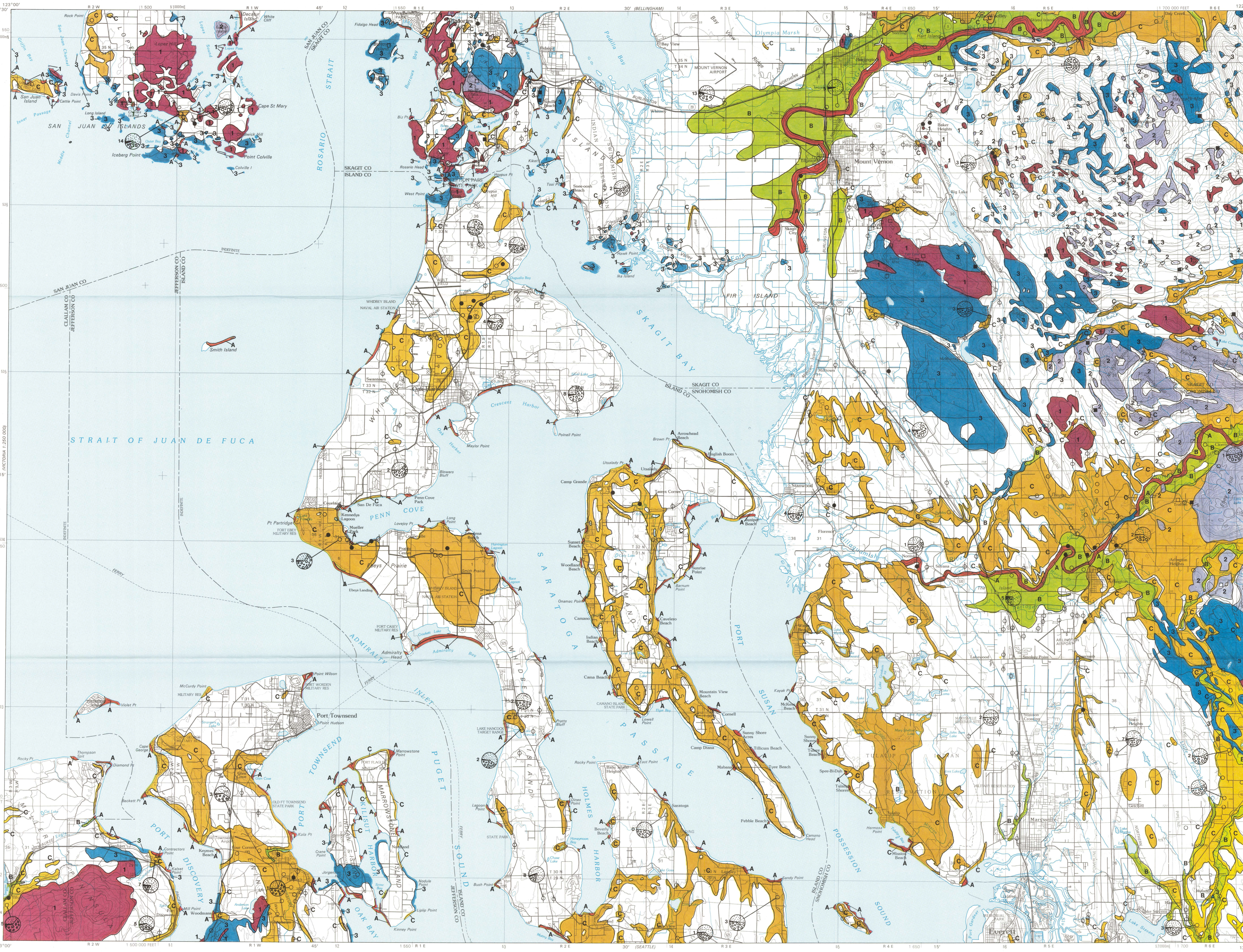
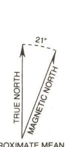
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY



Base from U.S. Geological Survey, 1973



SCALE 1:100 000

CONTOUR INTERVAL 50 METERS
WITH SUPPLEMENTARY CONTOURS AT 25-METER INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

Data compiled in 1981

INTRODUCTION

Sand, gravel, and quarry rock are nonmetallic mineral resources essential for most construction. With increases in population during the past several decades, demand for these resources has grown dramatically in western Washington. Bulk mineral resources such as sand, gravel, and quarry rock have a low unit value and are usually mined as close as possible to the area of use; trucking these materials more than 6 to 9 miles (10 to 15 km) is generally uneconomic. Potential sources of sand, gravel, and quarry rock are limited and are fixed by geologic, economics, and local zoning. These resources are generally nonrenewable, and may be depleted by exploitation, covered by urban construction, or foreclosed by restrictive zoning. As a result, the availability and cost of these raw materials have become important considerations in the formulation of zoning laws, county plans, and other land-use regulations.

Nonmetallic mineral production from Washington gravel pits and rock quarries had an estimated value in 1979 of $83 million and accounted for more than one-third of the total mineral production in the State (Washington Department of Natural Resources, Division of Geology and Earth Resources, written commun., 1980). Most pits and quarries are located near the urban areas of western Washington. The 1979 Directory of Washington Mining Operations (McFarland and others, 1980) list 27 active gravel pits and 5 active rock quarries in the Port Townsend map area alone. These actively used pits and quarries, as well as reclaimed (graded and revegetated) pits and quarries, are shown on the map. Detailed information about individual pits and quarries, and about Washington mining operations in general, can be obtained from the Department of Natural Resources, Division of Geology and Earth Resources, Olympia, Washington 98503, or from the U.S. Bureau of Mines, Spokane, Washington 99207.

This map is one of a series being prepared for the Port Townsend 1:100,000-scale quadrangle by the U.S. Geological Survey. These maps are intended to provide earth-science information for land-use planning, resource development, and environmental protection. This resource map has been prepared to assist planners in careful consideration of mineral resources—dominated in this region by sand, gravel, and quarry rock—as significant factors in comprehensive land-use planning. Availability of mineral resources in the Port Townsend quadrangle and the potential for environmental disruption caused by extraction and transport of these resources are discussed below.

GEOLOGIC HISTORY

Surficial deposits of sand and gravel in the map area were laid down in the last 20,000 years by glacial and river activity, whereas most bedrock (potential quarry rock) is volcanic and metamorphic rock that formed from tens to hundreds of millions of years ago. A brief review of the geologic history in the map area over the past 20,000 years explains the origin, distribution, and thickness, and character of the sand and gravel resources that dominate mineral production in the Port Townsend area.

About 20,000 years ago, a thick continental glacier advanced into northwestern Washington from British Columbia. Meltwater streams originating from the glacier built extensive sand and gravel deposits in front of the glacier as it advanced. Later the glacier passed over the area covered by this map (about 15,000 years ago), depositing a layer of till over the sand and gravel deposits. Till, commonly called "hardpan" or "boulder-clay," is a nonsorted, nonlayered, compact mixture of silt, sand, pebbles, and boulders. Because the material was compressed by the weight of ice more than 4,000 feet (1.2 km) thick and because it contains abundant fine particles as well as stones, some till resembles concrete in appearance and resistance. As the glacier front melted back from the map area (about 14,000 years ago), meltwater rivers distributed sand and gravel on top of the till, depositing thin sheets in upland areas and thicker fills in major river valleys. During the last 10,000 years, rivers such as the Skagit, Stillaguamish, and Snohomish eroded channels through these fills, constructed broad flood plains of alluvial materials, and built deltas into Puget Sound. Smaller streams constructed flood plains in tributary valleys and formed alluvial fans on flat valley floors. Concurrent coastal erosion and deposition produced extensive beach deposits along much of the northern Puget Sound area. Erosion and deposition of river channel and beach deposits continue today. With the exception of till, all of these deposits are potential sources of sand and gravel. Figure 1 shows generalized relations among the surficial deposits and between the surficial units and bedrock.

RESOURCE CHARACTERISTICS

The map shows the areal extent of surficial deposits and bedrock units that are potential sources of coarse aggregate and quarry rock. The location of active and inactive pits and quarries, combined with the mapped extent of the resources, provides a general indication of where future mining may occur, subject to such constraints as (1) economics of transporting the material, (2) zoning, ownership, and environmental restrictions, and (3) expansion of urban and suburban areas.

SAND AND GRAVEL

Table 1 lists generalized characteristics that are important in evaluating the economic potential of the sand and gravel deposits. The thickness of the deposit, the grain size of the material, the sorting or size-grading of the deposit, the continuity of the layering, and the percentage of undesirable rock types (schist, serpentinite, talc, and fine-grained rocks such as shale) are included. Because the percentage of fine material, reflected in both the texture and sorting of a deposit, is one of the most important factors, representative analyses (Washington Department of Transportation, written commun., 1980) for 36 deposits are shown on the map. High percentages of silt and clay generally make mining difficult and require washing of the resource material. Even though the available analyses suggest that only minor amounts of silt and clay are present, the information in table 1 and descriptions of individual deposits given by Pessl and others (unpublished data) indicate that lenses of silt are common in some of the alluvial and glacial deposits. Such lenses were apparently not included in samples from the 36 deposits but are common in active gravel pits in the Port Townsend area.

Some pit operators remove the overburden of till (see fig. 1) in order to mine thick deposits of underlying sand and gravel. Within the map area, most of these operations are located on steep valley walls where the sand and gravel were initially exposed on a free face and where till overburden was discovered as the pit expanded. Most small mining operations apparently become uneconomic where the ratio of gravel thickness to overburden thickness is less than 3:1 or 4:1, or where till is more than 15 feet (5 m) thick. However, a number of economically successful large operations commonly remove 35 feet (11 m) of till to reach thick deposits of well-sorted sand and gravel. The potential value of sand and gravel resources that lie beneath till can be assessed only if the thickness of the till is determined for individual deposits and if the quality of the underlying material is known.

QUARRY ROCK

Quarries in bedrock are an important source of rock aggregate and are the only local source of large rock used for riprap and landscaping. Large exposures of dense volcanic or metamorphic rock are rare in the map area, and these bedrock types are commonly concealed beneath thick overburden. Extensive exposures of sheared metamorphic rock and clay-rich sedimentary rocks are common in the area, but their usefulness is limited. Rock types such as schist and shale can be used for general land fill, but not for road gravel because they rapidly break down to fine particles. The fine particles absorb water and produce a road surface that is slippery and easily eroded. Many of the rock types in the east, northeast, and northwest parts of the map area occur naturally as sheared and crushed mixtures of resistant and much less resistant rock types. Mixing occurs on a scale such that blocks of resistant rock within the mixture form knobs thousands to hundreds of thousands of square feet in area and are surrounded by low-value rock types. The location of these resistant rock knobs cannot be illustrated at this map scale. They occur within more extensive metamorphic units and are the sites for several of the most productive rock quarries in the area.

For this map, the bedrock units of the Port Townsend quadrangle have been grouped, on the basis of resource potential, into three generalized types. Table 2 lists selected characteristics of the three bedrock types and possible uses of each. Not included in the table is overburden thickness; this important consideration must be evaluated for specific sites. Depth to the water table, an important consideration elsewhere, does not usually pose problems for rock quarries in the northern Puget lowland because most operations are located on free faces.

RESOURCE EXTRACTION AND PLANNING

Planners and resource managers in the Port Townsend area face the problem of achieving a reasonable balance between availability of essential minerals and the constraints that mineral development places upon other land (and water) uses. Sources of sand, gravel, and quarry rock must be located near urbanizing areas where construction is active and within acceptable haul-rate zones. Environmental concerns, including air and water quality, noise, heavy truck traffic, reclamation, esthetics, and zoning practices related to urban land-use patterns pose serious problems for planners charged with resource management. These problems, discussed in detail in a report by the U.S. Department of the Interior (1967) and summarized in Crosby, Hansen, and Pendleton (1978), are noted briefly here.

Availability of water and degradation of water quality are causes for concern where sand and gravel deposits are washed during processing, where mining occurs near active river channels or on beaches, and where mining extends into ground-water bodies. Water required for washing may deplete local water supplies, and serious turbidity problems may result from washing or mining of channel or beach deposits, although turbidity can commonly be minimized or eliminated by means of retention and settling ponds. In addition to producing undesirable sediment in the receiving waters, mining of channel and beach deposits can change the location and shape of local channels and thereby harm salmonoid fish. Offshore mining of gravel deposits would also likely produce high levels of turbidity and changes in sediment-transport patterns, but there are no offshore operations in the Port Townsend area at present.

Extraction and transport of rock materials commonly cause noise and dust, particularly where a rock crusher is used. The noise and dust from trucks and heavy machinery are common to all mining operations, whereas drilling and blasting are usually associated only with rock quarries. Ahearn (1964) has described a variety of methods for suppressing dust and noise. Among these are careful screening of pits and quarries, using vegetation and local topography, which can help reduce noise and visual impacts during and after exploitation.

Reclamation of exhausted gravel pits and revegetation of the regraded pit walls are generally successful in western Washington. The moist, temperate climate aids in rapid revegetation; even slopes composed of gravel normally become covered with alder seedlings within 10 years. Grading and revegetation of rock quarries are more difficult, particularly where the original working face was more than 65 feet (20 m) high. In some rock quarries, however, artificial terracing of the final face and screening with vegetation have been used successfully. Most pits reclaimed under provisions of the 1970 Surface Mining Land Reclamation Act are not the eyesores that many people associate with mining. In fact, reclaimed pits in this region can be difficult to locate because of dense vegetation covering them.

Regulation of air quality, water quality, and noise from mining operations is prescribed by Federal, State, and (in some cases) county and municipal laws. Two State agencies—the Department of Natural Resources (Division of Geology and Earth Resources), and the Department of Ecology—are responsible for issuing permits and for enforcement of State environmental regulations. County and municipal officials devise zoning laws and land-use plans that ultimately affect the use of mineral resources. Some resource lands in urbanizing areas may be protected for sequential use; for example, extracting the resource, regrading and revegetating the land, and then rezoning it for open-space, residential, or commercial use. Lands containing unmined sand and gravel may also be preserved for the future as "greenbelts" in urban zones and later converted to parks after mining and reclamation. Some exhausted gravel pits may be beneficially converted into recreational lakes, waste-disposal sites, or ground-water recharge zones. An adequate understanding of local geologic and hydrologic conditions in the affected areas is an essential foundation for effective planning and wise management of mineral lands before, during, and after resource exploitation.

REFERENCES CITED

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EXPLANATION

Surficial deposits of sand and gravel

- A — Beach deposits and alluvial deposits along active channel of Skagit and Stillaguamish Rivers
- B — Flood plain alluvium composed of sand and coarser material
- C — Glacial sand and gravel, older alluvium preserved as terraces along river valleys, and alluvial-fan deposits in upland areas

Exposures of potential quarry rock

- 1 — Tough, massive, resistant igneous and metamorphic rock
- 2 — Mixed rock types including zones of tough massive rock and areas of highly sheared rock that cannot be separated at this map scale
- 3 — Extensively fractured or clay-rich metamorphic and sedimentary rock

Contact

Gravel pit active in 1979 (McFarland and others, 1980)

Gravel pit with overburden, active in 1979 (McFarland and others, 1980)

Inactive or reclaimed gravel pit (Schuster, 1973; U.S. Bureau of Mines, written commun., 1977)

Inactive or reclaimed gravel pit with overburden (Schuster, 1973; U.S. Bureau of Mines, written commun., 1977)

Rock quarry active in 1979 (McFarland and others, 1980)

Inactive or reclaimed rock quarry (Schuster, 1973; U.S. Bureau of Mines, written commun., 1977)

Relative amounts (by weight) of gravel (g), sand (s), and fine (f) material (fine sand, silt, and clay) in sample collected and analyzed by the Washington Department of Highways (written commun., 1980). Number indicates percentage of fine material

Table 1. *Characteristics of sand and gravel deposits*

Type of deposit	Beach and river-channel deposits	Flood plain alluvium	Glacial sand and gravel and older alluvial and alluvial-fan deposits		
			Alluvial terraces	Alluvial fans	Glacial outwash deposits
Distribution	Beaches and active channels of the Skagit and Stillaguamish Rivers.	Modern flood plain and low terraces bordering the flood plain.	Terraces 10–35 ft (3–9.5 m) above modern flood plains, and isolated remnants in other valleys.	Small deposits in steep terrain in the NE part of the area.	Extensive deposits, thickest and best exposed along major river valleys.
Thickness	<16 ft (<5 m)	10–24 ft (3–7 m)	15–35 ft (5–9.5 m)	15–50? ft (5–15? m)	15 ft (5 m) (upland surfaces), to more than 100 ft. (30 m) (valleys).
Texture	Sand and gravel; sand	Sand and gravel with lenses of fine sand and silt, and organic-rich muck	Sand and gravel with finer material	Sand and gravel	Sand and gravel; sand
Sorting	Well sorted	Moderately well sorted	Moderately well sorted	Poorly sorted to moderately well sorted	Generally well sorted
Layering	Poorly to moderately well layered	Moderately well layered	Moderately well layered	Discontinuous layering	Well layered
Depth to water table	Commonly <6 ft (<2 m)	Commonly <6 ft (<2 m)	>15 ft (>5 m)	>15 ft (>5 m)	>15 ft (>5 m)
Undesirable rock types[1]	Uncommon: occur locally in the NW and SW parts of the area.	Uncommon: occur locally in the NE part of the area.	Pumice occurs in some deposits north of the Skagit River, otherwise uncommon.	Common where streams drain fractured or clay-rich metamorphic and sedimentary rock.	Uncommon: occur locally in the NE part of the area.
Remarks	Thickness, texture, and, to some extent, the location of these deposits change seasonally and from year to year.	Does not include fine-grained alluvial deposits in the delta areas of large rivers. May include small areas of alluvial fan deposits.	In the Skagit River valley, deposits north of the river, and east of Gilligan Creek are rich in pumice, silt and clay, or both.	Many of these deposits are locally rich in angular clasts and matrix material.	Outwash deposited during retreat of the ice usually overlies deposits of glacial till and is generally coarser than outwash deposited during the ice advance, which usually underlies glacial till. Thick deposits of recessional outwash occur in upland areas east of Arlington, south of Freeland, and west of Penn Cove, Whidbey Island, and at Cattle Point, San Juan Island. Outwash deposited during the ice advance and included in this unit may contain small zones of till. Sand and gravel beneath a thin till overburden are also an important resource but are not specifically identified on this map.

[1]Including serpentinite, phyllite, schist, pumice, weathered or highly fractured rocks, and other physically unsound or chemically reactive rock types.

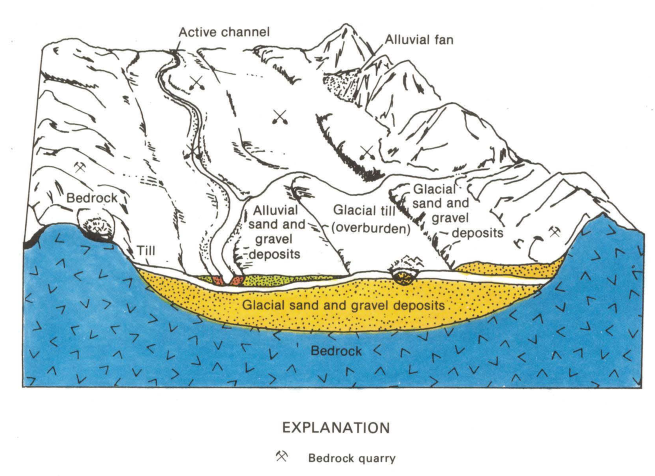

Figure 1. Block diagram showing relation between surficial deposits and bedrock in the Port Townsend quadrangle.

Table 2. *Characteristics of quarry rock*

Rock type	Resistant igneous and metamorphic rock	Mixed rock types	Fractured or clay-rich metamorphic and sedimentary rock
Distribution	Small 0.2 m^2 (0.5 km^2) knobs and more extensive isolated exposures in the NE and SW parts of the map area. Small areas are also found on Fidalgo, Lopez, and San Juan Island.	Extensive areas along the eastern margin of the map area.	The most extensive exposures occur near Lake McMurray, and in the SW part of the map area.
Undersirable rock types	Uncommon: shattered, layered rock rich in serpentine may occur at the margins of some exposures.	Common: Highly shattered rock types, clay and silt-rich rock, and serpentinite are commonly mixed with bodies of tough, massive, rock.	Common: clay and silt-rich rock, serpentinite and highly shattered or sheared rocks predominate.
Use	Concrete aggregate, road metal, railroad track ballast, and riprap; mine-run material for road subgrade and fill.	Concrete, aggregate, road metal, railroad track ballast, and riprap; mine-run material for road subgrade and fill.	Road subgrade and fill.
Remarks	Many of the large commercial quarries in the map area are located in these rocks.	Many small quarries have been developed in this unit in the NE part of the area. Most exploit bodies of dense, dark-green metamorphic rock that occur locally within badly sheared metamorphic rock.	Some granular sedimentary rocks in this unit are coherent enough to be used for riprap.

MAP SHOWING POTENTIAL SOURCES OF SAND, GRAVEL, AND QUARRY ROCK, PORT TOWNSEND QUADRANGLE, WASHINGTON

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1983

This map was printed from negatives prepared by photographic color separation of an author–prepared hand-colored original.

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