"Excellent"
–Washington Trails magazine,
Geology Hikes cover story, 9/07

A Geo-Tour of I-90

The Mountains to Sound Greenway

Seattle to Vantage, WA

PHILIP FENNER

A Geo-Tour of the I-90 Corridor

From Seattle to Vantage, WA
The Mountains to Sound Greenway

Text and photos by Philip Fenner

V57 February 13, 2008
This document is frequently updated and expanded. The latest release is available at:
http://www.seanet.com/~pfitech/I-90GeoTour.pdf

Cover photo: Mt. Si (L center) and the valley of the South Fork Snoqualmie River (R center) which I-90 follows to Snoqualmie Pass, reflected in the Mill Pond in the Snoqualmie River Valley near Snoqualmie, WA.

"Most men pursue pleasure with such breathless haste that they hurry past it."
Soren Kierkegaard (1813 - 1855)

"Thanks to the Interstate Highway System, it is now possible to travel from coast to coast without seeing anything."
Charles Kuralt (1934 – 1997)

"High-speed expressways… are noisy and frenetic, and they attract urban development like a pied piper. Unless we plan carefully, the scenic beauty, the working farms and forests, and the distinctive communities along this route could be smothered piece by piece under the next wave of urban growth."
James R. Ellis (1921 -)

"Certainly, travel is more than the seeing of sights; it is a change that goes on, deep and permanent, in the ideas of living."
Miriam Beard (1901 - 1983)

"Today is your day! Your mountain is waiting. So. . . get on your way."
Dr. Seuss (1904 - 1991)

Contents

Introduction

Interstate 90 through the Mountains to Sound Greenway is one of those modern miracles we so often take for granted these days. Northwesterners by the millions take the I-90 freeway to "get from point A to point B," and while they may enjoy some of the scenery along the way, they may not realize what a truly remarkable highway it is, through remarkable country. The driver sees a cross-section of the region and its landforms enroute from its western end in Seattle, where it crosses the terrain of the Puget Lowland shaped by a lobe of a continental ice sheet, to Snoqualmie Pass as it climbs up a glacial valley through temperate rainforest surrounded by high alpine peaks carved from a large body of granite, and down through the open country of the Kittitas Valley to the edge of the vast Columbia Plateau where ancient basalt flows were spectacularly eroded by some of the world's greatest floods.

We'll be taking you on what we call a Geo-Tour of I-90 across the Cascades from Seattle to Vantage. The foundation of this tour will be the geology that accounts for the scenery you see. Much of the corridor followed by I-90 is geologically very "fresh," abandoned by glacial ice only recently in terms of geologic time.[1] Roughly 15,000 years ago the last of the continental ice receded, leaving the terrain greatly modified, both by direct erosion and deposition, and by its effects on the courses of the rivers that flow from the Cascades. The scenery changes because of climate zones as well, since the Cascades act as a wall to moisture-laden weather systems coming in off the Pacific Ocean, so that the west side is covered in dense forest fed by heavy rain and streams of meltwater from deep annual snowfall, while the east is much dryer and more open, eventually becoming semi-arid eastward toward the Columbia River.

The highway has its own complex history. Between Seattle and Ellensburg you can find examples of every phase of the development of this transportation corridor from wagon trail to elevated superhighway. Access to some of the best examples of the geology, botany and history of the corridor are a short way off I-90, so we'll describe some easy ways to take a back road or hike a trail and see some of the area up close. If you have the time, you can drive some remaining segments of the old Sunset Highway (US 10) route, which we'll describe. We'll be passing many areas with great stories to tell of pioneers, railroads, water projects, mining, farming and urban growth.

I-90 is still in a state of transition east of Snoqualmie Pass. It's the only section of the US Interstate Highway system that doesn't comply with the Federal standards for lane width and curve radius. It's also very exposed to threats from avalanche and landslide, as some unlucky drivers learn every year. There's an ongoing debate as to how to ultimately complete it, and the geology of the area is a major factor. The wide ribbons of concrete form a barrier to animal migration in the Cascades, and some innovative ideas also are being proposed to try to reduce its impact on the alpine environment.

[1] see Appendix 2.

We'll try to keep this Geo-Tour as fun and non-technical as possible, using special terms as sparingly as we can, and defining those we use. We want you to enjoy making some of the same discoveries we made as we looked into how this beautiful land got to be the way it is. Different seasons provide different opportunities for seeing the geological features, so we encourage you to bring this Geo-Tour along all times of the year. Early and late winter are often best if you are lucky enough not to have too many clouds blocking your view, since snowfall will often "highlight" rock formations. If you want to get off the freeway and explore the back roads or on foot, we recommend the summer season unless you are well equipped for winter travel. Remember, Snoqualmie is a mountain pass and sudden weather changes can happen any time of year. Be prepared.

We've made use of some previously published materials and a lot of websites, some of which we'll list at the end of each section so you can explore them on your own. Parts of this Geo-Tour also appear in the quarterly newsletter of the *Mountains To Sound Greenway Trust*, an organization dedicated to preserving the corridor's green space. On the principle that the more you appreciate something the more likely you are to preserve it, we hope our Geo-Tour supports their goals.

A few technicalities before we begin. We want this to be a portable, "real-time" guide you can take along on your next trip on I-90. In order to be able to describe what you see in such a way that you know what we were describing, we'll refer to the exits by number when we're anticipating a notable landmark. Some things are between exits, and there we have to use mileposts, which are difficult at best to keep track of as you drive, but are the only way to be more specific. You'll see exits identified as [EX##] and mileposts as [MP##]. If you're reading this as you drive, please be very careful not to distract the driver. I-90 is a freeway and with the traffic speeds involved, the driver will need to pay closer attention to the traffic than to the scenery. The best plan is usually to allow a good deal more time than you usually take to drive the route, and stop frequently to refer to maps and to this narrative. To point out some sights, we'll use the hours of the clock as a way to easily convey direction, 12 o'clock being straight ahead, 3 o'clock off to the right, etc. We recommend topographic maps of the route as an excellent way to see what's ahead of you and get a feel for the terrain before and during your trip. Finally, this is a "work in progress," so stop by this website occasionally and check for new material as we proceed.

It seems appropriate to describe I-90's route through the Cascades at this time. 2006 is the 50th anniversary of the Eisenhower Interstate Highway System, as well as the 30th anniversary of the creation of the Alpine Lakes Wilderness, which protects the lands north of I-90 across the mountains. I-90 was the first Interstate highway to become a National Scenic Byway, a designation usually reserved for scenic rural roads, and remains one of the few Byways with an interstate running through it.

Someone back in the 1960s said that with the advent of space travel, humanity would come to feel like a fly on the face of the Mona Lisa, unaware of much outside its immediate surroundings until it got some distance away and looked back to discover the full beauty of the planet. We hope this narrative will give you something of that feeling, too, seeing familiar land in new ways.

About the Author and This Project

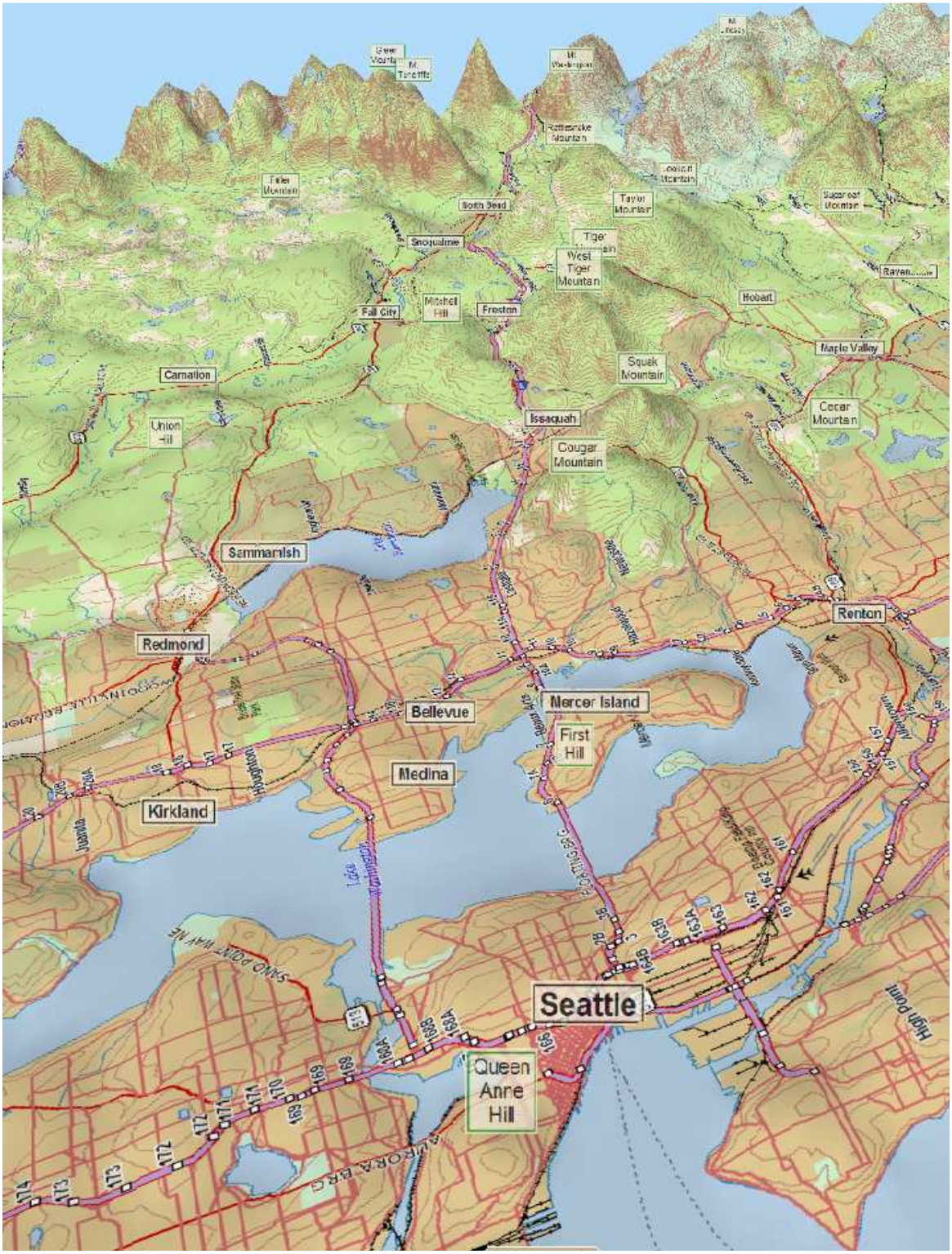
Philip Fenner has a B.A. in History and Geology from Whitman College. He pursues his career in medical imaging engineering in Seattle, WA. Dr. Robert "Bob" Carson, his Whitman geology professor, mentioned his Washington Geology from the Blues to Puget Sound: Road Log Across the Columbia Plateau and Cascades, (1990) while on a field trip Phil attended at "Summer College" for Whitman Alumni, and Phil played a copy of Bob's tapes while driving back to Seattle over I-90. Phil suggested to Bob that they collaborate to re-write the portion from Seattle to Vantage for more general audiences and add historical material, and he agreed. In 2005 Phil proposed to the Mountains To Sound Greenway Trust that they edit and publish excerpts in their newsletter. Excerpts written with Bob's help have been appearing there since the fall of 2005 in the *Rocks* column of Mountains To Sound, as the "Geology of the Greenway Series." He thanks Bob, Nancy Keith and Amy Brockhaus at MTSG, and Rowland Tabor of USGS who offered his input on the geology. Phil's email address is pfitech@seanet.com, and he welcomes your feedback on this project.

The MTSG "Geology of the Greenway series" columns in their newsletter are available at: http://www.mtsgreenway.org/newsandpublications/newsletterarchive.

See the latest about Dr. Carson at the Whitman College Geology Department website: http://www.whitman.edu/geology/

A note on the photos: The camera used was primarily a Panasonic Lumix DMC-FZ30 with Leica lens and optical image stabilization. The images are inserted in full resolution, and although some of the detail is lost in the PDF compression, a great deal more of the image detail is stored here than you can appreciate at the normal "fit screen" zoom level of Acrobat Reader. If you are viewing this on your computer screen in Adobe Reader, please "zoom in" several steps to see the additional image detail.

Dedicated to the memory of Harvey Manning, now on his 101st hike.



Map 1. Eastern Puget Lowland from 125,000 ft. looking ESE, showing the route of I-90 from Seattle to North Bend. The undulating surface in the foreground is a glacial "drift plain" formed by the Puget Lobe of the Cordilleran Ice Sheet during the Pleistocene, except for bedrock outcrops of the "Issaquah Alps" (Cougar, Squak, Tiger and Rattlesnake Mountains south of I-90 from Issaquah to North Bend). The Cascade Front across the horizon was the eastern limit of the Puget Lobe ice. (4x vertical exaggeration is used.)

◆ PART I ◆

THE PUGET LOWLAND: Seattle to North Bend

Fig 1: 3D Geologic map from Seattle to North Bend, from the same perspective shown in Map 1 on facing page. The Glacial deposits covering most of the Lowland are shown in gray.
(Courtesy 3dGeoMaps.com)

Drive I-90 through downtown Seattle today and you may find it hard to image that even the tallest buildings there would have been dwarfed by the thickness of the ice that occupied the entire Puget Lowland, estimated to have been about 3,000 feet thick over Seattle during the Pleistocene epoch, commonly referred to as the "ice age." Before the Pleistocene continental glaciations, the Puget Lowland was a broad plain with hills and a river system, bracketed by the Olympic Mountains to the west and the Cascades to the east. The Puget Lobe ice advanced rapidly southward from the margin of the Cordilleran Ice Sheet in British Columbia into this low country, excavated the river valleys to much greater depth, then receded and left behind a thick mantle of glacial deposits known as "drift" (colored gray on the map in Fig. 1), covering most of the bedrock. These glaciations happened repeatedly, from two million until about 12,000 years ago, which may seem to have been a long time ago but was really quite recent in geologic time, so the glacial landforms here remain distinct. Since the ice advanced from the north, many of these glacial features in the Lowland such as ridges and lakes are elongated in the north-south direction. Roads and highways will generally tend to follow valleys, but I-90 has to go 'against the grain' of this north-south valley and ridge country to cross the Puget Lowland before it can begin the climb to Snoqualmie Pass.

The Downtown Seattle Waterfront

We'll begin our tour on the waterfront in downtown Seattle. The city grew up along its waterfront, and many of the old wooden piers and warehouse buildings here still stand, converted to modern uses. "Land's End" is the sidewalk along Alaskan Way. Here, you're on fill from the ballast of 1800s lumber schooners and from early regrade projects, used to stabilize the land at the water's edge and raise it above the reach of high tide. The original shoreline was several blocks east. Puget Sound is tidal water and when the first buildings were built here, they weren't far enough above sea level to prevent the water from backing up the drain pipes and regularly flooding the first floor with sewage. If you have time, you can take the Seattle Underground Tour to visit what remains of the

original ground floor level in the oldest part of the city, known as Pioneer Square. Hydrology forced the residents to raise the street level one full story above the original; so today you're standing one story above what was once street level. The 1930s-era Alaska Way Viaduct is built atop this fill, which is retained by the old wooden seawall laced by worms and decay. A major earthquake could cause the seawall to collapse and the viaduct to tip over, similar to what took place in Kobe, Japan, in 1995. A plan has not yet been decided upon to replace the aging seawall and Viaduct despite this hazard.

I-90's ramps to 4th Ave and Atlantic St. in downtown Seattle feature some of the newest and most seismically secure elevated highway in the region, however. You can get to I-90 from the waterfront by going south of Safeco Field on 1st Ave. and turning left at S. Atlantic St.

Downtown Seattle to Beacon Hill

The western terminus of I-90 in Seattle is very urbanized and has been heavily modified from its original landscape in the relatively brief period since the arrival of the first Europeans less than two centuries ago, but it still offers the careful observer a chance to see evidence of the forces that shaped the landscape. As you drive east from downtown Seattle and the on-ramps converge, you will curve around the north slope of Beacon Hill. Beacon Hill is part of what geologists call a "drumlin," shaped by the Puget Lobe of the Cordilleran Ice Sheet, the last big glacier here, which left many such drumlins around Seattle. The freeway route is forced to make a series of sharp curves here because it's following an opening cut into the ridge that once connected Beacon Hill and First Hill to the north. I-90 passes beneath a green steel-frame bridge that now crosses that gap. In the 1890s city engineers used sluices to open this gap through the drumlin, creating the space that I-90 now passes through, separating First Hill from Beacon Hill. This was known at the time as the "Dearborn Regrade," and was one of many such regrades. These took place during the time of the Yukon Gold Rush, and large sluices were in the area on their way to the goldfields there. Seattleites used them to cut this gap, and wash away entire drumlin hills north of downtown Seattle, such as the former Denny Hill, creating more

Before the Bridges

US 10 and its predecessor the Sunset Highway originally went south around Lake Washington before the first floating bridge was build across the lake via Mercer Island. If you have an extra hour or so, you can get from Seattle to Issaquah on this original route. Leave I-90 east of downtown Seattle on either Rainer Avenue South or Martin Luther King Way southbound in the lowland between Beacon Hill and the ridge to its east, and drive to Renton, then through Renton on State Route 900. You'll see that it's named Sunset Ave. through Renton, an echo of is historic name. Follow SR 900 over the low ridges between Renton and May Creek. Nearby the town of Coalfield is a clue that you're in the heart of the old coal-mining district that we'll talk more about as I-90 approaches Issaquah. May Creek is an overflow channel that once drained glacial Lake Sammamish at the end of the last glaciation of the lowland. The May Valley probably held another glacial lake, judging from its steep sides and flat floor. SR 900 follows another, narrower overflow channel northward into the drainage of Tibbets Creek to the outskirts of Issaquah. Just before SR 900 reaches I-90, if you turn right you'll be on the original route of US 10 through Issaquah. And on the east end of town, we once again encounter a "Sunset Way!"

flat space for the city to grow, and filling in the shoreline behind a seawall, and the tide flats at the mouth of the Duwamish River to the south. The drumlins that Seattle is built on, and the valleys between them, are generally oriented north-south, which was the direction of the glacier's flow. Seattle is built on one of the few "drumlin fields" in the US, which makes a particularly challenging site for a city. I-90 is forced to go perpendicular to these glacial drumlins and the troughs between them, requiring bridges and tunnels in the Seattle area. Mile-for-mile, this part of I-90 is the most expensive highway in the US.

Beacon Hill to Lake Washington

We just rounded the north end of Beacon Hill, one of many drumlins in the Puget Lowland. Seattle features a "field" of drumlins, and we're about to encounter the next one, known to the residents of its east side as the "Mt. Baker Neighborhood," since it offers views of that Cascade volcano on clear days. Here, tunnels bore through the base of the drumlin, and then the highway is supported across the surface of Lake Washington on a pair of floating bridges. The original pair of round tunnels now serves eastbound traffic, while a newer tunnel carries traffic westbound. When we emerge from the tunnel we have a dramatic view of Lake Washington and Mercer Island from the approach to the floating section of the bridge (See Fig. 2). The floating bridge design was necessary because of the lake's great depth, as much as 214 feet. This lake is one of the largest and deepest "urban lakes" in the US, and the same forces of southward ice movement that left behind the drumlins carved its basin out. Take away the trees and buildings in your imagination and you have an image of the undulating landscape of elongated hills and deep troughs originally filled with meltwater that the Puget Lobe left behind as it receded at the end of the last glaciation roughly 15,000 years ago. Glance to 3 o'clock to see Seward Park on the Bailey Peninsula, jutting into the lake. Once an island before the lake level was lowered, this small drumlin still hosts a remnant of the original forest that once carpeted the region.

Fig 2. View east across Lake Washington to the Mercer Island drumlin from the I-90 floating bridge. Drumlins are aligned in the direction of ice advance, in this case north-south, so the Seattle drumlin field, including Mercer Island, forms a series of barriers to the east-west path of I-90. The floating bridge design was necessary because of Lake Washington's great depth, due in part to the excavation of the advancing Puget Lobe of the Cordilleran Ice Sheet.

Mercer Island

Straight ahead now as we cross the floating bridge on I-90 is Mercer Island, another drumlin. I-90 is built in a recessed channel across the island, with lids to reduce noise. If its retaining walls were transparent, you could see the mixture of grain sizes in the drumlin, from silt to boulders, all generally rounded, typical of glacial till deposited by the huge glacier. The Seattle-area drumlins consist mostly of

The Puget Lowland's Great Lake

Take a look at a USGS topographic map of Lake Washington with a scale at least as large as 1:24,000, and you'll see the shape of the lake basin under the water. Note that Mercer Island includes a large underwater terrace on its north end, one with a pronounced high point, part of the cluster of drumlin-like forms that make up the island. Note also the triangular depression between the north end of Seward Park and Mercer Island. Seismic surveys have revealed that the bedrock is very far down under Lake Washington and its basin is filled with glacial deposits to great depth. Lake Washington and Lake Sammamish to the east both appear to lie in deep structural depressions that have been partly filled with sediments. Lake Washington's water level is carefully controlled today, but prior to the construction of the canal that now connects it to Lake Union and Puget Sound, the lake was 9 feet higher on average, and experienced a seasonal level change as the spring snowmelt in the Cascades raised its level and flooded its shorelines every year. Before the floating bridges were built, roads and railroads were forced to go around the lake and a ferry crossed the lake from the foot of Seattle's Madison Street to the east shore in Kirkland. Look at a street map of the area and notice how the angle of Madison Street aligns perfectly with the streets on Kirkland's waterfront far across the lake! To trace the original shoreline of the lake around Union Bay and see how much old marsh became dry land when the lake was lowered, follow the route of today's Burke-Gilman Trail around the University Village Shopping Mall. The Burke-Gilman Trail is built on the former railroad grade of The Seattle, Lake Shore and Eastern, the first railroad built to haul logs from what was then virgin forest north of Lake Washington to sawmills on Lake Union, and closely follows the shoreline of the lake before it was lowered. Lake Washington became badly polluted in the 1960s as new "bedroom communities" sprang up along its shores, to the point that it had to be closed for swimming. In a landmark effort to restore clean water, a combined sewage-treatment system was developed in the late 1950s, and today the lake is one of the cleanest urban lakes in the nation. The "prime mover" of the lake cleanup, James Ellis, was as a founding member of the Mountains To Sound Greenway movement, about which you'll soon read more.

"lodgment till," emplaced at the base of the massive ice lobe. The rocks came from as far away as British Columbia and were abraded by the ice before being deposited here. Glacial till can be almost as hard as concrete but it is much easier to excavate than solid rock, so it did not require any blasting to excavate this trench across Mercer Island. The resulting earthworks with their greenery are a model of freeway building in a green landscape.

It may come as a surprise that we find ourselves here in the midst of a newly discovered fault zone that threatens the central Puget Sound region! The early pioneers had the first hint of this when they found their boats hung-up in the tops of huge trees standing underwater just off the south shore of the island. When Lake Washington was lowered nine feet in the process of cutting the canal to Lake Union in 1917, the treetops were exposed. A big chunk of the south end of Mercer Island slid into the lake during a sizable quake along the Seattle Fault about 900 AD. The slide stopped with huge trees still upright. You can see this slide on a topographic map, revealed as a series of bumps in the contour lines off of South Point. Evidence shows that other faults in western Washington moved at about the same time. No major quakes on this fault have occurred in historic time, and the fault scarps are mostly hidden by forest, unlike the obvious traces of the San Andreas Fault in California, so the Seattle Fault system went undetected until recently. Mercer Island turns out to be in the center of this east-west trending band of faults that crosses the Puget Lowland.

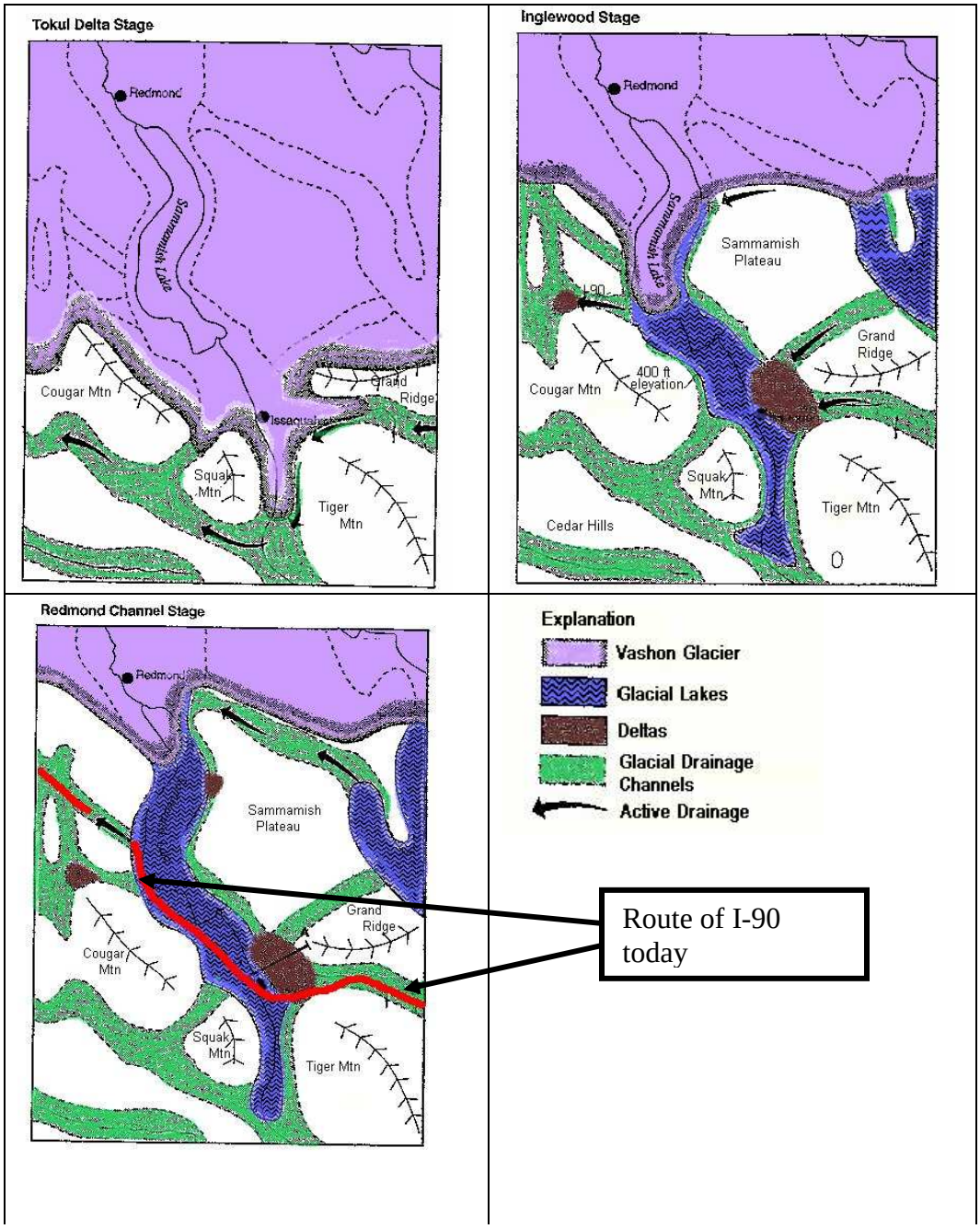


Fig. 3. Three stages of glacial lake drainage during Puget Lobe ice recession, shown in schematic form. The largest delta is the "Issaquah Delta" where two overflow/drainage channels converged. I-90 follows the routes of some of these channels between Factoria and Preston (shown in red).

Bellevue to Issaquah

Back on I-90 eastbound we cross the East Channel of Lake Washington from Mercer Island to Bellevue. On the right at 2 o'clock a marina now covers an area of the shoreline that extends into the lake. This was built on the results of an early disaster in the coal mining industry along the watershed of Coal Creek, which empties into the lake here. In a

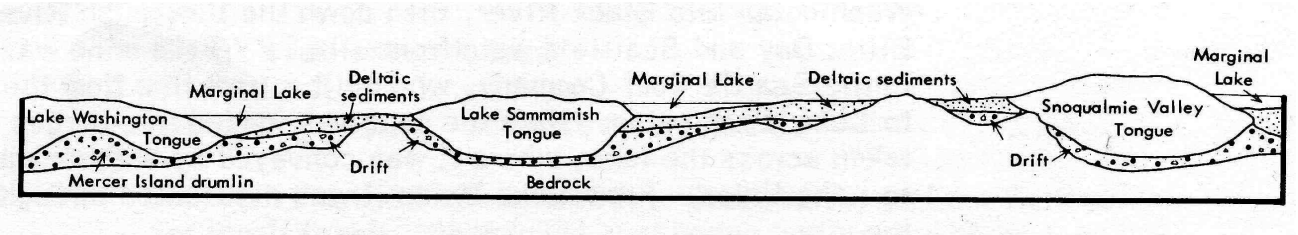


Fig 4. Cross-section (west to east) from Mercer Island to North Bend along the route of I-90 during Puget Lobe recession when separate "tongues" of ice sat in the three major valleys here. Later, the ice retreated north and dammed northward water flow from reaching the Pacific Ocean, creating huge glacial lakes that filled the valleys where these ice tongues had been.

big flood in the late 1800s, a slurry of coalmine tailings that had been retained behind a dam upstream was washed down Coal Creek and deposited here.

As the East Channel Bridge meets the mainland you soon cross the mouth of Mercer Slough on your left at 9 o'clock. This was a shallow arm of Lake Washington before the lake was lowered. Today its peat bogs have been largely preserved as open space by the City of Bellevue, including an active blueberry farm. Bellevue was largely rural until after World War II, but now the only remaining agricultural land is this blueberry farm. The acidic peat that formed there was ideal soil for growing berries. The valley that the slough lies in forms a sinuous channel that connects to other channels from here eastward that were formed during the time of the recession of the Puget Lobe of the Cordilleran Ice Sheet near the end of the last glaciation about 15,000 years ago. When the ice was fully advanced it extended to south of Olympia and stood about 2,000 feet thick here in Bellevue. Meltwater moving under its base and around its advancing and receding margins formed channels in the deposits under and near the ice, and when the glacier receded some of these channels remained, including ones such as this. The ice sheet plugged the drainage of the entire Puget Lowland, so the rivers flowing from the Cascades backed up behind the ice and flooded the lowland valleys. Each valley in this area was filled completely to its rim with water backed-up behind the ice dam to the

A Remnant of the Ancient Landscape

It's easy to take a close look at the Mercer Slough area. The City of Bellevue manages much of the lower part of the Mercer Slough as a nature park, including a Visitor Center in a restored 1920s Spanish Revival home and many miles of walking trails. The low-lying area's soils are highly acidic peat, formed over millennia by slow leaching. The only developments to intrude on the park are a Park and Ride lot, an Office Park built on stilts and limited to one-story buildings, and some radio towers. You can reach the park from I-90 by taking the Bellevue Way exit [EX10A] past the Park and Ride and Blueberry farm. Parking is at the Winters House Visitor Center. Guided nature walks and canoe trips are available. There's even a great blue heron rookery you can visit. Just take a long quiet walk along the network of boardwalks across this seemingly alien landscape, surrounded today on all sides by urban development.

King County's Black Diamonds

I-90 passes along the northern boundary of the King County Coal Field, a series of coal fields that extends southward from the Issaquah area almost to Enumclaw, covers more than 300 square miles, and was actively mined for over a century. Coal was first discovered here in 1853 along the Black River near Renton. Ten years later coal was also discovered near Issaquah and along Coal Creek near Newcastle (named after the famous coal-mining city in England). Newcastle was second only to Seattle in population at the peak of the coal-mining boom. Mine company owners had no trouble attracting a high quality labor force from back East and from Eastern Europe, the United Kingdom and Finland. That's because local coal is a low-sulfur lignite and didn't cause the dreaded black lung that crippled and killed miners elsewhere. The coal heated the homes and business in Seattle's original waterfront townsite. It was transported there by wagon and by barge across Lake Washington. Ultimately a tram was constructed to haul the coal, and production peaked in 1907 when 1 ½ million tons were marketed. By about 1960 only about 62,000 tons were being moved. Seattle operated a gasification plant in what is now Gas Works Park, and this fed the Lake Union Steam Plant. Coal-fired electric generation was replaced by hydroelectricity as Seattle City Light built the Skagit River dams in the North Cascades. Much coal remains underground today. Reports indicate that only 40 percent of King County's coal has been mined. You still see a lot of open space in the hills south of Issaquah as you drive I-90, and that's in part due to the hazard of abandoned mines collapsing. Much of this land has been closed to development.

northwest, forming huge glacial lakes that overflowed into the adjacent one lower and farther southwest (See Fig 3). As you drive I-90 eastward the next 2.5 miles to its high point overlooking Lake Sammamish [EX10-11], you're following one of these huge overflow channels, by which the overflow water from Glacial Lake Sammamish reached Glacial Lake Washington. To imagine the depth of these ice age lakes, look east across the Sammamish valley as you reach the crest on I-90 at Eastgate. Across the valley at the same level you'll see a horizontal green stripe across the hillside on the opposite of the valley, which is the top of an old delta at the same elevation as the rim of this overflow channel. This was the surface level of the glacial lake, so you can imagine how huge it was!

Other channels include the Mercer Slough and part of the route followed by Newport Way. By the time the ice from Canada filled the Puget Lowland, the valley glaciers in the Cascades had already melted away from the lowland, so the rivers flowing down the valleys flowed into huge lakes along the perimeter of the Puget Lobe near the Cascades. As the Puget Lobe receded north the lakes expanded to fill the valleys until the drainage opened through the Strait of Juan de Fuca and the lakes emptied. The valley floors meanwhile accumulated thick deposits of lake sediments, so the floors of these valleys today are relatively flat. Today's lakes are small remnants of the Glacial Lakes, occupying only the lowest parts of the basins. No modern lake remains today from the Glacial Lake Snoqualmie.

The retaining walls of I-90 in this area [EX11-13] obscure your view of the combination of till (a mixture of grain-sizes from silt to boulders deposited directly by the ice sheet) and glacial lake beds. If you leave the freeway at the Newport Way exit [EX13] you can see some of this "glacial drift," and also some rare bedrock outcrops including volcanics and siltstone of Oligocene age (30 million year old) that lie atop the coal-bearing strata to the south. Known as the King County Coal Field, it extends from here to near Enumclaw (see "Black Diamonds," above). Towns with names like Carbonado and Black Diamond were named after the coal and the mining industry that grew up around its extraction there. The land here in Eocene time (40-50 million years ago) before the Cascades arose was a vast coastal plain covered with vegetation. Coal was formed as the vegetation was buried under successive layers of sediment.

The Big Picture

Plate Tectonics is a relatively new part of geology. Like Quantum Theory in physics, it completely changed the dominant paradigm of geology over the last 30 years, and explains many phenomena, including how the Olympic and Cascade mountain ranges were raised. The Atlantic Ocean floor is spreading and pushing the entire north American continent westward. The Pacific Northwest sits above a subduction zone where Pacific oceanic crust is being pushed downward under the North American continent, and from time to time over the eons small chucks of continental and oceanic crust "docked" with North America here, extending our coastline further west. These pieces of ancient plates, known as "Exotic Terranes," form the bulk of the bedrock that is exposed in the region. When a piece of continental crust became docked, the forces pushing the subduction zone were halted for some time, and the subducted crust at great depth "floated" upward beneath the edge of the continent, raising a mountain range. That's the basic mechanism understood to have raised the Cascades and Olympics. Refer to the introductory chapters of Roadside Geology of Washington for a more detailed explanation of how Plate Tectonics accounts for the mountain uplift here, including maps and cross-sections.

I-90 traverses down across the Sammamish River valley wall onto the flatland southeast of Lake Sammamish on which Issaquah was built [EX 13-16]. Pay close attention and you may detect the freeway grade leveling-out briefly, and then descending again after it crosses a sort of terrace. This is probably a terrace formed either by successive ice advances and recessions during the glaciation, or by various levels of Glacial Lake Sammamish that were established when the ice was farther north. There are many overlapping features like terraces and moraines (ice-marginal drift deposits) in this recently deglaciated area. The freeway flattens out completely [EX15] as you drive across the floor of the ancient glacial lake that at times filled the valley up to its rim. Today's Lake Sammamish only occupies the deepest part of this trough. Lake Sammamish State Park on the left is a great place to see some of the lowlands and wetlands here.

On the north side of the freeway ahead of you at 11 o'clock just before the Issaquah Front Street exit [EX17] is a huge gravel pit, ideally situated for you to see a cross-section of what look like tilted layers of sediment. These layers may appear to have been deposited horizontally then tilted later, but in this

case they were deposited on a slope where a river entered a deep lake. You're looking at the "foreset beds" of an immense delta, built into the ancient lake that filled the Sammamish valley during the retreat of the Puget Lobe of ice. The lake stabilized at about the level of the plateau northeast of Issaquah while this delta was built. The waters carrying the deposits that formed the delta overflowed from the next major valley eastward, that of today's Snoqualmie River, which was also filled to its rim due to an ice dam to the northwest.

Fig 5. "Foreset beds" of the Issaquah Delta are exposed in a gravel pit north of I-90 at the Front Street exit. The layers were *not* deposited horizontally then tilted later, as is the case with most tilted sedimentary rock. Rather they were deposited *directly on a slope* as meltwater flowed into the gigantic Glacial Lake Sammamish that filled the entire valley, retained by an ice dam.

A Close-up of the Issaquah Delta

If you exit I-90 here at Front Street in Issaquah and drive north on Front Street, you can see the foreset beds in cross-section as you approach the entrance of the gravel pit (see Fig 5). It might appear that this large gravel pit is going to "consume" the entire delta, but the area of this delta is so large, the pit will be in operation for many years with no risk of that. The entire "Tradition Plateau" south of I-90 east of Issaquah is also made up of delta sediments from the mouth of the overflow channel that I-90 follows toward Preston. The Tradition Plateau delta and the delta with the gravel pit merged as the waters from the Snoqualmie River Valley continued flowing into the Sammamish Valley, until the Puget Lobe receded north of the Strait of Juan de Fuca and the ice dam there opened and the lakes drained. Delta and glacial moraine deposits are loosely consolidated and make ideal material for a gravel mine such as this.

Rather than having to blast and crush bedrock to get gravel, these operations only have to sort and wash the existing sediment. We'll encounter another major gravel-mining operation when we come to the moraine just east of North Bend called Grouse Ridge. If you look closely at the surface of much of the concrete poured in streets, sidewalks and buildings in the Puget Sound area, the individual rocks in it are rounded, likely by glacial meltwater streams. One of the big gravel and aggregate supply companies in the area is "Glacier Northwest, Inc." Controversies have erupted around large gravel mines, but

Alps by Any Other Name

The range of hills south of I-90 from Issaquah to North Bend is commonly known today as the "Issaquah Alps." Harvey Manning, the naturalist and guidebook author, gave them that name in his books both somewhat satirically, and in an effort to preserve their open spaces and forests by elevating their status from foothills to "Alps." Seen from I-90, they seem to resemble the Appalachians more than the Alps, with gradual slopes and more rounded tops than the rest of the Cascades. They aren't really foothills of the Cascades at all, but rather a distinct group of mountains extending west like a series of islands partially submerged in the glacial drift covering the Puget Lowland (see Fig. 1: the khaki colored areas south of I-90). They are the hanging wall of the Seattle Fault, a still active reverse fault with south side up, stretching across the Puget Lowland, with an east-west axis, parts of which are also exposed near Bremerton (Fig 1). Manning describes them as a "remnant of an old range that stretched across the region." This appears to be corroborated by geologists, since the uplift that raised them occurred during Miocene time (5-15 million years ago) at about the same time the main Cascade Range was uplifted. They might more accurately be considered to be a small sub-range of the Cascades that was unlucky enough to be in the direct path of the massive Puget Lobe of ice, and was overridden by it and greatly reduced in altitude by the encounter. The rocks of the Issaquah Alps are sedimentary and volcanic, preserving the complex early geologic history of the Puget Lowland before glaciation, which is almost entirely buried in glacial sediment elsewhere in the Lowland.

mitigation and reclamation efforts have allowed many such operations to go forward even in scenic areas like the Mountains to Sound Greenway along the route of I-90.

Issaquah to Preston

As you leave Issaquah eastbound on I-90, you'll be driving up one of the channels carved by glacial lake overflow water from the Snoqualmie River Valley. Other such channels cut across the highlands between Issaquah and Snoqualmie. You can see them on a topographic map, and imagine the immense volumes of water that carved them. Once the ice dam of the Puget Lobe ultimately receded north to the Strait of Juan de Fuca, the glacial lakes drained, and the rivers returned to their courses, which had been modified by the ice, then were partly filled with lake sediments. Rivers flow now in some of the overflow channels, too, but some flow opposite the direction of the Ice Age overflow water. The Raging River from Preston [EX22] to Fall City, for instance, flows northeast toward the Snoqualmie River, while the overflow that formed the canyon itself flowed southwest.

A new set of ramps [EX18] has been built over I-90 at the eastern end of Issaquah, forming something of a gateway effect. Note that the exit is for "Sunset Way," an echo of the former Sunset Highway that lies beneath the route of I-90 from here to Preston. If you take this exit and turn left to cross over the freeway you can quickly get to the top of the delta where the forest has been cleared to make way for development, allowing you to view the valley from the perspective of the former glacial lake level.

The Mountains to Sound Greenway

Formed by citizen action in 1990 with a dramatic "Mountains to Sound March," the Trust seeks to preserve the greenbelt surrounding I-90 from Seattle to Thorp, near Ellensburg, by negotiating and facilitating wise land use. As the advance of suburbia played itself out in other parts of the United States in the 1970s, residents of the Issaquah area took action to try to prevent the sprawl model from repeating itself here. It became clear that nobody could afford to buy all the land or even its development rights in the corridor, so in addition to advocating for public purchase of land, other goals were to keep working forests and farms in the corridor and encourage wise development practices by maintaining green open spaces between cities. Even through the now quite densely occupied Issaquah area, a visual screen of trees continues to give the driver a relatively pastoral experience, and once you're east of Issaquah, with a few exceptions the route is quite un-cluttered. The Mountains to Sound Greenway Trust has worked with governmental agencies, landowners, timber companies and local businesses to purchase lands for public ownership and to encourage good design in new development along the I-90 corridor. The Greenway Trust has succeeded in protecting this 100-mile corridor to a remarkable degree. We'll see evidence of more of their good work as we progress over Snoqualmie Pass.

MOUNTAINS TO SOUND GREENWAY

www.mtsgreenway.org

Continuing east on I-90 we enter the valley of the East Fork Issaquah Creek, and quickly seem to leave the urban and suburban areas behind. A large sign welcomes you to the "Mountains to Sound Greenway." The Greenway corridor extends from the shore of Puget Sound, but this dramatic transition point from developed to "green" is a fitting point to announce its beginning. Grand Ridge on the left and West Tiger Mountain on the right form a sort of gateway in and out of the urbanized area that has grown from Seattle to cover much of the Puget Lowland.

The v-shaped canyon of the East Fork Issaquah Creek was a major overflow channel for glacial Lake Snoqualmie westward into glacial Lake Sammamish. On a map you'll see Tradition Lake and Round Lake to the south on a terrace at the northwest foot of West Tiger Mountain. This plateau is more of the delta built by the overflow waters that came down this channel and merged with the delta built at the mouth of the North Fork of Issaquah Creek, where we saw the gravel pit a few minutes earlier. After the ice dam to the northwest broke and the lakes in these glacial troughs drained, the remaining flow of Issaquah Creek eroded its own "sub-canyon" into the delta sediments.

Somewhere in the area of the next exit at High Point [EX20] you will reach the head of the glacial delta and the creek now flows in the bottom of the main canyon carved by the glacial overflow from the lake that filled the Snoqualmie

River valley. Imagine for a moment that the entire valley you are in now was once full of water flowing westward, carrying a slurry of silt and remnants of ice from the melting Puget Lobe. And keep in mind that many glacial cycles (glacial advances and recessions) occurred during the Pleistocene (the last 3 million years), so this channel was nearly full of water on many occasions.

If you drive in the right lane as slowly as you can safely go when you round the first right-hand bend in I-90 after leaving Issaquah, you'll see an old concrete bridge, probably one of those crossed by US-10 in 1963, covered with moss and with large trees growing in its roadway (Fig. 6). This old bridge escaped destruction by just a few feet when I-90 was built, and often escapes the notice of hurried drivers today. This particular bridge doesn't appear to bear a date on its railings, but many others do, forming an important method of identifying the history of road building.

Fig. 6. Abandoned bridge from US 10 adjacent to eastbound I-90 east of Issaquah. The freeway builders narrowly missed demolishing this relic of the Sunset Highway. Other historic cast-concrete bridges can be found between Preston and Fall City, near North Bend, and off Exit 38 (see p. 39).

The old road was obliterated by I-90 between Issaquah and High Point, but if you take the High Point exit [EX20] you can leave the freeway to the north for a diversion onto a section of the Sunset Highway between High Point and Preston, and walk down-valley on the roadbed of the old Seattle, Lake Shore and Eastern railway. To the south, the High Point exit is the gateway for hikers to the Tradition Plateau and the northwest slopes of West Tiger Mountain. From Preston you have the opportunity of a side-trip up the Raging River valley to pastoral Upper Preston, as well as a scenic detour down the Raging River on the route of the old Sunset Highway from Preston northeast to Fall City and Snoqualmie, meeting I-90 again on the eastern edge of North Bend. This detour is highly recommended, and has many historic and geologic points of interest.

Fig. 7. Preston Lodge wall made of glacial cobbles. The wall forms a gallery of the wide variety of rock types typical of the glacial till covering the Puget Lowland. The Puget Lobe of the Cordilleran Ice Sheet transported many of these rocks from British Columbia.

A Scenic Detour to Snoqualmie Falls and the Snoqualmie Valley

Take a trip back in time for the cost of just a couple of hours! (*If you choose to continue on I-90 here, go to page 30.)* Leave eastbound I-90 at the Preston exit [EX22] and stop briefly in the old town of Preston. A 1930's era lodge on the left as you come into the old town site features exterior walls made of cobbles, sorted out of the ubiquitous local glacial till (Fig. 7). Rounded rocks 6 to 10 inches in diameter, they were broken in half to form the walls, exposing unweathered interior surfaces. This wall is a gallery of the wide variety of rock types transported by the Puget Lobe from as far away as British Columbia during the Pleistocene glaciations. This sort of rock is often referred to as "river rock," but it could be more accurately described as "glacier rock."

Fig. 8. Left: Snoqualmie Falls in 1908, before the majority of the water was diverted for a power plant. **Right: The falls today** at typical summer flow levels. Flow may more than double during winter storms, but typically it's a fraction of its historic size. [L photo from historylink.org]

Look around the old mill site across the road, and the historic town, and then proceed to descend the dramatic canyon of the aptly named Raging River. About halfway to the end of the valley, a short spur road to the right crosses an old cast-concrete bridge from the original Sunset Highway era. Just beyond, the rail-bed of the former Seattle, Lake Shore and Eastern Railroad, now converted into a multi-use trail, crosses the highway (this is an extension of the same railroad bed that forms the Burke-Gilman Trail in Seattle). The town of Fall City lies in the fertile bottomland of the Snoqualmie River valley. The

Snoqualmie retains its original meandering course; its channel was never artificially straightened like that of its twin river the Sammamish.

Cross the river and stay to the right to go to Snoqualmie Falls (Fig. 8). This dramatic falls resulted from the reshaping of the entire valley floor by the glaciations and glacial lakes. The river cut a pre-existing valley before the glaciation, which was filled with glacial drift and lake sediments by the Puget Lobe and its ice dam. After the ice receded and the ice dam broke, the lake drained and the river flowed across the top of the accumulated glacial and lake sediments at a higher elevation, and found a new course over a bedrock shoulder that projected out into the side of the pre-glacial valley. The bedrock exposed here is Eocene[2] volcanic rock, altered andesite, a rare window into some of the bedrock under the glacial till that covers most of the Puget Lowland.

The falls area was the site of a large Native American village, and was a popular salmon fishing location since the migratory fish could not get above the falls. A lodge was built at the falls to house travelers on the railway and roads of the early 20th century, and parts of that lodge survive today as the core of a resort complex there. Public viewing platforms and short trails provide easy access to spectacular views of the falls. Part of the river's flow was diverted around the falls for hydroelectric power by the city of Seattle, an impressive engineering feat in its day, with a powerhouse built inside solid rock. The Snoqualmie Tribe advocates for the full flow to be restored, as the falls is sacred to their culture and traditions. Go there right after a big storm when the flow is high, feel the thunder shake the little viewing platform and watch the immense mist cloud rise from the base of the falls to far above the lodge and you can imagine why the Snoqualmie Tribe sees that as a connection from heaven to earth.

The largest lumber mill in the area was just northeast of the town of Snoqualmie, a few miles southeast of the falls. All such mills required a "mill pond" to store the cut logs before milling. The pond for this mill was created by flooding an abandoned oxbow of the Snoqualmie River. This appears on the map as a doughnut-shaped "slough" between the mill site and the town, and a photo of it is featured on the cover page. A freely meandering river leaves behind these oxbows when their course changes with flooding with the result that an old bend in the river is cut off from the new main channel. These abandoned former channels are bypassed by the main river channel, but often continue to hold water, forming crescent shaped lakes. There's an ox harness in the Snoqualmie Valley Historical Museum in North Bend, where you can see how the shape got its name from the "bow" portion of the harness that fit under the ox's neck. Glance again at a map of the lower valley and you'll see many of these abandoned ox-bow lakes near the river. The Snoqualmie Millpond is a rare example of an oxbow lake that formed an almost complete circle, which was connected by the millpond builders. A dam was built to prevent the mill's precious logs from being carried away by winter floods. Mill Pond Road traverses this dam, southwest of the pond. Today the pond offers habitat for wildlife and forms a reflecting pond for Mt. Si (see cover photo).

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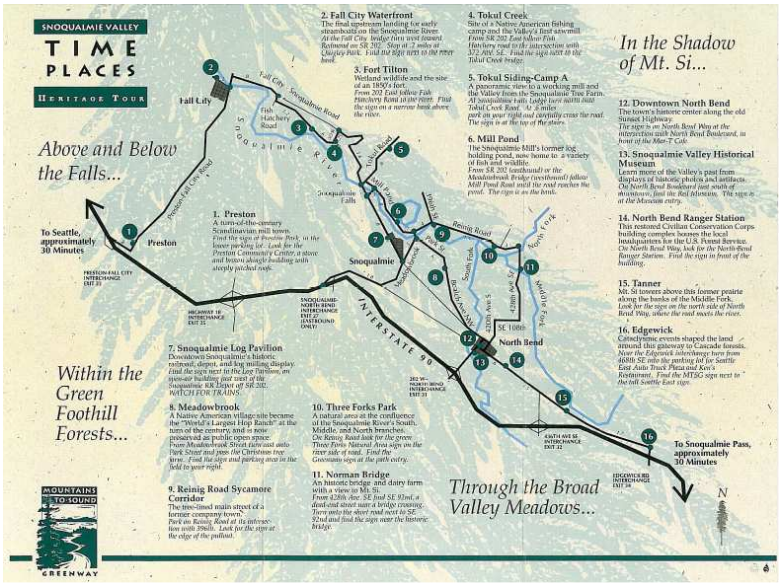
[2] 37-58 million years ago

Fig. 9. Old-growth log on display in Snoqualmie. The mill nearby operated from 1917 – 1964, cutting more than 2.5 billion board feet of wood. Such immense trees eventually became scarce and the mill was downsized and finally closed. Trees could grow to this size here due to the mild maritime climate and heavy annual rainfall as warm, wet Pacific airmasses are forced up into colder air by the rising slopes of the Cascade range. Living examples of old growth Douglas Fir and western red cedar can be found along I-90 east of North Bend (see Part II).

The town of Snoqualmie is a railroad buff's dream come true, with over a mile of track hosting antique rolling stock from throughout the region, including many steam engines, cranes and passenger cars in various states of decay. The town also features a restored depot where scheduled weekend rides on restored steam trains are offered, and a "log pavilion," a shrine of sorts to the old-growth logging industry that sustained the area economy for 50 years while the mill was in operation. The trunk of a gigantic old-growth Douglas Fir cut in 1987 sits astride a carriage used in a mill similar to the one nearby, which is now closed (see Fig. 9). The trusses of the pavilion roof were taken from the mill building. The tree was a seedling at the time of the defeat of the Spanish Armada, but considering Native Americans occupied the area for about 5,000 years, this 400-year-old tree lived a small fraction of the time humans have been here. To further enhance your tour of this beautiful valley, print out a copy of *Time Places*, a self-guided historic and cultural driving tour guide, leading you to many roadside historic interpretive signs.



Time Places is online at the Mountains to Sound Greenway Trust website: (http://www.mtsgreenway.org/).

Continue southeast on State Route 202 past the site of the Meadowbrook Hop Ranch, once the largest single hop-growing site in the world (now preserved as pubic open space), and cross the area once known as Ranger's Prairie into the town of North Bend, the last "outpost" of the Puget Lowland. State Route 202 brings you back to I-90 Exit 31 in North Bend.

If you chose not to take the Snoqualmie Valley scenic detour, continue here.

I-90 passes directly over the site of a former lumber mill where the High Point interchange is located today. The remnant of the mill town of High Point clings to the hillside just north of the freeway ramps. This valley was probably a low point in the surrounding ridges prior to glaciation, but when the overflow waters from glacial Lake Snoqualmie flowed thorough here, the channel was carved out. The actual "high point" of the route of I-90 near here is under the overpass at the Preston Exit [EX22]. Lost in the construction of I-90 here are many formerly open road cuts which were noted in a 1963 road log of US 10 as showing good exposures of Tertiary (11-70 million years old) rocks,

Glacial Duel

"Advance and Retreat" are terms used for changes in the size of a glacier, since the terminus or snout of the glacier appears to move into new territory (advance) or back toward its source (retreat). Glacial ice, however, doesn't move upstream any more than a river does. A glacier's ice always moves downward, but the glacier's terminus appears to move up-valley as the glacier retreats, or more accurately, as its ablation (melting) exceeds the accumulation at its source. These military metaphors of advance and retreat seem to apply particularly well in the North Bend area, though. Valley glaciers from the Cascades and the Puget Lobe of the Cordilleran ice sheet had very different dynamics, and they interacted all along the western front of the Cascades. So much fresh water was frozen in the continental ice sheets during the last major global glaciation that the valley glaciers in the Cascades had already retreated up from the lower valleys before the Puget Lobe advanced into the area just east of North Bend. Valley outlets in this area were blocked by lateral moraines deposited by the Puget Lobe long after the higher-elevation valley glaciers retreated eastward. That's the opposite of what you typically find on the eastern slopes of the Cascades and elsewhere, where the large moraines found today were left by valley glaciers, such as the moraine retaining Lake Chelan. Early resource managers developing water supplies for Seattle assumed that moraines found at the mouths of the western Cascade valleys were produced by valley glaciers like most such moraines elsewhere. This mistaken assumption had disastrous consequences in the valley just south of the one followed by I-90. Take the tour of the Cedar River Watershed and learn how the clay layer was expected to be on the upstream side of that moraine but was actually on the downstream side, allowing reservoir water to penetrate the moraine and flood the town of Cedar Falls. The "Boxley Burst," also resulting from this miscalculation, wiped the entire town of Edgewick off the map!

including the cast of a fossil tree that was buried by volcanic ash, its base rooted in shale. The openings of abandoned coalmines were also still visible at that time along the side of this valley. The original trail and wagon road probably followed Issaquah Creek closely up this narrow canyon. The Sunset Highway, which later was designated US-10, stayed close to the creek, too.

Finally, the 6 lanes of I-90 went through here like a huge bulldozer and eliminated most traces of the previous roads. The old road must have had many more turns, since the road log from 1963 mentions 8 bridges between Issaquah and High Point. The Sunset Highway then went northeast from Preston to Fall City, so if you took our recommended scenic detour to Fall City and Snoqualmie (in a previous section), you followed its route. By 1963, a new section of road had been built as part of the US 10 project, bypassing Fall City and Snoqualmie by following a more direct route up and over the glaciated highlands between Preston and North Bend, which is roughly the same route taken by I-90 today. The east- and west-bound lanes of the freeway are separated between the Preston and exit 27 for Snoqualmie, suggesting that one set of I-90's lanes was probably built atop the old alignment of US 10 there (we'll see evidence of this technique again just east of Snoqualmie Pass). US 10's former route (today's SE North Bend Way) splits off from I-90 at exit 27 at such a shallow angle that this exit is only accessible to eastbound traffic. All the traffic on the I-90 freeway followed the route of US-10 through downtown North Bend until the early 1980s when the main line was built from exit 27 to exit 32, one of the last "missing links" in I-90 across the US. The traffic light where State Route 202 crosses North Bend Way in downtown North Bend was the last light to stop I-90 traffic, at the corner where you'll recognize the Mar-T Café, made famous by the TV series "Twin Peaks."

Preston to North Bend

The town site of Preston (named for an executive of the historic Seattle, Lake Shore and Eastern Railway that was built through the town) is located at the convergence of two glacial lake overflow channels, a deep and distinct V-shaped valley extending NE toward Fall City, and a wider and less distinct one going SE toward Upper Preston. I-90 traverses up the side of the latter valley to reach its next crest in the area of the State Route 18 interchange [EX25]. Several deep road-cuts here expose the bedrock, Eocene (40-60 million years old) sedimentary and volcanic rocks, with a thin layer of much younger glacial drift covering them. This is the last we'll see of bedrock until we are well up into the valley of the South Fork Snoqualmie River east of North Bend. The entire Snoqualmie River valley bottom we're about to cross is made up of lake bed deposits which deeply bury the bedrock beneath them. Further east we have to cross the moraines left behind by the Puget Lobe before bedrock surfaces again.

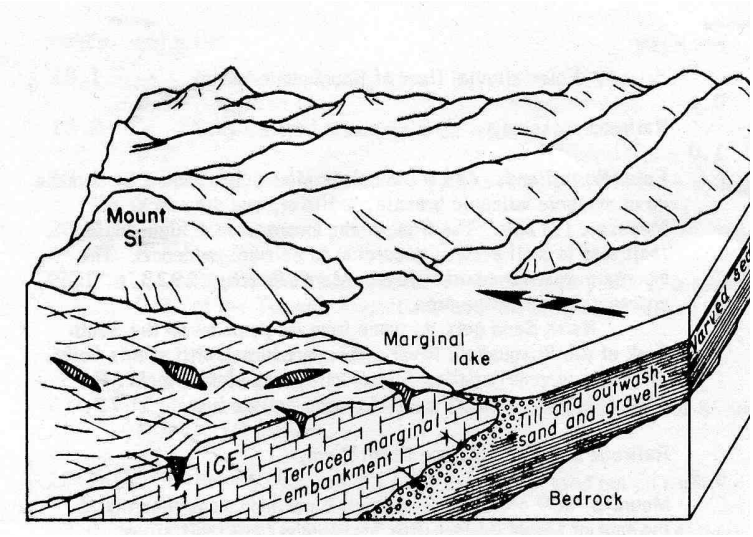


Fig. 10. Artist's conception of the ice-marginal lake that sat in the valleys of the Middle and South Fork Snoqualmie Rivers, in the vicinity of North Bend, during the Pleistocene advances of the Puget Lobe. To see an overview of this area today a short but steep hike to Rattlesnake Ledge from the Cedar River Watershed Visitor's Center offers a birds-eye-view of this landscape dominated by the moraines deposited along the margin of the Puget Lobe and the bed of a huge ice-marginal lake.

North Bend and the Cascade Front

On a clear day you'll get your first close-up views of the "Cascade Front" as you traverse eastward down across the side of the Snoqualmie River valley approaching North Bend [EX27-31], eastbound on I-90. Mt. Si, featured in our cover photo and named for pioneer Josiah Merritt who lived at its base, is the most prominent peak to the east across the valley, and is a dramatic example of geologic forces at work: tectonics and the sculpting effect of the Puget Lobe. The rocks Si's made of were transported here from far across the Pacific Ocean, riding on oceanic crust, and "docking" with North America. The igneous and metamorphic rocks here were metamorphosed by the intense heat and pressure of this "docking" process. The steep western wall rises 3,500 vertical feet from the valley floor to the summit in about a mile. The ice probably extended about 2000 feet up from the base of the mountain, abrading and polishing rocks on its western face. A huge ice-marginal river, collected from all the western valleys of the Cascades to the north and meltwater from the immense Puget Lobe itself, flowed southward against the face of Mt. Si. The North Fork of the Snoqualmie River follows the route of this former ice-marginal river for 10 miles north of North Bend. Part of the flow of the ice-marginal river may have opened the gap between Little Si and the main body of the mountain. In the vicinity of North Bend, the river spread out into a huge lake that filled the mouths of the valleys of the Middle and South Fork (See Fig. 10). To the south, this glacial river passed through the gap where Rattlesnake Lake now sits. Ultimately, at maximum glaciation, a vast river at least the size of today's Columbia carried the waters of all the rivers flowing west out of the Cascades and east out of the Olympics, as well as all the meltwater from the Puget Lobe itself to the Pacific Ocean by way of the valley of the Chehalis River to Grays Harbor.

North Bend's name comes from the sharp northward bend that the three forks of the Snoqualmie River take when they enter the Puget Lowland near the town. The rivers from the western valleys of the Cascades generally flow westward until they encounter the Puget Lowland, where the topography changes abruptly to trend north-south due to the sculpting and deposition of the Puget Lobe ice advance and recession, perpendicular to the Cascade mountain valleys.

Hay from the East for Milk from the West

I-90 makes cross-state truck transportation routine today, so the best of both climates and soils can benefit everyone in the region who drinks milk. Dairy cows in the Snoqualmie River Valley feed on hay trucked over Snoqualmie Pass from fields in the Columbia Plateau. The hay is grown on the mineral soil there, enriched by volcanic ash. The Snoqualmie Valley dairy cows live in the milder west-side climate - much milder than where their hay is grown, helping them produce record-setting quantities of milk year round. You'll see many flatbed trucks piled high with hay bales west-bound on I-90 in the summer and fall. Think of them when you see an ad sponsored by the Dairy Farmers of Washington that asks you if you've "got milk."

The Eastern Issaquah Alps and Rattlesnake Ledge

Harvey Manning didn't include the mountains east of the Raging River in his designation of the "Issaquah Alps" (maybe because they are just too far from Issaquah), but they are geologically related to Tiger and Cougar mountains. Like them, Rattlesnake Mountain was overridden by the Puget Lobe of the Cordilleran Ice Sheet during the Pleistocene Ice Age, ending about 15,000 years ago. But not all of the Issaquah Alps are smoothly contoured. A dramatic cliff punctuates the end of Rattlesnake Mountain on its eastern end. This impressive cliff was left behind as the Puget Lobe ice sheet melted and water accumulated along the eastern margin of the ice westward out of the North Cascades merged with the vast amount of water released by the through the gap between Rattlesnake Mountain and the slopes of the Cascades to the east. All that water had a tremendous erosive force and carved Rattlesnake Ledge. Today a new 2.1 mile trail leads from Rattlesnake Lake, just south of I-90 at Exit 32, to the top of the ledge for panoramic views of the Snoqualmie Valley, Mt. Si, and up the Cedar River valley to the east. Greenway initiatives have improved the trail that follows the length of Rattlesnake Mountain from the Ledge west to Snoqualmie Point Park. Hike this trail for spectacular views of the glacial landscape. And don't fear rattlesnakes on the trail –the names derive from the rattle of camas plant seed pods, a food source of Native Americans and common in this area when white settlers arrived.

Useful Web Links for Part I

- Seattle waterfront and Pioneer Square:

  http://www.undergroundtour.com/

- The Alaska Way Viaduct and seawall:

  http://www.wsdot.wa.gov/projects/Viaduct/

- The Seattle Fault and LIDAR:

  http://earthquake.usgs.gov/regional/pacnw/activefaults/sfz/index.html

  http://pugetsoundlidar.ess.washington.edu/

- Lake Washington:

  Water: http://wa.water.usgs.gov/realtime/htmls/lake_wash.html

  The cleanup: http://dnr.metrokc.gov/wlr/Waterres/lakes/biolake.htm

- The Puget Lobe of the Cordilleran Ice Sheet:

  http://vulcan.wr.usgs.gov/Glossary/Glaciers/IceSheets/description_ice_sheets.html

  http://faculty.washington.edu/dbooth/Ch_02_INQUA_volume.pdf

  http://prism.washington.edu/lc/cev/ps_glaciationsm.mov - a simulation movie

  http://pugetsoundlidar.ess.washington.edu/faults/index.html - click on (*Cartoon of last glaciation, 908 kB, requires QuickTime plugin.)*

- Glacial Lake drainage patterns:

  http://www.issaquah.org/COMORG/gwac/Stage.htm

- The King County Coalfields:

  http://seattletimes.nwsource.com/html/localnews/2002586143_minehike27e.html

- The Issaquah Alps:

  http://www.issaquahalps.org/

- Current info on Snoqualmie River flows (Snoqualmie Falls):

  http://dnr.metrokc.gov/wlr/flood/snoqualmie-river.cfm.

  NOAA has a chart of river flow over time at:

  http://ahps2.wrh.noaa.gov/ahps2/hydrograph.php?wfo=sew&gage=squw1&view=1,1,1,1,1,1

  (If the river is flowing above 1000 cfs, the falls will be quite spectacular.)

- Snoqualmie Valley history:

  http://www.snoqualmievalleymuseum.org

  http://trainmuseum.org

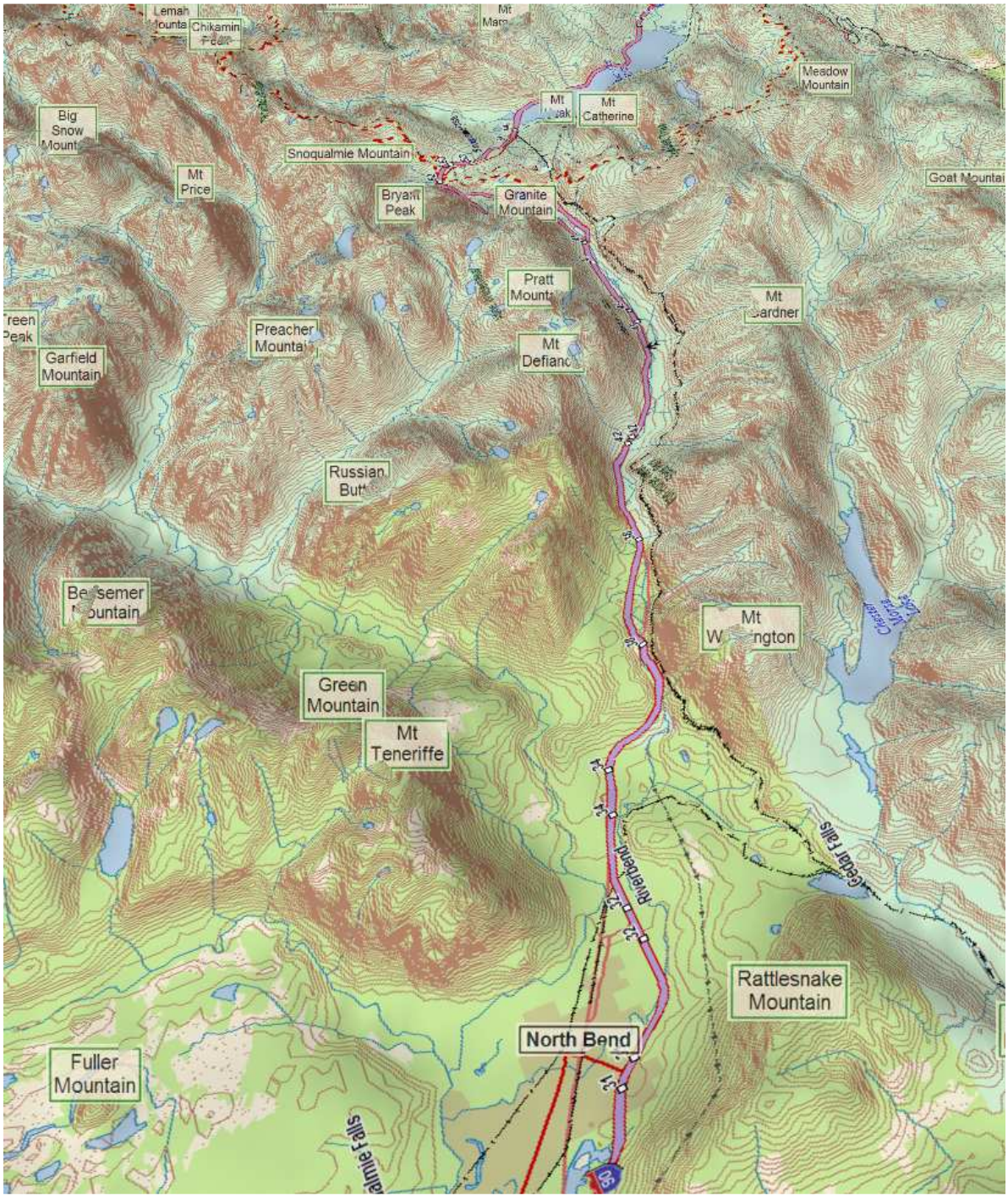
- The Cedar River Watershed:

  http://www.cedarriver.org

  http://www.scn.org/cedar_butte/

Cedar River Changes Course Twice

The Cedar River was the original “south fork” of the Snoqualmie, prior to the glaciation of the Puget Lowland. It probably met the other forks of the Snoqualmie River in the basin southeast of North Bend before the Pleistocene epoch. But glacial action by both the Puget Lobe and the valley glacier that carved-out the upper Cedar River valley “breached" the drainage of the Cedar River from its pre-glacial course into the Snoqualmie River, so that it now flows southwest, away from the Snoqualmie River. The Puget Lobe’s moraines in that basin and in the mouth of the Cedar River valley further cut-off the river from its ancestral course. Farther downstream, the Cedar River merged with the Black River near Renton. The Black River was the largest outlet of Lake Washington, and proceeded to join the Duwamish River and flow into Puget Sound at Elliot Bay, but when the level of Lake Washington was lowered 9 feet by the cutting of the Ship Canal to Lake Union in the early 20th century, the Cedar was diverted to flow *into* Lake Washington rather than out of it, and the Black River channel dried up.



Map 2. Western approach to Snoqualmie Pass, looking ESE from 100,000 feet above North Bend. I-90 follows the South Fork of the Snoqualmie River, a valley carved out by an alpine valley glacier during the Pleistocene epoch. Elevation gain is from 450 ft. in North Bend to almost 3,000 feet at Snoqualmie Pass. (2x vertical exaggeration is used.)

◆ PART II ◆

THE WEST SIDE: North Bend to Snoqualmie Pass

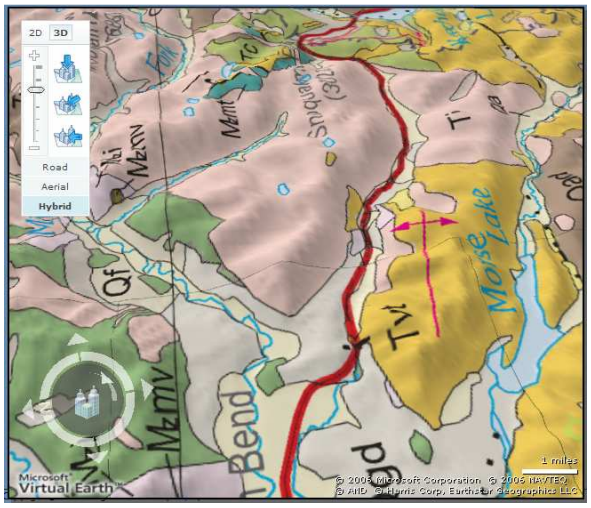


Fig. 11. 3D geologic map from North Bend to Snoqualmie Pass from same perspective as Map 2 on facing page. I-90 climbs through a glacial valley cut into the approx. 17 million year old Snoqualmie Batholith, a body of granitic rock that intruded into the surrounding rock deep underground, then was exposed by erosion (colored pink). This body of granite is one of several punctuating the Cascade Range, and its resistance to erosion makes for dramatic, sharp peaks and steep cliffs. The more easily eroded volcanic rock south of I-90 (in khaki) tends to form more rounded mountains.

(Courtesy 3dGeomaps.com)

As you head east on I-90 near North Bend, you're facing a different and formidable terrain. The Cascade Front seems to rise up like a wall before you. You're crossing land that was near the edge of the Puget Lobe that occupied the lowland you just crossed. The basin I-90 crosses east of North Bend is the bed of an ice-marginal water channel that flowed alongside the Puget Lobe ice. Before we can begin to ascend into the upper valley of the South Fork Snoqualmie River toward the pass, we have to climb over and around a huge ridge called a "moraine" formed at the edge of the Puget Lobe. Beyond that, we're in the former realm of a very different sort of glacial ice – an alpine valley glacier that carved out the upper drainage of the South Fork Snoqualmie River. So we're passing through a transition zone between the effects of continental ice and mountain valley ice. Once we begin to make our way up the valley, there are several short side trip options, and we'll describe the highlights of them for you. Detours and short hikes will take you to vantage points where you can see for yourself how spectacularly varied this country is, and let you encounter some examples of its constituent rocks up close. With only a few hours or as much time as you can spare, you can follow parts of the former routes of US 10, the Sunset Highway, old railroad grades, and even fragments of the first wagon road. As you approach the summit of Snoqualmie Pass, a huge body of granite is exposed and its resistant rock forms a dramatic series of alpine peaks and ridges. North of I-90 the terrain is more dramatic and is protected as the Alpine Lakes Wilderness Area. In contrast, south of I-90 the volcanic rock is more easily eroded and so the mountains are generally not as steep. The route of I-90 passes through an area that forms a dividing line between the North Cascades, which were raised higher and so eroded deeper into their "crystalline core," and the South Cascades which were not raised as high and so still have much of their volcanic "mantle" intact.

Exits 32 – 38: North Bend to Olallie State Park

While the Puget Lobe covered the Puget Lowland with as much as 4,000 feet of glacial ice, it acted as a huge conveyor belt, carrying an immense load of rocks from its source in British Columbia. Global temperatures had warmed significantly by the time the Puget Lobe extended south across the lowland. The warming had caused the valley glaciers in the Cascades to recede away from the lowland before the Puget Lobe arrived, and because the temperatures were comparable to today the Puget Lobe was melting rapidly at its margins even as it advanced. As all that ice melted, it dropped its load of rock fragments in a mixture called "till," which blanketed the lowland and collected in immense ridges along the ice margins. Grouse Ridge, which extends across the mouths of the valleys of the South and Middle Forks of the Snoqualmie River, is just such a ridge of glacial drift, called a "moraine." This moraine crosses the map like a dotted line showing exactly how far up these valleys the Puget Lobe got, and you face it like a long wall as you drive east of North Bend (see Fig. 12). As the

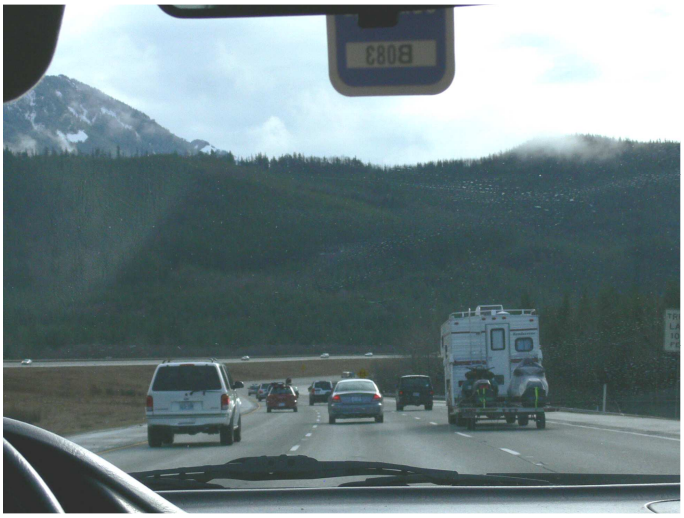


Fig 12. The Grouse Ridge moraine runs perpendicular to the path of I-90 in the vicinity of exit 34. This moraine marks the eastern margin of the Puget Lobe of the Cordilleran Ice Sheet in the basin where the valleys of the Middle and South Forks of the Snoqualmie River meet east of North Bend. Eastbound I-90 traverses SE up across the western, formerly ice-contact face of this moraine to gain 400 feet of elevation above the basin floor and enter the upper valley of the South Fork. This moraine was built at the margin of the Puget Lobe ice as it melted into the lakes dammed-up behind it. So these moraines are partly deltas.

Fig. 13. The upper part of 100 ft. Twin Falls in Olallie State Park. The falls is located where the South Fork Snoqualmie River passes over a bedrock outcrop as it leaves the upper valley and enters the Puget Lowland. A trail provides access to a series of boardwalks adjacent to and above the falls, where it ultimately connects to the Iron Horse State Park / John Wayne Trail.

rivers reestablished their courses gradually after the Puget Lobe receded, they ponded behind these moraines, then overtopped them and cut new courses though them. I-90 takes advantage of the Grouse Ridge moraine to gain some altitude to enter the upper valley of the South Fork, by traversing up across its west slope. It then passes through the channel cut by the river after it overtopped the moraine. The top of this moraine is almost perfectly flat, since a lake formed behind the ice front, so the top of the moraine became the bottom of this lake, which remained until the ice receded.

The last eastbound North Bend exit [EX34] gives you a chance to see the notch where the South Fork drops out of the upper valley and enters the Puget Lowland in a spectacular falls accessible only by trail. It's surprisingly close to the freeway, but hidden in a canyon and surrounded by a spectacular grove of old growth forest. This is the first of several chances you'll have to personally witness a "primeval" forest, passed-over by early logging operations due to the steep terrain, and subsequently protected as part of Ollalie State Park. Twin Falls trail begins just a mile south of I-90 off of 468th Ave. SE. The trail is built on a series of boardwalks near the falls (see Fig. 13), only a couple of miles from the trailhead. Even though you're quite close to the freeway as you approach the falls, at one point walking along the slopes of its embankment, you'll hardly notice the traffic noise since the freeway is above you and the river's roar mostly drowns it out. This trail is probably the closest place to Seattle where you can visit a remnant of the low-elevation old growth forest that completely covered the Puget Lowland when the first Europeans arrived.

The same exit [EX34] offers access to the Middle Fork Snoqualmie River, to the north (left at the exit). The Middle Fork cut a similar gap in the Grouse Ridge moraine, and the Middle Fork Road makes an "S" curve to pass through this gap. The floor of the Middle Fork at its opening is 700 feet below the floor of the South Fork above Twin Falls, probably because the valley glacier that carved out the Middle Fork valley was larger and extended further into the basin where the Middle and South Forks meet, while the glacier in the South Fork was smaller, leaving a narrower valley with a mouth that ended up "hanging" above the basin floor. Sometimes referred to as the "Quiet Fork," hikers appreciate the relative silence you find here compared to the ubiquitous traffic noise along the I-90 corridor. Thanks to the cooperative efforts of MTSG and the Forest

Fig 14. Lake bed sediments exposed by excavation north of I-90 near Exit 38. Alternating light and dark colored strata may be "varves," caused by annual cycles of deposition, with coarser grains (silt) accumulating in the summer and finer grains (clay) in winter. Varves are one of the tools of paleo-climatology, the study of ancient climates. Like tree rings, they reveal annual climatic variations long ago. These exposures are being rapidly covered by vegetation.

Service, a new campground has been built at the confluence of the Middle Fork and Taylor River, offering hiking in 3 directions. A slab of polished granite several hundred feet high is just a short walk off the Taylor River Trail, a couple of miles from the campground, at Otter Falls.

Lakes grew behind the moraines that the Puget Lobe deposited across the valley mouths of both forks of the Snoqualmie River. You can see evidence of the lake that sat up in the South Fork valley if you look to the north at 9 o'clock as I-90 turns eastward after going up across Grouse Ridge [EX38]. Excavation there has exposed a series of horizontal beds of sediment (see Fig. 14). These are the silt and gravel that accumulated on the floor of the lake, and are generally more coarse (sand and gravel) down-valley where these coarser sediments came from the Puget Lobe ice, and finer-grained (silt and clay) up-valley, where the stagnant lake water acted like a settling pond for the South Fork as it ponded behind the moraine. Once Puget Lobe receded and the lake overflowed the moraine ridge, cutting a new channel through it, the lake beds eroded away in the river channel, and today are present only against the valley sides. Since the post-glacial river channel formed on the south side of the valley, the remaining lake beds are only on the north side today.

The bridges over the Snoqualmie River that are built at Exit 38 are a good place to take a short break from freeway driving, even if you don't have enough time to explore the detour we're about to recommend. You can pull over as soon as you are off the exit ramp and take a look around at the new valley landscape you've entered. The dark rocks exposed in roadcuts are mostly volcanic Keechelus Formation andesite, about 30 million years old. This formation of solidified lava flows

Electric Train Route
Now a "Pioneer Trail"

Just east of North Bend we meet the route of the Milwaukee, St. Paul and Pacific Railroad, later known as "The Milwaukee Road." The original rail line came up the Green River Valley from Renton, through the gap at Rattlesnake Lake, rounded the north slope of Mt. Washington and proceeded up the south side of the valley of the South Fork of the Snoqualmie River, parallel to I-90 much of the way to Snoqualmie Pass. You can see several trestles crossing tributaries across the river valley from I-90 beginning at Exit 38 (Olallie St. Pk.). The former railbed has been converted into a regional trail called the "John Wayne Pioneer Trail," and is Washington's longest, narrowest State Park. In a case of historical reversal, equestrians use it today to recreate the experience of crossing the Cascades by pioneers, but it was never a pioneer trail. A riding club from Cle Elum was the first to start converting the rail to trail, and the trail came to be named for their club, the John Wayne Riding Club. Its original role as cross-continental transportation corridor has given way to a dual purpose in service of the past and the future - as a recreational trail and as the route of a high-speed fiber optic cable carrying the "cargo" of the information age. The view of the varved lake beds in Fig 13 is from above the freeway on the John Wayne Pioneer Trail. Often the best views of rock exposures are from points just off the freeway, and to get to viewpoints like this you can either start where the John Wayne Trail begins less then 5 miles south of I-90 off exit 34 at the Cedar River Watershed Visitor Center, or you can gain access to it uphill on spur roads off several I-90 exits (see Useful Web Links for Part II). Finally, as the trail approaches the pass, it enters a long tunnel, which is open to non-motorized users but requires equipment and preparation to safely pass through.

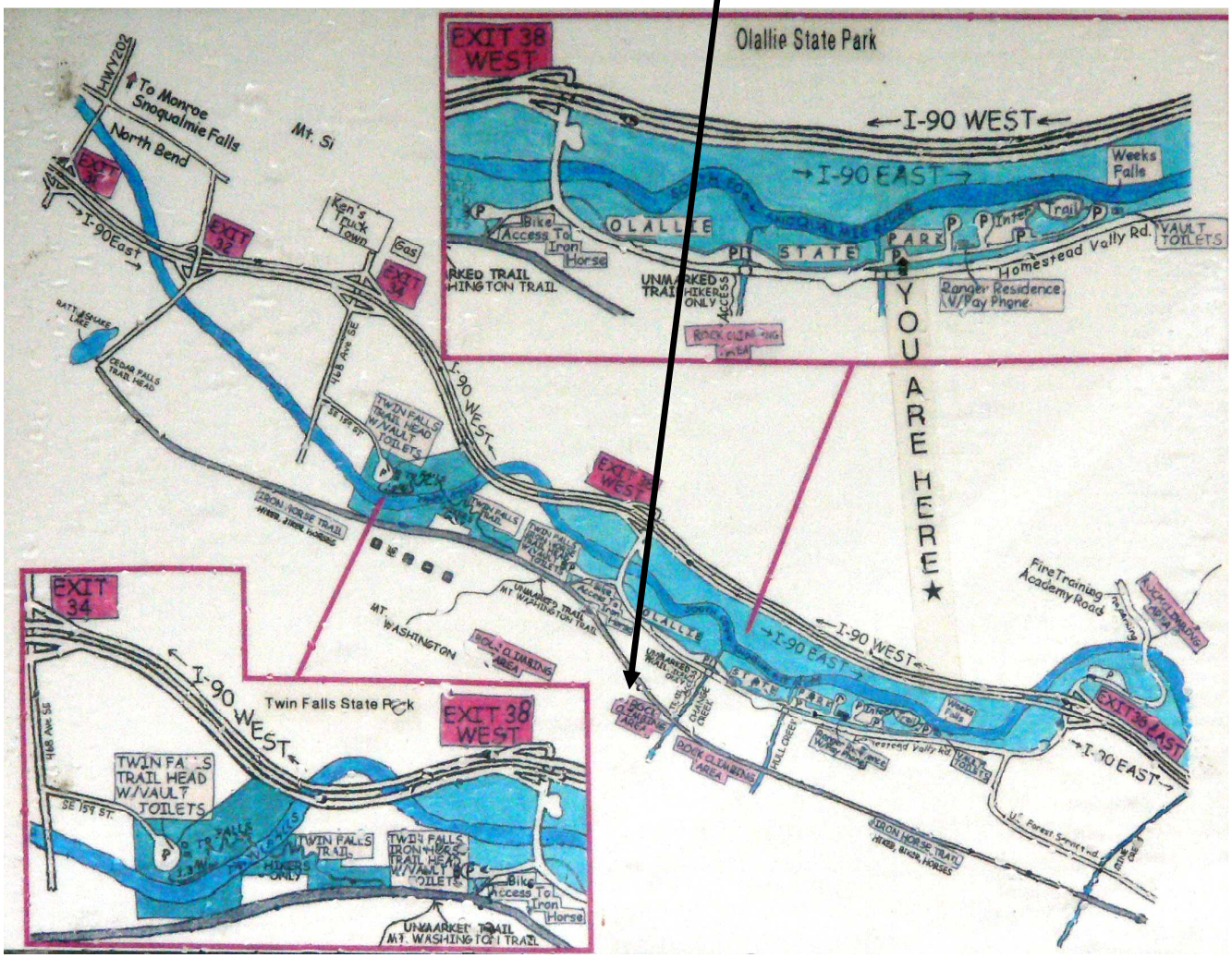
(khaki color in Fig. 11) is widespread in the southern Cascades, extending into the vicinity of Mt. Rainier.

A Scenic Detour at Exit 38: Sunset Highway, Wagon Roads, Railroad Trestles, and Rock Climbing Walls

At Exit 38 you get a great chance to get off the main line of I-90 and see some of the country here up close. *(If you remain on I-90, skip ahead to page 45.)* There are really two Exit 38s, one eastbound and one westbound, about 2 miles apart. Between these two exits is a section of the old road, and the east unit of Ollalie State Park. If you miss the exit eastbound, you'll have to drive on to exit 42 and go back, since exit 38 only allows you to get off at the beginning of this segment of old road. The loop road you'll follow is a combination of Sunset Highway and US10 remnants. The best place to see the multiple stages of road building here is at the bridges over Change Creek. Two cast-concrete bridges (see Fig. 15) cross the creek in parallel, with a date of 1953 visible on the northern one. While the southern one looks distinctly older, its southern railing has been replaced by generic modern guardrail, and there's no visible date. The most likely sequence of events is that the Sunset Highway went over the southern span, then when US10 was built a second set of lanes was built parallel to it to the north, and finally the upstream guardrail on the old bridge was damaged and replaced by the modern metal and "Jersey barrier" combination. The shape of the openings in the railings is another indication of the relative ages of these bridges: the rounded arch is typical of an earlier, more decorative style, while the square openings came later. Bridges of similar design to the 1953 bridge can be found west of North Bend on North Bend Way, dated 1941. So US 10 was put through during this time frame.

Fig 15. Cast concrete bridges over Change Creek on the Exit 38 scenic detour. The bridge in the foreground is the northern one with 1953 embossed on its abutment; its design is consistent with ones west of North Bend marked 1941. The one in the background is probably the older one from the original Sunset Highway.

Fig 16. (R) Climbers on a cliff of "hornfelsed" Ohanapecosh Formation volcanic rock (andesite), above Exit 38 at Change Creek. Here the soft volcanic rock was close enough to the hot magma of the Snoqualmie batholith to be baked and hardened into hornfels in the process, so it's solid enough to safely climb (see pp. 38-39 re. McClellan Butte and hornfels). The former roadbed of the Milwaukee Road, now the Iron Horse State Park / John Wayne Pioneer Trail, forms an ideal platform from which to see and climb the cliffs here.



Map 3. Detail map of Olallie State Park, from sign at park entrance. Lower-left inset map shows the western park unit around Twin Falls, while upper-right inset shows eastern area between the two Exit 38s referred-to as "Exit 38 West" and "Exit 38 East." The road on the south side of the river is a remnant of the Sunset Highway and US10. A portion of the old wagon road over Snoqualmie Pass and its puncheon roadbed can be found along the Interpretive Trail between the 2nd and 4th parking lots (counting west to east) shown in the upper inset map. Use the Adobe Reader ZOOM IN tpl to see the details, or look for the sign when you arrive at the park.

If you have time to do some walking you can follow a trail on the west side to Change Creek from the road bridges up to the old railroad trestle that spans the creek canyon, only about ¼ mile uphill from the road. This a popular place for rock climbing, and you also get a dramatic look at the bedrock here, the dark volcanic andesite of the Keechelus formation, of Oligocene[3] age. The railroad trestle is anchored into it.

If you drive east from here to the next bridge at Hall Creek, you'll be at a boundary between the older volcanic rock that's prevalent to the south and west, and the granitic rock of the Snoqualmie Batholith, which intruded into the older surrounding volcanic rock, so you'll start seeing both rock types, the former dark and the latter light-colored.

The river valley bottom is a treasure-trove of ancient forest and historic road remnants (See Map 3). Take the spur road down into the park (itself probably a relic of one of the first paved roads over the pass) and park in the second lot, behind the ranger residence. At the north end of the lot you'll find the beginning of an interpretive trail that leads down another old route, this one roughly atop the oldest route to survive, the 1850s wagon road. You'll come to a sign pointing out a short stretch of "puncheon" road, built of the most abundant local material - wood. Logs were split lengthwise and the flat surfaces faced upwards to form a surface, not a very smooth one, but nonetheless far superior to the soft soil that would otherwise swallow a wagon wheel. The soils here are soft and moist much of the year, with the combination of wet climate and heavy old-growth vegetation, which surrounds you now. If you didn't take the side-trip to Twin Falls, this detour gives you your first chance to admire some huge trees, some up to 14 feet in diameter at the base. Most of the bigger ones here are western red cedar, others are Douglas fir. "Olallie" is Chinook Jargon for "berry;" the flats along the riverside grow abundant huckleberries on the sandy soils deposited there by the river, and these berries were an important food source for the Snoqualmie people.

When the interpretive trail meets the road, continue on up the spur road to see Weeks Falls and the small hydropower project here. The bedrock exposed around the falls is more of the andesite prevalent here. Weeks Falls hydro project is designed to be "fish-friendly" by not diverting any more water than necessary when river flows decrease in summer. Rejoin I-90 at the eastern end of the Exit 38 loop.

[3] 37 – 24 Million years ago

Exits 38 - 47: Garcia, Bandera, and Tinkham

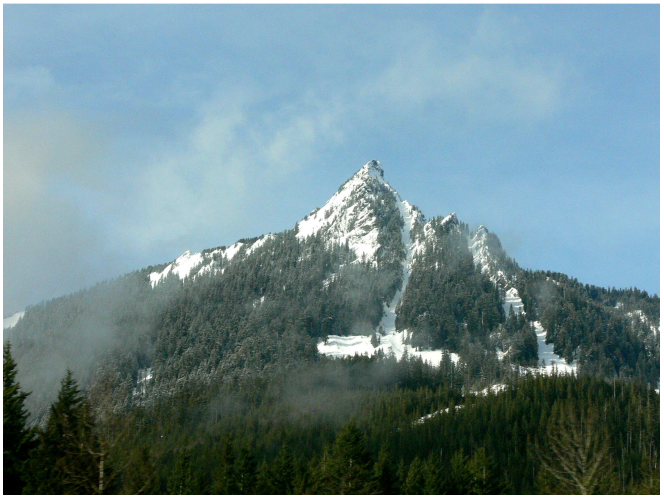


Fig 17. McClellan Butte, named for Gen. George McClellan, U.S. Army surveyor who abandoned his search for a route over the Cascades from the west up the Cedar River valley, and from the east over Yakima Pass, within sight of this peak in 1853-54. It is a classic glacial horn peak, created by several glaciers that surrounded a ridge and removed rock from all sides, leaving the pointed core.

As you re-enter the main line of I-90 at exit 38 east, you're back in the center of this glacial trough, and are now above the area where the valley bottom was filled with lake sediments when the outlet was dammed by the Puget Lobe, so the valley bottom becomes narrower. Glacial troughs abound in the Cascades, and are generally U-shaped due to the action of the glacier that filled them, with valley walls steeper and floors flatter than a valley created only by river erosion, which forms a shape more like the letter V. The glaciers that filled these valleys began as permanent snowfields along the Cascade crest, where altitude and precipitation were sufficient to prevent all the snow from melting each summer; then as the climate cooled, the accumulating snow formed ice, which gradually expanded as more snow accumulated than melted and began flowing down the valleys in the form of a glacier. Later when the climate warmed the glaciers receded until they were small or non-existent. This cycle repeated itself many times during the Pleistocene, in glacial advances known as "stades," followed by relatively warm interglacial periods during which the valley glaciers receded and remained only near the crest or disappeared. We're in a warm, interglacial period now, so the only permanent ice is far up on the highest peaks. To see a valley glacier today, you can visit one of the Cascade volcanoes, where elevations are high enough to sustain permanent glaciers today. The easiest one to visit is Mt. Rainier, just a few hours drive south. It's surrounded by glaciers, with more ice on it than in all the mountains in the lower 48 states combined!

General McClellan's legacy

Gen. McClellan's failures were due in part to rumors that spread ahead of his expedition that he was out to take native land by force, which made it difficult for him to secure reliable native guides. Despite this failure, McClellan went on to be General in Chief of all the Union Armies in the Civil War, though his legacy, both as a surveyor and General, remains controversial.

Between Exit 38 east and 42 you'll have several good views to your right of McClellan Butte. It is a steep-sided pyramid-shaped peak, created by erosion from all sides by the heads of several glaciers that surrounded it. It's a "horn" peak, the namesake of which is the Matterhorn in Switzerland. The views of

its summit from the freeway are truly spectacular, especially when some snow "dusts" its summit pyramid (see Fig 17). Another factor that contributes to the impressive horn atop this peak is that it's located near the margin of the Snoqualmie Batholith, where the granite ends and the older surrounding volcanic rocks begin. The older, surrounding rock was baked and hardened by the heat of the molten magma that slowly cooled several miles within the earth to form the batholith. The German word "hornfels" is used to describe this type of rock, which is harder than the unaltered rock surrounding it, and so forms horn peaks like McClellan Butte when subjected to glaciation.

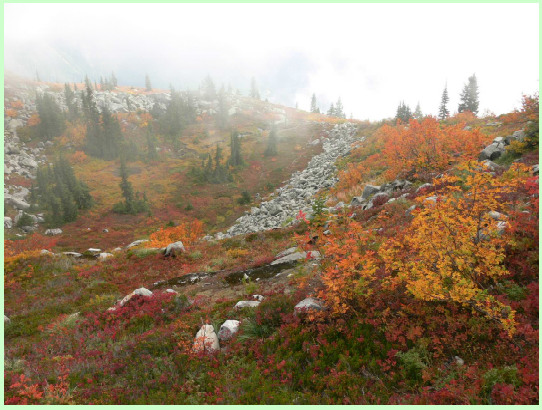
Fig. 18. Garcia and the other three "flag stops" along the old Milwaukee Road rail line on the west side of the pass are still marked by their original signs along the Iron Horse Trail. You can hunt at these locations for rusty relics of the railroad construction and maintenance work that was done here from 1908-1980.

At the foot of McClellan Butte is a small rock promontory in the valley bottom, also of very resistant rock – so resistant in fact that the valley glacier that occupied this valley was unable to grind it all down, so the freeway hugs the north side of the valley bottom here to pass around it. Just after we make the bend to the right around this promontory, we come to exit 42, Tinkham, where you have another opportunity to stop briefly and take a look around. Tinkham road is unpaved, follows the south side of the river valley up to exit 47, and is in deep second-growth forest, and so offers few opportunities for seeing the landscape. Since it's near the river, the rocks in the area are mostly recent river sediments. The road is probably a relic of the first permanent road over the pass, from the 1910s and 1920s, although evidence of this is not abundant. Tinkham road is named for Abiel Tinkham, an engineer colleague of territorial governor Isaac Stevens and a native of Maine, chosen by Stevens to survey a route across the Cascades after Gen. George McClellan, of McClellan Butte, had failed. Tinkham made a mid-winter crossing of the range via Yakima Pass, a pass only a few miles south of Snoqualmie and favored by natives, in 1854. It would be two more years before the first government-backed white American party is documented to have gone over the true Snoqualmie Pass.

Look for the highway maintenance shops across the river off exit 42 –a long-time wayside camp and inn once stood here, first known as Camp Bide-A-Wee and later as Camp Mason, one of several build over the Snoqualmie Pass route before the coming of the freeway, when it took days, not hours, to cross the pass. We'll see the only remaining intact example of one of these inns across the pass in Part III.

The Passing of a Legend

A moment of silence now. This is the point in the preparation of this manuscript when it was announced that Harvey Manning had passed away on Nov 12, 2006, at age 81. Most of what's been done to preserve the landscape of the Cascades would not have happened without him. We owe him an incalculable debt every time we go.



Exit 45, FS Road 9030, Bandera, gives access to a small airstrip in the last relatively flat part of the river valley bottom. You can drive north from this exit to access the Bandera Mountain trailhead, and hike to the summit and on into the Alpine Lakes Wilderness. To your right at 1 o'clock at this exit you'll see a small indentation near the ridge crest to the south. This is a "cirque," an armchair-shaped depression excavated by a small equidimensional glacier called a cirque glacier. Cirque is the French word for circle, and that's roughly the shape of both the glacier and the bowl it carves out. Often a small, roughly circular lake called a "tarn" will occupy a cirque after the glacier recedes (see Fig. 19). A tiny tarn named Scout Lake sits in this cirque. Small glaciers that start in cirques at the beginning of a glacial stade may expand as they did here down into adjacent valleys to make a valley glacier. In winter and spring you may be able to see some snow hugging the base of the cliffs surrounding this cirque. These little snowfields represent both the first incipient and final waning stages of a glacier. If you hike up the ridge to the north and out of the valley of the South Fork, you'll enter a land covered with many of cirque lakes, now protected in large part in the

Fig. 19. A typical tarn, or lake filling the basin of a glacial cirque. This is Tuscohatchie Lake north of Granite Mountain. Tarns are often retained by the terminal moraine of the cirque glacier that carved out the bowl they occupy. The Alpine Lakes Wilderness Area protects much of the area between Snoqualmie Pass and Stevens Pass to the north, and most of the lakes that it was named after are tarns.

Alpine Lakes Wilderness. Cirques and tarns are much more common north of Snoqualmie Pass due to the prevalence of resistant granite and metamorphic rocks.

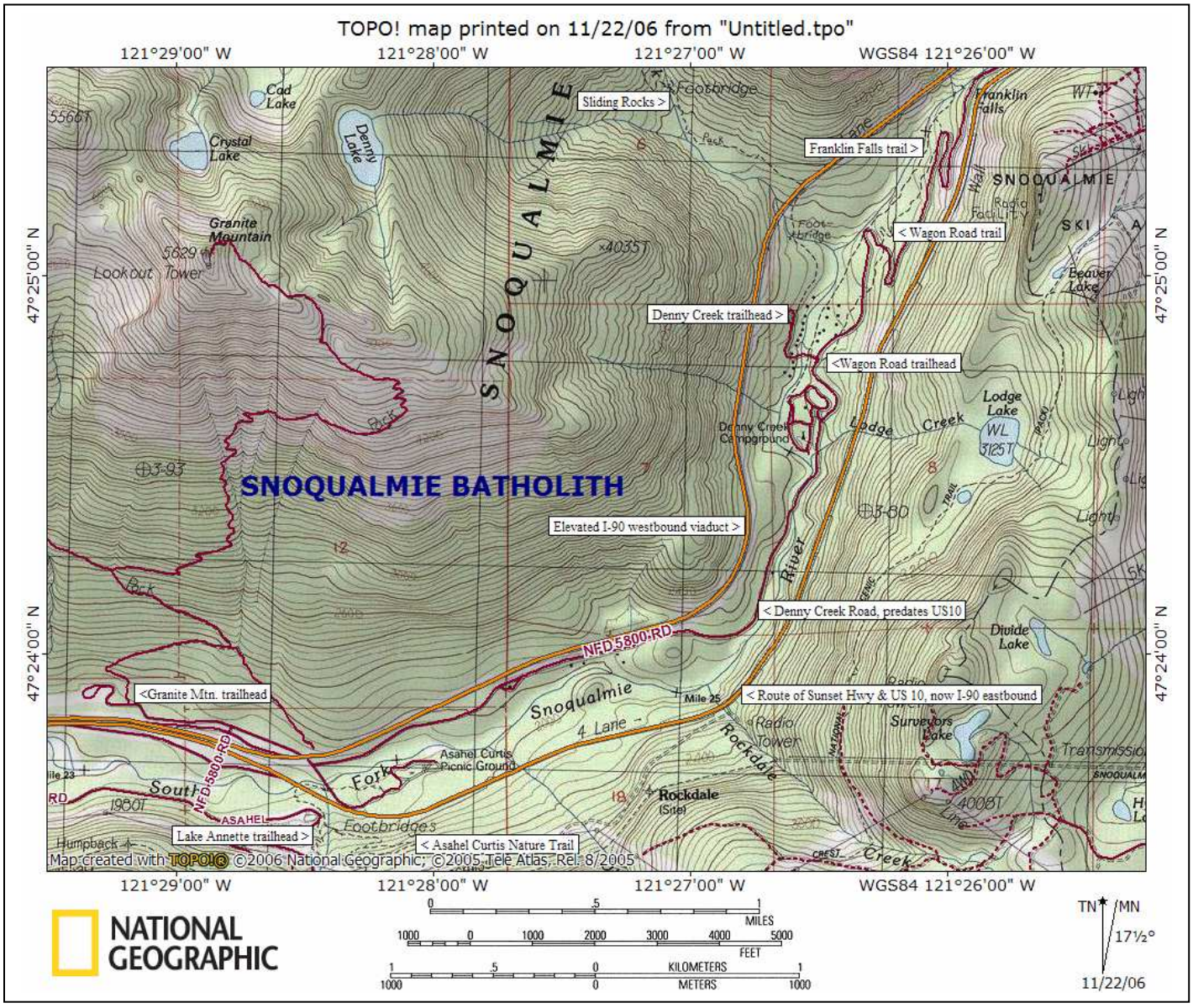
Bandera is the name of one of the "flag stops" along the Milwaukee Road railroad, which was located at a point just up the south valley slope from the Bandera airfield and freeway exit (See Fig. 18). There were four of these points along the railroad between Cedar Falls, where the Cedar River Watershed visitor center stands today, and the Snoqualmie railroad tunnel entrance. They were named (west to east): Ragnar, Garcia, Bandera, and Rockdale. You can get to them by either following the Iron Horse State Park / John Wayne Pioneer Trail or by taking Forest Service spur roads that cross the trail near them. Garcia is the closest flag stop to a spur road, and you can still find some artifacts of train work there. Cedar Falls was the main operation base for the west side approach, where the foundation of the electrical substation that powered the engines has been preserved near the visitor center parking lot, but the other four flag stops were also important points where supplies and equipment were stored, crews assembled and repair work performed. There is a long tradition of towns growing up along the first railroads through the West, often starting at these seemingly arbitrary points where the railroad chose to store supplies and house crews. Had the train remained the primary mode of transport through Snoqualmie Pass as it once was, these wide spots in the hillsides might still be significant facilities today.

A Scenic Detour from Asahel Curtis/Denny Creek to West Snoqualmie Summit

The area off the I-90 main line from Exit 47 up to the pass is unlike any other along the Mountains to Sound Greenway. If you've avoided the temptation to pull off the freeway so far, don't miss out now! (S***kip to p. 48 if you must skip this area.***) This area is at a high elevation so there is the potential that outside of mid-summer you could encounter snow, so remember our advice to always carry chains and supplies, but the interchange area at exit 47 ("Asahel Curtis, Denny Creek") is generally kept open year-round, so even if the old road between here and the pass is closed in the "off" season, it's still a good place to stop, get out, and take a look at the surroundings. There are so many important and interesting places to visit here, we'll make a list, starting at Exit 47's interchange and working our way up toward the pass. Also refer to Map 4.

Place/Route	***Significance***
Asahel Curtis Picnic Area	Old growth forest, river bank
Asahel Curtis Nature Trail	More old growth, glacial erratics
Granite Mountain Trail	Spectacular, steep view hike to an old lookout tower, Alpine Lakes Wilderness access
Annette Lake Trail	Hike to a tarn lake in a cirque
Denny Creek Road	Remnant of original road over the pass, pre-US 10
Denny Creek Trail	Old growth, waterfalls, "Mineral Gulch," Alpine Lakes Wilderness access

Wagon Road Trail	Surviving fragment of old wagon road
Franklin Falls Trail	River views, short easy walk to huge falls
Old road to the pass beyond Denny Creek	Pre-US 10 route, easy to drive between Exits 47-52, follow all the way to Hyak



Map 4. Western approach to Snoqualmie Pass, from Asahel Curtis/Denny Creek Exit 47 to Franklin Falls. The roads and trails in this area are complex and can be confusing to locate. From the Asahel Curtis Exit to the Picnic Area, you're driving on a short section of the Sunset Highway and former US 10. Northwest of the Asahel Curtis exit, the trailhead for Granite Mountain trail is just a short way west on the north side of I-90. Asahel Curtis Nature Trail is shown as multiple trail loops just south of the westbound lanes of I-90 near the word "Footbridges" at the bottom-left. The connecting trail between the Picnic Ground and the Nature Trail, described in the text, is also shown. The Denny Creek Road (labeled NFD 5800 RD) is a section of road that predates US 10, and may be part of the original "Yellowstone Highway" (See Part III). Across from the Denny Creek Trailhead parking area turnoff, you can find the beginning of a restored portion of the old trace of the wagon road, shown here as a trail that crosses over the upper Denny Creek Road 3 times, and ultimately connects back to the Franklin Falls trail just below the falls. Along the eastern riverbank, the Franklin Falls trail leads from the falls back to the Denny Creek trailhead spur road and the Campground, forming a loop. Denny Creek Trail leaves from the spur road off Denny Creek Road, and reaches the Sliding Rocks at the point labeled "Footbridge" at top-center. ZOOM IN with Acrobat Reader to see details.

A good place to start is to take the short walk from the Asahel Curtis Picnic Area to and through the Asahel Curtis Nature Trail. This gives multiple benefits, since you'll experience the environment along the river bank, see the memorial to Asahel Curtis, the famous photographer of the old forests, walk under a classic cast-concrete bridge from the Sunset Highway and finally experience a self-guided walk through a grove of old-growth forest preserved in honor of Curtis. You can "short-cut" this itinerary if you're short on time by driving to the Annette Lake Trailhead and starting on the Nature Trail directly from there, but you'll miss a very pleasant river walk, the Curtis memorial, and a bridge museum. So start at the picnic area and find your way by following the signs near the entrance down to the side of the river. Often this is the loneliest part of the trail, as it takes you through deep forest and along a rocky riverbank. Pause at the memorial. Note that almost all the rocks you see in the riverbank are rounded into some variation of an oblong sphere. This is due to the erosive action of the valley glacier that occupied the entire valley, and to the transport of some of these rocks by the river during periods of flooding. Soon you'll come to where the trail goes under the bridge you drove over as you followed the old road to the picnic area. Note its graceful concrete arches. Unfortunately for the bridge historian, the highway department replaced the guardrails some time ago with the standard "Jersey barriers," so there's no longer a visible date stamp, but parts of the old concrete guardrail can be found on the ground under the bridge abutments. Proceed on and you'll go under the freeway bridge, climb up the riverbank a bit and reach the parking lot for the Annette Lake trail and the beginning of the official Asahel Curtis Nature Trail, named for the famous photographer (see sidebar). Except for the freeway noise (which you've probably gotten accustomed to by

Asahel Curtis

(1874-1941) Photographer and brother of Edward S. Curtis, was a co-founder of the Mountaineers Club and was involved in the early years of Mt. Rainier and Olympic National Parks as a strong advocate of access to these scenic places by more and better roads. He owned orchard land near Ellensburg, and served as president of the Washington State Good Roads Association, all of which may help explain how the roadside grove of old growth forest on I-90 came to be preserved in his name. His historical photos of the northwest form a unique resource: 60,000 of his photos are in the collection of the Washington State Historical Society, and the University of Washington has over 1,000 of his photographs online now as part of their "digital collections" (see Useful Links at the end of Part II).

Photo of downtown Seattle in 1900 by Asahel Curtis (image in public domain).

Fig 20. Near the summit of Granite Mountain. Lookout tower on summit is seen on the horizon. The granodiorite of the Snoqualmie batholith breaks or "cleaves" in large, roughly rectangular blocks. The lookout offers 360-degree views.

now - if not try earplugs or headphones), this is the most authentic old-growth forest walk experience near I-90. Refer to 55 Hikes around Snoqualmie Pass for details of this and other hikes. But don't miss this one even if you don't do any others. There are some small streams that are crossed, including the outlet from Annette Lake, and some large glacially transported granite boulders, known as "erratics" are along the path, one is split in half and has a wooden bench installed at its base.

The road to the picnic area over the old bridge was Sunset Highway and then US10. When you turned left into the picnic area you entered what was a Forest Camp spur road before I-90 was built. The old US 10 grade ahead "disappears" under the eastbound lanes of I-90 which was built atop it from here to the pass.

Before we leave the exit 47 interchange and head uphill toward Denny Creek, the parking lot for the Granite Mountain and Olallie Lake trailheads is just a short way back down the valley on the north side of I-90. These hikes are some of the most strenuous and demanding of all those in this area, but also some of the most rewarding. Granite Mountain (see Fig 20) is a peak carved from the heart of the Snoqualmie Batholith, and the trail goes right to the top, to an old Forest Service fire lookout tower. When the weather is clear the view from the top is a panorama of the central Cascades, where you can see the obvious difference between the northern and southern parts of the range. The steep climb up the north side of the valley crosses over several avalanche chutes, where large trees never have a chance to grow as they do in the surrounding forest because snow and rock routinely roars down them every winter. The upper meadows are beautiful in summer, covered with wildflowers, and in fall, with colorful foliage. Allow all day for the Granite Mountain hike, and be prepared for rapidly changing weather. The granodiorite rock here, a variety of granite, is exposed throughout the high open country

above treeline, fractured by freeze-thaw action into huge rectangular blocks. Granite is mostly made up of the minerals quartz and feldspar, which form the white crystalline material. The dark flecks are biotite mica. Individual crystals can grow to visible size due to the long time the molten magma remains far below the earth's surface, where it cools slowly. This granite was about 1 ½ miles deep in the earth's crust when it first intruded and solidified. If you turn right on the north side of the exit 47 overpass, then turn left and drive up toward Denny Creek, you're following a section of road that predates US 10 and may predate the Sunset Highway as well. In her book on the history of the pass, Yvonne Prater labels it part of the "first permanent road, 1910s –20s." This old route is narrow

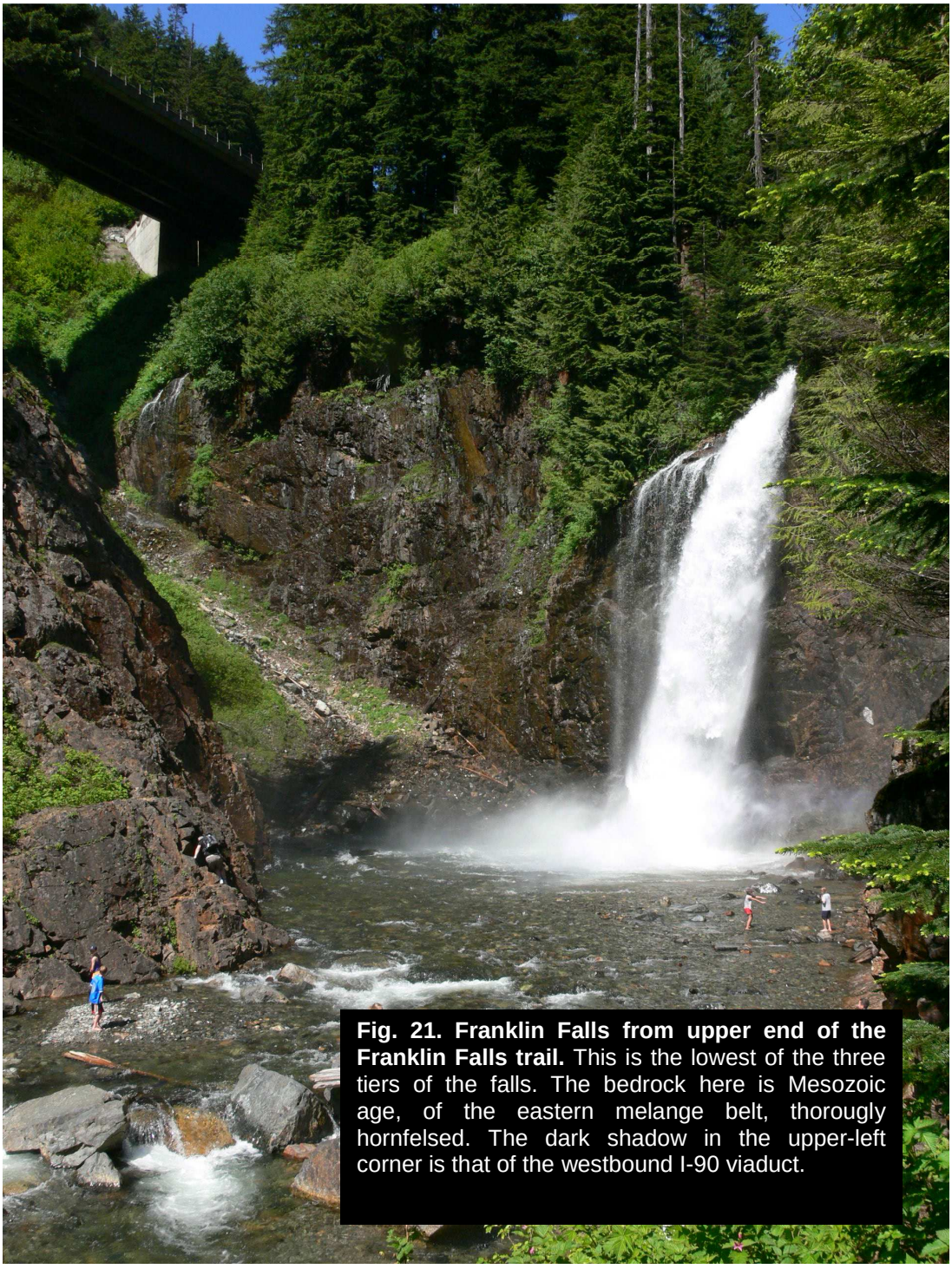
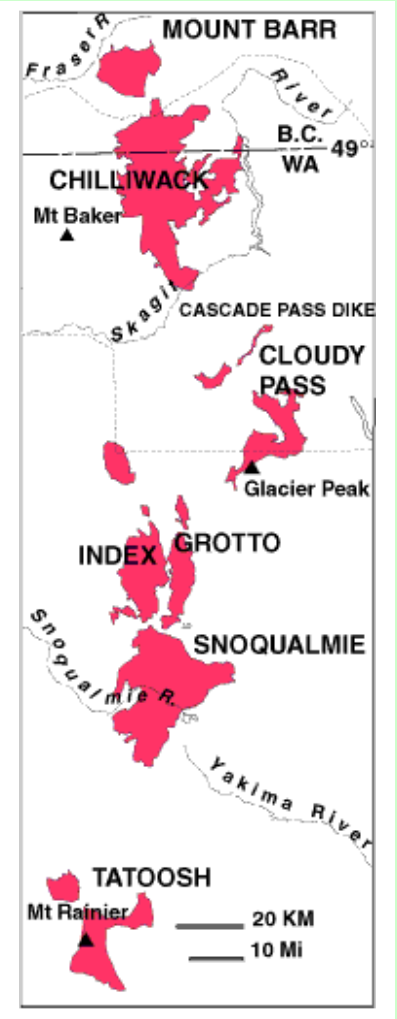


Fig. 21. Franklin Falls from upper end of the Franklin Falls trail. This is the lowest of the three tiers of the falls. The bedrock here is Mesozoic age, of the eastern melange belt, thorougly hornfelsed. The dark shadow in the upper-left corner is that of the westbound I-90 viaduct.

Cascade Granite and Its Roots

The beautiful rock of Granite Mountain is part of a huge body of granodiorite exposed near Snoqualmie Pass, one of several such "batholiths." They intruded in molten state into the rock formations that once lay above them and acted as a layer of thermal insulation, allowing the magma to cool slowly so large crystals formed. The overlying layers of rock were then gradually eroded away, exposing the granite to the surface. In the Cascades, these batholiths are referred to as "arc-root plutons," since they formed in magma chambers that lay about 7000 ft beneath an arc of volcanoes in the distant past. All evidence of the volcanoes they were once beneath eroded away long ago. In the map on the right the major groups of batholiths and smaller units known as "plutons" are shown, and as you can see, the Snoqualmie is one of the largest, second only to the Chilliwack near the Canadian border. The Mt. Stuart, Entiat and Chelan plutons further east in the Cascades are some of the oldest, at approx 80 million years, while the 25-17 million year old Snoqualmie and the Tatoosh to the south are the youngest. The source of all that magma was the melting of subducted crust under the western margin of North America. This magma is less dense than surrounding rock so it rises up into the crust above its melting zone. By happy coincidence, the upper valley of the South Fork Snoqualmie River is located directly on top of this particular granite body, so it's much easier to access than many of the other Cascade plutons, located in more remote country. (Map courtesy USGS)



but paved and passes several creeks and some private homes as it goes the next 3 miles to the Denny Creek campground. If you see any light-colored rocks along the road they're granite come from the Snoqualmie Batholith, with its salt-and-pepper appearance.

Several trails begin near the Denny Creek Campground area: Franklin Falls, the Old Wagon Road, and Denny Creek. Which ones you take may depend on how much time you have, so we'll start with the quickest one first and work our way up, although we recommend all three. The Franklin Falls trail is short and spectacular, leading you along a small gorge cut by the South Fork and through deep forest. In just under a mile you reach the falls (see Fig. 21), which has the unique distinction of being now located in the "median" of I-90, since the new viaduct for westbound lanes was built in 1981. The elevated westbound lanes offer easy passage for wildlife and greatly reduce the noise

heard at ground level. The entire falls consists of three tiers, totaling 135 feet; what you see from the trail is only the final 70-foot step. You can see the amazing viaduct structure overhead just up to the north of the falls, but you may not notice it since its impact is so much less than the conventional "cut and fill" method of road-building.

We're near the southeast margin of the Snoqualmie Batholith here, and two rock types are exposed here for the first time on our tour. Older (Mesozoic) metamorphic rocks and younger (Tertiary) sedimentary ones appear here as we pass the edge of the batholith and begin to encounter the first rocks typical of the pass area itself and the eastern approaches to it.

The Old Wagon Road Trail begins directly across the road from the entrance to the Denny Creek Campground. It's a different sort of trail, rarely walked compared to the others in the area. The wagon road is really just a series of ruts and channels cut into the forest floor, in some cases now largely overgrown and difficult to distinguish from the surroundings. This area was the subject of a preservation effort in 1965, when the Boy Scouts, the Forest Service and local landowners cooperated to mark the old wagon road as a trail. Many of the marker posts they placed then are missing or damaged now, but look closely and you may find one. Some relics along the way include an old wagon wheel and a "watering trough" for Model Ts. This is the oldest section of road over Snoqualmie Pass that's officially marked and open to the public. It's a short walk and well worth your time. Even on a busy summer weekend you'll be unlikely to see any others on this trail, since the nearby Franklin Falls route seems to draw the crowds.

Finally, the Denny Creek Trail is one you can enjoy no matter how much or how little time you have. Within a mile you come to an opening in the forest where the creek crosses

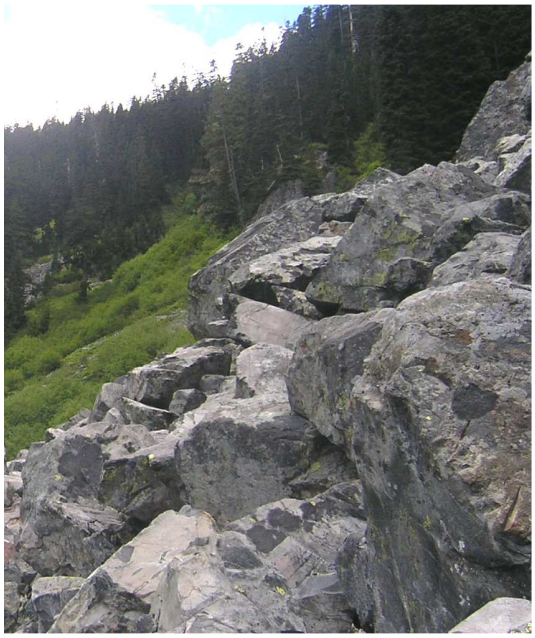


Fig. 22. Pieces of the surrounding rock broke away and became mixed in with the molten magma of the Snoqualmie Batholith and are now trapped within it, forming "xeonoliths" that appear here as dark spots on lighter-colored granite boulders on the upper Denny Creek trail.

Fig. 23. Westbound I-90 viaduct crosses high above the Denny Creek Trail. This method of freeway construction, more common in the Alps, allows free movement of wildlife and greatly reduces the impact on the landscape, as well as reducing avalanche and rockfall risks to motorists.

over polished granite slabs in a series of chutes and pools known as Sliding Rocks. This trail and its geology are detailed in Scott Babcock and Bob Carson's Hiking Washington's Geology, which should be "required reading." Among the wonders you'll see are exfoliating granite slabs "peeling off the glaciated rock walls like the layers of an onion," a "synplutonic dike" of basalt that invaded the Snoqualmie Batholith and then was broken up by it so that now it "looks like the snake in the famous Don't Tread On Me flag." Other details of this exposure of glacially-polished granite near the margin of the batholith are due to how close you are to its edge, where many pieces of the older surrounding rock broke away and became mixed in with the intruding magma and now look like dark spots in the lighter granite background (see Fig. 22). If you follow the description of a short climb up Denny Creek from Sliding Rocks in Babcock and Carson's book, you'll come to what they call "Mineral Gulch," where many beautiful crystals are said to be literally there for the taking! Further up the Denny Creek trail are two large waterfalls and beautiful forest. Ultimately the trail crosses the ridge crest and drops to a tarn lake, with connecting trails deep into the Alpine Lakes Wilderness Area. On your way up and back you'll walk under the overhead viaduct of westbound I-90, which becomes almost a work of modern art in an otherwise natural setting (see Fig. 23). Drive slowly up the last 2 or 3 miles of the old road, pause as it turns around its hairpin switchbacks, and imagine the road unpaved and muddy and your car being a lot less comfortable, powerful, and reliable. You'll understand why you would have been considered a brave soul indeed to try crossing Snoqualmie Pass by car in the "good old days!"

The old road passes under the westbound viaduct and comes to an intersection with Alpental Road, and Exit 53 (Summit West).
If you chose not to take the scenic detour at Denny Creek/Asahel Curtis, continue here.

Exits 47 – 53: Up to the Pass

The final five miles up to the West Summit [EX53] are on the old roadbed of US 10, which ran in both directions here, but is now used only as the eastbound lanes of I-90. It's a slide-prone area (see sidebar p. 59) and has many road-cut exposures of Snoqualmie Batholith granodiorite. The general northward curve of the road indicates you're about to enter the "merging zone" of an alpine valley glacier system that split in half when it reached the pass saddle. That's what explains the relatively low elevation of Snoqualmie compared to the other passes over the Cascades: the area was completely over-ridden by converging and diverging glaciers which flowed south from the South Fork Snoqualmie and Commonwealth Creek drainages until they reached the pass, then split in half and curved around east and west to flow down the main approaching valleys. The other passes in the Cascade range are just glacial coincidences in which the heads of two glaciers happened to be more or less directly across the Cascade crest from each other, but Snoqualmie Pass was actually *under* a glacier.

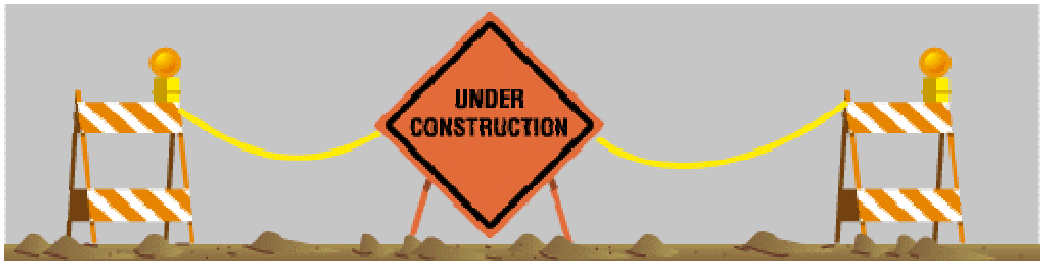
Roadside Raptors

It almost seems as though freeways were designed as raptor habitat. You have wide-open grassy areas in the medians, shoulders and around interchanges, and there are lamp-posts and signpost structures that form ideal perches. The Red-tailed Hawk is the most common roadside raptor. It will often be seen perching patiently on a lamp-post overlooking a grassy area along I-90. When they take flight, you'll recognize them by the distinctive color of their tail feathers (see photo below). They prey on small mammals that thrive in the man-made prairies along the freeway margins. They spend most of their time patiently watching for movement on the ground below, conserving precious energy, but occasionally you'll see them circling overhead or even swooping down to capture prey in their talons. You may even see one of their nests in a tree nearby, especially in winter when the deciduous trees are bare. Mated pairs will often stay in the same general area all year, but change their nesting site. Some pairs have been observed to use the same nesting sites every other year! Other large birds you may see include bald eagles, turkey vultures, northern harriers, and of course the ubiquitous crows and ravens. You can identify them by their unique shapes when perched and in flight, and by their flight patterns. Grab a bird book before your next trip and see how many you can spot along the way!

Watch for Falling Rock

The roads approaching the pass from the west cross a steep slope in an area particularly prone to rockslides. When the Milwaukee Road put through its train tracks, it suffered blockages for many years before the tunnel was built to avoid this high-angle slope. A road log by the UW Geology Department members who crossed the pass in 1963 mentions that "When the roadway [of US 10] was being widened in 1953, rocks on the hanging wall of a fault gave way, causing a landslide that covered the road and carried two trucks over the side." Yvonne Prater says of the upper section of the old road right below the pass, "The road winds up through a huge rockslide that closed the main highway [US 10, farther uphill] for a whole summer in the early 1960s." The culprit was the conventional method of road-building in mountain terrain, known as "cut-and-fill." You can imagine how cutting into a hillside for a road could undermine a fault by, then the constant vibration of vehicles could trigger a rockslide as the rock above fractures along the weak fault line. When the capacity of I-90 from the pass down to Denny Creek was judged to be inadequate, widening the existing lanes on the southeast slope was out of the question, so a new approach was taken - an aerial viaduct was built on the opposite side of the valley in 1981, where immense talus fans (old rockslides) made the cut-and-fill method impossible. The aerial viaduct was very expensive but offered immunity to road closures from avalanches and rockslides. The only drawback from a traffic standpoint is that since it's up in the air, the pavement surface tends to freeze before a conventional road would, so when temperatures drop and it starts to snow, be very careful as you drive down the west side!

Coming in Part III: The east side of the pass and three huge lakes dammed by glacial moraines.



Useful web links for Part II

- Twin Falls: (search at)
  http://www.waterfallsnorthwest.com/

- Varve images:
  http://www.earthscienceworld.org/images/search/results.html?Keyword=Varves

- Paleoclimatology:
  http://earthobservatory.nasa.gov/Study/Paleoclimatology/

- General geologic history of the Cascades:
  http://www.washington.edu/burkemuseum/geo_history_wa/Cascade%20Episode.htm

- Olallie State Park:
  http://parks.wa.gov/parkpage.asp?selectedpark=Olallie&pageno=1

- Rock climbing at Exit 32 and 38:
  http://www.northbendrock.com/

- Snoqualmie batholith:
  http://www2.nature.nps.gov/geology/USGSNPS/noca/nocageol8a.html - re. arc-root origins
  http://www.washington.edu/newsroom/gemstones.html - re. gemstones

- General George McClellan:
  http://en.wikipedia.org/wiki/George_B._McClellan#General_in_chief

- A list of access points to the Iron Horse State Park / John Wayne Pioneer Trail from I-90 is available at:
  http://www.parks.wa.gov/parkpage.asp?selectedpark=Iron%20Horse

- The Milwaukee Road railroad:
  http://www.mrha.com/
  http://www.milwelectric.org/ -Click on “Milwaukee Road History”

- Harvey Manning:
  http://seattlepi.nwsource.com/local/292252_manning14.html
  http://www.wta.org/%7Ewta/cgi-bin/wtaweb.pl?0+pr+10197

- Asahel Curtis
  http://content.lib.washington.edu/curtisweb/index.html - collection at the University of Washington
  http://www.washingtonhistory.org/wshm/online-exhibits/curtis/exhibit1.htm - Exhibit about the Curtis brothers

- Middle Fork Snoqulamie River Road
  http://www.mfsnoqualmie.org

Selected Resources

General Reference:

Roadside Geology of Washington, 1984, Alt and Hyndman, Mountain Press
Hiking Washington's Geology, 2000, Babcock and Carson, Mountaineers Press
Geology of the Pacific Northwest, 1995, Orr and Orr, McGraw Hill
Exploring Washington's Past: A Road Guide to History, 1995, Kirk and Alexander, University of Washington Press
Snoqualmie Pass: From Indian Trail to Interstate, 1981, Prater, Mountaineers Press
Mountains to Sound: The Creation of a Greenway across the Cascades, 1993, Chasan, Sasquatch Books
Mountains to Sound Greenway Trust website: http://www.mtsgreenway.org, 206.382.5565
Cascadia: The Geologic Evolution of the Pacific Northwest, 1972, McKee, McGraw-Hill
A Geologic Trip along Snoqualmie, Swauk, and Stevens Pass Highways, 1963, UW Geology Dept. Staff, State of Washington Printing Plant
Glaciers and Landscape, 1976, Sugden and John, Edward Arnold Publishers Ltd.
55 Hikes Around Snoqualmie Pass: The Mountains to Sound Greenway, 2001, Manning, Mountaineers Books
Historylink is an excellent online resource of northwest history, at http://www.historylink.org

Maps:

A good paper road map is essential when you're driving. We recommend the DeLorme Washington Gazetteer, combining very thorough road and trail information with topographic background including shading to make it easy to visualize the landscape (www.delorme.com) . The map of the Alpine Lakes Wilderness published by the Alpine Lakes Protection Society includes much of the Greenway, and has by far the best-visualized topography; see http://www.alpinelakes.org/fram?url_id=10 . Green Trails has the most complete and up-to-date trails on their maps, and has begun publishing a series of the Issaquah Alps and North Bend area that are very highly detailed and useful for Part I; see http://greentrails.com and click Downloads for a free sample for Mt. Si. You can find all these paper maps for sale at http://www.rei.com , as well as the CD-based ones described below and of course many GPS devices.

To keep track of the exits on I-90 online, try Mapquest (http://www.mapquest.com), and Google Maps (http://maps.google.com) which is somewhat easier to use.

You can view free online topographic maps at http://www.topozone.com. Paper topographic maps are published by the USGS, while those from Green Trails include updated roads and trails. CD-ROM series from DeLorme (TopoUSA®) and National Geographic (TOPO!®) allow interactive 3-D views. For free online 3D views, try "Google Earth" at http://www.earth.google.com . The most powerful 3D globe viewer by far, based on satellite imagery, is available free from NASA at

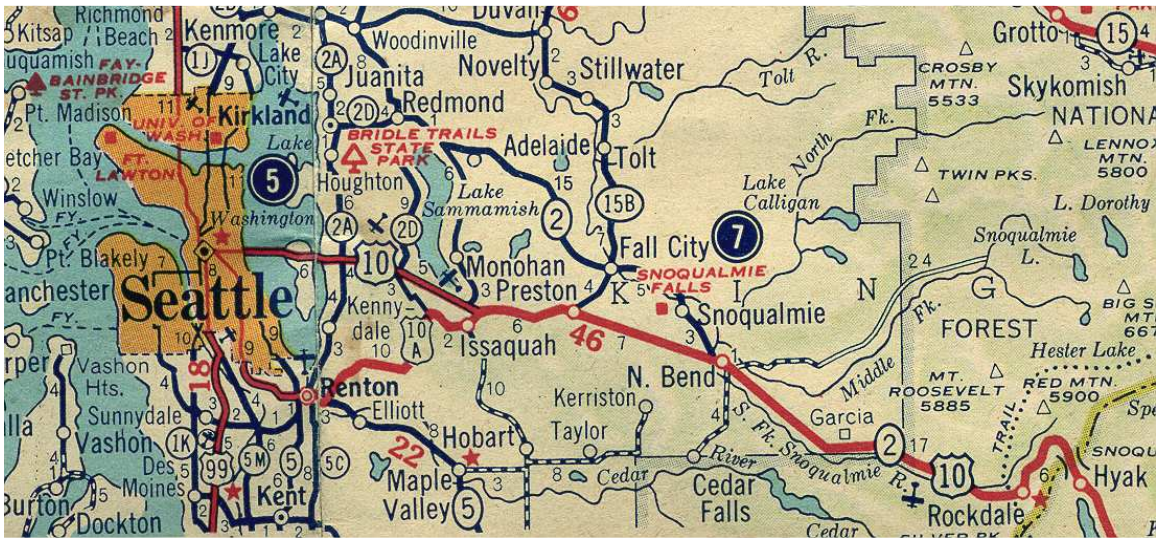
http://worldwind.arc.nasa.gov/ , but requires a fairly powerful computer and fast Internet connection.

A simplified geologic map of the region can be downloaded from Washington state Dept. of Natural Resources at http://www.dnr.wa.gov/geology/pagemap.htm , while a more detailed one is available from the USGS at http://wrgis.wr.usgs.gov/wgmt/pacnw/nc/snp2.html An innovative new technique combines 3D topography and geologic maps, so you can at last see a visual model of terrain with the geologic mapping overlaid on a 3D model, at http://www.3dGeomaps.com , currently available only for limited parts of the US, luckily including Washington State. One of the more challenging aspects of most geologic maps is finding the formation name in the key, and one interactive web-based map solves the problem – you just click on the formation and the name appears: http://home.comcast.net/~a0000002/q404_frames.html

And we should mention the Washington Trails Association both for their good work to keep trails open and improve them, and for their very useful website where you can search reports filed by others who recently hiked where you want to go, at http://www.wta.org .

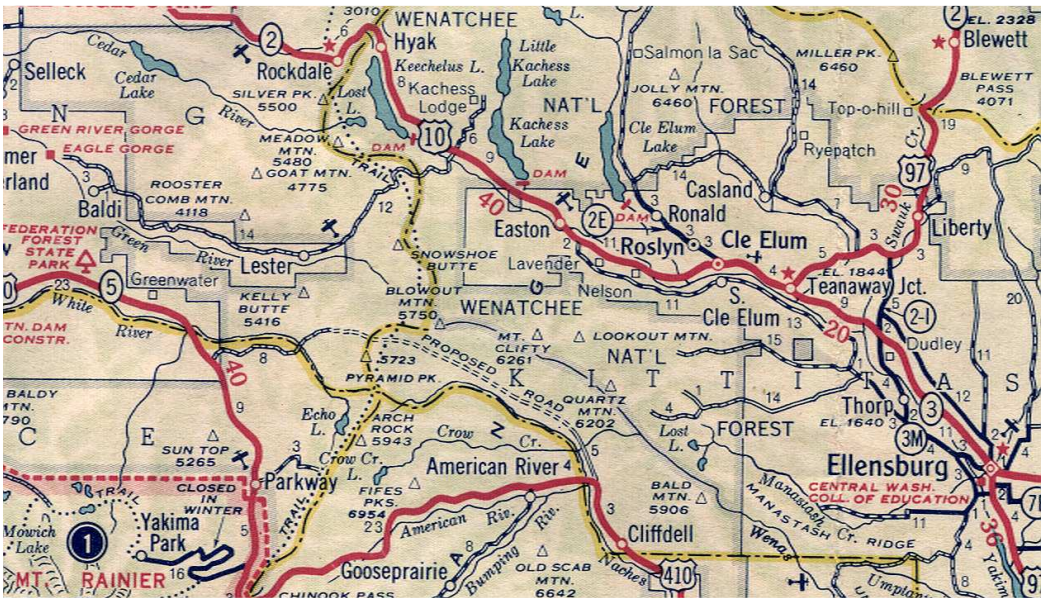
Appendix 1: The Highways through Snoqualmie Pass before I-90

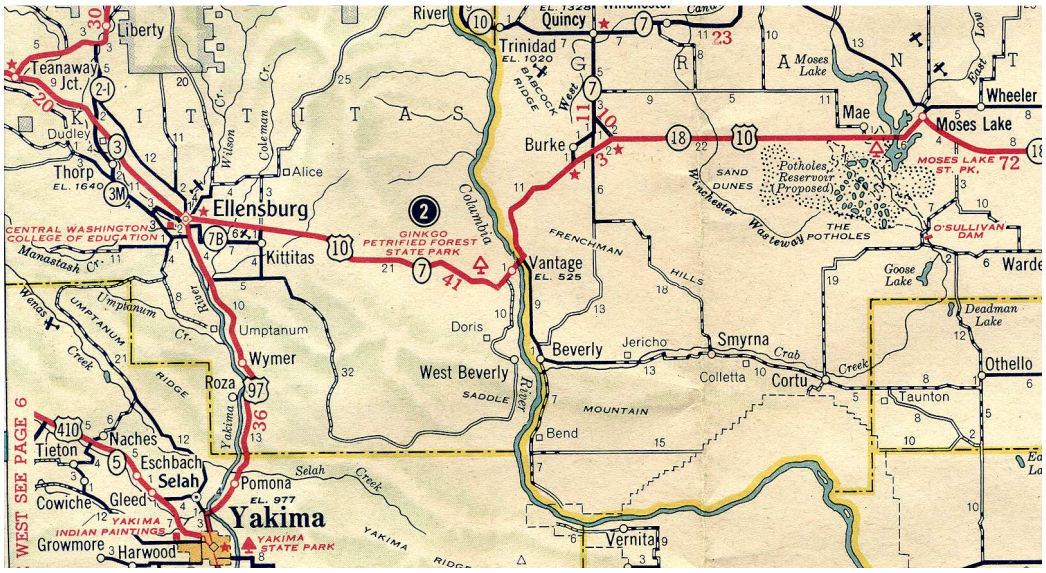
Parts of a highway map of Washington from 1952 show the roads before I-90.



ABOVE: West Side - US 10 crossed Lake Washington on the floating bridge by 1952, but the old route south around the lake was been re-labeled US 10A (today's SR 900). Also the older route of the Sunset Highway retained a designation as SR 2, shown by the oval number 2, which goes around the north end of Lake Washington through Woodinville and Redmond, Fall City and Snoqualmie, meeting US 10 at North Bend (today's SR 202). US 10 east of North Bend also carries the SR 2 designation, since this was the route of the Sunset Highway.

BELOW: East Side – US 10's route was followed by I-90 from Snoqualmie Pass as far as Cle Elum. One set of I-90's current lanes are the old US-10 roadway here. At Cle Elum, I-90 begins a long bypass route to the south of US 10, which left behind US 10's route, which became SR 10. The Sunset Highway turned north at "Teanaway Jct." and went over Blewett Pass and east along the route of today's US 97. As of 1952 the portion of the Sunset Highway NE of Teanaway Junction has been designated US 97, which it remains today (its route east from Leavenworth is now US 2). The oval SR 2 designation appears here, following this route of the Sunset Highway.





ABOVE: East of Ellensburg – US 10's route was one valley north of the route taken by I-90 eastward from Ellensburg to Vantage, and the old road remains accessible today in its entirety here. Beyond Vantage, I-90 obliterated the old route.

Appendix 2: Geologic Time

First, here's a basic geologic time scale. Colored areas are those referred-to in the text. Note that the vertical time scale is NOT linear. Since more is known about more recent time, the scale becomes increasingly compressed as you go back in time.

EON	ERA	PERIOD		EPOCH	TIME SPAN (million years)	AGE of	
Phanerozoic	Cenozoic	Quaternary		Holocene	0-2	Mammals	Humans
				Pleistocene			Mammals develop and become dominant
		Tertiary	Neogene	Pliocene	2-5		
				Miocene	5-24		
			Paleogene	Oligocene	24-37		
				Eocene	37-58		
				Paleocene	58-66		Extinction of dinosaurs (beginning of Paleocene)
	Mesozoic	Cretaceous			66-144	Reptiles	Flowering plants, height of dinosaurs
		Jurassic			144-208		1st birds/mammals, abundant dinosaurs
		Triassic			208-245		First Dinosaurs
	Paleozoic	Permian			245-286	Amphibians	End of trilobites & other marine animals
		Carbon-iferous	Pennsylvanian		286-320		Abundant insects, first reptiles
			Mississippian		320-360		Large primitive trees
		Devonian			360-408	Fishes	First amphibians
		Silurian			408-438		First land plant fossils
		Ordovician			438-505	Marine Invertebrates	First Fish
		Cambrian			505-570		1st shelled organisms, trilobites dominant
Proterzoic	**Also known as Precambrian**				570-2,500		First Multicelled organisms
Archean					2,500-3,800		First one-celled organisms
Hadean					3,800-4,600		Approx age of oldest rocks (3800)

From: http://arnica.csustan.edu/common/geologic_time.htm

Here are some websites with other perspectives on geologic time:

- "Imagine that all the earth's history is laid out on a yardstick. The original measure of the yard was the distance from the king's nose to the tip of his fingers. If one yard represents all of geologic time, then one swipe of a nail file across the tip of king's finger will remove all of human history." To make other analogies of your own, go to:

  http://www.athro.com/geo/hgfr1.html

- Interactive timeline with detailed text describing each time period:

  http://www.nmnh.si.edu/paleo/geotime/main/index.html

- Timescale featuring continental drift paleomaps, so you can see how the continents have rearranged themselves over time, particularly how the Atlantic basin has opened up and pushed North America westward, which caused the accretion of parts of the Pacific ocean floor onto the Pacific Northwest:

  http://www.nhnct.org/geology/timescale.html

"A stock broker I know said to me recently, 'I really like your newsletter, it always has real information in it. And this last one – I just loved that article about the mill pond and ox bow – I thoroughly enjoyed learning about that.' So you see you are playing a very important role in helping the Greenway Trust and preserving the long-term support for the Greenway itself. Your diligence and research and flexibility … are wonderful. Warmest thanks."

-Nancy Keith, Executive Director, Mountains to Sound Greenway Trust

"I enjoyed reading your guide… It has some fascinating history. I hope someday to make a leisurely trip across Snoqualmie Pass and look for all those old artifacts. I wish that I had had your guide when we were mapping in there."

–Rowland Tabor, USGS, author with Ralph Haugerud, Geology of the North Cascades: A Mountain Mosaic