

**INTRODUCTION**

The McNeil Island quadrangle is located at the south end of Puget Sound. The quadrangle includes McNeil, Anderson, and Keron Islands and parts of Fort Stevens, Kinnear, and Fort Lewis Military Reservations. All of the landmass in the quadrangle falls within Pierce County. The quadrangle is rural residential and agricultural land.

**GEOLOGIC HISTORY**

Late Wisconsinan-age Vashon Drift covers most of the quadrangle. Pre-Vashon units are generally exposed only along coastal or river bluffs, where mass wasting is common. Landslides and colluvium disrupt and obscure the continuity of exposures so that pre-Vashon geologic history is not easily deciphered. In the Puget Lowland south of Tacoma, all fine-grained sediments reported before 1966 are suspect due to laboratory contamination (Fairhall and others, 1966, p. 501). Stratigraphic assignments based on these radiocarbon ages are now questionable and should be re-evaluated. We have systematically sampled dated material from non-glacial sediments subject to the Vashon Drift and found them to be older than previously reported. With a few exceptions, these sediments have been beyond the range of radiocarbon dating. The antiquity of the pre-Vashon units causes radiocarbon dates to be of little help for making correlations, and abrupt facies changes within glacial and nonglacial units also render correlations uncertain. Despite these difficulties, we have developed a conceptual model for the more recent pre-Vashon geologic history that is consistent with our observations but by no means compelling. The oxygen-isotope stage 6 glaciation, called the Double Bluff Glaciation in northern Puget Sound, was probably as extensive as the stage 2 or Vashon Stage of the Fraser Glaciation (MS, 1987, Fig. 1). The end moraines of this glaciation lie on the coast beyond the inferred limit of the Vashon ice in the vicinity of Tenino, south of this quadrangle (Le 1994). Subsequent erosion was probably similar to the erosion that Booth (1994) documented beneath Vashon ice and would have left accommodation space for deposition during the interglacial time of oxygen-isotope stage 5.

The oxygen-isotope stage 4 glaciation, called the Possession Glaciation in northern Puget Sound, was mild relative to stages 2 and 6 (MS, 1987, and Fig. 1). Because the Vashon and Double Bluff Drifts respectively in the Puget Lowland, the Possession ice sheet probably did not extend far south of Seattle (Lea, 1984; Troost, 1999). Because the Vashon and Double Bluff Drifts respectively in the Puget Lowland, the Possession ice sheet probably did not extend far south of Seattle (Lea, 1984; Troost, 1999). Because the Vashon and Double Bluff Drifts respectively in the Puget Lowland, the Possession ice sheet probably did not extend far south of Seattle (Lea, 1984; Troost, 1999).

**PLEISTOCENE GLACIAL DEPOSITS**  
**Deposits of Continental Glaciers—Corridorian Ice Sheet**  
 Vashon Stage of the Fraser Glaciation  
 Glacial sediments described in this section consist mostly of rock types of northern provenance, most from the Canadian Coast Range. A wide variety of metamorphic and intrusive igneous rocks not indigenous to the Puget Lowland and generally southerly directed current indicators help distinguish these materials from the volcanic-rich sediments of the eastern Puget Lowland and the Crescent Basins and Olympic core-rich sediments of the western Puget Lowland.

**Latest Vashon fine-grained sediments—Lacustrine clay and (or) fine sandy silt with sparse, disseminated dropstones, laminated and commonly vertically jointed, medium gray where fresh to pale yellow where oxidized, distinguished by relatively darker chocolate brown in oxidized exposures) horizontal bands about 1 in. thick that may represent annual winter depositional layers in a varve sequence; no more than about 20 appear varves were counted in any exposure, suggesting a short life for the glacial lake) in which unit Q<sub>gl</sub> was deposited; present in deposits up to 10 ft thick over much of southern Puget Lowland and most common at elevations below about 140 ft; mapped where it is thought to be at least about 5 ft thick or where it masks the underlying geomorphology; includes deposits of glacial Lake Russell and other lakes of the Vashon glacial recession.**

**Vashon recessional outwash gravel (Sitelocum Gravel)—Pebble to boulder gravel exposed in the southwest corner of the quadrangle. At Dypunt, the gravel is about 200 ft thick with large forests that dip west-northwest toward Puget Sound, forming the Squilachev Delta of Bretz (1913), who interpreted it as discharge from glacial Lake Pysyall.**

**Vashon recessional outwash gravel (Sitelocum Gravel)—Recessional and proglacial, moderately to well-sorted, poorly to moderately sorted outwash sand and gravel of northern or mixed northern origin; commonly laminated orange with iron-oxide staining; moderately to poorly sorted, commonly cross bedded but may lack primary sedimentary structures; inferred to be of glacial origin because interglacial conditions do not appear conducive to streams with sufficient competency to deposit widespread gravels in most of the Puget Lowland, and because the majority of the exposures include northern-source clasts.**

**Pre-Vashon till—Gray, unsorted, unstratified, highly compacted mixture of clay, silt, sand, and gravel of nonglacial source; clasts have no warring rinds, occur at Sandy Point on Anderson Island where it overlies with apparent conformity by unit Q<sub>gl</sub>; other exposures of possible pre-Vashon till occur at mid-slope on Dickinson Point and in Hennessey inlet near Shelton, both west of this quadrangle.**

**Pre-Vashon sediments, undifferentiated—Glacial and nonglacial sediments beneath Vashon Drift that are not separable at this map scale; may include some Vashon advance outwash.**

**PREVIOUS GEOLOGIC MAPPING**  
 The glacial history and geology of south Puget Sound are summarized by Bretz (1913), who mapped the entire Puget Sound basin in reconnaissance. Noble and Wallace (1960) and Walters and Kimmel (1968) produced small-scale water resources studies. The Coastal Zone Atlas (Washington Department of Ecology, 1979) provides mapping of a 200-ft wide strip along the shoreline at a scale of 1:24,000. Walsh (1987), Walsh and others (1987), and Palmer and others (1999a) compiled and augmented previous mapping.

**MAPPING METHODS**  
 For the present map, we inspected available construction site excavations, gravel pits, and roadcuts. We also inspected the shorelines by boat and took samples and measured sections at cliff exposures. Contacts between map units are commonly not exposed and are only approximately located on this map. They are generally located by stereo mapping, air photo and Light Detection and Ranging (LIDAR) interpretation, and interpretations of water well logs from Washington Department of Ecology. Geotechnical borings provided data on McNeil Island, U.S. Department of Agriculture soil maps (Pringle, 1990; Zulauf, 1979) helped guide the location of peats and the contacts between sandy and gravelly units. Location accuracy of contacts is judged to be about 200 ft in general. In addition, the contacts between some units are gradational. We have tried to consider geotechnical significance in mapping geologic units and have attempted to show units only where they are thicker than 5 to 10 ft or mask the underlying hydrology. Water wells are located only to within a 40-acre area on the well logs and are shown at the center of that area on the map. They are projected onto the cross section at locations having the same surface elevations as stated in the logs.

**CONTOUR INTERVAL 20 FEET**  
 Contact—Approximately located  
 Anticline—Dotted where concealed; queried where uncertain  
 Water well

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**DESCRIPTION OF MAP UNITS**

**Quaternary Unconsolidated Deposits**

**Holocene Nonglacial Deposits**

**Q<sub>gl</sub> Fill—**Clay, silt, sand, gravel, organic matter, shells, rip-rap, and debris deposited to elevate the land surface and reshape surface morphology; includes engineered and non-engineered fills shown only where fill placement is relatively extensive, sufficiently thick to be of geotechnical significance, and readily verifiable.

**Q<sub>ml</sub> Modified fill—**Silt, sediment, or other geologic material that has been locally reworked to modify the topography by excavation and (or) redistribution.

**Q<sub>al</sub> Alluvium—**Silt, sand, gravel, and peat deposited in stream beds and outcrops; includes some lacustrine and beach deposits.

**Q<sub>b</sub> Beach deposits—**Mud, sand, and gravel deposited in the intertidal zone, or residual gravel on a wave-cut platform.

**Q<sub>o</sub> Peat—**Organic and organic-matter-rich mineral sediments deposited in closed depressions; includes peat, musk, silt, and clay in and adjacent to wetlands.

**Q<sub>ls</sub> Landslide deposits—**Rock, soil, and organic matter deposited by mass wasting; depending on degree of activity, location within the slide mass, type of slide, geochemistry, and competence of materials, may be unstratified, broken, chaotic, and poorly sorted or may retain primary bedding structure; may be on or near primary bedding structure; may be on or near primary bedding structure; may be on or near primary bedding structure.

**Vashon till—**Unsorted and highly compacted mixture of clay, silt, sand, and gravel deposited directly by glacier ice; gray where fresh and light yellowish brown where oxidized; very low permeability; most commonly matrix-supported but may be clast-supported; matrix generally feels more gritty than outwash sands when rubbed between fingers, due to being more angular than water-worked sediments; cobbles and boulders commonly faceted and (or) striated; range in thickness from wispy, discontinuous layers less than 1 in. thick to more than 30 ft thick; thickness of 2 to 10 ft are most common; till may include outwash sand, silt, and gravel, or alluvial till that is too thin to substantially mask the underlying, rolling till plain; erratic boulders are commonly associated with till; peats may also occur as lag deposits where the underlying deposits have been modified by meltwater; typically, weakly developed modern soil has formed on the cap of loose gravel, but the underlying till is unweathered; local textural features in the till include flow banding and apertures extending 10 to 15 ft downward into underlying sand and gravel (or till) and that are oriented transverse to ice flow direction.

**Vashon advance outwash—**Sand and gravel and lacustrine clay, silt, and sand of northern source, deposited during glacial advance; contains some nonglacial sediments, such as cobbles and rip-rap of silt or peat as lag along channel sides and bottoms; gray where fresh, light yellowish gray where stained; sands (unit Q<sub>ga</sub>) locally 100 ft thick, well sorted, fine grained with lenses of coarse sand and gravel, generally permeable and porous with low cohesivity relative to overlying and underlying sediments, and subject to deep-seated landsliding.

**PLEISTOCENE DEPOSITS OLDER THAN VASHON DRIFT**

**Pre-Vashon glaciolacustrine deposits—**Parallel-laminated clay and (or) fine sand with rare dropstones; medium gray where fresh to light tan where dry and oxidized to olive tan where moist and oxidized; very low permeability and porous; cause this unit to readily pre-advance till; soil-development information common; locally exceeds 10 ft in thickness; organic matter rare; interpreted to have been deposited in a rich in organic matter. Rock supports and falls that are tall and shallow, loose, permeable soils that are rich in organic matter. Rock supports and falls that are tall and shallow, loose, permeable soils that are rich in organic matter.

**Pre-Vashon sandy deposits—**Thin to thick-bedded to cross-bedded sand interbedded with laminated silt and minor peat, diatomite, and gravel; commonly in upward-fining sequences dominated by varied Cascade-source volcanoclastic rock types; older than Vashon Drift and generally overlying or interbedded with unit Q<sub>gl</sub>; interpreted as proglacial, but may include glacial-stage deposits, particularly from oxygen-isotope stage 4.

**These sediments have previously been referred to the Kinnear Formation, and were interpreted to have been deposited during the Olympia nonglacial interval (Gardner and others, 1965; Decker (1979), however, was previously estimated to be approximately 14,000 radiocarbon yr B.P. based on apparent post-glacial deposits in the central Puget Lowland that were radiocarbon dated at about 13,600 radiocarbon yr B.P. (Porter and Swanson, 1998). However, five more-recently obtained radiocarbon dates from deposits that directly underlie Vashon till in the southern Puget Lowland indicate a maximum ice advance about 13,400 radiocarbon years B.P. (Borden and Troost, 2001, and this study), which leaves only about 200 years for the glacial advance into and recession from the southern Puget Lowland. We have therefore reinterpreted the Kinnear Formation as a glacial deposit, and we follow his suggestion that the name be abandoned.**

**Borden and Troost (2001) reported a radiocarbon age of 41,300±1940 yr B.P. from Solo Point near the southeast corner of the quadrangle, and Walsh and others (2003a) have reported nine radiocarbon ages in the Nisqually quadrangle immediately to the southeast. All ages we have obtained on this quadrangle, however, are radiocarbon infinite (Table 2).**

**At the south end of Keron Island, a highly concentrated, sand-strewn outwash terrace appears to have been deposited during oxygen-isotope stage 7 (T. W. Sisson, U.S. Geological Survey, written communication, 2001; Logan and others, 2002). This sand appears to be part of unit Q<sub>ps</sub>, which continues around the east side of Keron Island where it intertongues with unit Q<sub>gl</sub>. Another highly concentrated terrace is exposed near the southern tip of Anderson Island at Thompson Cove and the west shore of Nisqually Reach on the adjacent Lacey quadrangle to the southwest (Logan and others, 2003). Trace amounts of chemically similar terraces have also been found in sands exposed along Totten Inlet, west of this quadrangle. The age of this terrace is uncertain but may be as old as 100 to 200 ka (A. M. Sama-Wojcicki, U. S. Geological Survey, written communication, 2003).**

**Sediments mapped as unit Q<sub>ps</sub> apparently were deposited during oxygen-isotope stages 3, 5, and 7 (Walsh and others, 2003b), that is, during the Olympia interglacial and much older nonglacial intervals. Because we can establish that not all pre-Vashon nonglacial sediments are correlative, we have chosen not to assign them a stratigraphic name.**

**Pre-Vashon gravel—**Gravel and sand of northern provenance; stratigraphically underlies the Vashon Drift; most commonly exposed underneath unit Q<sub>gl</sub>; gravelly portions are relatively resistant to erosion; commonly laminated orange with iron-oxide staining; moderately to poorly sorted, commonly cross bedded but may lack primary sedimentary structures; inferred to be of glacial origin because interglacial conditions do not appear conducive to streams with sufficient competency to deposit widespread gravels in most of the Puget Lowland, and because the majority of the exposures include northern-source clasts.

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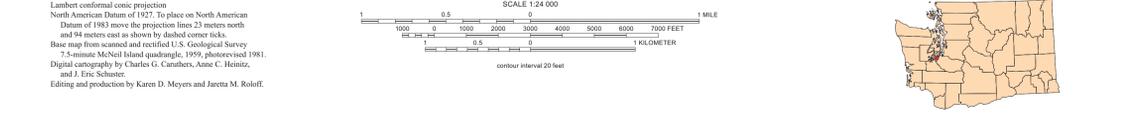
**Pre-Vashon sediments, undifferentiated—**Glacial and nonglacial sediments beneath Vashon Drift that are not separable at this map scale; may include some Vashon advance outwash.

**ACKNOWLEDGMENTS**

Support for identification of tephra was provided by Franklin F. Folt, Jr. (Wash. State Univ.) and Andrei M. Sama-Wojcicki and Thomas W. Sisson (U.S. Geological Survey). We have also benefited greatly from discussions with Derek Booth and Kathy Troost (Univ. of Wash.), Ray Wells and Brian Sherrod (U.S. Geological Survey), and Christine Neumiller (Wash. Dept. of Ecology). This map is supported by the National Geologic Mapping Program under Cooperative Agreement No. 99HQAC0033 with the U.S. Geological Survey. New radiocarbon ages (Table 1) were provided by Beta Analytic, Inc.

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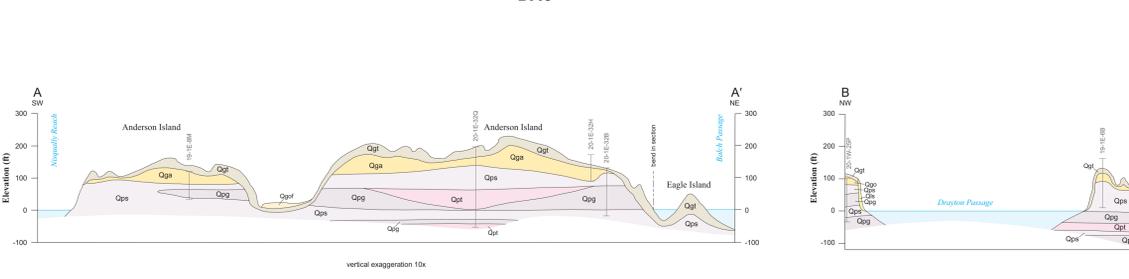
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# Geologic Map of the McNeil Island 7.5-minute Quadrangle, Pierce and Thurston Counties, Washington

by Timothy J. Walsh, Robert L. Logan, and Michael Polenz

2003



Vertical exaggeration 10x. Scale 1:24,000. Contour interval 20 feet. North arrow. Location map of Washington state.