WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

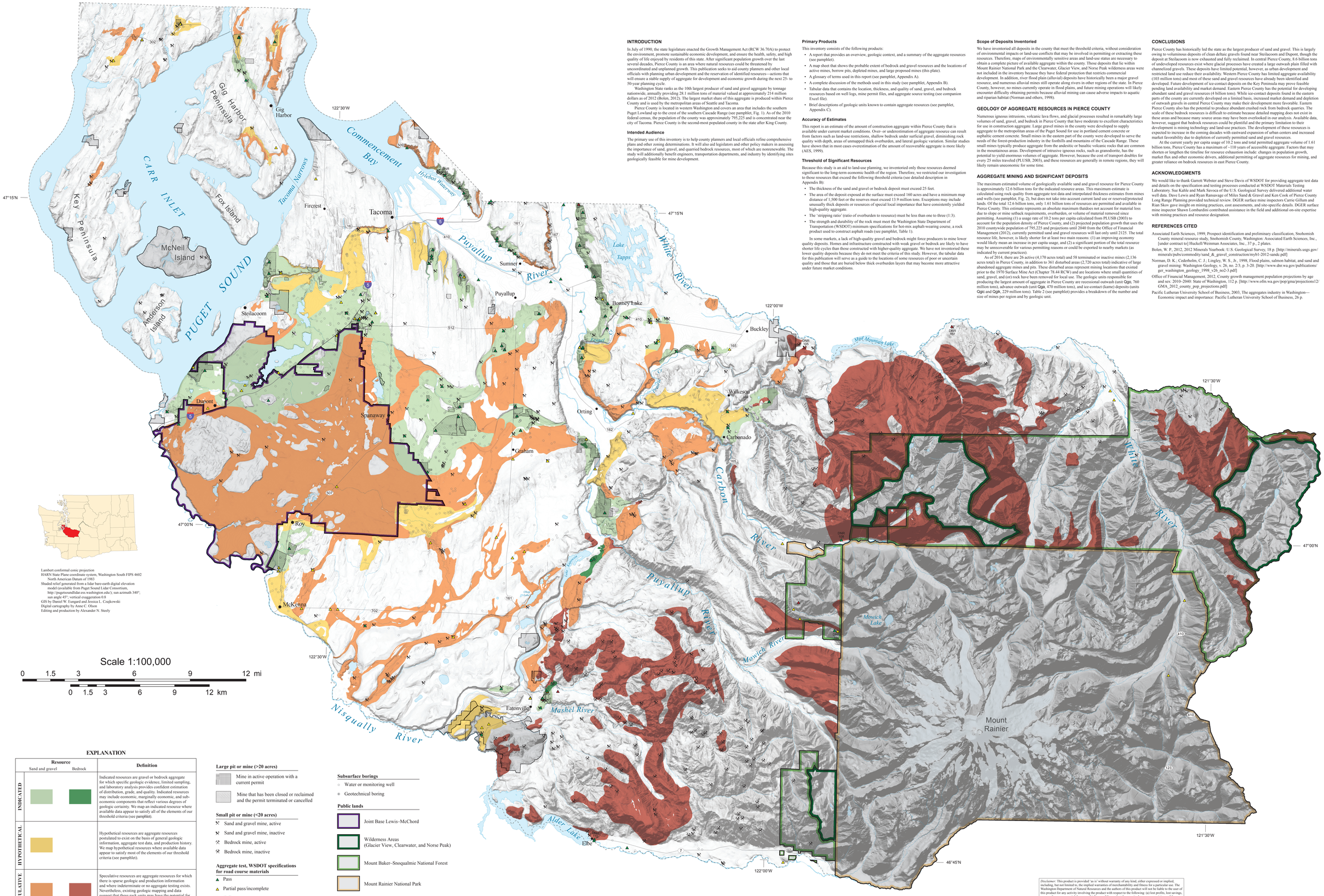
Division of Geology and Earth Resources
David K. Norman - State Geologist

Rock Aggregate Resource Inventory Map of Pierce County, Washington

by Daniel W. Eungard and Jessica L. Czajkowski

2015

WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
INFORMATION CIRCULAR 119
Rock aggregate resource inventory map of Pierce County, Washington
February 2015
Pamphlet accompanies map



Lambert conformal conic projection
HARN State Plane coordinate system, Washington South FIPS 4602
North American Datum of 1983
Shaded relief generated from a lidar bare-earth digital elevation model (available from Puget Sound Lidar Consortium, http://pugetsoundlidar.ess.washington.edu/); sun azimuth 340°; sun angle 45°; vertical exaggeration 0.8
GIS by Daniel W. Eungard and Jessica L. Czajkowski
Digital cartography by Anne C. Olson
Editing and production by Alexander N. Steely

INTRODUCTION

In July of 1990, the state legislature enacted the Growth Management Act (RCW 36.70A) to protect the environment, promote sustainable economic development, and ensure the health, safety, and high quality of life enjoyed by residents of this state. After significant population growth over the last several decades, Pierce County is an area where natural resources could be threatened by uncoordinated and unplanned growth. This publication seeks to aid county planners and other local officials with planning urban development and the reservation of identified resources—actions that will ensure a stable supply of aggregate for development and economic growth during the next 25- to 50-year planning cycle.

Washington State ranks as the 10th largest producer of sand and gravel aggregate by tonnage nationwide, annually providing 28.1 million tons of material valued at approximately 214 million dollars as of 2012 (Bolen, 2012). The largest market share of this aggregate is produced within Pierce County and is used by the metropolitan areas of Seattle and Tacoma.

Pierce County is located in western Washington and covers an area that includes the southern Puget Lowland up to the crest of the southern Cascade Range (see pamphlet, Fig. 1). As of the 2010 federal census, the population of the county was approximately 795,225 and is concentrated near the city of Tacoma. Pierce County is the second-most populated county in the state after King County.

Intended Audience

The primary use of this inventory is to help county planners and local officials refine comprehensive plans and other zoning determinations. It will also aid legislators and other policy makers in assessing the importance of sand, gravel, and quarried bedrock resources, most of which are nonrenewable. The study will additionally benefit engineers, transportation departments, and industry by identifying sites geologically feasible for mine development.

Primary Products

This inventory consists of the following products:

- A report that provides an overview, geologic context, and a summary of the aggregate resources (see pamphlet).
- A map sheet that shows the probable extent of bedrock and gravel resources and the locations of active mines, borrow pits, depleted mines, and large proposed mines (this plate).
- A glossary of terms used in this report (see pamphlet, Appendix A).
- A complete discussion of the methods used in this study (see pamphlet, Appendix B).
- Tabular data that contains the location, thickness, and quality of sand, gravel, and bedrock resources based on well logs, mine permit files, and aggregate source testing (see companion Excel file).
- Brief descriptions of geologic units known to contain aggregate resources (see pamphlet, Appendix C).

Accuracy of Estimates

This report is an estimate of the amount of construction aggregate within Pierce County that is available under current market conditions. Over- or underestimation of aggregate resource can result from factors such as land-use restrictions, shallow bedrock under surficial gravel, diminishing rock quality with depth, areas of unmapped thick overburden, and lateral geologic variation. Similar studies have shown that in most cases overestimation of the amount of recoverable aggregate is more likely (AES, 1999).

Threshold of Significant Resources

Because this study is an aid to land-use planning, we inventoried only those resources deemed significant to the long-term economic health of the region. Therefore, we restricted our investigation to those resources that exceed the following threshold criteria (see detailed description in Appendix B):

- The thickness of the sand and gravel or bedrock deposit must exceed 25 feet.
- The area of the deposit exposed at the surface must exceed 160 acres and have a minimum map distance of 1,500 feet or the reserves must exceed 13.9 million tons. Exceptions may include unusually thick deposits or resources of special local importance that have consistently yielded high-quality aggregate.
- The 'stripping ratio' (ratio of overburden to resource) must be less than one to three (1:3).
- The strength and durability of the rock must meet the Washington State Department of Transportation (WSDOT) minimum specifications for hot-mix asphalt-wearing course, a rock product used to construct asphalt roads (see pamphlet, Table 1).

In some markets, a lack of high-quality gravel and bedrock might force producers to mine lower quality deposits. Homes and infrastructure constructed with weak gravel or bedrock are likely to have shorter life cycles than those constructed with higher-quality aggregate. We have not inventoried these lower quality deposits because they do not meet the criteria of this study. However, the tabular data for this publication will serve as a guide to the locations of some resources of poor or uncertain quality and those that are buried below thick overburden layers that may become more attractive under future market conditions.

Scope of Deposits Inventoried

We have inventoried all deposits in the county that meet the threshold criteria, without consideration of environmental impacts or land-use conflicts that may be involved in permitting or extracting these resources. Therefore, maps of environmentally sensitive areas and land-use status are necessary to obtain a complete picture of available aggregate within the county. Those deposits that lie within Mount Rainier National Park and the Clearwater, Glacier View, and Norse Peak wilderness areas were not included in the inventory because they have federal protection that restricts commercial development. In addition, river flood plain (alluvial) deposits have historically been a major gravel resource, and numerous alluvial mines still operate along rivers in other regions of the state. In Pierce County, however, no mines currently operate in flood plains, and future mining operations will likely encounter difficulty obtaining permits because alluvial mining can cause adverse impacts to aquatic and riparian habitat (Norman and others, 1998).

GEOLOGY OF AGGREGATE RESOURCES IN PIERCE COUNTY

Numerous igneous intrusions, volcanic lava flows, and glacial processes resulted in remarkably large volumes of sand, gravel, and bedrock in Pierce County that have moderate to excellent characteristics for use in construction aggregate. Large gravel mines in the county were developed to supply aggregate to the metropolitan areas of the Puget Sound for use in portland cement concrete or asphaltic cement concrete. Small mines in the eastern part of the county were developed to serve the needs of the forest-production industry in the foothills and mountains of the Cascade Range. These small mines typically produce aggregate from the andesitic or basaltic volcanic rocks that are common in the mountainous areas. Development of intrusive igneous rocks, such as granodiorite, has the potential to yield enormous volumes of aggregate. However, because the cost of transport doubles for every 25 miles traveled (PLUSB, 2003), and these resources are generally in remote regions, they will likely remain uneconomic for some time.

AGGREGATE MINING AND SIGNIFICANT DEPOSITS

The maximum estimated volume of geologically available sand and gravel resource for Pierce County is approximately 12.6 billion tons for the indicated resource areas. This maximum estimate is calculated using rock quality from aggregate test data and interpolated thickness estimates from mines and wells (see pamphlet, Fig. 2), but does not take into account current land use or reserved/protected lands. Of the total 12.6 billion tons, only 1.61 billion tons of resources are permitted and available in Pierce County. This estimate represents an absolute maximum thatdoes not account for material loss due to slope or mine setback requirements, overburden, or volume of material removed since permitting. Assuming (1) a usage rate of 10.2 tons per capita calculated from PLUSB (2003) to account for the population density of Pierce County, and (2) projected population growth that uses the 2010 countywide population of 795,225 and projections until 2040 from the Office of Financial Management (2012), currently permitted sand and gravel resources will last only until 2125. The total resource life, however, is likely shorter for at least two main reasons: (1) an improving economy would likely mean an increase in per capita usage, and (2) a significant portion of the total resource may be unrecoverable for various permitting reasons or could be exported to nearby markets (as indicated by current practices).

As of 2014, there are 26 active (4,170 acres total) and 58 terminated or inactive mines (2,136 acres total) in Pierce County, in addition to 361 disturbed areas (2,720 acres total) indicative of large abandoned aggregate mines and pits. These disturbed areas represent mining locations that existed prior to the 1970 Surface Mine Act (Chapter 78.44 RCW) and are locations where small quantities of sand, gravel, and (or) rock have been removed for local use. The geologic units responsible for producing the largest amount of aggregate in Pierce County are recessional outwash (unit Qgo, 760 million tons), advance outwash (unit Qga, 470 million tons), and ice-contact (kame) deposits (units Qgic and Qgik, 229 million tons). Table 2 (see pamphlet) provides a breakdown of the number and size of mines per region and by geologic unit.

CONCLUSIONS

Pierce County has historically led the state as the largest producer of sand and gravel. This is largely owing to voluminous deposits of clean deltaic gravels found near Steilacoom and Dupont, though the deposit at Steilacoom is now exhausted and fully reclaimed. In central Pierce County, 8.6 billion tons of undeveloped resources exist where glacial processes have created a large outwash plain filled with channelized gravels. These deposits have limited potential, however, as urban development and restricted land use reduce their availability. Western Pierce County has limited aggregate availability (103 million tons) and most of these sand and gravel resources have already been identified and developed. Future development of ice-contact deposits on the Key Peninsula may prove feasible pending land availability and market demand. Eastern Pierce County has the potential for developing abundant sand and gravel resources (4 billion tons). While ice-contact deposits found in the eastern parts of the county are currently developed on a limited basis, increased market demand and depletion of outwash gravels in central Pierce County may make their development more favorable. Eastern Pierce County also has the potential to produce abundant crushed rock from bedrock quarries. The scale of these bedrock resources is difficult to estimate because detailed mapping does not exist in these areas and because many source areas may have been overlooked in our analysis. Available data, however, suggest that bedrock resources could be plentiful and the primary limitation to their development is mining technology and land-use practices. The development of these resources is expected to increase in the coming decades with eastward expansion of urban centers and increased market favorability due to depletion of currently permitted sand and gravel resources.

At the current yearly per capita usage of 10.2 tons and total permitted aggregate volume of 1.61 billion tons, Pierce County has a maximum of ~110 years of accessible aggregate. Factors that may shorten or lengthen the timeline for resource exhaustion include: changes in population growth, market flux and other economic drivers, additional permitting of aggregate resources for mining, and greater reliance on bedrock resources in east Pierce County.

ACKNOWLEDGMENTS

We would like to thank Garrett Webster and Steve Davis of WSDOT for providing aggregate test data and details on the specification and testing processes conducted at WSDOT Materials Testing Laboratory. Sue Kahle and Mark Savoca of the U.S. Geological Survey delivered additional water well data. Dave Lewis and Ryan Ranavaige of Miles Sand & Gravel and Ken Cook of Pierce County Long Range Planning provided technical review. DGER surface mine inspectors Carrie Gillum and Rian Skov gave insight on mining practices, cost assessments, and site-specific details. DGER surface mine inspector Shawn Lombardo contributed assistance in the field and additional on-site expertise with mining practices and resource designation.

REFERENCES CITED

Associated Earth Services, 1999, Prospect identification and preliminary classification, Snohomish County mineral resource study, Snohomish County, Washington: Associated Earth Sources, Inc., [under contract to] Huckell/Weinman Associates, Inc., 37 p., 2 plates.

Bolen, W. P., 2012, 2012 Minerals Yearbook: U.S. Geological Survey, 18 p. [http://minerals.usgs.gov/minerals/pubs/commodity/sand_&_gravel_construction/myb1-2012-sandc.pdf]

Norman, D. K., Cederholm, C. J.; Lingley, W. S., Jr., 1998, Flood plains, salmon habitat, and sand and gravel mining: Washington Geology, v. 26, no. 2/3, p. 3-20. [http://www.dnr.wa.gov/publications/ger_washington_geology_1998_v26_no2-3.pdf]

Office of Financial Management, 2012, County growth management population projections by age and sex: 2010–2040: State of Washington, 112 p. [http://www.ofm.wa.gov/pop/gma/projections12/GMA_2012_county_pop_projections.pdf]

Pacific Lutheran University School of Business, 2003, The aggregates industry in Washington—Economic impact and importance: Pacific Lutheran University School of Business, 26 p.

EXPLANATION

	Resource: Sand and gravel	Resource: Bedrock	Definition
INDICATED			Indicated resources are gravel or bedrock aggregate for which specific geologic evidence, limited sampling, and laboratory analysis provides confident estimation of distribution, grade, and quality. Indicated resources may include economic, marginally economic, and sub-economic components that reflect various degrees of geologic certainty. We map an indicated resource where available data appear to satisfy all of the elements of our threshold criteria (see pamphlet).
HYPOTHETICAL			Hypothetical resources are aggregate resources postulated to exist on the basis of general geologic information, aggregate test data, and production history. We map hypothetical resources where available data appear to satisfy most of the elements of our threshold criteria (see pamphlet).
SPECULATIVE			Speculative resources are aggregate resources for which there is sparse geologic and production information and where indeterminate or no aggregate testing exists. Nevertheless, existing geologic mapping and data suggest that these rock units may have the potential for meeting the threshold criteria established for this study and may possibly contain aggregate resources.

Large pit or mine (>20 acres)

- Mine in active operation with a current permit
- Mine that has been closed or reclaimed and the permit terminated or cancelled

Small pit or mine (<20 acres)

- Sand and gravel mine, active
- Sand and gravel mine, inactive
- Bedrock mine, active
- Bedrock mine, inactive

Aggregate test, WSDOT specifications for road course materials

- Pass
- Partial pass/incomplete
- Fail
- DNR 110 Samples collected and tested in this study

Subsurface borings

- Water or monitoring well
- Geotechnical boring

Public lands

- Joint Base Lewis–McChord
- Wilderness Areas (Glacier View, Clearwater, and Norse Peak)
- Mount Baker–Snoqualmie National Forest
- Mount Rainier National Park
- Other federal, state, county, and city public land