The Stateline Energy Center was fully operational in December 2001, just nine months after construction of the facility began. The first power from Stateline reached consumers in July 2001. The facility has the capacity to provide enough electricity to power ~60,000 homes and businesses. The Stateline Energy Center provides electricity for PPM customers including Bonneville Power Administration, Seattle City Light, the Eugene Water and Electric Board, and Avista Utilities.

FPL completed a 37 megawatt expansion of the Stateline Wind Energy Center in early December of 2002, making it the largest wind energy facility in the United States at 300 megawatts.

The Stateline Wind Project is the Northwest's largest commercial facility to generate electricity using wind. The project is located on Vansycle Ridge, an anticline ridge straddling the Washington-Oregon border, near Touchet, Washington. The ridge catches winds from the Columbia Gorge, which average 16–18 mph; this is considered excellent for wind farm development. The area around the project is used mostly for private farming, and this has continued beneath the completed wind project. The site is also close to preexisting transmission lines, reducing the need for new cables and minimizing the amount of power lost during transmission.

The Stateline Wind Project uses 660 kw Vestas wind turbines (Fig. 10), producing a maximum output of 300 megawatts (MW) of electricity. On average the project receives enough wind to deliver 30%–35% of its peak capacity year round: enough power for more than 21,600 Northwest homes. Electronic control systems point each turbine into the wind and adjust the pitch of the blades to make the best use of wind at any speed. The turbines can generate power at wind speeds of 7–56 mph. At higher speeds the turbines automatically shut down, a feature which allows them to withstand hurricane-force winds.

The Stateline Wind Project was planned carefully and underwent extensive review to minimize its environmental impact. Early biological studies indicated that the site receives little use by birds or other vulnerable species. The project uses tubular towers and buried cables in order to avoid adding new perching places for birds. Slower-moving blades and an upwind design further minimize any potential for avian fatality. As a clean power source, the project also eliminates some of the need for fossil fuel electric plants in the region. If natural gas or coal were used to generate the same amount of power, they would emit at least 310,000 tons of carbon dioxide per year, as well as air pollutants and acid rain precursors. Wind power produces no air emissions.

Return from the wind energy center to Highway 12. Turn left (south) onto Highway 730-395 south.

Cumulative Miles	*(km)*	
67.4	(108.4)	The highway and the Columbia River pass through Wallula Gap. Scabland topography can be seen up to ~1200 ft (366 m).
91.1	(146.6)	Take the exit onto Interstate 82 west, crossing the Columbia River from Oregon into Washington. Continue north, rising onto the Horse Heaven Hills. An application to the Bureau of Alcohol, Tobacco, and Firearms has recently been submitted to create a Horse Heaven Hills appellation.

Figure 10. Wind turbines seen during a dust storm at the Stateline Wind Energy facility near Walla Walla, Washington.

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100.1	(161.1)	Get off of I-82 at exit 122, Coffin Road. At the stop sign at the bottom of the offramp, turn right and drive east on Coffin Road.
104.9	(168.9)	Turn right (south) onto 9 Canyon Road.
105.8	(170.2)	Turn left (east) onto Easterday Ranch private road.
110.3	(177.5)	Turn right (south) onto Finley Road.
112.3	(180.7)	Entrance to Wallula Vineyards.

Stop 6. Wallula Vineyards

The purpose of this stop is to view the Columbia River and Wallula Gap from the downstream side and to see and discuss a very interesting and potentially outstanding new vineyard with a diverse array of vineyard sites ranging from gentle, south-facing sites on deep loess soils to steeply sloping terraced sites, to microvineyards on shallow soils on small scabland buttes (Fig. 11A).

The family farm, which has expanded steadily to include Wallula Vineyards LLC today, was started by Andrew denHoed in 1954. Andy started out raising traditional row crops such as sugar beets, mint, potatoes, and dry edible beans. The original "home place" included 15 acres of concord grapes. Today his sons, Andy denHoed Jr. and Bill denHoed, are partners with Andy Sr. Today's operation includes 980 acres of vinifera, 125 acres of juice grapes, and 85 acres of orchard. The denHoeds first planted vinifera in 1979 at the Desert Hills Vineyards near Grandview in the Yakima Valley. Planting started at Wallula Vineyards in 1998. Desert Hills Vineyards includes 560 acres of wine grapes; Wallula Vineyards has 420 acres of wine grapes. The majority of the denHoed's grapes are delivered to the Stimson Lane group: Chateau Ste. Michelle, Columbia Crest, and Snoqualmie Wineries. A small portion go to the Hogue Cellars in Prosser, Washington.

Wallula Vineyards totals 1550 acres. Approximately 950 of that is plantable. Development has been divided into three phases. Phase I is currently in production. Phases II and III are in the planning stages. Before the irrigation system was installed and the first vines were planted, multiple earth-moving machines worked 5 days a week, 45–50 weeks a year, for 3 years to prepare the site. Unique aspects of this vineyard include plantings of vines that range in elevation from 350 ft (107 m) to 1200 ft (366 m), a difference which provides a greater range of mesoclimates than any other vineyard in the state. Soil temperature is monitored in each vineyard with temperature probes to develop a database for management decisions and to inform future plantings. At the lower elevation sites, Lake Wallula provides a lake effect that moderates high temperatures in summer and low temperatures in winter.

Soils in deep loess at the upper elevations are classic Mollisols of the Ritzville series; those in deep loess below ~1000 ft elevation (305 m) actually receive enough less precipitation to be classed as Aridisols of the Shano series. Soils on margins of the scabland portion of the vineyard are formed in loess over stratified gravelly flood sediments (Fig. 11B) and are soils such as the Scooteney series (Fig. 5). Soils on the scabland buttes and benches are highly variable but include shallow and stony soils such as the Starbuck and Kiona series (Fig. 5).

Figure 11. A: Vineyard terraces and scabland topography at the Wallula Vineyard in Columbia Valley appellation. B: Scooteney-type soil formed of loess over outburst flood slackwater sediments at the Wallula Vineyard. The loess mantle is ~75 cm thick.

The Phase I vineyard produces Cabernet Sauvignon, with clones 4, 6, 8, and 15. Clone 8 is the predominant clone, and is widespread throughout the state. Clones 6 and 15 of Merlot are also planted, as are the Piccolo and Grosso clones of Sangiovese. Other red wine grapes include Syrah, Mourvedre, Barbera, Cinsault and Dolcetto. White varieties include Chardonnay, Viognier, and Pinot Gris.

All of the water comes from the Columbia River, is pumped from the river to a settling pond, and is distributed from there through a drip irrigation system. Because of soil variability, the irrigation system is divided into many zones and subzones to provide the flexibility to tailor water delivery to the vines to maintain uniformity throughout the vineyard for crop and canopy.

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Crop load ranges from 2.5 tons/yr (0.6 Mg/hectare) to 7 tons/yr (15.7 Mg/hectare) and is specified by the winery that takes each block of grapes.

124.5 (200.3) Retrace steps to the intersection of Coffin Road and Interstate 82. Enter onramp for I-82 toward Yakima (west).

213.4 (343.4) Continue on I-82 to Yakima. Take exit 33 (Yakima Ave., toward Terrace Hts.) to E Yakima Ave.

214.8 (345.6) Drive west on E Yakima to N 1st St. Turn right and immediately look for the train station that houses Grant's Brew Pub. Dinner at Grant's Brewpub, 2 N Front St., 509-575-2922.

216.2 (347.9) Retrace steps to I-82. Take onramp and enter I-82 west toward Seattle.

246.8 (397.1) Take I-82 west toward Ellensburg to junction with I-90 west.

355.6 (572.2) Take interchange from I-90 west to I-5 north.

356.4 (573.4) Take the I-5 north exit, number 2C, toward Madison St./Convention Place.

357.7 (573.9) Take the exit toward Madison St./Convention Place. Stay straight onto 7th Ave. Turn left onto Madison St.

357.9 (575.9) Turn right onto 6th Ave.

358.0 (576.0) Turn right onto 7th Ave.

358.1 (576.1) Turn right onto Union St., then onto Convention Place. Stop in front of Seattle Convention and Trade Center. End of trip.

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