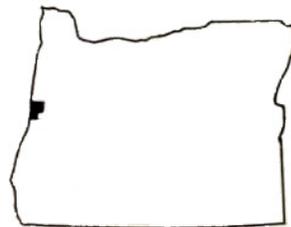




ENVIRONMENTAL GEOLOGY
of
COASTAL LANE COUNTY
OREGON



STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

1974

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building, Portland, Oregon 97201

BULLETIN 85

ENVIRONMENTAL GEOLOGY OF COASTAL LANE COUNTY OREGON

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* * * * *

The preparation of this report was financed in part through a Comprehensive Planning Grant from the Department of Housing and Urban Development, under the provisions of section 701 of the Housing Act of 1954, as amended, in partial fulfillment of HUD contract CPA-OR-10-16-1011.

* * * * *

Prepared under Contract No. LGR-73-16-06 for
OREGON DISTRICT COUNCIL OF GOVERNMENTS



GOVERNING BOARD
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R. E. Corcoran
1974



FOREWORD

BOARD OF COMMISSIONERS

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As population growth continues and the amount of leisure time increases, pressures for recreational development along the Oregon Coast, including Lane County's 29 miles of coastline, intensify. At the same time, the wood products industry of western Lane County supports a large number of persons who choose to live in this area. These pressures, and others like them, lead to increased demands for land to build upon and for public and private services to support the developing areas. Other factors, such as increasing property values, add further to demands for coastal development.

In the face of these development pressures, it becomes vitally important that land use decisions recognize the natural limitations, needs, and opportunities presented by the natural environment. In recent years, awareness of environmental factors has been integrated into land use planning and development across the state and in Lane County, and current planning programs within the County are refining this knowledge further. The constraints imposed by floods, unsuitable soils, landslide hazards, and other similar conditions are being considered in the County's planning and development process.

This study represents an important contribution to the store of environmental information which can be used for making land use decisions. Information presented here on the geologic structure of the Lane County coastal area will be valuable to County officials in preparing comprehensive land use plans and subsequent zoning studies, in issuing building permits, and in reviewing subdivision proposals. Private developers can use the information to their advantage in avoiding geologic hazards and making their investments in areas most suitable for development. Members of the general public can gain a further insight into environmental conditions and how these conditions affect their daily lives. Educators and students will be provided a foundation on which to base further detailed studies of specific areas along the Coast. Readily available environmental information such as this will, in short, bolster the planning and development process for all County residents.

This report represents months of intensive study by qualified professionals. It is only through the serious use of it that the investment of time and materials is justified. It is now up to the County's officials and citizens to ensure that the information is fully applied throughout the future.

Ken E. Omlid, Chairman

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ENVIRONMENTAL GEOLOGY OF COASTAL LANE COUNTY OREGON

INTRODUCTION

Purpose and Scope of Report

Urban expansion and recreational, commercial, and industrial developments have subjected the land to an ever-increasing intensity of use. Most areas have one or more hazardous conditions which must be considered if the development is to be successful. Too frequently, hazardous conditions not recognized by persons using the land can result in financial loss and possible physical harm.

The purpose of this investigation is to provide information on the existing and potential geologic problems that should be of prime concern in land use planning and land development in coastal Lane County. The report and accompanying maps are designed for use by governmental agencies, developers, engineers, and private citizens.

It should be emphasized that the study is general in scope. It delineates areas where hazardous geologic conditions may exist, but it is not sufficiently detailed for individual site evaluations; many areas too small to have been mentioned in the report or shown on the maps are potentially unsafe. Development of a particular site should proceed only after a careful, detailed evaluation is made of its geologic and engineering characteristics.

Responsibility of Government Regarding Geologic Hazards

County governments through their planning and building departments are responsible for the issuance of building permits. They require that certain construction standards and design criteria be followed. In recent years, some planning departments have taken on the increasingly larger function of providing information on the characteristics of the land.

In processing applications for subdivisions and other land use developments, physical characteristics of the site are usually reviewed. With a geologic map and supporting information on soils and geology, the permit-granting agency can advise developers and builders of conditions which must be evaluated.

Many California counties now retain geologists for staff consultants to review development plans and make on-site inspections. Certain counties have instituted ordinances that require developers to hire engineers and geologists to make site studies. For new developments, this procedure has helped avoid damages from landslides, erosion, and water.

It has been determined through the California courts that the issuance of construction permits by a governmental agency for land development implies that no dangerous or seriously damaging conditions will occur as a result of such construction or in relation to the presence of the development. The permit-granting agency thus may be held responsible for damages incurred because of lack of knowledge of, or concern about, the geologic hazards.

In a court case between Sheffet and Los Angeles County (Los Angeles Superior Court Case No. 32487), the court ruled that the County was responsible and must pay damages caused by water and mud flowing from a 12-lot subdivision above the plaintiff's property. In its decision, the District Court of appeals declared: "...where a public entity approved plans for a subdivision including a drainage system, and there is damage to an adjacent property as a result of those improvements, the public entity, not the subdivider, is liable. The fact that the work is performed by the contractor, subdivider, or private owner does not necessarily exonerate the public agency if [they] follow the plans and specifications furnished or approved by the public agency.

"When the work thus planned, specified, or authorized results in injury to adjacent property, the liability is upon the public agency under its obligation to compensate for the damage resulting from the exercise of its governmental power."

The Sheffet decision was upheld by Superior Court Judge William Fox of Pasadena, California. In addition, the County's petition for a rehearing was refused by the State Supreme Court. Refusal by the Supreme Court to rehear the case established a judicial precedent.

Since the Sheffet decision places the responsibility on the permit-granting agency, that agency is now faced with the necessity of obtaining adequate information on hazardous conditions for the protection of both the local government and the unwary public, who tend to minimize or ignore these hazards until the casualty occurs.

Construction by County Public Works Departments can also result in liability. The Los Angeles Superior Court (Case No. 684595) ruled that road building by Los Angeles County had triggered further damaging landslides in the Palos Verdes Hills and that the County must pay damages of approximately \$6 million.

Previous Work

Published geologic mapping of western Lane County includes that by Baldwin (1956) of the lower Siuslaw River area and a compilation by Wells and Peck (1961) of the geology of western Oregon at a scale of 1 to 500,000. Callahan (1927) mapped a part of the area for his master's thesis at the University of Oregon. In addition, geologic mapping was conducted in western Lane County for the Eugene Water and Electric Board as a part of site studies for nuclear power plant sites. Topical studies include studies on sand dunes by Nadeau (1952), Lund (1973), and Cooper (1958). Coastal erosion was studied by North and Byrne (1965) and by the U. S. Army Corps of Engineers (1971). Igneous rocks and their compositions were studied by Bray (1958), Snavelly and Wagner (1961), Snavelly and others (1965), and Snavelly and MacLeod (1974). Ground water in the dunes near Florence was reported on by Hampton (1963).

Acknowledgments

The authors are grateful to the organizations whose staffs gave generous assistance and cooperation in the preparation of this report.

James Ross and staff of the Oregon Coastal Conservation and Development Commission provided office space and secretarial services while the authors were working in Florence.

The following persons prepared sections of the report as noted: Donna Hepp, OCC&DC, Climate and Vegetation; Michael Copely of Lane County Planning Department and Chuck Bailey of Lane Council of Governments, together with their staffs, Economic Summary; and Vernon C. Newton, Jr., Oregon Department of Geology and Mineral Industries, Oil and Gas.

Flood and landslide damage information was furnished by Wilbur Ternyik and Paul Coyne, Port of Siuslaw, who also accompanied the authors on a field traverse of Umpqua River flood areas, and by Ruby Chapman, North Fork Road.

Frank Reckendorf furnished maps of the sand-dune areas, and William Dietrich, master's candidate at University of Washington, provided detail on landslides and intrusives in the Rock Creek drainage area. Eugene Water and Electric Board provided unpublished geologic data concerning coastal site studies. Parke D. Snavelly, Jr., and Norman S. MacLeod, U.S. Geological Survey, provided information on the Yachats Basalts. Dr. Robert Lawrence, Department of Geology, Oregon State University, provided data from ERTS and photos from infrared photography.

Information on quarries, gravel pits, and rock used was obtained from Elliott Parker, Clarence Gregg, Carl Nelson, Lloyd Woolfe, and Fred Yarbrough of the Oregon Highway Division; Jerry Gray, Consulting Geologist; Joseph Rohleder and Robert Young, Siuslaw National Forest; Harry Ludowise and Emery Richardson, Federal Highway Administration; and Philip Grubaugh, U.S. Army Corps of Engineers.

Ted Dietz, Soil Scientist, Lane County Environmental Health Department, provided soils data on coastal Lane County to accompany this report (see Appendix H and map in pocket).

Preliminary drafting was by Mike Evens, Lane County; final cartography and drafting by Steven Renoud and William Pokorny of the Oregon Department of Geology and Mineral Industries. Other assistance by Department personnel included camera-copy typing by Ruth Pavlat and editing and preparation for printing by Margaret Steere and Carol Brookhyser.

The authors also wish to thank Clyde Bowsby, Robert Dodge, Walter Huntington, Dick Swenson, Douglas Williamson, Jerri Button, Karen Dillen, Sandy Gerdes, Bonnie Jones, and Carla Henderson.

Photographs were obtained from Georgi Bumby and Dave Halman, Siuslaw News; Larry Bacon, Eugene Register Guard; Clarence Parker, Donna Hepp, and Wilbur Ternyik, OCC&DC, Florence. Photo preparation was by Lewis Nelson, Scott Photo, Corvallis.

The report was read by Jerry Gray and by Hughes and Associates, Inc., who made many helpful suggestions.

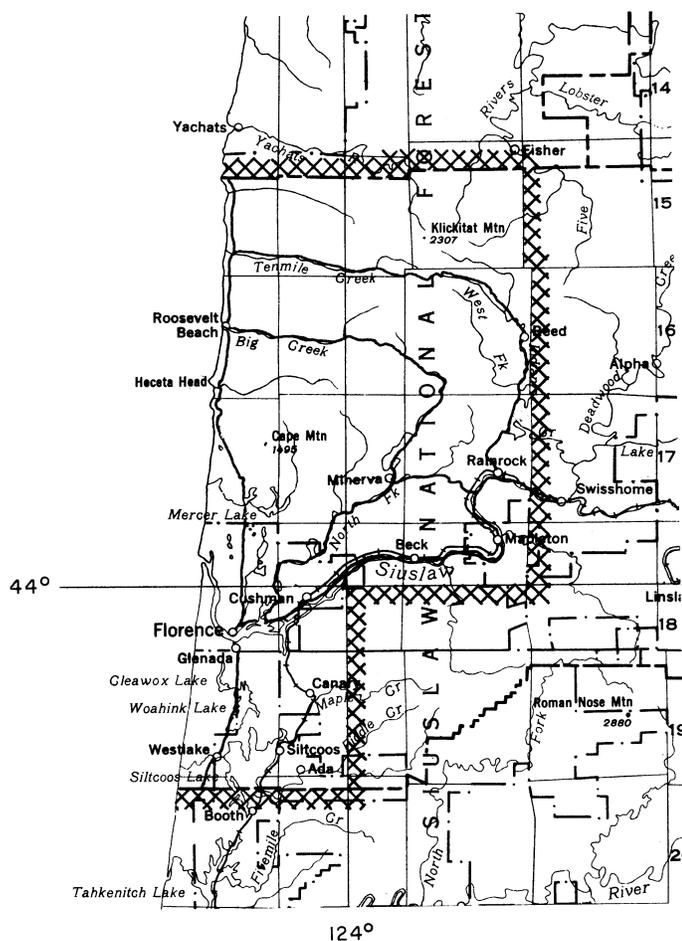


Figure 1. Index map of coastal Lane County.



Photo 1. Erosion of resistant headland composed of Yachats Basalt near Sea Lion Point.



Photo 2. Large active dune field south of Florence. Note "islands" of old tree-covered dunes; wet vegetation-covered interdune to left.

GEOGRAPHY

Location and Extent of Area

The study area includes only the western part of Lane County. It extends from its northern boundary at Captain Cook Point at approximate latitude 44°17' southward along the coast for 29 miles to the southern part of Siltcoos Lake at approximate latitude 43°52'. North of Florence, the study area extends inland from the Coast about 15 miles; south of Florence it extends inland about 7½ miles. The area covers about 340 square miles (Figure 1).

U. S. Highway 101 follows the coastline and serves that part of western Lane County. Two State highways provide access eastward to the Willamette Valley: State Highway 126 is a direct route from Florence to Eugene, and State Highway 36 extends north and east toward Junction City.

Quadrangle maps covered in this report include the south parts of the Waldport and Tidewater quadrangles, the entire Heceta Head quadrangle, the western two-thirds of the Mapleton quadrangle, and the north half of the Siltcoos Lake quadrangle.

Population Trends

Population data from several sources have been used in establishing population trends for western Lane County. In 1970 Lane County was divided into census tracts, and the U. S. Census Bureau statistics for tracts 6 and 7 (see Figure 2) are used for the 1970 population of the coastal strip. For the years prior to 1970, population was compiled from the U. S. Census Bureau statistics for the same general area. Population figures for Florence from 1950 through 1970 were taken from the Oregon Bluebook, and the 1970 population of Mapleton was determined by Lane County. For the years 1950 and 1960, the total population for the area was determined by combining the population of the coastal strip with the corrected population of Mapleton. The 1985 forecasts were made by Robert E. Keith, Bureau of Governmental Research at the University of Oregon, Eugene. The curves shown in Figure 3 were prepared from all the above data.

Population curves indicate a growth rate (compounded annually) from 1960 to 1970 of 4.3 percent for Florence; the total area indicates a growth rate of 3.5 percent annually. Future population is based on a growth rate of 4.3 percent, as indicated by latest trends.

In 1970, the total population in the study area was 6,889; nearly half (3,071) of this number lived in the cities of Florence and Mapleton. Population centers outside of Florence and Mapleton are located along U.S. Highway 101, in recreational and residential areas along the beach from Florence northward to Heceta Beach, and surrounding the many lakes both north and south of Florence. These areas include the communities of West Lake, North Lake, Dune City, Heceta Beach, and Glenada. Florence and Mapleton should grow as commercial centers partly from the pressure resulting from population increases outside of the city and partly as a result of annexations. An increasing tourist population (barring a permanent fuel shortage) will continue to be a major factor in the business growth of the coastal strip. Based on available figures, the population is predicted to increase in the study area from 6,889 in 1970 to 9,429 in 1985 for a total increase of 36½ percent.

Climate and Vegetation

Throughout the year, the climate of western Lane County is largely controlled by marine air masses which move inland from the ocean and release much of their moisture as they rise over the Coast Range. The prevailing winds are generally from the south and southwest during the winter, then gradually reversing to the north and northwest in the summer. Most of the precipitation falls as rain in the winter (i. e., from October to March) with summers remaining cool and dry. Late fall, winter and early spring cloudiness and

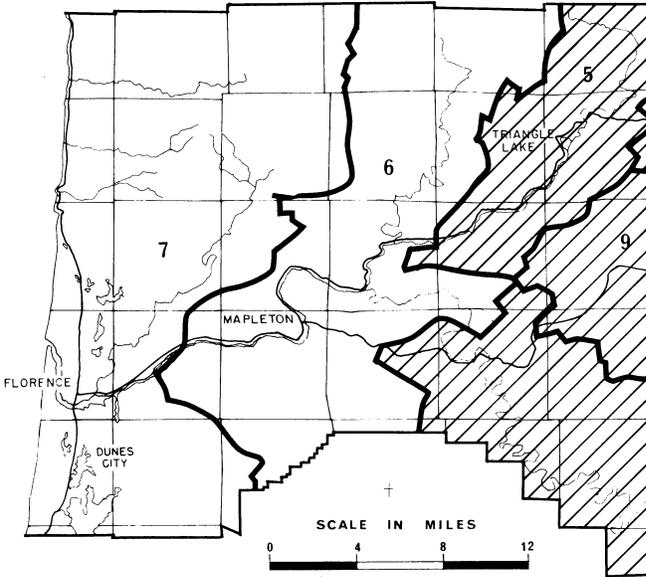


Figure 2.

Lane County census tracts 6 and 7.

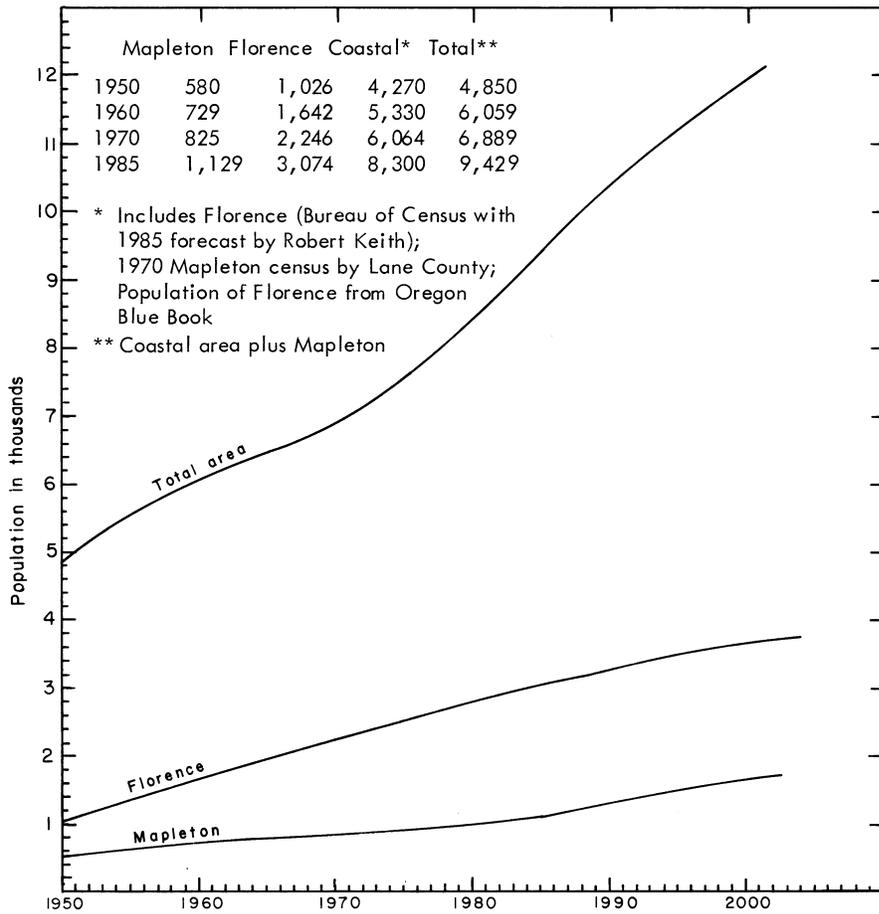


Figure 3.

Population curves for coastal Lane County.

rains are the result of warm, moist marine air masses encountering the higher relief and relatively cooler land surface; the air masses are forced to ascend and the resultant cooling intensifies the rainfall from 60 to 90 inches along the coast to 120 inches or more in the coastal mountains. Periods of snow and heavy freezing are rare and vary with elevation. In the warmer months, a narrow coastal fog belt often occurs when moist marine air is forced upward as it moves inland.

The mild winters and dry summers of the region give evergreen conifers the advantage over other types of vegetation and contribute significantly to productivity of the forests. Sitka spruce (*Picea sitchensis*) characterizes a narrow zone along the immediate coastal strip and fingers further inland along the river valley bottoms; this zone is uniformly mild and humid with frequent summer fogs and generally is below 500 feet in elevation. Western red cedar (*Thuja plicata*) and Western hemlock (*Tsuga heterophylla*) associate with the spruce, especially in the older stands with wetter conditions.

Shore pine (*Pinus contorta*) joins the spruce in low areas and wet places in the dunes and replaces it on coastal sites with less favorable moisture conditions, such as dune ridges where it may be associated with Western hemlock and Douglas-fir (*Pseudotsuga menziesii*). Red alder (*Alnus rubra*) frequently colonizes in open disturbed areas. Specialized non-forest vegetation communities occur in fresh- and salt-water marshes, coastal swamps and bogs, sand-dune areas, and headlands.

Most of the forest has Douglas-fir as the dominant species, associated with the more shade-tolerant Western red cedar and Western hemlock. Inland from the uniform and moderate climate of the coastal strip, vegetation at higher elevations is subject to greater stress from temperature and moisture extremes. Understory species vary with site conditions.

Early successional sites and river-bottom plant communities are characterized by deciduous hardwoods, especially Red alder.

Topography

Western Lane County lies on the western flank of the Coast Range. The region is characterized by rugged mountainous terrain, bold headlands along the coast, steep-sided stream valleys in the uplands, and a 2- to 3-mile-wide coastal plain with sand dunes extending northward 16 miles from the southern boundary of the County to Big Creek. The major headlands from north to south are Cape Perpetua, Heceta Head, and Sea Lion Point. Cummins Peak, elevation 2,475, is the highest peak in the area; other prominent peaks are Klickitat Mountain, elevation 2,307; Fairview Mountain, elevation 2,306; and Saddle Mountain, elevation 2,297.

The major rivers are the main Siuslaw River and the North Fork of the Siuslaw River. In the volcanic terrain north of Sea Lion Point, a series of west-flowing creeks separated by prominent ridges have eroded steep canyons that are cut nearly to sea level. The major canyon-forming streams are Cummins Creek, Ten Mile Creek, Big Creek, and Cape Creek.

Prominent lakes border the coastal plain. The largest is Siltcoos Lake to the south; others include Woahink Lake, Munsel Lake, Clear Lake, Mercer Lake, and Sutton Lake. These occur largely as a result of damming stream valleys by sand dunes.

The geomorphic cycle is youthful to mature. The Siuslaw and North Fork Siuslaw Rivers appear to be antecedent streams; that is, the stream courses were established prior to the Coast Range uplift.

Economic Summary

The coastal economy's major sectors include manufacturing (primarily forest products), retail and wholesale trade, fishing and shipping activities, and tourism. Additional major employers in the coastal area are governmental and educational agencies.

Manufacturing

Manufacturing activities in the coastal area center on lumber and wood products. In 1970, an estimated 41 percent of the labor force in Census Tracts 6 and 7 (Figure 2) was employed in the wood-

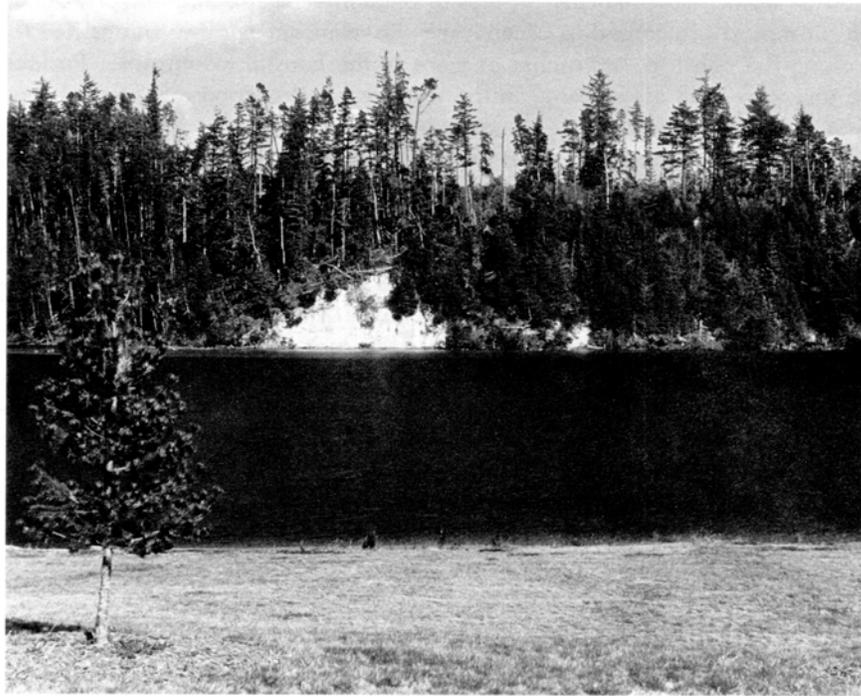


Photo 3. Slope failure on old, stabilized dune on shore of Woahink Lake.



Photo 4. Housing development on shore of Woahink Lake. Increased use of septic tanks could cause contamination of lake.

products industry alone. Much of the land is forested, including the Siuslaw National Forest, and the proximity of the resource to coastal shipping facilities tends to maintain the strength of this economic activity.

In 1970, eleven firms were engaged in the production of lumber, plywood and veneer, hardwood, and chips. Of these, four were sawmills, six were plywood and veneer plants, and one produced hardwood. Estimated employment during the year was about 1,100 in the coastal wood-products industry. Plants are located in the Cushman and Mapleton areas.

Wholesale and retail trade and services

The trade and service sector of the coastal economy is second only to the wood-products industry. Most of this activity is centered in the Florence area and extends upriver to the Mapleton area. Much of it is related to the tourist industry (discussed below) although it also serves local permanent residents. Because of the distance to the Eugene-Springfield trade centers, the Florence and Mapleton areas meet the day-to-day commercial needs of the coastal Lane County population.

Wholesale and retail trade was carried on by about 75 firms in the coastal area (Tracts 6 and 7), and employed about 500 persons. Financial services, including real estate, accounted for another 18 firms employing about 115 persons. Personal and business services were provided by about 25 firms employing around 300 persons. Most of these activities are year-round operations, although seasonal variations in business volume are common.

Trade and service activities are not normally considered to be "basic" economic activities; however, much of the trade and service activity in the coastal area is tourist oriented, and results in a tangible "imported" income from short-term or seasonal visitors. Therefore, this economic sector is extremely important to the coastal portion of Lane County.

Sport and commercial fishing; shipping

Most fishing activity along the coast is centered around sport or recreational fishing. Commercial fishing, which once was central to the Florence area, has tended to shift away to other ports to the north and south of the city (although some commercial boats are moored along the Siuslaw and a limited amount of fish storage and processing still occurs in the area). Sport fishing accounts for most coastal activity, and tends to center on the Siuslaw estuary.

Fishing activity includes boat fishing along the estuary, with Dungeness crab and Pacific staghorn sculpin being among those species most often taken. Shore fishing along the estuary results in the taking of Redtail surfperch, Pile perch, and Pacific staghorn sculpin most frequently. Softshell clams are dug in the tide flats.

The Siuslaw estuary provides moorage facilities for an estimated 570 boats. During the summer months when boat fishing is at its peak, these facilities are filled nearly to capacity. Most local employment in the fishing industry on the Coast falls into the trade and service categories described above.

Shipping activity is carried on by the Port of Siuslaw at Florence. Most shipping activity centers around wood products, with lumber being a major item. In 1971, total tonnage shipped out of the port was 95,500, of which over 66,000 tons was lumber. Log rafts also account for a large proportion of shipping volume. The Port is presently involved in efforts to improve its facilities and is working with the County in the preparation of a County comprehensive plan and a more detailed Siuslaw estuary planning study.

Tourism

The scenic and natural values of the Coast are an attraction for tourists, and the tourist-vacation industry is vital to the coastal economy. Since the Florence area is only about 60 miles from the Eugene-Springfield metropolitan area, a large volume of vacation traffic comes to nearby coastal recreation areas, especially in the summer months. Also of benefit is the establishment of the Oregon Dunes National Recreational Area, which extends to Florence from the south and promises to draw large numbers of visitors. This and the nearby Siuslaw National Forest facilities account for much of the local vacation-industry potential.

Detailed information is not available for the tourist-based economy since most trade and service activities serve both local and transient markets. One indicator for which data is available, however, is the number of transient lodging facilities, including motels and trailer park spaces. A 1973 estimate indicates that in the coastal area, including Mapleton, 470 motel units and 515 trailer spaces are available. Most of these operate on a year-round basis, although some are open only during the summer season. The amount of transient lodging in the area clearly demonstrates the importance of tourism to the coastal economy.

A permanent gasoline shortage problem would threaten the continued well-being of the previously expanding tourist industry along the Lane County coast. The true impact of this problem will probably be felt during the summer months. Coastal tourist activities are presently engaged in promotional efforts aimed at residents of the Willamette Valley, which is readily accessible to the coast.

Other activities

Other economic activities along the coast include agriculture and food products and government services. For the former, land areas are extremely limited, and the recent trend has been toward conversion of agricultural lands into developed lands; rising property assessments and the necessity for economies of scale in agriculture have been chiefly responsible for this. At the present time, agricultural activity in the coastal area consists of several Grade-A dairy farming operations, beef cattle production, sheep production (especially farm flocks), and Christmas tree production.

Local, State and Federal government employment is important to the coastal economy, as well. In 1970, an estimated 400 persons were employed by government agencies, including schools.

The coastal economy is still in the process of readjusting from an earlier dependence on the wood-products industry (a sector that is still very strong in the area) to a concentration on local and area-wide services, primarily in connection with the tourist trade. Because of its relative isolation from the more populated areas of the County, the Coast has had to "make its own way" economically, but also benefits from this in that the resource base, especially as it relates to vacation and tourist attractions, is still relatively unspoiled and offers potential for carefully guided economic development.

GEOLOGIC UNITS AND THEIR ENGINEERING CHARACTERISTICS

General Discussion

The description of each geologic unit is followed by a discussion of its engineering characteristics. Engineering characteristics refer to features within a geologic unit, such as drainage, ground stability, and erosion potential, that should be considered in land development and construction. Laboratory data on soil performance are provided in Appendix A.

The bedrock underlying most of the area consists of indurated sedimentary and volcanic units ranging in age from middle Eocene through upper Eocene, intruded by basalt and gabbro dikes. Oligocene, Miocene, and Pliocene rocks that are present in other parts of the Oregon Coast are missing from the western part of Lane County. However, exploration for oil and gas offshore from Lane County reveals the presence of these rocks on the continental shelf (Braislin and others, 1971).

The bedrock units of Eocene age include the Tyee Formation, made up of sandstone and siltstone, and the overlying Yachats Basalt, composed of a heterogenous complex of volcanoclastic rocks and basaltic lava flows. A thin band of sandstone and siltstone mapped as the Nestucca Formation (Snively and others, 1972) lies stratigraphically between the Tyee Formation and the Yachats Basalt in the northeast part of the map area. Fine- and coarse-grained basaltic dikes cut the older rocks in numerous localities. These bodies range from a few feet to several hundred feet thick.

Marine terrace sediments of Pleistocene age and sand dunes of Holocene age overlie the bedrock units along the Coast. Alluvial deposits on elevated terraces along the north side of the Siuslaw River were probably formed during the Pleistocene. Alluvial deposits on the low terraces and flood plains of the rivers and streams are of recent origin. Tidal-flat muds occur in the lower Siuslaw estuary.

Figure 4 shows the stratigraphic relationship of the geologic units in western Lane County. (A geologic time chart is given in Appendix I.)

Tyee Formation (Tet)

Geology

The Tyee Formation is the most widespread indurated rock unit in the area. It occupies approximately 65 percent of the map area, extending from near the coast to the eastern boundary of the map area. The formation is composed of massive, rhythmically bedded sandstone and siltstone and is more than 5,000 feet thick.

The name Tyee Formation was applied to outcrops in the Roseburg area by Diller (1898), was extended to the southwest coastal area by Vokes and others (1949), and later into western Lane County by Baldwin (1956).

The topography of the region dominated by the Tyee Formation is characterized by incised stream valleys and elongate strike ridges that have crest elevations ranging from 750 to 1,000 feet msl. Ravines and canyons range from 200 to 300 feet deep and side slopes are generally moderate (15° to 25°) but locally are more than 40°.

Exposures of the Tyee Formation consist of massive beds of gray-green, micaceous sandstone alternating with easily weathered beds of gray to brown siltstone. The sandstone is fine grained, occasionally coarse grained, and the beds range in thickness from a few inches to as much as 15 feet; typically they are 5 to 10 feet thick. The interlayered siltstone beds range from 2 to 20 feet in thickness but are more typically 2 to 5 feet thick. The sandstone is generally harder than the siltstone and forms prominent ridges. Locally, however, the sandstone is deeply weathered and provides the parent material for thick colluvial deposits.

EPOCH		UNIT SYMBOL	GEOLOGIC UNIT Description
Holocene (Recent)		Qal tf	<u>Alluvium</u> Flood plain and river channel deposits Tidal-flat deposits in estuaries, tf
		Dp Ad Sd	<u>Sand-dune deposits</u> Deflation plain, Dp Active dunes, Ad Stabilized dunes, Sd
Pleistocene		Qt	<u>Elevated alluvial terrace deposits</u> Silt, sand, and thin layers of gravel on north side of Siuslaw River
		Qed	<u>Estuarine deposits</u> Sand with thin layers of clay, silt, and peat. May be old dune and bog deposits
		Qmt	<u>Marine-terrace deposits</u> Weakly cemented, brownish, silty sand; thin beds of gravel, organic silt, and clay; scattered wood fragments
Eocene	Upper	Teyb	<u>Yachats Basalt</u> Subaerial and submarine volcanoclastic rocks and flows
		Ten	<u>Nestucca Formation</u> Tuffaceous siltstone and sandstone with interbeds of tuff, glauconite, and arkosic sandstone. Small outcrop area in north- ern part of map area
	Middle	Tet	<u>Tyee Formation</u> Massive, gray-green micaceous sandstone beds alternating with thinner, gray to brown siltstone beds; 5,000 feet thick; occupies 65 percent of map area
		Ti - Intrusive rocks	

Figure 4. Chart showing stratigraphic positions, map symbols, and relative ages of geologic units in coastal Lane County.



Photo 5. Roadcut in typical sandstone-siltstone sequence of Tyee Formation about 1 mile east of Siltcoos Lake.

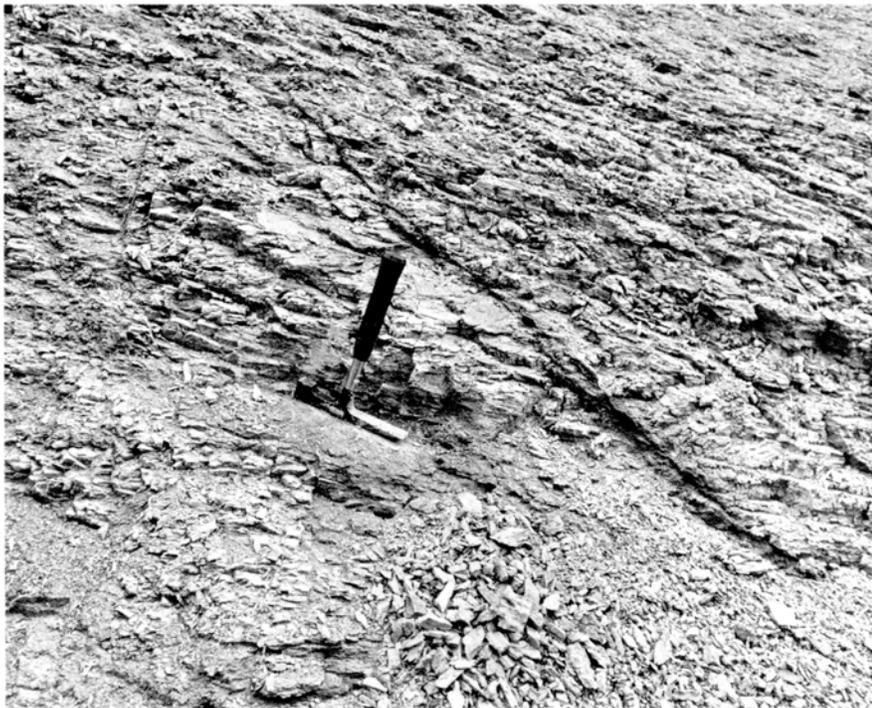


Photo 6. Thick-bedded siltstone of the Tyee Formation has been intensely sheared. Photo taken near junction of South Inlet and Canary roads.

Several areas of thick, shaley siltstone occur within the formation. These areas, discussed later, have been involved in extensive slope failures. Landslides are common in the Tyee siltstone.

The dominant structures within the Tyee Formation from a regional point of view are gentle to moderate folds with northeast-trending axes. The limbs of the folds dip 5° to 10°, and only rarely 20° to 30°. In the map area, the dips are mainly to the west, but in the eastern margin of the area, they reverse to the southeast, forming a large, open anticline.

Faulting in the Tyee Formation has been shown to be extensive where detailed mapping has been done. Although some faults in western Lane County were observed in the field, others are suggested by lineations on the topographic maps and on side-view radar imagery (see section on Structure).

The age of the Tyee Formation is inferred to be middle Eocene on the basis of stratigraphic position and fossil identifications (Turner, 1938; Baldwin, 1961; and Baldwin and Beaulieu, 1973).

Engineering characteristics

The Tyee Formation occurs in the upland and mountainous areas and along the inland valleys and the borders of several coastal lakes. Because the formation is so widespread, considerable development, including logging roads, major highways, large mill installations, and dwellings, occurs on it.

Alternating beds of thick sandstone separated by thinner layers of siltstone are typical of the Tyee Formation. However, two areas mapped as Tyee are predominantly shaley siltstone which weathers to clay. One area, covering about 3 square miles northeast of Sutton Lake, has been affected by landslides and nearly all of it is potentially unstable. The other area, west of Canary and east of the north end of Woahink Lake shows much evidence of landslides. Outcrops at both locations reveal that the siltstone is highly sheared in places and altered to an unstable bentonitic type clay. The heavy clays are impermeable and highly susceptible to shrink and swell as the result of wetting and drying. Roadcuts in this material should be limited to shallow excavations with gentle cut slopes. The material does not appear to be suitable for use in construction of major embankments.

The massive sandstone beds in the Tyee Formation are much better for construction sites than the siltstone, especially where the sandstone bedding is nearly flat. Slopes of about one horizontal to one vertical are usually stable in the sandstone. Steeper cuts can produce extensive ravelling, rockfall, and slump failure, especially where the rock is weathered or severely jointed. The strata can fail along bedding planes where the beds dip into a steep-walled valley or large roadcut.

Hard, unweathered Tyee strata composed of massive sandstone beds separated by thin siltstone layers must be excavated by blasting. Large diameter holes loaded with ammonium nitrate and diesel oil have been most effective in breaking the rock. Blast holes spaced too far apart usually produce an abundance of large angular blocks which are nearly impossible to compact in embankments, and settlement will occur when weathering causes the contact points of the individual blocks to fail. Settlement of this type will continue over a long period of time and be difficult to correct.

Soils developed on the Tyee Formation are 4 to 6 feet thick in places and composed of sandy silt and clay derived from weathered rock. These soils are generally found where slopes are gentle and material weathered from the bedrock has not been removed by erosion. This type of soil also occurs in colluvial deposits at the foot of slopes.

The thin granular soils developed on moderate to steep slopes typically contain up to 15 percent coarse fragments over 3 inches in diameter. From 35 to 45 percent is sand, and from 40 to 50 percent is mostly silt with some clay (U.S.D.A., Soil Conservation Service, 1969).

Nestucca Formation (Ten)

Geology

The Nestucca Formation of late Eocene age crops out in the northern part of the area in a narrow band about 3 miles long and a quarter of a mile wide. The outcrop area parallels a northwest-trending fault. As mapped by Snavely and others (1972) in the Tidewater quadrangle, the formation consists of thin-bedded to massive tuffaceous siltstone and sandstone with interbeds of tuff and fine-grained arkosic



Photo 7. Wave-cut bench on Yachats Basalt near Gwynn Knoll is a favorite basking site for sea lions.



Photo 8. Sea stacks produced by erosion of Yachats Basalt headland. Minor slope failure has occurred on steep bluff below lighthouse.

sandstone. The Nestucca Formation was not recognized to the south in this investigation and if present is assumed to occupy areas too small to be significant to this study.

Engineering characteristics

Although this unit covers only one square mile, it may be involved in future forest-road maintenance and construction. The soils developed from the Nestucca Formation are fine grained and contain weathered volcanic ash partly altered to bentonitic clays which shrink and swell with moisture changes and, therefore, perform poorly in road construction. The material is relatively impermeable and will drain very slowly. It is poor embankment material and requires adequate drainage installations beneath all side-hill fills. Embankments need to be placed at rigid moisture control and compacted at very near optimum moisture content for the soil. Major cut slopes should be no steeper than 3 (horizontal) to 1 (vertical). Ravelling of small fragments from cut slopes can block drainage ditches, causing drainage waters to erode ruts.

Yachats Basalt (Teyb)

Geology

Yachats Basalt (Snively and MacLeod, 1974) crops out north of Florence in a continuous band 3 to 8 miles wide from Cape Mountain northward beyond the map boundary to the Alsea River. The volcanic terrain is steep and rugged and is characterized by a series of east-west linear ridges separated by parallel canyons eroded by small streams. The ridges terminate along the coastline in bold headlands, the most prominent of which are Cape Perpetua, Heceta Head, and Sea Lion Point.

The Yachats Basalt is composed of a heterogenous assemblage of subaerial and submarine volcaniclastic rocks and flows. The assemblage contains subaerial porphyritic basalt and basaltic-andesite flows, typically 10 to 20 feet thick, with flow breccia developed in the upper and lower parts of the flow units (Snively and others, 1972; Snively and MacLeod, 1974). The flows commonly display irregular jointing and occasionally columnar jointing. Near-vent breccias with spatter cones locally contain volcanic bombs. Interbedded pillow basalt, isolated pillow breccias, lapilli tuff, cobbles and boulder conglomerate, and basaltic sandstone and siltstone are locally abundant adjacent to volcanic centers. In several places, basalt associated with basaltic breccias is porphyritic with tabular feldspar crystals up to 1 inch across, particularly prevalent in roadcuts along Big Creek.

Numerous dikes and irregularly shaped intrusive bodies are present throughout the outcrop area; some are large enough to be utilized for rock quarries.

Along the coast where weathered material is being continually removed by erosion, the exposures of volcanic rocks are hard and dense. Inland where weathering products have not been eroded, the exposed rock is rather soft, particularly the thicker sedimentary interbeds and breccias. The residual soil cover on narrow ridges and steep slopes appears to be thin in most places. Thick colluvial soils have developed on moderately steep slopes and in some areas have produced landslide masses. Stony colluvium is locally present in narrow strips along the steeper slopes. In some places along the coast, it is found both beneath and above marine terrace deposits.

The geologic structure of the Yachats Basalt is not well known. The nearly straight lineal pattern of many of the stream valleys in the Yachats Basalt suggests structural control (see section on Structure).

Stratigraphic relationships indicate the relative geologic age of the Yachats Basalt. It overlies both the Tyee Formation of middle Eocene age and the Nestucca Formation of upper Eocene age (Snively and MacLeod, 1974) and underlies the basaltic sandstone of late Eocene age north of Yachats. Therefore, late Eocene age is inferred for the Yachats Basalt (similar to the basalt at Cascade Head in Lincoln County).

Engineering characteristics

Engineering characteristics of the Yachats Basalt vary, depending upon the type of material, topography, and degree of weathering.

Dense, unweathered basalt and breccia are resistant to erosion and form steep cliffs. Excavation of

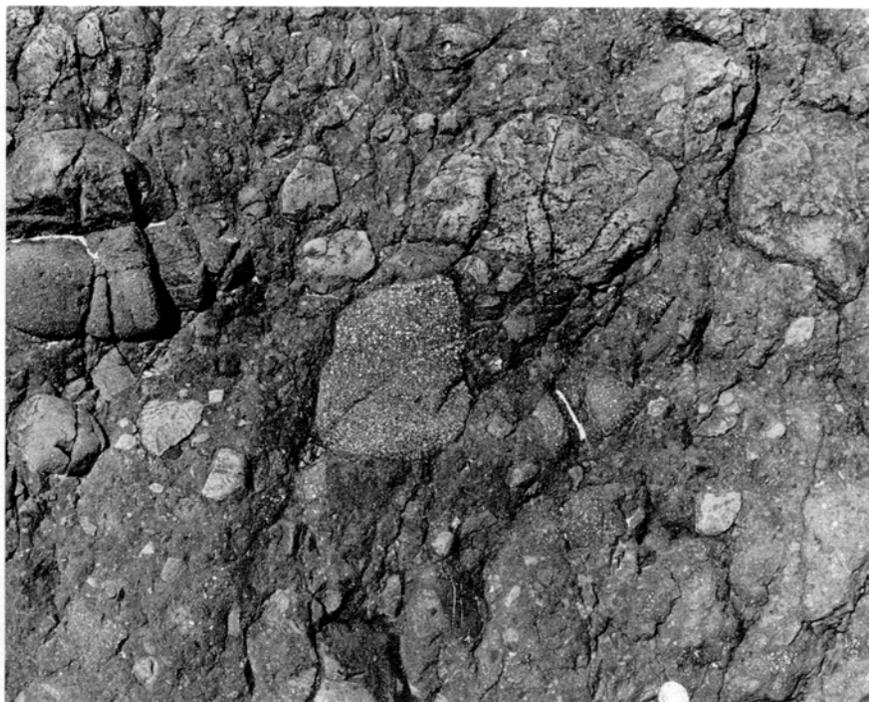


Photo 9. Breccia in Yachats Basalt is composed of volcanic ash and rock fragments; speckled rock in photo center is about 10 inches across.



Photo 10. Deeply weathered breccia of Yachats Basalt retains outline of large rock fragment.

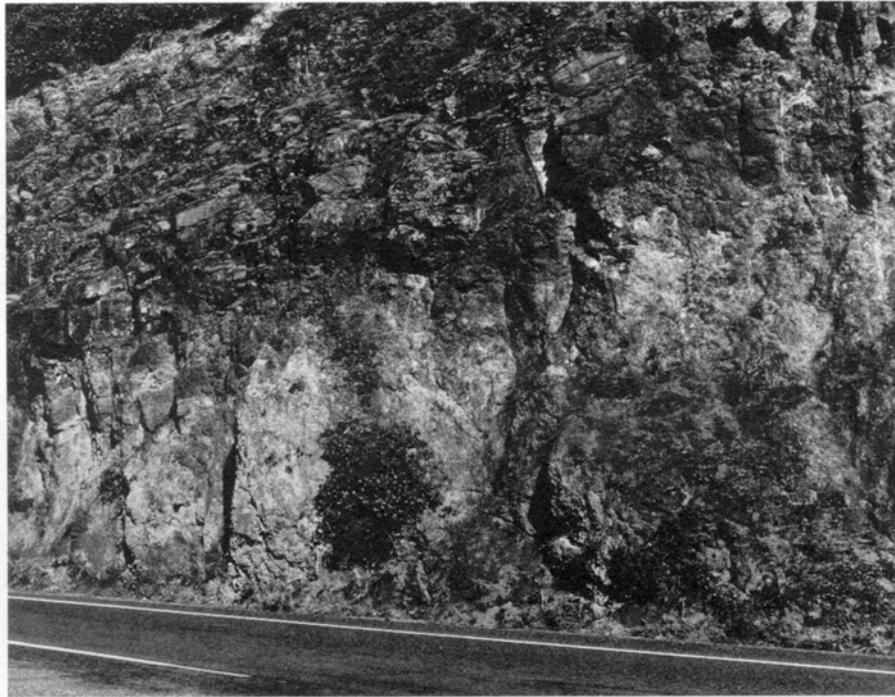


Photo 11. Massively jointed Yachats Basalt grades upward into more closely jointed lavas.



Photo 12. Feeder dikes for Yachats Basalt exposed on wave-cut terrace near Captain Cook Point.

this material will require drilling and blasting. Moderately high cuts will stand steeply; however, large cuts can produce slides and rockfalls because of weathering along fractures and joint surfaces. Large cuts should be designed with benched slopes to prevent slope failures in the cut and to protect the lower slopes from rockfall.

Deeply weathered volcanic breccias with tuffaceous clayey interbeds are highly unstable. Many such areas have a hummocky, landslide topography. These areas and the surrounding slopes are usually unstable. Clayey soil derived from Yachats Basalt requires close moisture control for satisfactory compaction of embankments.

Moderate to gently sloping areas along the coast or stream valleys have stony colluvium composed of soil and rock fragments. Colluvial slopes were formed at nearly the maximum angle of repose and have a high potential for sliding; therefore, caution should be exercised in construction or development on colluvial slopes, especially in making excavations, oversteepening of the slope, or disrupting normal surface drainage (see causes of landslides in Geologic Hazards section).

Intrusive Rocks

Intrusive rocks occur in numerous, widely scattered places throughout the area. As indicated on the geologic map, they are most abundant along the coast from Cape Perpetua to Heceta Head and easterly in the uplands, where they intrude the Yachats Basalt. They also occur in the Tyee Formation.

The intrusive bodies are predominantly northwest-trending basalt and gabbro dikes. They range in thickness from a few feet to several hundred feet and extend in outcrops from a quarter of a mile to several miles. One large dike near Mapleton extends eastward for about 15 miles. The smaller dikes are primarily composed of fine-grained basalt. The larger dikes, such as the one near Mapleton, are composed of gabbro.

A small nepheline syenite stock northeast of Cape Ridge in the northern part of the map area is described by Snavely and others (in press). A quartz diorite dike has been mapped across the access road just west of Fairview Mountain by William Dietrich (written communication, 1974).

The larger dikes are commonly of excellent quality for aggregate. The basalt is dense, finely crystalline, unweathered, and dark gray to black. Jointing ranges from close cubic to crudely columnar and massive. The gabbro is medium grained, dense, and blocky. It can be used for crushed rock and riprap, and for jettystone if the jointing is wide enough (see section on Economic Mineral Resources).

Marine-Terrace Deposits

Geology

Marine terraces fringe the volcanic terrain of the coastline from Big Creek northward. They occur as narrow, discontinuous segments separated by basalt headlands.

The terrace deposits range from about 10 to 30 feet thick and are composed of weakly cemented beds of brownish, silty sand and gravel, with occasional thin layers of organic silt and clay and scattered wood fragments. In places, rocky colluvium occurs within the terrace deposits or overlies them.

The deposits are flat-lying and rest on wave-cut benches of bedrock at or near sea level. The bedrock benches are mainly Yachats Basalt but in places are colluvium derived from the basaltic rocks.

The terraces are seldom more than a few hundred feet wide. Their upper surfaces are nearly flat to gently undulating and generally slope seaward at low angles. Their seaward edges are being eroded by wind and waves, which produce nearly vertical cliffs 10 to 40 feet high.

The terrace deposits may be correlative with the late Pleistocene Elk River Beds in Coos County originally defined by Diller (1902) and later studied by Baldwin (1945), who extended the Elk River Beds northward along the Oregon Coast.

Engineering characteristics

Although marine terraces of Lane County have small areal extent, they offer some of the most desirable building sites, with ocean view, beach access, and favorable topography.



Photo 13. Beach bluff exposure showing thin bed of marine terrace sediment overlying beach gravel, with Yachats Basalt at base.

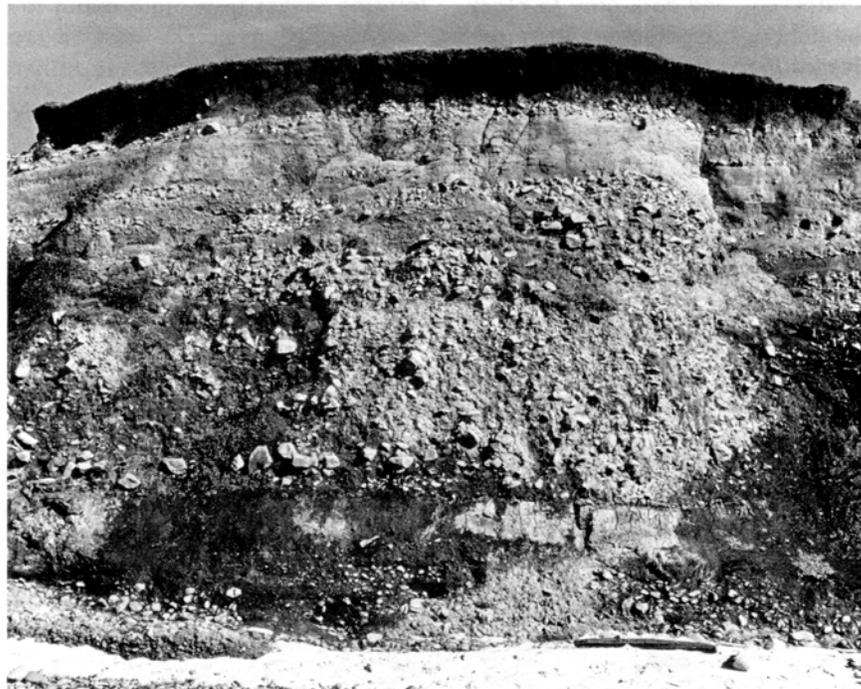


Photo 14. Stony colluvium sandwiched between two layers of marine terrace sediment. Top 2 feet is a dark soil zone.

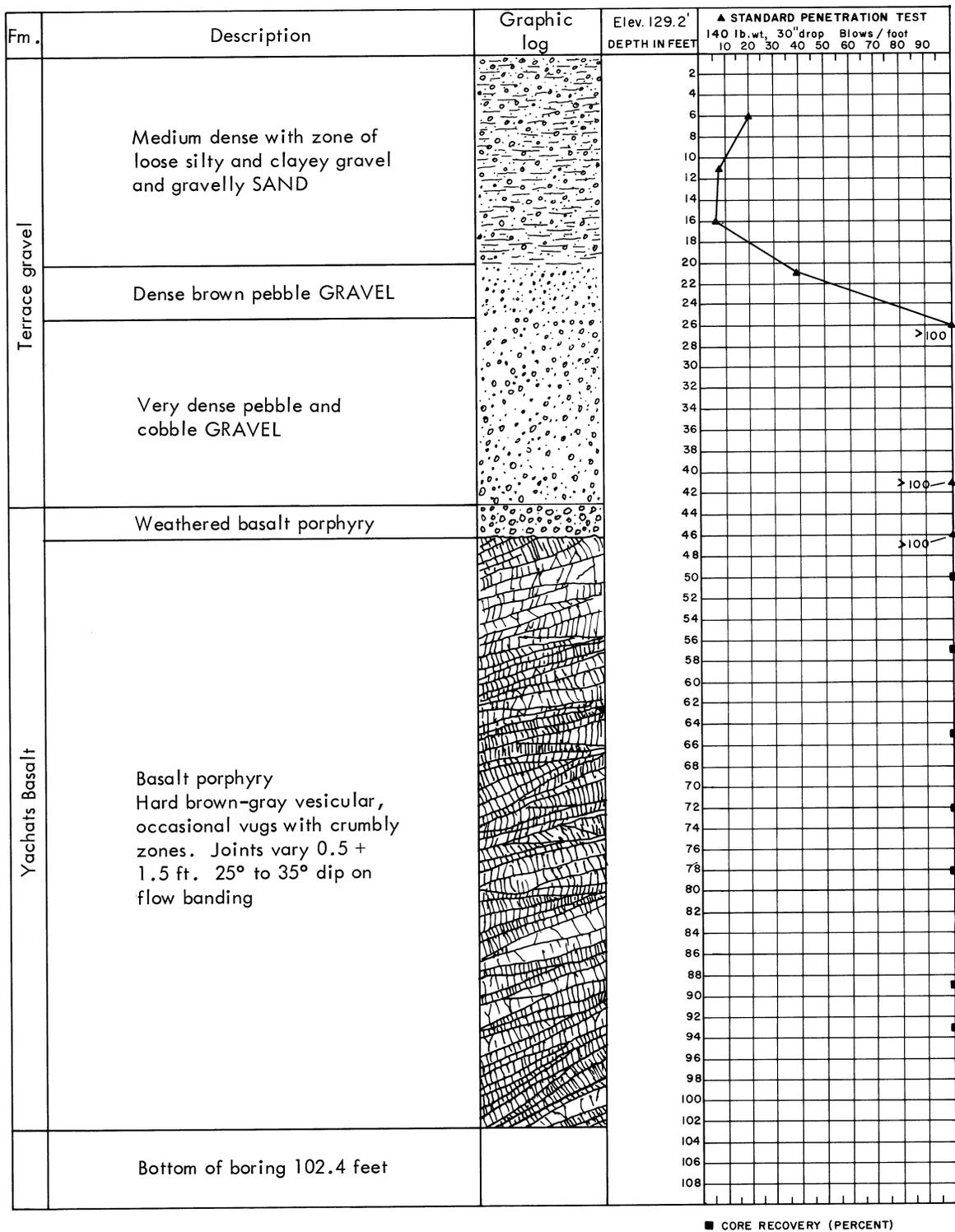


Figure 5. Boring log of terrace gravels and Yachats Basalt, Big Creek site half a mile east of beach. (Data from Shannon and Wilson, Inc.)



Photo 15. Severe erosion in low terrace composed of stony colluvium. Gwynn Knoll in background is a small basalt headland.



Photo 16. Large Indian shell mound overlies marine terrace. Yachats Basalt exposed in foreground extends beneath terrace.

The terraces have had a long history of erosion along the beach escarpment. Erosion averages about one foot per year; therefore, buildings should be located a safe distance from the edge of the bluff. A precautionary rule would be to place the structure approximately 50 feet from the edge of the bluff plus one foot for each year the building will be used.

Foundations for light structures can be placed on spread footings after removal of the topsoil, but if heavy foundation loads are anticipated, the presence of peat or organic clays in the subsurface could result in excessive settlement. Therefore, exploration and testing should be accomplished to provide adequate data for engineering of foundations.

The permeability of the terrace material will vary from place to place depending upon presence of clay, cemented layers, and organic material. Septic tank drain fields on marine terraces can be efficient if there is a suitable thickness of soil overlying the sand and if the water table remains deep enough to allow drain field operation throughout the year. A boring log typical of the terrace deposits is shown in Figure 5.

Estuarine Deposits (Qed)

Geology

A sedimentary deposit composed primarily of sand with thin layers of clay, silt, and peat is present beneath the dune-sand area from the Siuslaw River north to Sutton Creek and probably underlies some of the lowland south of the river. It appears to be an older estuarine deposit of the Siuslaw River. This unit was first observed in outcrops exposed at low tide in the Siuslaw River near the U. S. Coast Guard Station northwest of Florence. The extent of these deposits in the subsurface is indicated by information from logs of wells. The deepest well (No. 15 M1, Appendix E) which provides information on these deposits is located near the U. S. Coast Guard Station in the SW $\frac{1}{4}$ sec. 15, T. 18 S., R. 12 W. The well log indicates the following (Hampton 1963):

Sand	0 feet to 35 feet
Silt and clay	35 feet to 37 feet
Sand with streaks of wood and silt	37 feet to 67 feet
Brown clay	67 feet to 69 feet
Peat and sand	69 feet to 72 feet
Sand, gray, clean with streaks of peat	72 feet to 87 feet

A well drilled farther east in sec. 14, T. 18 S., R. 12 W. to a depth of 81 feet penetrated a similar section. The thickness of the deposit is unknown, but a total thickness of over 150 feet is a reasonable estimate. The outcrops of the unit near the Coast Guard Station consist of compact, fine brown sand with scattered organic material. The age of the deposit has been determined to be about $4,620 \pm 130$ years B.P. (before present) by carbon 14 (Rubin, 1965). This unit may represent the latest backfilling of the estuary beginning when sea level was several hundred feet lower than at present. On the other hand, the lack of fossil shells reported from wells may indicate it is an older dune-sand deposit with interdune bogs and swamps which developed as sea level was rising. Because of the aerial extent and significance of this unit to engineering and groundwater, it is described separately from the overlying sand. Logs of three borings penetrating dune sand and estuarine deposits are shown in Figure 6.

Engineering characteristics

Although these sediments crop out in a very limited area, water-well logs indicate that they are extensive in the subsurface north of the river to at least Sutton Lake.

The unit is generally present at a depth of 35 feet or less beneath unconsolidated sand-dune deposits. Soft and compressible clay and peat or organic soils may be present in both estuarine deposits and sand dunes. Since this material could cause excessive settlement of heavy buildings, it is highly advisable when planning for such buildings that adequate subsurface investigations be performed.

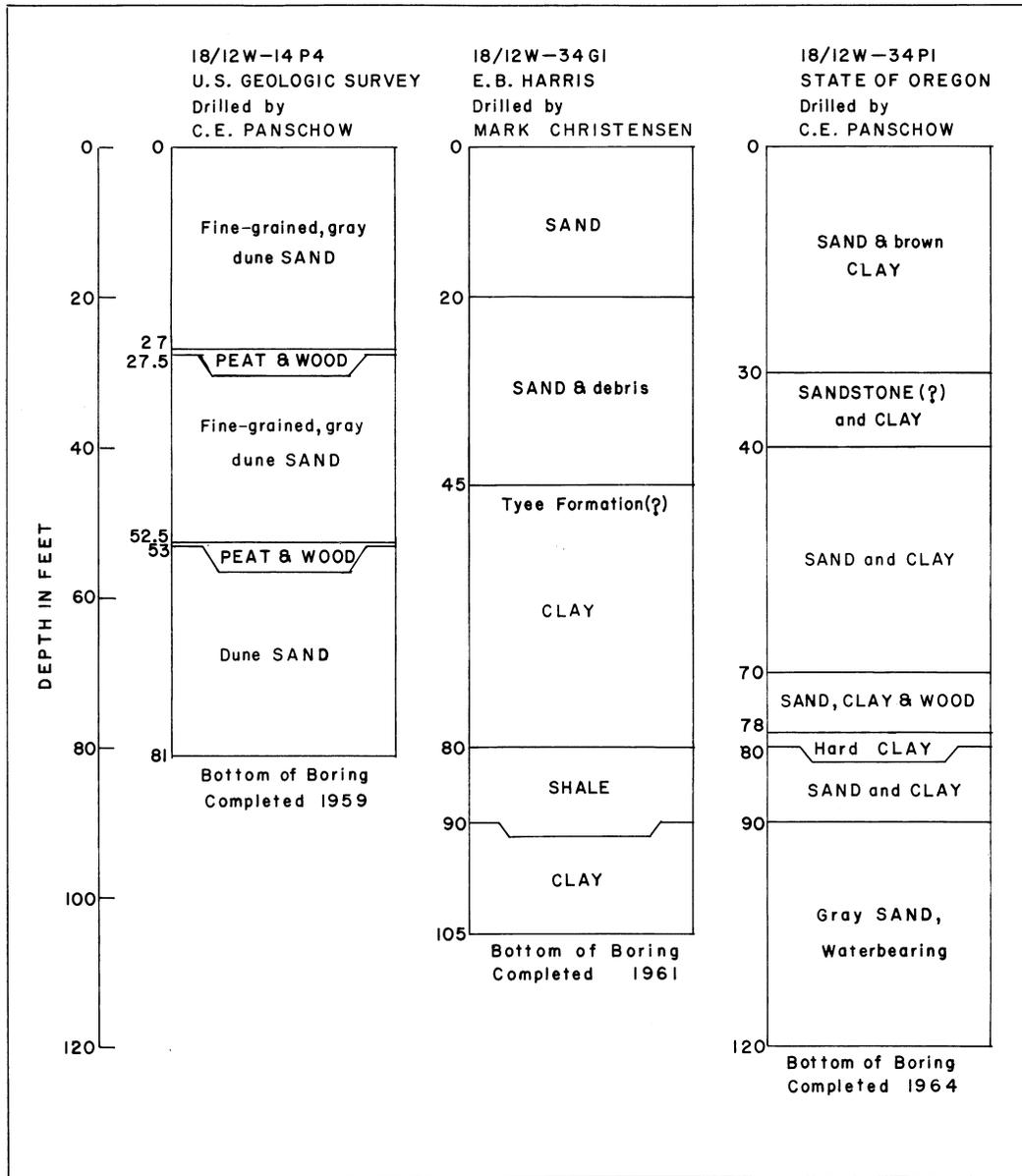


Figure 6. Three boring logs of dune sand and estuary deposits.

Elevated Alluvial Terrace Deposits

Geology

Remnants of a former river flood plain occur as high terrace deposits along the north side of the Siuslaw River, extending from near its confluence with the North Fork to about 1 mile east of Tiernan. The deposits are as much as 40 feet thick and consist of silt, sand, and thin layers of gravel. They lie on tilted strata of the Tyee Formation.

The individual terrace surfaces slope toward the river at about 2 to 4 degrees. The average elevation of the terraces ranges from approximately 250 feet m.s.l. at Cushman to 350 feet at Tiernan. The 100-foot difference in elevation is more probably due to regional folding and uplift than to a steep ancestral stream gradient.

Minor elevated terrace deposits are also present near the mouth of Big Creek. Subsurface investigation carried out for an industrial plant at this locality indicates that the deposits consist of approximately 30 feet of sand and gravel.

Engineering characteristics

Although the alluvial terraces are limited in extent, their location and nearly flat to gently sloping surfaces make them attractive sites for development.

Development of these areas along the Siuslaw River will require building steep access roads from near river level and will involve extensive cuts into the Tyee bedrock and the overlying terrace material. Since the Tyee strata dip southwesterly and tend to slide where beds dip toward a cut, possible slope instability resulting from road-building excavation should be expected. The occurrence of landslides in some areas adjacent to the terraces is an indication of Tyee instability.

Sand-Dune Deposits

Extensive sand deposits are present in the coastal lowlands in a continuous strip 16 miles long and 2 to 3 miles wide, extending from the southern boundary of Lane County to Lily Lake, about 8 miles north of Florence. Smaller, isolated areas of sand are present north of Heceta Head at Muriel O. Ponsler State Park and at Cummins Creek just south of Captain Cook Point.

Description of dune areas

South of the Siuslaw River the dune areas are characterized by a well-developed foredune adjacent to the beach. The foredune has sufficient vegetation cover to trap most of the sand blowing from the beach, hence little sand is available for replenishing the active dunes to the east. The active dunes overlie older stabilized dunes and marine terraces. The eastern edge of the stabilized dune sand bordering some of the lakes rests on Tyee strata.

North of the Siuslaw River the sand-dune area covers about 15 square miles. The sand extends about 3 miles inland from the Siuslaw River to Mercer Lake, farther than any other coastal dunes in Oregon and Washington (Cooper, 1958). More than half of this area is deflation plain and stabilized sand, and the remainder is made of five actively moving sand dunes ranging in size from $\frac{1}{2}$ to 1 mile wide and $1\frac{1}{2}$ to 3 miles long. The active dune, stabilized dune, and deflation-plain areas are indicated on the geologic map.

As described by Lund (1973):

The essential ingredients in dune formation are abundant loose sand, wind, and a favorable terrain. Other factors that may play significant roles in the dune-forming processes are water and vegetation. To the extent that his activities affect the dune setting, man also has an influence on these processes.



Photo 17. Dunes being eroded from top of marine terrace. Basalt breccia, lower left of photo, is the bedrock beneath the terrace sediments.



Photo 18. Foredune south of the Siuslaw River is stabilized with beach grass. (Photo by Frank Reckendorf, USDA Soils Conservation Service)



Photo 19. Parabolic dunes encroaching on older, tree-covered dunes and the channel of the Siltcoos River. Moving dunes repeatedly alter course of river near its mouth.



Photo 20. Slumping on face of over-steepened oblique dune west of Honeyman State Park.

The immediate source of sand for the coastal dunes is the beach, and the beach, in turn, receives its supply from the currents that move along the shore. These currents, that flow northward in winter and southward in summer, acquire their sand-load by direct erosion along the shore and from sediment transported to the shore by streams. An ample supply of sand for dune building is available along the coast, and wherever the terrain is receptive to wind-blown sand, dunes have formed.

Foredunes

The foredune is a 25-foot-high ridge of sand paralleling the beach immediately above the high-tide limit. Before the introduction of European beach grass (*Ammophila arenaria*) in about 1910, the foredunes were limited to low, log-strewn segments frequently washed out by storm waves. But since that time the grass has effectively trapped the sand blowing from the beach and built the foredunes to their present size and extent. Occasional large storms have eroded the beach side of the dunes by severely undercutting and, in some places, breaking through the foredunes.

The ability of large waves to reach the foredune with enough energy to erode depends upon the width and slope of the beach and the intensity and direction of the waves. The periods of beach build-up and beach erosion are cyclic and dependent upon factors which are not fully understood. They may be related to the movement of ocean currents, to tidal influences of the moon and sun, to movements within the Earth's crust, to long-range climatic variations which cause changes in sea level, to seasonal changes, and to variations in the configuration of near-shore sand ridges. Since most of these factors are not predictable and several may occur simultaneously, severe problems may unexpectedly occur to some part of the coastline.

Engineering characteristics: There is strong economic pressure forcing development of foredunes. Because of scarcity of land which overlooks the beach, this land brings high frontage prices. Development of the foredune should be considered extremely hazardous. The combination of high tides and large storm waves can remove a section of a foredune within hours.

Destruction of dune grass on the foredune by foot and vehicle traffic and by land development allows the sand to blow and expose building foundations, drift across roadways, and block views around houses.

Septic tank effluent flowing through loose sand in the foredune can flow directly onto the beach. Sewerage systems are necessary in any area of the foredune that is already significantly developed.

Deflation plain

A deflation plain is a depression within a sand-dune area which was formed by wind erosion. It is eroded down to the level of the summer water table; consequently during the winter when the water table rises, the interdune area becomes a series of lakes and ponds. In spring and summer, the abundance of fresh water at the surface promotes the rapid growth of vegetation. Buried layers of peat and other vegetation are common in the subsurface. The maintenance of a stable interdune area is dependent upon the continued effectiveness of the foredune to stop sand migration.

The deflation plain provides cover and food for a variety of wildlife. In addition, certain areas have been planted with grain to feed migratory waterfowl.

Engineering characteristics: The development of deflation plains with semi-permanent or permanent structures is not considered practical because of winter flooding, high water table in summer, poor foundation support, and the possible burial by sand. In addition, wind-blown sand will frost window glass and cause paint damage to houses and vacation trailers.



Photo 21. Sand dunes migrating into Cleawox Lake at a rate of about 17.5 feet per year will eventually destroy the lake unless halted.

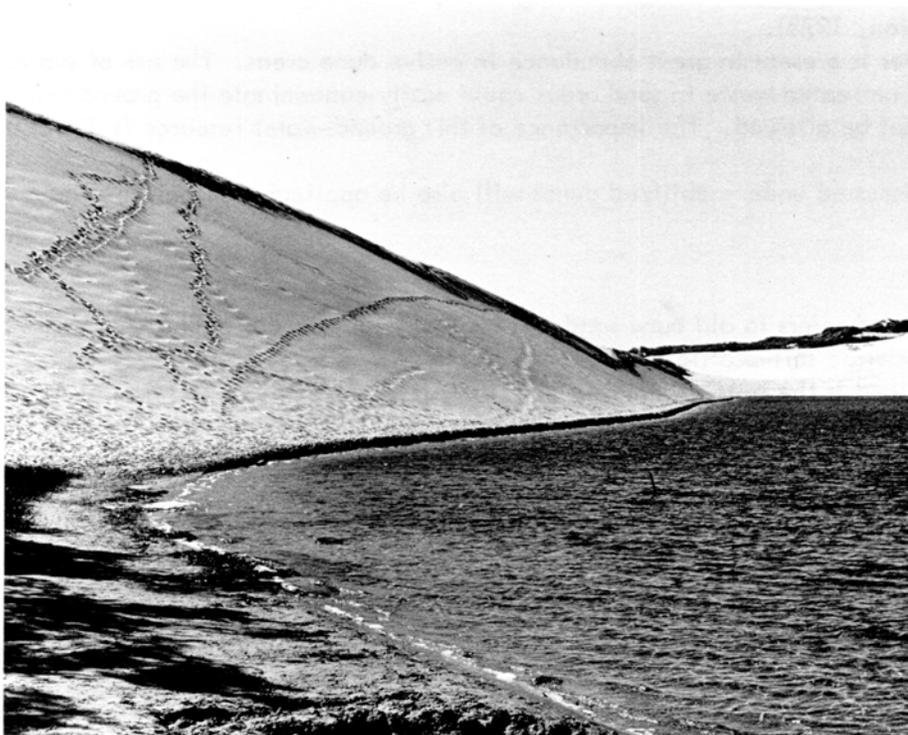


Photo 22. Sand dune is blocking exit of Cleawox Lake (center right).

Active sand dunes

The active dune-sand areas are located along the coast south of the Siuslaw River in a continuous strip 1 to 1½ miles wide and in five discontinuous north-south trending dune areas north of the Siuslaw.

Wind blowing from the ocean normally drives sand inland from the beach to produce the large dune fields which extend from the deflation plain to the forested areas and lakes to the east. Because of well-developed foredunes, many areas have not been receiving sand from the ocean for several decades. The dunes along the eastern edge of the dune field are as much as several hundred feet high and the lee side slopes at about 33 degrees.

The dunes migrating eastward have precipitation ridges encroaching on some of the lakes and pine forests. Well-developed oblique ridges are present along the eastern edge of the dune area, and smaller transverse dunes occupy the surface of the western part.

The major active dune areas migrate northeasterly at various rates. According to Frank F. Reckendorf (written communication, 1973), the dunes encroaching on the west side of Clear Lake northeast of Florence are moving at an average rate of 6½ feet per year. The dunes on Cleawox Lake (Honeyman State Park) have been moving northeastward into the lake at an average rate of 17½ feet per year. In other areas, active migration of dunes onto the forest margin is indicated by dead and dying trees.

Engineering characteristics: It is apparent that stabilization methods should be employed immediately on encroaching dunes; otherwise, some of the lakes will become sand-filled sloughs in 10 to 15 years. Because the dunes are continually shifting in response to the seasonal changes in wind direction, from southwest in winter to northwest in summer, development on open sand areas is not possible. The placement of structures in the path of moving sand dunes is hazardous and will require continual removal of unwanted sand. Large, active dunes are presently moving onto stabilized dunes and onto sand-free areas. Two methods have been employed to help control migration of sand into these areas. Fences were used successfully to provide protection from sand blowing on the access road to the south jetty of the Siuslaw River. Selective planting of European beach grass on more than 2,000 acres of high dune south of the Siuslaw River in recent years has been successful in controlling sand migration, according to Wilbur Ternyik, Florence, Oregon (oral communication, 1973).

Ground water is present in great abundance in active dune areas. The use of septic tanks and other direct disposal of untreated waste in sand areas could easily contaminate the ground-water supplies, and their use should not be allowed. The importance of this ground-water resource is discussed in the section on ground water.

Problems discussed under stabilized dunes will also be applicable to active dune-sand areas.

Stabilized dunes

Stabilized sand refers to old dune sand and small interdune areas having extensive vegetation cover and a weak to moderate soil-profile development.

Stabilized sand is the most significant unit in western Lane County in terms of intensity of development and land use. It extends continuously along the Coast Highway from the Douglas County line northward to Lily Lake, a distance of 16 miles. Two small isolated areas of stabilized sand farther north are at Muriel O. Ponsler State Park and at Cummins Creek.

Engineering characteristics: Like present-day dune sands, old dune sands have buried a variety of land surfaces, including swamps, estuaries, and tidal flats. Thus the subsurface may contain an appreciable thickness of buried vegetation, organic muds, and peat, all of which will compress if loaded with a heavy structure or embankment. The subsurface of stabilized sand areas should be investigated to determine the position and character of the material beneath the sand in order to design adequate foundations for an engineering structure.

Thick sand found in stabilized dunes is usually unconsolidated and uncemented. It is therefore subject to settlement by placement of heavy foundation loads. An extremely critical condition exists in unconsolidated sand during earthquake ground motion. During a quake, the sand grains will re-arrange according to the minimum space requirement, and settlement could be considerable. Terzaghi and Peck (1948, p. 374, 375) state that settlement is 20 to 40 times greater from vibrations than that produced by an equivalent static load.



Photo 23. Precipitation ridge of large oblique dune is overwhelming and killing old forest. Photo taken west of Coast Highway in south part of Lane County.



Photo 24. Strong winter winds cause high oblique dunes to overtake a young pine forest west of Honeyman State Park.



Photo 25. Sand dune encroaching on Collard Lake has killed trees growing on old stabilized dune.



Photo 26. Sand moving onto parking lot in Honeyman State Park must be removed frequently. Dune grass has recently been planted on upper surface of large dune to stop drifting sand.



Photo 27. Grass and trees planted in blowout through a forested area at Alder Glen Forest Camp north of Florence helps stabilize sand.



Photo 28. Small transverse dunes along the South Jetty road southwest of Florence. Note grass-covered wet land in foreground.



Photo 29. Deflation basin exposes remains of a former buried pine forest.



Photo 30. Ponded water in interdune area adjacent to South Jetty road attracts swans and other waterfowl.



Photo 31. Grass-covered hummocks are remnants of foredune west of Lily Lake. Blowouts, in foreground, provide paths for sand migrating inland from beach.



Photo 32. Deer are common inhabitants of dune areas. Photo taken from South Jetty road.



Photo 33. Sand migrating through blowout in foredune west of Lily Lake may eventually supply sand to dune field to the east.

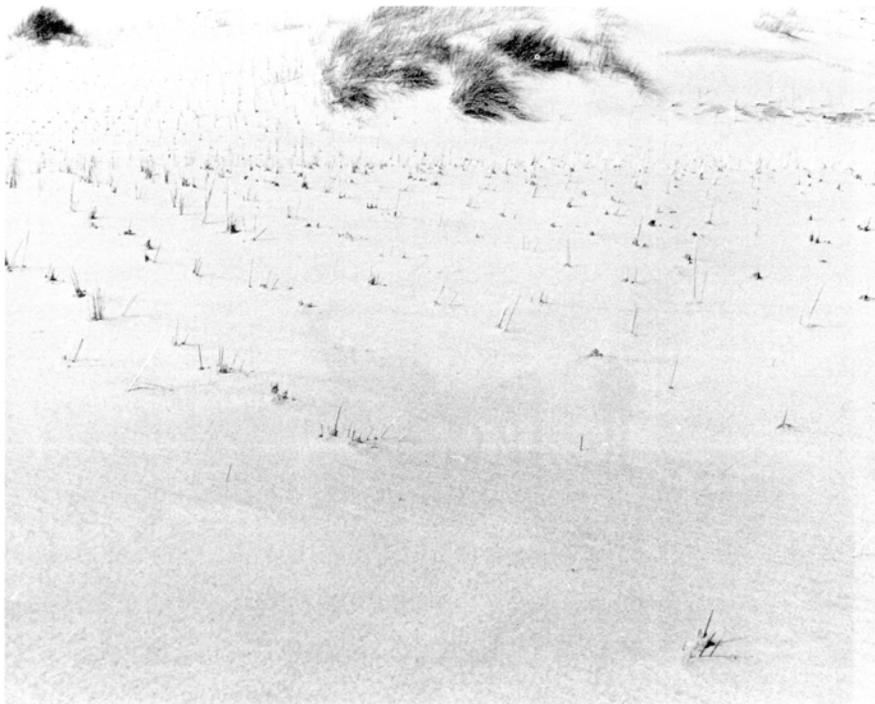


Photo 34. Recently planted dune grass west of Honeyman State Park is partially buried by drifting sand.



Photo 35. Iron bands in open dunes near Florence. (Photo by Frank Reckendorf, USDA Soil Conservation Service)



Photo 36. Active sand dunes advancing on wet interdune area. (Photo by Clarence Parker, OCC&DC)

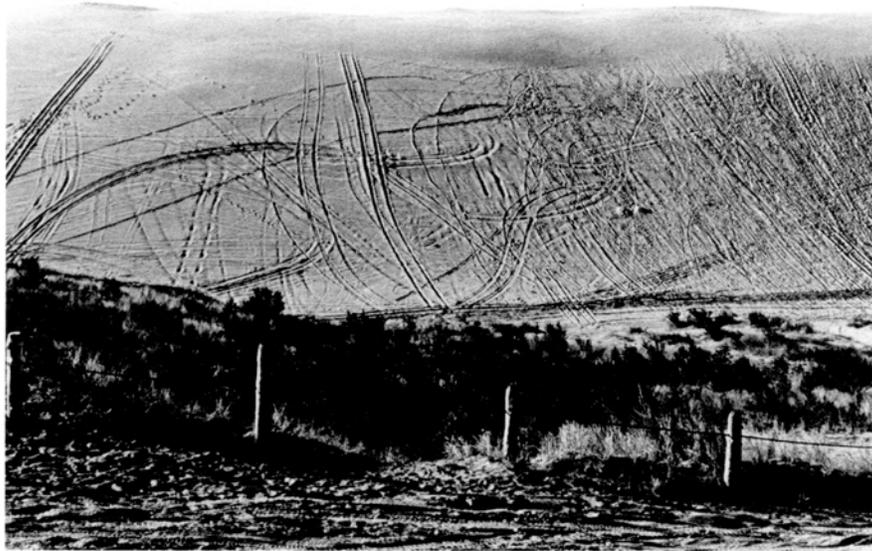


Photo 37. Vehicle and foot tracks on large dune west of Glenada show heavy recreational use. Moving sand has nearly obliterated upper tracks.



Photo 38. Sand dune engulfing a pine forest in southern coastal Lane County.



Photo 39. Leeward side of foredune and adjacent deflation plain, with transverse dunes in background. (Photo by Frank Reckendorf, USDA Soil Conservation Service)

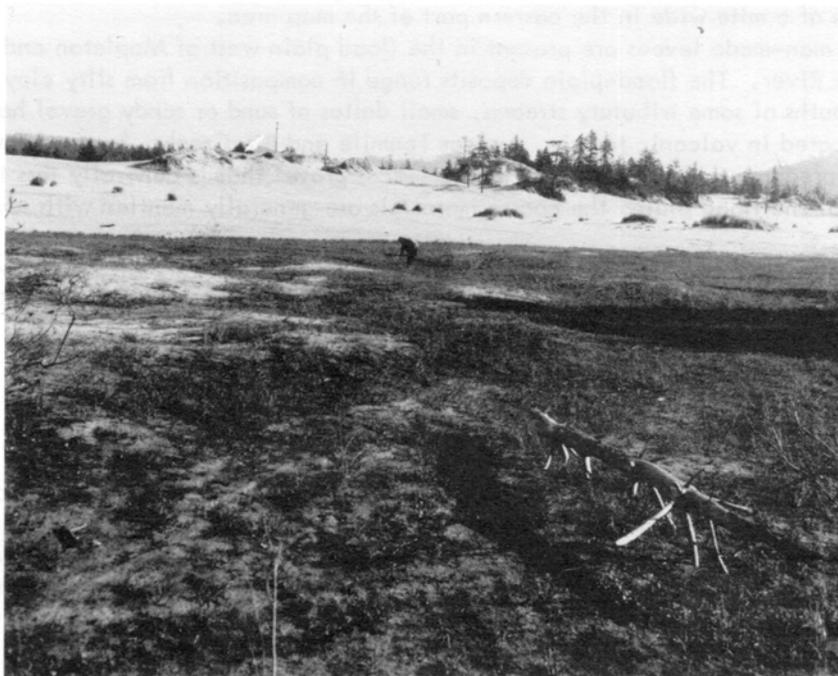


Photo 40. Wet interdune area north of Florence. (Photo by Frank Reckendorf, USDA Soil Conservation Service)

The edges of a stabilized sand area can be eroded by undercutting along streams or by gullyng on steep slopes.

The areas underlain by stable sand are being subjected to development pressure for both permanent and recreational housing. The main areas being developed are those bordering the lakes, the land adjacent to the coast highway, and a significant area between Heceta Beach and Florence.

Stabilized sand areas can be damaged easily by improper land use; therefore, the capabilities and limitations of each site should be fully understood and developed accordingly. Because loose sand will be exposed to the wind where the soil cover and vegetation is removed, such areas may need to be temporarily stabilized during extended construction periods. All cut slopes and graded areas that are to remain uncovered by construction should be permanently stabilized by replacing soil and planting vegetation.

Septic tank drainfields do not operate properly in many situations. Open sands allow the effluent to reach the water table and contaminate the ground water. Sand, although highly permeable, has inadequate pore space for storage of effluent; therefore, drain fields must be unusually large. In a short time the pore spaces and passages for effluent plug up, the drain field becomes inoperative, and effluent is forced to the surface. It may also come to the surface along moderate to steep slopes and enter drainage channels, especially where iron-cemented layers or other impermeable zones are present.

As the density of housing increases, more and more effluent will enter and contaminate the coastal lakes -- if such has not happened already. To prevent contamination of the lakes, public sewerage systems should be installed or land development restricted.

Alluvium (Qal)

Geology

The Siuslaw and smaller streams in coastal Lane County are situated in narrow canyons and most of the low terraces are subject to flooding (see Hazards Map). The valley bottom is half a mile wide maximum in the lower reaches of the Siuslaw River and the North Fork of the Siuslaw River and tapers to less than one-tenth of a mile wide in the eastern part of the map area.

Natural and man-made levees are present in the flood plain west of Mapleton and in the North Fork of the Siuslaw River. The flood-plain deposits range in composition from silty clay to sandy silt. Adjacent to the mouths of some tributary streams, small deltas of sand or sandy gravel have been deposited. Smaller streams located in volcanic terrain, such as Tenmile and Big Creeks, have narrow flood-plain deposits composed predominantly of small- to medium-size gravel that is generally less than 10 feet thick. In the wider parts of the flood plain, the coarse materials are generally mantled with several feet of sand or sandy silt.

The low terraces and flood plains of the Siuslaw River and North Fork of the Siuslaw River are used extensively for agriculture. In addition, lumber and plywood mills and marine installations associated with shipping and fishing are located on the river and adjacent flood plain as far east as Mapleton. The mill sites have been diked to protect them from all but the highest floods.

Engineering characteristics

Developments in the flood plain should be limited to those which can withstand floods or can be adequately protected from flood damage. Diking to control flood waters and improperly located land fills can produce adverse effects by retarding the escape of flood water from upstream areas. This can not only cause extended periods of flooding but can produce higher than normal flood-water elevations. A combination of heavy runoff and very high tides makes floodgates temporarily ineffective. Stream banks are frequently subject to excessive erosion. Stream-bank erosion is most likely to occur along a meandering stream such as the North Fork of the Siuslaw River. Flood-plain deposits are also being eroded along the Siuslaw River, Tenmile Creek, and Big Creek.

The use of car bodies, riprap, and piling will temporarily retard erosion, but in some cases the erosion will be directed elsewhere along the channel and continual maintenance of riprap will be necessary.



Photo 41. House is situated on natural levee of Siuslaw River near Tiernan. Highest part of levee seldom floods.



Photo 42. Flat land in foreground underlain by Quaternary alluvium which has filled old stream valley. Slopes in background modified by ancient landslide.

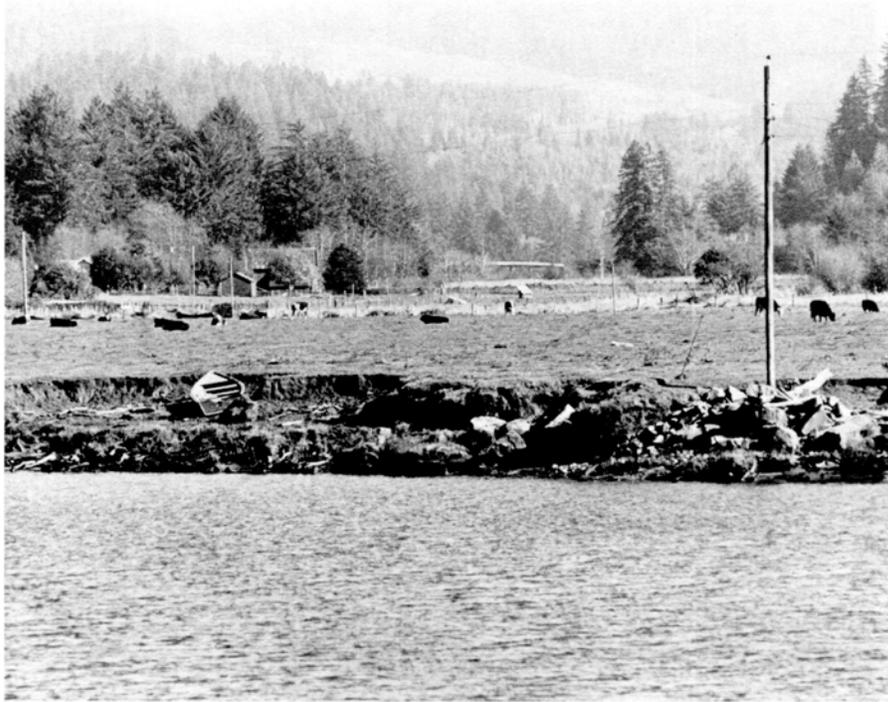


Photo 43. Erosion has occurred along bank of Siuslaw River. Note riprap placed to protect power pole.



Photo 44. Tidal flat in Siuslaw River estuary near Cushman. (Photo by Clarence Parker, OCC&DC)

Flood-plain sediments are usually saturated to within a few feet of the surface, and shallow sub-surface disposal of effluent is not practical. Because the sediments are generally soft or contain alternating soft layers, the use of piling is necessary to carry heavy foundation loads for industrial installations.

Tidal-Flat Deposits

Geology

Tidal flats are present along the Siuslaw River from Florence to the vicinity of Cushman and in the North Fork of the Siuslaw River from its mouth for about 1 mile upstream. These areas are inundated by most high tides and are exposed during most low tides. They are composed of fine-grained sediments deposited in the brackish water interface between sea water and fresh water.

The tidal flats consist of about 6 inches of soft sandy-clayey silt and organic material at the surface, underlain by several feet to as much as 80 feet of soft to moderately soft, silty clay containing lenses of sand and peat. The bottom profile of the tidal flat sediments can have considerable relief due to the presence of old buried channels.

Engineering characteristics

Engineering foundations placed in tide flats will probably be associated with landfills, bridges, docks, and warehouses. Problems relating to engineering structures are stream and ocean flooding, erosion, and uneven and excessive settlement. Drilling and sampling are necessary prior to making engineering designs to determine the thickness and consistency of the foundation soils and the nature of the underlying bedrock. Where the depth to bedrock is shallow, foundation loads can be carried by end-bearing piling or piers. Where soft sediments are thicker, friction piles may be needed.

Areas covered by landfill or roadways should be explored to determine the rate and amount of total settlement which will take place for a given load and what measures must be taken to prevent shear failure of the foundation soils. Improperly designed and constructed embankments will settle unevenly and may continue to settle for an unpredictable time span extending into years. In addition, shearing of the foundation can occur.

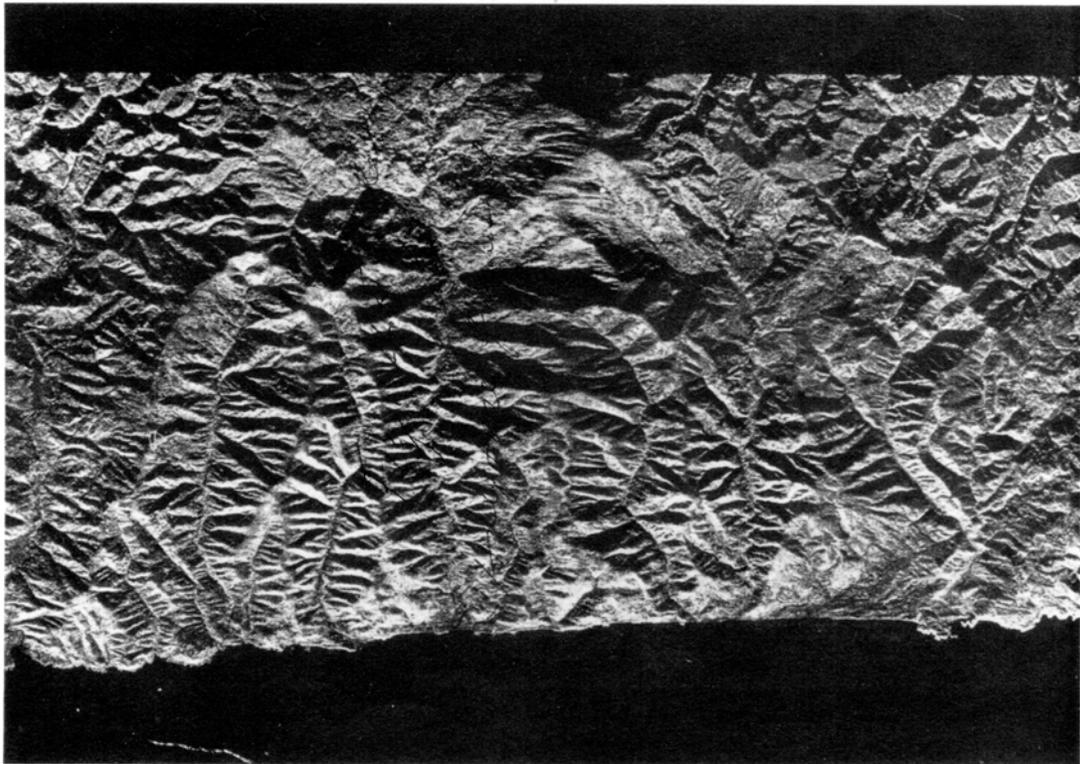
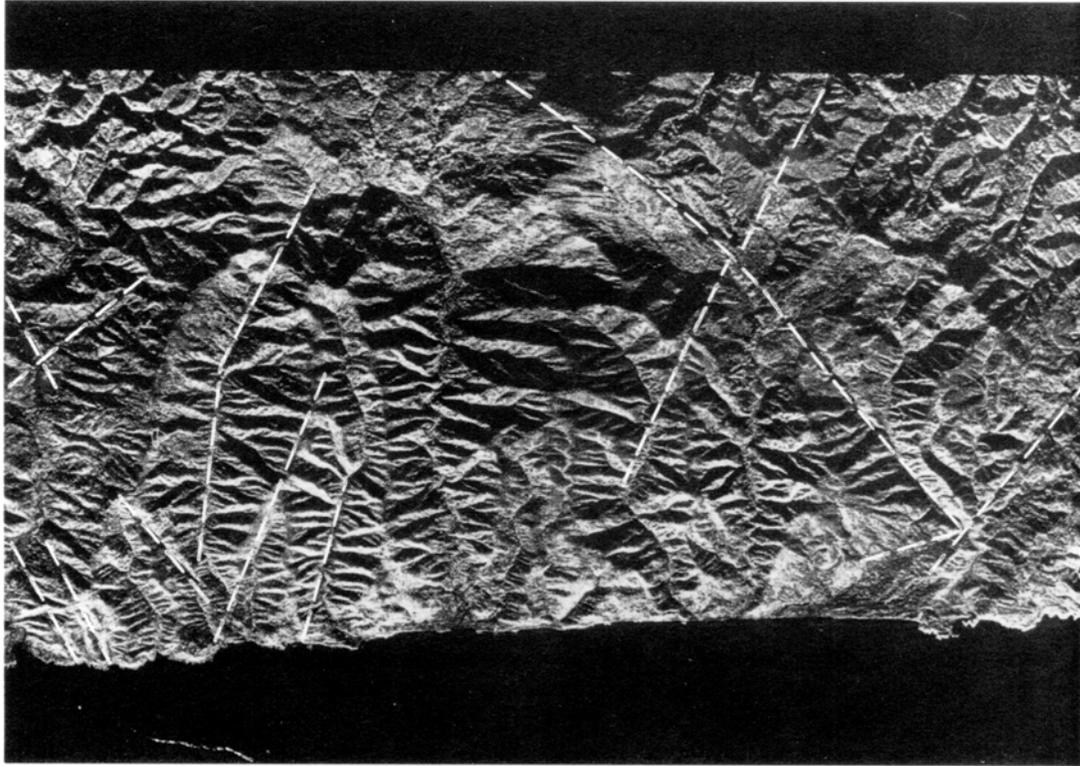


Photo 45. Side-look radar imagery penetrates soil and vegetation, revealing probable fault and fold structures in bedrock (NASA Radar Imagery). Picture on right shows structural trends interpreted from picture on left.

STRUCTURAL GEOLOGY

Information on the structural geology for the map was obtained from Baldwin (1956) and Snavely and others (1972) and through field work by the authors and study of photo lineations indicated on high-altitude radar imagery of the coastal margin.

The map area lies on the west flank of the Coast Range geanticline, a complex north-trending structural high with strong northeast-trending anticlines and synclines developed in the Tyee Formation. Most of the study area lies on the west flank of a large anticline whose axis is located approximately $2\frac{1}{2}$ miles west of Mapleton. The Tyee beds dip at low to moderate angles (5° to 15°) to the southwest, except in the northern part of the outcrop area where the beds dip mainly to the northwest.

Structural relationships in the Yachats Basalt are unclear. The predominant strike of the unit appears to be northwest, with dips ranging from 10° to 20° southwest. Mapped dips and strikes suggest that a number of west- and northwest-trending ridges are strike controlled. Tenmile Creek and Big Creek appear to be controlled by strike of the volcanic strata.

Many of the major streams in Yachats Basalt appear to be fault controlled. Faulting is indicated on the map along Cummins, Little Cummins, Bob, Upper Rock, and Cape Creeks. A northwest-trending fault along the lower part of Cape Creek has brought up sedimentary rock mapped as Tyee; detailed mapping, however, may prove this to be a younger unit. Upper Cape Creek and the North Fork of Cape Creek appear to follow a northeast-trending fault.

A study of linear trends on the radar imagery provides further conformation of faulting in Yachats Basalt (Photo 45). Radar imagery detects rock types and structures in areas of dense vegetation and thick soil cover, which makes it superior to aerial photographs for determining structures (MacLeod and Snavely, 1968).

The radar imagery photo reveals faults trending northwest across the structural grain of folding. It shows the northwest-trending lineation along lower Cape Creek where Tyee has been upfaulted against Yachats Basalt. It also reveals several northeast-trending lineations, particularly along upper Cape Creek and North Fork of Cape Creek.

The northwest-trending series of dikes in the Tyee Formation suggest emplacement along weakened fault zones, some of which follow the trend of mapped faults.

Structural deformation is reflected in the elevated alluvial terraces on the north side of the Siuslaw River where the southwesterly gradient of the deposits has been exaggerated by continued uplift of the Coast Range. The elevation of the marine terraces above the present sea level may represent uplift of land or a higher stand of the sea during the Pleistocene. No structural deformation is evident in the younger geologic units.

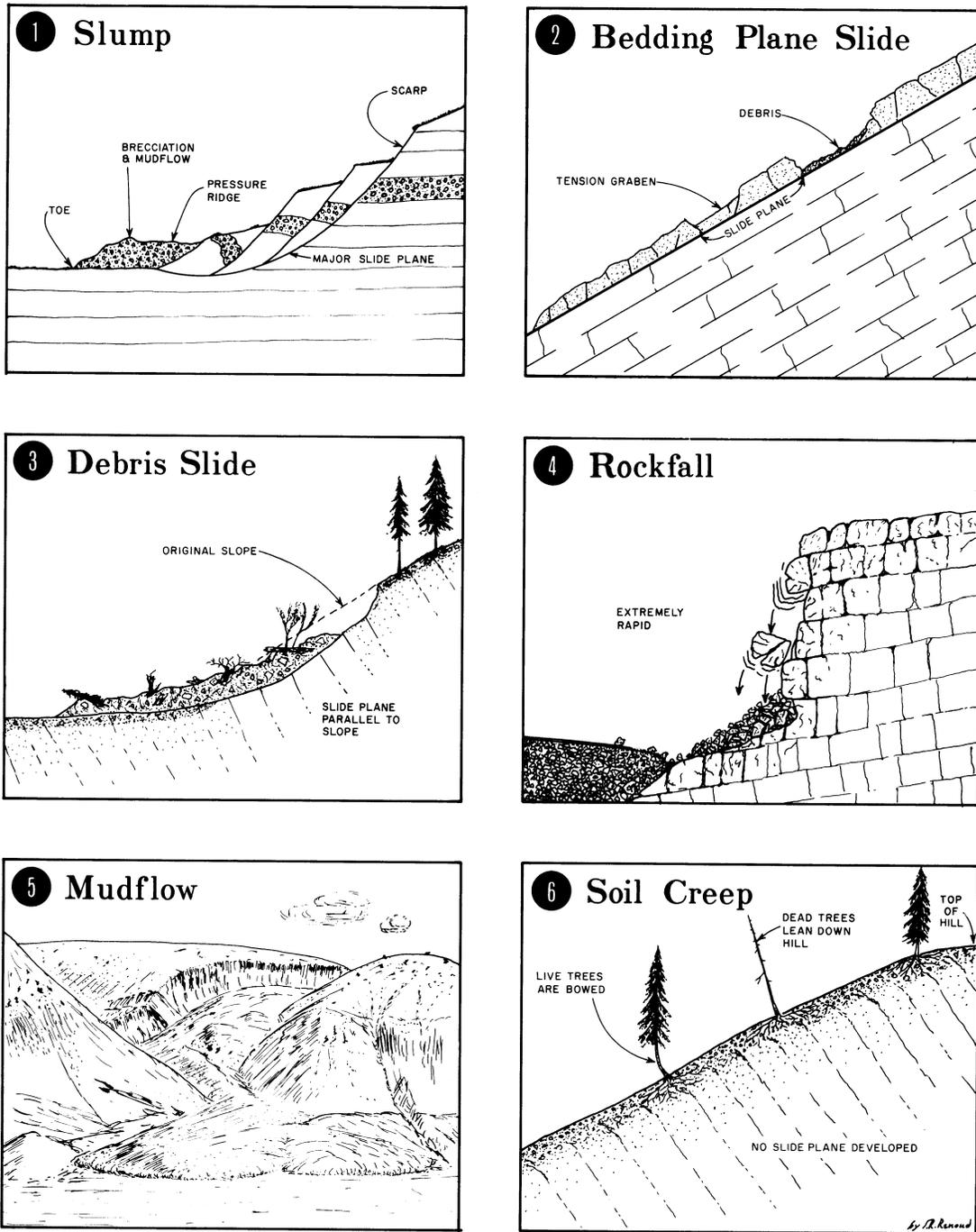


Figure 7. Diagrams of types of landslides.

GEOLOGIC HAZARDS

Landslides

A downslope movement of earth materials in response to gravity is termed a landslide, or mass wasting. A slope which has not failed by landslide but which could fail through natural geologic processes or man-made operations is called an unstable slope or potential landslide. Landslide, or mass wasting, is a normal process of slope development and therefore is widespread in Lane County and elsewhere in Western Oregon.

Active landslides are easily recognized, but ancient landslide surfaces, areas of slow creep, and unstable slopes may not be apparent except to the experienced geologist who has worked in the area.

Even minor landslides have a disastrous effect on structures or land developments. Because of the high cost of corrective procedures which may be only partially effective, areas of unstable slope and landslide should be avoided whenever possible.

Causes of landslides

A slope will fail whenever the forces of gravity acting on a rock or soil mass exceed the strength of the material. The effect of gravity can be increased by increasing the slope angle at or near the foot either by erosion or by man-made excavations. It can also be increased by addition of weight to the upper part of the slope either by adding moisture to the soil or by placing an embankment at the upper part of the slope.

The strength of the material in a slope is decreased gradually over a period of time. Weathering softens the rock and soil and forms water-sensitive clays; water percolating through the ground dissolves and removes the agents that cement the soil grains together; water in the pore spaces exerts an outward force on the soil; and certain clay materials which absorb moisture will expand, forcing the soil apart. When the strength of the soil on a slope becomes equal to or less than the forces tending to move the material, a landslide will occur.

Landslides can occur on steep slopes or very gentle slopes; they may move rapidly, intermittently, or very slowly. They may begin slowly, increase markedly, and slow to an imperceptible creep which may continue for many tens of years. Landslides, except for some of the very ancient ones, exhibit certain characteristics depending upon their age, size, and type of movement. The surfaces of landslides range from highly irregular to gently rolling topography. Tilted or bent trees, curved fence lines, sag ponds, and large displaced blocks of rock can be observed on the surface of a landslide area. Contour maps having a scale large enough to show the landslide may exhibit closed contours, irregular contour lines, a general decrease in slope relative to adjacent slopes, and a lobate or triangular-shaped area of deformation.

Types of landslides

Landslides are commonly classified as slump, bedding plane, debris slide, rockfall, mudflow, and soil creep (Figure 7). The type of landslide that is likely to occur in any one site will depend on the geology, topography, weather, and type of slope modification by natural causes or by man.

Slump: Slumps (also called rotational slides) develop major spoon-shaped slip planes in homogeneous materials. The slip plane at the top or heel of the slide is usually vertical. The radius of the curve increases toward the toe of the slide, which causes the sliding mass to develop a series of parallel subsidiary slide blocks. Each block tilts or rotates backward as the sliding mass moves downslope. Where the arc of the slide plane intersects the surface, the sliding material rides out over the original ground surface in a jumbled heap which eventually resists further movement. On the surface of the slide, trees and fence posts tilt uphill.



Photo 46. Hummocky landslide topography in Yachats Basalt on upper Cape Creek road caused by weathering of sediments, breccia, and tuff underlying basalt flow .



Photo 47. Recent landslide in upper Cape Creek drainage .

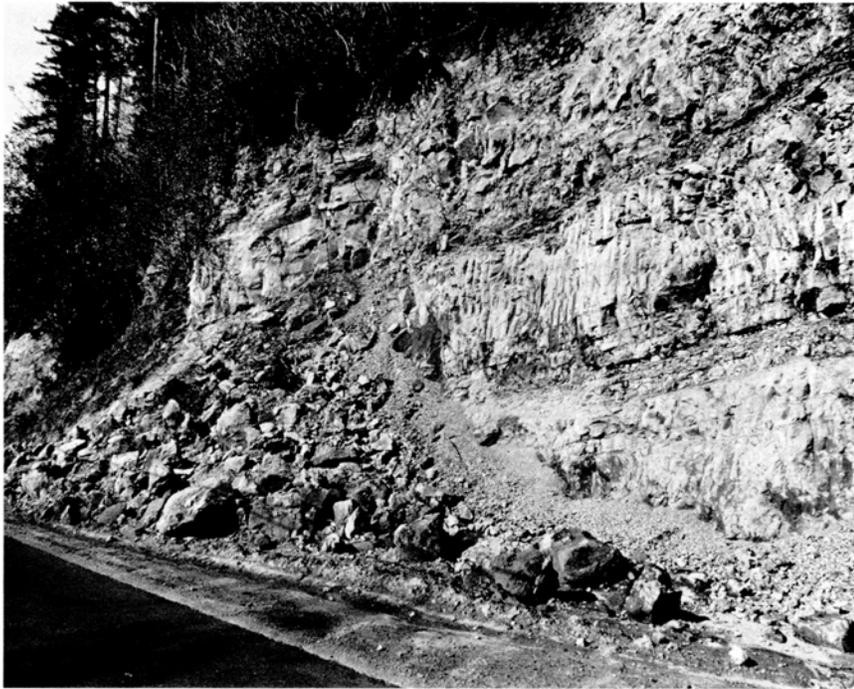


Photo 48. Rockfall in Tye Formation along North Fork road. Failure of weathered siltstone beds has removed support for overlying sandstone beds.



Photo 49. Mudflow destroyed railroad tracks near Mapleton during storms and floods of December and January 1964-65. (Photo by Siuslaw News)

Bedding plane: Bedding plane (also called block glide, or planar) landslides develop in layered rocks where lateral support is removed and sliding takes place along a plane of weakness which slopes nearly parallel to the ground surface. Bedded rocks often contain clay layers. Only one such layer a few inches thick in a thick strata of otherwise sound rock can easily lead to failure. The effects of structure on the stability of a slope are clearly shown in highway roadcuts in the Tyee Formation, where on one side the bedding dips towards the cut while on the other it dips into the hill. In the latter instance, no sliding can be detected, but the former shows significant failure.

Debris slide : Debris slides occur on steep slopes covered with granular rock fragments and soil; they tend to develop rapidly during heavy rainfall. Debris slides are easily reactivated by natural or man-made alterations in slope, water content, or surface runoff.

In western Lane County, debris slides occur mainly in colluvium from volcanic headlands along the coast and on the steep side slopes of the major stream valleys cut in the Yachats Basalt and the Tyee Formation.

Rockfall: Rockfalls occur on very steep surfaces when material becomes dislodged and tumbles, slides, or falls downward to the bottom of the slope. Rockfalls are generally limited to areas where rivers or ocean waves are undercutting the toe of a steep slope to produce an overhang which fails abruptly with little warning. Small rockfalls occur in steep, high roadcuts in combination with bedding plane and slump type slides.

Mudflow: Mudflows are a common type of slope failure on construction projects. They occur in moisture-sensitive soils which become oversaturated. The soil mass begins to move due to weight and loss of strength, and the subsequent decrease of pore space caused by the shifting of the silt and sand grains produces excess water which buoys the mass down even gentle slopes. Once these slides have developed velocity, they will travel hundreds of feet on a horizontal surface.

Mudflows move downslope in any available channel. As they reach the toe of the slope, they fan out, leaving a characteristic interlobed deposit. These can vary in size, but only the larger ones will show up on a topographic map.

Soil creep: Soil creep is a slope failure in which no slip surface has developed. It most frequently occurs in weathered surface materials and colluvium. Because the surface moves a greater distance than the subsoil, trees and fence posts tip or are displaced downhill. The rate of movement may be imperceptible, but structures will suffer damage within a short period of time. Cracks form in the soil which introduce more water into the ground, and other types of landslides can develop from creep.

Recommendations

It is imperative that all landslides, potential landslides, and unstable slopes be identified in an area where development or construction is to take place.

Large, obviously active landslides will in almost every instance cost more to stabilize than the property is worth afterwards. Such areas should be left undeveloped. If the original cause of the landslide is still in effect, such as erosion of the toe of the slide by a stream or wave action along a shoreline, future sliding will probably occur.

Old landslides which still exhibit features such as bent trees and water-filled sag ponds should be viewed with suspicion. Many such areas may be moving very slowly and intermittently, up to a few inches per year, and motion can be detected only by surveyor instruments. This type of movement can cause continual damage to a structure, and maintenance costs can in time force abandonment. Housing developments placed on this type of landslide often cause the slide movement to increase by addition of moisture to the ground.

In contrast to old landslides, ancient landslides are those having no historical movement but which exhibit a subdued rolling topography, sag ponds now drained, large straight trees (if present), and a surface slope less than that of the adjacent areas. If an ancient slide area can be identified as being stable and distinguished from an "old landslide" which may still have movement, certain uses can be made of the land.



Photo 50. Excavation in toe of old landslide mass in Tye Formation about $1\frac{1}{2}$ miles east of Tiernan.



Photo 51. Slumping in toe of old landslide material at east end of cut shown in above photo.



Photo 52. Minor slope failure in stony colluvium overlying weathered Yachats Basalt.



Photo 53. Embankment failure on county road north of Sutton Lake occurred in thick, unstable shale within the Tye Formation.

Housing developments must be properly designed and drainage installed so that the moisture content of the slope will not increase. Excavations and embankments should be small and the density of housing light.

Ancient and old landslides, if not properly developed, can be re-activated, but this does not usually take place until about 5 years to as long as 25 years after the houses have been built and the development established. In a dense housing area, almost half of the ground is covered by streets, driveways, sidewalks, and houses. Most of the moisture that strikes the ground will be concentrated in the areas remaining open if sewerage and drainage systems are not installed or are not adequately designed. Open areas include lawns and gardens which tend to be routinely irrigated. All water that soaks into the ground adds considerably to the subsurface-soil water content. Much of the overall soil moisture is not reduced during the dry season because evaporation and transpiration losses are eliminated in ground covered by the development (foundation slabs, pavement, etc.). The moisture content of the ground increases to a critical degree, and slope failure is likely to occur, particularly where the slopes have been increased.

Erosion

Foredunes

Bordering the beach from Sea Lion Point southward, a foredune has built up. During storms and high tides, waves attack and erode the loose sand on the seaward side of the foredune, producing nearly vertical slopes 5 to 15 feet high. Which section of the foredune will erode in a given year is unpredictable and varies from time to time, depending upon such factors as wind and wave direction and configuration of the beach.

Construction of beach-front homes, motels, and condominiums on foredunes is increasing. On occasion, storms have eroded the foredune to the extent that the structures have been endangered, damaged, or destroyed.

Protection of the foredune from wave erosion is not considered practical for several reasons. Large riprap is costly, requires frequent repair, and is unsightly. Persons using the beach where riprap has been installed are forced to climb over large, angular boulders and blocks of heavy rock with the risk of falling or dislodging a rock, which could cause serious injury.

A more permanent protection, but at considerably greater expense, is the construction of a concrete seawall. Such a seawall can cost approximately \$300 or more a lineal foot. The design and construction of the wall poses many problems and requires the services of experts in this field.

Because of the hazards associated with developments there, foredunes should not be used for building sites. Where sand immediately behind the foredune has been stabilized by vegetation, certain types of development may be satisfactory. However, engineering and construction must consider all of the problems associated with sand areas, including sewage disposal, shifting sand, weak foundation strength, and wind erosion.

Marine terraces

Marine terraces, although limited in extent, are in demand for housing, recreation, and commercial uses. The marine terraces are almost the only places along the County's north shoreline which provide both flat ground to build on and access to the beach.

The terraces are generally narrow and in many places are bisected by U.S. Highway 101, which limits buildable areas. Erosion of the vertical escarpments facing the beach further reduces the terrace area. Sandy marine terraces retreat about 1 foot per year on the average, although slump or landslide may remove as much as 50 feet at one time.

A straight or gently curved, nearly vertical terrace escarpment is indicative of a terrace undergoing slow, steady erosion and having slight possibility of large slope failures. Conversely, an extremely irregular terrace face with uneven slopes is probably eroding at a faster rate, accelerated by frequent slumping.

Buildings located on marine terraces should be set back in accordance with the rate of erosion, degree of stability, and the length of time the site will be used.

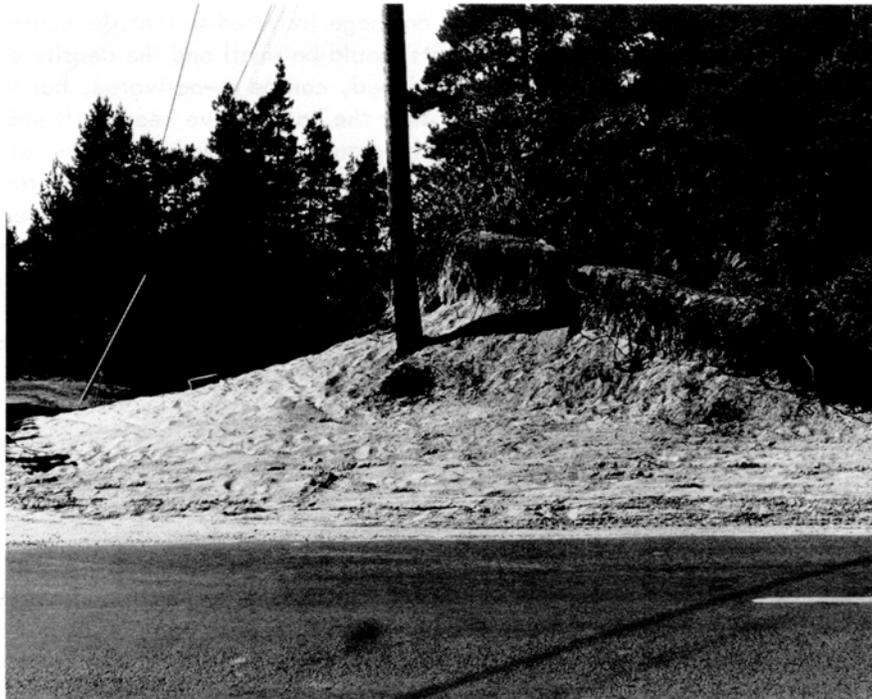


Photo 54. Roadcut in stabilized dune area near Munsel Lake exposes sand to active erosion where vegetation and soil have been removed.



Photo 55. Riprap provides only temporary protection for resort motel situated on foredune where wave and wind erosion are a constant threat.



Photo 56. Remnants of foredune destroyed by wave and wind erosion north of Heceta Beach. (Photo by Clarence Parker, OCC&DC)



Photo 57. Grass cover protects foredune from wind erosion but not from storm waves. Driftwood washed high on beach aids development of foredune by collecting sand and allowing grass to take hold.



Photo 58. South spit of Siuslaw River undercut by storm erosion; riprap placed to reduce erosion. (Photo by Frank Reckendorf, USDA Soil Conservation Service)



Photo 59. Development of a beach between headlands in Yachats Basalt indicates an area of unstable slope that may extend inland to affect highways and buildings. Note active debris slide at far end of beach.



Photo 60. Severe erosion of terrace north of Tenmile Creek shows need for locating buildings far back from retreating bluff. Wave-borne driftwood contributes to erosion during winter storms.



Photo 61. Wooden piling and riprap are used to retard stream-bank erosion.



Photo 62. Severe erosion of stream bank along flood plain on North Fork of Siuslaw River.



Photo 63. Alder Lake situated in a blowout in a forested dune area. Lake level fluctuates with water table in the adjacent dunes.



Photo 64. Building site in stable dune area south of Heceta Beach.
Soil is being tested by hand auger prior to placement of septic tank
drain field.



Photo 65. Locally active sand area in foredune near Heceta Beach.
(Photo by Frank Reckendorf, USDA Soil Conservation Service)

Headlands

Rocky knolls or headlands seldom receive the pressure of development that occurs on other types of terrain, mainly because of the limited number of good development sites available and the difficulty of excavating the hard basalt and breccia.

Because of the relatively greater ability of the volcanic rocks to withstand coastal erosion, they extend farther seaward than do the terraces.

In many areas the hard rock is covered with several feet of soil and rocky colluvium. This material is susceptible to slope failure on the eroding ocean-facing escarpment or in excessively high, steep cuts.

The use of septic tank drain fields will sometimes be satisfactory where the soil is thick (5 feet or more) and in an area that is adequately large. If the drain field is located too close to the escarpment, the effluent can seep to the surface at the contact between the colluvium and the volcanic rock. This can create a health hazard as well as disagreeable odors. Steeply sloping colluvial surfaces are not satisfactory for drain-field operation because effluent can seep to the surface farther downslope, and the added moisture of the effluent will create instability and possibly cause sliding.

Stream banks

Erosion is common along the banks of the major rivers in the area and to some extent along the smaller streams. The most rapid erosion occurs as a result of flooding. The edges of the flood plains along the Siuslaw River and North Fork of the Siuslaw are being eroded in many places. When erosion threatens an expensive structure or valuable farmland, it becomes economically feasible to provide protection. The most common practice is to use large angular stone or riprap from a local rock quarry. Piling can also be used; however, this requires the use of expensive pile-driving equipment. In some cases, a properly placed piling wing can divert the force of the water from an eroding stretch of bank, but the force of the current may then be diverted to another area on the opposite side of the stream, causing serious problems there.

Small streams flowing directly into the ocean in the northern part of the County have fairly high gradients, and during flood stage the water has considerable erosive power. Most of the stream channels are nearly straight, but only slight deflection in direction can divert the force of the water into a stream bank. Where colluvial slopes extend to the creek channel, erosion can proceed until the oversteepened slope fails by landslide. Road fills placed in the reach of flood waters can be damaged by water erosion.

Changes in stream pattern can occur where gradient is suddenly reduced, causing velocity to be decreased and gravels to be deposited. The gravels can block the stream channel and force the stream to seek a new channel, frequently against an easily erodable slope.

Generally, structures which need protection in inland mountainous areas are roadbeds, fills, and bridges. Riprap is generally used for this purpose if it is available.

High Water Table

High water table refers to near-surface ground water which presents problems in land development and construction. It may be caused by impermeable layers beneath the ground surface which collect water and prevent it from moving downward. Water is also introduced into the ground by springs and hillside seepage, and collects in natural swampy, low-lying areas. Water stands near the ground surface in the low-lying areas of both stable and unstable sand. In the deflation plains in winter, the water table rises above the ground surface, forming ponds and lakes.

High water table is undesirable for several reasons. It precludes the use of basements, septic tanks are inoperable, and hydrostatic pressures can rupture empty swimming pools and force buried storage tanks to the surface when contents are pumped down.

Flooding

This portion of the report provides information concerning flooding in the valleys of the Siuslaw River, the North Fork of the Siuslaw River, and on several of the smaller streams in western Lane County.

Sources of information

Most of the information in this report has been gathered from the Port of Siuslaw and from brief studies by various State and Federal agencies, including reports by the U.S. Geological Survey, the Water Resource Research Institute of Oregon State University, and the State Soil and Water Conservation Commission (1973), the U.S. Army Corps of Engineers Portland District, the U.S. Department of Agriculture (1964), and the State Water Resources Board (1965). Other data were obtained from the Siuslaw News of Florence and from discussions with individuals who were present during the flood.

Flood damage

The flood of December 1964, and to a lesser degree the floods of February 1972 and December 1973-January 1974, did considerable damage in western Lane County and created severe hardships for many people. The Siuslaw News of December 24, 1964 reported that water crossed the highway at Cushman during periods of high tides on December 19, 20, and 21.

On December 21, 1964, tides raised the Siuslaw River nearly to street level in the Florence waterfront area. After the major 1964 flood, the Siuslaw News of December 29, 1964, displayed many photographs of flood damage. A barn and many logs were pictured jammed together against the bridge at Cushman. Water was 46 inches deep in one house and more than 30 inches in many others, forcing families to leave their homes.

In Mapleton the Schwartz Grocery had a foot of water in the store, and the Evangelical United Brethren Church had 19½ inches in the sanctuary. About 90 percent of the houses in Mapleton were damaged, and after the flood waters receded, Riverview Avenue was covered with 6 to 10 inches of silt. It was reported that rainfall at Florence for the 8-day period beginning December 20, 1964 was 9.25 inches, while during the same period at Mapleton, rainfall was 20.09 inches.

State and local agencies reported the following losses:

	<u>1964-1965</u>	<u>1972</u>
Private property (includes manufacturing and businesses)	\$157,431	\$296,000
Public property (includes governmental agencies, railroads, and public utilities)	192,000	479,700
Agriculture	<u>not surveyed</u>	<u>80,500</u>
Total	\$349,431	\$856,200

Most of the preceding data were taken from an inventory of flood damages by Wilbur Ternyik and Paul Coyne of the Port of Siuslaw.



Photo 66. The 1964-65 flood on the Siuslaw River severely damaged lumber industry west of Mapleton when dikes were topped. (Photo by Siuslaw News)



Photo 67. Mapleton was almost entirely under water during the 1964-65 flood. (Photo by Siuslaw News)



Photo 68. Houses located on natural levee of the Siuslaw River near Mapleton are only occasionally flooded. (Photo by Siuslaw News)



Photo 69. Mapleton residential area during the 1964-65 flood. (Photo by Siuslaw News)

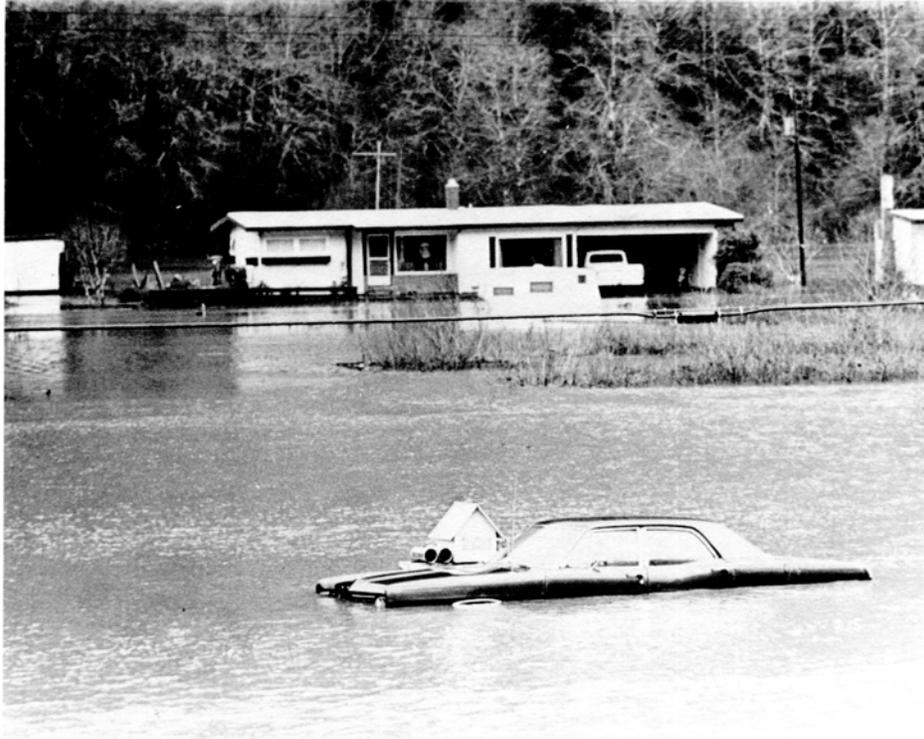


Photo 70. Highway traffic halted between Mapleton and the coast during the 1964-65 flood. (Photo by Siuslaw News)



Photo 71. Siuslaw Valley Bank at Mapleton flooded in 1973-74. (Photo by Larry Bacon, Eugene Register Guard)



Photo 72. Farm animals were stranded by the 1964-65 flood when most of the flood-plain pasture land along the Siuslaw River was covered with water. (Photo by Siuslaw News)



Photo 73. Chickens take refuge on small raft during 1974 flood at Mapleton. (Photo by Larry Bacon, Eugene Register Guard)



Photo 74. Flooding at Siuslaw marina in 1974; previously, water had been across highway. (Photo by Donna Hepp, OCC&DC)



Photo 75. Rescue operations at Mapleton during the 1974 flood. Water entered many houses along the Siuslaw River. (Photo by Larry Bacon, Eugene Register Guard)

Causes of stream flooding

The coastal streams flood frequently and sometimes more than once in one year. Large damaging floods are less frequent but occur on an average of about every $5\frac{1}{2}$ years. Flooding along the coast is caused by a number of factors present in the coastal environment. Large winter storms coming from the ocean bring considerable amounts of moisture which precipitate in excessive amounts when the air cools as it is being lifted over the mountains of the Coast Range. Rain falling on the Coast Range runs off almost immediately because of steep canyons, short streams with high gradients, and because the underlying bed-rock in most of the area is composed of impermeable sedimentary rocks.

Extensive road systems and clear-cut logging operations in the mountainous areas during the past several decades not only speed runoff but add wood debris and sediment to the flood waters. Constriction of the waterways by log jam, landfill, piling, and structures such as bridges, marinas, and docks can increase the effects of flooding. Diking placed to resist the spread of flood waters can hold back flood water and raise the water level upstream.

A major contributing factor to flooding is the effect of high tides generated by winter storms. Published tide tables do not consider the effect of wind, which can push a normal 6 or 7 foot tide to a height of 12 feet and more. When this occurs, the effects of the flood are extended greatly.

Soft Compressible Soils

Soils which settle unevenly under light to moderate foundation loads may be of several categories. The most critical of these is peat. Peat contains a large percentage of organic matter, mostly fibers, and is spongy and lightweight. It is usually water saturated and under load will frequently consolidate to less than 50 percent of its original volume. Peat occurs at the surface in swampy areas where the water table is rising slowly enough to allow the vegetation to remain and grow without being submerged. These conditions prevail along the margins of bays, estuaries, and mouths of streams in conjunction with a rising sea level or a subsiding seacoast. The build-up of a dune blocking the entry of a small stream to the sea will cause a rise in water level and promote the growth of peat. Shifting sands can cover the peat and form a buried layer of compressible soils. Recent and old dune areas should be thoroughly investigated for buried peat soils if the site is to serve as a foundation for a structure.

Soft compressible soils can be several tens of feet thick in alluvium within the estuaries of the Siuslaw River and North Fork of the Siuslaw River. These soils are composed of sand, silt, and organic material and are subject to flowage under foundation loads such as road fills or foundation mats. In addition to excessive uneven settlement, the soil can fail by shearing under heavy embankment loads, causing an elevated ridge to form parallel to the toe of the embankment. Counterweights should be designed to prevent pressure build-up and shearing, and, if more rapid settlement is desired, sand drains can be installed to drain off water forced out during the consolidation of the soil. Compressible soils can also be effectively treated by pre-loading, which requires a period of from several months to a year for the soils to consolidate.

Fine-grained alluvial soils deposited in the tidal areas of the major flood plains may contain layers of soft soils. Roads built on these areas will settle unevenly and produce an undulating grade. Subsurface investigations are needed to determine the extent of such material and the engineering design necessary to minimize the extent of the uneven settlement.

Earthquakes

Earthquakes in western North America are believed to be caused by the interacting motion of two large lithospheric plates, the North American Plate and the Pacific Plate. Off the Gulf of California, earthquake epicenters show that the locus of interaction of these two plates is associated with the East Pacific Rise. North of the Gulf, in southern California, the loci of earthquake epicenters appear to divide into two branches, according to Barazangi and Dorman (1969).

The western branch of epicenters, associated with the San Andreas fault system in California, passes out to sea in the vicinity of Cape Mendocino. Between Cape Mendocino and the northern end of Vancouver Island, the locus of epicenters is associated with the ridge-rise-transform fault system which exists off the coasts of northern California, Oregon, Washington, and Vancouver Island.

The eastern branch of epicenters is less well defined, appearing as a broad zone or belt extending northward through Nevada, Utah, Wyoming, and Montana. The eastern earthquake zone either ends in northern Montana or is diffusely connected to the earthquake activity in the Puget Sound region. Oregon and parts of Washington and Idaho appear to be a relatively quiet island between the two zones of plate interaction.

Earthquakes are products of deep-seated faulting and subsequent release of large amounts of energy. Vibrations radiating from the fracture are felt or recorded at the earth's surface as earthquakes. In some places, such as the San Andreas fault in California, the fault producing the earthquake can be mapped at the surface, but in many instances the fault is buried (concealed) and cannot be observed at the surface.

In western Lane County several significant faults or photo lineations (which probably indicate zones of faulting) are present. These are shown on the geologic map and are located primarily in the Yachats Basalt but some extend easterly into the Tyee Formation. They form similar patterns to those mapped to the north and east in Lincoln County by Snavely and others (1972) and Schlicker and others (1973). The age of the faulting is not well established, but the youngest bedrock unit involved in western Lane County is upper Eocene (38 m.y.). To the north in Lincoln County, the youngest bedrock unit involved in faulting is late Miocene (15 m.y.). Although the marine terrace deposits of Pleistocene age along the Coast occupy only small areas, no faulting was observed, indicating that fault movement is at least older than the deposits and suggesting that faulting is probably older than 0.5 m.y. Although faulting is extensive, no master earthquake-producing fault system is indicated.

Earthquake summaries by Berg and Baker (1963) and Couch and Lowell (1971) provide the historical earthquake data for the region. The data indicate that the recorded seismic history extends back to the late 1880's. During this period, no earthquakes were reported in Lane County, but in the Newport area (approximately 25 miles north of Florence) six earthquakes were reported. These included four at Newport, with intensity ratings (Modified Mercalli) of IV; one at Waldport, intensity rating IV; and one at Seal Rock, intensity rating IV. Northeast of the area at the community of Asea, an earthquake with an intensity rating of III was reported (see Appendix C for Modified Mercalli scale).

Couch and Lowell (1971) have summarized information on seismic energy release in the entire Coast Range physiographic province of western Oregon. They report the seismic energy release for a 100-year period (1870-1970) as 6.4×10^{16} ergs per year, which they computed as approximately equivalent to one magnitude 5.0 earthquake each decade. This compares with 2.6×10^{17} ergs per year for the same period at Portland, an approximate earthquake level of one magnitude 4.8 earthquake each year or one magnitude 5.2 each decade.

Couch and Deacon (1972), recognizing that the seismic history of the Coast Range is not sufficiently long to record the maximum "likely" earthquake, made an attempt to evaluate the maximum level of seismicity to be expected in the region. These studies indicate that a distant earthquake from Port Orford (approximately 80 miles south) could produce ground motions of intensity IX (MM) at Florence. This estimate is based on empirically derived attenuation curves and is probably too high. Historical data show the Port Orford earthquake of 1873, intensity VIII (MM), was the highest intensity recorded. It would seem probable, therefore, that the maximum intensity that could occur in the Florence area from a distant earthquake should be on the level of intensity VIII (MM). Present seismic zoning in the Uniform Building Code (1973) indicates that the Florence area lies in Zone 2--a zone of moderate damage corresponding to an earthquake level of intensity VII (MM). Our estimate of a maximum earthquake of intensity VIII would place the area in Zone 3 of the Uniform Building Code seismic zoning, which is indicated as a zone of major damage.

Ground motion during earthquakes can affect not only buildings, bridges, and similar structures but also areas of potential land subsidence and landslides. Granular soils, especially thick sections of loose, saturated sand and gravel, will consolidate and subside as a result of ground shaking. Because subsidence is usually uneven, structures on such ground may settle differentially, resulting in extensive damage. In areas of moderate to high relief with existing landslides or unstable slopes and saturated ground conditions (such as many areas of western Lane County during winter months), an earthquake could trigger numerous landslides. In addition, ground response in saturated lowland soils could result in liquefaction or downslope flow, even on gentle slopes.

ECONOMIC MINERAL RESOURCES

Construction Aggregate

Crushed rock and sand and gravel are used extensively as aggregate in the construction industry. Aggregate is the basic ingredient in concrete and is used in the building of highways, roads, streets, embankments, landfills, and buildings.

Rock is used in three main areas of construction in western Lane County: forestry, highway construction, and commercial uses. The requirements for the first two uses are related to the size of the area, and for commercial use requirements are related to population growth and industry.

Forest roads

Most of the land in western Lane County is forest land. The area is covered by a network of roads maintained for forest access and fire protection. Additional roads are constructed annually for access to logging and timber sale areas.

It is estimated that approximately 45,000 tons of rock are used annually by the Siuslaw National Forest, the major timber owner in the study area. Although about a dozen rock quarries are located in the National Forest lands, only four or five are actively used. The others are available and utilized whenever local sources are warranted. Rock is obtained from commercial quarries when it is available within a reasonable haul distance.

Future requirements for forestry uses should not change much. The amount of new road construction is decreasing, but maintenance and improvements on existing roads are increasing. Although some sources may become depleted, expansion of others and the development of new quarries should provide adequate rock for the future, possibly at higher costs.

Highway construction

The Oregon Highway Division and the Federal Highway Administration have both been active in highway construction in western Lane County in recent years. The amount of rock used is large but highly sporadic; records for the past 10 years show that in 3 different years about twice the normal annual production was needed. For this reason, we have used averages of aggregate use over a 10-year period to obtain annual usage and future predictions.

Occasionally, requirements for large quantities of rock having highway-quality specifications can not be met within western Lane County because of limited capacities of local plants, and the expense of enlarging plants for short-term need would not be justified. Therefore, gravel has been imported from the Umpqua River in Douglas County and the Willamette River near Eugene.

Rock from local sources is used for maintenance of the highways. This repair work normally requires several thousand tons per year, but after a disastrous storm and flood, such as occurred during the December 1964-January 1965 period, much more is used.

Future requirements for highway construction and maintenance should remain at about the same level. New highways are not likely to be constructed; however, existing roads will require major improvements or rebuilding. An average of about 45,000 tons of crushed rock has been used annually in highway construction for the past 10 years, and, in addition, 354,000 tons of sandstone was used for embankments and widening. Sandstone is not suitable for aggregate and is seldom used for base rock as it disintegrates rapidly on exposure and breaks down under heavy wheel loads.



Photo 76. Berry Creek quarry north of Florence (No. 24 on geologic map). Rock is mainly weathered breccia of Yachats Basalt. Large block, center of photo, is about 15 feet across.

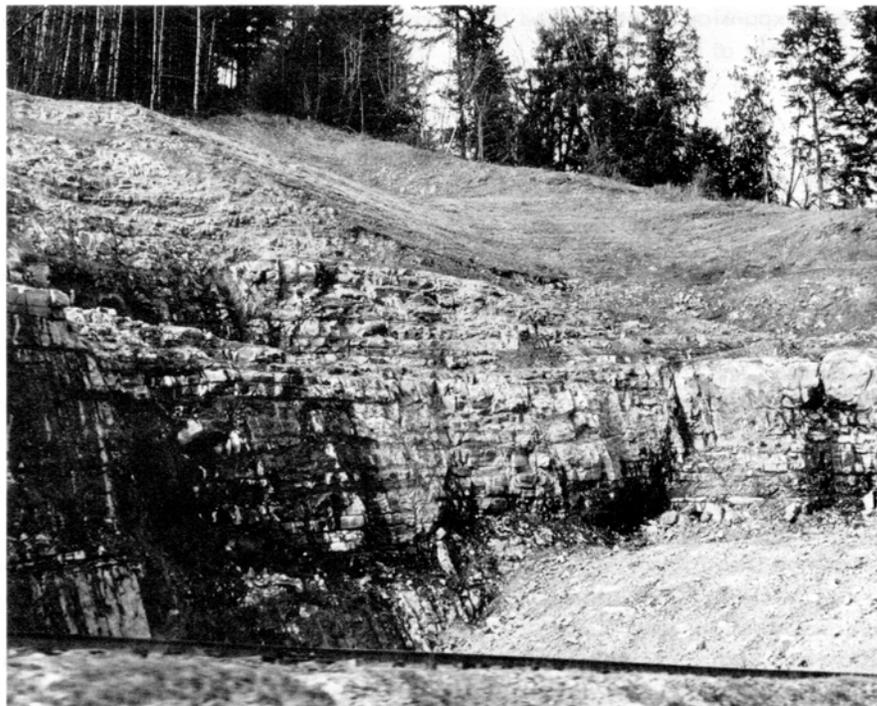


Photo 77. Sandstone quarry in Tye Formation west of Mapleton (No. 30 on geologic map). Rock was used in Siuslaw jetty and for road between Florence and Mapleton.

Commercial use

Commercial use refers to rock that is used locally by industry for construction and land development, and local requirements for commercial aggregate are related directly to population and industrial growth. Increased population means new housing, together with streets, roads, commercial establishments, and industry. Commercial rock requirements in the area amount to about 10 tons annually per person or 70,000 tons total. By 1985 the population is predicted to be almost 9,500, and requirements for aggregate will approach 95,000 tons annually.

Most of the rock used in the area is produced from the Berry Creek quarry. Other commercially owned quarries are at present either out of production or too far from the market to be competitive. If local supplies should become inadequate in the future, rock could be imported from Reedsport or from the Willamette Valley, but at greater cost.

Jettystone

Jettystone is needed for the construction of new jetties and for maintenance, rebuilding, and extension of existing jetties. Several classes of stone are used in jetty construction and the quantities of each used on a single jetty will vary; the total often exceeds several million tons. Armor stone (class A) is placed on the outside surface of the jetty to resist the force of the largest storm waves. The interior of the jetty is built of smaller stone (classes B and C) and rubble.

The size of individual stones used in jetty construction is based on a number of considerations: unit weight of the rock, maximum expected wave height, method of placement on the jetty, and side-slope angle of the jetty. In addition, the sizes used are influenced by the maximum weight of material which can be quarried and handled with available equipment.

It is not economically feasible to make every jetty resistant to storm-wave damage. For example, to withstand the maximum expected wave height of 25 feet common to Oregon, class A select stone of 170 pounds per cubic foot would need to weigh 48,000 pounds each (Kidby and Price, 1965).

Early in the construction of the jetty at Florence, sandstone from the Tye Formation, quarried near Mapleton, was used. Although large stones could be quarried, they were too soft to withstand erosion. In order to prohibit continued use of this sandstone in jetty construction, the U. S. Army Corps of Engineers introduced standards for jettystone which require the stone to have a unit weight greater than 160 lb./ft³ (Table 1). Since Tye sandstone weighs less than the minimum allowable, it can no longer be used.

Table 1. U. S. Army Corps of Engineers requirements for jettystone

Unit wt. of stone lb/ft ³	Select Class A Minimum weight (tons)	Class A Min. wt. (tons)	Class B Min. wt. (tons)	Class C Min. wt. (pounds)
160*	27.8	15.2	7.6	500
165	24.8	13.5	6.8	500
170	22.0	12.0	6.0	500
175	19.8	10.8	5.4	500
180	17.8	9.7	4.9	500

*160 lb/ft³ is minimum allowable

Approximate percentages of each class of stone used on a major Oregon jetty:

- Class A stone - not less than 40 percent
- Class C stone - not more than 17 percent
- Class B stone - remainder

Most quarrying operations in Coast Range basalt and gabbro have been unsuccessful in producing jettystone because of close jointing in the rock. Even in apparently suitable rock, some operators produce an abundance of sizes too small to be used because they loosen big volumes of rock with a large "coyote" charge which fractures it extensively. An alternative method would be to do selective drilling and shooting. Since most contracts involve several million tons of rock at prices approaching \$15 a ton in today's market, use of local rock should reduce costs and be good for the economy of the County. Most recent work on the jetty utilized rock from the Mapleton quarry.

Riprap

Selective quarrying of intrusives in the Mapleton area could produce rock of adequate quality for shoreline and riverbank protection. These uses do not require the rigid standards set by the U. S. Army Corps of Engineers for jettystone. However, the stone should be large enough to withstand storm waves and flood currents and be resistant to weathering and erosion. For shoreline protection, a properly constructed wall should be faced with a large proportion of individually placed angular stone, each weighing a few tons. Riverbank protection can be constructed from smaller stone weighing about one ton. Sandstone from the Tye Formation can be used for riprap for riverbank protection; however, it is not as durable as the igneous rock available in the area.

Oil and Gas

Only one significant well has been drilled onshore in western Lane County in search of petroleum. This was the Sinclair Oil & Gas Company "Federal Mapleton #1", located on the west flank of the Coast Range anticline near Mapleton. Sinclair found 6,700 feet of marine sedimentary rocks (Tye and Umpqua Formations) overlying lower Eocene basalt (Siletz River Volcanics) at the Mapleton site (Figure 8). The firm attempted to drill through the volcanic sequence, but gave up at a depth of 12,880 feet after penetrating more than 6,000 feet of basalt. Traces of hydrocarbons were found in the Umpqua shale at 5,310 to 5,320 feet. No flow tests were made during the drilling, and the hole was abandoned as a dry test. A small amount of oil was reported years ago in cavities in a basalt dike that cut Eocene sediments (Table 2).

Three holes were drilled on the continental shelf offshore from Lane County in 1965. Information released by Union Oil Company (Braislin and others, 1971) indicated that the well on Heceta Bank bottomed in upper Eocene marine sediments at 12,285 feet (Figure 8). Tertiary marine rocks may extend to a depth of 20,000 feet or more off the central Oregon Coast. Bids for leases offshore from Florence in 1964 totalled \$16.4 million. Eleven major oil companies participated in the bidding (Figure 9).

Prospects for commercial deposits of oil and gas offshore from Lane County are good. Several oil companies hope to return to this area in the future to do more drilling. Although information has not been released, reportedly nearly all the drillings off the Oregon Coast obtained shows of hydrocarbons.

Onshore prospects in Lane County are less favorable, but some areas may still hold out promise. Along the coastal areas, hydrocarbon deposits may exist in middle and lower Eocene marine sediments.

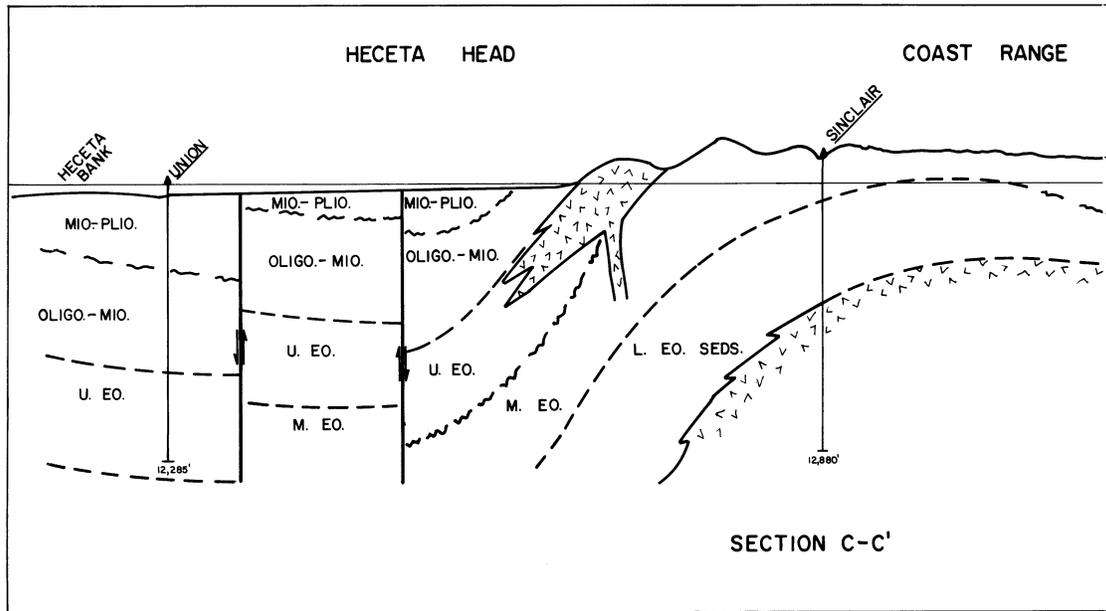
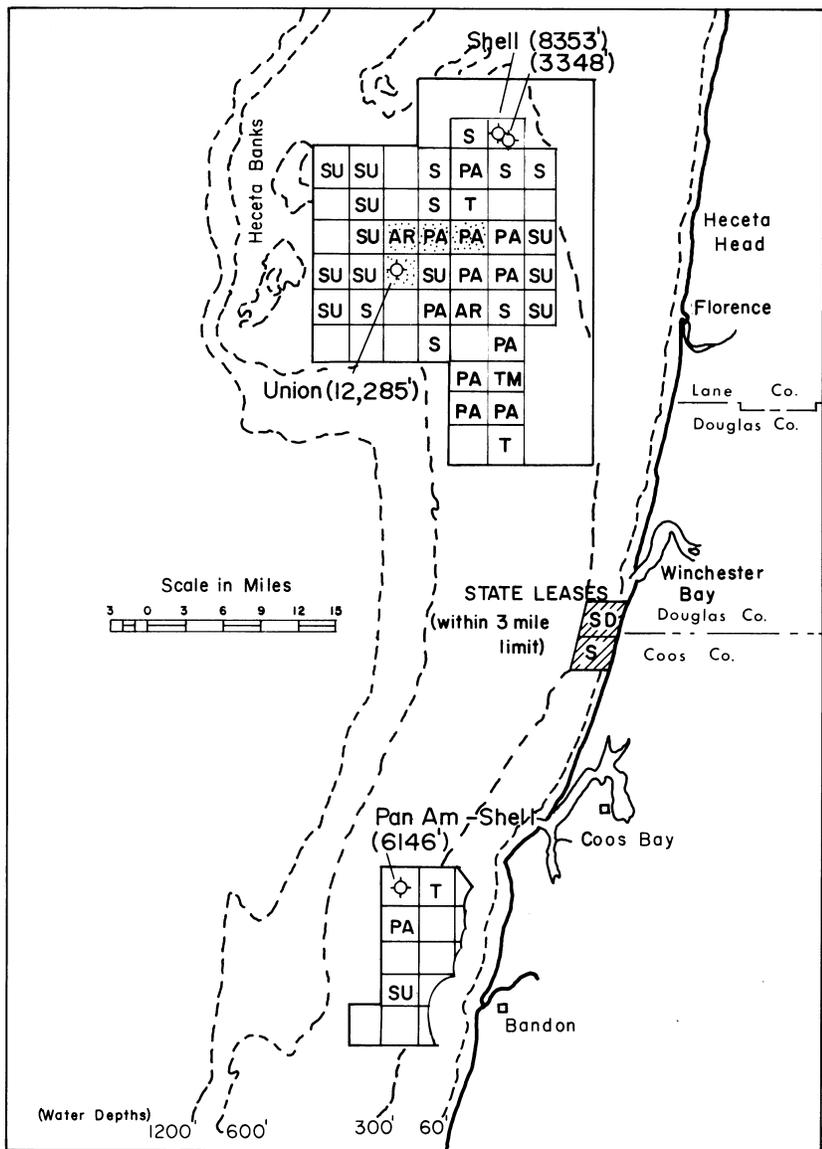


Figure 8. Diagrammatic cross section of western Lane County and continental shelf offshore showing structure and stratigraphy.

Table 2. Oil and gas exploration in western Lane County, Oregon

Company	Well	Location	Year	Depth	Log
<u>ONSHORE WELLS</u>					
Johnson Ranch		North Fork of the Siuslaw River approx. 6 mi. northeast of Florence, sec. 31, T. 17 S., R. 11 W.			Small amount of oil in cavities in basalt, less common in joints. The oil was found in a basalt dike cutting Eocene sediments. The oil was analyzed and two types of oil described (Harrison and Eaton, 1920).
Sinclair Oil and Gas Co.	Federal-Mapleton No. 1	Mapleton area, SE $\frac{1}{4}$ sec. 12, T. 16 S., R. 10 W. Elevation 483'		12,880'	Deepest hole drilled in Oregon. Penetrated approximately 3,000' of Tyee Form. and 4,000' of Umpqua sediments above the Siletz River volcanics. Hydrocarbon fluorescence in Umpqua shale and tar in sand shale contact at 5,310'. Coarse sandy lithic pebble conglomerate from 6,030' to 6,660' overlying Siletz River volcanics. No shows in it.
<u>OFFSHORE WELLS</u>					
Shell Oil Co.	E.T. #1	OCS #43, 16 miles off the coast	1965	3,348'	Abandoned. Records of wells drilled on Federal lands are not released to the public.
Shell Oil Co.	E.T. #2	OCS #43, 16 miles off the coast	1965	8,306'	" "
Union Oil Co.	Well #1	OCS #130, 26 miles off the coast	1965	12,285'	" *
* Union released stratigraphic data in an article by Braislín and others, 1971.					



Atlantic-Richfield AR	Standard Oil and Union Oil SU
Pan American Petrol. Group PA	Texaco, Inc. and Mobil Oil TM
Shell Oil Co. S	Texaco, Atlantic-Richfield, Mobil T
Standard Oil SD	

[Stippled areas indicate cancelled Federal leases, and lined areas show state leases.]

Figure 9. Deep wells drilled off southern part of Oregon Coast.
Heavy outlines show area offered by U.S.B.L.M.

GROUND WATER RESOURCES

by

R. C. Newcomb and R. L. Jackson

Introduction

The ground water stored in the unconsolidated earth materials that underlie the coastal plains and the flood plains of the streams forms the principal storage of fresh water in the coastal area of Lane County. This region, like the rest of Oregon's coast, is characterized by poorly permeable bedrock and streams with flashy runoff.

The volume of the runoff from the mountainous topography of the Coast Range varies in accordance with the precipitation, excessive during the winter and deficient during summer. The flow of these streams is especially low in late summer, the period of largest population and greatest water needs.

Tabulated Data

Appendix E of this bulletin lists 44 wells that are representative of the estimated 300 wells used for water supply in the coastal lowland of the County. Brief data are listed to show the character of the wells, the occurrence of the ground water, and the use of the wells. Locations of the wells listed are shown on the geologic map of the area.

Appendix F gives drillers' logs of the materials penetrated during construction of some representative wells listed in Appendix E.

As is evident from the uneven distribution of wells within the coastal lowland, information on ground water is concentrated in the more densely settled areas and is lacking in many parts of the lowland.

Occurrence of Ground Water

Alluvium

Alluvial deposits underlie the flood plain of the Siuslaw River and its lowest tributaries upstream from Florence and should contain some lenses of sand and gravel that will yield water to wells. The flood plains are thinly populated and data are lacking for ground water in these deposits. Ground water in such situations is commonly in balance with the adjacent stream, and the water table is subject to periodic fluctuations along with the level of the stream.

Bedrock

The shaley sandstones of the Tyee Formation include some soft sandstones that are sufficiently permeable to yield small amounts of water to wells, but even this small permeability at shallow depth is not present uniformly. In many places, wells 200 to 300 feet deep have not obtained usable quantities of good quality domestic water.

The volcanic rocks which form Heceta Head have some irregular zones of slight to moderate permeability from which small springs and wells provide small supplies of water, but water in excess of household supplies cannot be dependably obtained from wells.

Sand Aquifer

The ground water within the sand, which underlies the coastal plains southwest, north, and northwest of Florence, is by far the largest body of fresh water in this region. The extent of this water, the characteristics of the aquifer, and the utility and protection of this source is described below.

Size and character of the sand deposit

Thickness: Of the few places where drilling has identified the base of the sand deposit, most are located near the edges of the sand area. Elsewhere data show that the sand continues downward beyond minus 40 feet m.s.l. (altitude) at Cannery Hill northeast of Florence, minus 20 feet at Heceta Beach, and minus 15 feet at well 18/12W-14P3, a mile north of Florence. One well (18/12W-33C1) was drilled to a depth of 175 feet near the beach west of Florence, and the base of the sand deposit was believed found at a depth of 170 feet, or about minus 150 feet altitude. In the absence of direct information on the sand's thickness, Hampton (1963) estimated that the sand aquifer had an average saturated thickness of 100 feet. A maximum thickness of at least 150 feet at the coastline is indicated for parts of the coastal area. This indication is derived from hypothetical projections of the top of the bedrock, westward from the coast range, through places where wells have been drilled and the materials logged. The bedrock surface, on which the sand lies, slopes westward at the rate of about 120 feet per mile for the first mile west from the bedrock line near Munsel Lake and about 80 feet in the first mile west from outcrops at Sutton Lake; thus, 125 feet seems to be a realistic estimate for the average thickness of the Pleistocene and Holocene sand deposit at the coastline (cross sections shown on Figure 10).

Eastern limits: The sand laps irregularly onto the westward sloping top of the bedrock at the foot of the Coast Range. The inner boundary of the sand deposit (see geologic map) is rather arbitrarily drawn through a zone wherein the eolian sand becomes thin and the clayey soil cover of the bedrock becomes increasingly evident. The inner boundary of the sand deposit is relatively definite north of the Siuslaw River but is indefinite in many parts of the low ridges of bedrock to the south, especially along the west side of Woahink Lake.

Composition: The sand deposit consists mostly of siliceous subangular to rounded grains ranging from very fine to medium grain sizes. The range in grain size for representative samples and the percentage content of the various grain diameters are shown by curves in Figure 11. Though the sand deposit is composed essentially of wind-blown sand, the deposit contains some variations--clayey lenses, peat strata, and limited zones of weak cementation. A flat-lying, 1- to 2-foot thick clayey peat and wood layer is rather extensive just above sea level in the sand deposit west of Florence. Wood from this layer has been dated by the carbon-14 method as 4,630±130 years B.P. (Rubin, 1965).

The prevalence of linear bogs and lagoons on the landward side of east-moving dune ridges indicates that lenses of peat, silt, and clay can be expected to occur where such lagoons were later buried by the advancing sand.

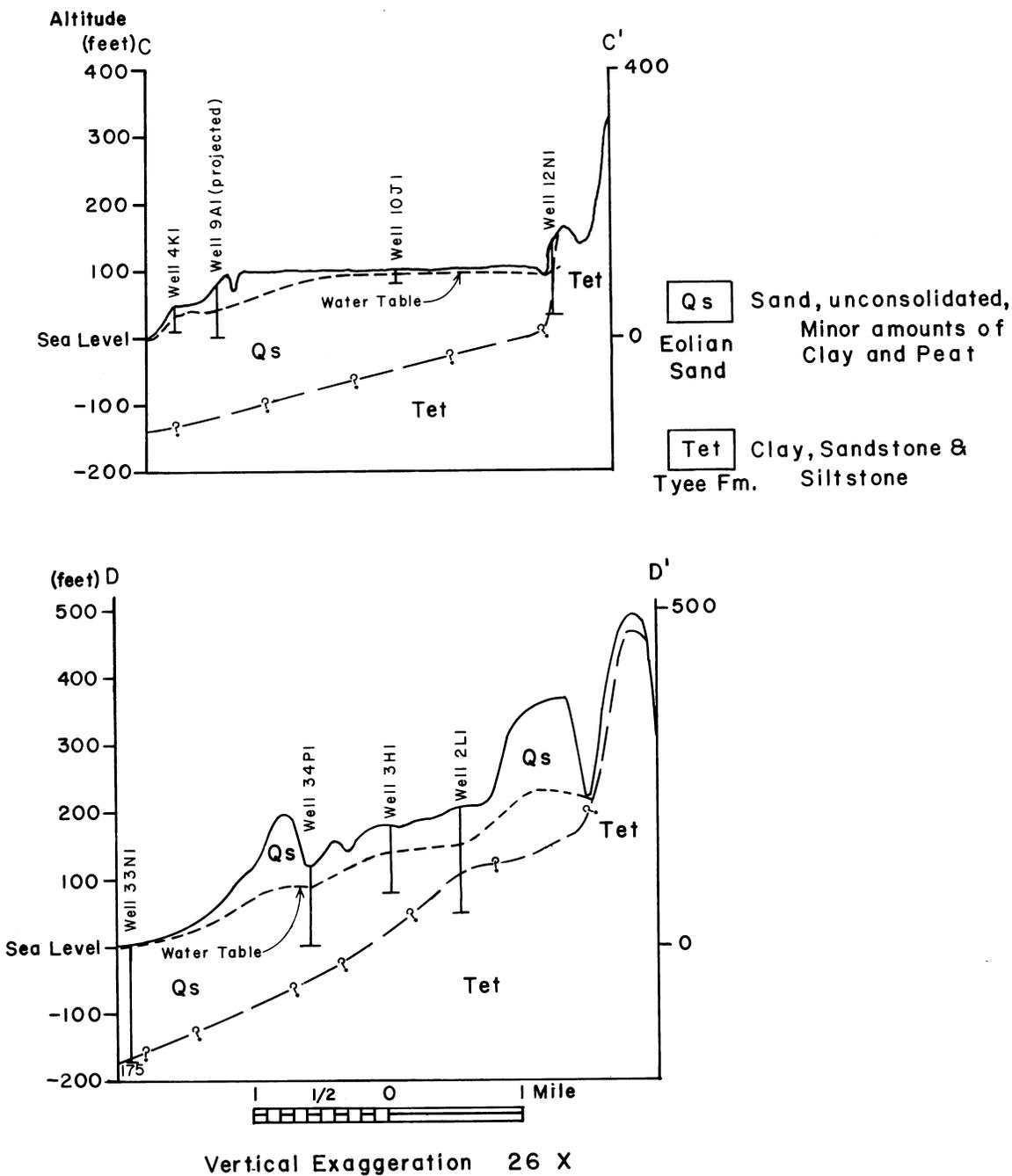


Figure 10. Two cross sections of sand aquifer.

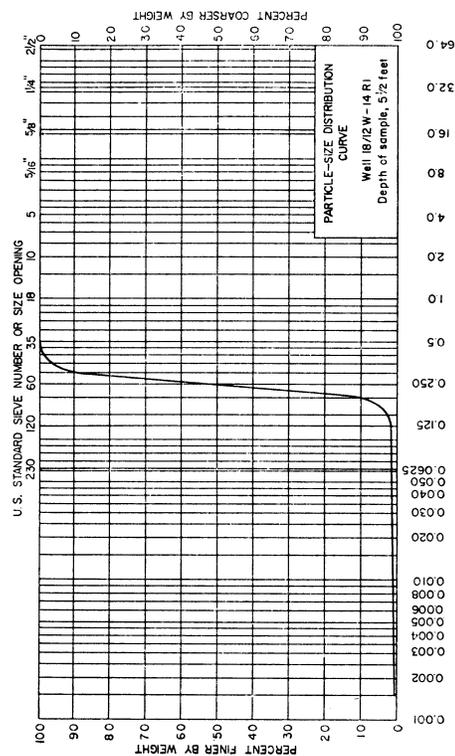
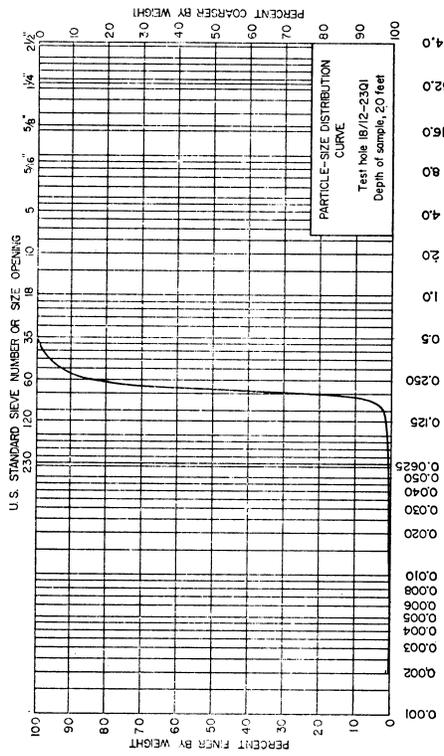
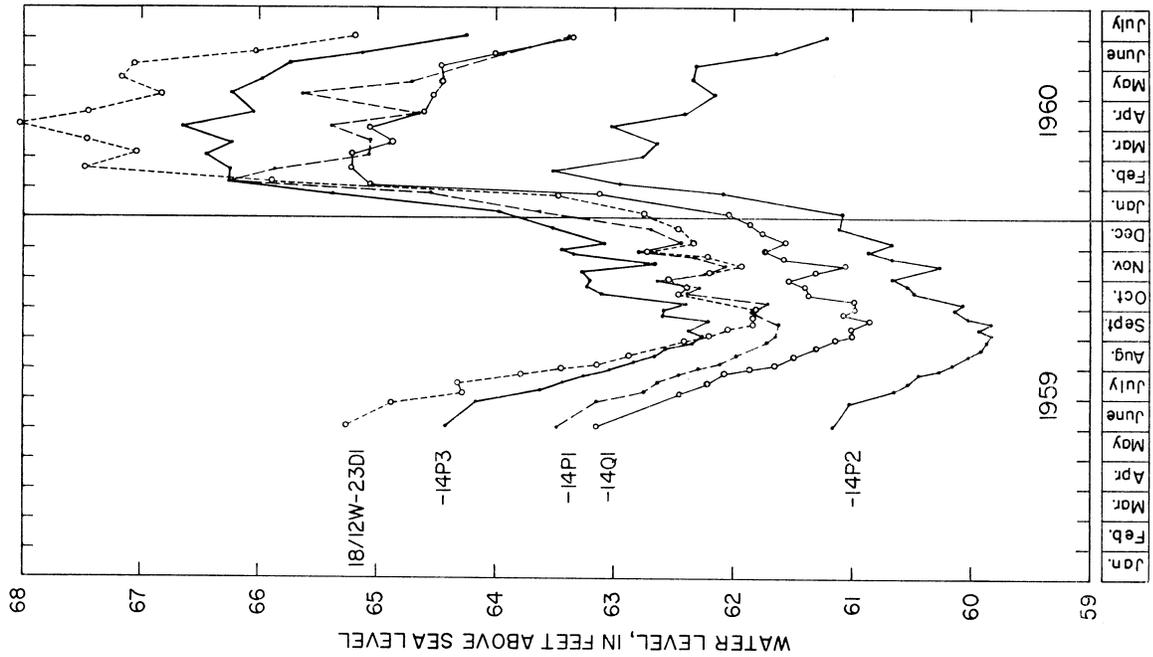


Figure 11. (above) Graphs of curves showing distribution of grain sizes in the sand aquifer of the Florence dune lands (taken from Hampton, 1963).

Figure 12. (right) Fluctuations of water table at wells during 1959 and 1960 (taken from Hampton, 1963).

Hydrologic characteristics: The sand is typical of such dune lands along the Oregon Coast; the grain-size curve for this sand deposit (Figure 11) is practically a duplicate of that plotted for samples of the Coos Bay dune lands (Brown and Newcomb, 1963) and the Clatsop dune lands (Frank, 1970). The grain-size curves indicate these coastal sands are all of similar grain size; 80 percent of each sample consists of grains at, or very near, the screen size of 60 mesh to the inch, or 0.25 millimeters diameter.

In laboratory tests, the porosity of 4 samples from the sand deposit of the Coos Bay dune lands ranged from 35.8 to 38.5 percent (Brown and Newcomb, 1963), and 4 samples from the Florence sand deposits ranged from 36.5 to 39.2 (Hampton, 1963); the specific yield ⁽¹⁾ of the respective samples ranged from 34.5 to 37.0 and 32.3 to 35.0 percent. The laboratory permeability ⁽²⁾ derived for the eight samples ranged from 270 to 630 gpd/ft² (gallons per day per square foot) and averaged 535. This general range of permeability has been substantiated by pumping tests on partial penetrating wells wherein transmissivity⁽³⁾ of the sand formation has been derived as ranging from 27,000 to 60,000 for the Coos Bay sand deposit (Brown and Newcomb, 1963), as 50,000 for the sand in well 18/12W-14P4 at Florence * (Hampton, 1963) and as 27,000 in a well in the Clatsop sand deposit (Frank, 1970). When the average laboratory permeability (535 gpd/ft²) is multiplied by the saturated thickness of 100 feet (a common thickness for the Florence sand deposit), the resultant transmissivity of 53,500 would be in general agreement with the average transmissivity derived by test pump methods mentioned above.

The water table

Below the surface level of the streams and lakes, and below the depth of a few feet to a few tens of feet over much of the dune lands, the void spaces in the earth are filled with ground water. The top of the saturated zone is the water table. The depth to the water table has not been observed in many uninhabited parts of the Florence dune lands, but its general shape is sufficiently well known from existing wells, springs, and surface water that its general position can be inferred. The general shape is a subdued replica of the surface. The water table slopes upward from the stream levels in the valleys and curves up to its highest levels beneath the higher parts of the dune lands. Its shape is indicated in cross sections, Figure 10. As is evident in the sections, the water table lies close to, or above, the surface over large areas of the sand plain north of Florence. In places, this shallow water table has detrimental effects on the drainage and usability of parts of the area.

Recharge of the ground water

The storage of water in the sand aquifer increases in the winter months and decreases during the summer. The high point in ground storage is reached in February or March and the low point in September or October of most years.

An example of the rate at which water from precipitation (directly on the dune lands) reaches the water table is shown by Figure 12 (taken from Hampton, 1963). This graph shows that during the period July 1 to October 1, 1959 (a period of 6.6 inches of rainfall [Reedsport]), the water table at well 18/12W-23D1, a mile north of Florence, dropped 2½ feet, but from October 1 to March 1, 1960 (a period of 63.6 inches [Reedsport]), the water level rose 5.15 feet.

-
- (1) As used in most field studies of ground water and as defined by O. E. Meinzer (Wenzel, 1942), the specific yield is the volumetric percentage of the water that drains compared to the volume of the sand from which it drains under the force of gravity.
 - (2) Likewise, the permeability is the rate of flow of water, in gallons per day, through a cross sectional area of 1 square foot under a hydraulic gradient of 100 percent at the prevailing water temperature.
 - (3) Transmissivity (formerly called coefficient of transmissibility) is equal to the permeability multiplied by the thickness of the aquifer. It was defined by Theis (1935) as the number of gallons of water per day, at the prevailing temperature, that will pass through a section of the aquifer 1 foot wide extending the full saturated thickness of the aquifer under a hydraulic head of unit.

* Computed from the specific capacity method of Theis (1954).

The response of the water table to additions, or lack, of water from precipitation is complex in detail, but in both the Coos Bay (Brown and Newcomb, 1963) and the Florence (Hampton, 1963) dune lands, the estimates of the portion of the average annual precipitation that reaches ground water exceeds 75 percent. A ground-water addition of 75 percent of 65 inches precipitation over the 30 square miles of the Florence dune lands would amount to 77,000 acre feet of recharge per year.

The larger lake systems (Siltcoos-Woahink, Munsel-Collard, Mercer, and Sutton) have surface water inlet and outlet streams. The lakes and their outlet streams are in general balance with the water table nearby, and the levels of the lakes are higher than the ground water only during lowest levels of the water table in late summer. If the slightly higher lake level shown for Munsel Lake on Hampton's (1963) Figure 10 is taken as typical for the $4\frac{1}{2}$ miles of lake-water table contact in the sand aquifer, an estimate of only 33 acre feet per mile is indicated as ground-water recharge from the lake during the whole 5 months of low water table each year. This shows that the recharge from the lake is insignificant.

Discharge of ground water

Because unconfined ground water moves in the general direction of the slope of the water table, the greatest water movement in the sand aquifer is westward to the ocean, and a minor amount moves east to the lake systems. Because about nine-tenths of the sand aquifer lies west of the north-south ground-water divide, the western part (56,500 acre feet) of the ground water discharge must move to the ocean or to the lowest part of the Siuslaw River. This oceanward percolation of ground water moves under an average water-table gradient of 50 feet per mile through a section 15 miles long and 125 feet thick.

According to D'Arcy's law and with the above determined permeability of 535 gpd/ft², the annual discharge oceanward through the sand aquifer should equal 50.3 million gallons per day or 56,400 acre feet per year. The total annual estimate of the discharge to surface water, both west and east, would be 62,750 acre feet per year. Apparently, most of this ground water discharges inconspicuously below the level of the surface water, because the small springs that can be observed would account for only a few thousand acre feet of water per year.

The discharge of ground water by transpiration from the vegetation (Lodgepole pine and rhododendron), which covers about half of the Florence dune lands, may be approximated by use of Hampton's (1963) measurements. His Figure 3 shows that transpiration of vegetation lowered the water table .02 foot during 10 daylight hours in August at a location where the water table was 4 to 5 feet below the surface. An estimate of the total is possible if the following assumptions are allowed: (1) this drawdown (0.02 ft) represents one-half the water depth actually removed by the vegetation, (2) the sand has a specific yield of 34 percent, and (3) this rate of withdrawal by vegetation is twice the average of the total (wooded and bare) area for 10 hours each day in 5 months of each year. This computation would indicate 7,830 acre feet of ground water is discharged per year by the transpiration of vegetation within 12 square miles having a relatively shallow water table.

Only about 250 acre feet of ground water is withdrawn per year for consumptive use,* as described below.

Thus, these empirical estimates placed in an annual budget for the ground water of the Florence dune lands would indicate:

<u>Agency</u>	<u>Recharge</u> (acre feet)	<u>Discharge</u> (acre feet)
Infiltration from precipitation	77,000	
Infiltration from lake systems	250	
To surface waters		62,750
Transpiration		7,830
Pumping withdrawals		250
	<u>77,250</u>	<u>70,830</u>

* Consumptive use - that water lost to the ground water system by evaporation, transpiration, or discharge directly to the ocean after use.

Because of the empirical nature of these estimates, no attempt is made to show a balance between input and output. Closer estimates of the water budget for the sand aquifer must be based on a larger and better fund of water facts. However, the estimation from two different approaches (input and output) show that a quantity of 70,000 to 75,000 acre feet per year may be a reasonable approximation of the average annual water budget for the sand aquifer.

Quality of the Ground Water

The ground water in the sand aquifer is of good chemical quality except for slightly excess amounts of dissolved iron in part of the water and a generally low pH (acidic condition). The four comprehensive and six partial analyses published by Hampton (1963) show that the water has a small amount of dissolved solids, ranging from 14 to 47 ppm (parts per million), and has no detrimental constituents except iron.

The iron content in Hampton's samples ranged from .02 to 2.07 ppm and exceeded the maximum desired limit of 0.20 ppm in four of the ten samples. The desired limit of 0.20 ppm is the approximate content at which the staining of containers, laundry, and plumbing fixtures becomes noticeable. The low pH, ranging from 5.7 to 6.2 on the scale which uses 7 as a neutral condition, is due to dissolved organic material, mostly carbon dioxide. The iron is in solution as the bicarbonate and will precipitate readily as the insoluble iron oxide. Treatment to remove the iron incorporates a neutralization of the acidity with soluble calcium compounds, like limestone, followed by aeration and a filtration of the precipitated iron oxide. Thus the removal of the two detrimental conditions, acidity and iron content, is a simple treatment that can be accomplished by improvised or engineered facilities.

The physical quality of the ground water is good. It has a temperature of 53° or 54°F; most of it is odorless and has a satisfactory taste. Part of the water, in a few places, has a light brownish or amber color acquired from peaty or woody matter in the sand. This brownish color is common to surface water in some of the lakes and lagoons. Ground water extracted from the sand at a distance of several hundred feet from wells having brownish, more acid water may be free of color and may be less acid.

The ground water from properly sited, constructed, and sealed wells is free of bacterial and other disease-causing agents. The location of wells in respect to sewage disposal will be an increasing problem for wells at dwellings, most of which have septic-tank disposal systems. Health authorities prescribe minimum distances that wells must be from septic tanks. Some of the most advanced studies of the subsurface travel of pathogens indicate that the disease-causing bacteria do not travel far, generally less than 100 feet, from the point of input in sand and fine sand materials (Mallman and Mack, 1961). This subsurface cleansing of septic tank fluids has been found to be especially effective where the water table is 10 to several tens of feet below the surface. The concentration of some chemical ions, particularly chloride, nitrate, and phosphate may be raised slightly in the ground water beneath the points of sewage disposal. Planning could wisely provide for areas free of sewage disposal so that future withdrawals of ground water can be sited in esthetically appealing areas.

Use of the Ground Water

Present Withdrawals

A very small part of the ground water in the sand aquifer is now withdrawn for use. At present the principal use is domestic water for about 700 families outside of Florence and public-supply water for another 700 families served by the Florence water system. The total withdrawal is estimated as 500,000 gallons per day; much of this is returned to the sand.

Historical Development of Water-well Construction

Prior to the cooperative investigation of the ground water by the U. S. Geological Survey and the city of Florence (Hampton, 1963), dug wells or small-diameter drivepoint wells were the custom, and Florence obtained its water supply from Munsel Creek. The 6-inch test well (18/12W-14P4) of Hampton (1963) incorporated 15 feet of 10-slot well screen 4-inches in diameter. The well yielded 53 gpm with only 8 feet of drawdown during a short pumping test and was concluded to have a sustained capacity of at least 150 gpm. Since that test well was constructed, the customary good household well has become a 6-inch well using 5 feet of well screen (7-, 8-, or 10-slot). An 8- or 10-inch starter casing 20 feet long allows the 18 feet of concrete grout to be placed for the surficial sanitary seal required by the Oregon well-construction regulations.

The public-supply well of Florence (18/12W-23L1) continued the modernization trend in well construction by the use of 12-inch casing with 35 feet of well screen (10-slot), set from 62 to 97 feet depth in the sand aquifer. The well was pump-tested at 325 gpm with 58 feet of drawdown. This well confirmed the test results of Pacific Power and Light Company in the Coos Bay dune lands that single wells yielding 200 to 300 gpm can be constructed readily (Brown and Newcomb, 1963), and lines of such wells can obtain large amounts of economical water from the dune sand.

Future Potential

In the alluvium

Aquifers in the smaller alluvial deposits are probably present (and usable beneath small areas), but the meager information suggests that they will be important only in the area of the flood plain of the Siuslaw River.

In the bedrock

The general lack of permeability of the bedrock precludes more than small household supplies, and even these will not be produced from every well drilled for that purpose.

In the sand aquifer

As indicated by the above estimates of the water budget, the total annual input to the dune land sand aquifer is near 70,000 to 75,000 acre feet under present and native conditions. To form an estimate of the usable part of this average annual recharge, it is necessary to calculate the amount required to maintain at least a 10-foot per mile westward gradient of the water table. By similar application of D'Arcy's equation, that non-removable portion is derived as 22,000 acre feet per year. Thus 50,000 acre feet (45 million gpd) of ground water could be consumptively withdrawn from the sand aquifer of the Florence dune lands and still leave sufficient protective head against sea water intrusion. However, a withdrawal of 50,000 acre feet of ground water per year would have side effects, possibly both beneficial and detrimental. The lowering of the water table would improve drainage conditions in places where the water table is now too high, but it might also remove the ground water containment of lakes, such as the Munsel-Collard Lake system. These and other effects will be pertinent factors to consider in future plans for the determination of the optimum usable ground water resource of the sand aquifer.

South of the Siuslaw River, most of the lakes appear to be contained more by ridges of impermeable material, and the height of the water table in the dune lands seems to be a minor factor in the retention of Woahink and Siltcoos Lakes at their historic levels. The levels of their outflow, the Siltcoos River, are partly dependent on ground water inflow to the lakes, but the river flows so near to sea level (3 to 12 feet altitude) that no great lowering of the water table would ordinarily be contemplated. Cleawox Lake and a few temporary ponds in the northern part of this dune-land segment are maintained by the level

of the water table. Between Siltcoos River and Cleawox Lake, a centrally located 3-mile length of the dune land might serve as a site for the withdrawal of large quantities of ground water, possibly as much as 10,000 acre feet per year (9 million gallons per day), without adverse effects on the existing water conditions. Likewise, north of the Siuslaw River, the sand plain northwest of Florence and west of Heceta Junction is another area where large withdrawals from judiciously located wells would help the chronic drainage conditions and provide large amounts of water.

From these preliminary estimations, it is evident that many times the present rate of ground-water withdrawal is available, and consumptive extractions of as much as several tens of million gallons per day can be made without detrimental effects on the existing water resources. In addition, there are great possibilities for artificial recharging of the ground water by routing surface water, which now wastes to the ocean, into recharge channels and basins in the dunes.

Also evident from these preliminary estimations is the necessity for a collection of basic water facts in the dune land region, so that the optimum development of the ground water resource can be wisely planned and executed.

The development and management of the ground water resource for its optimum water yield may seem to be a matter for the distant future, in view of its present meager use, but a fresh water storage of this magnitude in a region of short supplies, like the Oregon Coast, holds values now unappreciated.



Photo 78. Water level of Carter Lake reflects low water table in late summer.



Photo 79. Wave energy is gradually eroding away the low basalt terrace at Cape Perpetua. Storm waves use logs, such as the one in the lower right corner of photo, for battering rams.

SUMMARY AND RECOMMENDATIONS

Almost every area has geologic and environmental conditions that jeopardize normal use of the land; Lane County is no exception. With information on the geologic problems that might reasonably be expected, better use can be made of the land and geological hazards can either be circumvented or minimized.

Although this report is of a general nature, it will serve as a guide to County planners, officials, and the general public who are involved in planning and land use. It can be used to determine when the services of specialists should be employed to the benefit of both the County and the developer.

The following discussion reviews the major geologic problems which need to be considered in land development with emphasis on the areas having the greatest development pressures.

Sand Areas

Sand areas include both the active dunes and the old stabilized dunes extending several miles inland to the margins of the many lakes in the area.

Although the areas of actively moving sand dunes are not generally developable, they will in places be used for roads, parking, and recreational sites. Problems here include drifting sand, high water table, winter flooding, and foundation problems in low strength, unconsolidated sand or peat. Drifting sand can be partially controlled by sand fences and plantings to protect roadways and parking areas. Restroom facilities will need to be located in areas sufficiently higher than the summer water table. Winter use when the water table is high could be negligible. Flooding in winter can temporarily halt traffic with little consequences. Only light foundation loads should be necessary for this type of recreational development.

Development pressures for new commercial residential and recreational land is mainly centered in areas underlain by sand. These are located adjacent to lakes along the U. S. Highway 101 and from Heceta Beach to Florence. Much of the sand is tree and brush covered and has moderate to thin soil development overlying unconsolidated sand.

Low-lying areas are subject to a near-surface water table much of the year, and septic tanks will not be operable. These areas should not be developed until the land is filled above the water table and sewerage systems have been installed.

Areas of thin sand or soils overlying Tye bedrock adjacent to the lakes do not generally have a water-table buildup because the water drains freely to the lake. This indicates that, in most cases, septic tanks also drain directly into the lake. Since several of the local water-supply systems draw from the lakes, a health problem already exists or will in the future. A public sewer system should be installed before the density of homes increases and the lake pollution becomes critical.

In constructing roads and leveling ground for buildings in old dune areas, the removal of ground cover and soil will expose loose sand to wind erosion and transport, causing buildup of sand dunes on driveways, streets, and around buildings. All loose sand exposed in development should be quickly stabilized by appropriate methods.

Foredunes have been used for building sites in a few areas but generally with undesirable results. Wave undercutting and wind erosion of the foundations is a constant threat. Heavy use of the foredune causes its destruction by killing the grass cover, allowing the wind to blow the sand inland. Protection of a structure located on a foredune by riprap is costly, unattractive, and a never-ending task to maintain.

Coastal Terraces

Terraces composed of weakly cemented sand, colluvium, and gravel terminate at the beach in vertical to nearly vertical bluffs. The coastal terraces are being continually eroded by wind and waves.

Terrace sands commonly contain layers of peat or rotted wood which will settle excessively under heavy loads. Hard, impermeable iron-cemented layers may be present, which will create a near-surface water table by preventing water from percolating downward through the terrace deposits.

Developments on marine terraces should consider placement of structures where they will not be jeopardized by erosion, where the water table will not prevent operation of the septic tank, and where foundation strength of the soil has been determined to be adequate for the weight of the structure to be built.

Rocky Headlands

Rocky headlands are found along the northern coast of Lane County in the rock mapped as Yachats Basalt. The more resistant volcanic rock erodes more slowly than the breccias, sediments, and marine terraces and therefore protrudes into the ocean as headlands. The rock slopes are steep and rugged; usually there is no beach or only a very small one at low tide.

Building-site excavations will require blasting of the hard basalt. If the slopes have a cover of colluvium, this material may slide if the lower slope is oversteepened by excavation. Should the colluvium be unstable and show signs of movement before any excavation is made, sliding can be expected during construction or soon after.

Stream Valleys

Estuaries of the Siuslaw and North Fork of the Siuslaw have large marshy tidal flats composed of sandy silt and decomposed organic material. These soils are saturated up to the ground surface and are weak and highly compressible. Structures located in this material should be founded on piling if even moderate foundation loads are contemplated, and the structure should be floodproof.

Roadways constructed across tidal flats should be designed and built to anticipate a large amount of uneven settlement. Environmental impact studies should be done to determine the effects of the construction on both river and ocean flooding because roadway embankments will act as dams to restrict water spreading.

The flood plains of rivers are mainly suitable for agriculture. Structures placed on the flood plain should be located on the highest ground available and be able to withstand major floods. Flood-plain developments, other than water or farm oriented ones, should probably be avoided.

Flood-plain soils generally have low strength, requiring special foundation treatment for heavy structures. Roads built on the flood plain will normally develop a rolling grade, resulting from the uneven settlement caused by variable embankment heights and variations in the thickness and consistency of the valley alluvium. Rapid buildup of pore pressures during normal embankment construction may cause shear failure of the foundation soils.

If a level roadway or foundation mat is required which will not settle later, it will be necessary to drill and sample the site at frequent intervals to determine the type, thickness, and extent of the foundation sediments. The amount of settlement which can be expected at each location can be determined and designs made to handle the proposed foundation loads. The most appropriate of several methods of construction and design can then be employed.

Surcharges can be placed on the embankment to speed settlement, and the excess material can be removed after the settlement has occurred. A thick permeable mat and vertical sand drains can be installed prior to placement of the embankment to allow the moisture to move out under low pressure during the construction period. Charges set off beneath the embankment can force the soft material to liquify and flow outward while the embankment settles. Counterweights can be placed adjacent to the embankments to prevent undesirable shearing; this method requires additional land, however.

Construction Aggregate

Rock is used in western Lane County for construction and maintenance of forest roads, highways, County roads, and local building and development. Much of the rock used by the Siuslaw National Forest is produced from Federally owned quarries; almost all of that used by the Federal Highway Administration and the Oregon Highway Division has been imported from outside the study area. These two agencies use about 90,000 tons total annually, and this amount is not expected to change much in the future since it is not related to local population increase.

The local use of aggregate for housing, industrial developments, commercial buildings, public buildings, and County roads is directly related to population. Rock for these purposes is consumed at a rate of about 10 tons per person annually, for a total of 70,000 tons. By 1985, western Lane County, with a predicted population of 9,500, would require at least 95,000 tons of aggregate annually at the present rate of consumption.

Only one major commercial aggregate source is presently operating in western Lane County. Others could possibly be developed; however, it may be necessary to import rock from Reedsport or Eugene to meet the needs.

Oil and Gas

Prospects for commercial deposits of oil and gas are good offshore from Lane County. Several oil companies still hope to come back to this area in the future to do more drilling. Although information has not been released, reportedly nearly all the drillings off the Oregon Coast obtained shows of hydrocarbons.

Onshore prospects in Lane County are less encouraging, but some areas may still hold promise. Along the Coast, hydrocarbon deposits may exist in middle and lower Eocene marine sediments.

Ground Water

Large quantities of ground water are stored in the dune sands that occupy the coastal plain of western Lane County. The dune deposits are as much as 150 feet thick and are composed of fine-grained, wind-blown sand and minor amounts of silt, clay, and organic material. Significant but lesser amounts of ground water are stored in the flood-plain deposits. Bedrock units underlying the remaining region have low permeability and consequently meager ground water.

Water recharge in the dunes is responsive to the period of high (65-inch) rainfall between October 1 and March 1. About 75 percent of the precipitation which falls on the area, or about 77,000 acre feet, enters the aquifer. Only 250 acre feet of ground water is withdrawn, with the remainder discharged to surface waters or lost by transpiration. Approximately 50,000 acre feet (45 million gpd) of ground water could be withdrawn without danger of sea water intrusion. Except for a low pH (acid condition) and a slight excess of dissolved iron, the water is chemically good. The removal of the acidity and the iron is a simple process.

The water temperature is 53° or 54° F and most of the water is odorless and has satisfactory taste. Locally the water is a brownish color from organic material in the sand, but usually water from wells several hundred feet deep will be clear.

Contamination of the ground water will be an ever-increasing problem unless precautions are taken to control the use of septic tanks and to eliminate sewage disposal in sand areas. Studies should be made to determine the feasibility of utilizing the ground water in the future, and areas should be set aside where the ground water can be protected from surface activities which could cause contamination.

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APPENDIX

APPENDIX A
SOILS CLASSIFICATION, LABORATORY TEST DATA, AND PERFORMANCE OF SOILS OF GEOLOGIC UNITS

Geologic unit	Tet Type Formation	Teyb Yachats Basalt	Ten Nestucca Formation	Qmt Quaternary Marine Terrace	Ad-Sd Sand Area	Tf Tidal Flat	Qal Alluvial Deposits
Soil Classification	A-6, A-7 ML - CL Clayey silt and silty clay	A-5, A-7-6 ML - MH Clayey silt	A-7-5, A-7-6 ML - CL - MH Clayey silt and silty clay	A-2, A-5 ML Sandy clayey silt Stoney colluvium	A-2 SM Fine sand	A-7, A-8 ML - MH, OH - Pt Peat Organic-clayey silt	A-4, A-6 ML - MH - CL Clayey silt
Screen	Percent passing	96-100	91-100	100	100	100	100
Analysis	10	92-100	86-100	90-100	100	100	100
	40	86-99	78-99	95	60-80	95-99	90-99
	200	53-91	65-97	20-75	10-35	90-97	75-95
Hydrometer Analysis	Percent sand	21-41	3-32	30-95	99	4	24-49
	silt	31-51	22-43	5-35	0-1	61	33-58
	clay	18-50	23-63	0-25	0	35	15-26
Shear Strength	Internal Friction ϕ	9-13	6-14	14-38	32-37	19	50-60
	Cohesion p.s.i.	4-23	11-14	4-7	0	9	10-20
Atterberg Limits	Liquid limit	49-76	40-63	15-25	20-33	46-64	25-58
	Plasticity Index	5-27	17-30	0-4	0	11-21	11-30
Proctor Density (Harvard Miniature)	Optimum moisture	44-45	21-38	18-34	5-17	33	21-43
Density	Dry density	74-76	80-104	82-104	99-109	86	73-104
Modified from Casagrande Soil Charts	Foundation rating	Moderate	Low	Low-moderate	Moderate	Very poor	Moderate
	Shrink and swell	Low-moderate	High	Low-moderate	Low	Moderate-high	Low-moderate
Internal drainage	Internal drainage	Poor	Poor	Low-moderate	Excessive	Poor	Low-moderate
	Dry strength	Moderate	Low-moderate	Low	Low	Low	Moderate
Slope stability	Slope stability	Moderate	Low	Low-moderate	Low	Low	Moderate
	Permeability m/hr.	Low	Low	0.6 - 6.0	6.0 - 20.	0.6 - 2.0	0.6 - 2.0
Uses for Septic tank drainfield Embankment material	Septic tank drainfield	Poor	Poor-very poor	Poor	No	No	Variable
	Embankment material	Fair	Fair-poor	Fair	Good if confined	Very poor	Fair-good
Hazard	Steep slopes	Steep slopes	Slope failure	Impermeable	Wind erosion	Floods	Floods
	Landslide	Slides in soils	Impermeable	layers	High water table	High water table	Irregular settlement
	Poor ground water	Poor ground and colluvium water	and colluvium	Erosion by ocean	Compressible soils	Compressible soils	High water table

Data adapted from U.S. Soil Conservation Service OR-Soils-1 and laboratory data from the Oregon Highway Division and private engineering reports

APPENDIX B

Unified Soil Classification System Chart *

The unified soil classification system is based on the system developed by Dr. Arthur Casagrande, of Harvard University, for the Corps of Engineers during World War II. The original classification has been expanded and revised in cooperation with the U.S. Bureau of Reclamation so that it now applies to embankments and foundations as well as to roads and airfields. It is used by both the Corps of Engineers and the USBR.

The accompanying table and the discussion given below are from "The Unified Soil Classification System," Military Standard 619, U.S. Army Corps of Engineers, 1960. More detailed information may be obtained from that publication.

The unified soil classification system identifies soils according to their textural and plasticity qualities, and their grouping with respect to their performances as engineering construction materials. The following properties form the basis of soil identification:

1. Percentages of gravel, sand, and fines (fraction passing the No. 200 sieve).
2. Shape of the grain-size distribution curve.
3. Plasticity and compressibility characteristics.

The soil is given a descriptive name and a letter symbol indicating its principal characteristics. Four soil fractions are recognized: cobbles, gravel, sand, and fines (silt or clay).

The soils are divided as (1) coarse-grained soils, (2) fine-grained soils, and (3) highly organic soils. The coarse-grained soils contain 50 percent or less material smaller than the No. 200 sieve, and fine-grained soils contain more than 50 percent material smaller than the No. 200 sieve. Highly organic soils can generally be identified visually.

The coarse-grained soils are subdivided into gravels (G) and sands (S). The gravels have the greater percentage of the coarse fraction (that portion retained on the No. 200 sieve) retained on the No. 4 sieve, and the sands have the greater portion passing the No. 4 sieve. The four secondary divisions of each group--GW, GP, GM, and GC (gravel); SW, SP, SM, and SC (sand)--depend on the amount and type of fines and the shape of the grain-size distribution curve**. Representative soil types found in each of the secondary groups are shown in the accompanying table under the heading "Typical names."

Fine-grained soils are subdivided into silts (M) and clays (C), depending on their liquid limit and plasticity index. Silts are those fine-grained soils with a liquid limit and plasticity index that plot below the "A" line in the diagram in the table, and clays are those that plot above the "A" line. The foregoing definition is not valid for organic clays since their liquid limit and plasticity index plot below the "A" line. The silt and clay groups have secondary divisions based on whether the soils have a relatively low (L) or high (H) liquid limit.

The highly organic soils, usually very compressible and with undesirable construction characteristics, are classified into one group designated by the symbol "Pt." Peat, humus, and swamp soils are typical examples.

* From PCA Soil Primer, published by Portland Cement Assn., Chicago, Ill., 1962.

** The grain-size curves of well-graded materials are generally smooth and concave, with no sizes lacking and no excess of material in any size range.

Unified Soil Classification System

Major divisions	Group symbols	Typical names	Laboratory classification criteria	
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 Not meeting all gradation requirements for GW
		GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	
	Gravels with fines (Appreciable amount of fines)	GM*	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4 Atterberg limits above "A" line with P.I. greater than 7
		GC		
	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 Not meeting all gradation requirements for SW
		SP	Poorly graded sands, gravelly sands, little or no fines	
	Sands with fines (Appreciable amount of fines)	SM*	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4 Atterberg limits above "A" line with P.I. greater than 7
	Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silt and clays (Liquid limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
CL			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
OL			Organic silts and organic silty clays of low plasticity	
Silt and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		CH	Inorganic clays of high plasticity, fat clays	
		OH	Organic clays of medium to high plasticity, organic silts	
Highly organic soils		Pt	Peat and other highly organic soils	

*Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

**Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

APPENDIX C

MODIFIED MERCALLI EARTHQUAKE INTENSITY SCALE

Scale degree	Effects on persons	Effects on structures	Other effects	Rossi-Forel equivalent	Equivalent shallow magnitude (Richter scale)
I	Not felt except by few under favorable circumstances			I	
II	Felt by few at rest		Delicately suspended objects swing	I-II	2.5
III	Felt noticeably indoors		Duration estimated	III	
IV	Felt generally indoors		Cars rocked, windows rattled	IV-V	3.5
V	Felt generally	Some plaster falls	Dishes, windows broken, pendulum clocks stop	V-VI	
VI	Felt by all, many frightened	Chimneys, plaster damaged	Furniture moved, objects upset	VI-VII	
VII	Everyone runs outdoors, felt in moving cars	Moderate damage		VIII	5.5
VIII	General alarm	Very destructive and general damage to weak structures. Little damage to well-built structures.	Monuments, walls down, furniture overturned. Sand and mud ejected. Changes in well-water levels.	VIII-IX	6
IX	Panic	Total destruction weak structures, considerable damage well-built structures.	Foundations damaged, underground pipes broken.	IX	
X	Panic	Masonry and frame structures commonly destroyed. Only best buildings survive.	Ground badly cracked, rails bent. Water stopped over banks.		
XI	Panic	Few buildings survive	Broad fissures, fault scarps. Underground pipes out of service	X	8.0
XII	Panic	Total destruction	Acceleration exceeds gravity. Waves seen in ground. Lines of sight and level distorted, objects thrown in air.		8.5

APPENDIX D
ROCK QUARRIES AND GRAVEL PITS

No.	Location	Name	Type	Material	Structure	Fm.**	Lb/ft ³	Abrasion Na ₂ SO ₄	Quality	Quantity	Remarks
*	T. 13S., R. 11W. Sec. 33	Eckman Creek Q.	Q	Basalt	Volcanics	Teyb		20-26	Variable	Large	Commercial; L. R. Kauffman, owner
1.	T. 15S., R. 10W. Sec. 29	Klickitat Quarry	Q	Basalt	Dikes	Ti		14-15	Good	Large	Major local source; forest road use
2.	Sec. 36		Q	Basalt	Dikes	Ti					No data
3.	T. 15S., R. 11W. Sec. 22	Cummins Ridge Q.	Q	Basalt	Breccia	Teyb		15-31	Variable		Highly fractured; weathered in joints; forest road use
4.	T. 15S., R. 12W. Sec. 34, 35	Tennile Creek	G	Gravel	Bar	G		20-25	Fair	Small	State Hwy. Dept. Hwy 101; small, thin deposit
5.	T. 16S., R. 10W. Sec. 3	Indian Creek	Q	Nepheline syenite	Dikes	Tns					No data, forest road use
*	T. 16S., R. 9W. Sec. 35	Deadwood Quarry	Q	Diabase	Dike	Ti		16-17			U.S.F.S.-B.L.M. ownership/over-brdn. consid.
6.	T. 16S., R. 11W. Sec. 7	Fairview Road	Q	Basalt	Dike	Ti					No data
7.	Sec. 8	Fairview Mtn.	Q	Basalt	Dike	Ti		13-17	Good		Reported good source
8.	Sec. 13	Saddle Mtn.	Q	Basalt	Dike	Ti		22-28			Forest road use
9.	Sec. 30	Cape Creek	Q	Basalt	Dike			15			U.S. Forest Service quarry
10.	Sec. 34	Three Buttes	Q	Basalt	Dike			14-22 19.2			U.S. Forest Service q.; rpt. good source
11.	T. 16S., R. 12W. Sec. 11	Fairview Road	QP	Basalt	Dike	Ti					Appears large and good quality
12.	Sec. 15	Big Creek	G	Gravel	Bar	Qal-G				Small	State Hwy. Dept. Hwy. 101; small, thin deposit
13.	Sec. 34	Cape Creek	G	Gravel	Bar					Small	" " " " " " " "
14.	Sec. 36	Cape Creek Road									No data
15.	T. 17S., R. 9W. Sec. 17	Indian Creek	Q	Basalt	Dike	Ti					U.S. Forest Service; used for riprap
16.	Sec. 29	Cape Horn	Q	Basalt	Dike	Ti		18			
17.	Sec. 29		QP	Diabase	Sill	Ti					U.S.F.S. prospect near Vaughn Quarry
18.	Sec. 30	Vaughn	Q	Diabase	Sill	Ti		22-24			Davidson Industries; nearly depleted
19.	T. 17S., R. 10W. Sec. 5	N. Fork Stiuslaw R.	Q	Basalt	Dike	Ti					No data
20.	Sec. 24	Rainrock	Q	Basalt							No data
21.	Sec. 35	U.S. Plywood	Q	Gabbro	Dike	Ti	173.2	16-19 5	Good	Large	Jettystone and crushed rock
22.	Sec. 35	Mapleton Quarry	Q	Gabbro	Dike	Ti	174				Jettystone high face; nearly depleted

* Not in map area; ** Formation symbol Q - Quarries; QP - Prospects; G - Gravel pits

APPENDIX D - continued
ROCK QUARRIES AND GRAVEL PITS

No.	Location	Name	Type	Material	Structure	Fm**	Lb/ft ³	Abrasion	Na ₂ SO ₄	Quality	Quantity	Remarks
23.	T. 17S., R. 12W.											
	Sec. 4	Herman Peak	Q	Basalt	Dike	Ti		16	5-5			
24.	Sec. 10	Berry Creek	Q	Breccia	Volc	Teyb				Variable	Large	Commercial, high face
25.	Sec. 24	Dryden property	QP	Breccia	Volc	Teyb		16-25			Unknown	Opened by dozer
26.	Sec. 25	Erlanson property	GP	Breccia	Volc	Teyb		28			Unknown	Surface sample
	T. 18S., R. 10W.											
27.	Sec. 2	Mapleton Bar	G	Gravel	Bar	Qal						State Hwy. Dept.
28.	Sec. 3	Neely Mountain	Q	Diabase	Dike	Ti		13				
29.	Sec. 5	Walker Creek	Q	Diabase	Dike	Ti	170.9	15-24	5			Riprap Siuslaw jetty repair, rock weath.
30.	Sec. 8	Haskins Quarry	Q	Sandstone		Tet	150					Siuslaw jetty construction
31.	Sec. 9	Chicha Quarry	Q	Sandstone		Tet						State Hwy. Dept.
32.	Sec. 14	U.S. Government	Q	Sandstone		Tet				Poor		Siuslaw jetty construction in 1911
33.	Sec. 17	Stiles Quarry	Q	Sandstone		Tet	151					
	T. 18S., R. 11W.											
34.	Sec. 9		Q	Basalt	Dike	Ti		15				
35.	Sec. 10		Q	Basalt	Dike			21				
	T. 19S., R. 9W.											
*	Sec. 20	Baldy Mountain	Q		Sill			18-22			Large	U.S.F.S. forest roads; new source
	T. 19S., R. 10W.											
*	Sec. 4	Elk Wallow	Q	Basalt	Sill			15-17		Good	Large	U.S. Forest Service
*	Sec. 16	Goodwin Peak	Q	Basalt				16		Good		Breaks too small for jettystone
*	Sec. 23	Gray Back Mtn.	Q	Basalt				24			Large	

* Not in map area
** Formation symbol

Q - Quarries
QP - Prospects
G - Gravel pits

APPENDIX E

REPRESENTATIVE WELLS IN THE COASTAL AREA, LANE COUNTY, OREGON

WELL NUMBER	OWNER	ALT. (FT)	DEPTH (FT)	DIA. (IN)	WATER-BEARING ZONE		WATER LEVEL		USE	REMARKS
					DEPTH (FT)	THICKNESS (FT)	DEPTH (FT)	DATE		
<u>T17S., R12W.</u>										
35C2	U.S. Forest Serv.	37	131	6		Sandstone	1	5-59	PS	SOURCE:USGS 1539 - K, L
35F1		50	18.5	1 1/4	13.8	4.7+		13.8	12-27-73	N
35L1		50						4.3	12-28-73	N
36E1	O. Roberts	36	10	2	4	6+	do	4	12-28-73	D
<u>T18S., R12W.</u>										
2E1	Mr. Lee	100	12	1 1/4	Surface	10+	do	Surface	12-28-73	I
2K1	Mr. Willisie	119	13.6	1 1/4	5.5	8.1+	do	5.5	8-28-59	O
2N2	Glen Muncy	120	50	6	8	42+	Sand	8	12-28-73	N
4K1		40	26.2	1 1/4	12.1	27.9+	do	12.05	12-22-73	N
9A1	C. A. Bonnett	80	78	6	40	38+	do	40	1950	
10J1	Clores Felver	100	14.9	3	Surface	14.9+	do	Surface	12-22-73	N
11K1	U.S. Geological Survey	101	6.4	1 1/4	2.7	3.7+	do	2.70	8-28-59	O
12N1	George Martin	130	94	6	32.6	65.4+	do	32.57	12-22-73	D
14B1	Siuslaw Rod and Gun Club	96	14.1	1 1/4	6.2	7.9	do	6.15	6-4-59	O
14P3	U.S. Geological Survey	67	9.7	1 1/4	Surface	9.7+	Sand	surf.	12-27-73	O

APPENDIX E, continued
 REPRESENTATIVE WELLS IN THE COASTAL AREA, LANE COUNTY, OREGON

WELL NUMBER	OWNER	ALT. (FT)	DEPTH (FT)	DIA. (IN)	WATER-BEARING ZONE		WATER LEVEL		USE	REMARKS	
					DEPTH (FT)	THICKNESS (FT)	DEPTH (FT)	DATE			
T18S., R12W. (continued)											
14P4	do	70	59	6	3.68	55.3+	do	3.68	12-27-73	O	Well drilled to 89 feet, backfilled to 59', used as a pump-test well by USGS, 1539-K. L.
15E1		50	19.8	1 1/4	9.69	10.1+	do	9.69	12-22-73	N	
15M1	Cecil Ames	40	87	6	35	42+	do	35	8-59	D	USGS 1539-K
23E1	Berry Cr.Const.Co.	65	63	6	7.1	55.9+	do	7.10	12-27-73	Ind	Screen 53-58 feet
23L1	City of Florence	40	105	12	11.9	93.1+	Sand	11.90	4-15-64	PS	screen 62-97 feet. Supplies city.
26B1	U.S. Geological Survey	31	12.4	1 1/4	4.35	8.0+	Sand	4.35	6-22-59	O	USGS 1539-K
26E1	Raymond Bruner	40	11	1 1/4	1.0	10+	do	1.0	12-27-73	I	L.
26L1	City of Florence	24.5	24.4	1 1/4	16.37	8.1+	do	16.37	8-6-59	O,N	USGS 1539-K
26N1	Siuslaw Junior High School	40	48	6	19	29+	do	19	7-3-64	N	Screen 42.5-47.5 feet
33N1	Bureau of Land Management		175	6	70	100	Sand	70	2-22-70		Well abandoned, screen 139-179 feet. Gravel pack 100-175 ft.L
34G1	E.B. Harris	90	105	6	41.3		Sand and Shale	41.25	12-21-73	D	L.

APPENDIX

APPENDIX E, continued
 REPRESENTATIVE WELLS IN THE COASTAL AREA, LANE COUNTY, OREGON

WELL NUMBER	OWNER	ALT. (FT)	DEPTH (FT)	DIA (IN)	WATER-BEARING ZONE		WATER LEVEL		USE	REMARKS
					DEPTH (FT)	THICKNESS (FT)	DEPTH (FT)	DATE		
<u>T18S., R12W. (continued)</u>										
34J1	Ernest Harris	80	95	4			27.93	12-21-73	N	
34J4	Pier Point Inn	50	50	48			11.35	12-21-73	PS	Dug well, supplies motel
34P1	State of Oregon	120	120	6	33	87+	33	10-1-64	PS	Supplies MacLaren School. L.
35L1	A. Jacobson	120	55	6			20.58	12-21-73	D	
35M1	L. Buckley	80	212	6	28	9	28	9-11-69		Well Destroyed
35N1	R.W. Ulman	100	140	6	38	92	40	3-19-68	D	L.
<u>T19S., R12W.</u>										
2L1	R. Bond	210	159	6			59.76	12-21-73	D	screen 130-134 ft.
2N2	Honeyman Village Nursery	100	85(?)	6			15.72	12-20-73	D,I	Water partly used for nursery stoc
3H1	Lutheran Church	180	100	6	95	5	42.68	12-20-73	N	L.
10G1	Mr. Miller	100	28.3	6			8.85	12-20-73	D	
10G2	K.J. Braun	100	242	6	32	120	32	4-10-68	D	Drilled to 73 ft., screen 66 to 72 ft.

APPENDIX E, continued
 REPRESENTATIVE WELLS IN THE COASTAL AREA, LANE COUNTY, OREGON

WELL NUMBER	OWNER	ALT. (FT)	DEPTH (FT)	DIA. (IN)	WATER-BEARING ZONE		WATER LEVEL		USE	REMARKS	
					DEPTH (FT)	THICKNESS (FT)	DEPTH (FT)	DATE			
T19S., R12W., (continued)											
14K1	Jake Mann	120	75	6	8.0	67+	Sand	8.04	12-20-73	N	Gravel pack from 19-65 feet, screen set 35-40 ft.
22L1	M.B. Taylor	100	100	6	47	53+	do	47	7-26-69	D	L.
22L2		70	13.4	1 1/4	9.6	3.5+	do	9.9	12-21-73	N	
23L1	R. Collins	120	90	6	40.0	Shale & Clay-	stone	17.22	12-19-73	D	Casing perforated 40 to 50 feet and 70 to 80 ft.
27K1	A. Vermilyn	30	60	6	12	Sandstone & Claystone		20	3-7-67	D	
33P1	U.S. Forest Service	100	142	6	27.1	14.91	Sand	27.08	12-19-73	I	Supplies maintenance building. I.
34C1	L. Pearce	70	43.5	6	26.2	17.3+	do	26.24	12-19-73	D	L.
(1)	Wells are designated by township, range, section, and 40-acre subdivisions. For example, the symbol 17/12W-35C2 indicates the well is located in township 17 and range 12 and south and west of the Willamette base line and meridian. The section is indicated by 35 and the letter C indicates the 40-acre tract according to a system in which "A" is the NE1/4 NE1/4, thence successively westward and eastward across the section ending with "R" in the SE1/4 SE1/4, with "I" and "O" omitted.										
(2)	Altitude estimated from topographic map.										
(3)	USE: D, domestic; PS, Public Supply; I, irrigation; Ind, industrial; O, observation N, not used.										
(4)	"L" means log in Appendix F.										

APPENDIX F

LOGS OF WELLS

MATERIALS	THICKNESS (feet)	DEPTH (feet)
<u>17/12W - 35C2: U.S. Forest Service, drilled by C. E. Panschow, 1959</u>		
Quaternary deposits:		
Sand, dune, yellow	20	20
Sand, Blue, silt and peat	20	40
Log, fir (?)	6	46
Sand, blue, silt and peat	14	60
Tye formation:		
Clay, blue	4	64
Sandstone	61	125
Shale, gray-blue	6	131
Cased, 6 inch, 0-66 feet		
<u>18/12W - 9A1: C. A. Bonnett, drilled by C. E. Panschow, 1950</u>		
Quaternary deposits:		
Sand, dune	40	40
Hard pan (silt and sand?)	4	44
Sand, beach, water-bearing	34	78
Cased, 6 inch, 0-73 feet, screen 73-78 feet.		
<u>18/12W - 12N1: George E. Martin, drilled by C. E. Panschow, 1956</u>		
Quaternary deposits:		
Clay	4	4
Sand, beach	90	94
<u>18/12W - 14P4: U.S. Geological Survey, drilled by C. E. Panschow, 1959</u>		
Quaternary deposits:		
Sand, dune, fine-grained, gray	27	27
Peat, dark-brown, and wood	1/2	27 1/2
Sand, dune, fine-grained, gray	25	52 1/2
Peat, dark-brown, and wood	1/2	53
Sand, dune	28	81
Cased, 6 inch, 0-44 feet, 4 inch screen 44-59 feet.		

APPENDIX F, continued

MATERIALS	THICKNESS (Feet)	DEPTH (feet)
<u>18/12W - 23E1: Berry Creek Construction Company, drilled by C. E. Panschow, 1967</u>		
Quaternary deposits:		
Fill	4	4
Sand, wood	1	5
Sand and clay	22	27
Clay and silt, wood and pine needles(?)	3	30
Clay and sand, wood	10	40
Wood, decomposed, bark, leaves, and needles	1/4	40 1/4
sand, gray, water bearing	14 3/4	56
Sand, gray, wood and bark, water bearing	7	63
Cased, 6 inch, 1-54 feet, screen 53-58 feet.		
<u>18/12W - 23L1: City of Florence, drilled by Carter Drilling and Pump Service, 1964</u>		
Quaternary deposits		
Sand	105	105
Cased, 12 inch, 0-62 feet, 10 inch screen 62-97 feet.		
<u>18/12W - 33N1: Bureau of Land Management, drilled by Rotary Drilling Company, 1970</u>		
Quaternary deposits:		
Sand, dune, fine	40	40
Sand, fine	130	170
Tye formation:		
Sandstone (?) and claystone (?)	5	170
Cased, 8 inch, well destroyed.		
<u>18/12W - 34G1: E. B. Harris, drilled by Mark Christensen, 1961</u>		
Quaternary deposits:		
Sand	20	20
Sand and debris	25	45
Tye formation:		
Clay	43	88
Shale	2	90
Clay	15	105
Cased, 6 inch, 3-87.9 feet.		

APPENDIX

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APPENDIX F, continued

MATERIALS	THICKNESS (feet)	DEPTH (feet)
<u>18/12W - 34 P1: State of Oregon, drilled by C. E. Panschow, 1964</u>		
Quaternary deposits		
Sand and brown clay	30	30
Sandstone(/) and clay	10	40
sand and clay	30	70
Sand and clay, wood	8	78
Clay, hard	2	80
Sand and Clay	10	90
Sand, grey, water-bearing	30	120
Cased, 6 inch, 0-103 feet, gravel pack 18-30 feet (?), screen 103-113 feet.		
<u>18/12W - 35N1: R. W. Ulman, drilled by Miller Jensen Co., 1968</u>		
Quaternary deposits:		
Sand, Fine, clay	30	30
Tyee formation:		
Clay, brown	8	38
Shale, blue	92	130
Muck, blue (clay?)	10	140
Cased, 6 inch, 0-138, perforated 70-80 feet.		
<u>19/12W - 3H1: Lutheran Church, drilled by Beaver Drilling Co., 1964</u>		
Quaternary deposits:		
Soil	2	2
Clay, yellow	1	3
Sand, fine, brown	67	70
Tyee Formation:		
Clay, blue, soft	3	73
clay, blue, sandy, some water	2	75
Claystone, blue	20	95
Claystone, blue, fine gravel water bearing (?)	5	100
Cased, 6 inch, 0-90 feet, perforated 80-90 feet.		

APPENDIX F, continued

MATERIALS	THICKNESS (feet)	DEPTH (feet)
<u>19/12W - 22 L1: M. B. Taylor, drilled by Casey Jones Drilling Co., 1969</u>		
Quaternary deposits:		
Sand and red clay	9	9
Sand, some brown clay	58	67
Tyee formation:		
Sand, brown, packed	18	85
Shale, gray, hard	15	100

Cased, 6 inch, 0-60 feet, screen 57-67 feet.

19/12W - 33P1: U. S. Forest Service, drilled by C. E. Panschow, 1963

Quaternary deposits:		
Sand	72	72
Tyee Formation:		
Clay, yellow	6	78
Clay, blue and sand, grey	34	112
clay, blue, hard	6	118
Shale	1/2	118 1/2
Clay, blue	7 1/2	126
Shale	1/2	126 1/2
Clay, blue	4	130 1/2
Shale	1/2	131
Clay, blue, sandy	11	142

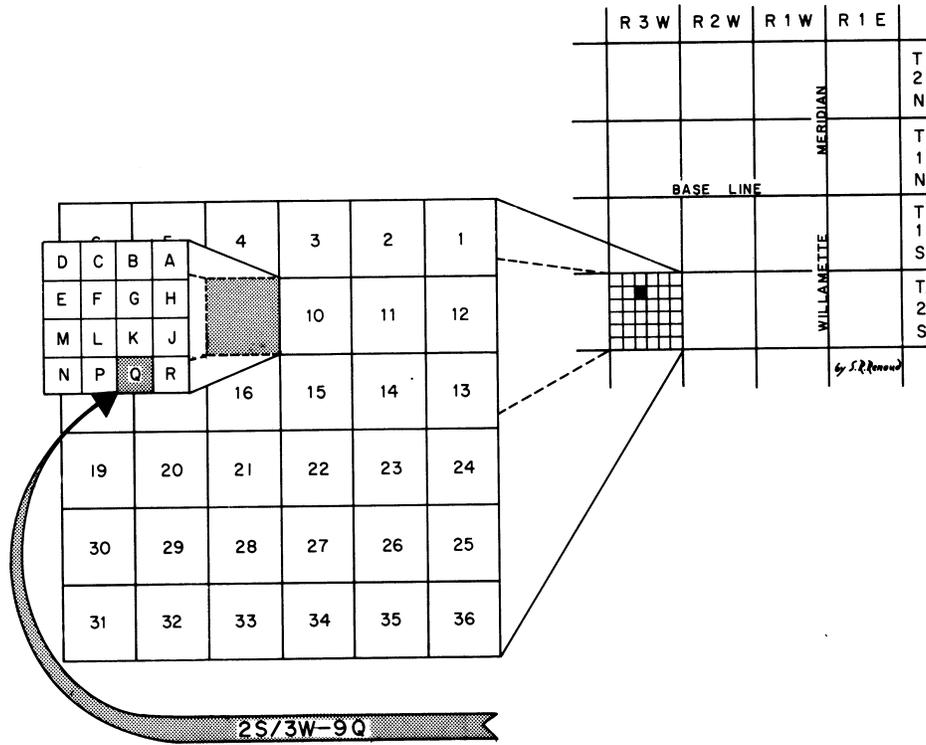
Cased, 6 inch, 0-64 feet, gravel pack 70-80 feet, screen 64-69 1/2 feet.

19/12W - 34C1: Leo Pearce, drilled by C. E. Panschow, 1957

Quaternary deposits:		
Sand	43.5	43.5

APPENDIX G

WATER WELL NUMBERING SYSTEM



Wells are designated by symbols that indicate location according to the rectangular subdivision of public lands. Thus, in the above example:

- 2S refers to Township 2 south
- 3W refers to Range 3 west
- 9 refers to section 9
- Q refers to tract Q

APPENDIX H

SOIL INTERPRETIVE GUIDE AND DESCRIPTIVE LEGEND

Ted Dietz, Soils Scientist
Lane County Environmental Health Department

Coastal Soils

Soils of this region vary from dune sands to very thin silty clays over Basalt and sedimentary bedrock. Generally, the sand-dunes area of the Florence Coastal Plain and the Blowout Creek area, north of Heceta Head are marine sand-dune deposits that have been actively occurring for many thousands of years. The soil varies from deep Bare dune sands to Westport fine sandy loam which has from 10 to 20 inches of fine sandy loam surface developed over loose dune sand substrata having varying amounts of iron-oxidation cementing in the upper 48 inches of soil. The Inter-dunal flats are dominated by wet Yaquina fine sands having organic and iron-oxide formations which create water tables at or near the surface during most rainy periods. Netarts fine sandy loam is found on dune ridges and has 5 to 10 inches gray loamy fine sand horizon, then a reddish-brown iron cemented zone at 7 to 20 inches from the surface.

The older terraces and foothills along the coast have partially re-worked marine sediments and loess type material over sandstone and older dunal material. Lint, Bullards-Ferrelo, Bandon, and some Netarts series will be found on these areas.

Lint has silty clay loam upper horizons with non-plastic, high liquid limit, silty loams to clay loams in the lower strata. The soil usually has sandstone or compacted sands as bedrock.

Bullards-Ferrelo, Bandon, and Netarts usually occur over compacted sands or sandstone bedrock with loam to sandy loam surfaces to 40 inches where the loamy fine sand or fine sand occur. Bullards and Ferrelo have weak to strong, iron cemented shot-size nodules in the surface 40 inches.

Bandon has reddish-brown sandy loam in the surface with a weakly cemented hardpan at 20 to 36 inches. Stratified and compacted loamy sand with some sand grain weathering occurs below this zone.

Netarts is described in the Dune Areas part of this section. The deeper soils of the uplands are described as deep, well drained, and having erosion and stability limitations that vary with the depth of soil and slope degree.

The Uplands Region east of the Coastal lakes and south of Cape Mountain have predominately Tyee sandstone parent material soils of Preacher, Slickrock, Tahkenitch and Ead with deep surfaces up to 60 inches. Digger and Bohannon are shallow rocky members of this association.

The Digger series has up to 50% coarse fragments up to 6 to 8 inches, in size with loam to gravelly loam in the upper 30 inches. Tyee sandstone occurs at 30 inches.

The Preacher series has up to 40 inches of clay loam with 30 plus inches of loam to sandy loam over partially fractured sandstone. This soil presents some limitations on slopes over 20% due to limitation induced by depth and conditions of the bedrock face; smooth tilted faces of the bedrock will produce mass movements on the steeper slopes.

Slickrock series has a gravelly loam surface with increased gravel content as the profile deepens. Rock content can be up to 40% of the volume in the lower horizons and are semi-rounded. Slope stability limitations are severe where the bedrock is tilted and the soils are deep.

Tahkenitch is a new series established on the east side of Tahkenitch Lake in Douglas County. Tahkenitch has a gravelly loam profile that is deep and well drained. The clay content does increase with depth and should be predominately loam to clay loam.

In some area of the terraces a Lint complex is mapped. This soil has a gray, marine sediment zone occurring at 24 to 30 inches. This zone can be up to 12 inches thick and is a Silty Clay to Clay texture. The typical site is on Clear Lake Road west of the Woahink Lake arm crossing.

Ead has silty clay loam over silty clay or clay over sandstone bedrock at about 40 inches. The soil is usually found on outwash fans and terraces. The upper surface is well drained with restrictions at about 20 inches.

Tidal and Alluvial soils are composed of flood-water (alluvial) deposits of organic and mineral soils separates and the effect of lake and stream edge degradation. Peats, sands, sandy loams and loams characterize the soil types. Series designations are Brailler, Gardiner, Nestucca, Nehalem, Willanch, and Tidal Marsh.

Brailler is a peat- or muck-type soil that has combination horizons of organic and mineral silts. There are some profiles that have silt loam or sandy loam over the organic layers. They occur in tidal back-water areas as well as lake arms that are filling by degradation into marshes and finally into raised soil areas.

The Gardiner series has a dark-brown fine sandy loam surface that gets sandier with depth. The soil is deep and is found along the flood terraces of the rivers and creeks of the area. Flood-plain limitations are present.

Nehalem has silty loam surfaces that overlay silty clay loams and tend to have restrictive drainage in the lower surfaces. Some mottling can occur in the lower part of the profile starting at about 20 inches. The flood-plain position of this soil presents some limitation for its use.

Nestucca consists of deep, somewhat poorly drained, silt loams and loams with mottled silty clay loams at 20 inches. Ponding does occur on the soil which limits its use in development. Flooding is a limitation.

Willanch soil, a series found along Canary Creek and other fresh-water creek banks, is a deep, poorly drained loam to sandy loam with stratified sandy loam and loamy sand that is heavily mottled with brown and strong reddish-brown colors. Foundation loading and sewerage disposal are major limitations.

The Tidal flats series is one that occurs where tidal and marine beds are being built due to the slack-water deposition of organics and silts on shallow calm areas of the estuarine. The soil characteristics vary greatly due to deposits.

The Basalt-affected area north and east of the Heceta Head and Cape Mountain has a complex soils format due to the intrusive and flow geology of the area. Soil on the area is developed from a predominately Basalt parent material that was deposited during early volcanic occurrences.

Kilchis, Klickitat, and Hembre are the principal known series of this area; others may be established as upland mapping progresses.

Hembre has a silty loam to loamy surface with restrictive silty clay loams to silty clays at 18 to 20 inches over Basalt bedrock at 30 to 40 inches. Rock fragments can be common in the upper horizons. It is found on the convex ridges and steeper sloped hills.

Kilchis stony loam is a shallow soil that occurs over Basalt bedrock on ridges and steeper slopes of the Coast Range. Stony loam is seldom over 28 inches deep over the bedrock. Plant growth and excavation have major problems on the soil due to the shallow soil cover conditions.

Klickitat is a series that has gravelly loam at the surface with up to 50 inches of soil over fractured Basalt with 65% gravelly pebbles in the surface and 30% stony material in the lower 20 inches.

Bohannon has 12 to 24 inches of gravelly loam over fractured bedrock with increased sandstone fragments to Tyee bedrock at 60 inches. The soil is formed in Tyee sandstone colluvium with loam surfaces, subsoil of loam and sandy loam with fractured sandstone at a depth of 40 inches with soil full of loam and sandy loam. Hard sandstone will occur at 60 inches plus depth. The soil is generally found on steeper dissected hills of the Coast Range.

Several other series may be added to the region as soil mapping progresses. The uplands are not scheduled for extensive mapping at this time. The major areas will have slope stability mapping done by the U.S. Forest Service as time progresses.

General Setting and Table* Use Guide

This soil interpretive guide is designed to give general, quick reference to soil suitabilities for planning. The criteria used for suitabilities ratings generally follow good engineering practice in design consideration based on soil properties to support a particular activity.

The guide criteria are generally the ones used to rate soils under the U.S.D.A. Soil Conservation Service from OR-1 Soil Interpretive Guides for soil mapping units. The soils included in this interpretive guide are units mapped under the Lane County Soil Survey legend as of February 1974. As mapping units are added to the legend these will be interpreted and OR-1 guides and Lane County guides will become available.

Reference material supporting the interpretive guide are available in the office of the Soil Conservation Service in Lane County and the office of the Lane County Resource Soil Scientist with the Water Pollution Division of the Environmental Management Department.

Soils survey field sheet photos and soils maps at 1 inch to 3,000 feet, based on U.S.G.S. quadrangle gradient sheets, are available with the soils data overlays for Elmira, Eugene, Marcola, Leaburg, Cottage Grove, Lowell, Anlauf, Blue River, and McKenzie Bridge quadrangles. The Lakes area of Siltcoos and Heceta quadrangle gradients have mapping available at 1 inch to 2,640 feet. As soil mapping data becomes available from the Soil Conservation Service and other sources, it is added to the quadrangle sheet bases.

Rating criteria

Agricultural capability classification: Follows the U.S.D.A. Soil Conservation Service system of capability classes I through VIII with sub-class designations of "e" - open soil erosion hazards, "w" - water effected conditions of ponding or poor internal drainage, "s" - shallow, droughty or stony. Capability classes I-II, III are considered as "prime agricultural lands."

Class description

Development suitability ratings: The system used to rate a soil for development suitability considers the properties of each soil to support urban land use activities on a rating of 1, 2, 3, 4.

Dwelling hazards, subsurface sewage disposal suitability, road and street construction and natural hazard conditions are used. Slight, moderate, and severe limitations are used for each consideration and a weighted number of their occurrence in each category is used to determine the class that the soils fits into. The following grouping is used for this rating:

Factor	Rating Number			
	1	2	3	4
Dwelling limitation	Slight	Slight	Moderate	Severe
Septic tank drain field limitation	Slight	Moderate	Severe	Severe
Road and street limitation	Slight	Slight	Moderate	Severe
Natural hazards	Slight	Moderate	Moderate	Severe

Dwelling suitability

Conditions considered in setting these suitabilities include depth to bedrock, foundation loading conditions; slope; subsoil moisture hazards. Example: A soil with a 0 to 5% slope, 20 inches to base rock, with loam to silty clay loam substrata would have a slight limitation; however, a soil 60 inches deep with clay of a high shrink-swell character on a 10% slope would have severe rating.

*On Soils Map in pocket

Subsurface sewage disposal system

Limitation on this grouping was based on conditions as outlined in the April 1974 D.E.Q. rules for subsurface sewage disposal. The criteria for "Slight" had no soil limitation for depth to water, restrictive or impermeable zones or other limitation listed in those rules; "Moderate" had a minor limitation of one item. "Severe" had two minor problems, and "Unsuited" more than two. This rating does not preclude on-site investigation for actual installation of a system but is to serve as a guide to suitability.

Roading group

Suitability for roading is based on normal engineering criteria for road design and natural barriers to these design considerations. Attaburg limits, shrink swell, ASSHO class, depth to bedrock, natural slope, and slumpage stability hazard were added to the engineering design criteria.

Utility installation

This group is considered for installation of water, sewerage, power or communications lines (underground or above ground), gas lines, or other service type utilities.

Rating criteria considered are soil stability of shrink swell and compression, trenching stability, bedrock, depth, erosional hazard, slope, and presence of gravels or sands.

General landscape stability

This area had consideration made for hazards of both slope as well as foundation hazards for most types of loading; criteria were shrink-swell, compressibility, loading character, depth to bedrock, character of shear strength in cut-bank stability, wetness of bedrock surfaces, slope and other hazards.

Erosional hazard

This rating is based on freshly excavated, filled, or tilled soil surface of a non-protected nature. Slope, surface texture, and general water-flow conditions are considered.

Depth

Depth of soil is considered the depth of the soil to a hardpan, bedrock, or very gravelly conditions and is considered in dwelling, road construction, stability, and utility ratings.

Unified engineering soil classification data

This system rates soils at 18-inch depth from the surface of the soil. The ratings are all based on OR-1 soils interpretive sheets and are not a replacement for actual engineering tests for design criteria. They are to be used for planning and estimate purposes only.

Hydrologic groups

For general planning for hydrologic calculations, Mannings formula should be used for actual hydraulic engineering design of conduits and open-drainage structures.

Remarks

This section is meant to give general information or some particular condition on character of soils present that is deemed especially important.

For further detailed interpretive data refer to the U.S.D.A. Soil Conservation Service OR-1 Soil Interpretive guide form available at the U.S.D.A. Soil Conservation Service local office.

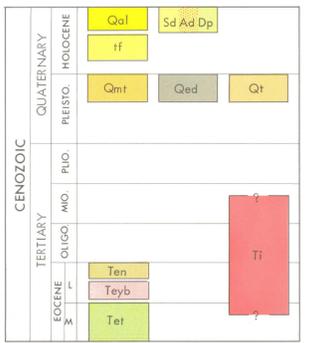
APPENDIX I

GEOLOGIC TIME CHART					
STRATIGRAPHIC DIVISIONS			TIME	DOMINANT LIFE	
ERA	SYSTEM OR PERIOD	SERIES OR EPOCH	Estimated ages of time boundaries in millions of years	ANIMALS	PLANTS
CENOZOIC	QUATERNARY	Holocene	— 2-3 —	Man	Flowering trees and shrubs
		Pleistocene			
	TERTIARY	Pliocene	— 12 —		
		Miocene	— 26 —		
		Oligocene	— 37-38 —		
		Eocene	— 53-54 —		
Paleocene	— 65 —				
MESOZOIC	CRETACEOUS	Upper (Late) Lower (Early)	— 136 —	Dinosaurs and Flying and swimming reptiles	Conifers, Cycads, Ginkgos and Ferns
	JURASSIC	Upper (Late) Middle (Middle) Lower (Early)			
	TRIASSIC	Upper (Late) Middle (Middle) Lower (Early)	— 190-195 —	Ammonites	
PALEOZOIC	PERMIAN	Upper (Late) Lower (Early)	— 225 —	Giant insects, Primitive reptiles & Amphibians	Scale trees, Cordaites, Calamites, and Tree ferns Primitive scale trees and tree ferns Lycopods and Psilophytes Algae and Fungi
		Carboniferous	PENNSYLVANIAN		
	MISSISSIPPIAN		Upper (Late) Lower (Early)	— 345 —	
	DEVONIAN	Upper (Late) Middle (Middle) Lower (Early)	— 395 —		
	SILURIAN	Upper (Late) Middle (Middle) Lower (Early)	— 430-440 —	Corals,	
	ORDOVICIAN	Upper (Late) Middle (Middle) Lower (Early)	— 500 —	Brachiopods,	
	CAMBRIAN	Upper (Late) Middle (Middle) Lower (Early)		and Trilobites	
PRECAMBRIAN		Z - base of Cambrian to 800 m.y. Y - 800 to 1,600 m.y. X - 1,600 to 2,500 m.y. W - older than 2,500 m.y. (U.S.G.S. Bull. 1394-A, 1974)		Beginning of primitive plant and animal life	
<p>(More than 80% of earth's estimated 4.5 billion years falls within this era)</p> <p>Oldest rocks known in Oregon: Limestones in central Oregon containing Middle Devonian fossils - about 370 million years old. Oldest rocks known in North America: Granitic gneisses in Minnesota - 3550 million years old. Oldest fossils known in the world: Algal stromatolites in southern Rhodesia - 2.7 billion years old. Oldest rocks known in the world: Australia, Finland, South Africa, and North America have rocks about 3.5 billion years old. Age of the earth: about 4.5 billion years old.</p>					
Adapted from U.S. Geological Survey and other sources. Ages of oldest rocks and fossils from T. W. Stern, U.S.G.S. Isotope Branch, March 1970.			State of Oregon Department of Geology and Mineral Industries 1069 State Office Building, Portland, Ore. 97201		

GENERALIZED GEOLOGIC TIME CHART FOR OREGON				
ERA	PERIOD		AGE* (in millions of years)	
	EPOCH			
CENOZOIC	QUATERNARY	HOLOCENE	Glaciers in mountains receding. Crater Lake and Newberry Crater formed by explosion and collapse of volcanic cones. Lava flows near Mt. Hood, at McKenzie Pass, and in central and southeastern Oregon.	.011
		PLEISTOCENE	Active glaciers in mountains. Growth of large volcanoes along crest of Cascades and in central Oregon. Pluvial lakes in south-central part of State. Mastodons and giant beavers in Willamette Valley; camels and horses in grasslands of central and eastern Oregon.	2-3
	TERTIARY	PLIOCENE	First eruptions of lava at crest of Cascade Range. Extensive outpouring of lava in south-central Oregon. Horses, rhinos, camels, antelope, bear, mastodons living in John Day country. Cascade Range high enough to form climate barrier. Drier climate east of High Cascade Range. Warm temperate climate west of Cascades initiates period of laterization.	12
		MIOCENE	Thick layers of lava extruded over much of State (middle and upper Miocene). Seas invade coastal areas; mollusks, fish, whales, sea lions. Oreodonts, rodents, 3-toed horses, giant pigs, rhinos, tiny camels, wolves, and saber-tooth cats living in John Day country. Mild, humid climate with extensive forests of Metasequoia. Last emplacement of granitic plutons in the State (Cascade Range) with accompanying mineralization. Coast Range begins uplift. Cascade Range growing in height.	26
		OLIGOCENE	Willamette Valley and parts of Coast Range covered by warm, shallow seas. Inhabited by abundant and varied mollusks. Warm temperate flora growing in both eastern and western Oregon, with Metasequoia, maple, sycamore, ginkgo, and katsura trees plentiful. Three-toed horses, camels, giant pigs, saber-toothed cats, oreodonts, tapirs in John Day country. Cascade Range too low to affect climate of eastern Oregon.	37-38
		EOCENE	A subtropical climate. Coal forming in coastal swamps. Palms, figs, avocados, pecans, and walnuts grow in central Oregon. Four-toed horses, rhinos, tapirs, crocodiles in Clarno area. Western Oregon covered by arm of ocean, locally many mollusks. Large volcanoes in area of Cascade Range.	53-54
		PALEOCENE	Not mapped separately in Oregon, but rocks of this age known in southern Coast Range.	65
MESOZOIC	CRETACEOUS	Most of State covered by warm seas. Ammonites, trigonia, and other mollusks, abundant in Medford and Mitchell areas. Tree ferns growing near Austin in Grant County. Formation of principal metalliferous deposits in State following batholithic intrusions.	136	
	JURASSIC	Oregon largely covered by seas. Brachiopods, mollusks, and ammonites abundant. Some marine reptiles. Ferns, cycads, ginkgoes, and conifers growing on land areas. Period of serpentine intrusion with formation of chromite deposits followed by granitic intrusions in Klamath Mountains, Blue Mountains, and possibly Wallawa Mountains.	190-195	
	TRIASSIC	Most of Oregon covered by warm seas. Sponges, corals, ammonites, gastropods, and nautiloids. Volcanoes active and widespread especially in northeastern and southwestern Oregon.	225	
PALEOZOIC	PERMIAN	Warm seas cover much of State. Limestone reefs forming. Fusilinids common. Volcanism in northeastern part of State. Rocks now exposed in central and eastern Oregon.	280	
	CARBONIFEROUS	Much of State covered by warm seas containing brachiopods and corals. Ferns and calamites growing on land areas. Rocks now exposed in Suplee area of central Oregon.	345	
	DEVONIAN	Seas probably covered Oregon. Small limestone outcrops in central Oregon contain Middle Devonian corals (about 370 m.y.).	395	
	PRE-DEVONIAN	"Pre-Devonian" includes the vast stretch of geologic time extending back to the oldest rocks found on the earth. Rocks of this age are not known in Oregon. Nearest "pre-Devonian" rocks (450 m.y. old gabbro) in Klamath Mountains, northern California.		

* Adopted from U.S. Geol. Survey

STRATIGRAPHIC TIME CHART



EXPLANATION

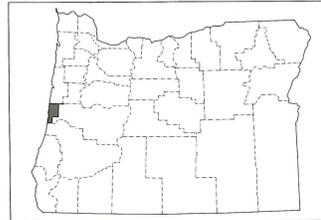
- Qal** Alluvial bottom lands
Flood plain and river-channel sediments composed of clay, silt, sand, and gravel; layers of organic material locally.
- if** Tidal flat
Low-lying areas of alluvial sand, silt, and organic mud in the lower reaches of the Siuslaw River which are inundated by normal high tides.
- Ad** Active dunes
Deposits of open sand up to 200' thick which move in response to wind. Composed of clean fine sand but locally may have layers of silt, clay, and peat, and hard iron-stained layers a few inches thick. Buried soil horizons may be present at several levels.
- Sd** Stabilized dunes
Old dunes covered by vegetation; weak to moderate soil development overlying unconsolidated fine sand. Iron bands and buried soil horizons are common.
- Dp** Deflation plain
Interfluvial areas eroded by wind to the summer level of the water table. Includes soil, plants, and brush-covered areas partly flooded most of winter and spring months when the water table is high.
- Qt** Elevated alluvial terrace deposits
Remnants of former river flood plain along the north side of the Siuslaw River and near the mouth of Big Creek; composed of silt, sand, and thin gravel.
- Qed** Estuarine deposits
Silty and clayey sand with peat layers in a buried ancient channel of the Siuslaw River. Exposed in bank of Siuslaw River at Coast Guard Station and recognized in water-well logs beneath the sand dunes to the north.
- Qm1** Marine terrace deposits
Silty sand, gravel, and colluvium on flat benches adjacent to the beach; mainly north of Sea Lion Point.
- Ti** Intrusive rocks
Predominantly northeast-trending basalt and gabbro dikes. Rare nepheline syenite and quartz diorite bodies.
- Teyb** Yachats Basalt
Subvolcanic and subvolcanic rocks and flows. Includes porphyritic basalt, basaltic andesite, pillow basalt, lapilli tuff, conglomerate, occasional sandstone and siltstone interbeds.
- Ten** Nestucca Formation
Thinly bedded siltstone and sandstone with interbeds of glauconite and arkosic sandstone.
- Tet** Tye Formation
Rhythmically bedded sandstone and siltstone. Sandstone is micaceous, fine to medium, and occasionally coarse-grained; beds up to 15 feet thick; siltstone is micaceous and contains scattered organic matter.

GEOLOGIC SYMBOLS

- Faults and lineations**
Dashed where approximate, and dotted where concealed. U, upthrown side; D, downthrown side.
- Contacts**
Solid where definite, dashed where approximate, and dotted where concealed.
- Attitudes**
Strike and dip of beds of flows.
- Horizontal beds**
⊕
- Landslide areas**
Landslide developed topography. Only larger areas shown on the map. Includes active, recent, old, and ancient (archaeologic) landslide areas.
- Headscarp (combined with landslides)**
Boundary of disturbed ground
- Quarries**
⊗
- Gravel pits**
⊙
- Wells**
○
- Springs**
⋈

ENVIRONMENTAL GEOLOGY
of
COASTAL LANE COUNTY
OREGON

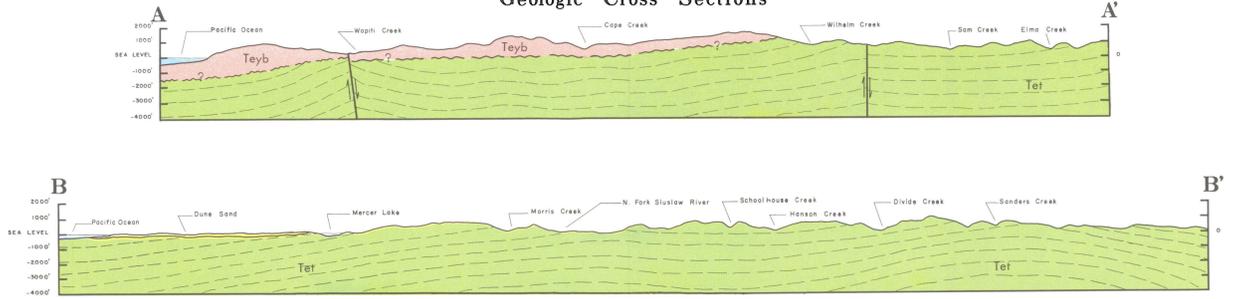
LOCATION MAP



Geology by H. G. Schlieker and R. J. Deacon, modified from Baldwin (1956) and Snavely, MacLeod, and Wagner (1972). Sand dunes map modified from Reckendorf (1973).

Cartography by S. R. Renoud and W. H. Pakorny of Oregon Dept. of Geol. and Mineral Indus., and M. P. Evans and T. G. Krebs of the Lane County Surveyor's Office Published 1974.

Geologic Cross Sections



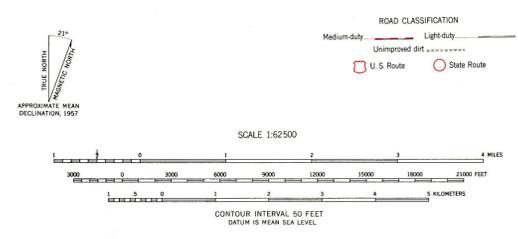
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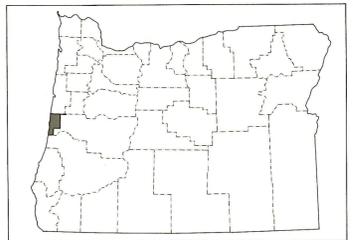
EXPLANATION

- Slopes**
- Less than 10%
 - 10 to 25%
 - 25 to 50%
 - Greater than 50%
- Advancing dunes**
Indicated areas show direction of movement. Does not indicate amount or rate of movement.
- Landslides with direction of movement**
Includes areas of disturbed ground which could be reactivated by improper use. The degree of hazard will depend on the use made of the ground.
- Headscarps (combined with landslides)**
Boundary of disturbed ground.
- Critical coastal erosion**
Erosion which needs to be considered with reference to location of buildings and engineering structures or loss of valuable land.
- Faults and lineations**
Dashed where approximate, and dotted where concealed. U, upthrown side; D, downthrown side.
- Flooding**
Shows areas subject to flooding based on experiences of major floods of the past ten years.



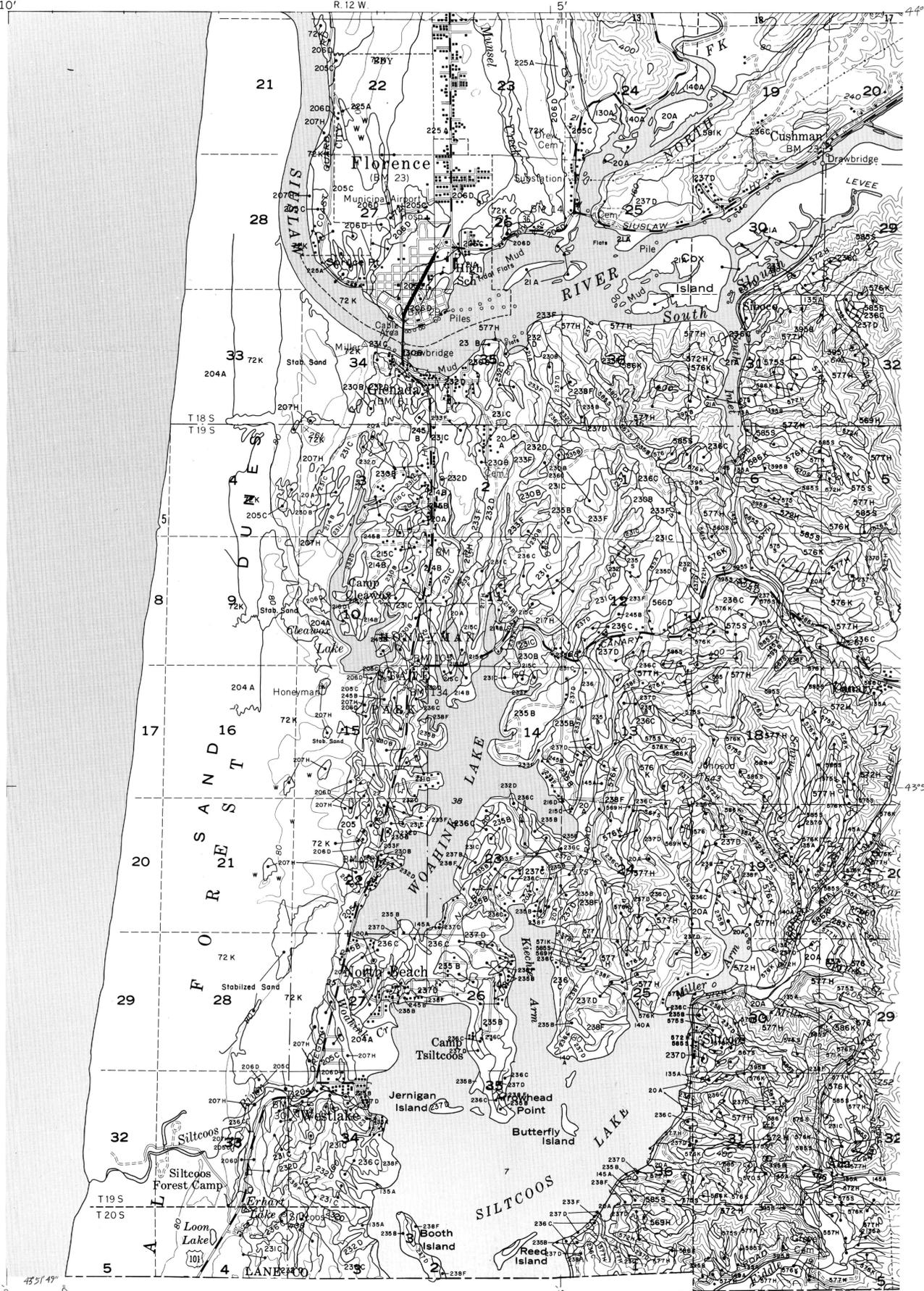
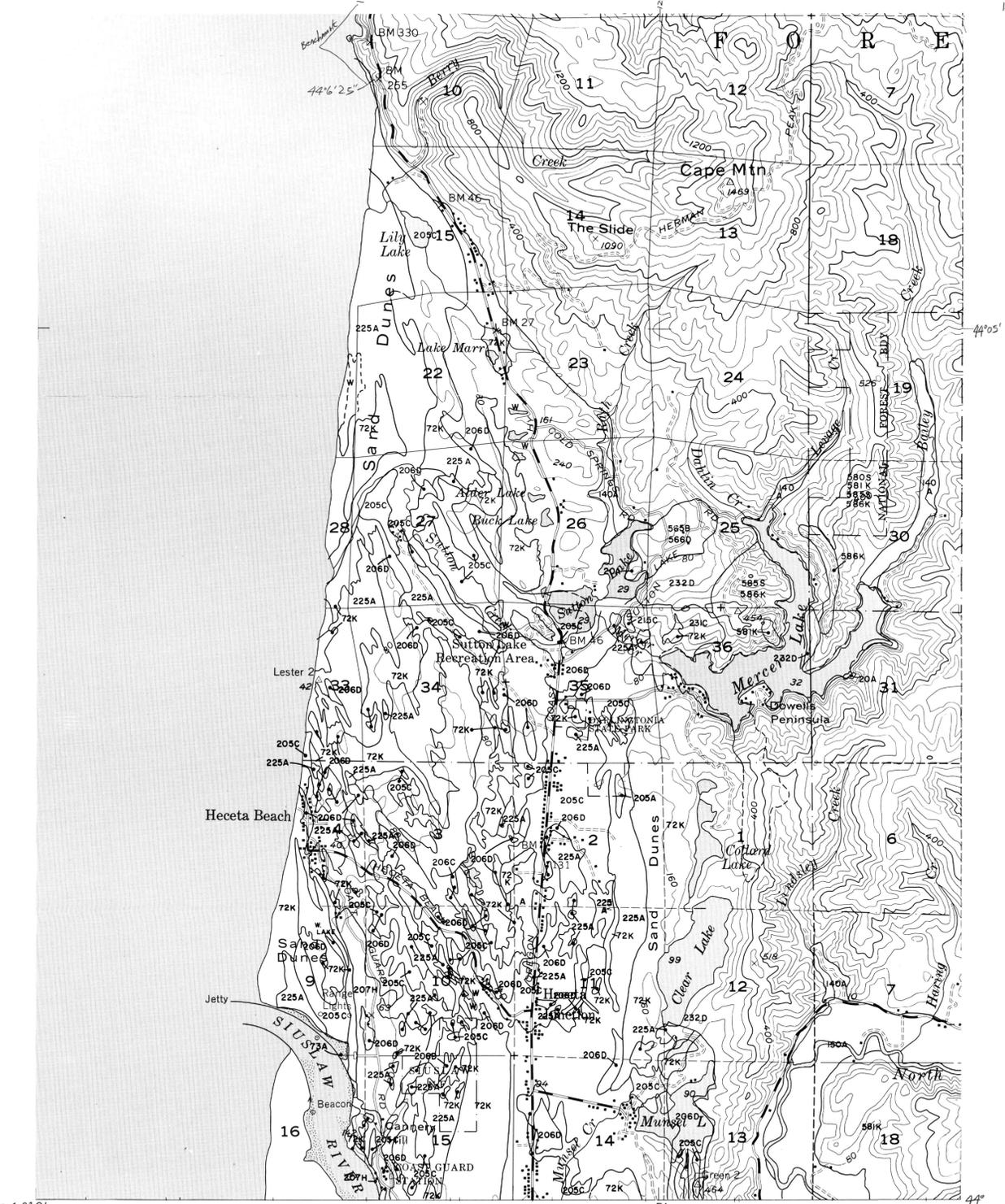
GEOLOGIC HAZARDS
of
COASTAL LANE COUNTY
OREGON

LOCATION MAP



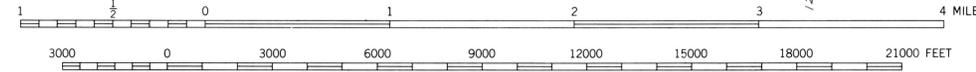
Geology by H. G. Schlicker and R. J. Deacon, modified from Baldwin (1956) and Snavely, MacLeod, and Wagner (1972). Sand dunes map modified from Reckendorf (1973).
Cartography by S. R. Renoud and W. H. Pokorny of Oregon Dept. of Geol. and Mineral Indus., and M. P. Evens and T. G. Krebs of the Lane County Surveyor's Office Published 1974.

SOILS MAP of COASTAL LANE COUNTY OREGON

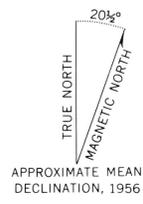


SYMBOL	SOIL NAME	SLOPE	POSITION	DS	AC	S.D.S.	DRILL	UTILITY	STABILITY	REACTION	DEPTH IN FEET	REMARKS		
20A	Bratler Muck	0-2	Flood	4	llw	U	Sv	Sv	Sv	M	60	PT	D	Periodic tidal flood
21A	Bratler Muck-tidal	0-2	Flood	4	Vw	U	Sv	Sv	Sv	M	60	PT	D	Periodic tidal flood - limited urban use
72K	Dunal sands	0-70	Coast	4	Ville	U	Sv	Sv	Sv	M	60	SP	B	Active sand dunes unstabilized
75A	Tidal Marsh	0-2	Tide basin	4	Vll	U	Sv	Sv	Sv	M	60	CH	D	Actual tide basin bottom
77K	Escarpments	0-25	Terrace	4	Vle	U	Sv	Sv	Sv	M	60	ML	B	Terrace edges - steep slopes
130	Gardner FSL	0-3	Flood	4	llw	U	Sv	Sv	Sv	M	60	SM	A	Flood-plain soil H ₂ O at 24" inches
140A	Brenner S1 clay	0-3	Flood bottom	4	llllw	U	Sv	Sv	Sv	S	60	CL	C	Flood-bottom soil high compression (wet)
141	Brenner S1 clay thick variant	0-3	Flood bottom	4	llllw	U	Sv	Sv	Sv	S	60	CH	D	Deeper surface variant
145A	Neulocca S1 loam	0-3	Bottom	4	Vll	U	Sv	Sv	Sv	M	60	ML	B	Wet site - bottom depressions flood
150A	Nehalem S1 loam	0-3	Bottom	3	llw	U	Sv	Sv	Sv	S	60	ML	B	Low PI and compaction wet
204A	Heceta F.S.	0-2	Deflation plain	4	Vllllw	U	Sv	Sv	Sv	S	60	CH	D	Wet
205C	Westport Fs	0-12	Arrested dune	4	Vll	U	Sv	Sv	Sv	M	60	SP	C	Arrested sand dune
206D	Westport Fs	12-34	Arrested dune	4	Vll	U	Sv	Sv	Sv	M	60	SP	C	Arrested sand dune
207H	Westport Fs	30-70	Arrested dunes	4	Vll	U	Sv	Sv	Sv	M	60	SP	D	Caving hazard for utilities and road
214B	Bandon SL	0-7	Terrace	4	lllls	U	Sv	Sv	Sv	M	60	SM	C	Iron cemented 18 inches
215C	Bandon SL	7-12	Old dune	4	lllls	U	Sv	Sv	Sv	M	60	SM	G	Water-table hazard on low percent slope
216D	Bandon SL	12-30	Areas	4	Vll	U	Sv	Sv	Sv	M	60	SM	C	Cut surface could severely erode
217H	Bandon SL	30-70	Areas	4	Vll	U	Sv	Sv	Sv	M	60	SM	C	Cut surface could severely erode
225A	Yaquina F.S.	0-3	Deflating plain	4	Vllw	U	Sv	Sv	Sv	M	60	SM	B/D	Non-cohesive, low shear
230B	Bullards-Ferrello	0-7	Coastal foothills, low	2	lllls	U	Sv	Sv	Sv	M	60	SM	B	Consolidated sands and restrictive layer at 30 inches
231C	Bullards-Ferrello	7-12	Coastal foothills, low	2	lllls	U	Sv	Sv	Sv	M	60	SM	B	Some stability hazard of surface slide
232D	Bullards-Ferrello	12-20	Coastal foothills, low	2	lllls	U	Sv	Sv	Sv	M	60	SM	B	Some stability hazard of surface slide
235B	Lint S1 loam	0-7	Coastal foothills	1	lls	U	Sv	Sv	Sv	S	60	ML	B	Low fertility - non-plastic
236C	Lint S1 loam	7-12	Coastal foothills	2	lllls	U	Sv	Sv	Sv	S	60	ML	B	Slope hazard
237D	Lint S1 loam	12-20	Coastal foothills	4	Vll	U	Sv	Sv	Sv	M	60	ML	B	Slope hazard
238F	Lint S1 loam	20-40	Coastal foothills	4	Vll	U	Sv	Sv	Sv	M	60	ML	B	Slope hazard
240C	Netarts	3-12	Coastal foothills	4	Vll	U	Sv	Sv	Sv	M	60	SM	B	Iron pan 12 plus inches
241D	Netarts FSL	2-30	Coastal foothills	4	Vll	U	Sv	Sv	Sv	M	60	SM	B	Slope moderate
245B	Lint S1 L complex	0-7	Coastal terrace	1	lls	U	Sv	Sv	Sv	S	60	ML	B	Non-plastic low shrink swell
250D	Neslowin S1 loam	12-20	Coastal hillsides	2	Vll	U	Sv	Sv	Sv	M	30	ML	C	Low shear moderate shrink swell
251F	Neslowin S1 loam	20-40	Coastal hillsides	4	Vll	U	Sv	Sv	Sv	M	30	ML	C	Shallow bedrock
255C	Marty Loom	3-12	Mountain	1	Vll	U	Sv	Sv	Sv	M	60	ML	C	Shear low slumpage hazard
257D	Marty Loom	12-25	Coastal uplands	3	Vll	U	Sv	Sv	Sv	M	60	ML	C	Shear low slumpage hazard
257K	Marty Loom	25-50	Coastal	3	Vll	U	Sv	Sv	Sv	M	60	ML	C	Shear low slumpage hazard
260	Knappa-like S1 L	0-7	Coastal	3	lls	U	Sv	Sv	Sv	M	60	ML	C	Clay films at 30 inches
395B	Meda Loom	2-12	Alluvial fans	2	Vll	U	Sv	Sv	Sv	M	60	GM	B	Gravelly substrata moderate strength
396B	Meda loam wet variant	2-12	Alluvial fans	3	Vllw	U	Sv	Sv	Sv	M	60	GM	C	Restrictive lens 14 inches wet
565B	Lead S1 loam	0-12	Cascade foothills	3	Vll	U	Sv	Sv	Sv	M	40	MH	C	Slope hazard clay 20 inches
566D	Lead S1 loam	12-25	Cascade foothills	4	Vll	U	Sv	Sv	Sv	M	40	MH	C	Slope hazard clay 20 inches
567S	Tahkenitch Loom	3-20	Cascade foothills	4	Vll	U	Sv	Sv	Sv	M	60	ML	C	Deep surfaces
568K	Tahkenitch Loom	20-45	Cascade foothills	4	Vll	U	Sv	Sv	Sv	M	60	ML	C	Stability hazard due to slope
569H	Tahkenitch Loom	45-75	Cascade foothills	4	Vll	U	Sv	Sv	Sv	M	60	ML	C	Slope stability
570S	Bahannon Cobbly loam	3-24	Coastal mountain	4	Vll	U	Sv	Sv	Sv	M	30	SM	C	Shallow bedrock, 30 plus inches
571K	Bahannon Cobbly loam	25-50	Coastal mountain	4	Vll	U	Sv	Sv	Sv	M	30	SM	C	Steep slope high cobble content
572H	Bahannon Cobbly loam	50-75	Coastal mountain	4	Vll	U	Sv	Sv	Sv	M	30	SM	C	Steep slope ripplable rock
575C	Preacher Loom	2-15	Coastal mountain	3	lllls	U	Sv	Sv	Sv	M	60	MH	B	Moderate strength
576K	Preacher Loom	15-45	Coastal mountain	4	Vll	U	Sv	Sv	Sv	M	60	MH	B	Same hazard to slope
577H	Preacher Loom	45-70%	Siltcock complex	4	Vll	U	Sv	Sv	Sv	M	60	MH	B	See individual units
580S	Digger Gravely loam	3-25	Coastal ridges	4	Vll	U	Sv	Sv	Sv	M	40	SM	V	Shallow to bedrock fractured sandstone
581K	Digger Gravely loam	25-50	Coastal ridges	4	Vll	U	Sv	Sv	Sv	M	40	SM	B	Unstable surface in cuts
582F	Digger Gravely loam	50-75	Coastal ridges	4	Vll	U	Sv	Sv	Sv	M	40	SM	B	Unstable surface in cuts
585S	Siltcock Gravely loam	3-25	Coastal ridges	4	Vll	U	Sv	Sv	Sv	M	60	SM	B	Some slope hazard on cut slopes
586K	Siltcock Gravely loam	25-50	Coastal sed. slopes	4	Vll	U	Sv	Sv	Sv	M	60	SM	B	Not suited for cultivation
600K	Klickitat Cob. loam	10-45	Steep uplands	4	Vlls	U	Sv	Sv	Sv	M	30	GM	C	Slope hazard
601H	Klickitat Cob. loam	45-70	Steep uplands	4	Vlls	U	Sv	Sv	Sv	M	30	GM	C	Shallow bedrock high rock content
617K	Klickitat Cob. loam	45-70	Mountain slopes	4	Vlls	U	Sv	Sv	Sv	M	50	CL	B	Shallow bedrock high rock content
617KN	Klickitat Cob. loam	45-70	N. Mountain slopes	4	Vlls	U	Sv	Sv	Sv	M	50	CL	B	Coarse fragments in upper strata 50% or higher

Base Map from U. S. G. S. 15' Quadrangle Series (Topographic) Siltcoos Lake Quad. 1958 and Heceta Head Quad. 1956



CONTOUR INTERVAL 80 FEET
DATUM IS MEAN SEA LEVEL
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 5 FEET



by T. E. Dietz 1974