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Geologic Map of the Harts Lake 7.5-minute Quadrangle, Pierce and Thurston Counties, Washington

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Geologic Map of the Harts Lake 7.5-minute Quadrangle

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Lambert conformal conic projection
North American Datum of 1983
Base map from U.S. Geological Survey Harts Lake 7.5-minute quadrangle, 2020
Shaded relief generated from a lidar bare-earth digital elevation model (available from the Washington Geological Survey, https://lidarportal.dnr.wa.gov/)
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SCALE 1:24,000

1 MILE: 1 — 0.5 — 0
7,000 FEET: 1,000 — 0 — 1,000 — 2,000 — 3,000 — 4,000 — 5,000 — 6,000 — 7,000
1 KILOMETER: 1 — 0.5 — 0

contour interval 20 feet

15°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2023

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CROSS SECTION EXPLANATION

Qgo Qgic — Geologic units too thin to show as polygons at the scale of the cross section—vertical tics mark separate units.

W04 — Water well or boring

ABSTRACT

We present a geologic map of the Harts Lake quadrangle in Washington's southern Puget Lowland. We combine new geologic mapping, well log data, and geophysical modeling to better understand the glacial history, volcanic hazards, and local faulting in the map area. Quaternary glacial drift covers most of the map area, with a veneer of ablation till covering most of the glaciated and fluted surfaces. We interpret deposits along the Nisqually River and Tanwax Creek that were previously mapped as Miocene Mashel Formation (Walters, 1965) as younger Pleistocene lahars and alluvium from the Cascade Range. A review of cuttings and well logs from the E.F.E. Willhoite et al. No. 1 oil exploration well, drilled by the Humble Oil & Refining Company in 1961, helped inform the cross section and geophysical model for the quadrangle, providing new insight into the structure of the subsurface. Some water wells in the southeast portion of the map area produce water with arsenic concentrations above the Washington State Department of Health's recommendations for drinking water. We believe that the high concentration of arsenic in these wells may be related to the decay of organic material that was preserved by Pleistocene or older Pliocene–Miocene volcanic mudflow deposits.

LIST OF MAP UNITS

Holocene to Pleistocene Nonglacial Deposits

ml — **Modified land (Holocene)**—Varied amounts of locally derived soil, gravel, sand, silt, and clay; excavated and (or) redistributed to modify topography for agricultural and industrial developments, including but not limited to gravel pits, ponds, and canal infrastructure.

Qp — **Peat (Holocene to Pleistocene)**—Organic and organic-rich sediment, includes peat, gyttja, muck, silt, clay, and sand; typically deposited in kettles, areas between drumlins, abandoned drainages, or other poorly drained flat areas; mapped in areas where lidar reveals such landforms and where we interpret hydrophilic vegetation or wet conditions without trees based on aerial photos.

Qa — **Alluvium (Holocene to Pleistocene)**—Unconsolidated gravel, sand, silt, and peat in varied amounts; mapped in active river and stream channels and floodplains.

Qaf — **Alluvial fan (Holocene to Pleistocene)**—Varied amounts of pebble- to cobble-gravel and sand with minor silt; generally unconsolidated and poorly sorted; mapped where stream channels open up into unconfined topography and a characteristic fan-shaped morphology can be observed in lidar.

Qls — **Landslide deposits (Holocene to Pleistocene)**—Sand, silt, clay, pebbles, cobbles, and boulders, in varied amounts, derived from deposits upslope; mostly loose, unsorted, and jumbled; mapped from landforms expressed in lidar. We infer that unit Qls is post-glacial in age because glaciation would have destroyed many older Qls deposits within the map area. Absence of a mapped landslide does not indicate the absence of landslide hazard.

Qmw — **Mass-wasting deposits (Holocene to Pleistocene)**—Loose soil, gravel, sand, silt, and clay, all in varied amounts, deposited by shallow ravel and soil creep; locally includes colluvium, small landslides, and alluvial fans; thickness is poorly constrained but likely ~1–5 m based on estimates from lidar data; deposits lie along the base of steep slopes throughout the quadrangle; identified from lidar and shown where colluvium covers the underlying units. Unit Qmw is post-glacial in age.

Late Pleistocene Glacial and Interglacial Deposits

VASHON DRIFT

Qgo — **Recessional outwash, undivided (late Pleistocene)**—Pebble-gravel, less commonly cobble- and boulder-gravel, pebbly sand, or sand; light tan-brown to light gray-brown, or variegated with iron and silica cement; loose; well-rounded to subrounded; moderately sorted to well-sorted; gravel is clast supported but locally with a matrix of sand and silt and interbeds of silt and sand; otherwise massive. Observations of exposures in borrow pits suggest a thickness of 3–10 m is common. Mapped in gently sloping outwash channels and stratigraphically above other Vashon glacial deposits (unit Qgic) and older units (unit Qpc) that the outwash or subglacial meltwater cut into. We query unit Qgo where outwash deposits exist but do not appear to be within obvious outwash channels as seen in lidar. Sometimes used for aggregate. The unit is locally subdivided into:

Qgog — **Recessional outwash gravel (late Pleistocene)**—Cobble- to pebble-gravel with minor sand and (or) silt; tan to light brown; loose; subrounded; moderately sorted; found in outwash channels in the northern and central portions of the map; a patchy silica coating on some clasts marks where the clasts were in contact.

Qgos — **Recessional outwash sand (late Pleistocene)**—Sand with minor silt and rare pebble-gravel; sand is mostly fine- to medium-grained quartz and lithics; tan to brown; generally loose; angular to subangular; moderately to well-sorted; found in the northwest corner of the map area; deposited on top of unit Qgic; unit Qgos is observed in areas with flat or subdued topography and in low-lying areas between fluted deposits of unit Qgic.

Qge — **Eskers (late Pleistocene)**—Sandy pebble- to cobble-gravel and diamicton; tan to light brown; clasts are subangular to rounded; moderately sorted; mapped where narrow, sinuous ridges are visible in lidar imagery; usually found adjacent to, or on top of, deposits of unit Qgic. Deposited by meltwater in subglacial or englacial channels as the ice sheet stagnated and melted (Benn and Evans, 1998). Sometimes used for aggregate.

Qgic — **Ice contact deposits (late Pleistocene)**—Undivided stagnant ice deposits, consisting of ablation till, kame deposits, subglacial outwash, and rare lodgment till; primarily loose to compact silty diamicton, with minor sandy pebble- to cobble-gravels; color is generally light gray to light brown-gray; grain size in the diamicton ranges from silt to boulder; clasts are generally subrounded; typically a chaotic mixture of variably sorted and bedded sediment and diamict; forms a veneer up to 10–15 m thick; clast lithology is diverse and includes rare metamorphics and granitoids, which suggest a northern provenance.

Qgt? — **Lodgment till (late Pleistocene)**—Diamicton containing boulders, cobbles, sand, and an unsorted or poorly sorted matrix of sand- to clay-sized particles, all in varied amounts; clast lithology is diverse and contains rare, northern-sourced metamorphic and granitoid clasts; thickness is unknown, but likely less than a meter or two based on observations of till-like diamiction observed within the quadrangle; found in the northwestern corner and southern edge of the map area.

UNDIFFERENTIATED GLACIAL AND INTERGLACIAL SEDIMENTS

Qguc — **Pre-Vashon glacial and nonglacial undifferentiated sediment (Pleistocene) (cross section only)**—Undivided sediment consisting of diamicton, till, clay, silt, sand, pebble–cobble–gravel, and occasional wood; interbedded with thick layers of orange, brown, and blue clay and silty/sandy clay; hard or dense. We interpret unit Qguc as a combination of glacial and non-glacial sediment, including dense, clayey, pre-Vashon alluvium and lahars (unit Qpc).

Qps — **Pre-Vashon sandy deposits (Pleistocene)**—Sand with rare pebbles; tan to gray; loose; moderately sorted fine to medium sand with minor silt; angular to subangular sand and subrounded pebbles; beds appear massive in isolated exposures; sand is quartz-rich and pebbles are compositionally diverse, including rare metamorphic clasts that we interpret as having been transported from the North Cascades or British Columbia by the Puget Lobe ice sheet; approximately 7 to 10 m thick; found in the northeastern portion of the map area.

PRE-VASHON SEDIMENT

Qpc — **Pre-Vashon alluvium and lahars from the Cascade Range, undivided (late Pleistocene)**—Boulder- to pebble-gravel, diamicton, sand, silt, and clay; most clasts are andesite from the Cascade Range; variably colored, including pale-gray, light-brown, yellow-brown, and blue-gray; compact; sand primarily plagioclase, andesite lithics, and glassy volcanic fragments that alter to clay; unsorted to well sorted; at least 60 m thick; best exposed along the Nisqually River and Tanwax Creek. Unit Qpc may contribute to high arsenic concentrations in groundwater, see discussion in accompanying pamphlet.

Tertiary Bedrock Units

RMc — **Continental sediment (Pliocene to Miocene?) (cross section only)**—Interbedded clay, silt, sand, medium-coarse gravel, and peat; sand and gravel contain primarily Cascade-sourced volcanic clasts and grains, including ash, pumice, and andesite. Cuttings of unit RMc from the Willhoite well resemble the Mashel Formation type section exposed ~4 km southeast of the map area, but clarity on their stratigraphic relationship awaits additional geochronologic analysis.

ΦEn — **Nearshore sedimentary rocks (Oligocene to late Eocene) (cross section only)**—Tuffaceous, silty, and sandy claystone with minor subangular volcanic and siliceous pebbles; described as "greenish-gray" in the Willhoite well log and appears light tan to buff in the well cuttings; approximately 160 m thick based on descriptions in the well log.

Ev_n — **Volcanic and volcaniclastic rocks, undivided (late to middle Eocene) (cross section only)**—Reported as interbedded basalt and volcaniclastic sedimentary rock in the E.F.E Willhoite et al. No. 1 oil well log. Basalt is brown, black, red, gray, purplish, and greenish in color, and is porphyritic to aphanitic, locally with vesicles. Volcaniclastic sedimentary rock consists of lithic tuff and crystal-rich claystone, siltstone, and minor sandstone. Based on geophysical modeling (Fig. M1B), we interpret these volcanic rocks as part of the Northcraft Formation of Snavely and others (1951), which is exposed farther south in the uplands of the Bald Hill quadrangle (Polenz and others, 2022, 2023).

CORRELATION OF MAP UNITS

PERIODS AND EPOCHS BASED ON USGS FACT SHEET 2010-3059

GEOLOGIC SYMBOLS

Contact—Solid where location accurate; long-dashed where approximate; short-dashed where inferred

Qpc — Geologic unit too thin to show as a polygon—Location inferred; identity and existence certain; see Qpc unit description

A — A' Cross section line

Perennial stream

Intermittent stream

GD2 Age site, ^{14}C, carbon-14

GD1 Age site, infrared-stimulated luminescence

W2 Water well

W10 Drill hole for hydrocarbon exploration or exploitation

Open pit, quarry, or glory hole

TS26 Thin section sample

	ρ	χ	Magnetic Remanence Mr	Magnetic Remanence Incl	Magnetic Remanence Decl
Undifferentiated Pliocene and younger sediments	1,920–2,210	0–6	0	---	---
Andesitic flow or intrusion	2,530	20–25	2–2.9	68	15
Volcaniclastic, andesite, and sedimentary interbedded mix	2,295	25	0	---	---
Eocene basin sediments	2,600	4	0	---	---
Crescent Formation basalt	2,880	52	0	---	---

Figure M1A. Combined isostatic gravity and aeromagnetic map (reduced-to-pole filtered), and lidar bare earth hillshade. Gravity contours are 1 mGal. Newly collected gravity stations are gray dots. Older compiled gravity datasets are white circles. Relative size of the gravity max spots is proportional to the magnitude of the gravity gradient in that location. X–X' shows the geophysical model location and coincides with the geologic cross section A–A'.

Figure M1B. Two-dimensional potential-fields forward model along profile X–X'. Units and properties shown in the table predict gravitational and magnetic anomalies shown in the top two panels (ρ–saturated bulk density in kg/m3; χ–magnetic susceptibility in SI×10^3)(Data Supplement; Telford and others, 1976; WGS unpublished records). 'Flight line' shows the elevation of the airplane that flew the aeromagnetic survey. Table shows geophysical properties used in the modeling process. Density (ρ) has units of kg/m³. Magnetic susceptibilities (χ) are in SI units multiplied by 10^3. Magnetic remanence values (Mr) are in ampere/meter. Inclination (Incl) and declination (Decl) are in units of degrees.