Series 1957, No. 15

Issued November 1962

SOIL SURVEY

San Juan County Washington

OUR SOIL * OUR STRENGTH

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
WASHINGTON AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of San Juan County will serve various groups of readers. It will help farmers and ranchers in planning the kind of management that will protect their soils and provide good yields, and it will add to the fund of knowledge about soils.

Soils scientists studied and described the soils and made a map that shows the kind of soil everywhere in the survey area. The base for the soil may is a set of aerial photographs that show fields, woods, roads, and many other landmarks.

Locating the soils

Use the index to map sheets to locate areas on the large map. The index is a small map of the county that shows the location of each sheet on the large map. When the correct sheet of the large map is found, it will be seen that boundaries of the soils are outlined in red, and that there is a symbol for each soil. Suppose, for example, an area on the map has the symbol Be. The legend for the detailed map shows that this symbol identifies Bellingham silt loam. This soil and all others mapped in the county are described in the section "Descriptions of Soils."

Finding information

The report has special sections for different groups of readers. The section "General Information About the County," which discusses the physiography, drainage, relief, climate, vegetation, and other general facts, will be of interest mainly to those not familiar with the county. The "Guide to Mapping Units" at the back of the report will help the reader to use the map and the report. Soil terms that may be unfamiliar to some readers are defined in the Glossary.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of Soils," and then go to the section "Use and Management of the Soils." In this way they first identify the soils on their farms and then learn how these soils can be managed and what yields can be expected. The soils are grouped by capability units; that is, groups of soils that need similar management and respond in about the same way. For example, Bellingham silt loam is in capability unit IIw-1. The management needed for cultivated crops grown on this soil will be found under the heading Capability Unit IIw-1, in the section "Management by Capability Units." The woodland uses of this soil are described under woodland group 4 in the section "Uses of Soils for Woodland." A list just before the map sheets gives the name of each soil, the page where it is described, the symbol of the capability unit in which it has been placed, and the page where the capability unit is described.

Foresters and others interested in woodlands can refer to the section "Uses of Soils for Woodland." In that section the kinds of trees in the county are described and the factors affecting the management of woodlands are discussed.

Engineers will want to refer to the section "Engineering Properties of Soils." Tables in that section show characteristics of the soils that affect engineering.

Persons interested in science will find information about how the soils were formed and how they are classified in the section "Formation and Classification of Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

Newcomers in San Juan County will be especially interested in the section "Soil Associations," which describes the broad patterns of the soils. They may also wish to read the section "General Information About the County," which gives general information.

* * *

Fieldwork for this survey was completed in 1956. Unless otherwise indicated, all statements in the report refer to conditions in the county at that time. This publication is part of the technical assistance furnished to the San Juan Island, Orcas Island, and Lopez Island Soil Conservation Districts.

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SOIL SURVEY OF SAN JUAN COUNTY, WASHINGTON

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UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE WASHINGTON AGRICULTURAL EXPERIMENT STATION

SAN JUAN COUNTY consists of islands that are along the coast in the northwestern part of the State of Washington (fig. 1). The county is irregular in shape but

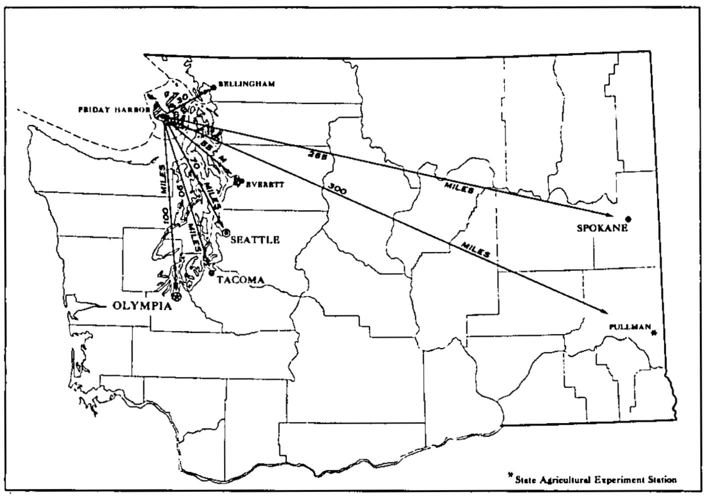

Figure 1.—**Location of San Juan County in Washington.**

occupies an area about 27 miles long and 24 miles wide. It is bounded on the west by Haro Strait and by Boundary Pass. On the north it is bounded by the Strait of Georgia, and on the east, by Rosario Strait. On the south it is bounded by the Strait of Juan de Fuca.

At low tide the county consists of a group of 473 islands and reefs, but there are only 428 islands and reefs at high tide. Only 175 of the islands have been named. The principal ones are Orcas, San Juan, Lopez, Shaw, Decatur, Blakely, Waldron, Stuart, Spieden, Johns, James, Sucia, Matia, Patos, Clark, and Barnes. The land area of the county is 110,080 acres, or about 172 square miles. Friday Harbor is the county seat.

Livestock are raised extensively on the islands. The location of the county and the difficulty of reaching markets on the mainland is responsible for livestock raising being more important than the growing of perishable fruits and vegetables. Less than half of the acreage is agricultural land in farms. The rest is in trees or grass, or is used for resorts, camps for recreational purposes, or is wasteland. The land used for agriculture is largely in grass, but the soils and climate are favorable for berries, vegetables, small grains, and hay crops, as well as pasture. Approximately 15 percent of the acreage in farms is used for cultivated crops, 32 percent is in pasture, and 42 percent is woodland. The rest is used for roads, farmlots, buildings, fence rows, and other miscellaneous purposes.

How Soils Are Named, Mapped, and Classified

Soil scientists made this survey to learn what kinds of soils are in San Juan County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down to the rock material that has not been changed much by leaching or by the roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. To use this report easily, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first described and mapped. San Juan and Orcas, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

Many soil series contain soils that are alike except for the texture of their surface layer. According to this difference in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. San Juan gravelly sandy loam and San Juan loam are two soil types in the San Juan series. The difference in the texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, San Juan gravelly sandy loam, 0 to 8 percent slopes, is one of several phases of San Juan gravelly sandy loam, a soil type that ranges from nearly level to sloping.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used aerial photos for their base map because these show woodlands, buildings, field borders, trees, and similar detail that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the same aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientist has a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Indianola-Roche complex, 0 to 8 percent slopes. Also, in most mapping there are areas to be shown that are so rocky, so shallow, or so frequently changed by wind and water that they cannot be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Rock outcrop or Rock land, and are called land types rather than soils.

Only part of the soil survey was done when the soil scientist had named and described the soil series and mapping units and had shown the location of the mapping units on the soil map. The mass of detailed information he had recorded then needed to be presented in different ways for different groups of users, among them farmers, managers of woodlands and rangelands, and engineers.

To do this, he had to consult with persons in other fields of work and jointly prepare with them groupings that would be of practical value to different users. Such groupings are the capability classes, subclasses, and units, designed mainly for those interested in producing short-lived crops and tame pasture; woodland suitability groups, for those who need to manage wooded tracts; and the classifications used by engineers who build highways or structures to conserve soil and water.

Soil Associations

After studying the soils in a locality and the way they are arranged, it is possible to make a general map that shows the main patterns of soils. Such a map is the colored general soil map in the back of this report. The general soil areas are also called soil associations. Each kind of general soil area, or association, as a rule contains a few major soils and several minor soils in a pattern that is characteristic, although not strictly uniform.

The soils within any one association are likely to differ greatly among themselves in some properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general map does not show the kind of soil at any particular place, but a pattern that has in it several kinds of different soils.

The soil associations are named for the major soil series in them, but, as already noted, soils of other series may also be present. The major soil series of one general soil area may also be present in other areas but in a different pattern.

The general map that shows patterns of soils is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Association 1

Poorly drained to imperfectly drained soils of the basins and low glacial till plains on glaciated uplands: Bellingham-Coveland-Bow association

This association occurs on all the larger islands and on some of the smaller ones. The topography is nearly level to gently sloping. The original vegetation was mostly trees, but approximately two-thirds of the timber has been cut.

Soils of the Bow series are the most extensive in this association. The Coveland soils are slightly less extensive. There are fairly large areas of Bellingham soils, especially on San Juan and Orcas Islands; a few small areas of Norma soils; and a few large areas and a number of smaller ones of organic soils of the Semiahmoo, Tanwax, and Orcas series. In addition, there are small, but prominent, areas of Roche-Rock outcrop complexes.

The Coveland and Bow soils are in slightly higher positions than most of the other soils of the association, but they are lower than the areas of Roche-Rock outcrop complexes. The Coveland and Bow soils have a surface layer of silt loam that is underlain by a clayey subsoil at a shallow depth. The Bellingham soils have a surface layer of clay loam or silt loam and a subsoil of clay or silty clay. The surface layer of the Norma soils is loam. It overlies irregularly stratified layers of sandy loam, clay loam, or clay. The Semiahmoo soils consist of muck derived from sedge peat; the Tanwax soils, of finely divided sedimentary peat; and the Orcas soils, of moss peat. The Tanwax soils are alkaline. All other soils in this association are acid, especially near the surface.

In winter and in spring, all the soils are saturated and water stands on the surface of the organic soils. The excess water accumulates because the areas do not have adequate outlets for drainage, the soils do not have enough slope for water to run off, the subsoils have very slow permeability, or there is a combination of all of these factors. For the most productive agricultural use, all the soils in this association require some artificial drainage. Except for areas of organic soils on San Juan and Lopez

Islands, where drainage outlets are blocked by basalt, most of the areas have been drained successfully.

Most of the cash crops in the county are grown on soils of this association. Fairly large amounts of a complete fertilizer are commonly used on most of the soils where crops are grown. Little is used on hay or pasture, but greater yields would be obtained if more fertilizer were applied. Supplemental irrigation is used by a few farmers, particularly on the Bow soils.

Association 2

Dominantly moderately well drained to well drained soils of the glacial till plains and rocky uplands: Roche-San Juan association

This is the most extensive association in the county. The largest areas are on San Juan Island, but the association also occurs on the other large islands and on many of the smaller ones. The topography is predominantly gently rolling to rolling. The areas originally were nearly covered by timber, but about half the trees have been removed.

In addition to Roche and San Juan soils, there are large areas of Rock land in the association and fairly large areas of Alderwood soils. The association also includes small, isolated areas of Everett, Indianola, Pickett, Coveland, and Semiahmoo soils.

The Roche soils have a brown, medium-textured surface layer, and in many places they are gravelly or stony. They are underlain by dense, very slowly permeable glacial till.

The San Juan soils of this association have a dark-colored, moderately coarse textured surface layer that is gravelly or stony. Their subsoil and substratum are coarse textured and overlie cemented, moderately fine textured glacial till. The Alderwood soils also have a gravelly or stony surface layer and are underlain by cemented till. The Everett soils are gravelly or stony. They are moderately coarse textured and are underlain by a loose, porous, gravelly and sandy substratum.

The Indianola soils are similar to the Everett but are nearly free of gravel. The Pickett soils are medium textured and stony and are underlain by sandstone bedrock. The areas of Rock land consist mainly of outcrops of sandstone, argillite, or basalt. The Coveland and Semiahmoo soils are described briefly under association 1.

The soils of this association are nearly as important agriculturally as the soils of association 1. They are used mainly for hay, pasture, and grazing. There is also extensive logging, and some areas are used to grow oats and barley.

The soils are moderate to low in moisture-holding capacity. They are moderately well drained to somewhat excessively drained, but there is a temporary high water table in some of the areas in winter and spring. In a few places artificial drainage is needed to improve yields. The soils are low in fertility, but they respond well if manure and a commercial fertilizer, especially nitrogen and phosphate, are added.

A large part of the timber produced in San Juan County is grown on the soils of this association. Logging is limited to the drier months because the soils are saturated during the rainy season. Logging while the soils are too wet destroys the structure of the surface soil, increases runoff, and makes the areas better suited to deciduous species than to Douglas-fir. Douglas-fir can be restocked by planting, but other species will dominate unless they are controlled by cutting or by using selective sprays. Many of the trees have shallow roots because they are growing on soils that have a dense subsoil and substratum. They are susceptible to windthrow if they are left standing alone or in small blocks during selective logging operations.

Association 3

Somewhat excessively drained soils on glaciated uplands and outwash plains: San Juan-Everett association

This is the least extensive association in the county. It occurs in comparatively small areas on all of the larger islands, except Lopez, and on some of the smaller islands. The topography is rolling to steep. Originally, most of the areas were wooded, but about 15 percent of the acreage now has been cleared.

The San Juan series consists of dark-colored soils that support a cover of grass. In most places their surface layer is moderately coarse textured, and in places it is gravelly or stony. The Everett soils are gravelly or stony and are moderately coarse textured. The soils of both series are underlain by a subsoil and substratum of loose, porous, gravelly and sandy material. The Indianola soils are also important in this association. In addition, there are small areas of Roche and Alderwood soils.

The San Juan soils of this association are grasslands. The Everett soils are used to grow Douglas-fir. Following logging, the Douglas-fir restocks readily. Because of the somewhat excessive drainage, there are no seasonal limitations to logging.

The principal crops grown in the cultivated areas are oats, barley, grasses, and legumes. The soils are limited in moisture-storing capacity. Yields are fairly low unless barnyard manure and nitrogen and phosphate fertilizers are added to help establish new seedings and to increase the yields.

Association 4

Dominantly well drained soils on uplands: Pickett-Rock land association

This association is mainly on Orcas and Blakely Islands. The topography is irregular, and in most places it is rolling to steep or precipitous. The areas are almost all in timber.

Soils of the Pickett series and areas of Rock land are dominant in this association, but there are small, isolated areas of organic soils of the Semiahmoo, Orcas, and Tanwax series. Except for the organic soils, the soils of this association are well drained. The Pickett soils and the areas of Rock land are described briefly under association 2. The organic soils are described under association 1.

Only small areas of this association are farmed. The crops are mainly grasses and legumes grown for hay or pasture. Some areas are grazed, but the most important uses of the soils are for timber production, recreation, and wildlife habitats. Some areas still have much of the virgin cover of Douglas-fir, but part of the original timber on the Pickett soils has been logged, and the vegetation now is mainly second-growth Douglas-fir.

Descriptions of Soils

This section contains detailed descriptions of the soils mapped in San Juan County. After the name of each soil is the letter symbol that identifies that particular soil on the map in the back of the report. At the end of the description is given the capability unit to which the soil belongs and the site class for Douglas-fir or other kinds of trees. The approximate acreage and the proportionate extent of each mapping unit are shown in table 1.

Active Dune Land

Active dune land (Ad).—This land type consists of unsorted sands blown by wind from beach areas or from sandy soils that have a sparse cover of vegetation. The dunes move from a westerly to an easterly direction, burying soils, vegetation, and fences as they advance. They occur on beach areas and on the black, sandy San Juan soils of Cattle Point. In some places areas of San Juan soils have been buried by shallow dunes.

Sand dunes contain only small amounts of silt and clay, because these fine materials are carried away by wind. The absence of fine-textured materials lowers the capacity of this land type to retain the moisture and nutrients needed for growth of plants; consequently, the moisture-supplying capacity and fertility are very low.

The sand is generally uniform and is brown to very dark brown. It ranges from 8 inches to more than 5 feet in depth. The hazard of further wind erosion is severe. This land type is in capability unit VIIIs-1. It is not suited to trees.

Alderwood Series

The Alderwood series consists of medium-textured to moderately coarse textured, well-drained soils that are gravelly or stony throughout their profile. The soils are underlain dominantly, at a depth of more than 30 inches, by weakly to strongly cemented, gravelly and sandy material. The slope range is from nearly level to hilly. The soils are on undulating and rolling glacial plains, mainly on

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Active dune land	90	0. 1
Alderwood gravelly loam, 3 to 8 percent slopes	400	([1])
Alderwood gravelly loam, 15 to 30 percent slopes	130	. 1
Alderwood gravelly sandy loam, 3 to 8 percent slopes	100	. 1
Alderwood gravelly sandy loam, 8 to 15 percent slopes	160	. 1
Alderwood gravelly sandy loam, 15 to 30 percent slopes	180	. 2
Alderwood stony loam, 3 to 8 percent slopes	1, 090	1. 0
Alderwood stony loam, 8 to 15 percent slopes	460	. 4
Alderwood stony loam, 15 to 30 percent slopes	250	. 2
Bellingham silt loam	1, 410	1. 3
Bellingham clay loam	390	. 4
Bow gravelly silt loam, 0 to 3 percent slopes	2, 910	2. 6
Bow gravelly silt loam, 3 to 8 percent slopes	6, 310	5. 7
Bow gravelly silt loam, 8 to 30 percent slopes	180	. 2
Bow silt loam, 0 to 3 percent slopes	1, 260	1. 1
Bow silt loam, 3 to 8 percent slopes	2, 640	2. 4
Bow stony silt loam, 3 to 8 percent slopes	1, 390	1. 3
Coastal beaches	1, 120	1. 0
Coveland silt loam, 0 to 3 percent slopes	5, 290	4. 8
Coveland silt loam, 3 to 8 percent slopes	850	. 8
Coveland gravelly silt loam, 0 to 3 percent slopes	1, 160	1. 1
Coveland gravelly silt loam, 3 to 8 percent slopes	790	. 7
Coveland stony silt loam, 0 to 15 percent slopes	470	. 4
Everett gravelly sandy loam, 3 to 8 percent slopes	3, 290	3. 0
Everett gravelly sandy loam, 8 to 30 percent slopes	830	. 8
Everett stony sandy loam, 8 to 30 percent slopes	260	. 2
Hovde loam	70	. 1
Indianola sandy loam, 0 to 15 percent slopes	1, 700	1. 5
Indianola-Roche complex, 0 to 8 percent slopes	1, 870	1. 7
Indianola-Roche complex, 8 to 30 percent slopes	440	. 4
Neptune gravelly sandy loam	40	([1])
Norma loam	460	. 4
Norma loam, moderately deep	140	. 1
Orcas peat	50	([1])
Pickett-Rock outcrop complex, 0 to 30 percent slopes	7, 860	7. 1
Pickett-Rock outcrop complex, 30 to 70 percent slopes	11, 170	10. 1
Roche gravelly loam, 3 to 8 percent slopes	5, 870	5. 3
Roche gravelly loam, 0 to 3 percent slopes	520	. 5
Roche gravelly loam, 8 to 15 percent slopes	1, 250	1. 1
Roche gravelly loam, 15 to 30 percent slopes	470	. 4
Roche loam, 0 to 3 percent slopes	500	. 5
Roche loam, 3 to 8 percent slopes	260	. 2
Roche loam, 8 to 15 percent slopes	110	. 1
Roche stony loam, 3 to 8 percent slopes	3, 280	3. 0
Roche stony loam, 8 to 15 percent slopes	3, 950	3. 6
Roche stony loam, 15 to 30 percent slopes	870	. 8
Roche gravelly sandy loam, 3 to 8 percent slopes	500	. 5
Roche stony sandy loam, 8 to 15 percent slopes	500	. 5
Roche-Rock outcrop complex, 8 to 30 percent slopes	21, 230	19. 3
Roche-Rock outcrop complex, 30 to 70 percent slopes	3, 320	3. 0
Rock land, rolling	850	. 8
Rock land, steep	4, 490	4. 1
San Juan gravelly sandy loam, 0 to 8 percent slopes	540	. 5
San Juan gravelly sandy loam, 8 to 30 percent slopes	190	. 2
San Juan stony sandy loam, 3 to 15 percent slopes	820	. 7
San Juan stony sandy loam, 15 to 30 percent slopes	380	. 3
San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes	410	. 4
San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes	110	. 1
San Juan loam, moderately deep, 0 to 15 percent slopes	180	. 2
San Juan stony loam, moderately deep, 8 to 30 percent slopes	180	. 2
Semiahmoo muck	1, 370	1. 2
Semiahmoo muck, shallow	310	. 3
Tanwax peat, alkaline variant	180	. 2
Tidal marsh	130	. 1
Total	110, 080	100. 0

[1] Less than 1 percent.

San Juan, Orcas, and Lopez Islands. They have formed in glacial till that contains material from many kinds of rocks, including granite, basalt, diabase, sandstone, shale, conglomerate, and quartzite. The Alderwood soils are associated chiefly with the Bow, Everett, and Roche soils.

The native vegetation on the Alderwood soils consisted of a dense stand of Douglas-fir, some western hemlock, western redcedar, lodgepole pine, and deciduous trees, such as red alder, bigleaf maple, and willow. Most of the virgin timber has been logged off. Following logging, the soils restock with red alder, bigleaf maple, and willow. Douglas-fir comes in very slowly.

Forestry is the major use of these soils. Small areas are used for small grains, hay, and pasture.

Alderwood gravelly loam, 3 to 8 percent slopes (AmB).—This is a well-drained, moderately coarse textured soil. It has formed in glacial till and is underlain by weakly to strongly cemented, gravelly and sandy materials at a depth dominantly below 30 inches. This soil is gently undulating, and the slope range is from 4 to 7 percent. The areas are mainly on Decatur, Orcas, and Lopez Islands.

Representative profile:

Surface layer—
 0 to 12 inches, dark-brown gravelly loam; granular structure; friable when moist; abundant roots; slightly acid.

Upper subsoil—
 12 to 21 inches, dark yellowish-brown gravelly sandy loam; single grain; very friable when moist; plentiful roots; medium acid.

Lower subsoil—
 21 to 42 inches, light-olive to olive-gray gravelly sand; single grain; loose and porous; few roots; roots spread horizontally over underlying horizon; neutral.

Substratum—
 42 inches +, dark yellowish-brown gravelly sand; massive; strongly cemented; very few roots, except in fractures; neutral.

In some places there are stones and cobbles in the lower part of the subsoil and in the substratum. Depth to the substratum ranges from about 24 inches to 54 inches. The degree of cementation in the substratum varies considerably within short distances, and in some areas the substratum is only weakly cemented. The substratum in places is sandy clay loam. Approximately 10 percent of this mapping unit consists of Roche gravelly loam, 3 to 8 percent slopes.

The permeability of Alderwood gravelly loam, 3 to 8 percent slopes, is moderate above the hardpan. The hardpan is very slowly permeable, and roots penetrate only through cracks. The moisture-supplying capacity is moderate. The soil is moderate in fertility. Runoff is slow, and there is a slight hazard of erosion.

This soil can be cultivated within a wide range of moisture content. Logging should be curtailed, however, during the winter and early in spring to prevent excess puddling and compaction.

The soil is used primarily for growing timber, but a few areas are used to grow small grains, hay, and pasture. These crops respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit IIIs–2 and in site class 4 for Douglas-fir.

Alderwood gravelly loam, 15 to 30 percent slopes (AmD).—This soil is similar to Alderwood gravelly loam, 3 to 8 percent slopes, but it has stronger slopes and is generally slightly shallower. The cementation is also more variable. The substratum ranges from weakly to strongly cemented within short distances. This soil has slightly lower moisture-supplying capacity than Alderwood gravelly loam, 3 to 8 percent slopes. Surface runoff is medium, and there is a moderate hazard of water erosion. In most places this soil is adjacent to areas of Roche soils. Approximately 10 percent of the acreage consists of Roche gravelly loam, 15 to 30 percent slopes.

Alderwood gravelly loam, 15 to 30 percent slopes, is used mainly for growing timber. A few small areas are in native pasture, but, in general, the carrying capacity is low. Fertilization would increase yields of forage. This soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Alderwood gravelly sandy loam, 3 to 8 percent slopes (AgB).—This soil occurs mainly in association with Alderwood gravelly loam, 3 to 8 percent slopes, and Alderwood stony loam, 3 to 8 percent slopes. It is undulating. The surface layer, to a depth of about 5 to 8 inches, is dark-brown, friable, slightly acid gravelly sandy loam. Below the surface layer, the profile is similar to that of Alderwood gravelly loam, 3 to 8 percent slopes.

In places the substratum is only weakly cemented and the soil closely resembles the Everett gravelly sandy loams. In other places the substratum consists of thin, discontinuous layers of yellowish-brown and brown silty clay loam and resembles the substratum of the Roche soils. About 8 to 10 percent of this mapping unit consists of Everett gravelly sandy loams, Roche gravelly sandy loams, and Alderwood gravelly loams.

In Alderwood gravelly sandy loam, 3 to 8 percent slopes, permeability is rapid above the layer of cemented material. The cemented material is very slowly permeable. The soil has moderately low available moisture-supplying capacity. The effective depth of root penetration is determined by the depth of the strongly cemented substratum of gravelly sandy loam. The soil has good tilth, is easy to work, and can be cultivated within a wide range of moisture content. It has low natural fertility. Surface runoff is slow. There is a slight hazard of water erosion.

Most of this soil is used to grow timber, but a few areas are used for small grains, hay, and pasture. These crops respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit IVs–3 and in site class 4 for Douglas-fir.

Alderwood gravelly sandy loam, 8 to 15 percent slopes (AgC).—This soil is similar to Alderwood gravelly sandy loam, 3 to 8 percent slopes, but it has stronger slopes and depth to the cemented substratum is 28 to 36 inches. Surface runoff is slow to medium; most runoff occurs in winter and spring. There is a moderate hazard of water erosion.

This soil is used mostly for timber. If it is cultivated, yields are a little lower than on Alderwood gravelly sandy loam, 3 to 8 percent slopes. This soil is in capability unit IVs–3 and in site class 4 for Douglas-fir.

Alderwood gravelly sandy loam, 15 to 30 percent slopes (AgD).—This soil is generally on hillsides and in steeply rolling areas. Except for having stronger slope and more variable depth to the cemented substratum, it is similar to Alderwood gravelly sandy loam, 3 to 8 percent slopes. In places where the cemented substratum is near the surface, the moisture-supplying capacity is moderately low. Surface runoff is medium. There is a moderate hazard of water erosion.

Because it is steeply rolling this soil is better suited to timber than to tilled crops or pasture. Nevertheless, small areas have been cleared for pasture. Good yields of forage are obtained from the moderately deep areas. Yields are only fair in the shallow areas. The soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Alderwood stony loam, 3 to 8 percent slopes (AsB).—This soil is similar to Alderwood gravelly loam, 3 to 8 percent slopes, except for its content of stone. It occurs mainly with the Roche soils and with other Alderwood soils.

This soil is better suited to pasture or timber than to tilled crops. It is not well suited to tilled crops—the stones on the surface interfere with the preparation of the seedbed necessary for tilled crops or for seeding pastures. This soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Alderwood stony loam, 8 to 15 percent slopes (AsC).—This soil resembles Alderwood gravelly loam, 3 to 8 percent slopes, except that it is sloping to rolling and its profile is stony throughout. The soil is closely associated with Alderwood stony loam, 3 to 8 percent slopes; Roche stony loam, 3 to 8 percent slopes; and Roche stony loam, 8 to 15 percent slopes. The surface layer, in most places, is 5 to 8 inches thick. The substratum is at a depth of 30 to 42 inches.

This soil has moderately low moisture-supplying capacity. Surface runoff is slow to medium, and there is a moderate hazard of water erosion.

The combination of stoniness and rolling topography makes this soil better suited to timber than to pasture or cultivated crops. In places where the soil has been cleared, pasture is fair. This soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Alderwood stony loam, 15 to 30 percent slopes (AsD).—This soil is similar to Alderwood gravelly loam, 3 to 8 percent slopes, except that it has stronger slope, is stony throughout, and has a profile more variable and generally shallower over the cemented substratum. The moisture-supplying capacity is moderately low. Runoff is medium, and the hazard of water erosion is moderate. In most places this soil is adjacent to areas of Roche soils. Approximately 8 to 10 percent of this mapping unit consists of Roche stony loam, 15 to 30 percent slopes.

Alderwood stony loam, 15 to 30 percent slopes, is used mainly for growing timber. A few areas are in woodland pasture. This soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Bellingham Series

The Bellingham series consists of nearly level, poorly drained soils in ponded areas or on flats in the glaciated uplands. The surface layer is a slightly acid silt loam or silty clay loam. Typically, the subsoil is very plastic, mottled silty clay loam. It is generally underlain by stratified layers of sandy clay loam, loam, and gravel, but in many places it is underlain by marine shells. The subsoil is slightly acid in the upper part, neutral at greater depths, and mildly to moderately alkaline in the layer that contains shells.

The Bellingham soils have formed in fine-textured, old marine and glacial-lake sediments. The native vegetation was western redcedar, hemlock, red alder, willow, and bigleaf maple, with an understory of shrubs and herbs.

Large areas of Bellingham soils are on San Juan and Orcas Islands, and small areas are on many of the smaller islands. These soils are associated with the Bow, Coveland, and Roche soils.

The Bellingham soils are used for row crops, hay, and pasture. When drained and properly managed, they are the most productive soils in the county.

Bellingham silt loam (0 to 3 percent slopes) (Be).—This poorly drained soil occurs in basins, flats, or depressions in the uplands.

Representative profile:

Surface layer—
0 to 8 inches, very dark brown silt loam; granular; hard when dry, friable when moist; abundant roots; slightly acid.

Upper subsoil—
8 to 25 inches, olive-gray silty clay loam; many, medium, distinct mottles of yellow and brown; angular blocky structure; hard when dry, firm when moist, sticky and very plastic when wet; slightly acid.

Lower subsoil—
25 to 37 inches, gray silty clay loam; many, medium, prominent mottles of yellow, brown, and reddish brown; massive to weak, coarse, prismatic structure breaking to moderate, medium, angular blocky; extremely hard when dry, firm when moist, sticky and very plastic when wet; neutral.

Substratum—
37 to 51 inches, gray clay, silt loam, or loam; common, fine, distinct mottles of reddish brown and brown; massive to weak, medium, prismatic structure; extremely hard when dry, firm when moist; very sticky to sticky, and very plastic to plastic when wet; upper part of the horizon is neutral, but the soil material is mildly alkaline below 43 inches.

Lower substratum—
51 inches +, mixed lenses of sand and clay containing marine shells; moderately alkaline.

The principal variation in the profile of this soil is in the color of the surface layer. In some places the surface layer is black. About 10 percent of the mapping unit consists of areas of Bellingham clay loam too small to be shown separately on the soil map.

Bellingham silt loam has very slow permeability and internal drainage. The moisture-supplying capacity is high, and fertility is moderately high. The soil is ponded, and there is little hazard of erosion.

This soil can be drained by using tile and ditches. After it is drained, it is suited to peas, small grains, hay, and pasture. Yields of crops are high. The crops respond well if manure and a complete commercial fertilizer are added. If the soil has not been drained, it is suited to grasses that tolerate water.

This soil is in capability unit IIw–1. The trees to which it is suited are red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar. The soil is not suited to Douglas-fir.

Bellingham clay loam (0 to 3 percent slopes) (Bc).—This soil is similar to Bellingham silt loam, except that the surface layer is clay loam and is 10 to 12 inches thick. It also occurs at a slightly higher elevation than Bellingham silt loam. The use and management of the two soils are similar.

This soil is in capability unit IIw–1. The trees to which it is suited are red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar. The soil is not suited to Douglas-fir.

Bow Series

The Bow series consists of imperfectly drained soils of uplands. The soils have a surface layer of silt loam, which in many places is gravelly or stony. The subsoil is a dense, mottled clay that is very sticky and plastic when wet and very hard when dry. These soils are nearly level to steep. They occupy large areas on most of the islands of the county.

The Bow soils formed in fine-textured glacial till and glacial-lake sediments. The native vegetation is Douglas-fir, western hemlock, western redcedar, red alder, bigleaf maple, and willow. The understory is salal, Oregongrape, spirea, ocean-spray, and brackenfern. Most of the virgin timber has been logged from the soils. Early restocking is mainly with deciduous trees, such as red alder, bigleaf maple, and willow. Douglas-fir and western hemlock come in slowly.

The Bow soils are associated chiefly with Roche, Coveland, Alderwood, and Everett soils. They are similar to the Roche soils, but they have a finer textured subsoil and are imperfectly drained rather than moderately well drained. In many places the Bow soils are adjacent to, but slightly above, areas of Coveland soils. Their drainage is similar to that of the Coveland soils, but the Coveland soils differ in having a black surface layer.

The Bow soils are used for row crops, small grains, hay, pasture (fig. 2), and timber. They are slightly less productive than the Bellingham soils.

Bow gravelly silt loam, 0 to 3 percent slopes (BgA).—This imperfectly drained soil occurs on broad, nearly level uplands. A few areas are adjacent to areas of Bellingham soils. The slopes are mainly long and smooth and range from 2 to 3 percent.

Representative profile:

Surface layer—
0 to 11 inches, dark-brown gravelly silt loam; granular; friable when moist; roots abundant; slightly acid.

Upper subsoil—
11 to 16 inches, dark grayish-brown gravelly silt loam; angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; roots plentiful; slightly acid.

Lower subsoil—
16 to 32 inches, gray silty clay loam mottled with strong brown; prismatic structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; very few roots on the faces of prisms; slightly acid.

Substratum—
32 to 60 inches, gray silty clay; massive; extremely hard when dry, extremely firm when moist, very sticky and very plastic when wet; no roots; neutral.

The color of the surface layer of this soil ranges from dark brown or brown to dark grayish brown. The areas where the surface layer is dark grayish brown occur where depth to the substratum of silty clay is less than 30 inches. In many places the stones have been removed from the surface to make this soil suitable for cultivation. Included are areas of a stony silt loam as much as 1 acre in size.

Permeability is moderate in the surface layer of Bow gravelly silt loam, 0 to 3 percent slopes, and slow in the subsoil. Surface runoff is very slow. The moisture-supplying capacity is moderate. The effective depth of root penetration is moderately deep. It is limited by the dense silty clay loam in the subsoil. The slowly permeable subsoil causes water to stand on the soil during winter and spring.

Figure 2.—**Typical pasture on a Bow gravelly silt loam.**

This soil can be drained by using a combination of tile, bedding or ridging, and open ditches. Natural fertility is moderate. There is a slight hazard of water erosion.

This soil is suited to small grains (fig. 3) and to grasses and legumes grown for hay or pasture. Yields are moderate to high. The crops respond well if manure and a complete commercial fertilizer are added.

Yields of Douglas-fir are fair on this soil. Clear cutting of the timber is desirable, as individual trees or small blocks left during logging operations are susceptible to windthrow. Douglas-fir regenerates slowly on this soil. Nevertheless, the second growth consists of Douglas-fir, western redcedar, red alder, and willow. This soil is in capability unit IIIw-2 and in site class 4 for Douglas-fir.

Bow gravelly silt loam, 3 to 8 percent slopes (BgB).—This soil occurs on glacial till plains throughout the islands. Except for having stronger slope and a slightly thinner surface layer, it is similar to Bow gravelly silt loam, 0 to 3 percent slopes. The surface layer, in most places, is 8 to 10 inches thick. This soil lacks the dark

Figure 3.—**Wheat growing on a Bow gravelly silt loam.**

grayish-brown color in the surface layer that is characteristic of some areas of Bow gravelly silt loam, 0 to 3 percent slopes. The content of gravel is between 20 and 50 percent, by volume. The gravel makes this soil somewhat difficult to cultivate and reduces its moisture-supplying capacity.

This soil has slow to medium surface runoff. Most of the runoff comes during the wet winter and spring seasons when the soil is saturated. There is a moderate hazard of water erosion.

This soil is fairly well suited to the growing of peas for processing. It is also suited to the same crops as are commonly grown on Bow gravelly silt loam, 0 to 3 percent slopes. Careful management is required to reduce runoff and erosion and to maintain or improve production. Seeding of waterways helps to reduce losses from erosion. This soil is in capability unit IIIw–2 and in site class 4 for Douglas-fir.

Bow gravelly silt loam, 8 to 30 percent slopes (BgD).—This soil differs from Bow gravelly silt loam, 0 to 3 percent slopes, in having stronger slopes and a thinner surface layer. In most places the slope is between 15 and 25 percent, but, in about one-third of the acreage, the slope is between 8 and 15 percent. The surface layer ranges from 6 to 10 inches in thickness. This soil lacks the dark grayish-brown color in the surface layer that is characteristic of some areas of Bow gravelly silt loam, 0 to 3 percent slopes.

Because of its strong slope, this soil is difficult to till. Surface runoff is medium to rapid, and there is a moderate hazard of water erosion.

This soil is better suited to trees grown for timber than to pasture or tilled crops, and most of it is in trees. In areas that have been cleared and pastured, yields are fair. Clear-cut logging is desirable. The soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Bow silt loam, 0 to 3 percent slopes (BoA).—This soil occurs in close association with Roche soils and with other Bow soils. Except for the texture of the surface layer, it is similar to Bow gravelly silt loam, 0 to 3 percent slopes, and the two soils are used and managed about the same. This soil is in capability unit IIIw–2 and in site class 4 for Douglas-fir.

Bow silt loam, 3 to 8 percent slopes (BoB).—Except that it is undulating and has a slightly thinner surface layer that is free of gravel, this soil is similar to Bow gravelly silt loam, 0 to 3 percent slopes. Its surface layer, in most places, is 8 to 10 inches thick. Surface runoff is slow to medium. Most of the runoff occurs during the wet winter and spring seasons when the soil is saturated. There is a moderate hazard of water erosion.

This soil is fairly well suited to the growing of peas for processing. In addition, it is suited to the same crops as are commonly grown on Bow gravelly silt loam, 0 to 3 percent slopes, and it requires about the same management. This soil is in capability unit IIIw–2 and in site class 4 for Douglas-fir.

Bow stony silt loam, 3 to 8 percent slopes (BsB).—Except for containing stones and cobbles and having a thinner surface layer and stronger slope, this soil is similar to Bow gravelly silt loam, 0 to 3 percent slopes. The surface layer, in most places, is 6 to 10 inches thick. The areas where the stones and cobbles have been removed from this soil are now mapped as Bow gravelly silt loam, 3 to 8 percent slopes. The classification of other areas may be expected to change if the stones and cobbles are removed.

This soil is associated with Roche soils and with other Bow soils. It also occurs near areas of Rock land. Mapped with it are small areas in which the slope is between 8 and 15 percent and other areas in which it is between 1 and 3 percent.

Bow stony silt loam, 3 to 8 percent slopes, has low moisture-supplying capacity. The stones, cobbles, and pebbles throughout the solum interfere with cultivation and materially reduce the amount of moisture the soil can hold. Surface runoff is slow to medium. There is a moderate hazard of erosion.

This soil is better suited to trees grown for timber than to tilled crops or pasture. Most of the acreage is in trees. Clear-cut logging is desirable, as individual trees or trees in small blocks that are left standing are susceptible to windthrow because they have shallow roots. This soil is in capability unit VIs–7 and in site class 4 for Douglas-fir.

Coastal Beaches

Coastal beaches (Cb).—This miscellaneous land type consists of long, narrow areas of sloping, sandy and gravelly beaches along the margins of the islands. The areas are above mean low tide. They are bare of vegetation and are subject to continual wave action during periods of storm or high tide.

This land has value for recreation and for the production of clams. Small areas of Tidal marsh and of Neptune soils are included in the mapping unit. This land type is in capability class VIIIs–1. It is not suited to trees.

Coveland Series

The Coveland soils are in slight depressions in the uplands and terraces of the larger islands. The surface layer is black silt loam and is medium acid. In some places it is gravelly or stony. The subsoil is distinctly mottled, slightly acid sandy clay loam, clay loam, or clay that is very hard when dry, very firm when moist, and very sticky and very plastic when wet. These imperfectly drained soils have formed in fine-textured glacial till. They are dominantly nearly level, but a few areas are gently sloping or moderately sloping. The native vegetation was probably grass and sedges.

The Coveland soils are associated chiefly with the Bow and Roche soils. In many places they are adjacent to, but slightly below, areas of those soils.

The Coveland soils are used for cultivated crops, hay, and pasture. Artificial drainage benefits most crops grown on them. In general, these soils are slightly less productive than the Bellingham soils and are slightly more productive than the Bow soils.

Coveland silt loam, 0 to 3 percent slopes (CsA).—This imperfectly drained soil is in depressions and in broad basins on the uplands and terraces of the San Juan Islands. Most of the areas are nearly level and range in slope from 1 to 3 percent.

Representative profile:

Surface layer—

0 to 9 inches, black silt loam; fine, granular structure; soft to hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; abundant roots; medium acid.

Lower surface layer—
9 to 14 inches, grayish-brown gravelly fine sandy loam; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; roots plentiful; slightly acid; irregular lower boundary with occasional tongues that extend downward to a depth of 20 inches.

Upper subsoil—
14 to 18 inches, grayish-brown sandy clay loam; fine mottles of brownish yellow and yellowish red; moderate, medium, prismatic structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; few roots, except on the faces of prisms; slightly acid.

Lower subsoil—
18 to 32 inches, gray clay with reddish-brown mottles; strong, fine to medium, prismatic structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; very few roots; slightly acid.

Substratum—
32 to 48 inches +, olive-gray clay mottled with dark reddish brown; massive to thin, platy structure; extremely hard when dry, extremely firm when moist, very sticky and very plastic when wet; no roots; neutral.

In this soil, depth to the substratum ranges from about 18 to 40 inches. Occasional pebbles occur throughout the profile. In some of the areas in upland basins, bedrock is within 4 feet of the surface. Included are a few areas that have a surface layer of sandy loam and an upper subsoil of gravelly sandy loam.

Coveland silt loam, 0 to 3 percent slopes, has moderate permeability in the surface layer and very slow permeability in the subsoil. The moisture-supplying capacity is moderate. The effective depth of root penetration is shallow to moderately deep. Roots can penetrate the lower part of the subsoil only between the prisms and in fractures.

The soil has very slow surface runoff. In many places water stands on the surface during rainy seasons. The natural fertility is moderate. The soil has good tilth, but tillage in spring is delayed by the very slow runoff. Drainage can be improved by installing tile and digging shallow surface drains. It can also be improved by bedding. There is a slight hazard of water erosion.

This soil is well suited to peas grown for processing and to oats, barley, wheat, strawberries, alfalfa, clover, and grass. These crops respond well if large amounts of manure and a complete commercial fertilizer are added. This soil is in capability unit IIw–3. It is not used extensively for trees.

Coveland silt loam, 3 to 8 percent slopes (CsB).—This soil is similar to Coveland silt loam, 0 to 3 percent slopes. It has stronger slopes, however, and the profile is more variable in thickness. In general, the claypan is at a shallower depth, or at a depth between 16 and 30 inches.

Because of its thinner profile, this soil holds less moisture for plants to use than Coveland silt loam, 0 to 3 percent slopes. As a result, crop yields are slightly lower than on the less sloping soil, although the two soils are used and managed about the same. Surface runoff is slow to medium, and there is a moderate hazard of water erosion. This soil is in capability unit IIw–3. It is not used extensively for trees.

Coveland gravelly silt loam, 0 to 3 percent slopes (CoA).—This soil is similar to Coveland silt loam, 0 to 3 percent slopes, except that it contains gravel. There is enough gravel in the surface layer and throughout the profile to make this soil more difficult to till and to reduce its moisture-holding capacity. Consequently, crop yields are slightly less than those on the nongravelly soil, although the two soils are used and managed about the same. This soil is in capability unit IIw–3. It is not used extensively for trees.

Coveland gravelly silt loam, 3 to 8 percent slopes (CoB).—Except that 15 to 25 percent of the surface layer is gravel, this soil is similar to Coveland silt loam, 0 to 3 percent slopes. It is also gently undulating rather than nearly level. Surface runoff is slow to medium, and there is a moderate hazard of water erosion. This soil is suited to the same crops as Coveland silt loam, 0 to 3 percent slopes, and use and management are much the same. This soil is in capability unit IIw–3. It is not used extensively for trees.

Coveland stony silt loam, 0 to 15 percent slopes (CtC).—This soil occurs throughout the glacial uplands of the county near areas of Rock land, Rock outcrop, and stony Bow and Roche soils. Except that it has stronger slopes and a thinner surface layer that is stony, the soil is similar to Coveland silt loam, 0 to 3 percent slopes. The surface layer, in most places, is only 5 to 8 inches thick. Its slopes are mainly between 2 and 8 percent, but a few small areas are as steep as 12 percent.

A few small, strongly sloping areas of this soil have moderately rapid runoff, but in most places surface runoff is medium. There is a moderate hazard of erosion. About 10 percent of the acreage is underlain by bedrock at a depth between 30 and 40 inches. The mapping unit includes about 80 acres of Coveland gravelly silt loam in which the slope is between 8 and 15 percent.

Coveland stony silt loam, 0 to 15 percent slopes, is better suited to grasses and legumes for pasture than to cultivated crops. The rocks have been cleared from a few areas, however, and the soil is used the same as Coveland silt loam, 0 to 3 percent slopes. The soil requires a cover of grass to protect it from erosion during rainy periods. This soil is in capability unit VIs–6. It is not used extensively for trees.

Everett Series

The Everett series consists of nearly level to hilly, somewhat excessively drained soils on glacial plains. The surface layer and the subsoil are moderately coarse textured, and the substratum is coarse textured. The soils are gravelly and stony throughout. They occur on glacial moraines on all of the larger and some of the smaller islands, generally in small areas. The Everett soils on Orcas Island are finer textured than those on San Juan and Lopez Islands.

The Everett soils on south- and east-facing slopes have a darker colored surface layer than those on ridgetops and on north-facing slopes. This is particularly noticeable in the vicinity of Point Lawrence and Obstruction Pass.

The Everett soils have formed in morainic material. This material was sandy, gravelly, and cobbly and was derived from sandstone, granite, and basalt. The native vegetation was largely Douglas-fir, lodgepole pine, and madrona (Pacific madrone); the understory was salal, Oregongrape, swordfern, brackenfern, and moss. A few deciduous trees, such as alder, bigleaf maple, and willow, are growing on recently cutover areas, especially near Bow and Roche soils or near areas of Rock land.

The Everett soils are associated with Bow, Roche, Indianola, Alderwood, and San Juan soils. They are also associated with areas of Rock land.

The Everett soils are used mainly for forestry. Small areas are used for hay and pasture, and a small acreage is cultivated.

Everett gravelly sandy loam, 3 to 8 percent slopes (EgB).—This somewhat excessively drained soil is gently undulating. The slopes are mainly between 2 and 6 percent.

Representative profile in an undisturbed forested area:

2 inches to 0, very dark grayish-brown forest litter consisting of needles, leaves, twigs, cones, moss, and roots.

Surface layer—
0 to 7 inches, dark yellowish-brown gravelly sandy loam; fine, granular structure; very friable; abundant roots; medium acid.

Subsoil—
7 to 24 inches, yellowish-brown gravelly fine sandy loam; weak, fine, granular structure; very friable; plentiful roots; medium acid.

Substratum—
24 inches +, grayish-brown very gravelly coarse sand; single grain; loose; few roots; medium acid but less acid with increasing depth.

The principal variation in this soil is in the thickness of the surface layer and of the upper part of the subsoil. In places the surface layer is as thin as 4 inches, and the upper part of the subsoil is only 8 to 10 inches thick. Included are a number of cobbly and stony areas. These are mostly small and are near areas of Rock land.

Everett gravelly sandy loam, 3 to 8 percent slopes, has rapid permeability in the surface layer and subsoil and very rapid permeability in the substratum. The moisture-supplying capacity and fertility are low. Surface runoff is very slow, and there is a slight hazard of erosion. Effective moisture stored for plants to use is mostly in the soil layers above the substratum of very gravelly coarse sand. Roots seldom penetrate more than a few inches into the substratum.

Some areas of this soil are adjacent to areas of Roche soils and Rock land. These areas benefit by receiving runoff from the adjoining soils and are better suited to timber than the other areas.

This soil is better suited to trees grown for timber than to tilled crops or pasture. Where the soil has been cleared for cultivation, it is suited to early maturing crops, as small grains, strawberries, vegetables for seed, and deep-rooted legumes. These crops respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit VIs–2 and in site class 4 for Douglas-fir.

Everett gravelly sandy loam, 8 to 30 percent slopes (EgD).—This soil is on the rolling to hilly slopes of glacial moraines. Except for having stronger slopes and a thinner surface layer, which is 3 to 6 inches thick, it is similar to Everett gravelly sandy loam, 3 to 8 percent slopes.

Surface runoff is very slow to slow. There is a slight hazard of water erosion.

This soil is better suited to growing trees for timber than to tilled crops. Small areas have been cleared for pasture, but the pastures are only fair. Areas used for crops require careful management to maintain the supply of organic matter. This soil is in capability unit VIs–2 and in site class 4 for Douglas-fir.

Everett stony sandy loam, 8 to 30 percent slopes (EsD).—This soil is on hilly ridges and on the rolling slopes of glacial moraines. It differs from Everett gravelly sandy loam, 3 to 8 percent slopes, mainly in having stronger slopes, a thinner surface layer, and stones and cobbles throughout the profile. In most places slopes are between 10 and 25 percent. The thickness of the surface layer ranges from 3 to 6 inches.

Surface runoff is very slow to slow on this soil, and there is a slight hazard of erosion. The soil has very low moisture-supplying capacity and is very low in fertility; the stones, cobbles, and pebbles reduce the amount of moisture that is retained for plants to use.

This soil is only fairly productive of timber, but it is more suitable for trees than for tilled crops or pasture. It is in capability unit VIs–3 and in site class 4 for Douglas-fir.

Hovde Series

The Hovde series consists of poorly drained basin soils. The areas are behind ridges in areas of Coastal beaches. The soils have a high water table that remains near the surface during most of the year. They are within a few hundred feet of areas covered by tidal waters. As a result, the lower part of the profile is affected by salt water.

The surface layer of these soils is dark colored, and it overlies coarse-textured sediments that extend to a depth of many feet. The vegetation consists of sedges, reeds, and grasses that tolerate water. Most of the acreage is idle. Only one soil of this series, Hovde loam, is mapped in San Juan County.

Hovde loam (Ho).—This soil occupies only a few areas in the county. It is on Shaw, Decatur, and Stuart Islands.

Representative profile:

Surface layer—
0 to 14 inches, dark-gray, highly organic loam containing a high proportion of sand.

Subsoil and substratum—
14 inches +, dark-gray to bluish-gray, loose, porous sand that is many feet thick.

The surface layer of this soil ranges from 10 to 14 inches in thickness.

Most of this soil is idle, and the vegetation growing on it provides protection for wildlife. In some places the areas are used for limited grazing. This soil is in capability unit VIw–1.

Indianola Series

The Indianola series consists of nearly level to hilly, somewhat excessively drained soils on sandy glacial till. The surface layer in most areas is moderately coarse textured, but in some places it is coarse textured. The subsoil is coarse textured, and in places it contains a small amount of fine gravel. The native vegetation was Douglas-fir, lodgepole pine, madrona, and scattered red alders; the understory consisted of salal, Oregongrape, ocean-spray, and swordfern.

The Indianola soils are associated with Everett, Alderwood, and Roche soils. In places the Indianola and Roche soils are so intermingled that they could not be shown separately on the soil map. In these places the soils are designated as Indianola-Roche complexes.

The Indianola soils are well suited to trees grown for timber. They are only fairly well suited to small grains and grasses and to alfalfa and other legumes grown for hay and pasture. Only small areas of these soils have been cleared for cultivation.

Indianola sandy loam, 0 to 15 percent slopes (InC).—This soil is somewhat excessively drained. It occurs mostly in small areas in association with Everett gravelly sandy loam, 3 to 8 percent slopes, and with Roche gravelly sandy loam, 3 to 8 percent slopes. The areas are mainly gently undulating, but a few areas are nearly level, and others are gently rolling. In most places the slope is between 4 and 8 percent.

Representative profile in a forested area:

2 inches to 0, litter of needles, cones, leaves, fragments of wood, fern fronds, and moss.

Surface layer—

0 to 15 inches, dark yellowish-brown sandy loam; weak, granular to weak, fine, subangular blocky structure; very friable; abundant roots; slightly acid to neutral.

Subsoil—

15 to 24 inches, yellowish-brown loamy sand; single grain, but in places subangular blocky structure; loose when dry, very friable when moist; abundant roots; neutral.

Substratum—

24 to 54 inches +, olive-brown fine sand that in places contains some fine gravel; single grain; loose both when dry and moist; contains few roots; neutral.

In places a faint, thin, gray horizon occurs immediately below the organic layer. In places where this soil is closely associated with Roche soils, the loamy sand in the substratum is slightly more coherent than normal, but it crumbles readily to single grains. In places gravel occurs throughout the subsoil, and in other places it is in lenses. The surface layer is 8 to 12 inches thick in areas where the slope is between 8 and 15 percent.

Permeability is moderately rapid in the surface layer of this soil and very rapid in the subsoil and substratum. Internal drainage is rapid. The moisture-supplying capacity and natural fertility are low. Roots can penetrate deeply. The soil has good tilth, is easy to work, and can be cultivated under a wide range of moisture conditions. Surface runoff is very slow to slow, and there is only a slight hazard of water erosion.

This soil is better suited to growing Douglas-fir for timber than to use for tilled crops or pastures. The yields of Douglas-fir are good. The soil is fairly well suited to deep-rooted legumes and early maturing small grains. Crops respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit VIs–2 and in site classes 3 and 4 for Douglas-fir.

Indianola-Roche complex, 0 to 8 percent slopes (IrB).—This complex consists of well-drained, sandy soils on gently undulating glacial moraines in the uplands. In most places the slopes are long and smooth and range from 2 to 7 percent. The native vegetation consisted of Douglas-fir, western hemlock, western redcedar, and red alder with an understory of brackenfern, swordfern, Oregongrape, salal, and wild rose.

The soils are too closely associated and occur in too intricate a pattern for them to be mapped separately. The profile of the Indianola soil is similar to that described for Indianola sandy loam, 0 to 15 percent slopes. The following is a profile that is representative of the Roche soil.

Representative profile in an undisturbed area:

2 inches to 0, needles, leaves, twigs, and moss.

Surface layer—

0 to 10 inches, very dark brown to dark reddish-brown sandy loam; granular structure; very friable; porous; medium acid.

Upper subsoil—

10 to 25 inches, dark yellowish-brown fine sandy loam; weak, subangular blocky structure to massive; very friable and very porous; neutral.

Lower subsoil—

25 to 50 inches, grayish-brown loamy fine sand; single grain; loose and very porous; plentiful roots form mat at lower boundary of horizon.

Substratum—

50 to 62 inches +, dark grayish-brown sandy clay loam; massive; hard when dry, very firm when moist; very few roots; roots form a mat on top of this layer, penetrating only through fractures in the substratum; neutral.

The principal variations in the soils of this complex are in the thickness of the surface layer and subsoil over compact glacial till. In places the surface layer is only 6 inches thick. On some of the undulating slopes, the subsoil is only 24 to 30 inches thick. In some places this mapping unit consists of areas of Roche loam, 1 to 2 acres in size, within larger areas of Indianola sandy loam. Yields of crops and tree site indexes are variable in these areas.

In Indianola-Roche complex, 0 to 8 percent slopes, permeability is moderately rapid in the surface layer and rapid to moderate in the subsoil. The moisture-supplying capacity is moderate, except in areas of Indianola sandy loam, where it is low. Roots can penetrate moderately deep to deep. The soils have good tilth, are easy to work, and can be cultivated under a wide range of moisture conditions. They are low to moderate in natural fertility. Runoff is very slow to slow, and there is a slight hazard of water erosion.

These soils are suited to small grains and to grasses and legumes grown for pasture or hay. The crops respond well if manure and a complete commercial fertilizer are added. The soils are well suited to Douglas-fir grown for timber, and Douglas-fir regenerates well. These soils are in capability unit VIs–7 and in site classes 4 and 5 for Douglas-fir.

Indianola-Roche complex, 8 to 30 percent slopes (IrD).—The soils in this complex are on the rolling to hilly slopes of glacial moraines. They are associated with Indianola sandy loam, 0 to 15 percent slopes, and with Roche loam, 8 to 15 percent slopes. Except for having stronger slopes, the soils are similar to those of Indianola-Roche complex, 0 to 8 percent slopes.

In most places runoff is slow on these soils, but in areas of Roche loam it is medium. There is a slight to moderate hazard of water erosion.

These soils are not suited to row crops but are fairly well suited to grasses and legumes for pasture. They are better suited to trees grown for timber than to either row crops or pasture. The mapping unit is in capability unit VIs–7 and in site classes 4 and 5 for Douglas-fir.

Neptune Series

The Neptune soils are on old beaches above areas that are covered by water when the tide is high. The soils have formed in coastal beach sands in which a large number of marine shells are embedded. The native vegetation was grass and a few shrubs and trees. Only one soil of this series, Neptune gravelly sandy loam, occurs in San Juan County.

Neptune gravelly sandy loam (Ng).—This soil occurs in a few scattered areas on old beaches in the county. The areas are high enough so that they are not covered by tidal waters.

Representative profile:

Surface layer—
0 to 5 inches, dark grayish-brown to black gravelly sandy loam; very friable; mildly alkaline.

Upper subsoil—
5 to 17 inches, dark gray to very dark gray gravelly coarse sand; loose; mildly alkaline.

Substratum—
17 inches +, gray, loose sand and gravel containing numerous marine shells.

This soil has somewhat excessive natural soil drainage. Internal drainage is very rapid, and surface runoff is very slow. The natural fertility is very low, and there is a severe hazard of wind erosion. This soil is better suited to native grasses for pasture and browse than to tilled crops or trees. The grasses will provide protection against wind erosion. This soil is in capability unit VIs–8. It is not used extensively for trees.

Norma Series

The Norma series consists of poorly drained soils in basins in the glaciated uplands. The water table is high. It is usually at, or near, the surface during the rainy season in winter. The surface layer of these soils is very dark grayish-brown to black loam; the subsoil is brown fine sand that ranges from very firm to weakly cemented. The Norma soils formed in sandy glacial drift derived from sandstone, basalt, and granite. The native vegetation was Douglas-fir, Sitka spruce, white fir, lodgepole pine, red alder, and willow. The understory was largely ocean-spray, wild rose, brackenfern, skunkcabbage, sedges, and grasses that tolerate water. These soils are associated with the Bow, Roche, and Coveland soils.

The Norma soils are fair to good for trees. Where they have been cleared, they are used to grow small grains and grasses and legumes for hay and pasture.

Norma loam (Nm).—This soil occurs in basins in the glaciated uplands. It is wet in winter and in spring.

Representative profile in an undisturbed area:

2 inches to 0, forest litter of needles, leaves, twigs, and moss in various degrees of decomposition.

Surface layer—
0 to 7 inches, very dark grayish-brown loam; granular; firm; abundant roots; medium acid.

Subsurface layer—
7 to 11 inches, dark-brown loam; subangular blocky structure; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; roots few; slightly acid.

Upper subsoil—
11 to 14 inches, dark grayish-brown to gray sandy loam; weak, fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; neutral.

Lower subsoil—
14 to 40 inches, brown fine sand; massive; slightly hard when dry, firm when moist; many weakly cemented, irregular nodules of strong brown to dark reddish brown; few roots; neutral.

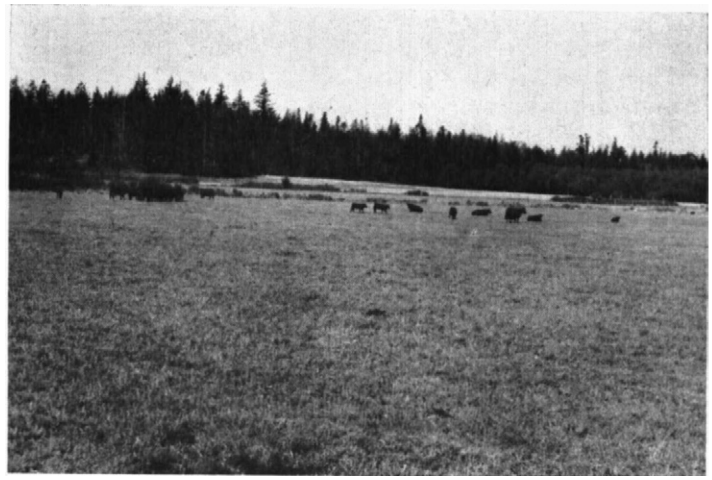

***Figure 4.*—Pasture on an area of Norma loam.**

Substratum—
40 to 60 inches +, olive-gray clay loam; weak, prismatic structure; extremely hard when dry, extremely firm when moist, very sticky and very plastic when wet; no roots; neutral.

Permeability is moderate in the surface layer of this soil and slow in the subsoil. Surface runoff is very slow. Water stands on the surface in winter and in spring. There is a slight hazard of water erosion. The moisture-supplying capacity and natural fertility are moderate.

Unless artificial drainage is provided, this soil is not suited to cultivated crops. Most areas can be pastured without drainage (fig. 4), but drainage lengthens the season of use and improves the quality of the pasture. The drainage can be improved by surface ditches and tile drains. When the soil is wet, cultivating or pasturing it causes it to pack and become hard when dry. Native grasses and sedges usually dominate the vegetation before drainage is established.

After drainage is established, this soil is suited to small grains and to clover and grass grown for hay and pasture. The crops respond well to manure and a complete commercial fertilizer. Douglas-fir, grown for timber, does well in drained areas. To avoid compacting the soil, logging operations need to be curtailed during the wet season in winter and spring. If the soil is compacted, water does not enter it readily and internal drainage is retarded. This creates an environment better suited to the regeneration of broadleaf species than to conifers, for Douglas-fir regenerates slowly in a wet environment. This soil is in capability unit IIIw–1. The trees to which it is suited are red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar. Unless this soil is drained, it is poorly suited to Douglas-fir.

Norma loam, moderately deep (No).—The profile of this soil is similar to that of Norma loam, but the substratum is at a depth of only 20 to 36 inches. The substratum is moderately fine textured, dense, and slowly permeable.

The drainage of this soil can be improved by surface ditches and tile drains. The slowly permeable substratum and subsoil layers limit the depth to which roots can penetrate.

After this soil has been drained, it can be used the same as Norma loam. To keep from compacting it, logging should be curtailed during the wet season in winter and spring. The regeneration of Douglas-fir is reduced if the soil becomes compacted, and broadleaf species will dominate the vegetative cover. This soil is in capability unit IIIw–1. The trees to which it is suited are red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar. Unless this soil is drained, it is poorly suited to Douglas-fir.

Orcas Series

The Orcas series consists of very poorly drained soils formed from sphagnum moss. The soils occur in deep, flat-bottomed depressions, or basinlike areas. Many of the areas do not have outlets, and the water table remains at, or near, the surface during most of the year. These soils occur near areas of Semiahmoo muck and are in the wettest parts of the bogs. In many places the bogs consist of a uniform, brown, fibrous peat ranging from 2 to 10 feet in depth. In places they are as deep as 40 feet.

The vegetation growing on these soils consists of sphagnum moss, hypnum moss, Labrador-tea, spirea, wild cranberry, and skunkcabbage. A few lodgepole pines grow on the bogs, and cedars and firs grow around the edges of the bogs.

These soils are low in natural fertility. Attempts have been made to clear some of the areas and to develop them for pasture, but the results were disappointing. Some areas have been burned over to destroy the moss peat, yet productivity remained low. Moss peat has commercial value as a soil conditioner. Only one soil of this series, Orcas peat, occurs in San Juan County.

Orcas peat (Op).—This organic soil is in deep depressions. It is very poorly drained.

Representative profile:

Surface layer—
0 to 6 inches, dark reddish-brown to brown, raw, fibrous moss peat; contains a mixture of living and dead sphagnum moss and roots of other plants that grow on the bog; extremely acid.

Subsoil layer—
6 to 84 inches, pale-brown, spongy, fibrous peat; consists of partly disintegrated sphagnum moss; extremely acid.

In places the sphagnum peat is underlain by sedge peat or by sedimentary peat. The surface layer varies from bog to bog. In places it is muck, and in other places it is peat. The texture depends mainly upon the degree of drainage. It depends partly on the amount of sedges or wood fragments that are mixed with the sphagnum moss and on the amount of use the areas have had. The soils that have a surface layer of muck occur in bogs that have been drained. The ones that have a surface layer of peat are in undrained bogs or in bogs that have been drained recently.

The supply of mineral plant nutrients is low in this soil. Surface runoff is ponded. Permeability is moderate, and there is a continuous high water table. The sphagnum moss and hypnum moss from which the soil was derived decompose very slowly. The stems of the moss are like small tubes and retain large quantities of water. Before the moss has been dried, it will retain as much as 1,300 times its weight in water. After it has been dried, its moisture-holding capacity is only a fraction of what it was originally.

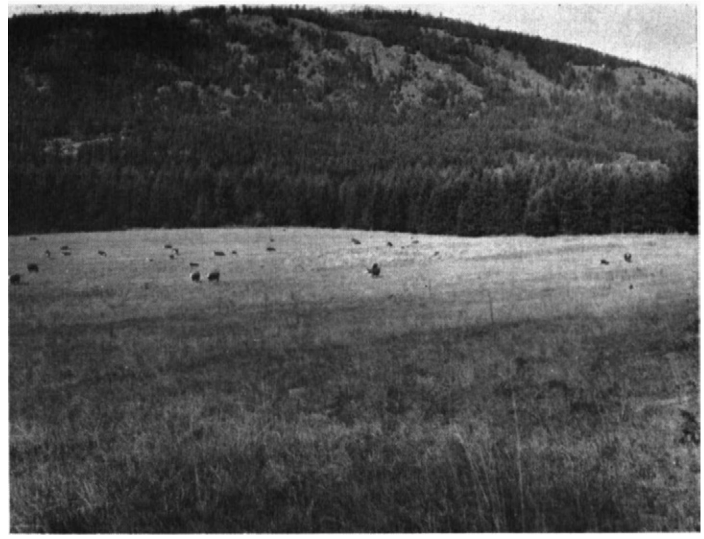

Figure 5.—**Cattle on a Bow gravelly silt loam in the foreground and on a Pickett-Rock outcrop complex in the background.**

Some areas of this soil have been drained and cleared of brush. These areas have then been pastured, but the pastures were of low quality. This soil is in capability unit VIIIw–1.

Pickett Series

The soils of the Pickett series are well drained. They have formed mainly in material weathered from arkose sandstone and graywacke. In places, however, the surface layer has been influenced slightly by glacial till derived from basalt, graywacke, serpentine, and sandstone.

The native vegetation is mainly Douglas-fir, lodgepole pine, and western redcedar, but there are a few madrona trees. The understory is huckleberry, Oregongrape, swordfern, brackenfern, and moss.

In San Juan County the Pickett soils have not been mapped separately. They have been mapped with Rock outcrop in complexes in which Rock outcrop occupies 20 to 50 percent of most areas (fig. 5). Some areas of the complex are near sea level, but others are on the slopes or crests of ridges as high as Mount Constitution. Where the areas are at the lower elevations, they are associated with the Roche, Bow, and Alderwood soils.

Pickett-Rock outcrop complex, 0 to 30 percent slopes (PrD).—This complex is mainly on the crests of ridges and on the lower slopes at a slightly higher elevation than the glacial plains. Most of the slopes are long and smooth or are hilly and complex. The following describes a profile that is typical of the Pickett soils. Rock outcrop is described under the name Rock outcrop.

Representative profile:

3 inches to 0, organic mat consisting of twigs, moss, and needles from firs and hemlocks overlies the mineral soil.

Surface layer—
0 to 13 inches, dark reddish-brown stony silt loam; granular structure; friable; roots abundant; slightly acid.

Upper subsoil—
13 to 30 inches, yellowish-brown stony silt loam; fine, angular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; slightly acid.

Lower subsoil—
30 to 40 inches, light yellowish-brown stony loam; angular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; slightly acid; lower part of this horizon grades to fractured bedrock, with silt between the fractures.

Substratum—
40 inches +, bedrock of arkose sandstone.

In this complex the principal variation in the Pickett soils is in the thickness of the solum over bedrock. The solum ranges from 18 to about 48 inches in thickness. It is thinner on the crests of ridges and on the steeper slopes than in less sloping areas.

Permeability is moderate in both the surface layer and subsoil of the Pickett soil, and surface runoff is very slow to medium. In areas of Rock outcrop, runoff is rapid to very rapid. The available moisture-supplying capacity of the Pickett soil is moderate, but it is very low in the areas of Rock outcrop. The Pickett soil is moderate in natural fertility. There is a moderate to severe hazard of water erosion.

In the vicinity of Mount Constitution, a few areas of Orcas peat are included with this complex. These areas are 5 to 9 acres in size. The peat is in basin areas, and it is very poorly drained.

Pickett-Rock outcrop complex, 0 to 30 percent slopes, is better suited to trees than to pasture or tilled crops. Only small areas have been cleared for cultivation. The areas should be kept under a cover of grass during the wet winter and spring seasons to protect them from erosion. The stones and gravel make tillage difficult. The complex is fairly well suited, however, to grasses and legumes grown for pasture and is well suited to Douglas-fir grown for timber. Because the areas are wet in winter and spring, it is desirable to curtail logging operations to keep from compacting the soil material. This complex is in capability unit VIs–7. The Pickett soil is in site class 3 for Douglas-fir and hemlock.

Pickett-Rock outcrop complex, 30 to 70 percent slopes (PrE).—This soil complex occurs on the outer edges of ridge crests throughout the county. About 30 to 50 percent of the acreage consists of Rock outcrop. The complex differs from Pickett-Rock outcrop complex, 0 to 30 percent slopes, mainly in having stronger slopes and a greater acreage where rocks outcrop. The soil material is also thinner over bedrock. The slopes are steep to very steep and precipitous. The soil mantle overlying bedrock ranges from less than 10 inches in thickness to about 40 inches.

Runoff is rapid to very rapid on this complex. There is a severe hazard of water erosion.

This complex is better suited to Douglas-fir grown for timber than to pasture or field crops. A large part of the acreage is in Moran State Park and is used for recreational and wildlife areas. This soil complex is in capability unit VIIe–1. The Pickett soil is in class 3 for Douglas-fir and hemlock.

Roche Series

The Roche series consists of nearly level to hilly, moderately well drained soils. The surface layer is dark brown and is generally medium textured. In places it is gravelly or stony. The subsoil and substratum are moderately coarse textured but are hard to extremely hard when dry. The soils occur on all of the larger islands and on many of the smaller ones. They have formed in glacial till that was derived from sandstone, granite, basalt, and graywacke. The native vegetation was Douglas-fir, lodgepole pine, willow, and red alder, with an understory of salal, Oregongrape, brackenfern, and moss.

The Roche soils are closely associated with Bow, Coveland, Alderwood, and Indianola soils, and with areas of Rock outcrop. Where this soil is associated with Rock outcrop, the areas are so intermixed that the two units are not mapped separately but are mapped as Roche-Rock outcrop complexes. Also, in places the Roche soils are mapped in complexes with the Indianola soils.

Roche gravelly loam, 3 to 8 percent slopes (RgB).—This moderately well drained soil is on glacial plains in the uplands throughout the county. It occupies the largest acreage of any of the glaciated soils. Most of its slopes are long, smooth, and gently undulating.

Representative profile in an undisturbed area:

2 inches to 0, forest litter consisting of needles, cones, leaves, twigs, and moss. The lower part of this layer is composed of black organic material that has a greasy feel.

Surface layer—
0 to 9 inches, dark-brown gravelly loam; fine, granular structure; friable, slightly acid.

Subsurface layer—
9 to 17 inches, grayish-brown fine sandy loam; massive; hard when dry, firm when moist; roots plentiful; medium acid.

Subsoil—
17 to 24 inches, olive-gray fine sandy loam; prominent, strong-brown mottles; contains some fine gravel; massive to weak, thin, platy structure; very hard when dry, very firm when moist, sticky and plastic when wet; very few roots penetrate into this horizon; medium acid.

Upper substratum—
24 to 34 inches, olive fine sandy loam; many, distinct mottles of reddish brown and yellowish red; light-gray, horizontal lenses; massive to weak, thin, platy structure; very hard when dry, very firm when moist, plastic and sticky when wet; very few roots; medium acid.

Lower substratum—
34 to 48 inches +, olive gravelly fine sandy loam; bands of olive gray and distinct mottles of reddish brown; massive to weak, thin, platy structure; extremely hard when dry, firm when moist, very sticky and plastic when wet; no roots; medium acid.

This is one of the most variable soils in the county. The thickness of the surface layer and subsoil over the dense, extremely hard, platy substratum ranges from 20 to about 48 inches. In many places the deeper profiles have a horizon of sandy loam or gravelly sandy loam that occurs intermittently immediately above the dense substratum. This horizon ranges from 4 to 12 inches in thickness. The content of gravel in the surface layer ranges from 15 to 25 percent. In many places this soil grades to Roche stony loam.

This soil has slow runoff. Permeability above the substratum is slow, and the permeability of the substratum is very slow. Water stands on the surface in places during the wet seasons in winter and spring. In contrast, the soil becomes very dry and hard in summer and early in fall when there is little precipitation. This soil has moderate moisture-supplying capacity. Depth of root penetration is restricted by the platy substratum. The soil has moderate natural fertility. There is a slight hazard of water erosion.

Approximately 5 percent of the acreage of this mapping unit consists of Roche stony loam in areas too small to show on the map. Also included are smaller areas of Alderwood gravelly loam, 3 to 8 percent slopes; Bow silt loam, 3 to 8 percent slopes; and Indianola sandy loam, 3 to 8 percent slopes (not mapped separately in this county). The included soils occupy less than 10 percent of the total acreage.

This soil can be drained by using a combination of tile, shallow surface ditches, and bedding or ridging. Supplemental sprinkler irrigation can be used to supply moisture during the dry season.

About one-third of the acreage of this soil has been cleared, and the rest remains in trees. The soil can best be cultivated when its supply of moisture becomes low enough to permit it to crumble readily. If the soil is cultivated or pastured when too wet, it becomes hard when dry and cultivating it later will be difficult. Logging operations should be curtailed while the soil is wet. If heavy equipment is moved over a wet soil, it destroys the soil structure and intensifies the drainage problems. This makes the soil more favorable for the reproduction and growth of broadleaf trees and shrubs than for desirable conifers.

This soil is well suited to Douglas-fir grown for timber. Where it has been cleared, it is suited to small grains, alfalfa, clover, and grasses. The crops respond to applications of manure and a complete commercial fertilizer. This soil is in capability unit IIIs-2 and in site classes 4 and 5 for Douglas-fir.

Roche gravelly loam, 0 to 3 percent slopes (RgA).—Except that this soil is nearly level and is deeper over the substratum, it is similar to Roche gravelly loam, 3 to 8 percent slopes. In most places it is about 44 inches thick over the substratum.

This soil occurs in association with Alderwood gravelly loam, 3 to 8 percent slopes. In places it is adjacent to areas of Rock outcrop.

Surface runoff is very slow on this soil. There is a slight hazard of water erosion.

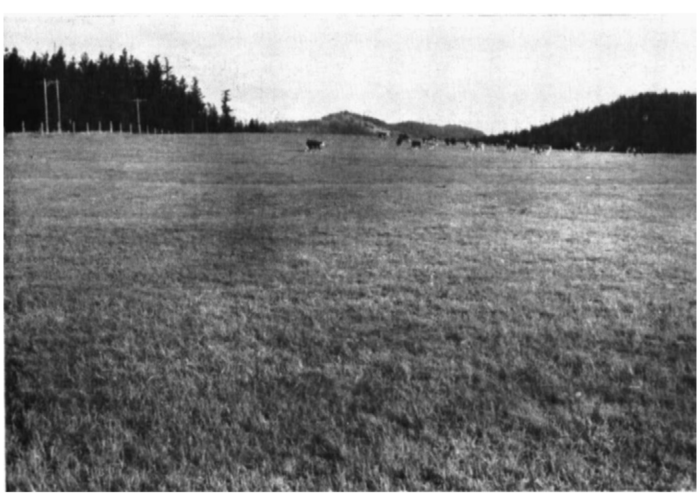

Figure 6.—**Pasture on a Roche gravelly loam.**

A few areas of a Roche stony loam have been mapped with this soil. These areas were too small to map separately.

About one-third of the acreage of Roche gravelly loam, 0 to 3 percent slopes, has been cleared. The cleared areas are suited to small grains, alfalfa, legumes, and grasses (fig. 6). The soil is used to grow the same kinds of crops as are grown on Roche gravelly loam, 3 to 8 percent slopes.

The management of this soil is concerned chiefly with maintaining good tilth, increasing productivity, and removing the excess surface water that collects in winter and early in spring. The soil can be drained by using a combination of tile, shallow surface drains, and bedding or ridging. Supplemental sprinkler irrigation can be used to supply moisture during the dry season. This soil is in capability unit IIIs-2 and in site classes 4 and 5 for Douglas-fir.

Roche gravelly loam, 8 to 15 percent slopes (RgC).—Except for slope, this soil is similar to Roche gravelly loam, 3 to 8 percent slopes. At a depth between 24 and 40 inches, it has a hard, platy substratum that restricts the penetration of roots. Runoff from this soil is slow to medium. In places losses from erosion may be severe if the soil is not protected by a cover of plants in winter.

This soil is suited to legumes and grasses grown for hay and pasture, but yields are somewhat lower than on the less sloping areas. Less than one-third of the acreage has been cleared for cultivation. This soil is in capability unit IVe-1 and in site classes 4 and 5 for Douglas-fir.

Roche gravelly loam, 15 to 30 percent slopes (RgD).—This soil is similar to Roche gravelly loam, 3 to 8 percent slopes, except that the surface layer is 3 to 6 inches thick, the soil above the substratum is 20 to about 40 inches thick, and slopes are moderately steep. The substratum consists of dense, very slowly permeable glacial till.

This soil is closely associated with Roche stony loam, 15 to 30 percent slopes. It is also closely associated with areas of Rock land.

Runoff is medium. The hazard of erosion is moderate.

This soil is suited to trees grown for timber and is used mainly for that purpose. Douglas-fir grows at a slightly more rapid rate in tracts near areas of Rock outcrop than elsewhere on this soil. Water drains from the areas of Rock outcrop onto this soil, thereby making more moisture available. This soil is in capability unit VIs-7 and in site classes 4 and 5 for Douglas-fir.

Roche loam, 0 to 3 percent slopes (RoA).—Except for being nearly level and having a surface layer that is free of gravel, this soil is similar to Roche gravelly loam, 3 to 8 percent slopes. Runoff is very slow on this soil, and water stands on the surface somewhat longer. There is a slight hazard of erosion.

Depth to which roots can penetrate this soil is limited by the dense, platy substratum, which is at a depth between 30 and 40 inches. The drainage requirements, suitability for crops, and response to fertilizer are the same as for Roche gravelly loam, 3 to 8 percent slopes.

Roche loam, 0 to 3 percent slopes, is in capability unit IIIs-2. It is in site classes 4 and 5 for Douglas-fir.

Roche loam, 3 to 8 percent slopes (RoB).—Except that the texture of the surface layer is loam, this soil is similar to Roche gravelly loam, 3 to 8 percent slopes, and the use and management requirements of the two soils are about the same. This soil is in capability unit IIIs–2 and in site classes 4 and 5 for Douglas-fir.

Roche loam, 8 to 15 percent slopes (RoC).—This soil is similar to Roche gravelly loam, 3 to 8 percent slopes, but it has stronger slopes and a surface layer that is only 5 to 7 inches thick. It also varies more in thickness over the substratum.

This soil has slow to medium runoff. The hazard of erosion is moderate. The soil should be protected by a cover of plants in winter.

Less than 30 percent of the acreage of this soil has been cleared for cultivation. In the areas that have been cleared, the soil is suited to grasses and legumes grown for hay and pasture. The soil is well suited to Douglas-fir grown for timber. It is in capability unit IVe–1 and in site classes 4 and 5 for Douglas-fir.

Roche stony loam, 3 to 8 percent slopes (RsB).—This soil is similar to Roche gravelly loam, 3 to 8 percent slopes. It differs in having numerous stones on the surface and throughout the profile. The stones range from 12 to 24 inches in diameter. The surface layer ranges from 5 to 7 inches in thickness.

Because of the stones, this soil is better suited to growing trees for timber than to tilled crops or pasture. Management of the woodlands is the same as that described for Roche gravelly loam, 3 to 8 percent slopes. If the stones are removed, the soil can be used the same as Roche gravelly loam, 3 to 8 percent slopes.

This soil is in capability unit VIs–7 and in site classes 4 and 5 for Douglas-fir.

Roche stony loam, 8 to 15 percent slopes (RsC).—This soil is similar to Roche gravelly loam, 3 to 8 percent slopes, but it has stronger slopes and a surface layer that is only 3 to 8 inches thick. It also contains stones. The content of stones in the surface layer ranges from 15 to 35 or 40 percent, by volume. In some places the content of stones and cobbles in the subsoil is as much as 50 percent.

Runoff from this soil is slow to medium. There is a moderate hazard of water erosion.

This soil is better suited to trees grown for timber than to pasture or tilled crops. Management of the woodlands is the same as that described for Roche gravelly loam, 3 to 8 percent slopes. The soil is in capability unit VIs–7 and in site classes 4 and 5 for Douglas-fir.

Roche stony loam, 15 to 30 percent slopes (RsD).—The profile of this soil is similar to that of Roche gravelly loam, 3 to 8 percent slopes, except that it contains stones and the surface layer is only 3 to 5 inches thick. The soil ranges from 20 to 48 inches in thickness over the dense, very slowly permeable substratum. In many places stones that range in diameter from 12 to 24 inches cover 10 to 15 percent of the surface. In other places 25 to 50 percent of the subsoil, by volume, consists of cobbles and stones. This soil is closely associated with areas of Rock outcrop and with other Roche soils.

Because of the moderately steep to hilly topography, this soil has medium runoff and there is a moderate hazard of water erosion. The soil is better suited to trees grown for timber than to pasture or tilled crops. This soil is in capability unit VIs–7 and in site classes 4 and 5 for Douglas-fir.

Roche gravelly sandy loam, 3 to 8 percent slopes (RhB).—This soil is similar to Roche gravelly loam, 3 to 8 percent slopes, except that the texture of its surface layer and subsoil is gravelly sandy loam instead of gravelly loam. In most places the substratum of the two soils is similar, but in places it is moderately fine textured glacial till that contains gravel or sand. This soil is closely associated with Roche gravelly loam, 3 to 8 percent slopes, and with Alderwood gravelly sandy loam, 3 to 8 percent slopes.

Water drains off the soil at a slightly slower rate than from the associated Roche gravelly loam, 3 to 8 percent slopes. There is a slight hazard of water erosion. The moisture-supplying capacity is moderately low. Natural fertility is low.

This soil benefits from the same drainage practices as were suggested for Roche gravelly loam, 3 to 8 percent slopes. It can be cultivated and pastured when it is slightly more moist than can Roche gravelly loam, 3 to 8 percent slopes.

The soil is suited to small grains, alfalfa, grasses, and legumes. The crops respond well if manure and a complete commercial fertilizer are added. The soil is also well suited to Douglas-fir grown for timber. It is in capability unit IVs–3 and in site classes 4 and 5 for Douglas-fir.

Roche stony sandy loam, 8 to 15 percent slopes (RtC).—This soil is similar to Roche gravelly loam, 3 to 8 percent slopes, but it has a thinner surface layer, a texture of stony sandy loam, and stronger slopes. The surface layer is only 4 to 6 inches thick, and 15 to 50 percent of it, by volume, consists of gravel and stones. The lower part of the subsoil is a very stony and gravelly fine sand. About 80 percent of it, by volume, consists of stones, cobbles, and fine gravel. The substratum is massive to weak, platy gravelly loam. It is very hard to extremely hard when dry and very firm when moist. Roots do not penetrate into the substratum except in a few fractures. The moisture-supplying capacity is moderately low.

This soil is better suited to trees grown for timber than to pasture or tilled crops. In a few places it has been cleared and the native grasses are used for pasture. The soil is too stony to cultivate and to establish other grasses and legumes. It is in capability unit VIs–7 and in site classes 4 and 5 for Douglas-fir.

Roche-Rock outcrop complex, 8 to 30 percent slopes (RxD).—This mapping unit consists of areas of Roche soils and of Rock outcrop too intricately associated to be mapped separately. Rock outcrop is described under the heading Rock outcrop. The profile of the Roche soil is similar to that described for Roche gravelly loam, 3 to 8 percent slopes, and variations are about the same. It differs in that many stones, ranging from 12 to 24 inches in diameter, are on the surface and throughout the profile. About 15 to 50 percent of the acreage of this complex consists of Rock outcrop. This complex occurs in association with Bow silt loam, 3 to 8 percent slopes, and with Roche loam, 3 to 8 percent slopes.

The Roche soils in this complex have moderate natural fertility. Surface runoff is slow to medium, and the moisture-supplying capacity is moderately low. The areas of Roche soil receive runoff from the adjacent areas of Rock outcrop. Plants growing on the Roche soil benefit from the added moisture, but there is a moderate hazard of water erosion.

This complex is better suited to trees than to pasture or tilled crops. Some areas have been cleared and are used for pasture of native grass. The areas that have been cleared are usually not seeded to improved grasses because it is too difficult to prepare a suitable seedbed. This complex is in capability unit VIs–7; the Roche soil is in site classes 4 and 5 for Douglas-fir.

Roche-Rock outcrop complex, 30 to 70 percent slopes (RxE).—The Roche soil in this complex is similar to Roche gravelly loam, 3 to 8 percent slopes, except that the surface layer is thinner, or 4 to 8 inches thick, and contains many stones. Also, the thickness of the profile is more variable. Between 15 and 50 percent of the surface layer, by volume, consists of stones ranging in diameter from 12 to 24 inches. The thickness of the solum ranges from 12 to 40 inches. Slopes range from steep to very steep.

The Roche soil has moderate to moderately low natural fertility. In most places the moisture-supplying capacity is moderately low, but it is low in places where the soil is shallow. Runoff from this complex is rapid to very rapid, and there is a serious hazard of water erosion.

This complex is better suited to trees grown for timber than to pasture or tilled crops. It is in capability unit VIIe–1; the Roche soil is in site classes 4 and 5 for Douglas-fir.

Rock Land

Rock land, rolling (Ry).—Between 50 and 90 percent of this miscellaneous land type consists of rock outcrops made up primarily of sandstone, argillite, and basalt. Between the outcrops are mainly Pickett and Roche soils. The texture of the soils between the outcrops varies greatly within short distances, as do the number of stones. The profile characteristics of these soils, however, are similar to those of soils of the same series in adjacent areas.

Surface runoff is rapid to very rapid on the areas of rock outcrop. The runoff causes a serious hazard of erosion on adjacent soil areas, but in those areas it also increases the amount of moisture available for plants to use. This land type is in capability unit VIIe–1.

Rock land, steep (Rz).—This miscellaneous land type is similar to Rock land, rolling, but it is steeper. Surface runoff is very rapid. As a result, there is a serious hazard of water erosion on adjoining soil areas. Rock land, steep, occurs in association with the Pickett and Roche soils and with other areas of Rock land. It is in capability unit VIIe–1.

Rock Outcrop

This miscellaneous land type consists mainly of areas of bare bedrock. In the places where there are soil materials, there is little usable vegetation because the soil materials are too shallow to support most plants. This land type is closely associated with areas of Rock land, and it also occurs in intricate association with the Pickett and Roche soils. In this county Rock outcrop is not mapped separately but is mapped in complexes with the Pickett and Roche soils. The Pickett-Rock outcrop complexes are described under the Pickett series, and the Roche-Rock outcrop complexes, under the Roche series.

San Juan Series

The San Juan series consists of nearly level to hilly soils that are somewhat excessively drained. The soils have a surface layer that is black. The surface layer is moderately coarse textured, and the subsoil and substratum are coarse textured. The San Juan soils occur mainly in the southern part of San Juan Island, but a few smaller areas are on some of the other islands. The San Juan soils occur in association with the Everett, Roche, and Alderwood soils. Their subsoil and substratum resemble those of the Everett soils.

These soils formed in gravelly glacial outwash or till that originated from many different kinds of rock. The parent material is loose and is irregularly stratified. The native vegetation consisted of grass and brackenfern, with an occasional Oregon white oak and Douglas-fir. The present vegetation consists of bromegrass, soft chess, downy chess, California oatgrass, filaree, and brackenfern.

These soils are used to grow small grains, grasses, and legumes. They are used mostly for hay crops and pasture.

San Juan gravelly sandy loam, 0 to 8 percent slopes (SaB).—This soil is somewhat excessively drained. It has gently undulating to undulating slopes.

Representative profile:

Surface layer—
- 0 to 15 inches, black gravelly sandy loam; fine, granular structure; soft when dry, very friable when moist; roots abundant; medium acid.

Subsoil—
- 15 to 23 inches, dark-brown to very dark grayish-brown gravelly loamy coarse sand; weak, fine, prismatic structure breaking to fine granules or single grain; soft when dry, very friable when moist; roots plentiful; slightly acid.

Substratum—
- 23 to 60 inches +, dark-brown grading to light olive-brown gravelly loamy coarse sand; single grain; loose when moist or dry; very few roots; slightly acid in the upper part but neutral below a depth of 30 inches.

The content of gravel in the surface layer of this soil ranges from 15 to 30 percent, by volume. It ranges from 20 to 40 percent in the subsoil.

This soil is very porous, and its drainage is somewhat excessive. Surface runoff is very slow to slow, and permeability is rapid. The soil is low in natural fertility. In some places roots can penetrate to only a moderate depth, but the depth to which they usually penetrate is moderately deep. If the soil is left bare, it is susceptible to severe damage from wind erosion (fig. 7). The soil has good tilth, is easy to work, and can be cultivated within a wide range of moisture conditions.

Mapped with this soil are small areas in which the texture of the surface layer is loam or sandy loam. These areas occupy about 30 percent of the total acreage. The surface layer in the nongravelly areas is 6 to 12 inches thick.

San Juan gravelly sandy loam, 0 to 8 percent slopes, is used mostly for grazing. It is not well suited to row crops but is better used to grow small grains, grasses, and alfalfa and other legumes. Most of the vegetation is bromegrass, soft chess, downy chess, California oatgrass, filaree, and brackenfern.

Careful management is required to establish crops and to maintain a good ground cover on this soil. The soil is too droughty for crops to be seeded in fall. The crops

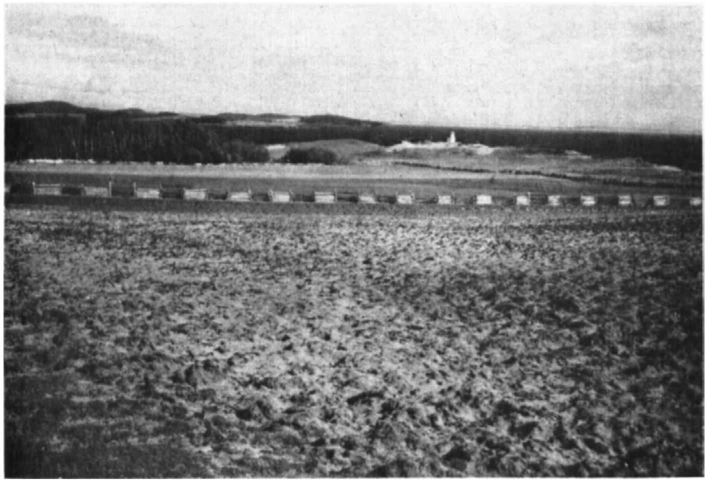

Figure 7.—**Area of a San Juan gravelly sandy loam, which is susceptible to erosion by wind if it is not protected by a cover of plants.**

respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit VIs–4. It is not used extensively for trees.

San Juan gravelly sandy loam, 8 to 30 percent slopes (SaD).—This somewhat excessively drained soil is on rolling ridges and slopes in the southern part of San Juan Island. Except for having stronger slopes and a surface layer that is thinner (8 to 15 inches thick), it is similar to San Juan gravelly sandy loam, 0 to 8 percent slopes. Slopes are mostly between 7 and 15 percent, but about 40 acres is included in which slopes are between 15 and 30 percent. There are many low sand dunes on this included soil.

San Juan gravelly sandy loam, 8 to 30 percent slopes, is not suited to row crops, but it is suited to the same crops and requires the same management practices as San Juan gravelly sandy loam, 0 to 8 percent slopes. Yields are generally slightly lower on this soil. The vegetation is mainly bromegrass, soft chess, downy chess, California oatgrass, filaree, and brackenfern. This soil needs to be kept under a cover of plants to protect it from erosion by wind. It is in capability unit VIs–4. The soil is not used extensively for trees.

San Juan stony sandy loam, 3 to 15 percent slopes (StC).—This soil is stony. It is on undulating to rolling upper slopes on San Juan Island near Cattle Point. This soil is similar to San Juan gravelly sandy loam, 0 to 8 percent slopes, but it has stronger slopes, the texture in the surface layer is stony sandy loam, and the surface layer is only 6 to 13 inches thick. There are many stones on the surface of this soil. The stones range from 1 to 2 feet in diameter and are less than 30 feet apart.

The stones on the surface and throughout the profile make this soil unsuitable for growing tilled crops. Careful management is required to improve the natural cover of plants so that the soil will be protected against wind erosion. It may be necessary to control rabbits so that the vegetative cover can be improved adequately to prevent erosion. This soil is in capability unit VIs–5. It is not used extensively for trees.

San Juan stony sandy loam, 15 to 30 percent slopes (StD).—This soil is near the upper parts of slopes on ridges in the vicinity of Cattle Point. It is similar to San Juan gravelly sandy loam, 0 to 8 percent slopes, but it has a thinner surface layer, the texture of the surface layer differs from that of the less sloping soil, and this soil has stronger slopes. The surface layer is only 8 to 12 inches thick. About 20 percent of it, by volume, is gravel. Stones, about 1 to 2 feet in diameter, are at intervals of about 30 feet on the surface.

Runoff is slow to medium on this soil. There is a moderate hazard of water erosion and a serious hazard of wind erosion.

This soil is not suited to cultivation, because the slopes are hilly to steep and the numerous stones make cultivation difficult. The areas can be used for grazing. Careful management is necessary, however, to keep a cover of plants on the soil to protect it from erosion. This soil is in capability unit VIs–5. It is not used extensively for trees.

San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes[1] (SdB).—This well-drained soil is mainly on San Juan Island, but small areas are on the other islands. It is moderately deep over till and has a subsoil of gravelly clay loam that is very hard when dry. The surface layer is only about 8 inches thick, and the solum is about 20 to 24 inches thick over the massive, hard glacial till. This soil was included in the San Juan series because of its limited extent in the county.

The native vegetation on this soil was mainly a cover of grasses and brackenfern, but in places there were scattered stands of Oregon white oak and Douglas-fir.

Representative profile:

Surface layer—
0 to 8 inches, black gravelly sandy loam; fine, granular structure; slightly hard when dry, friable when moist, very slightly plastic when wet; roots abundant; slightly acid.

Upper subsoil—
8 to 20 inches, brown to very dark brown gravelly loam; subangular blocky structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; roots plentiful; slightly acid.

Subsoil—
20 to 24 inches, light-gray to olive-gray gravelly clay loam; weak, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few roots; slightly acid.

Substratum—
24 to 36 inches +, grayish-brown to olive-brown gravelly sandy clay loam; massive to weak, thin, platy structure, but massive at a lower depth; extremely hard when dry, extremely firm when moist, sticky and plastic when wet; no roots; neutral.

This soil is well drained and has moderate natural fertility. In the upper layers, permeability is moderate, but in the substratum it is slow. Runoff is very slow to slow. The capacity of this soil to hold moisture is limited by the dense, slowly permeable glacial till in the substratum. The moisture-supplying capacity is moderate. There is a slight hazard of water erosion.

Water stands on this soil for short periods during the rainy season, and the soil remains wet until late in spring. It can be drained by using shallow surface drains and ridging or bedding. Cultivation can best be accomplished after

[1] This soil was included in the San Juan series because of its limited extent. Its properties and behavior are outside the permissible range of the San Juan soils as now defined.

the soil is dry enough to crumble readily. The soil becomes hard if cultivated when too wet.

This soil is suited to small grains and to grasses and legumes grown for hay or pasture. The crops respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit IIIs-2. It is not used extensively for trees.

San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes (SdC).—This soil is mainly on San Juan Island. Except for having stronger slopes, it is similar to San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes. The surface layer is only 4 to 7 inches thick, and the soil above the substratum is 20 to 24 inches thick.

Runoff is slow to medium on this soil. There is a moderate hazard of water erosion.

This soil is suited to grasses and legumes grown for hay or pasture. Careful management is required to improve its drainage, to protect it from erosion, and to maintain and increase its productivity. Surface drainage can be improved by constructing cross-slope drains that lead to grassed waterways. By constructing the drains across the slope, the soil will be protected from water erosion. Crops grown on it respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit IVe-1. It is not used extensively for trees.

San Juan loam, moderately deep, 0 to 15 percent slopes (SmC).—This soil is similar to San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes, except that the surface layer is free of gravel and is black loam to a depth of 8 to 10 inches.

The absence of gravel in the surface layer increases the moisture-holding capacity of this soil over that of San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes. This soil is easily tilled and has moderate natural fertility. Runoff is very slow to medium, and there is a slight to moderate hazard of water erosion. In the upper part of the profile, permeability is moderate, but in the substratum it is slow. The drainage of this soil can be improved by shallow surface drains and by ridging or bedding.

This soil is suited to small grains and grasses and to alfalfa and other legumes grown for hay or pasture. The crops respond well if manure and a complete commercial fertilizer are added. This soil is in capability unit IIIs-2. It is not used extensively for trees.

San Juan stony loam, moderately deep, 8 to 30 percent slopes (SsD).—This soil is mainly on San Juan Island. It is similar to San Juan loam, moderately deep, 0 to 15 percent slopes, but it has stronger slopes and a thinner surface layer. It also has a texture of stony loam and a moderately deep solum. The surface layer is 4 to 7 inches thick, and the soil is 20 to 24 inches thick over the massive, hard glacial till.

This soil has moderate natural fertility. Permeability is moderate. Surface runoff is slow to medium, depending upon the amount of slope. There is a moderate hazard of water erosion.

This soil is not suited to tilled crops, because the numerous stones and cobbles on the surface make tillage difficult. The native grasses growing on the soil are grazed. Care needs to be taken to keep a cover of plants on the soil at all times to protect it from water erosion. This soil is in capability unit VIs-6. It is not used extensively for trees.

Semiahmoo Series

The Semiahmoo series consists of very poorly drained organic soils formed in accumulations of various sedges and water-tolerant grasses. The material in the uppermost 6 to 10 inches is in an advanced state of decomposition so that the original plant remains are not easily recognized. The lower layers are fibrous, and the kind of plant materials can be identified in many places. In places, especially in the deeper bogs, the lower layers consist of finely divided organic materials that are not readily identified. This material is called sedimentary peat.

The Semiahmoo soils are in depressions or basins and on flats. In some places the soils are associated with Orcas peat. These soils differ from Orcas peat in that Orcas peat developed from mosses rather than from sedges and grasses.

A large part of the acreage of Semiahmoo soils has been cleared and is used for pasture. In places the soils are used to grow small grains and vegetables.

Semiahmoo muck (Sm).—This organic soil is in basins or depressions or on flats. It is very poorly drained.

Representative profile:

Surface layer—
0 to 10 inches, black muck; fine, granular structure; loose; many roots; medium acid.

Subsoil—
10 to 48 inches, dark reddish-brown, fibrous peat that becomes black when it is exposed to air; strongly acid.

Substratum—
48 to 72 inches +, dark reddish-brown, disintegrated (finely divided) peat; becomes black when exposed to air; strongly acid to neutral.

In places a layer of volcanic ash, 1 to 2 inches thick, is at a depth between 10 and 30 to 40 inches in this soil. The depth to the layer of volcanic ash depends upon the amount of decomposition and settling of the overlying peat and muck. Numerous logs are buried in the peat bogs. The buried logs become exposed on the surface as the overlying peat and muck decompose and settle. The logs interfere with cultivation.

Runoff is ponded on this soil. The soil is high in moisture-supplying capacity, but the moisture-supplying capacity is materially reduced following drainage and the initial settling of the peat. The content of mineral plant nutrients is low.

In places small areas of Mukilteo peat (not mapped separately in this county) and Orcas peat have been included with this soil. These inclusions occupy about 5 to 10 percent of the total acreage.

Semiahmoo muck is highly productive if it is drained. Careful management is necessary to maintain the high productivity and good drainage. The soil can be drained by using open ditches (fig. 8). Overdrainage should be avoided, because it accelerates the rate of decomposition and settling. Experience has shown that draining the soil to a depth of 24 inches is best. If the soil is drained to that depth, settling at the rate of ¾ inch to 1 inch annually may be expected. In other areas, where organic soils have been drained to a depth of 4 to 5 feet, the rate of decomposition and settling has ranged from 1½ to 2

Figure 8.—**Open ditch used to drain an area of Semiahmoo muck.**

inches annually. The life of a drained bog can be lengthened materially by using correct drainage practices.

If this soil is drained, it is suited to grasses and legumes. The bogs where drainage has not been improved are suited to reed canarygrass. Grasses and other crops grown on this soil respond well if manure and a commercial fertilizer are added. This soil is in capability unit IIw–2.

Semiahmoo muck, shallow (Ss).—This soil consists of areas of Semiahmoo muck in which the organic material is less than 36 inches deep over mineral material. In places entire bogs consist of shallow muck. In other places the shallow muck is around the edges of bogs made up of deeper muck.

The organic material overlying the mineral soil closely resembles that in Semiahmoo muck, but it is only 20 to 36 inches thick. In most places the underlying mineral material is medium-textured gravelly glacial till, but in some places it consists of marine sands and silts that contain numerous seashells.

This soil is low in content of mineral nutrients. Runoff is ponded, and the soil is often covered by water during the winter and spring seasons (fig. 9). When the soil is dry, there is a slight hazard of water erosion and a moderate hazard of wind erosion.

The use and management of this soil is the same as that described for Semiahmoo muck. Other suggestions for the use of this soil are discussed in the section "Management by Capability Units." This soil is in capability unit IVw–2.

Tanwax Series

The Tanwax series consists of very poorly drained organic soils. The soils formed from finely divided organic materials, including algae and excreta from minute marine animals. The surface layer is similar in color and texture to that of Semiahmoo muck. It differs in that the Tanwax soils have a surface layer of relatively raw, finely divided peat, and the Semiahmoo soils, a muck surface layer made up of decomposed coarse sedges and grasses that tolerate water.

Tanwax peat, alkaline variant (Ta).—This soil occupies a large area north of Richardson. It occurs in a drainageway that leads into Davis Bay. The area was reclaimed from tidal marsh during the 1890's by constructing a 15-foot dike that had a tidal gate across the outlet of the marsh. There is some seepage of salt water into the area.

Representative profile:

Surface layer—
- 0 to 14 inches, dark reddish-brown peat; granular structure; friable; neutral.

Upper subsoil—
- 14 to 24 inches, very dark brown to black, finely divided peat containing small marine shells; friable; mildly alkaline.

Subsoil—
- 24 to 48 inches, very dark brown to brown, finely divided peat containing small marine shells; mildly alkaline.

Substratum—
- 48 to 84 inches +, dark reddish-brown sedimentary peat; mildly alkaline.

This soil is very poorly drained and is usually flooded in winter and spring. It is covered by a dense growth of reed canarygrass, which provides abundant pasture throughout the summer months. Near the margins of the area, there are white fir, spruce, hemlock, and crabapple trees. This soil is in capability unit IVw–4.

Tidal Marsh

Tidal marsh (0 to 1 percent slopes) (Tm).—This miscellaneous land type consists of very wet, salty or brackish areas within the overflow limits of high tides. It consists of a number of different soils and soil materials, similar to the Hovde, Bellingham, Orcas, and Tanwax soils.

In most places the soil material is a deep deposit of delta alluvium in which no horizons have developed. It is friable, gray, and mottled and is medium to moderately fine textured. Natural drainage is very poor. Surface runoff and internal drainage are both very slow. The natural fertility is low. This land type is in capability unit VIIIw–1.

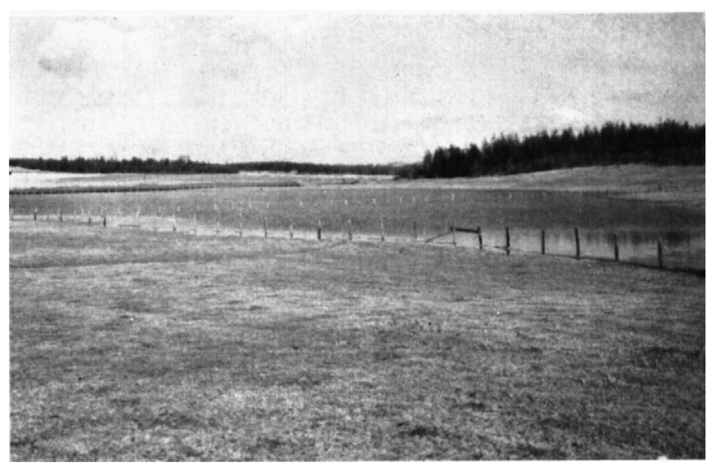

Figure 9.—**Semiahmoo muck, shallow, is often ponded in winter and in spring.**

Use and Management of the Soils[2]

This section has four main parts. In the first, the system of capability classification used by the Soil Conservation Service is explained and management practices are suggested for the soils of each capability unit. In the second, estimated average acre yields are given for the soils of the county. In the third, the uses of the soils for woodland are discussed, and, in the fourth, the suitability of the soils for engineering.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable the soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soils are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so steep, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

Subclasses are used to indicate major kinds of limitations within the classes. Within most of the classes, there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *s*, *w*, and *c*, because the soils in it have little or no erosion hazard but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping of soils for many general statements about their management. Capability units are generally identified by numbers assigned locally, for example, IIw-1 or IIIs-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible, but unlikely, major reclamation projects.

The eight classes in the capability system, and the subclasses and units in this county, are described in the list that follows.

Class I.—Soils that have few limitations that restrict their use. (None in this county.)

Class II.—Soils that have some limitations that reduce the choice of plants or that require moderate conservation practices.
- Subclass IIw: Soils that have moderate limitations because of excess water.
  - Unit IIw-1: Nearly level, poorly drained soils in basins.
  - Unit IIw-2: Very poorly drained, deep organic soils.
  - Unit IIw-3: Imperfectly drained basin soils underlain by dense clay.

Class III.—Soils that have severe limitations that reduce the choice of plants, or that require special conservation practices, or both.
- Subclass IIIw: Soils that have severe limitations because of excess water.
  - Unit IIIw-1: Poorly drained basin soils with moderately permeable subsoils.
  - Unit IIIw-2: Imperfectly drained soils with slowly permeable subsoils.
- Subclass IIIs: Soils that have severe limitations of moisture capacity or tilth.
  - Unit IIIs-2: Soils that have a dense substratum and that have only moderate available moisture-supplying capacity.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, that require very careful management, or both.
- Subclass IVe: Soils subject to very severe erosion if they are cultivated and not protected.
  - Unit IVe-1: Well drained and moderately well drained, sloping to rolling soils of uplands underlain by a dense substratum.
- Subclass IVw: Soils that have very severe limitations for cultivation because of excess water.
  - Unit IVw-2: Very poorly drained organic soil that is shallow over mineral material.
  - Unit IVw-4: Very poorly drained sedimentary peat.
- Subclass IVs: Soils that have very severe limitations of gravel, low moisture capacity, or other soil features.
  - Unit IVs-3: Well drained and moderately well drained soils of uplands underlain by a dense substratum.

Class V.—Soils not likely to erode but that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover. (None in this county.)

Class VI.—Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Subclass VIw: Soils severely limited by excess water and generally unsuitable for cultivation.

[2] Assistance in preparing this section was given by WILLIAM W. BAKER, agricultural agent for San Juan County, and CLARENCE C. WILLIAMS, work unit conservationist.

Unit VIw–1: Poorly drained basin soil with a permanent high water table.

Subclass VIs: Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Unit VIs–2: Moderately deep and deep, somewhat excessively drained soils of uplands formed in glacial drift.

Unit VIs–3: Moderately deep, somewhat excessively drained, sloping to hilly soil of uplands.

Unit VIs–4: Somewhat excessively drained, nearly level to hilly soils of uplands, underlain by loose, sandy and gravelly glacial outwash.

Unit VIs–5: Somewhat excessively drained soils that are undulating to hilly.

Unit VIs–6: Well-drained and imperfectly drained soils of uplands, underlain by dense, glacial till.

Unit VIs–7: Well-drained to imperfectly drained soils of uplands underlain by a dense, weakly to strongly cemented glacial till or bedrock (undulating to moderately steep or hilly).

Unit VIs–8: Somewhat excessively drained, calcareous soil in positions above areas covered by high tide.

Class VII.—Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation, and that restrict their use largely to grazing, woodland, or wildlife.

Subclass VIIe: Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Unit VIIe–1: Well-drained, stony soils and bedrock outcrops in the rolling to very steep uplands.

Class VIII.—Soils and landforms that have limitations that preclude their use, without major reclamation, for commercial production of plants; and that restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIw: Very poorly drained or marshy land.

Unit VIIIw–1: Orcas peat and Tidal marsh.

Subclass VIIIs: Rock or soil materials that have little potential for production of vegetation.

Unit VIIIs–1: Active dune land and Coastal beaches.

Management by capability units

The soils in San Juan County have been placed in 21 capability units. The soils in a given capability unit have about the same limitations and susceptibility to damage, need about the same management, and respond to management in about the same way. In the following pages each capability unit is described, the soils in it are named, and management for the group is suggested.

CAPABILITY UNIT IIw–1

This capability unit consists of nearly level, poorly drained soils in basins. The surface layers are dark colored. They are medium textured to moderately fine textured and are granular and friable. The subsoils are moderately fine textured, mottled, and very plastic. These soils are slightly acid in the upper part and have mildly alkaline substrata. They occur in areas that are ponded. The soils have very slow permeability; water stands on or near the surface in many places during the winter and spring. The moisture-supplying capacity of the soils is high. Fertility is moderately high. The soils in this capability unit are:

Bellingham silt loam.
Bellingham clay loam.

These soils require artificial drainage before they can be used for crops. If adequately drained, they are the most productive of any of the soils in the county. The soils can be drained by tile, surface drains, bedding or ridging, open ditches, or a combination of these. Removing the excess water makes the soils warm up much earlier in spring and makes it possible to till and plant crops early. In many of the small, isolated areas, deep drainage outlets are not easily constructed. Therefore, the soils will respond best if shallow surface drains and bedding or ridging are used.

The better drained areas are highly productive if small grains and peas for processing are grown as cash crops and mixtures of orchardgrass, alta fescue, and red and alsike clovers are grown for hay or pasture. The less well drained areas are suited to meadow foxtail or lotus, and the poorly drained areas can be used to grow reed canarygrass for summer pasture.

Yields of peas and small grains grown on these soils are increased if heavy applications of manure and a commercial fertilizer are added. Applications of a nitrogen fertilizer and phosphate help to establish new stands of grasses and legumes. Established stands also benefit if nitrogen and phosphate are added annually.

Tilling these soils when too wet causes them to become very hard when dry. It also causes the soils to become more dense so that moisture cannot penetrate so readily and the normal growth of roots is reduced. If the soils are tilled when too dry, they will break into hard clods and a good seedbed is difficult to prepare. Bellingham silt loam can be cultivated within a wider range of moisture content than Bellingham clay loam. It is best to prepare the seedbed when the content of moisture is just low enough to permit the soil to crumble easily. A cropping system in which the soils are kept in grasses and legumes about half the time is suggested to maintain good tilth and high fertility.

CAPABILITY UNIT IIw–2

Only one soil, Semiahmoo muck, is in this capability unit. This is a deep, very poorly drained organic soil that formed in accumulations of sedges and grasses that tolerate water. The plant remains differ in degree of decomposition. The material in the topmost 6 to 10 inches is in an advanced state of decomposition so that the original plant remains are not easily recognized.

The surface layer of this soil is black muck that is granular and loose. The lower layers are composed of peat. The soil has a surface layer that is medium acid, and its lower layers are strongly acid to neutral. It is naturally low in mineral plant nutrients.

This soil occurs in depressions or in basins that are difficult to drain. Surface runoff is ponded, and in many places water stands on the surface during winter and spring.

For crops to make their best growth on this soil, it is first necessary to establish drainage that will maintain the

Figure 10.—Areas of Semiahmoo muck may remain wet because of high or obstructed outlets.

water table at a depth of about 24 inches. Open ditches are better for drainage than tile because the soil settles at the rate of about three-quarters of an inch to 1 inch per year. Overdrainage accelerates the rate of settling.

In areas of this soil in Beaverton Valley, an obstructed outlet makes adequate drainage difficult (fig. 10). The areas that are covered by water in winter and early in spring can be used only in summer and early in fall. In some of the areas, poor air drainage causes frost pockets to form and limits the use of the areas to the production of grasses and legumes grown for hay and pasture.

The areas that are better drained and that have good air drainage are well suited to oats, barley, red clover, celery, and rhubarb. The less well drained areas are suited to meadow foxtail and lotus, and the least well drained areas, to reed canarygrass. In the pastures, sedges and weeds are strong competitors with the grasses and legumes, but they can be controlled by spraying.

All crops grown on this soil require applications of a complete commercial fertilizer. The amounts to use should be determined by soil tests. If small grains, legumes, and vegetables are to be grown, potash is particularly needed to increase yields and to improve quality.

Deficiencies in copper have been observed in animals grazing on Semiahmoo muck in other Washington counties. Particular attention needs to be given to animals grazing for prolonged periods on this soil for indications of impaired health.

CAPABILITY UNIT IIw-3

This capability unit consists of imperfectly drained basin soils underlain by very plastic clay. The surface layers are black, medium textured, granular, and friable. The subsoils are moderately fine textured to fine textured. They contain some fine sand, and, at a depth of 18 to 40 inches, are underlain by clay that is very plastic when wet and hard when dry. These soils have a surface layer that is medium acid, but they are less acid with increasing depth. Their substrata are neutral. The subsoils and substrata are very slowly permeable. Roots are able to penetrate only between fractures in the subsoil.

These soils have moderate natural fertility. They are nearly level to gently undulating. Surface runoff ranges from very slow to medium. There is a slight hazard of water erosion on the soils that have slopes of 0 to 3 percent and a moderate hazard on the soils that have slopes of 3 to 8 percent. Water stands on or near the surface in many places in winter and early in spring. The soils in this capability unit are:

Coveland silt loam, 0 to 3 percent slopes.
Coveland silt loam, 3 to 8 percent slopes.
Coveland gravelly silt loam, 0 to 3 percent slopes.
Coveland gravelly silt loam, 3 to 8 percent slopes.

These soils require artificial drainage if they are to be used for crops. They are productive if they are adequately drained. The soils can be drained by tile, shallow surface drains and bedding or ridging. If tile are used, they should be placed 1 to 3 inches above the dense substratum. The effectiveness of tile placed in the substratum is greatly reduced by clay that moves in and seals over the soil material above the tile.

Good tilth is easy to maintain in these soils. Relief is favorable for growing tilled crops. The range of moisture within which these soils can be tilled is comparatively wide. It is narrower for Coveland silt loam, 0 to 3 percent slopes, and Coveland gravelly silt loam, 0 to 3 percent slopes, than for the gently undulating soils.

The better drained areas are suited to peas grown for processing, oats, barley, wheat, strawberries, alfalfa, clover, and grass. Crop yields are lower on the Coveland gravelly silt loams than on the silt loams because the gravel reduces the amount of moisture that the soil can store for crops to use. Grass-legume pastures are excellent on these soils. On some areas a few farmers have grown mixtures of alfalfa and orchardgrass successfully. Keeping a cover crop on the undulating areas in winter is important in reducing the rate of runoff and in protecting the soils from erosion.

Crops yields on these soils are increased if large amounts of manure and commercial fertilizer are added. Manure, phosphate, and a fertilizer high in nitrogen are necessary to establish new seedings of grasses and legumes. Annual applications of fertilizer improve the quality and increase the yields on old seedings of grasses and legumes. Lime may be required to establish alfalfa. The amount of lime needed can be determined by testing the soils.

Areas of these soils that are in basins may be suitable to use as reservoirs for storing water if a dam made of earth fill is built across the outlet of the basin. Extreme care is needed so that the dense, hard clay in the substratum will not be used as fill material. This clayey material is difficult to pack and bind. When it dries, it checks, cracks, and allows seepage and eventually, possible failure of the structure.

CAPABILITY UNIT IIIw-1

This capability unit consists of poorly drained basin soils that have slowly permeable subsoils. The surface layers are dark colored and are medium textured, granular, friable, and moderately permeable. The subsoils are coarse textured. They are weakly cemented with iron. The substrata, at depths ranging from 40 to more than 60 inches, consist of nonconforming, olive-gray clay loam that is very plastic when wet, extremely hard when dry, and slowly permeable. The surface layers of these soils are medium to slightly acid, and the lower layers are neutral.

These soils occur in depressions or in nearly level areas. Surface runoff is very slow. Water stands on the surface in many places in winter and early in spring. The moisture-supplying capacity of the soils is moderate, and the soils have moderate natural fertility. The depth to which roots can penetrate is limited by the depth to a weakly cemented iron layer or a water table. The soils in this capability unit are:

Norma loam.
Norma loam, moderately deep.

The soils in this unit require artificial drainage to make them suitable for agricultural use. They can be drained by surface ditches and tile drains. After they are drained, the soils are suited to oats, barley, grasses, and clover grown for hay or pasture. The less well drained areas are suited to meadow foxtail and lotus.

Cultivating or pasturing the soils when they are wet destroys the dark-colored, friable surface layer that is common to forested areas. It packs the surface soil and causes the soil to become hard when dry, so that water penetrates slowly. In contrast, water can penetrate readily soils that have not been allowed to become packed and that have a moderate to high content of organic matter. If the soil has already become packed, the condition can be corrected by applying manure, improving drainage, and grazing or cultivating only when the content of moisture is low enough to permit the soil to crumble readily.

These soils are extremely dry late in summer and early in fall. A few farmers are using sprinkler irrigation successfully to keep crops growing through this dry period.

The Norma soils are only moderate in productivity. Crop yields are increased if heavy applications of manure and a commercial fertilizer are added. Applications of manure, nitrogen fertilizer, and phosphate are necessary to establish seedings of grasses and legumes. If these soils are well managed, good-quality pastures can be obtained.

The characteristics that cause these soils to be poorly drained create an environment favorable to the growth of spruce, white fir, lodgepole pine, red alder, willow, Oregon maple, and deciduous species of brush. Red alder and willow dominate in the vegetation after Douglas-fir has been logged. The other species mentioned are associated with the red alder vegetative growth.

Logging when these soils are wet causes the soils to become packed and intensifies wetness. It contributes to conditions more favorable for revegetating to deciduous species and brush than to Douglas-fir. Unless these soils are drained, they are poorly suited to Douglas-fir. Drainage is not commonly practiced, however, in the wooded areas.

CAPABILITY UNIT IIIw-2

The soils in this unit are imperfectly drained and have slowly permeable subsoils. The surface layers are dark-colored silt loams or gravelly silt loams. They are granular and friable. The subsoils are gray and mottled and are moderately fine textured. They have a prismatic or blocky structure and are very hard when dry and very plastic when wet. The substrata have a gray color, are fine textured, and are massive. They are extremely hard when dry and very plastic when wet. The surface layers and subsoils are slightly acid, and the substrata are neutral to mildly alkaline.

These soils are nearly level to gently undulating. They are on old terraces and in the uplands. The depth of the soils over the dense, fine-textured substratum is about 27 inches, but it ranges from 20 to 36 inches. A few fine roots penetrate the dense substrata through fractures. The substrata are very slowly permeable.

Surface runoff is very slow from the nearly level areas and slow to medium from the undulating ones. The hazard of water erosion is slight on the lower slopes and moderate on the stronger slopes. During rains in winter and in spring, water stands on or near the surface in many places. The soils in this capability unit are:

Bow silt loam, 0 to 3 percent slopes.
Bow silt loam, 3 to 8 percent slopes.
Bow gravelly silt loam, 0 to 3 percent slopes.
Bow gravelly silt loam, 3 to 8 percent slopes.

These soils become very hard and are difficult to till when they dry out in summer. A few farmers have used supplemental irrigation successfully during the dry seasons in summer and early in fall (fig. 11). Farm ponds and nearby lakes are used to supply water for irrigation.

Crops growing on these soils are damaged when water stands on the surface during the winter and spring. The soils can be drained by using a combination of tile and bedding, or of bedding and open ditches. The sides of open ditches need protection from erosion by water. This can be done by constructing the ditches so that the sides are not steep, or by using grassed waterways.

The soils in this group are moderate in productivity. They are suited to peas, oats, barley, orchardgrass, and clover (*3*).[3] Barnyard manure and green-manure crops are beneficial in maintaining the tilth of the soils, which have a natural tendency to pack and become hard. The experience of farmers shows that lime, nitrogen, and phosphate are essential in successfully establishing and maintaining mixtures of grasses and legumes. A complete commercial fertilizer is required if peas are to be grown for processing. It is also required for sustained high yields of hay crops and pasture. Pastures on these soils make good yields.

[3] Italic numbers in parentheses refer to Literature Cited, p. 72.

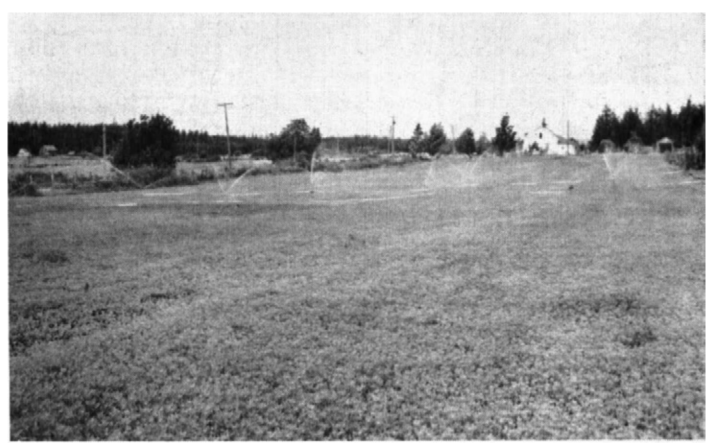

***Figure 11.*—Sprinkler irrigation used on a field of Bow gravelly silt loam to supply moisture for alfalfa during the dry season.**

Figure 12.—**Windthrow in a forest of Douglas-fir on an area of Bow gravelly silt loam where a claypan is at a shallow depth.**

The Bow silt loams have a site index rating of 114 for Douglas-fir, and the Bow gravelly silt loams, regardless of slope, have a site index rating of 112. Roots can grow only in the surface layer and upper part of the subsoil. They do not penetrate the dense, fine-textured, lower subsoils and substrata, which are dense and very slowly permeable. Because of the shallowness of the root system, trees grown on these soils are susceptible to windthrow when the areas are wet (fig. 12). Clear cutting of timber is desirable. Selective logging leaves individual trees exposed to wind, and windthrow is almost certain to occur. Natural restocking of forest trees on these soils is fair to good. In general, alder, bigleaf maple, willow, and other deciduous trees seriously compete with Douglas-fir, particularly in the low, wet areas.

These soils are too wet for logging operations during the season when there is a temporary high water table. Logging when the soils are wet destroys the soil structure. As a result, the soils become hard and water drains through them more slowly. Logging when the soils are wet also encourages revegetation with poor-quality brush and deciduous trees rather than species that are of value commercially.

CAPABILITY UNIT IIIs-2

This capability unit consists of soils that have a dense subsoil and substratum and only moderate available moisture-supplying capacity. The soils are well drained to moderately well drained. The surface layers and subsoils consist mainly of loam or gravelly loam and range from 28 to 48 inches in thickness. They are underlain by a substratum of dense, weakly to strongly cemented gravelly sandy loam, gravelly loam, coarse sand, or sandy clay loam. The substrata are slowly or very slowly permeable to moisture and roots. However, they materially help in retaining moisture for plants early in summer.

These soils have medium to slightly acid upper horizons and medium acid to neutral substrata. They are nearly level to gently undulating. Natural fertility is moderate. Surface runoff is very slow in the nearly level areas and slow to medium in the undulating areas. Permeability is moderate in the Alderwood and San Juan soils and slow in the Roche soils. Water stands on the surface for short periods during rains in winter and in spring. The soils in this capability unit are:

Alderwood gravelly loam, 3 to 8 percent slopes.
Roche loam, 0 to 3 percent slopes.
Roche loam, 3 to 8 percent slopes.
Roche gravelly loam, 0 to 3 percent slopes.
Roche gravelly loam, 3 to 8 percent slopes.
San Juan loam, moderately deep, 0 to 15 percent slopes.
San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes.

Surface drainage is a problem on the soils of this capability unit. The combination of very slow to medium surface runoff and very slowly permeable substrata causes water to stand on the surface during rains in winter and spring. The soils can be drained by using a combination of tile, shallow surface ditches, and bedding or ridging. If tile are used, they should be placed above the slowly permeable substratum. The effectiveness of tile placed in the substratum is greatly reduced because the soil materials seal over above the tile.

The soils in this group dry out during July and August. A few farmers have constructed dams so that they can store water, or they have piped water from nearby lakes to use for sprinkler irrigation (fig. 13). Supplemental irrigation keeps crops growing throughout the summer, improves the quality of the crops, and increases yields. Irrigated crops require more fertilizer to maintain quality and to sustain high yields than crops that have not been irrigated. If a sprinkler irrigation system is used, particular attention should be given to managing the soils so as to maintain good structure and a rapid intake of water. This can be accomplished by plowing under barnyard manure or crops grown for green manure and avoiding grazing when the soils are wet.

The soils in this unit are suited to small grains and to grasses and legumes grown for hay or pasture. They can be used in a regular cropping system consisting of 1 year each of a row crop and small grain, or 2 years of small grains and 3 or more years of mixtures of grasses and legumes (*3*) grown for hay or pasture.

Figure 13.—**A farm pond on soils of capability unit IIIs-2 used to provide water for supplemental irrigation and for recreation.**

Yields of small grains, hay, and pasture can be increased by applying manure, nitrogen, and phosphate. Nitrogen and phosphate are essential if new seedings of grasses and legumes are to be established successfully. Seedings of alfalfa may require lime, in addition to nitrogen and phosphate. Soil tests will show how much lime to use.

About one-third of the acreage of Alderwood and Roche soils has been cleared, and the rest is wooded. The San Juan soils are grassland soils, and only small areas have sparse stands of Oregon white oak, Douglas-fir, and lodgepole pine. The Roche and Alderwood soils are suited to Douglas-fir grown for timber and are moderate in productivity for that species. In San Juan County, Douglas-fir grown on the Alderwood and Roche soils has a site index of about 111, but, on soils of the same series on the mainland, the site index is somewhat higher for Douglas-fir. The lower site index in San Juan County is probably caused by the smaller amount of annual precipitation.

The roots of trees growing on these soils can penetrate to a depth of only 20 to 48 inches because of the hardpan or clay in the substratum. The average depth to which roots can penetrate is about 25 inches. It is important to recognize this limitation when timber is removed. The final harvest of timber needs to be clear cut because individual trees left standing are susceptible to windthrow. Logging operations should be curtailed when the soils are wet. If the soils are wet when heavy equipment is used, they become packed, their structure is destroyed, and drainage difficulties are intensified. This encourages broadleaf species to grow, rather than conifers.

Restocking of Douglas-fir is slow on these soils after logging has taken place. Tilled areas that have been abandoned restock naturally to alder. Water stands on the surface in winter and in spring. As a result, the moisture and temperature are suitable for natural restocking to red alder, willow, bigleaf maple, western hemlock, and western redcedar, with an understory of ocean-spray, spirea, salal, Oregongrape, wild rose, blackberry, brackenfern, and moss.

Immediate stocking to Douglas-fir can be obtained by planting. Competition from broadleaf species can be controlled by spraying large areas or by using hand methods in small woodlots. Thinning and pruning will increase the rate of growth and will improve the quality of the timber. The sale of wood products removed by thinning will provide a continued source of income up to the time of final harvest.

CAPABILITY UNIT IVe-1

This capability unit consists of well drained and moderately well drained, sloping to rolling soils of uplands. The soils are underlain by a dense substratum and resemble the soils of capability unit IIIs-2 but are more sloping. The surface layers and subsoils have a texture of loam, gravelly loam, or gravelly sandy loam and range from 28 to 48 inches in thickness. They are underlain by dense gravelly sand or sandy clay substrata. The depth and thickness of the surface layers and subsoils over the substrata are more variable than those in the related soils that have more gentle slopes.

These soils have medium acid to slightly acid upper horizons and neutral substrata. Surface runoff is slow to medium. Permeability is slow to very slow in the substrata, and there is a severe hazard of water erosion. The soils in this capability unit are:

Figure 14.—**Drainage ditches on Roche gravelly loam are susceptible to erosion if they are not protected by a cover of plants.**

- Roche loam, 8 to 15 percent slopes.
- Roche gravelly loam, 8 to 15 percent slopes.
- San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes.

The surface drainage of these soils can be improved by constructing shallow surface drains in areas where slopes are gentle (fig. 14). Seeding the waterways to grass helps to reduce the hazard of water erosion (fig. 15).

These soils are suited to small grains, grasses, and legumes. They are susceptible to severe water erosion if they are not protected by a good cover of vegetation during fall, winter, and spring. If cleared, the soils are better suited to pasture and hay than to tilled crops. They need to be kept in permanent pasture or hay most of the time. The areas should be cultivated and seeded to small grains only long enough to control weeds and to reestablish the

Figure 15.—**Grassed waterways used to protect an area of Roche gravelly loam from erosion.**

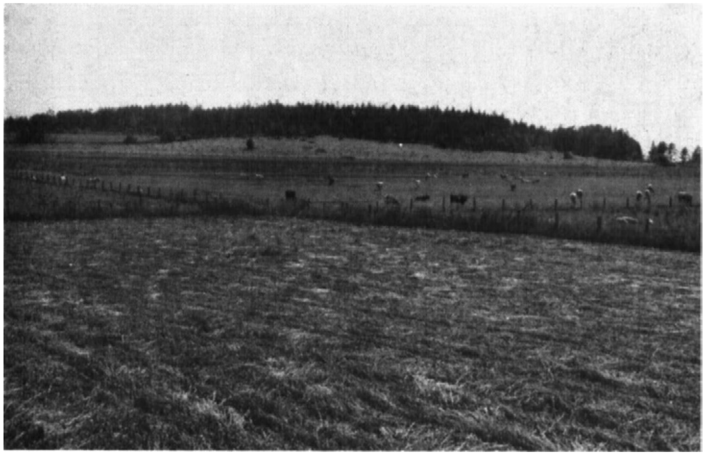

***Figure 16.*—Semiahmoo muck, shallow, is pastured in summer and early in fall.**

desired mixture of grasses and legumes. Tillage across the slope slows runoff and reduces the hazard of erosion.

New stands of grasses and legumes are best established by seeding in spring without a nurse crop, provided weeds are controlled. The supply of moisture is generally not adequate in fall to establish seedings that will survive through the winter.

Woodland management practices and the site index for Douglas-fir are the same for these soils as for the less sloping soils of the same series in capability unit IIIs–2.

CAPABILITY UNIT IVw-2

Only one soil, Semiahmoo muck, shallow, is in this capability unit. This poorly drained organic soil is less than 36 inches deep over mineral material. This soil differs from the one in capability unit IIw–2 in that mineral material is nearer the surface.

This soil has drainage similar to that of Semiahmoo muck, described under capability unit IIw–2, and is used and managed about the same. It is ponded frequently in winter and early in spring, but it can be used for pasture throughout the summer and early in fall (fig. 16).

The rate of settling is critical in this soil. As the organic matter decomposes and settles, the water table is progressively closer to the surface. Drainage outlets and ditches must then be deepened periodically. Otherwise, the bogs become too wet for crops other than the most water-tolerant species, such as reed canarygrass and sedges.

The very shallow muck soils that have been mixed with the underlying mineral soil material become similar to the Bellingham or Norma soils. They then require the same kind of use and management as that described for the Bellingham soils of capability unit IIw–1.

CAPABILITY UNIT IVw-4

Only one soil, Tanwax peat, alkaline variant, is in this capability unit. This very poorly drained soil consists of sedimentary peat. It differs from Semiahmoo muck, in capability unit IIw–2, because it consists of finely divided organic materials that are somewhat more difficult to drain. If it is overdrained, this soil becomes hard and is difficult to till.

This soil has moderately low value for agriculture. Surface runoff is ponded, and the soil is flooded frequently during the winter and spring. If it is drained, the soil is well suited to reed canarygrass grown for pasture.

CAPABILITY UNIT IVs-3

This capability unit consists of well drained and moderately well drained soils of uplands underlain by a dense subtratum. The soils formed in glacial till. The uppermost horizons are made up of dark-colored gravelly sandy loam. They are about 25 inches thick and overlie a substratum of dense, weakly to strongly cemented gravelly sandy loam or clay loam. Plant roots do not penetrate the substratum readily, and the available moisture-supplying capacity is moderately low. The limited moisture-storing capacity causes the soils to be droughty during summer and early in fall. The soils in this capability unit are:

Alderwood gravelly sandy loam, 3 to 8 percent slopes.
Alderwood gravelly sandy loam, 8 to 15 percent slopes.
Roche gravelly sandy loam, 3 to 8 percent slopes.

These soils are suited to oats, barley, wheat, grasses, alfalfa, clover, and strawberries. The crops make moderate yields. A suitable cropping system is one in which grass-legume mixtures are grown for hay or pasture at least three-fourths of the time. Oats, barley, and wheat are grown primarily to clean up the weeds before seeding grasses and legumes for hay and pasture. Fertilizer required and drainage and irrigation needed are the same as those described under capability unit IIIs–2.

The soils in this group have a forest site index of 114 for Douglas-fir. Management requirements for the woodlands are the same as those discussed under capability unit IIIs–2.

CAPABILITY UNIT VIw-1

Only one soil, Hovde loam, is in this capability unit. This very poorly drained basin soil has a permanently high water table. Its surface layer is dark colored, and its substratum is sandy. The soil occurs back of the ridges along areas of Coastal beaches.

The wetness of this soil makes it better suited to light grazing, along with better drained soils, than to other uses. Most of the areas are idle and provide protection for wildlife.

CAPABILITY UNIT VIs-2

This capability unit consists of moderately deep and deep, somewhat excessively drained soils of uplands that formed in glacial drift. The surface layers are a dark yellowish-brown sandy loam or gravelly sandy loam and are very friable. The substratum is at a depth of about 24 inches and consists of gravelly sand or fine sand. The subsoils and substrata are moderately coarse textured to coarse textured and are very rapidly permeable.

These soils are sloping to rolling and have slight susceptibility to water erosion. They are medium acid to neutral. Plant roots seldom penetrate more than a few inches into the gravelly, coarse-textured substratum. The soils in this capability unit are:

Everett gravelly sandy loam, 3 to 8 percent slopes.
Everett gravelly sandy loam, 8 to 30 percent slopes.
Indianola sandy loam, 0 to 15 percent slopes.

Small areas of these soils have been cleared for agricultural use. The moderately coarse textured, thin surface layer overlying the coarse textured substratum causes the soils to be low in moisture-holding capacity. The soils are droughty and are low in natural fertility. They contain little organic matter.

The soils of this group are well suited to timber production. The Everett soils have a forest site index of 117, and the Indianola soils a site index of 140 for Douglas-fir. The Everett and Indianola soils restock readily to Douglas-fir after timber has been harvested. The soils are somewhat excessively drained; consequently, there is no seasonal limitation on logging.

CAPABILITY UNIT VIs-3

Only one soil, Everett stony sandy loam, 8 to 30 percent slopes, is in this capability unit. This is a moderately deep, somewhat excessively drained, sloping to hilly soil of uplands, and it formed in glacial drift. The surface layer is a stony sandy loam underlain by coarse, loose, porous, sandy and gravelly glacial drift.

This soil is slightly acid and is droughty. It has slight susceptibility to erosion.

This soil is better suited to trees than to pasture or tilled crops. The strong slopes and stones make it unsuitable for cultivation. If the stones are removed, the soil is suited to about the same crops as the soils of capability unit VIs–2, and yields are about the same.

CAPABILITY UNIT VIs-4

This capability unit consists of somewhat excessively drained, nearly level to hilly soils of uplands. The soils are underlain by loose, sandy and gravelly glacial outwash. They have black or very dark brown surface layers. The surface layers and upper subsoils are medium acid, and the lower subsoils and substrata are slightly acid to neutral.

The coarse-textured substrata cause these soils to be low in moisture-supplying capacity. Only a few roots penetrate more than a few inches into the coarse-textured material. The soils are naturally low in fertility, and there is a severe hazard of wind erosion. The soils in this capability unit are:

San Juan gravelly sandy loam, 0 to 8 percent slopes.
San Juan gravelly sandy loam, 8 to 30 percent slopes.

These moderately coarse textured soils are susceptible to severe wind erosion if the cover of plants is removed. Blowout areas form quickly if the soils are left bare. The blowouts are difficult to control, and the soil material from the surface layer is lost at an increasing rate once sand dunes begin to form and advance (fig. 17).

Figure 17.—**After sand begins to drift in areas of the San Juan gravelly sandy loams, dunes are difficult to control.**

These soils do not retain enough moisture so that seedings can be established in fall. Wheat and oats should be grown only often enough to control weeds, rather than as part of a regular cropping system.

Heavy applications of nitrogen and phosphate are necessary to establish seedings of grasses and legumes. Established seedings of small grains and of grasses and legumes respond well if a complete commercial fertilizer is added.

Domestic rabbits that have escaped are a serious problem in this county, particularly on these sandy soils, where they can burrow readily and establish colonies. They destroy the vegetation. The rabbits are especially destructive of seedings of grasses and legumes. They also are particularly destructive of vegetation where a complete fertilizer has been added, especially where phosphate has been applied. Control of the rabbits would materially increase yields on these soils.

CAPABILITY UNIT VIs-5

This capability unit consists of somewhat excessively drained, undulating to hilly soils formed in glacial outwash. The soils have black surface layers of stony sandy loam. The subsoils and substrata are coarse textured and are gravelly and stony.

These soils are rapidly permeable and are low to very low in moisture-holding capacity. Their natural fertility is low. Runoff is very slow to medium. There is a slight to moderate hazard of water erosion and a severe hazard of wind erosion. The soils in this capability unit are:

San Juan stony sandy loam, 3 to 15 percent slopes.
San Juan stony sandy loam, 15 to 30 percent slopes.

The soils of this unit are too stony or too steep for cultivation, and they are used primarily for grazing. The stones have been removed to prepare a few areas for cultivation. In the areas where stones have been removed, the soils have the same management requirements as the nonstony soils in capability unit VIs–4.

The soils of this unit are suited to grasses and legumes grown for grazing. A nitrogen fertilizer and phosphate are required to establish and maintain new seedings. The soils have the same susceptibility to wind erosion as the San Juan soils in capability unit VIs–4, and there is the same problem of controlling rabbits.

CAPABILITY UNIT VIs-6

This capability unit consists of well-drained and imperfectly drained soils of uplands that are underlain by dense, compact glacial till. The soils formed under grass. The surface layers are black stony silt loam or stony loam and are granular and friable. The subsoils are mostly medium textured but contain some fine sand. They are underlain at a depth of 18 to 40 inches by glacial till consisting of loam or clay loam. This underlying material is plastic when wet and extremely hard when dry.

The slowly to very slowly permeable substratum causes water to stand on the surface on the more gentle slopes of these soils. On the steeper areas runoff is slow to medium. Unless a cover of plants is kept on these steeper areas, there is a moderate hazard of water erosion. The soils in this capability unit are:

Coveland stony silt loam, 0 to 15 percent slopes.
San Juan stony loam, moderately deep, 8 to 30 percent slopes.

Mapped with Coveland stony silt loam, 0 to 15 percent slopes, is an area, about 80 acres in size, of Coveland gravelly silt loam, 8 to 15 percent slopes.

Because of the stones, the soils in unit VIs-6 are better suited to grazing than to cultivated crops. The stones have been removed from a few areas on the lower slopes to prepare them for cultivation or for hay and pasture. If the stones have been removed, the Coveland soil is managed about the same as the Coveland silt loams in capability unit IIw-3, and the San Juan soil is managed about the same as the San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes, in capability unit IVe-1.

These soils are suited to the same kinds of grasses and legumes as the Coveland and San Juan soils that are free of stones, and they need the same kinds and amounts of fertilizer.

The vegetation on these soils is primarily grasses. Douglas-fir, Oregon white oak, and lodgepole pine are growing on some of the areas. Management of Douglas-fir on these soils is the same as that described under capability unit IIIs-2.

CAPABILITY UNIT VIs-7

This capability unit consists of a number of well-drained to imperfectly drained soils of uplands that are underlain by dense, weakly to strongly cemented glacial till or bedrock. The soils are undulating to moderately steep or hilly. All have medium-textured or moderately coarse textured surface layers that are gravelly, stony, or rocky, and all have stony or gravelly substrata.

The surface runoff from these soils is very slow to medium. There is a slight to severe hazard of water erosion. The soils in this capability unit are:

Alderwood gravelly loam, 15 to 30 percent slopes.
Alderwood gravelly sandy loam, 15 to 30 percent slopes.
Alderwood stony loam, 3 to 8 percent slopes.
Alderwood stony loam, 8 to 15 percent slopes.
Alderwood stony loam, 15 to 30 percent slopes.
Bow stony silt loam, 3 to 8 percent slopes.
Bow gravelly silt loam, 8 to 30 percent slopes.
Indianola-Roche complex, 0 to 8 percent slopes.
Indianola-Roche complex, 8 to 30 percent slopes.
Pickett-Rock outcrop complex, 0 to 30 percent slopes.
Roche gravelly loam, 15 to 30 percent slopes.
Roche stony loam, 3 to 8 percent slopes.
Roche stony loam, 8 to 15 percent slopes.
Roche stony loam, 15 to 30 percent slopes.
Roche stony sandy loam, 8 to 15 percent slopes.
Roche-Rock outcrop complex, 8 to 30 percent slopes.

The combination of gravel or stoniness, strong slopes, and susceptibility to water erosion makes these soils better suited to trees than to pasture or tilled crops. The stones have been removed from some of the less sloping areas. The areas where stones have been removed can now be used and managed about the same as the soils in capability units IIIs-2 and IVe-1.

In Bow gravelly silt loam, 8 to 30 percent slopes, there is a tract of about 60 acres in which the relief is rolling. Management in this rolling area is about the same as for the soils in capability unit IVe-1.

In this capability unit the soils that have slopes of less than 15 percent are fairly well suited to pasture. The numerous stones reduce the amount of moisture available to crops and make seeding and management difficult.

Suitable trees for these soils, as well as growth limitations and management problems, are the same as for the soils in capability unit IIIs-2. The site index rating for Douglas-fir grown on these soils is given in the section "Uses of Soils for Woodland."

CAPABILITY UNIT VIs-8

Only one soil, Neptune gravelly sandy loam, is in this capability unit. This soil is somewhat excessively drained and is calcareous. It occurs in positions above areas covered by high tide. It is near beaches and is thickly littered with marine shells.

This soil is very low in natural fertility. Permeability is very rapid. There is a severe hazard of wind erosion.

About 40 acres of this soil is in San Juan County. The areas are not cultivated but are used for pasture or browse, or they remain idle. The vegetation is Oregon-grape, salal, ocean-spray, and native grasses that tolerate salt. A cover of plants should be kept on this soil at all times to help protect it from wind erosion.

CAPABILITY UNIT VIIe-1

This capability unit consists of well-drained, stony soils and associated outcropping bedrock in uplands. The soils are rolling to very steep. Surface runoff ranges from rapid to very rapid, and there is a severe hazard of water erosion if the soils are not protected by a cover of plants. The depth of the soils over bedrock is extremely variable. The moisture-supplying capacity ranges from very low, in the areas of Rock land, to moderate, in the areas of Roche soil. The soils in this capability unit are:

Pickett-Rock outcrop complex, 30 to 70 percent slopes.
Roche-Rock outcrop complex, 30 to 70 percent slopes.
Rock land, rolling.
Rock land, steep.

The soils of this capability unit are better suited to the production of timber and to wildlife or recreation than to other uses. Most of the soils are in Moran State Park and are used for recreation and wildlife. Other areas are on Mount Pickett, Turtleback Range, Blakely Peak, Mount Dallas, Lopez Hill, and in other rocky, steep areas.

These soils are moderately productive of Douglas-fir. Red alder and willow are common on the imperfectly drained areas that are included in the unit. The included areas of very poorly drained bogs are suitable as wildlife habitats.

A protective cover of plants to control erosion is advisable on these soils at all times.

CAPABILITY UNIT VIIIw-1

This capability unit consists of miscellaneous land types and organic soils that are very poorly drained and marshy and are not suitable for trees, pasture, or tilled crops. The soils and land types in this capability unit are:

Orcas peat.
Tidal marsh.

CAPABILITY UNIT VIIIs-1

This capability unit consists of miscellaneous land types that are not suitable for trees, pasture, or tilled crops. The soils and land types in this capability unit are:

Active dune land.
Coastal beaches.

Active dune land occurs in association with the San Juan soils and with areas of Coastal beaches. The dunes range from a few inches to 5 feet or more in height. The areas where dunes have formed are exposed to wind, which causes the sands to shift.

Maintaining a permanent cover helps to prevent the dunes from shifting and protects the adjacent areas. Grasses and legumes suitable for growing on sand are creeping red fescue, chewings fescue, sheep fescue, subterranean clover, and flat pea. Scotch-broom has been used in some places to stabilize the dunes. The areas. can be grazed lightly after cover is established. However, precautions should be taken against exposing the soil, or blowout areas may begin to develop.

Estimated yields

Table 2 gives estimated average acre yields of the principal crops grown on the soils of San Juan County. The estimates are based on observations made during field trials and during the progress of the soil survey. They also take into account estimates given by farmers, soil conservationists, and the county agent.

The figures shown in columns A represent yields to be expected under common management. Common management consists of using only limited amounts of manure, applying little or no commercial fertilizer, and of failing to drain areas adequately where drainage is needed. Under common management crops are generally not rotated, because many of the soils are pastured or are used to grow hay.

The figures shown in columns B represent yields to be expected under improved management. Under improved management the soils are adequately drained and a nitrogen fertilizer and phosphate are added when pastures are established. For all crops, a complete fertilizer is used in

TABLE 2.—*Estimated average acre yields of the principal crops and estimated suitability for pasture*

[Dashes indicate crop is not commonly grown or soil is not suited to the crop]

Soils	Peas (green)		Oat hay		Barley hay		Wheat hay		Alfalfa and orchard-grass hay		Orchard-grass, alta fescue, and clover hay		Straw-berries		Suitability for pasture
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	
Active dune land	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Alderwood gravelly loam, 3 to 8 percent slopes.	-----	-----	0.5	1.3	0.8	1.9	0.8	2.1	1.0	2.5	1.0	2.5	-----	-----	Good.
Alderwood gravelly loam, 15 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Alderwood gravelly sandy loam, 3 to 8 percent slopes.	-----	-----	.4	1.2	.5	1.4	.5	1.5	1.0	2.0	1.0	2.5	0.8	4.0	Good.
Alderwood gravelly sandy loam, 8 to 15 percent slopes.	-----	-----	.3	1.0	.4	1.2	.4	1.4	.8	1.7	.8	1.9	-----	-----	Fair.
Alderwood gravelly sandy loam, 15 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Alderwood stony loam, 3 to 8 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.8	2.0	-----	-----	Fair.
Alderwood stony loam, 8 to 15 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.7	1.7	-----	-----	Fair.
Alderwood stony loam, 15 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Bellingham silt loam	1.0	2.1	1.0	1.6	1.2	2.1	.9	2.3	-----	-----	1.5	3.7	-----	-----	Excellent.
Bellingham clay loam	1.0	2.0	1.0	1.5	1.2	2.0	.9	2.3	-----	-----	1.5	3.5	-----	-----	Excellent.
Bow gravelly silt loam, 0 to 3 percent slopes.	-----	-----	.5	1.4	.6	2.0	-----	-----	1.5	2.4	1.4	2.9	-----	-----	Good.
Bow gravelly silt loam, 3 to 8 percent slopes.	.4	.9	.4	1.3	.7	1.7	-----	-----	1.4	2.3	1.4	2.8	-----	-----	Good.
Bow gravelly silt loam, 8 to 30 percent slopes.	-----	-----	.3	.9	.5	1.3	-----	-----	1.0	1.8	1.2	2.2	-----	-----	Fair.
Bow silt loam, 0 to 3 percent slopes	-----	-----	.5	1.3	.7	1.8	-----	-----	-----	-----	1.5	3.0	-----	-----	Good.
Bow silt loam, 3 to 8 percent slopes	.5	1.0	.5	1.5	.8	2.0	-----	-----	1.5	2.5	1.5	3.0	-----	-----	Excellent.
Bow stony silt loam, 3 to 8 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	2.3	-----	-----	Fair.
Coastal beaches	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coveland silt loam, 0 to 3 percent slopes.	1.0	1.6	.7	1.5	1.0	2.0	1.5	3.0	1.5	2.5	1.5	3.0	.8	7.0	Excellent.
Coveland silt loam, 3 to 8 percent slopes.	1.0	1.4	.6	1.4	.9	1.9	1.4	2.9	1.4	2.4	1.4	2.9	.8	7.0	Excellent.
Coveland gravelly silt loam, 0 to 3 percent slopes.	1.0	1.5	.5	1.4	.8	1.8	1.3	2.8	1.4	2.3	1.4	2.8	.8	7.0	Excellent.
Coveland gravelly silt loam, 3 to 8 percent slopes.	.8	1.2	.4	1.3	.7	1.7	1.0	2.7	1.4	2.2	1.4	2.7	.8	6.0	Good.
Coveland stony silt loam, 0 to 15 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	1.8	-----	-----	Fair.
Everett gravelly sandy loam, 3 to 8 percent slopes.	-----	-----	.4	.9	.6	1.2	-----	-----	1.0	5.5	.8	2.0	.8	7.0	Fair.

TABLE 2.—*Estimated average acre yields of the principal crops and estimated suitability for pasture*—Continued

Soils	Peas (green)		Oat hay		Barley hay		Wheat hay		Alfalfa and orchard-grass hay		Orchard-grass, alta fescue, and clover hay		Straw-berries		Suitability for pasture
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	
Everett gravelly sandy loam, 8 to 30 percent slopes.	-----	-----	0.3	0.7	0.4	0.9	-----	-----	0.8	4.1	0.6	1.5	-----	-----	Fair.
Everett stony sandy loam, 8 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Hovde loam	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Indianola sandy loam, 0 to 15 percent slopes.	-----	-----	.3	.7	.4	.9	-----	-----	.8	4.1	.6	1.5	-----	-----	Fair.
Indianola-Roche complex, 0 to 8 percent slopes.	-----	-----	.4	1.0	.6	1.2	-----	-----	-----	-----	.4	2.3	.8	7.0	Good.
Indianola-Roche complex, 8 to 30 percent slopes.	-----	-----	.3	.8	.5	.9	-----	-----	-----	-----	.3	1.7	-----	-----	Fair.
Neptune gravelly sandy loam	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Fair.
Norma loam	-----	-----	.4	1.0	.6	1.2	-----	-----	-----	-----	.4	2.3	-----	-----	Good.
Norma loam, moderately deep	-----	-----	.4	1.0	.6	1.2	-----	-----	-----	-----	.4	2.3	-----	-----	Good.
Orcas peat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Pickett-Rock outcrop complex, 0 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Pickett-Rock outcrop complex, 30 to 70 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	
Roche gravelly loam, 3 to 8 percent slopes.	-----	-----	.5	1.3	.8	1.9	.8	2.1	1.0	2.5	1.0	2.5	-----	-----	Good.
Roche gravelly loam, 0 to 3 percent slopes.	-----	-----	.5	1.3	.8	1.9	.8	2.1	1.0	2.5	1.0	2.5	-----	-----	Good.
Roche gravelly loam, 8 to 15 percent slopes.	-----	-----	.4	1.2	.7	1.8	.7	2.0	.9	2.3	.9	2.3	-----	-----	Good.
Roche gravelly loam, 15 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Roche loam, 0 to 3 percent slopes	-----	-----	.6	1.5	.8	2.1	.8	2.3	1.0	2.5	1.2	2.8	-----	-----	Excellent.
Roche loam, 3 to 8 percent slopes	-----	-----	.6	1.5	.8	2.1	.8	2.3	1.0	2.5	1.2	2.8	-----	-----	Excellent.
Roche loam, 8 to 15 percent slopes	-----	-----	.5	1.4	.8	2.0	.8	2.1	1.0	2.5	1.0	2.5	-----	-----	Good.
Roche stony loam, 3 to 8 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.8	2.0	-----	-----	Fair.
Roche stony loam, 8 to 15 percent Slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.7	1.7	-----	-----	Fair.
Roche stony loam, 15 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Roche gravelly sandy loam, 3 to 8 percent slopes.	-----	-----	.4	1.2	.5	1.4	.5	1.5	1.0	2.0	1.0	2.5	-----	-----	Good.
Roche stony sandy loam, 8 to 15 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.5	1.3	-----	-----	Fair.
Roche-Rock outcrop complex, 8 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Roche-Rock outcrop complex, 30 to 70 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Rock land, rolling	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	
Rock land, steep	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	
San Juan gravelly sandy loam, 0 to 8 percent slopes.	-----	-----	.3	.7	.5	2.2	.7	1.0	1.4	1.7	.4	1.5	-----	-----	Poor.
San Juan gravelly sandy loam, 8 to 30 percent slopes.	-----	-----	.25	.6	.5	1.2	.7	1.0	1.4	1.7	.4	1.5	-----	-----	Poor.
San Juan stony sandy loam, 3 to 15 percent slopes.	-----	-----	.3	.7	.5	1.2	.7	1.0	1.4	1.7	.4	1.5	-----	-----	Poor.
San Juan stony sandy loam, 15 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes.	-----	-----	.5	1.3	.5	1.5	.5	1.8	1.0	1.2	1.0	2.5	-----	-----	Good.
San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes.	-----	-----	.4	1.0	.4	1.3	.4	1.5	.8	1.8	.8	2.2	-----	-----	Good.
San Juan loam, moderately deep, 0 to 15 percent slopes.	-----	-----	.6	1.5	.8	2.1	.8	2.2	1.0	2.3	1.2	2.7	-----	-----	Excellent.
San Juan stony loam, moderately deep, 8 to 30 percent slopes.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Semiahmoo muck	-----	-----	.5	1.8	.5	1.8	-----	-----	-----	-----	.5	3.5	-----	-----	Excellent.
Semiahmoo muck, shallow	-----	-----	.5	1.8	.5	1.8	-----	-----	-----	-----	.5	3.5	-----	-----	Excellent.
Tanwax peat, alkaline variant	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.5	3.5	-----	-----	Excellent.
Tidal marsh	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.

accordance with the needs indicated by soil tests and large amounts of manure are added. Also, supplemental irrigation is used where necessary, crops are rotated, and the residue from crops is turned under.

Uses of Soils for Woodland [4]

The soil affects the growth of trees and their response to management. Differences in growth are fairly easy to recognize and can be measured.

Site indexes and site classes

Like other plants, trees grow more rapidly and produce more wood on some soils than on others. The capacity of a soil to produce wood products can be measured and described in units per acre, just as the productivity of wheatland can be described in bushels of wheat per acre. Wood products are measured in many different units, however, and it is, therefore, convenient to use site indexes to show the potential productivity of a soil. The site index is determined by measuring the total height, attained at 100 years of age, of representative trees of the dominant species.

The following gives the site indexes for Douglas-fir growing on important soil types in San Juan County. Site indexes have not been indicated for other soil types in the county because the soils are not suited to Douglas-fir, are not used for trees, or are under a cover of grass.

Soil type:	*Site index rating*
Alderwood gravelly loam	111
Alderwood gravelly sandy loam	[1] 114
Alderwood stony loam	120
Bow silt loam	114
Bow gravelly silt loam	112
Bow stony silt loam	[1] 100
Everett gravelly sandy loam	117
Everett stony sandy loam	[1] 112
Indianola sandy loam	140
Indianola-Roche complex	119
Norma loam	135
Norma loam, moderately deep	106
Pickett-Rock outcrop complex	[1] 140
Roche loam	93
Roche gravelly loam	111
Roche stony loam	100
Roche gravelly sandy loam	114
Roche stony sandy loam	79

[1] Site index estimated on the basis of data obtained in sampling similar and associated soils.

Site classes of soils are also a convenient relative measure of the wood-producing ability. Under this system the highest producing soil is designated as in site class 1, and the lowest, in site class 5. Soils in classes 2, 3, and 4 are progressively lower in wood-producing ability than the soils in class 1, but higher than the soils in class 5. The grouping of soils into site classes is based on the average total height of the dominant and codominant trees at the age of 100 years. The trees at that age are the largest trees in the stand. Their crowns form the general level of the forest canopy and, in places, extend above it.

The relationship between the site classes and site indexes is as follows: Site class 1 equals a site index of 190 to 210; site class 2, a site index of 160 to 180; site class 3, a site index of 130 to 150; site class 4, a site index of 100 to 120; and site class 5, a site index of 70 to 90. A more extensive table and discussion are given in USDA Technical Bulletin No. 201 (*4*).

[4] Clyde E. Deardorff, soil scientist, SCS, William J. Lloyd, forest specialist, SCS, and Orlo W. Krauter, woodland conservationist, Western States, assisted with this section.

Table 3 shows the site classes of several important soil series in San Juan County. The series are grouped according to their topographic position and parent material. The site classes refer mainly to the productivity of the soils for Douglas-fir. They were determined by using procedures described in USDA Technical Bulletin No. 201 (*4*).

Table 3.—*Douglas-fir site classes of major soil series according to topographic position*

Topographic position, parent material, and series	Site class	Predominant forest trees
Soils on uplands not affected by glaciation:		
Pickett	3	Douglas-fir; hemlock.
Soils on uplands formed from—		
Glacial till; substratum cemented or compact:		
Alderwood	4	Douglas-fir.
Bow	4	Douglas-fir.
Roche	4 and 5	Douglas-fir.
Glacial outwash or drift:		
Everett	4	Douglas-fir.
Indianola	3 and 4	Douglas-fir.
Soils in depressions in upland terraces:		
Bellingham	([1])	Red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar.
Norma	([2])	Red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar.

[1] No site class given, because these soils are not well suited to Douglas-fir.
[2] No site class given, because these soils are poorly suited to Douglas-fir.

Management of the woodlands is closely related to the productivity of the soils. For example, if an owner has a large acreage of soils that are not fully stocked with desirable trees, or if the areas are in need of planting, he should first plant seedlings on the soils that have the highest potential productivity and plant trees on those of lower productivity last. Some owners are interested in pruning to improve the quality of the trees so that they can be used for clear lumber or for veneer logs. Trees on the better soils should be pruned first because early financial gains from pruning depend upon the rapid growth of the trees (*10*). It does not pay to prune trees on soils of site class 5; many owners consider pruning trees on soils of site class 4 to be a debatable practice.

Woodland suitability groups

In addition to influencing productivity, the soil influences woodland management in other ways. A discussion of management of woodlands, described by groups of related soils, follows. Not all of the soils in the county have been placed in a woodland suitability group because some are not used for trees or are under a cover of grass.

WOODLAND GROUP 1

Soils in this group belong to the Pickett series. They are in uplands and have not been affected or have been but little affected by glaciation. These soils are the most productive for forest use of all of the soils in San Juan County. In addition, they are stable under use and are not difficult to manage.

When the stands of Douglas-fir and hemlock are logged, there is a tendency for less desirable species to come in. The soils can be managed intensively, and there is serious loss of production if inferior species claim the areas.

When the trees are mature, the stands on these soils should be clear cut in blocks less than 40 acres in size. In this way trees are left to supply seed for the blocks nearby. If there is evidence that brush will encroach, some planting should follow soon after the trees have been logged. Spraying or slashing may be necessary during the first 5 to 10 years after the areas have been restocked. This will release the Douglas-fir seedlings from overtopping brush and trees.

WOODLAND GROUP 2

Soils in this group belong to the Alderwood, Bow, and Roche series. They are in uplands and have formed from glacial till. The soils have a compact or cemented substratum.

These soils are fairly well suited to Douglas-fir, but hardwoods have established themselves in many areas. Red alder grows in most of the areas where surface drainage is slow.

Where the underlying compact or cemented layer is at a moderate depth in these soils, windthrow is a hazard. When harvested, the trees should be clear cut in blocks containing at least 2 acres. Seed trees left in blocks of an acre or more give protection from wind.

The roots of trees in this group are near the surface, and in some places they are exposed. Equipment used in logging may damage the roots of trees that are left to grow. As a result, rot-producing fungi can gain entry. Permanent access roads, made as straight as practical, should be built through the woodlands to minimize damage. Only light equipment or horses should be used for yarding logs toward main trails and roads. Logging needs to be curtailed during the wet season to minimize the damage to the soil structure and to encourage regeneration to Douglas-fir.

WOODLAND GROUP 3

Soils in this group belong to the Everett and Indianola series. They occur in uplands and have formed in glacial outwash or drift. The soils are somewhat excessively drained and are stable under use.

Forests on these soils consist mainly of Douglas-fir, but lodgepole pine is a component of the stand. In places there are pure stands of lodgepole pine. The lower lying areas are ideally suited to the production of Christmas trees because Douglas-fir restocks readily on cutover areas and competing hardwoods are not a problem.

Trees on these soils have a deep, well-anchored root system. Because the roots are deep, heavy equipment does not damage them and can be used in the forest the year round. Trafficability is good, even in winter.

WOODLAND GROUP 4

Soils in this group belong to the Bellingham and Norma series. They are poorly drained and are in depressions on upland terraces.

The forests on these soils consist mainly of hardwoods and redcedars. In a few places there are stands of

TABLE 4.—*Yield and stand data, per acre, for well-stocked, unmanaged natural stands of Douglas-fir when growing on stated site classes* [1]

[No site class 1 in this county]

Age of stand	Stand volume: Trees 7 to 12 inches diameter	Stand volume: Trees 12 inches and larger	Periodic annual growth [2]	Average diameter of trees	Number of trees
Years	*Cords*	*Board-feet* [3]	*Board-feet* [3]	*Inches*	
SITE CLASS 2					
20			260	4.5	880
30	28.2	2,600	930	7.0	555
40	35.1	11,900	1,540	9.4	385
50	26.9	27,400	1,550	11.8	290
60	16.0	42,800	1,440	14.0	228
70	9.3	57,200	1,280	16.0	186
80	5.5	70,000	1,105	17.9	159
90	3.4	81,000		19.6	138
SITE CLASS 3					
20	1.7		30	3.4	1,460
30	20.6	300	420	5.5	865
40	35.2	4,500	790	7.4	585
50	38.3	12,400	1,140	9.3	430
60	31.7	23,800	1,140	11.1	337
70	22.7	35,200	1,050	12.8	274
80	15.6	45,700	930	14.3	232
90	10.7	55,000		15.6	205
SITE CLASS 4					
20				2.2	3,069
30	7.0			3.9	1,472
40	22.1	200	310	5.5	927
50	32.5	3,300	480	7.0	659
60	36.3	8,100	590	8.5	500
70	34.3	14,000	610	9.8	405
80	29.8	20,100	590	10.9	345
90	24.4	26,000		11.9	304
SITE CLASS 5					
20				1.3	6,920
30				2.6	2,700
40	4.2			3.8	1,530
50	14.0	30	107	4.9	1,050
60	22.5	1,110	130	6.0	780
70	27.9	2,400	200	7.0	625
80	30.3	4,400	250	7.9	525
90	30.0	6,900		8.7	451

[1] According to USDA Tech. Bul. No. 201 (*4*).
[2] Average growth each year in the decade, beginning at age shown opposite in column on extreme left.
[3] According to Scribner rule.

Douglas-fir. The predominant trees are red alder, Oregon maple, willow, hemlock, lodgepole pine, spruce, white fir, and redcedar. Willow is the main species on areas where the soil is fine textured. Alder and maple predominate on the soils of coarser texture that have less standing water. Drainage is the main problem in management. The removal of standing water greatly increases the growth of the trees.

Any kind of partial cutting is difficult on these soils because the trees have a shallow root system. In many places the trees are growing on top of old stumps or on hummocks or mounds.

Areas of these soils revert to brush very easily after logging has taken place. The ground vegetation is dense under the hardwood trees and consists of elderberry, spirea, swordfern, salmonberry, vine maple, and trailing blackberry. These species completely occupy the areas when the overhead canopy has been cut. They effectively prevent the restocking of desirable trees. When the trees of these soils are harvested, the areas should be clear cut. Competing vegetation needs to be removed and the mineral soil exposed to assure reseeding of desirable trees.

Estimated yields of Douglas-fir

The average yields per acre that can be expected from well-stocked stands of Douglas-fir growing on various sites are shown in table 4. The information was taken from USDA Technical Bulletin No. 201 (*4*).

Engineering Properties of Soils [5]

This soil survey report contains information that can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make more accurate estimates of runoff and erosion for use in designing drainage structures and other structures for water and soil conservation, such as reservoirs for water, bridges, culverts, spillways, and diversions.
3. Obtain information of value when preparing proposals for irrigation systems. This information would include the estimated water-holding capacity of the soils and the permeability of the underlying strata.
4. Locate sand, gravel, and other material suitable for use in construction, such as masonry or quarry rock.

[5] ROY E. TUTTLE, civil engineer, SCS, assisted in the preparation of this section.

TABLE 5.—*Engineering test data* [1] *for*

Soil name and location	Parent material	Depth	Horizon	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture
		Inches		*Lb. per cu. ft.*	*Percent*
Bow silt loam:					
SE¼SE¼ sec. 34, T. 34 N., R. 3 W. (Modal profile)	Glacial till	0–11	B_{2ir}	108	16
		16–32	B_{22}	104	20
		40–50	D	104	21
SE¼NE¼ sec. 34, T. 37 N., R. 2 W. (Modal profile)	Glacial till	0–9	B_{2ir}	103	19
		20–33	B_{2t}	113	15
		33–41	C(B_{31})	117	14
Roche loam:					
SE¼NE¼ sec. 32, T. 36 N., R. 3 W. (Modal profile)	Vashon glacial drift	0–9	B_{2ir}	106	16
		17–24	A_2B_2 or C_1	121	12
		34–48	C_2	125	10
NE¼SE¼ sec. 5, T. 35 N., R. 3. W. (Modal profile)	Vashon glacial drift	0–9	B_{21ir}	109	14
		21–35	C_1	123	10
		48–54	C_3	124	9

[1] Tests performed by the Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Mechanical analyses according to the American Association of State Highway Officials Designation: T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil-survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil-survey procedure,

5. Determine the suitability of the soil units for cross-country movement of heavy vehicles and construction equipment.
6. Develop estimates of problems in operation and maintenance as related to the soil mapping units used for proposed structures. Such structures would include townsites and sites for highways, county roads, logging roads, approaches to beaches and piers, small airplane landing strips, corrals for stock, and feedlots.
7. Supplement information obtained from other published maps and reports and aerial photographs, for the purpose of making soil maps and reports that can be readily used by engineers.

The mapping and descriptive reports are somewhat generalized, however, and should be used only in planning more detailed field surveys to determine the in-place condition of the soil at the site of the proposed engineering construction.

Some of the terms used by soil scientists may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, sand, aggregate, and granular—have special meanings in soil science. Most of these terms, as well as other special terms that are used in this section and in the rest of the soil survey report, are defined in the Glossary at the back of this report.

Soil test data and estimated physical properties

To be able to make the best use of the soil map and the soil survey report, the engineer should know the physical properties of the soil materials and the in-place condition of the soils. After testing the soil material and observing the behavior of the soils when used in engineering structures and foundations, the engineer can develop design recommendations for the soil units delineated on the soil map.

This section contains five tables. Table 5 gives test data for the soils of two extensive series in the county; table 6 gives a brief description of the soils, their estimated physical properties, and their estimated AASHO and Unified classifications; and table 7 gives estimates of the suitability of the soils for highway construction and for conservation engineering.

Tables 8 and 9, respectively, are provided for those not familiar with the soil properties considered in arriving at the AASHO and Unified classifications. In the second column of table 9, the symbols used in the Unified system are listed, and, in the last column, the equivalent symbols used in the AASHO classification.

To arrive at the test data given in table 6, and thus to help evaluate the soils for engineering purposes, soil samples from two of the most extensive soil series in San Juan County were tested according to standard procedures by the Bureau of Public Roads. The results of these tests and the classification of each sample according to both the AASHO and the Unified systems are given in table 5.

soil samples taken from four soil profiles

Mechanical analysis [2]: Percentage passing sieve—1-in.	¾-in.	⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Percentage smaller than [3]: 0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	Liquid limit	Plasticity index	Classification: AASHO	Unified [4]
------	100	98	96	91	76	60	57	42	23	15	26	5	A-4(5)	ML-CL.
------	-------	100	99	98	96	89	87	78	62	45	46	24	A-7-6(15)	CL.
98	98	98	98	98	97	91	87	74	56	43	45	23	A-7-6(14)	CL.
99	99	97	96	94	87	79	76	68	34	17	30	6	A-4(8)	ML-CL.
100	99	98	96	93	87	61	57	45	31	22	29	13	A-6(6)	CL.
100	99	97	95	93	86	60	53	41	29	19	24	9	A-4(5)	CL.
99	98	97	96	93	86	58	51	36	21	13	25	3	A-4(5)	ML.
------	100	99	98	96	90	58	49	39	22	13	18	3	A-4(5)	ML.
99	99	98	96	93	86	51	45	44	21	13	18	4	A-4(3)	ML-CL.
99	98	93	87	77	64	40	35	26	15	8	23	2	A-4(1)	SM.
99	99	97	95	92	86	49	40	23	14	8	15	1	A-4(3)	SM.
99	99	97	95	92	87	39	30	16	9	6	(5)	(5)	A-4(1)	SM.

the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming the textural classes of soils.

[3] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1 ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. AASHO Designation: M 145-49.

[4] Based on the Unified Soil Classification System, Tech. Memo. No. 3-357. v. 1, Waterways Expt. Sta., Corps of Engin., March 1953.

[5] Nonplastic.

TABLE 6.—*Brief description of the soils*

[Dashes indicate information does

Symbol on map	Soil name	Depth to seasonally high water table	Depth to bedrock	Brief description of site and soil
Ad	Active dune land.	------------------	More than 50 feet.	Fine and medium sands that contain little clay or silt; near beaches and shifted by winds that blow from a westerly direction.
AgB AgC AgD	Alderwood gravelly sandy loam, 3 to 8 percent slopes. Alderwood gravelly sandy loam, 8 to 15 percent slopes. Alderwood gravelly sandy loam, 15 to 30 percent slopes.	2 to 3 feet in local areas.	More than 10 feet.	Well-drained gravelly sandy loams formed in glacial till; has gravel and some stones throughout the profile; weakly to strongly cemented below a depth of 30 inches.
AmB AmD	Alderwood gravelly loam, 3 to 8 percent slopes. Alderwood gravelly loam, 15 to 30 percent slopes.	2 to 3 feet in local areas.	More than 10 feet.	Well-drained gravelly loams consisting of sandy and silty material over a cemented substratum, which in most places is at a depth of about 40 inches; depth to the substratum varies but becomes less as steepness of slope increases.
AsB AsC AsD	Alderwood stony loam, 3 to 8 percent slopes. Alderwood stony loam, 8 to 15 percent slopes. Alderwood stony loam, 15 to 30 percent slopes.	2 to 3 feet in local areas.	More than 10 feet.	Well-drained soils similar to the gravelly loams, except that they contain numerous stones that have a diameter greater than 10 inches.
Be	Bellingham silt loam.	2 feet-----------	Very deep------	A poorly drained soil formed in marine and glacial-lake sediments; the subsoil of very plastic silty clay loam causes permeability to be very slow; the soil has slopes of less than 3 percent.
Bc	Bellingham clay loam.	1 foot-----------	Very deep------	This soil is in basins at somewhat higher elevations than the positions occupied by Bellingham silt loam; the surface layer and subsoil are moderately fine textured.
BoA BoB	Bow silt loam, 0 to 3 percent slopes. Bow silt loam, 3 to 8 percent slopes.	1½ feet----------	Deep----------	Imperfectly drained soils of uplands formed in fine glacial till and glacial lake sediments; they have a substratum of silty clay at a depth of about 30 inches.
BgA BgB BgD	Bow gravelly silt loam, 0 to 3 percent slopes. Bow gravelly silt loam, 3 to 8 percent slopes. Bow gravelly silt loam, 8 to 30 percent slopes.	2½ feet----------	Deep----------	Gravelly silt loams that are in small areas----
BsB	Bow stony silt loam, 3 to 8 percent slopes.	3 feet-----------	10 to 15 feet----	A stony silt loam that has cobbles and stones on the surface and in the profile; the stones are as large as 12 inches in diameter.
Cb	Coastal beaches.	------------------	----------------	Variable beach sands, subject to wave action at high tide.
CsA CsB	Coveland silt loam, 0 to 3 percent slopes. Coveland silt loam, 3 to 8 percent slopes.	1½ feet----------	Deep---------- More than 20 feet.	Imperfectly drained soils formed in fine-textured glacial till; the soils are in slight depressions in uplands; a layer of tight clay at a depth of 18 to 20 inches restricts drainage.

See footnotes at end of table.

and their estimated physical properties

not apply or is not available]

Depth from surface	Classification			Percentage passing [1]			Permeability [2]	Available moisture capacity [3]	Reaction	Shrink-swell potential [4]
	USDA texture	Unified	AASHO	No. 4 sieve (5.0 mm.)	No. 10 sieve (2.0 mm.)	No. 200 sieve (0.8 mm.)				
Inches							*Inches per hour*	*Inches per foot of depth*	*pH*	
0–8	Sand	SP	A–3	98+	90–95	1–3	10. 0+	0. 90	6. 6–7. 3	Low.
8–36	Sand	SP	A–3	98+	90–95	2–3	10. 0+	. 90	6. 6–7. 3	Low.
36–60	Sand	SP	A–3	98+	90–95	2–3	10. 0+	. 90	6. 6–7. 3	Low.
0–20	Gravelly sandy loam	SM		65–70	55–60	15–20	5. 0–10. 0	1. 1	5. 6–6. 0	Low.
20–30	Gravelly sandy loam	SM	A–1	55–65	50–60	10–15	5. 0–10. 0	1. 0	6. 1–6. 5	Low.
30–50	Gravelly sandy loam	GM–SM	A–1, A–4	55–65	50–55	20–30	(5)		6. 6–7. 3	Low.
0–12	Gravelly loam	SM	A–1, A–2	65–70	50–60	15–20	0. 8–2. 5	1. 5	6. 1–6. 5	Low.
12–21	Gravelly sandy loam	SM	A–1	60–65	45–50	10–15	0. 8–2. 5	1. 2	5. 6–6. 0	Low.
21–42	Gravelly sand	SM	A–1	70–75	40–50	10–15	2. 5–5. 0	1. 3	6. 6–7. 3	Low.
42+	Gravelly sand	SC	A–2	75–80	60–70	25–30	(5)		6. 6–7. 3	Low.
0–12	Sandy loam	SM	A–2, A–1	50–55	35–45	15–20	0. 8–2. 5	1. 2	6. 1–6. 5	Low.
12–24	Stony sandy loam	SM–GM	A–2, A–1	40–45	30–35	10–15	0. 8–2. 5	1. 1	6. 6–7. 3	Low.
24–45	Stony sandy loam	SM–GM	A–2, A–1	35–40	35–40	15–25	(5)		6. 6–7. 3	Low.
0–8	Silt loam	OL	A–5, A–7	100	97–99	75–90	0. 20–0. 80	2. 3	6. 1–6. 5	High.
8–25	Silty clay loam	OL–CH	A–7	100	97–99	55–60	0. 05–0. 20	2. 3	6. 1–6. 5	High.
25–37	Silty clay loam	OH–CH	A–7	100	98–100	80–85	(5)	2. 3	6. 1–6. 5	High.
37–51	Silty clay	CH–CL	A–6	100	100	97–99	(5)	1. 8	7. 4–8. 4	Moderate to high.
0–10	Clay loam	OH	A–6, A–7	100	90–95	75–90	0. 05–0. 20	2. 2	6. 1–6. 5	High.
10–25	Clay loam	CH	A–7	95–100	90–95	70–90	0. 05–0. 20	2. 3	6. 1–6. 5	High.
25–50	Clay loam	CL	A–6, A–7	95–100	85–90	55–80	0. 05–0. 20	2. 3	6. 1–6. 5	High.
50–60	Silty clay loam	CL	A–6	100	95–100	60–80	(5)	1. 9	7. 4–8. 4	Moderate.
0–12	Silt loam	ML–CL	A–4	95–100	90–95	60–80	0. 80–2. 50	2. 2	6. 1–7. 3	Moderate.
12–33	Silty clay loam	CL	A–6, A–7	95–100	90–100	60–90	0. 05–0. 20	2. 3	6. 1–6. 5	Moderate to high.
33–50	Silty clay	CL	A–7, A–6	95–100	90–100	60–90	(5)	2. 3	6. 6–7. 8	Moderate to high.
0–16	Gravelly silt loam	SM–ML	A–4	75–85	70–80	40–60	0. 80–2. 5	1. 6	6. 1–7. 3	Low to moderate.
16–32	Silty clay loam	CL	A–6	90–100	80–90	60–75	0. 05–0. 20	2. 3	6. 1–6. 5	Moderate.
32–60	Silty clay	CH	A–6, A–7	95–100	90–100	60–90	(5)	2. 2	6. 6–7. 8	Moderate to high.
0–10	Stony silt loam	ML	A–4	60–70	55–65	40–50	0. 80–2. 50	1. 6	6. 1–7. 3	Low to moderate.
10–30	Stony silt loam	CL	A–6	80–90	70–80	50–65	0. 20–0. 8	1. 5	6. 1–7. 3	Moderate.
30–50	Silty clay	CH	A–6, A–7	95–100	90–100	66–90	(5)	2. 2	6. 6–7. 8	Moderate to high.
0–9	Silt loam	OL	A–5	95–100	75–85	65–70	0. 80–2. 5	2. 3	5. 6–6. 0	Low to moderate.
9–18	Fine sandy loam to sandy clay loam.	SM–SC	A–1	95–100	60–70	45–50	0. 20–0. 80	2. 2	6. 1–6. 5	Low to moderate.
18–32	Clay	CL	A–6, A–7	95–100	80–85	60–70	(5)	2. 3	6. 1–6. 5	High.
32–48	Clay	CL	A–6, A–7	95–100	90–95	80–90	(5)	2. 3	6. 6–7. 3	High.

TABLE 6.—*Brief description of the soils*

Symbol on map	Soil name	Depth to seasonally high water table	Depth to bedrock	Brief description of site and soil
CoA CoB	Coveland gravelly silt loam, 0 to 3 percent slopes. Coveland gravelly silt loam, 3 to 8 percent slopes.	2 feet	Deep More than 20 feet.	Imperfectly drained soils that have gravel on the surface and throughout the profile; depth to the claypan is 16 to 20 inches, but the depth varies with the steepness of slope.
CtC	Coveland stony silt loam, 0 to 15 percent slopes.		In most places more than 15 feet; in 10 percent of the acreage, it is at a depth of 30 to 40 inches.	This stony soil contains cobbles and stones as large as 15 inches in diameter; depth of the profile and the texture vary greatly with differences in the steepness of slope.
EgB EgD	Everett gravelly sandy loam, 3 to 8 percent slopes. Everett gravelly sandy loam, 8 to 30 percent slopes.		Very deep	Somewhat excessively drained soils formed in sandy morainic material.
EsD	Everett stony sandy loam, 8 to 30 percent slopes.		Very deep	This soil has stones on the surface and throughout the profile; the stones are generally between 10 and 24 inches in diameter, but some are larger.
Ho	Hovde loam.	0 to 1 foot	Very deep	A poorly drained organic loam over sand; this soil occurs in basins immediately behind areas of Coastal beaches; it is on Shaw, Decatur, and Stuart Islands; the surface layer overlies bluish-gray sand; it is salty in places.
InC	Indianola sandy loam, 0 to 15 percent slopes.		Very deep	A somewhat excessively drained sandy loam that overlies sand; in most places the slope is between 3 and 8 percent; the soil is somewhat like the Everett soils, except that it contains little gravel.
IrB IrD	Indianola-Roche complex, 0 to 8 percent slopes. Indianola-Roche complex, 8 to 30 percent slopes.	3 feet for a short time only.	Very deep	This complex consists of somewhat excessively drained Indianola soils and moderately well drained Roche soils formed in glacial till; the Indianola soil is like the Indianola sandy loam just described; the substratum of the Roche soil is sandy clay loam and is at a depth of about 50 inches.
Ng	Neptune gravelly sandy loam.	Depth to water table generally controlled by height of the tide.	Deep	This soil is adjacent to beaches and consists mainly of beach sand and seashells; its slope is mainly less than 3 percent.
No	Norma loam, moderately deep.	½ foot	More than 15 feet.	This poorly drained soil formed in sandy glacial drift, mainly in basins in the uplands; the profile has sandy strata that overlie a layer of very plastic clay loam, which is at a depth of 20 to 36 inches; the slope is less than 3 percent.
Nm	Norma loam.	2 feet	More than 15 feet.	This soil is deeper over clay loam than Norma loam, moderately deep; the substratum is slowly permeable; it is at a depth between 40 to 60 inches.

See footnotes at end of table.

and their estimated physical properties—Continued

Depth from surface	Classification: USDA texture	Classification: Unified	Classification: AASHO	Percentage passing [1]: No. 4 sieve (5.0 mm.)	Percentage passing [1]: No. 10 sieve (2.0 mm.)	Percentage passing [1]: No. 200 sieve (0.8 mm.)	Permeability [2]	Available moisture capacity [3]	Reaction	Shrink-swell potential [4]
Inches							*Inches per hour*	*Inches per foot of depth*	*pH*	
0–11	Gravelly silt loam	SM	A–4	60–75	55–60	45–50	0. 80–2. 5	1. 8	5. 6–6. 0	Low to moderate.
11–20	Gravelly sandy loam	SM–SC	A–2, A–4	70–80	65–70	30–40	0. 20–0. 80	1. 9	6. 1–6. 5	Moderate.
20–45	Silty clay loam	CH	A–7	80–90	85–90	70–80	(5)	2. 2	6. 1–7. 3	High.
0–8	Stony silt loam	SM–ML	A–4	50–60	45–55	35–45	0. 80–2. 50	1. 6	5. 6–6. 0	Low to moderate.
8–25	Sandy loam to sandy clay loam.	SM–SC	A–4	75–85	70–80	30–40	0. 20–0. 80	1. 1	6. 1–6. 5	Moderate.
25–45	Silty clay loam	CH	A–7	75–85	60–75	55–65	(5)	2. 1	6. 1–7. 3	High.
0–7	Gravelly sandy loam	SM	A–1, A–2	60–70	45–50	20–30	5. 0–10. 0	1. 0	5. 6–6. 0	Low.
7–24	Gravelly fine sandy loam.	SM–GM	A–2, A–1	50–60	35–45	15–20	5. 0–10. 0	1. 0	5. 6–6. 0	Low.
24+	Very gravelly coarse sand.	SM–GM	A–1	45–55	25–35	10–15	10. 0+	. 8	5. 6–6. 0	Low.
0–10	Stony sandy loam	GM	A–1	45–50	35–50	15–25	5. 0–10. 0	. 90	5. 6–6. 0	Low.
10–25	Stony sandy loam	SM	A–1	40–50	20–30	10–15	5. 0–10. 0	. 90	5. 6–6. 0	Low.
25–48	Very gravelly coarse sand.	GM–SM	A–1	35–50	15–35	5–10	10. 0+	. 70	5. 6–6. 0	Low.
0–14	Loam	OL	A–3	90–95	75–90	20–25	0. 80–2. 5	. 90	----------	Moderate.
14+	Sand	SP–SM	A–2, A–3	95–100	80–90	5–15	10. 0+	. 80	----------	Low.
0–15	Sandy loam	SM	A–2	90–95	80–90	25–35	5. 0–10. 0	1. 20	6. 1–7. 3	Low.
15–24	Loamy sand	SM	A–1, A–2	90–95	75–80	20–30	4. 0–10. 0	1. 20	6. 6–7. 3	Low.
24–54	Fine sand	SP or SM	A–1, A–2	90–95	60–65	10–15	10. 0+	1. 00	6. 6–7. 3	Low.
0–10	Sandy loam	SM	A–2	90–95	80–90	25–35	2. 5–5. 0	1. 20	5. 6–6. 0	Low.
10–25	Fine sandy loam	SM	A–1, A–2	90–95	75–80	20–30	2. 5–10. 0	1. 20	6. 6–7. 3	Low.
25–50	Loamy fine sand	SP or SM	A–1, A–2	90–95	60–65	10–15	10. 0+	1. 00	6. 6–7. 3	Low.
50–62	Sandy clay loam	SC	A–4	95–100	75–80	35–45	0. 8–2. 5	1. 80	6. 6–7. 3	Low to moderate.
0–5	Gravelly sandy loam	SM	A–1	85–90	45–60	10–20	5. 0–10. 0	. 90	7. 4–7. 8	Low.
5–17	Gravelly coarse sand	SW–SP	A–1	70–85	35–50	5–10	10. 0	. 90	7. 4–7. 8	Low.
17+	Gravelly sand	SW–SP	A–1	65–80	25–40	5–10	10. 0+	. 80	7. 4–8. 5	Low.
0–11	Loam	ML–CL	A–4, A–6	95–100	75–85	25–40	0. 80–2. 5	1. 90	5. 6–6. 5	Moderate.
11–25	Sandy loam to fine sand.	SM	A–2	90–95	50–69	20–25	0. 80–2. 50	. 90	6. 6–7. 3	Low.
25–45	Clay loam	CH	A–7	98–100	90–95	60–80	0. 05–0. 20	2. 3	6. 6–7. 8	High.
0–11	Loam	ML–CL	A–4, A–6	95–100	75–85	25–40	0. 80–2. 50	1. 90	5. 6–6. 5	Moderate.
11–40	Sandy loam to fine sand.	SM	A–2	65–75	45–60	10–20	0. 80–2. 50	. 90	6. 6–7. 3	Low.
40–60	Clay loam	SM–SC	A–2, A–4	85–95	80–95	50–75	0. 05–0. 20	. 90	7. 4–8. 5	High.

TABLE 6.—*Brief description of the soils*

Symbol on map	Soil name	Depth to seasonally high water table	Depth to bedrock	Brief description of site and soil
Op	Orcas peat.	0 to 1 foot	Deep	This very poorly drained soil formed from sphagnum moss; the moss decomposes slowly; living moss is growing on the surface; areas of this soil are in basins that have flat bottoms and do not have outlets where water can drain out.
PrD PrE	Pickett-Rock outcrop complex, 0 to 30 percent slopes. Pickett-Rock outcrop complex, 30 to 70 percent slopes.		More than 24 inches.	This complex is in the uplands; the Pickett soil is well drained; between 20 and 40 percent of it consists of gravel and stones; the underlying material is graywacke or arkose sandstone; depth of the soil material over bedrock is more variable on the steeper slopes.
RoA RoB RoC	Roche loam, 0 to 3 percent slopes. Roche loam, 3 to 8 percent slopes. Roche loam, 8 to 15 percent slopes.	½ foot to 1½ feet	More than 10 feet.	These soils are similar to the Alderwood soils, except that they do not have cemented material in the profile; these soils are more variable than other soils in the county.
RgA RgB RgC RgD	Roche gravelly loam, 0 to 3 percent slopes. Roche gravelly loam, 3 to 8 percent slopes. Roche gravelly loam, 8 to 15 percent slopes. Roche gravelly loam, 15 to 30 percent slopes.	1½ feet	More than 10 feet.	In these soils from 15 to 35 percent of the surface layer and 40 to 50 percent of the subsoil consist of gravel; drainage is slow through the profile; the substratum consists of very slowly permeable glacial till and is at a greater depth than that in the Roche loams; the soil contains no cemented material.
RsB RsC RsD	Roche stony loam, 3 to 8 percent slopes. Roche stony loam, 8 to 15 percent slopes. Roche stony loam, 15 to 30 percent slopes.	1½ feet	More than 10 feet.	Stony and gravelly, slow-draining loams; stones occupy 15 to 35 or 40 percent, by volume, of the surface layer.
RhB	Roche gravelly sandy loam, 3 to 8 percent slopes.		More than 10 feet.	This soil is moderately well drained and contains gravel.
RtC	Roche stony sandy loam, 8 to 15 percent slopes.		More than 10 feet.	This soil is moderately well drained; gravel and stones occupy 15 to 50 percent of the profile; depth to the substratum is variable on the stronger slopes.
RxD RxE	Roche-Rock outcrop complex, 8 to 30 percent slopes. Roche-Rock outcrop complex, 30 to 70 percent slopes.		2 to 5 feet	Rock outcrop occupies 15 to 50 percent of the acreage in these complexes.
Ry Rz	Rock land, rolling. Rock land, steep.			Between 50 and 90 percent of the acreage of these mapping units consists of rock outcrops; the rocks are sandstone, argillite, and basalt, and the soils between areas of rock outcrop are those of the Pickett and Roche series; the slopes are generally between 0 and 30 percent, but in places they are as steep as 70 percent.

See footnotes at end of table.

and their estimated physical properties—Continued

Depth from surface	Classification			Percentage passing [1]			Permeability [2]	Available moisture capacity [3]	Reaction	Shrink-swell potential [4]
	USDA texture	Unified	AASHO	No. 4 sieve (5.0 mm.)	No. 10 sieve (2.0 mm.)	No. 200 sieve (0.8 mm.)				
Inches							*Inches per hour*	*Inches per foot of depth*	*pH*	
0–6	Peat	Pt					0. 80–2. 50	4. 50	(6)	Very high.
6–84	Peat	Pt					0. 80–2. 5	3. 00	(6)	
0–13	Stony silt loam	ML–CL	A–4, A–6	60–70	40–45	20–35	0. 80–2. 50	1. 40	6. 1–6. 5	Low to moderate.
13–30	Stony silt loam	ML–CL	A–4, A–6	60–70	50–60	45–50	0. 80–2. 50	1. 80	6. 1–6. 5	Low to moderate.
30–40	Sandy loam	SC	A–2	55–65	35–50	25–30	0. 80–2. 50	1. 40	6. 1–6. 5	Low.
0–9	Loam	ML	A–4	95–100	75–95	40–60	0. 20–0. 80	1. 9	6. 1–6. 5	Low to moderate.
9–17	Gravelly fine sandy loam.	SM	A–4	95–100	90–95	50–60	0. 20–0. 80	. 70	5. 6–6. 0	Low.
17–34	Gravelly fine sandy loam.	SM	A–4	95–100	90–95	45–60	0. 05–0. 20	. 70	5. 6–6. 0	Low.
34–48	Gravelly fine sandy loam.	SM	A–4	95–100	90–95	40–55	(5)	. 70	5. 6–6. 0	Low.
0–9	Gravelly loam	GM–SM	A–4	65–75	55–65	35–40	0. 20–0. 80	1. 8	6. 1–6. 5	Low.
9–34	Gravelly fine sandy loam.	GM	A–2	55–65	55–65	15–25	0. 05–0. 20	. 70	5. 6–6. 0	Low.
34–48	Gravelly fine sandy loam.	SC	A–4 or A–6.	60–70	55–60	40–50	(5)	. 70	5. 6–6. 0	Low.
0–15	Stony loam	SM	A–1, A–2	55–65	30–40	10–15	0. 20–0. 80	1. 2	6. 1–6. 5	Low.
15–35	Stony sandy loam	SM	A–1, A–2	50–55	30–40	15–25	0. 05–0. 20	. 60	5. 6–6. 0	Low.
35–60	Stony fine sandy loam.	SC	A–4, A–6	50–55	30–45	25–30	(5)	. 60	5. 6–6. 0	Low.
0–12	Gravelly sandy loam	SM	A–1, A–2	75–85	50–60	15–25	0. 20–0. 80	1. 2	6. 1–6. 5	Low.
12–30	Gravelly sandy loam	SM	A–1, A–2	70–85	55–65	20–30	0. 20–0. 80	. 70	5. 6–6. 0	Low.
30–48	Gravelly fine sandy loam.	SM	A–1, A–2	80–85	45–55	25–40	(5)	. 70	5. 6–6. 0	Low.
0–6	Stony sandy loam	SM	A–1, A–2	60–70	40–50	10–20	0–20–0. 80	1. 00	6. 1–6. 5	Low.
6–35	Stony sandy loam	SM	A–1, A–2	50–60	40–50	15–25	0. 20–0. 80	. 70	5. 6–6. 0	Low.
35–55	Sandy loam	SC	A–1, A–2	55–65	40–50	15–30	(5)	. 70	5. 6–6. 0	Low.
Characteristics of the Roche soil are like those of the Roche stony loams.										

TABLE 6.—*Brief description of the soils*

Symbol on map	Soil name	Depth to seasonally high water table	Depth to bedrock	Brief description of site and soil
SaB SaD	San Juan gravelly sandy loam, 0 to 8 percent slopes. San Juan gravelly sandy loam, 8 to 30 percent slopes.	----------------	More than 15 feet.	These soils are somewhat excessively drained; between 15 and 30 percent, by volume, is gravel; the soils are mainly on San Juan Island.
SdB SdC	San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes. San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes.	1 foot for short periods.	More than 15 feet.	These well-drained soils contain gravel throughout the profile; a dense layer of clay loam that restricts the movement of water and air through the profile is at a depth of 20 to 24 inches.
StC StD	San Juan stony sandy loam, 3 to 15 percent slopes. San Juan stony sandy loam, 15 to 30 percent slopes.	----------------	More than 15 feet.	These soils are somewhat excessively drained and contain stones that are 1 to 2 feet in diameter.
SmC	San Juan loam, moderately deep, 0 to 15 percent slopes.	1 foot for short periods.	More than 15 feet.	This soil has a few pebbles in the surface layer; below the surface layer, the profile is similar to that of the moderately deep San Juan gravelly sandy loams, but the dense substratum is at a depth between 20 and 30 inches; the soil is well drained.
SsD	San Juan stony loam, moderately deep, 8 to 30 percent slopes.	1 foot for short periods.	More than 15 feet.	This soil is similar to the moderately deep San Juan gravelly sandy loams, except that it has stones, from 3 to 15 inches in diameter, on the surface and throughout the profile; the soil is associated with the stony Coveland and Roche soils; it is well drained.
Sm	Semiahmoo muck.	0 to 2 feet--------	More than 15 feet.	This organic soil occurs in basin areas; it has formed from sedges and grasses that tolerate water; in places there is fine-textured material that is sedimentary in origin deep in the profile; drainage is very poor.
Ss	Semiahmoo muck, shallow.	0 to 2 feet--------	----------------	This soil is similar to Semiahmoo muck, but gravelly glacial till is at a depth of 20 to 36 inches; slopes are less than 3 percent.
Ta	Tanwax peat, alkaline variant.	0 to 1 foot--------	None----------	This very poorly drained sedimentary peat has been reclaimed from areas of salt water marsh; the soil has formed from algae, excreta from minute marine animals, and other organic materials; it occurs only in an area north of Richardson.
Tm	Tidal marsh.	0 to 1 foot--------	----------------	This soil is in very wet, salty or brackish areas and is often covered by water when tides are high; it is associated with Hovde, Bellingham, Orcas, and Tanwax soils; the slope is less than 1 percent; drainage is very poor.

[1] The percentages shown passing the respective sieves (Nos. 4, 10, and 200) indicate the normal ranges for the soil.
[2] Permeability refers to the rate of movement of water through the soil material in its undisturbed state; permeability depends largely upon the texture of the soil and the structure and porosity.
[3] Available moisture in inches per foot of soil depth is the water available for plant use; it is the water held in the range between field capacity and the wilting point.

and their estimated physical properties—Continued

Depth from surface	Classification			Percentage passing [1]			Permeability [2]	Available moisture capacity [3]	Reaction	Shrink-swell potential [4]
	USDA texture	Unified	AASHO	No. 4 sieve (5.0 mm.)	No. 10 sieve (2.0 mm.)	No. 200 sieve (0.8 mm.)				
Inches							*Inches per hour*	*Inches per foot of depth*		
0–15	Gravelly sandy loam	SM	A-1	75–85	50–70	15–20	5. 0–10. 0	1. 20	5. 6–6. 0	Low.
15–23	Gravelly loamy coarse sand.	SM	A-1	65–75	40–50	10–15	5. 00–10. 0	. 80	6. 1–6. 5	Low.
23–60	Gravelly loamy coarse sand.	GW-SW	A-1	50–65	20–35	0–5	10. 0+	. 80	6. 1–7. 3	Low.
0–8	Gravelly sandy loam	SM	A-1, A-2	65–75	35–45	15–20	0. 80–2. 50	1. 50	6. 1–6. 5	Low.
8–20	Gravelly loam	SP-SM	A-1, A-2	65–75	30–40	10–15	0. 80–2. 50	1. 50	6. 1–6–5	Low.
20–24	Gravelly clay loam	CL	A-6	80–90	70–80	50–60	0. 05–0. 20	2. 20	6. 1–6. 5	Moderate.
24–36	Gravelly sandy clay loam.	SC	A-2, A-6	80–90	70–80	40–50	0. 05–0. 20	2. 20	6. 6–7. 3	Moderate.
0–12	Stony sandy loam	SP-SM	A-1	60–70	40–55	10–15	5. 0–10. 0	1. 10	5. 6–6. 0	Low.
12–18	Gravelly loamy sand	GW-GM	A-1	55–60	30–45	5–10	5. 00–10. 0	1. 10	6. 1–6. 5	Low.
18–50	Loamy sand	SW-SM	A-1	80–90	75–80	5–10	10. 0+	. 90	6. 1–7. 3	Low.
0–8	Loam	SM	A-1	85–95	55–60	20–25	0. 80–2. 50	1. 60	6. 1–6. 5	Low.
8–20	Gravelly loam	SP-SM	A-1, A-2	65–75	35–45	10–12	0. 80–2. 50	1. 50	6. 1–6. 5	Low.
20–24	Gravelly clay loam	CL	A-6	80–90	70–80	50–60	0. 05–0. 20	2. 20	6. 1–6. 5	Moderate.
24–45	Stony sandy clay loam.	SC	A-6	80–90	70–80	40–50	0. 05–0. 20	2. 20	6. 6–7. 3	Moderate.
0–10	Stony loam	GM-SM	A-1, A-2	40–50	30–40	15–25	0. 80–2. 50	1. 20	6. 1–6. 5	Low.
10–22	Gravelly loam	GM-SP	A-2	40–50	25–35	10–15	0. 80–2. 50	1. 20	6. 1–6. 5	Low.
22–27	Gravelly clay loam	GC-SC	A-4, A-6	65–75	50–60	35–45	0. 05–0. 20	1. 80	6. 1–6. 5	Moderate.
27–50	Gravelly sandy clay loam.	SC	A-2, A-6	65–75	50–60	30–40	0. 05–0. 20	1. 70	6. 6–7. 3	Moderate.
0–10	Muck	Pt	None	40–60	30–45	10–20	0. 20–0. 80	3. 5	5. 6–6. 0	Very high.
10–48	Peat	Pt	None	35–50	15–30	5–10	0. 80–5. 00	4. 5	5. 1–5. 5	
48–72	Peat	Pt	None	40–60	35–45	10–20	0. 05–0. 20	4. 5	5. 1–7. 3	
0–30	Muck	Pt	None	30–40	20–35	10–15	0. 20–0. 80	3. 5	5. 1–6. 0	Low.
30–60	Gravelly loam	GM, GC	A-1, A-2	40–60	20–35	15–25	(5)	1. 80	5. 1–7. 3	Low.
0–14	Peat	Pt		25–40	15–30		0. 20–0. 80	3. 00	6. 6–7. 3	Very high.
14–24	Peat	Pt		30–45	20–35		0. 20–0. 80	4. 00	7. 4–7. 8	
24–48	Peat	Pt		40–60	30–40		0. 20–0. 80	2. 50	7. 4–7. 8	
48–84	Peat	Pt		60–75	30–45		0. 20–0. 80	2. 50	7. 4–7. 8	

[4] Shrink-swell potential is an indication of the volume change to be expected in a soil as its moisture content changes.
[5] Less than 0.05 inch per hour.
Less than 4.5.

TABLE 7.—*Soil interpretations*

Soil type and map symbol	Suitability for excavation and grading [1]	Suscepti- bility to frost action	Suitability as a source of material for—		Suitability as a source of—		Soil features that affect vertical alinement of highways
			Road subgrade [2]	Road fill	Topsoil	Sand or gravel	
Active dune land (Ad).	Winter 1. Spring 1. Summer 1. Fall 1.	Not susceptible.	Good if confined.	Good if confined.	Poor; low in fertility.	Fair; too fine for some uses.	Highly erodible in cut slopes.
Alderwood gravelly sandy loam (AgB, AgC, AgD).	Winter 2W. Spring 2W. Summer 2. Fall 2.	Low to medium.	Good	Good	Topmost 30 inches good.	Poor	[5]
Alderwood gravelly loam (AmB, AmD).	Winter 3W. Spring 3W. Summer 2. Fall 2.	Medium to low.	Good	Good	Topmost 30 inches good.	Poor	[5]
Alderwood stony loam (AsB, AsC, AsD).	Winter 3WR. Spring 3WR. Summer 2R. Fall 2R.	Medium to low.	Poor to fair; stony.	Good	Poor	Poor	Stoniness
Bellingham silt loam (Be).	Winter 4WP. Spring 4WP. Summer 3. Fall 3H.	High	Poor	Poor	Poor	Not suitable	Highly plastic clay.
Bellingham clay loam (Bc).	Winter 5WP. Spring 3WP. Summer 3. Fall 3H.	High	Poor	Poor	Not suitable	Not suitable	Highly plastic clay.
Bow silt loam (BoA, BoB).	Winter 4WP. Spring 4WP. Summer 2. Fall 2H.	High	Poor	Poor	Fair to a depth of 24 inches.	Not suitable	Plastic clay
Bow gravelly silt loam (BgA, BgB, BgD).	Winter 3W. Spring 3W. Summer 2. Fall 2H.	Medium to high.	Poor	Poor to fair	Poor to fair	Not suitable	Plastic clay
Bow stony silt loam (BsB).	Winter 3WR. Spring 3R. Summer 2R. Fall 2HR.	Medium	Poor	Good to a depth of 3 feet; poor below that depth.	Not suitable	Not suitable	Stones and plastic clays.
Coastal beaches (Cb).							
Coveland silt loam (CsA, CsB).	Winter 5WP. Summer 2. Spring 4WP. Fall 2H.	Medium to high.	Fair to a depth of 2 feet; poor below that depth.	Poor to fair	Not suitable	Not suitable	Very plastic material below a depth of 2 feet.
Coveland gravelly silt loam (CoA, CoB).	Below a depth of 2 feet: Winter 5WP. Spring 4WP. Summer 2. Fall 2H.	Medium to high.	Upper 2 feet poor to fair; below 2 feet, poor.	Upper 2 feet fair; below 2 feet, poor.	Not suitable	Not suitable	Claypan; seepage in cuts.

See footnotes at end of table.

that affect engineering

Suitability of soil, or soil features that affect practices for—							
Dikes or levees [3]		Farm ponds [4]		Drainage	Agricultural irrigation	Terraces, diversions, and waterways	Suitability for compaction and compaction requirements
Foundations	Fill	Reservoir areas	Embankments				
Poor	Very poor	Not suitable	Limited; for filter use only.	Very good	Not suitable	Not suitable topographically.	Good.
Good; cutoff to substratum required.	Fair to good; may require protection from erosion.	Fair	Stable; use for homogeneous sections.	Fair to good	Fair to good	Good; may require use of other topsoil.	Good; close control essential.
Good; cutoff to substratum required.	Fair to good; may require protection from erosion.	Fair	Stable; use for homogeneous sections.	Fair to good	Fair to good	Good; may require use of other topsoil.	Good; close control essential.
Good; cutoff to substratum required.	Fair to good; may require protection from erosion.	Fair	Stable; use for homogeneous sections.	Fair to good	Fair to good	Good; may require use of other topsoil.	Good; close control essential.
Excellent	Poor	Good	Good	Poor below a depth of 18 inches; fair above 18 inches.	Good	Good	Poor to fair.
Good; cutoff to substratum required.	Good; use 3:1 slopes.	Very good	Excellent for core.	Very poor; practically impervious.	Fair; slow rate of infiltration.	Good	Poor to fair.
Good; cutoff to substratum required.	Good; use 2:1 slopes or slopes that are more nearly level.	Very good	Good for core	Very poor; practically impervious below a depth of 12 inches.	Fair; slow rate of infiltration.	Good	Poor to fair.
Good; cutoff to substratum required.	Good; slopes to be 2:1 or more nearly level.	Questionable; leakage may occur.	Reasonably stable; use for core or upstream zone.	Poor to fair in some areas.	Fair to good	Good	Poor to good; close control essential.
Fair to good; cutoff may be needed.	Good; slopes to be 2:1 or more nearly level.	Questionable; leakage may occur.	Reasonably stable; use for core or upstream zone.	Fair	Fair to good	Fair to good	Poor to good; close control essential.
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Good	Poor stability; make 3:1 slopes.	Good	Poor to fair; use in core only or make 3:1 slopes.	Very poor below a depth of 12 inches.	Suitable	Good	Fair to good.
Good	Poor stability; make 3:1 slopes.	Good	Poor to fair; use in core only or make 3:1 slopes.	Poor	Fair to good; variable content of gravel makes problem.	Good	Upper 2 feet fair to good; below 2 feet, fair to poor.

TABLE 7.—*Soil interpretations*

Soil type and map symbol	Suitability for excavation and grading [1]	Susceptibility to frost action	Suitability as a source of material for—		Suitability as a source of—		Soil features that affect vertical alinement of highways
			Road subgrade [2]	Road fill	Topsoil	Sand or gravel	
Coveland gravelly silt loam (CoA, CoB)—Con.	Above a depth of 2 feet: Winter 3. Spring 3. Summer 2. Fall 2.						
Coveland stony silt loam (CtC).	Below a depth of 2 feet: Winter 5WP. Spring 4WP. Summer 2. Fall 2H. Above a depth of 2 feet: Winter 3R. Spring 3R. Summer 2R. Fall 2R.	Medium to high.	Not suitable; upper 2 feet poor to fair, stony; below 2 feet, poor.	Upper 2 feet fair; poor below 2 feet.	Not suitable	Not suitable	Claypan; seepage in cut slopes; shallow to bedrock in places.
Everett gravelly sandy loam (EgB, EgD).	Winter 2. Spring 1. Summer 1. Fall 1.	Very low	Excellent	Excellent	Not suitable	Good for gravel.	No limitations.
Everett stony sandy loam (EsD).	Winter 1R. Spring 1R. Summer 1R. Fall 1R.	Very low	Excellent, except that it contains some cobbles.	Excellent	Not suitable	Good for gravel.	No limitations.
Hovde loam (Ho).	Winter 3W. Spring 3W. Summer 2. Fall 2.	Very low	Excellent if top 14 inches is discarded.	Good	Not suitable	Good for sand at a depth below 14 inches.	Water table at a depth of 1 foot requires drainage.
Indianola sandy loam (InC).	Winter 1. Spring 1. Summer 1. Fall 1.	Low	Excellent	Good	Fair	Fair to good; has pockets of sand.	Erodible on cut slopes.
Indianola-Roche complex (IrB, IrD).	Characteristics similar to those of the Indianola and Roche soils.						
Neptune gravelly sandy loam (Ng).	Winter 2. Spring 2. Summer 1. Fall 1.	Low	Excellent	Good	Not suitable	Poor quality sand at a depth below 6 inches.	Water table at high tide.
Norma loam, moderately deep (No).	Winter 3W. Spring 3W. Summer 2. Fall 2.	High to moderate.	Fair to good	Good	Fair to a depth of 18 inches; not suitable below that depth.	Not suitable	Water table at a depth of 6 inches.
Norma loam (Nm).	Winter 5WP. Spring 4WP. Summer 3. Fall 3H.	High to moderate.	Poor	Poor	Fair to a depth of 18 inches; not suitable below that depth.	Not suitable	Water table at a depth of 2 feet.

See footnotes at end of table.

that affect engineering—Continued

Suitability of soil, or soil features that affect practices for—							
Dikes or levees [3]		Farm ponds [4]		Drainage	Agricultural irrigation	Terraces, diversions, and waterways	Suitability for compaction and compaction requirements
Foundations	Fill	Reservoir areas	Embankments				
Good	Poor to fair	Fair to good	Fair	Poor	Poor	Fair to good	Fair.
Poor; very pervious.	Not suitable	Not suitable	Suitable only for downstream shell.	Very good	Not suitable	Poor to fair; erodible.	Good.
Poor; very pervious.	Not suitable	Not suitable	Suitable only for downstream shell.	Very good	Not suitable	Poor to fair; erodible.	Good.
Poor; may settle.	Not suitable	Not suitable	Not suitable	Poor; naturally high water level; salt water may intrude.	Not suitable	Not suited topographically.	Fair to good; close control essential.
Very poor	Not suitable	Very poor	Good for use in certain parts of zoned fill.	Very good	Good (with careful management).	Will require careful design and vegetative protection to control erosion.	Good; close control essential.
Very poor	For low dikes only.	Not suitable	Not suitable	Very good if outlet is established.	Not suitable	Not suitable topographically.	Good.
Good	Good	Excellent	Excellent for core and upstream third of zoned fill.	Very poor to poor.	Fair to good	Good	Poor to good; close control essential.
Good	Good	Excellent	Excellent for core and upstream third of zoned fill.	Poor	Fair to good	Good	Poor to good; close control essential.

TABLE 7.—*Soil interpretations*

Soil type and map symbol	Suitability for excavation and grading [1]	Suscepti-bility to frost action	Suitability as a source of material for—		Suitability as a source of—		Soil features that affect vertical alinement of highways
			Road subgrade [2]	Road fill	Topsoil	Sand or gravel	
Orcas peat (Op).	Winter 6W. Spring 6W. Summer 4W. Fall 3W.	Low	Not suitable	Not suitable	Not suitable	Not suitable	Deep peat
Pickett-Rock outcrop complex (PrD, PrE).	Winter 3R. Spring 3R. Summer 3R. Fall 3R.	Medium	Pickett soil good; Rock outcrop poor.	Good	Fair to a depth of 36 inches.	Not suitable	Bedrock anywhere.
Roche loam (RoA, RoB, RoC).	Winter 5W. Spring 4W. Summer 3. Fall 3H.	High	Fair to poor	Fair	Fair to good	Not suitable	Seasonal high water table at a depth of 6 to 18 inches.
Roche gravelly loam (RgA, RgB, RgC, RgD).	Winter 5W. Spring 4W. Summer 3. Fall 3H.	Medium	Fair	Fair to good	Fair	Not suitable	Seasonal high water table at a depth of 6 to 18 inches.
Roche stony loam (RsB, RsC, RsD).	Winter 5WR. Spring 3R. Summer 3R. Fall 3R.	Low to medium.	Poor to fair; stony.	Fair to good	Not suitable	Not suitable	Seasonal high water table; stoniness.
Roche gravelly sandy loam (RhB).	Winter 3W. Spring 2W. Summer 1. Fall 1.	Medium	Good	Good	Not suitable	Not suitable	No limitation
Roche stony sandy loam (RtC).	Winter 3WR. Spring 2R. Summer 2R. Fall 2R.	Low	Fair; stony	Good	Not suitable	Not suitable	Rock at a depth of 2 to 5 feet.
Roche-Rock outcrop complex (RxD, RgE).	Winter 5WR. Spring 3R. Summer 3R. Fall 3R.	Except for Rock outcrop, has characteristics similar to those of the Roche stony loams.					
Rock land (Ry, Rz).	Winter 6R. Spring 6R. Summer 6R. Fall 6R.	From 50 to 90 percent of acreage is bedrock; the rest consists of the Pickett-Rock outcrop complex or					
San Juan gravelly sandy loam (SaB, SaD).	Winter 1. Spring 1. Summer 1. Fall 1.	Not susceptible.	Good	Excellent	Not suitable	Good for sand; fair for gravel.	No limitations
San Juan stony sandy loam (StC, StD).	Winter 2R. Spring 2R. Summer 2R. Fall 2R.	Not susceptible.	Poor to fair	Excellent	Not suitable	Good for sand	Large stones

See footnotes at end of table.

that affect engineering—Continued

Suitability of soil, or soil features that affect practices for—								
Dikes or levees [3]		Farm ponds [4]		Drainage	Agricultural irrigation	Terraces, diversions, and waterways	Suitability for compaction and compaction requirements
Foundations	Fill	Reservoir areas	Embankments				
Not suitable	Not suitable	Not suitable	Not suitable	Poor because of location; outlet problem.	Not suitable	Not suitable topographically.	Not practical.
Not suitable topographically.	Not suitable	Questionable; leakage.	Fair	Good	Poor	Fair	Fair to good; close control essential.
Good	Good	Good	Good for core; also for homogeneous fills of moderate height.	Very poor below a depth of 18 inches.	Good	Good	Good to poor.
Good	Good	Good	Good for core; also for homogeneous fills of moderate height.	Poor in substratum.	Good	Good	Good; close control is essential.
Poor	Not suitable	Questionable; leakage.	Good only as shell or in downstream third of zoned fill.	Fair	Not suitable	Not suitable topographically.	Good; close control is essential.
Fair	Fair to good	Good	Good; use other material for cutoff core.	Fair	Good	Good	Good.
Fair	Not suitable		Good only as shell or in downstream third of zoned fill.	Fair	Not suitable	Not suitable	Good.
of Roche soils. Characteristics of the soil material are generally similar to those of the Roche soils or of the Pickett-Rock outcrop complexes.							
Poor	Not suitable	Not suitable	Use only for shell or downstream third of zoned fill.	Very good	Not suitable	Fair to good; may be subject to erosion.	Good to excellent.
Poor	Not suitable	Not suitable	Use only for shell or downstream third of zoned fill.	Very good	Not suitable	Not suitable topographically.	Good to excellent.

TABLE 7.—*Soil interpretations*

Soil type and map symbol	Suitability for excavation and grading [1]	Susceptibility to frost action	Suitability as a source of material for—		Suitability as a source of—		Soil features that affect vertical alinement of highways
			Road subgrade [2]	Road fill	Topsoil	Sand or gravel	
San Juan loam, moderately deep (SmC).	Below a depth of 2 feet: Winter 5W. Spring 4W. Summer 3. Fall 3H. Above a depth of 2 feet: Winter 3W. Spring 2W. Summer 2. Fall 2.	Low to medium.	Good to a depth of 2 feet; fair to poor below 2 feet.	Good to a depth of 2 feet; fair below 2 feet.	Poor	Not suitable	Clayey substratum.
San Juan gravelly sandy loam, moderately deep (SdB, SdC).	Below a depth of 2 feet: Winter 5WP. Spring 4WP. Summer 2. Fall 2H. Above a depth of 2 feet: Winter 2W. Spring 2. Summer 1. Fall 1.	Low to medium.	Good to a depth of 2 feet; poor to fair below that depth.	Good to a depth of 2 feet; fair below that depth.	Not suitable	Not suitable	Clayey substratum.
San Juan stony loam, moderately deep (SsD).	Below a depth of 2 feet: Winter 5WP. Spring 4WP. Summer 2. Fall 2H. Above a depth of 2 feet: Winter 3WR. Spring 2WR. Summer 2R. Fall 2R.	Low to medium.	Poor to fair; stony.	Fair	Not suitable	Not suitable	Clayey substratum.
Semiahmoo muck (Sm).	Winter 5W. Spring 5W. Summer 2W. Fall 2.	Low	Not suitable	Not suitable	Excellent if mixed with mineral soil.	Not suitable	High water table.
Semiahmoo muck, shallow (Ss).	Above a depth of 2½ feet: Winter 4W. Spring 3W. Summer 2. Fall 2. Below a depth of 2½ feet: Winter 2W. Spring 2W. Summer 2W. Fall 2W.	Low	Upper 2½ feet unsuitable; good below.	Upper 2½ feet unsuitable; good below.	Good if mixed with mineral soil.	Not suitable	High water table.
Tanwax peat, alkaline variant (Ta).	Winter 5W. Spring 5W. Summer 2. Fall 2.	Medium	Not suitable	Not suitable	Good if mixed with mineral soil.	Not suitable	High water table.
Tidal marsh (Tm).	Winter 5W. Spring 5W. Summer 3W. Fall 3W.	Medium	Not suitable	Not suitable	Not suitable	Not suitable	Water table and salt.

[1] Ease of working with usual construction machinery is rated from 1 to 6; the lowest number indicates the least difficulty, and the highest number, the most difficulty; letters used to indicate limitations to suitability for excavation and grading are: W=wetness problem; P=plastic and sticky material; H=hard if low in moisture; and R=large, imbedded rocks are within the profile (above bedrock).

that affect engineering—Continued

Suitability of soil, or soil features that affect practices for—							
Dikes or levees [3]		Farm ponds [4]		Drainage	Agricultural irrigation	Terraces, diversions, and waterways	Suitability for compaction and compaction requirements
Foundations	Fill	Reservoir areas	Embankments				
Fair to good	Good	Good	Good for core or upstream third.	Poor after soil is saturated to a depth of 18 inches.	Fair	Good	Good; close control essential.
Poor to fair	Fair for dikes 4 to 5 feet high.	Poor	Good for core or homogeneous fill of low structure (10 to 15 feet high).	Poor	Fair	Good	Fair to good.
Good	Fair to good for dikes 3 to 5 feet high.	Poor	Good in downstream third only.	Poor	Poor location	Not suitable topographically.	Good.
Not suitable	Not suitable	Doubtful	Not suitable	Poor; outlet problem.	Excellent	Not suitable topographically.	Not practical.
Poor to fair (remove the muck).	Not suitable	Good in most places.	Not suitable	Poor; outlet problem.	Excellent	Not suitable topographically.	Not practical.
Poor	Poor	Poor	Poor	Poor; outlet problem.	Fair	Not suitable topographically.	Not practical.
Fair	Can be used if soil material is not peaty.	Not suitable	Not suitable	Variable	Fair to good if dikes are constructed.	Not suitable topographically.	Fair.

[2] Make more detailed field survey to determine source within the area occupied by the mapping unit.
[3] Data refer to structure less than 10 feet high and subject to only intermittent use (usually of less than 1 day).
[4] Use data given only for preliminary proposal; make "at site" investigation and classification of material.
[5] No problems involved in vertical alinement.

TABLE 8.—*Classification of soils by*

General classification	Granular materials (35 percent or less passing No. 200 sieve)						
Group classification	A–1		A–3	A–2			
	A–1–a	A–1–b		A–2–4	A–2–5	A–2–6	A–2–7
Sieve analysis: Percent passing—							
No. 10	50 maximum.						
No. 40	30 maximum.	50 maximum.	51 minimum.				
No. 200	15 maximum.	25 maximum.	10 maximum.	35 maximum.	35 maximum.	35 maximum.	35 maximum.
Characteristics of fraction passing No. 40 sieve:							
Liquid limit			NP [2]	40 maximum.	41 minimum.	40 maximum.	41 minimum.
Plasticity index	6 maximum.	6 maximum.	NP [2]	10 maximum.	10 maximum.	11 minimum.	11 minimum.
Group index	0	0	0	0	0	4 maximum.	4 maximum.
Usual types of significant constituent materials.	Stone fragments, gravel, and sand.	Stone fragments, gravel, and sand.	Fine sand.	Silty gravel and sand.	Silty gravel and sand.	Clayey gravel and sand.	Clayey gravel and sand.
General rating as subgrade	Excellent to good.						

[1] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1; ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145-49.

TABLE 9.—*Classification of soil materials by the Unified soil*

Major divisions	Group symbol	Description	Value as foundation material [2]	Value as base course directly under bituminous pavement
Coarse-grained soils (*50 percent or less passing No. 200 sieve*):				
Gravels and gravelly soils (*more than half of coarse fraction retained on No. 4 sieve*).	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	Excellent	Good
	GP	Poorly graded gravels and gravel-sand mixtures; little or no fines.	Good to excellent	Poor to fair
	GM	Silty gravels and gravel-sand-silt mixtures.	Good	Poor to good
	GC	Clayey gravels and gravel-sand-clay mixtures.	Good	Poor

See footnotes at end of table.

American Association of State Highway Officials [1]

Silt-clay materials (More than 35 percent passing No. 200 sieve)				
A-4	A-5	A-6	A-7	
			A-7-5	A-7-6
36 minimum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.
40 maximum. 10 maximum.	41 minimum. 10 maximum.	40 maximum. 11 minimum.	41 minimum. 11 minimum.[3]	41 minimum. 11 minimum.[3]
8 maximum.	12 maximum.	16 maximum.	20 maximum.	20 maximum.
Nonplastic to moderately plastic, silty soils.	Highly elastic silts.	Medium plastic clays.	Highly plastic clays.	Highly plastic clays.
Fair to poor.				

[2] NP—Nonplastic.
[3] Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

classification system, selected characteristics,[1] *and suggestions for use*

Stability for embankments (dams and dikes)	Compaction characteristics and suitable equipment	Approximate range in AASHO maximum dry density [3]	Field (in place) CBR [4]	Subgrade modulus, k	Drainage characteristics	Comparable groups in AASHO classification
		Lb. per cu. ft.	*Percent*	*Lb. per sq. in. per in.*		
Very good stability; use in pervious shells of dikes and dams.	Good; use crawler-type tractor, pneumatic-tire roller, or steel-wheel roller.	125 to 135	60 to 80	300+	Excellent	A-1.
Reasonable stability; use in pervious shells of dikes and dams.	Good; use crawler-type tractor, pneumatic-tire roller, or steel-wheel roller.	115 to 125	25 to 60	300+	Excellent	A-1.
Reasonable stability; not particularly suited to shells, but may be used for impervious cores or blankets.	Good, but needs close control of moisture; use pneumatic-tire roller or sheepsfoot roller.	120 to 135	20 to 80	200 to 300	Fair to practically impervious.	A-1 or A-2.
Fair stability; may be used for impervious cores in dams and dikes.	Fair; use pneumatic-tire roller or sheepsfoot roller.	115 to 130	20 to 40	200 to 300	Poor to practically impervious.	A-2.

TABLE 9.—*Classification of soil materials by the Unified soil*

Major divisions	Group symbol	Description	Value as foundation material [2]	Value as base course directly under bituminous pavement
Coarse-grained soils—Continued Sands and sandy soils (*more than half of coarse fraction passing No. 4 sieve*).	SW	Well-graded sands and gravelly sands; little or no fines.	Good	Poor
	SP	Poorly graded sands and gravelly sands; little or no fines.	Fair to good	Poor to unsuitable
	SM	Silty sands and sand-silt mixtures.	Fair to good	Poor to unsuitable
	SC	Clayey sands and sand-clay mixtures.	Fair to good	Unsuitable
Fine-grained soils (*more than 50 percent passing No. 200 sieve*): Silts and clays (*liquid limit of 50 or less*).	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, and clayey silts of slight plasticity.	Fair to poor	Unsuitable
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays.	Fair to poor	Unsuitable
	OL	Organic silts and organic silty clays having low plasticity.	Poor	Unsuitable
Silts and clays (*liquid limit greater than 50*).	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, and elastic silts.	Poor	Unsuitable
	CH	Inorganic clays having medium to high plasticity, and fat clays.	Poor to very poor	Unsuitable
	OH	Organic clays and organic silts having medium to high plasticity.	Poor to very poor	Unsuitable
Highly organic soils	Pt	Peat and other highly organic soils.	Unsuitable	Unsuitable

[1] Ratings and ranges in test values are for guidance only; design should be based on field survey and test of samples from the construction site.

[2] Ratings are for subgrades and subbases for flexible pavements.

[3] Determined in accordance with test designation: T 99-49, AASHO (*1*).

classification system, selected characteristics,[1] *and suggestions for use*—Continued

Stability for embankments (dams and dikes)	Compaction characteristics and suitable equipment	Approximate range in AASHO maximum dry density [3]	Field (in place) CBR [4]	Subgrade modulus, k	Drainage characteristics	Comparable groups in AASHO classification
		Lb. per cu. ft.	*Percent*	*Lb. per sq. in. per in.*		
Very good stability; may be used in pervious sections; slope protection required.	Good; use crawler-type tractor or pneumatic-tire roller.	110 to 130	20 to 40	200 to 300	Excellent	A–1.
Reasonable stability; may be used in dike sections having flat slopes.	Good; use crawler-type tractor or pneumatic-tire roller.	100 to 120	10 to 25	200 to 300	Excellent	A–1 or A–3.
Fair stability; not particularly suited to shells, but may be used for impervious cores or dikes.	Good, but needs close control of moisture; use pneumatic-tire roller or sheepsfoot roller.	110 to 125	10 to 40	200 to 300	Fair to practically impervious.	A–1, A–2, or A–4.
Fair stability; use as impervious core for water-control structures.	Fair; use pneumatic-tire roller or sheepsfoot roller.	105 to 125	10 to 20	200 to 300	Poor to practically impervious.	A–2, A–4, or A–6.
Poor stability; may be used for embankments if properly controlled.	Good to poor; close control of moisture is essential; use pneumatic-tire roller or sheepsfoot roller.	95 to 120	5 to 15	100 to 200	Fair to poor	A–4, A–5, or A–6.
Good stability; use in impervious cores and blankets.	Fair to good; use pneumatic-tire roller or sheepsfoot roller.	95 to 120	5 to 15	100 to 200	Practically impervious.	A–4, A–6, or A–7.
Not suitable	Fair to poor; use sheepsfoot roller.[5]	80 to 100	4 to 8	100 to 200	Poor	A–4, A–5, A–6, or A–7.
Poor stability; use in core of hydraulic fill dam; not desirable in rolled fill construction.	Poor to very poor; use sheepsfoot roller.[5]	70 to 95	4 to 8	100 to 200	Fair to poor	A–5 or A–7.
Fair stability on flat slopes; use in thin cores, blankets, and dike sections of dams.	Fair to poor; use sheepsfoot roller.[5]	75 to 105	3 to 5	50 to 100	Practically impervious.	A–7.
Not suitable	Poor to very poor; use sheepsfoot roller.[5]	65 to 100	3 to 5	50 to 100	Practically impervious.	A–5 or A–7
Not used in embankments, dams, or subgrades for pavements.					Fair to poor	None.

[4] Figures are relative percentages of values obtained from a standard limestone rock (California Bearing Ratio).

[5] Pneumatic-tire rollers may be advisable, particularly when moisture content is higher than optimum.

Although each of the soils was sampled in two different localities, the test data do not show the entire range of soil characteristics in either series. The results of the tests, however, can be used as a general guide in estimating the physical properties of these and similar soils of the county.

The engineering soil classifications in table 5 are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. Mechanical analyses were made by combined sieve and hydrometer methods. Percentages of clay, obtained by the hydrometer method, are not to be used in naming textural classes of soils.

The tests for liquid limit and plastic limit measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a solid to semisolid or plastic state. As the moisture content is further increased, the material changes from the plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a solid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Table 5 also gives compaction (moisture-density) data for the tested soils. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material will increase until the "optimum moisture content" is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed maximum dry density. Moisture-density data are important in earthwork, for, as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density, when it is at approximately the optimum moisture content.

Engineering classification systems

Engineers commonly use two classification systems that express, by means of symbols, the relative suitability of soil materials for use in structures. As shown in table 8, the classifications take into account the size of soil separates (mechanical analyses), liquid limit, and plasticity index. The classification systems are explained as follows:

AASHO System.—Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (*1*). In this system soil materials are classified in seven principal groups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, consisting of clay soils having low strength when wet.

Within each of the principal groups, the relative engineering value of the material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest. The group index number is shown in parentheses, following the soil group symbol, in the next to last column of table 5. The principal characteristics according to which soils are classified in this system are shown in table 8. Classification of the tested soils according to the American Association system is shown in the next to last column of table 5.

Unified System.—Some engineers prefer to use the Unified soil classification system (*11*). In this system, soil materials are identified as coarse grained (8 classes), fine grained (6 classes), or highly organic. An approximate classification can be made in the field. For exact classification, mechanical analyses are used for GW, GP, SW, and SP soils; and mechanical analyses, liquid limit, and plasticity index data are used for GM, GC, SM, and SC soils and for the fine-grained soils.

A plasticity chart, on which the liquid limit and the plasticity index may be plotted, is required for classification of the fine-grained soils and for identification of the secondary component of the silty and clayey sands and gravels. The principal characteristics of the 15 classes of soil are given in table 9. The classification of the tested soils according to the Unified system is given in the last column of table 5.

Engineering interpretations

Some of the information needed by engineers can be obtained from the soil map and the soil association map. It will often be necessary, however, to refer to the text of the report, particularly to the section "Descriptions of Soils" and to the section "Formation and Classification of Soils." Table 6 will also be of use. The estimated properties of the soils and probable classifications given in table 6 were based partly on the soil test data given in table 5. They were also based partly on information given in the rest of the report and on experience with the same soils in other counties.

The headings in table 6 are self-explanatory for the most part. However, the following comments may be helpful.

The percentages shown passing the respective sieves (Nos. 4, 10, and 200) indicate the normal ranges for the soil type listed in the second column.

Permeability refers to the rate of movement of water through the soil material in its undisturbed state. Permeability depends largely upon the soil structure, texture, and porosity.

Available moisture in inches per foot of soil depth is the water available for plants to use. It is the water held in the range between field capacity and the wilting point.

Shrink-swell potential is an indication of the volume change to be expected in a soil as its moisture content changes.

Features affecting vertical alinement of roadways, table 7, are in two main categories—drainage and materials. Drainage factors that affect vertical alinement include high water table, seasonal flooding, seepage in cut slopes, and subsurface seepage. Material factors that affect vertical alinement include the presence of bedrock, cohesive soils, erodible soils, and interbedded, permeable and impervious soil materials in the cut sections and weak, compressible soil materials in the fill sections.

At many construction sites major variations in the soils occur within the depth of the proposed excavation, and several different soil units are often within short distances of one another. The soil map and profile descriptions, as well as the engineering interpretations, should be used in planning the detailed engineering surveys to be made at the construction site. The use of such information will enable the engineer to concentrate his efforts with a minimum of soil sampling for testing in the laboratory.

He can thus make an adequate investigation of the soils at minimum cost.

In general, soils of high clay content have a high shrink-swell potential, whereas soils composed of sands and gravels or those having slightly plastic or nonplastic fines have low shrink-swell potential.

Like the headings in table 6, most of the column headings in table 7 are readily understood; however, some clarification is desirable.

The susceptibility of a soil to frost action depends on the texture of the soil and depth to the water table during the freezing period. Soils, such as Bow silt loam or the upper 2 feet of Coveland silt loam, that have a texture of silt and very fine sand and a high water table are rated "High." Sandy and gravelly soils that have less than 5 to 10 percent passing the No. 200 sieve are described as "Not susceptible."

The rating of the soil for road subgrade is based on the estimated classification of the soil material. Soils, such as Bellingham clay loam and Coveland soils (below a depth of 2 feet), that have a layer of plastic clay that impedes internal drainage have low stability when wet; hence, they are given a rating of "Poor." Muck and peat are rated "Unsuitable," and the gravelly and sandy A–1 and A–2 soils are rated "Good."

The suitability of the soil material for road fill depends largely on its natural water content and on the texture of the soil. The plastic soils with high natural water content, such as the Bellingham, Coveland, and moderately deep Norma, are difficult to handle, compact, and dry to the desired water content; hence, they are given a rating of "Poor."

Formation and Classification of Soils

In the following pages the formation of soils in San Juan County is discussed. Also discussed is the classification of the soils.

How the Soils Were Formed

Soils are natural bodies, composed of organic and mineral materials, that occur on the surface of the earth. They are the product of the forces of weathering acting upon materials deposited by geologic agencies. The characteristics of the soil at any given point depend upon (1) the physical and mineralogical composition of the parent material; (2) the climate under which the parent material has existed since accumulation; (3) the relief or lay of the land; (4) the plant and animal life on and in the soil; and (5) the length of time the forces of development have acted on the parent material. The effects of these factors and their relationship to the soils of San Juan County are discussed in the following pages.

Parent material

Four kinds of soil parent material occur in San Juan County. They are (1) material weathered from intrusive and sedienmtary rocks, (2) glacial sediments, (3) lacustrine deposits, and (4) organic deposits. Soils formed from each of these kinds of parent material have different properties.

The soils of uplands formed in materials weathered from a number of different kinds of parent bedrock. The sedimentary rocks that contributed to the parent material are of the Paleozoic and Mesozoic eras, but the volcanic rocks are of the early Cenozoic era. Successive glaciers altered the landscape during the Pleistocene period by scouring peaks, filling older valleys, burying older glacial sediments, and obliterating soils of the earlier ages.

According to Bretz (*2*), the area that is now San Juan County has been covered by at least two continental glaciers. Nearly all evidence of the old glacial till has been buried or destroyed, except possibly on Spieden and Stuart Islands.[6]

The Puyallup interglacial sediments were deposited during a period of uplift and erosion. They were exposed to weathering for a long enough time so that soil profiles having a distinctive morphology developed. Later, Vashon glacial drift of the Wisconsin age buried the Puyallup sediments to a depth ranging from a few inches to many feet.

Two of the series mapped in San Juan County consist of bisequal soils. In these soils the upper horizons formed in Vashon drift and the lower horizons in the older glacial deposits. The Vashon drift is sandy, and a large part of it consists of fine gravel. It contains many stones and boulders, which are particularly numerous in the soils of Cattle Point.

Though the highest peaks were scoured by glaciers, little evidence of glacial sediments remains above elevations of 1,000 feet. Soils at the higher elevations of San Juan, Decatur, Shaw, Stuart, Spieden, Waldron, and Sucia Islands, and on Mount Constitution, Diamond Hill, and Mount Wollard formed in material weathered from sedimentary rocks. These rocks consisted of argillite, graywacke, slate, schist, chert, and limestone. According to Coe, soils at the higher elevations on Lopez and Blakely Islands, and on Mount Pickett, Buck Mountain, Double Hill, and Turtleback Range formed in material weathered from volcanic rocks consisting of igneous porphyrite, gabbrodiorite, quartz diorite, and serpentine.

The San Juan Archipelago, according to geologists, has been subject to uplift, erosion, and sinking throughout the geologic ages. Sediments washed into the basins and bays of glacial lakes, which subsequently were uplifted and drained, are another source of soil material in the county.

Organic soils have their source in closed glacial basins and shallow slack-water bays. In those areas the excreta and remains of minute marine organisms and the remains of plants have accumulated under water. Disintegration and decomposition in those areas have been relatively slow.

Climate

Climate is an important factor in the formation of soils. Soils formed under a dry climate have markedly different characteristics than those formed under a humid climate. Generally, soils formed where there is little rainfall are less leached than those formed in the subhumid climate typical of much of San Juan County.

Climate also influences the kind of vegetation, which, in turn, influences the formation of soils. Grasses are generally predominant in areas where the average annual

[6] COE, EARL. HISTORICAL HIGHLIGHTS OF THE STATE OF WASHINGTON. 77 pp. [Mimeographed 1950.]

precipitation is less than 20 to 22 inches. Forest predominates in areas where there is a great amount of precipitation.

Wind currents, elevation, relief, and exposure exert a marked influence on microclimate within short distances. They affect the climate to such a degree that marked differences in vegetation and in the properties of the soils can be observed readily. An outstanding example of this influence can be seen on Cattle Point, where the southern and western slopes are occupied by soils that have formed under grass. The soils formed under grass have a thick, dark surface layer. Brown Podzolic soils, formed under timber, are on the north-facing slopes that are protected from winds from the ocean and from direct exposure to the sun.

On San Juan Island and on some of the other islands in the county, the differences in climate are less marked than on Cattle Point. As one goes from an area of low precipitation toward an area where there is a great amount, differences can be seen in the kind of vegetation. The vegetation in the drier areas is mainly grass, but it is mainly Oregon white oak, Douglas-fir, hemlock, cedar, and spruce in the areas that receive more precipitation.

Topography

Topography, or the lay of the land, has an important bearing on the rate of drainage and on erosion, as well as on microclimate. Water drains very slowly or not at all from basins and depressions. In such areas the large amount of moisture encourages the growth of plants that require ample water. These are the areas where reeds, sedges, and mosses have accumulated to form organic soils. Gleyed soils are in the slight depressions and in nearly level areas.

In areas that have greater slopes, runoff is more rapid than on the less sloping areas. Consequently, the A and B horizons of soils in sloping areas have a predominance of brown and reddish-brown colors rather than being gray like the A and B horizons of less well drained soils.

Likewise, there is less mottling in the subsoil. On steeper slopes the soil profile may be modified by soil creep. Also, on the very steep slopes, where geologic erosion has kept ahead of soil formation, shallow spots and rock outcrops occur.

Living organisms

All life on and in the soil has an important bearing on its formation. The raw soil materials were first invaded by simple forms of life, such as bacteria and fungi, which grew and multiplied. When those organisms died, their bodies decayed and became incorporated with the soil material. Mosses and lichens next began to appear, followed by grasses, shrubs, and trees, all of which added organic matter to the soil. Soils become mixed when windthrow occurs in forests. Likewise, rodents that dig and make burrows in the soil, mix the subsoil with the surface soil.

Soils formed under grasses and ferns that have fibrous, deep-reaching roots have a very dark brown to black surface layer. In contrast, the surface layer of soils formed under coniferous and deciduous vegetation is brown to grayish brown. The depth to which roots can penetrate is often determined by the characteristics of the subsoil. The remains of sedges, sphagnum moss, labrador-tea, and other plants that tolerate wetness have added to the accumulations of peat in bog areas.

The presence of organisms and rodents in a soil exert an important influence on aeration and on the availability of plant nutrients. The kinds of organisms most active in a soil determine, to some extent, the degree of losses, gains, or translocation of nutrients and organic matter.

Time

Many important characteristics of soils are determined by the length of time the active soil-forming processes have been effective. Young soils show little horizon differentiation. Most soil materials that have weathered over a long period of time, however, develop distinct horizons as the result of clay minerals moving downward in the profile and accumulating in the B horizon. In the earlier stages of soil development, the soil material is much alike throughout the profile, except for differences in color. Later, definite amounts of clay accumulate, and, eventually, a claypan may form.

Classification of Soils

The combined soil-forming processes that have acted in San Juan County have resulted in the development of soils that are classified in six great soil groups. An explanation of the classification of great soil groups and their properties was outlined by Baldwin, Kellogg, and Thorp in "Soils and Men" (*8*), and this explanation was later modified by Thorp and Smith (*7*). Using the standards that these men outlined as the basis for classifying soils into higher categories, the soils of San Juan County were classified in the Brown Podzolic, "Prairielike," Humic Gley, Bog, and Alluvial great soil groups as shown in table 10.

Most soil series have characteristics that are representative of one or another of the great soil groups, and are classified accordingly. A few soil series, however, have some characteristics of two great soil groups. Such soil series are placed in the great soil group they resemble most closely, but they are classified as intergrading to other great soil groups. For example, soils, such as those in the Roche series, have the major characteristics of the Brown Podzolic group, but they also have less strongly expressed, lower horizons of clay accumulation that are somewhat characteristic of Gray-Brown Podzolic soils. Such soils are classified, therefore, as Brown Podzolic soils intergrading toward the Gray-Brown Podzolic group.

The classification of the soils in this county was based mainly on observations made in the field. Possibly, as more information is obtained, some of the soils listed under one group may be changed to another, or a new great soil group may be defined to accommodate soils that do not fit into the established classification.

BROWN PODZOLIC SOILS

The Brown Podzolic soils consist of somewhat excessively drained to moderately well drained, medium acid soils that have relatively thin A_{oo} and A_o horizons. In these soils there is an abrupt boundary between the A_o horizon and the dark-brown, brown, or reddish-brown, weak B_{ir} horizon. The lower part of the B_{ir} horizon grades to dark yellowish brown or light yellowish brown, but there is no appreciable increase in the content of clay.

TABLE 10.—*Soil series classified by soil orders and great soil groups and factors that have contributed to their morphology*

ZONAL SOILS

Great soil group and series	Relief	Natural drainage	Parent material
Brown Podzolic soils:			
Alderwood	Gently undulating to hilly	Good	Cemented, gravelly till.
Bow [1]	Gently undulating to hilly	Imperfect	Fine-textured till.
Everett	Nearly level to hilly	Somewhat excessive	Loose, gravelly drift.
Indianola	Nearly level to hilly	Somewhat excessive	Loose, sandy till.
Pickett	Rolling to very steep	Good	Sandstone and glacial till.
Roche [2]	Gently undulating to hilly	Moderately good	Moderately coarse textured, dense till.
"Prairielike" soils:			
San Juan	Gently undulating to strongly sloping.	Somewhat excessive	Loose, gravelly outwash.
INTRAZONAL SOILS			
Humic Gley soils:			
Bellingham	Nearly level	Poor	Glacial-lake sediments or clay till.
Coveland [3]	Very gently sloping to gently sloping.	Imperfect	Glacial-lake sediments or clay till.
Hovde	Nearly level	Poor	Marine sand.
Norma [4]	Nearly level	Poor	Sandy drift.
Bog soils:			
Orcas	Nearly level	Very poor	Accumulations of moss.
Semiahmoo	Nearly level	Very poor	Accumulations of sedges.
Tanwax	Nearly level	Very poor	Accumulations of sedimentary organic material.
AZONAL SOILS			
Alluvial soils:			
Neptune	Nearly level	Somewhat excessive	Marine sands and shells.

[1] The Bow soils are Brown Podzolic soils intergrading toward Low-Humic Gley soils.

[2] The Roche soils are in the Brown Podzolic great soil group but are intergrading toward Gray-Brown Podzolic soils.

[3] The Coveland soils are Humic Gley soils intergrading toward Planosols.

[4] The Norma soils are Humic Gley soils intergrading toward the Ground-Water Podzol group.

In places the underlying material is parent bedrock; in other places it is fine-textured glacial (basal) till, possibly of Puyallup interglacial age; in still other places it consists of cemented, coarse-textured (basal) till of the Vashon glacial epoch or of loose and porous, coarse-textured, stratified glacial drift and outwash.

The Brown Podzolic soils of San Juan County have formed under a mild maritime climate where the annual precipitation ranges from 20 to 30 inches. The summers in this area are cool and dry, and the winters are mild and wet. The average annual temperature ranges from about 42° F. at the higher elevations to about 48° F. near sea level. Little snow falls in winter, and the ground is seldom frozen more than 5 to 10 days at a time. These conditions have caused the soils to be only weakly podzolized. In most places there is only a weak sprinkling of bleached grains of sand immediately below the thin A_0 horizon. In a few profiles, however, there is a thin, discontinuous A_2 horizon.

Six soil series—the Alderwood, Bow, Everett, Indianola, Pickett, and Roche—are in the Brown Podzolic great soil group in this county. The Alderwood soils are underlain by moderately coarse textured glacial till; the Bow soils, by compact Vashon glacial till; the Everett and Indianola soils, by loose, porous glacial drift or till; the Pickett soils, by material weathered from the parent bedrock; and the Roche soils, by cemented, coarse-textured glacial till.

Alderwood Series—The Alderwood series consists of well-drained, medium-textured to moderately coarse textured soils formed in ablation till overlying strongly cemented, gravelly basal till. The till is moderately coarse textured to coarse textured and was derived from basalt, granite, diabase, sandstone, shale conglomerate, and quartzite. The soils are nearly level to hilly and occur in uplands where the vegetation is a dense forest of conifers.

The Alderwood soils are associated with the Roche and Everett soils. They are somewhat better drained than the Roche soils, and, unlike the Roche soils, overlie till that is not laminated. The Alderwood soils differ from the Everett soils in that they overlie cemented glacial till rather than stratified, loose glacial outwash.

Profile of an Alderwood gravelly loam (SW¼NE¼SW¼ sec. 35, T. 37 N., R. 2 W., 4 miles northeast of Orcas):

A_{00} 2½ to 2 inches of leaves, needles, and twigs from conifers, alders, and ferns; medium acid; abrupt, smooth boundary.

A_0 2 inches to 0, very dark brown (10YR 2/2), decomposed leaves, twigs, and needles, dark grayish brown (10YR 4/2) when dry; slightly acid; abrupt, smooth boundary.

B_{21ir} 0 to 12 inches, dark-brown (7.5YR 4/4) gravelly loam, brown (7.5YR 5/4) when dry; moderate, fine, granular; soft, friable, nonsticky and nonplastic; abundant fine roots; slightly acid; clear, wavy boundary.

B_{22ir} 12 to 21 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam, yellowish brown (10YR 5/4) when dry; single grain; loose or very friable; plentiful roots; medium acid; clear, wavy boundary.

C_1 21 to 30 inches, light olive-brown (2.5Y 4/4) gravelly sand, light yellowish brown (2.5Y 5/4) when dry; single grain; loose, moist or dry; neutral; plentiful fine and medium roots; clear, wavy boundary.

C_2 30 to 42 inches, olive-gray (5Y 4/2) gravelly sand, pale olive (5Y 6/3) when dry; single grain; loose, moist or dry; few roots that spread out abruptly along lower boundary; neutral; abrupt, wavy boundary.

C_m 42 to 66 inches, dark yellowish-brown (10YR 4/4) gravelly sand, yellowish brown (10YR 5/6) when dry; massive; strongly cemented; very few roots except in fractures; neutral; many feet thick.

Range in characteristics.—The hues in the surface layer range from 7.5YR to 10YR, and the hues in the subsoil, from 10YR to 2.5Y or 5Y. The thickness of the solum ranges from 28 to 48 inches. Cementation of the C_m horizon ranges from weak to strong. In places there is an A_2 horizon that is thin and discontinuous. In places occasional thin, patchy clay films occur in the lower part of the B_{ir} horizon. The amount of gravel in the surface layer and subsoil ranges from 15 to 25 percent.

Bow Series.—The Bow series consists of imperfectly drained, medium-textured Brown Podzolic soils intergrading toward Low-Humic Gley soils. The soils formed in compact Vashon glacial till of medium to fine texture (interstratified silt and clay). The soils are gently sloping to undulating and formed under a dense coniferous forest. The runoff from the Bow soils is slow to rapid, depending upon the slope, and permeability is slow through the subsoil.

The Bow soils have bisequal profiles. Characteristically, they have a podzolic B horizon, overlying an A_2, and a textural B horizon. The A_2 horizon is thick; in many places it has tongues that extend downward into the textural B horizon (fig. 18). The A_2B_2 horizon overlies a strong textural B horizon, which has characteristics like those of the B horizon of the Low-Humic Gley soils.

The Bow soils are associated geographically with the Roche soils. They are imperfectly drained, and the Roche soils are moderately well drained. The Bow soils have a weaker podzolic B horizon than the Roche soils and have a clayey B horizon in their lower sequum. The Bow soils resemble the Coveland soils, but they lack the black surface layer that characterizes the Coveland soils. Where the Bow soils are associated with the Coveland soils, they are at a somewhat higher elevation than in areas where they are associated with the Roche soils.

Profile of a Bow gravelly loam (SE¼SE¼ sec. 35, T. 34 N., R. 3 W., 1 mile east of False Bay):

A_{00}, A_0 2 inches to 0, organic litter composed of needles, leaves, twigs, and moss, with the lower part consisting of partially decomposed, black, greasy organic matter.

B_{2irh} 0 to 11 inches, dark-brown (10YR 3/3, moist) and very dark grayish-brown (10YR 3/2, moist) gravelly loam with some variations of grayer colors; moderate, fine, granular structure; slightly hard, friable, slightly plastic and slightly sticky; many medium pores; abundant fine and large roots; pH 6.7; clear, wavy lower boundary.

***Figure 18.*—Typical profile of a Bow gravelly silt loam showing the bisequal profile. Tongues from the A_2 horizon extend downward into the prismatic B_2 horizon.**

A_2B_2 11 to 16 inches, the B_2 consists of dark grayish-brown (10YR 4/2, moist) gravelly clay loam, and the A_2 consists of tongues of gray (10YR 5/1, moist) and brown (10YR 5/3, moist) gravelly fine sandy loam; the A_2B_2 composite texture is gravelly loam; the structure of the B_2 horizon is strong, fine, angular blocky, and the A_2 horizon is massive; consistence is very hard, very firm, plastic and sticky; few roots, chiefly along the surfaces of peds; common, fine and very fine, tubular pores; continuous, moderately thick clay films on the surfaces of peds in the B_2 horizon; a few, fine, faint mottles of dark reddish brown; pH 6.9; clear, wavy lower boundary.

B_{23} 16 to 32 inches, gray (5Y 5/1, moist) silty clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/6, moist); clay coatings are olive gray (5Y 4/2, moist), and there are some coatings of organic material of very dark grayish brown; strong, medium, prismatic structure to strong, coarse, angular blocky structure that is moderate to strong in the lower half; thick, continuous clay films on the horizontal and vertical surfaces of peds in the B_2 horizon and in the pores; very few pores in the peds and very few roots along the faces of peds; in places there is tonguing of the A_2 horizon in the upper 3 inches of the horizon; very hard, very firm, very plastic and very sticky; pH 6.9; abrupt, wavy lower boundary.

TABLE 11.—*Physical characteristics of a Bow gravelly loam*

[Determinations made by Riverside, Calif., Soil Survey Laboratory]

Sample number and horizon	Depth	Particle size distribution (in mm.)										Textural class
		Very coarse sand (2.0 to 1.0)	Coarse sand (1.0 to 0.5)	Medium sand (0.5 to 0.25)	Fine sand (0.25 to 0.10)	Very fine sand (0.10 to 0.05)	Silt (0.05 to 0.002)	Clay (Less than 0.002)	Other classes			
									0.2 to 0.02	0.02 to 0.002	More than 2.0	
Sample numbers 56472–56477:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
A_{00}, A_0	2–0	Organic material.										
B_{2irh}	0–11	6. 5	11. 7	7. 7	6. 4	5. 5	48. 7	13. 5	27. 0	30. 4	23	Gravelly loam.
A_2B_2	11–16	3. 8	8. 4	6. 2	6. 0	5. 1	45. 0	25. 5	22. 9	30. 3	19	Gravelly loam.
B_{23}	16–32	. 9	2. 6	2. 9	6. 6	6. 8	43. 5	36. 7	24. 4	29. 9	2	Silty clay loam.
B_{3u}	32–40	. 1	. 3	. 5	1. 2	1. 1	48. 3	48. 5	10. 6	39. 5	0	Silty clay.
D	40–50	. 1	. 3	. 5	1. 4	1. 6	45. 9	50. 2	6. 6	41. 8	0	Silty clay.

B_{3u} 32 to 40 inches, gray (5Y 5/1, moist) silty clay; weak, coarse, prismatic or weak, coarse, angular blocky structure to massive; interior of peds is olive gray (5Y 4/2, moist); consistence is extremely hard, very firm, very plastic and very sticky; very few fine pores and no roots; thin, continuous clay films on the surfaces of peds and in pores; pH 7.4; gradual, wavy lower boundary.

D 40 to 50 inches, gray (5Y 5/1, moist) silty clay; massive; extremely hard, very firm, very plastic and very sticky; pH 7.6; continuous to a depth of many feet.

Range in characteristics.—Variations in these soils are chiefly in the color and depth of the surface layer. The color of the surface layer ranges from light brownish gray or pale brown to dark brown or grayish brown, and the depth, from 4 to as much as 14 inches. In places virgin profiles have a very thin, discontinuous A_2 horizon that underlies an A_0 horizon and overlies the podzolic B horizon.

The lower part of the profile consists of a buried A_2 horizon over a textural B horizon. The lower sequum is a Low-Humic Gley soil. In places the A_2 horizon has a clear, wavy boundary. In other places tongues from the A_2 horizon extend downward through the entire upper B horizon.

Laboratory analysis.—Although this soil has the functional properties of a Planosol, textural analysis (see table 11) indicates that the functional properties are caused by stratification. The stratification appears to have been caused as the result of ablation till overlying a dense basal till that has properties resembling a fragipan. The B_{23} and B_{3u} horizons are dense, very hard, and very slowly permeable. Consequently, the overlying A_2B_2 horizon has gley characteristics. The B_{23} and B_{3u} horizons effectively limit the penetration of roots, and windthrow is common where trees are grown on this soil.

Everett and Indianola Series.—The Everett and Indianola soils are similar in having formed from till or glacial drift. The Everett soils formed on gravelly sandy drift and contain gravel. The Indianola soils are nearly free of gravel throughout. The Everett and Indianola soils have a rapidly to very rapidly permeable subsoil.

The Everett series consists of somewhat excessively drained, moderately coarse textured soils of the Brown Podzolic group that formed in coarse textured or very coarse textured, loose Vashon glacial drift. The soils are mainly undulating to gently rolling, but there are some steeper escarpments. Runoff from these soils is very slow to slow. The vegetation is a dense forest of conifers.

The substratum of the Everett soils is stratified sand and fine gravel. Typically, these soils do not have an A_2 horizon, and the A_2 horizon, if present, is thin and discontinuous.

The Everett soils are associated with Indianola and Roche soils. Their profile is more gravelly throughout than that of the Indianola soils. The Everett soils are distinguished from the Roche soils by their subsoil of loose, poorly stratified gravel and sand, as contrasted to the substratum of dense till underlying the Roche soils. Where the Everett soils are associated with the Roche soils, they are at a somewhat lower elevation than where they occur with other soils. Where they occur near the Indianola soils, they are at nearly the same elevation.

Profile of an Everett gravelly sandy loam (NW¼NE¼ sec. 7, T. 34 N., R. 2 W., on Cattle Point):

A_{00} 1½ inches to ½ inch of moss, leaves, needles, and twigs; pH 5.5.

A_0 ½ inch to 0, very dark brown (10YR 2/2) accumulation of decayed needles, leaves, twigs, and moss, dark yellowish brown (10YR 4/2) when dry; has soft, greasy feel; pH 5.5.

B_{2ir} 0 to 7 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam, yellowish brown (10YR 5/4) when dry; weak, fine, granular structure; soft, very friable, and slightly plastic; roots abundant; pH 6.0. 5 to 10 inches thick.

B_3 7 to 24 inches, yellowish-brown (10YR 5/4) gravelly fine sandy loam, light yellowish brown (10YR 6/4) when dry; weak, very fine, granular structure; soft, very friable; 25 percent of layer is gravel; many coarse pores; roots plentiful; pH 6.0. 8 to 30 inches thick.

C 24 inches +, grayish-brown (10YR 5/2) very gravelly coarse sand consisting of gray, black, and brown grains of sand, light brownish gray (10YR 6/2) when dry; single grain; loose; more than 30 percent of layer is gravel; few roots.

Range in characteristics.—In San Juan County soils classified in the Everett series have a somewhat finer textured B_{2ir} horizon and show more stratification of sand and fine gravel in the substratum than is normal for Everett soils in other areas in the vicinity of Puget Sound. In this county the Everett series includes soils that have an A_1 horizon, from 1 to 3 inches thick, which is very dark grayish brown (10YR 3/2) when moist. The texture of the A_1 horizon ranges from loam to gravelly sandy loam. In places the Everett soils on Orcas Island are medium textured, but those on San Juan and Lopez Islands are moderately coarse textured. Depth to the very gravelly substratum ranges from about 24 inches to 50 inches or more.

Indianola Series.—The Indianola series is made up of somewhat excessively drained, moderately coarse textured soils of the Brown Podzolic group that formed in loose, coarse textured Vashon glacial till. The soils are nearly level to hilly and have formed in uplands under a dense forest of conifers. Runoff from these soils is very slow to slow.

The Indianola soils have a substratum of fine sand. They lack a well-defined A_2 horizon, although, in a few places, bleached grains of sand are present.

The Indianola soils are associated with the Everett soils and are similar to those soils. They have a sequence of horizons that is comparable to that of the Everett soils, and they have hues of 10YR. The Indianola soils differ from the Everett soils in being nearly free of gravel.

Profile of an Indianola sandy loam (NE¼SE¼ sec. 21, T. 37 N. R. 2 W., 2 miles southeast of East Sound):

A_{00} 1½ inches to 0, needles, leaves, twigs, and moss; 1 to 3 inches thick.

A_1 0 to 2 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) when dry; strong, fine, granular structure; soft, very friable, nonsticky and slightly plastic; many medium pores; abundant roots; pH 6.2; abrupt, wavy boundary. 2 to 4 inches thick.

B_{21ir} 2 to 15 inches, dark yellowish-brown (10YR 4/4) sandy loam, light yellowish brown (10YR 6/4) when dry; weak, fine, subangular blocky structure; soft, very friable, nonsticky and nonplastic; many medium pores; abundant roots; pH 6.6; gradual, wavy boundary. 8 to 18 inches thick.

B_{22ir} 15 to 24 inches, yellowish-brown (10YR 5/4) loamy sand, light yellowish brown (10YR 6/4) when dry; weak, fine, subangular blocky structure that breaks readily to single grain; slightly hard, firm in place, and very friable to loose under slight pressure; many medium pores; abundant roots; pH 6.6; clear, wavy boundary. 10 to 20 inches thick.

C 24 to 54 inches, olive-brown (2.5Y 4/4) fine sand, light olive brown (2.5Y 5/4) when dry; contains about 5 percent gravel; single grain; loose; pH 6.6.

Range in characteristics.—In some areas the profile contains small amounts of gravel. There are small areas in which the sandy till overlies fine-textured till, which is at a depth of more than 60 inches. In one area on Orcas Island, bedrock is at a depth of about 60 inches. The B_{ir} horizon in the Indianola soils ranges in thickness from a few inches to about 36 inches. In places the B_{ir} horizon is so thin that the profile more nearly resembles that of a Regosol rather than the profile of a soil in the Brown Podzolic great soil group.

Pickett Series.—The Pickett series consists of soils that are reddish brown, gravelly, and stony. The soils formed in material weathered from arkose sandstone, modified slightly by medium-textured Vashon glacial till. The soils are well drained and medium textured. They are classified as Brown Podzolic soils. The Pickett soils are rolling to very steep and developed under a dense forest of conifers. Generally, they are at an elevation of less than 1,300 feet. Runoff from these soils is medium to rapid.

Typically, the sequence of horizons in the Pickett soils is A_2, B_{ir}, C, and D_r. The A_2 horizon is thin and discontinuous.

The Pickett soils resemble the Fidalgo soils, which are not mapped in San Juan County. Their parent material differs from that of the Fidalgo soils in that the Fidalgo soils formed in material weathered from bedrock that resembles serpentine. The soils of the two series also differ in that the Fidalgo soils lack an A_2 horizon and are strongly acid. The Pickett soils are slightly acid to neutral.

The Pickett soils resemble the Oso soils, which, like the Fidalgo soils, are not mapped in San Juan County. The Oso soils formed in material weathered from argillite.

Profile of a Pickett stony loam (NW¼SE¼ sec. 27, T. 37 N., R. 1 W., 0.6 mile southwest of Mt. Pickett):

A_{00} 2½ to 1½ inches of needles, twigs, and moss.

A_0 1½ inches to 0, black (10YR 2/1), decomposed mat consisting of moss and needles and twigs from Douglas-fir, hemlock, and lodgepole pine; very dark gray (10YR 3/1) when dry; greasy consistence; pH 4.6; abrupt, smooth boundary.

A_2 0 to ⅛ inch, gray (10YR 6/1) sand; light-gray (10YR 7/1) when dry; single grain.

B_{2ir} ⅛ inch to 10 inches, dark reddish-brown (5YR 3/4) stony loam, dark reddish brown (5YR 4/4) when dry; contains a mixture of sandstone fragments and occasional rounded glacial pebbles; moderate, fine, granular structure; slightly hard, friable, nonsticky and slightly plastic; common fine pores; roots abundant; pH 6.4; gradual, wavy boundary.

B_3 10 to 36 inches, brown (7.5YR 4/4) gravelly silt loam (angular sandstone pebbles and stones), light brown (7.5YR 6/4) when dry; moderate, fine, subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; roots abundant; thin, patchy clay films in pores and as bridges between peds; pH 6.6; gradual, wavy boundary.

C 36 to 50 inches, olive (5Y 5/3) stony fine sandy loam containing occasional flat, flaggy fragments of sandstone, pale olive (5Y 6/3) when dry; moderate, fine, angular blocky structure; friable, firm in place, nonsticky and slightly plastic; roots plentiful to a depth of 42 inches, but very few roots below that depth; pH 6.4; clear, wavy boundary.

D_r 50 inches +, fractured sandstone.

Range in characteristics.—In some areas material consisting of angular gravel is on the surface of these soils. There are also areas with some rounded pebbles of glacial age. Near Deer Harbor and West Sound, as much as 50 percent of the gravelly material consists of rounded glacial pebbles, and the rest consists of angular pieces of weathered sandstone. The depth of the soil over bedrock ranges from 8 to more than 50 inches.

Roche Series.—The Roche series consists of soils that are moderately well drained and medium textured to moderately coarse textured. The soils formed in dense, medium-textured Vashon glacial till, dominantly interstratified with silt and clay. They are undulating to gently rolling and formed under a dense forest of conifers.

These soils have a bisequal profile, typically without an A_2 horizon. In the profiles where the A_2 horizon is present, it is thin and discontinuous. In most places the Brown Podzolic profile overlies the profile of an old Gray-Brown Podzolic soil that varies in thickness and in degree of horizonation.

The Roche soils are classified as Brown Podzolic soils intergrading to Gray-Brown Podzolic soils. The Roche soils occur in association with the Bow soils. The soils of the two series are similar, but the Bow soils are more nearly level than the Roche. Also, the B_{1r} horizon of the Bow soils has a moderate, fine, granular structure and overlies moderately fine textured, planosolic horizons in which the structure is prismatic.

The Roche soils resemble the Alderwood soils, but their parent material differs in that it contains less gravel than that of the Alderwood soils. The Alderwood soils formed in cemented, sandy basal till that contains gravel.

The soils of the Roche series formed under a mild maritime climate in which the average annual precipitation is approximately 23 inches. In the area in which they formed, the summers are cool and the winters are mild. The average temperature in January is 40° F., the average temperature in July is 56° F., and the average annual temperature is 48° F. There is an average frost-free season of 229 days.

Profile of a Roche gravelly loam (SE¼NE¼ sec. 32, T. 36 N., R. 3 W., about 3½ miles northwest of Friday Harbor):

A_{00} 2 inches to 1 inch, organic litter composed of loose needles and leaves.

A_0 1 inch to 0, partially decomposed needles, leaves, and twigs; greasy; abrupt, smooth lower boundary.

B_{2ir} 0 to 9 inches, dark-brown (7.5YR 3/4) gravelly loam, light brown (7.5YR 5/4) when dry; weak, fine, granular structure; slightly hard, friable, slightly plastic and slightly sticky; many fine pores; abundant roots; slightly acid; abrupt, wavy boundary.

A_2 9 to 17 inches, grayish-brown (10YR 5/2) fine sandy loam, light brownish gray (10YR 6/2) when dry; occasional small lumps of material from the overlying B_{2ir} horizon and underlying textural B_2 horizon; massive; hard, firm, nonsticky and nonplastic; medium acid; clear, wavy boundary.

A_2B_2 17 to 24 inches, olive-gray (5Y 5/2) fine sandy loam, light olive gray (5Y 6/2) when dry; many, medium and coarse, distinct mottles of strong brown (7.5YR 5/6); massive to weak, thin, platy structure and weak, fine, subangular blocky structure in mottled areas; the mottled areas are slightly finer textured than the surrounding areas; thin, patchy clay films on the surfaces of peds in B_2 horizon; very hard, very firm, plastic and sticky; few pebbles; very few roots, most of which are growing horizontally; common fine pores; medium acid; clear, wavy lower boundary.

C_1 24 to 34 inches, olive (5Y 5/3) fine sandy loam, pale olive (5Y 6/3) when dry; many, coarse, distinct mottles of reddish brown (5YR 4/4) and yellowish red (5YR 5/6) and some light-gray horizontal lenses; massive to weak, thin, platy structure; mottles have a horizontal pattern; very hard, very firm, plastic and sticky; very few roots; medium acid; clear, wavy boundary.

C_2 34 to 48 inches, olive (5Y 4/3) gravelly fine sandy loam, olive gray (5Y 4/2) when dry; streaks of olive-gray (5Y 5/2) sandy clay loam; a few, medium, distinct mottles; massive to weak, thin, platy structure; very hard to extremely hard, plastic and sticky; no roots; thin clay films between fine plates; the plates are thought to be of geological origin; medium acid.

Range in characteristics.—In cultivated areas the organic mat that originally covered the Roche soils has been destroyed. The A_2 horizon is commonly missing in the upper sequum. In places there is an A_1 horizon that is 2 to 4 inches thick. In the areas where the soil is intergrading to the Bow soils, the A_2B_2 horizon is not distinct. It is believed that the C_1 horizon consists of older geologic material, presumably Puyallup interglacial sediments, and that it underlies all the Roche soils.

The sandier lenses occur at a depth of about 55 inches or greater in all the Roche soils. The lenses are brown (2.5Y 4/4, moist) and have a texture of gravelly sandy loam.

In the Roche loams that have an A_2B_2 horizon, the C_1 horizon is normally at a depth of 42 inches. In the Roche loams that do not have an A_2B_2 horizon, on the other hand, the C_1 horizon is typically at a depth of 33 inches. The Roche soils without an A_2B_2 horizon are inclusions within the series. They occupy about 10 percent of the acreage classified as Roche soils.

Laboratory analysis.—Analysis of the texture of the Roche soils indicates that slight stratification occurs between the C_1 and C_2 horizons. Evidence of stratification is absent in the overlying horizons. The substratum of these soils has platiness, color, and textural characteristics similar to those in the Coveland soils. It has properties that resemble a fragipan. The bulk density increases from 1.66 in the A_2 horizon to 1.89 in the C_1 horizon. The surfaces of the plates have thin clay films.

The C_1 horizons are hard to extremely hard when dry, and they effectively restrict the penetration of roots. Although these soils are moderately well drained, the C_1 horizons restrict internal soil drainage and cause the solum to become saturated during the winter and spring seasons.

When the Roche soils are examined in the field, the texture appears to be moderately fine. Laboratory determination, however, shows them to be medium textured to moderately coarse textured (see table 12). The difference is presumed to be caused by allophane, which is difficult to disperse after it has dried.

"PRAIRIELIKE" SOILS

"Prairielike" soils have a black surface layer and developed under grasses and ferns. In this county they have developed under a mild maritime climate in which the average annual precipitation is 20 to 25 inches. In the areas where these soils occur, microclimatic influences, caused by exposure, wind currents, evapotranspiration, and differences in soil materials, have produced an environment suited to the growth of a grass-fern type of vegetation rather than forest. The San Juan series is the only series in this county classified as "Prairielike."

San Juan Series.—The San Juan series consists of coarse-textured soils that are somewhat excessively drained. The soils formed in loose glacial drift or recessional moraine materials of mixed origin. They formed under grass-fern vegetation and have a thick, dark-colored A horizon.

Profile of a San Juan sandy loam that has been cultivated (SW¼NW¼NE¼ sec. 12, T. 34 N., R. 3 W.):

A_{1p} 0 to 6 inches, very dark brown (10YR 2/2, dry) sandy loam, black (10YR 2/1) when moist; moderate, very fine and fine, granular structure; soft, very friable, very slightly plastic; high in organic matter; abundant fine roots; pH 5.6; gradual, smooth boundary.

A_{12} 6 to 15 inches, very dark brown (10YR 2/2, dry) sandy loam, black (10YR 2/1) when moist; moderate, fine, granular and weak, prismatic structure; soft, very friable; high in organic matter; abundant fine roots; many pores; pH 5.6; abrupt, wavy boundary.

B_1 15 to 19 inches, dark-brown (10YR 3/3, dry) loamy coarse sand, dark brown (7.5YR 3/2) when moist; weak, fine, prismatic and fine, granular structure; soft, very friable, nonsticky and nonplastic; many medium, tubular pores; plentiful fine roots; 10 percent gravel finer than 10 millimeters; pH 6.0; gradual, wavy boundary.

B_2 19 to 23 inches, dark-brown (10YR 3/3, dry) loamy coarse sand, very dark grayish brown (10YR 3/2) when moist; weak, fine, prismatic structure and fine, granular; soft, very friable, nonsticky, nonplastic; many medium and fine pores; plentiful fine roots; pH 6.0.

C_1 23 to 29 inches, brown (10YR 4/3, dry) gravelly loamy coarse sand; dark brown (10YR 3/3) when moist; single grain; loose, nonsticky and nonplastic; very porous; contains 20 percent fine gravel; few roots; pH 6.4; gradual lower boundary.

C_2 29 to 60 inches +, light yellowish-brown (2.5Y 6/4, dry) gravelly coarse sand, light olive brown (2.5Y 5/4) when moist; single grain; loose; very porous; pH 6.6; 50 percent fine gravel.

Range in characteristics.—The texture of the surface layer in the San Juan soils ranges from loam to sandy loam or very fine sandy loam. In places it contains some fine gravel or stones.

The San Juan soils that are moderately deep over clay till are bisequal soils. The upper part is typical of the series. The lower sequum is a paleosol, probably consisting of Puyallup interglacial sediments, having buried A_2, A_2B_2, and B_2 horizons. The properties of the paleosol are similar to those of the lower sequum of the associated Bow and Coveland soils.

HUMIC GLEY SOILS

Humic Gley soils are poorly drained or imperfectly drained. They have moderately thick, dark-colored, organic-mineral surface horizons that are underlain by mineral gley horizons. In San Juan County the soils of this great soil group occur in low areas in the glaciated uplands and in areas surrounded by uplifted, old marine soils.

These soils have developed under a dense cover of mixed deciduous and coniferous trees, brush, and plants that tolerate water. This particular combination of plants, growing in a wet environment, has added large amounts of organic matter to the soils and has caused the soils to have a dark-colored surface layer. The horizons below the A_1 are gleyed and contain slightly more clay than the A_1. In San Juan County the Bellingham, Coveland, Hovde, and Norma soils are in this great soil group.

Bellingham Series.—The Bellingham series consists of poorly drained, medium-textured to moderately fine textured soils formed in fine textured lacustrine sediments. The soils are nearly level and occur in the glaciated uplands under a dense forest of conifers. Runoff is ponded. The soils have very slow permeability. Typically, they have gleyed B and C horizons (fig. 19).

The Bellingham soils occur in association with the Alderwood soils. Also, in depressions, they are associated with the Coveland, Roche, and Bow soils. The Bellingham and Coveland soils are somewhat similar, but the Bellingham are more nearly level and are poorly drained. Also, they have a very dark brown surface layer, whereas the Coveland soils have a black surface layer underlain by a moderately fine textured B horizon. The Bellingham soils resemble the soils of the Norma series more than they resemble other soils, but they lack sandy horizons in the lower part of the B and in the C horizons.

Profile of a Bellingham silt loam (SE¼NE¼ sec. 28, T. 35 N., R. 3 W.):

A_p 0 to 8 inches, very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) when dry; moderate, medium and fine, granular structure; hard, friable, slightly plastic and slightly sticky; high content of organic matter; abundant roots; slightly acid; abrupt, smooth boundary.

B_{21g} 8 to 25 inches, olive-gray (5Y 5/2) silty clay loam, light olive gray (5Y 6/2) when dry; many, fine and medium, distinct mottles of yellow and brown; moderate, coarse, prismatic and strong, medium, angular blocky structure; hard, firm, very sticky, very plastic; few roots; moderately thick, continuous clay films on the surfaces of peds and in pores; slightly acid; abrupt, wavy boundary.

TABLE 12.—*Physical characteristics of a Roche gravelly loam*

[Determinations made by Riverside, Calif., Soil Survey Laboratory]

Sample numbers and horizon	Depth	Particle size distribution (in mm.)										Textural class
		Very coarse sand (2.0 to 1.0)	Coarse sand (1.0 to 0.5)	Medium sand (0.5 to 0.25)	Fine sand (0.25 to 0.10)	Very fine sand (0.10 to 0.05)	Silt (0.05 to 0.002)	Clay (Less than 0.002)	Other classes: 0.2 to 0.02	Other classes: 0.02 to 0.002	Other classes: More than 2.0	
Sample numbers 56498–56503:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
A_{00} and A_0	2–0	Organic material.										
B_{2ir}	0–9	2. 2	3. 8	5. 9	19. 0	13. 1	47. 5	8. 5	46. 8	26. 2	19	Gravelly loam.
A_2	9–17	1. 1	5. 0	8. 0	24. 9	15. 1	38. 9	7. 0	49. 4	20. 2	7	Fine sandy loam.
A_2B_2	17–24	1. 3	4. 9	7. 8	24. 0	15. 1	37. 5	9. 4	48. 3	19. 3	11	Fine sandy loam.
C_1	24–34	1. 3	5. 6	8. 7	24. 9	13. 4	36. 6	9. 5	47. 7	17. 8	10	Fine sandy loam.
C_2	34–48+	3. 3	6. 4	8. 8	23. 3	12. 4	37. 1	8. 7	43. 4	20. 4	22	Gravelly fine sandy loam.

B_{22g} 25 to 37 inches, gray (5Y 5/1) silty clay loam, light gray (5Y 7/1) when dry; many, medium, prominent mottles of yellow, brown, and reddish brown; massive to weak, coarse, prismatic and moderate, medium, angular blocky structure; extremely hard, firm, very plastic and sticky; very few roots along the surfaces of prisms; thin to moderately thick, continuous clay films on the surfaces of peds and in pores; neutral; gradual, wavy boundary.

C_{1g} 37 to 43 inches, gray (5Y 5/1) clay, light gray (5Y 7/1) when dry; common, medium and fine, distinct mottles of reddish brown; massive to weak, medium, prismatic structure; extremely hard, firm, very sticky, very plastic; contains few pebbles; few patchy clay films in pores; common, fine and very fine, tubular pores; neutral; many feet thick.

C_{2gu1} 43 to 51 inches, dark-gray (5Y 4/1) clay or loam, light gray (5Y 7/1) when dry; common, medium, distinct mottles of reddish yellow; massive; hard, friable to firm, plastic and sticky; mildly alkaline; contains numerous seashells; irregular boundary.

C_{3gu2} 51 to 57 inches +, dark-gray (5Y 4/1) sandy clay or fine sandy loam, light gray (5Y 7/1) when dry; common, faint mottles of reddish yellow in clay lenses; massive; hard, friable, plastic, sticky; contains numerous seashells and pebbles of hornblende granite; moderately alkaline.

Range in characteristics.—The A horizon ranges from silt loam to clay loam in texture and from very dark brown to black in color. The underlying strata range from gravelly clay to clayey till. The presence of seashells is uncommon in the substrata of Bellingham soils in the Puget Sound Area.

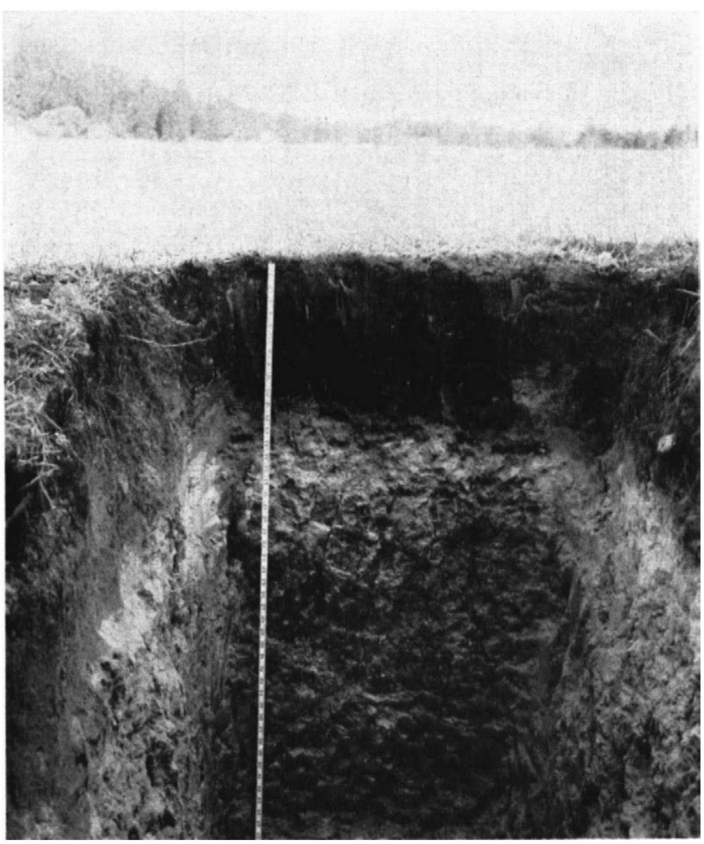

***Figure 19.*—Profile of a Bellingham silt loam. This soil has dark-colored A_p and A_{12} horizons, a light-colored A_2 horizon, and a prismatic B_2 horizon.**

Coveland Series.—The Coveland series consists of imperfectly drained, medium-textured soils formed in fine-textured glacial till. The soils are nearly level to gently undulating. The native vegetation under which they formed was mainly grasses and sedges, but in places there were small areas occupied by thin stands of Oregon white oak and Douglas-fir. The permeability of the subsoil in the Coveland soils is very slow, and runoff is slow to medium.

The Coveland soils have a black surface layer and a lighter colored, bleached A_2 horizon that overlies a B_{21t} horizon of firm clay. In many places tongues from the A_2 horizon extend downward into the B_{21t} horizon. Therefore, the Coveland soils are classified as Humic Gley soils intergrading to Planosols.

The Coveland soils are associated with the moderately well drained Roche soils, but they lack the podzolic B horizon that is characteristic of the Roche soils. The Coveland soils resemble the imperfectly drained Bow soils, but they have a black A_1 horizon and lack the podzolic B horizon that overlies the buried A_2 horizon in the Bow soils. A large part of the acreage of Coveland soils is ponded at times. Nevertheless, these soils are slightly better drained than the Bow soils, although the Bow soils have somewhat stronger slopes.

Profile of a Coveland silt loam (NW¼NE¼ sec. 34, T. 35 N., R. 3 W.):

A_{11} 0 to 6 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; moderate, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; abundant roots; medium acid; clear, smooth lower boundary.

A_{12} 6 to 12 inches, black (10YR 2/1) gravelly silt loam; dark gray (10YR 4/1) when dry; moderate, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; abundant roots; medium acid; abrupt, wavy boundary.

A_{13} 12 to 16 inches, dark-brown (10YR 3/2) gravelly sandy loam, brown (10YR 5/3) when dry; weak, prismatic structure breaking to moderate and coarse, medium, subangular blocky; slightly hard, friable, nonsticky and nonplastic; plentiful roots; slightly acid; clear, smooth boundary.

A_2 16 to 19 inches, light brownish-gray (2.5Y 6/2) sandy clay loam, light gray (10YR 7/2) when dry; massive; hard, firm, slightly sticky and slightly plastic; roots plentiful; neutral; clear, wavy boundary.

A_2B_2 19 to 25 inches, A_2 horizon is grayish-brown (2.5Y 5/2) sandy clay loam, light brownish gray (2.5Y 6/2) when dry; the B_2 horizon is grayish-brown (2.5Y 5/2) clay, gray (2.5Y 5/1) when dry; common, medium, distinct mottles of yellowish brown; hard, firm; the A_2 horizon is slightly sticky and slightly plastic when wet, and the B_2 is plastic and sticky; roots plentiful; slightly acid; gradual, wavy boundary.

B_{21t} 25 to 37 inches, dark grayish-brown (10YR 4/2, moist) and dark yellowish-brown (10YR 4/4, moist) clay strata; many, medium, distinct mottles of yellowish brown; strong, medium, prismatic structure; hard, firm, very plastic and very sticky; few roots; moderate, continuous clay films on the surfaces of peds and in pores; slightly acid; clear, wavy boundary.

B_{22t} 37 to 47 inches, gray (10YR 5/1), interstratified clay loam, sandy loam, and sandy clay loam with many, medium, prominent mottles (strata) of yellowish brown, brown, and light brownish gray; massive to weak, fine, subangular blocky structure; hard, firm, plastic and sticky; few roots; thin, patchy clay films between strata; slightly acid; abrupt, smooth boundary.

D_r 47 inches +, bedrock of graywacke or black, fine-grained sandstone.

Hovde Series.—The Hovde soil is near beaches in low basin areas, behind deposits of sandy and gravelly material. This soil is not extensive. It occurs mainly on Decatur, Henry, Stuart, and Waldron Islands.

Profile of Hovde loam:

0 to 14 inches, dark-gray, highly organic loam containing a high proportion of sand.

14 inches +, dark-gray to bluish-gray, loose, porous sand that is many feet thick.

Range in characteristics.—The surface layer ranges from 10 to 14 inches in thickness.

Norma Series.—The Norma soils have developed from sandy Vashon glacial drift. The native vegetation consisted of a dense growth of deciduous trees, conifers, brush, and other plants that tolerate water.

These soils have a dark, moderately thick A horizon over a brown to pale-brown B_{2gir} horizon and olive-gray B_{2b} horizon. The Norma soils are classified as Humic Gley soils, but they have some characteristics of Ground-Water Podzols. This classification is provisional; as the soils are studied more intensively in the future, the series may be defined more precisely, and classified somewhat differently. The lightly cemented, brightly colored nodules of sand in the B horizon are similar to those in the weakly expressed B horizon of the Ground-Water Podzols.

The relationship among the various horizons of the Norma soils is influenced, to a considerable extent, by vertical variations in texture throughout the profile. These textural variations appear to be caused more by periodic deposition of different kinds of parent alluvium than to changes brought about by soil-forming processes within the profile.

Profile of a Norma loam (NE¼NE¼SW¼ sec. 13, T. 37 N., R. 2 W.):

A_{00} 2 to 1½ inches of needles, twigs, and leaves.

A_0 1½ inches to 0, very dark gray (10YR 3/1), decomposing needles, twigs, and leaves; abrupt, smooth boundary.

A_{11} 0 to 7 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when dry; strong, medium, granular structure; slightly hard, firm, nonsticky and slightly plastic; abundant, fine and medium roots; medium acid (pH 5.8); clear, wavy boundary.

A_{12} 7 to 11 inches, dark-brown (10YR 4/3) loam, brown (10YR 5/3) when dry; strong, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few roots; slightly acid; clear, wavy boundary.

A_{13g} 11 to 14 inches, dark grayish-brown (10YR 4/2) sandy loam, light brownish gray (10YR 6/2) when dry; common, medium, faint mottles of yellowish red; weak, fine, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; few roots; neutral (pH 6.6); clear, wavy boundary.

B_{2gir} 14 to 47 inches, brown (10YR 5/3) fine sand, pale brown (10YR 6/3) when dry; many, coarse, prominent mottles of reddish brown; massive; slightly hard, firm, nonsticky and nonplastic; common, strong-brown to dark reddish-brown, fine, concretionary nodules of weakly cemented sand; few fine roots to a depth of 27 inches; neutral (pH 6.6); abrupt, wavy boundary.

B_{2b} 47 to 60 inches +, olive-gray (5Y 4/2) clay loam, light olive gray (5Y 6/2) when dry; weak, prismatic and moderate, coarse, angular blocky structure; extremely hard, extremely firm, very sticky and very plastic; no roots; thick clay films on peds; neutral (pH 7.1).

BOG SOILS

The Bog great soil group consists of very poorly drained organic soils in closed basins where there is a nearly continuous high water table. The accumulations of organic matter consist of the remains of plants and minute marine organisms in various stages of disintegration and decomposition. Generally, the soils have formed in various stages of succession. Aquatic vegetation and minute marine organisms in open water contributed to the formation of sedimentary (Tanwax) peat; then, sedges and reeds grew in the marshes and accumulated sedge (Mukilteo) peat; finally, remains of woody species of brush, shrubs, and trees accumulated to form woody (Rifle) peat. As the bases were exhausted, the marshes became extremely acid, creating an environment where sphagnum and hypnum mosses dominate the vegetative species to form moss (Orcas) peat. These successive stages of peat formation may be observed in deep peat bogs, such as those in Beaverton Valley.

Muck soils consist of the finely divided remains of organic matter that is well decomposed. The remains of plants are not recognizable in the uppermost 8 to 12 inches of soil material. Moss peat is extremely resistant to decomposition and does not readily decompose to muck.

In San Juan County three series of these organic soils have been recognized. These are Tanwax peat, Orcas peat, and Semiahmoo muck. In addition, Mukilteo peat was identified, but it did not occur in sufficiently large areas to warrant its separation from Semiahmoo muck formed from decomposed sedges and grasses. Shallow phases of Semiahmoo muck were identified where the organic deposit was less than 3 feet deep over mineral soil materials.

Profile of Semiahmoo muck (SE¼SE¼SE¼ sec. 15, T. 35 N., R. 3 W.):

0 to 9 inches, black (5YR 2/1) muck, very dark gray (5YR 3/1) when dry; weak, very fine, granular structure; loose, very friable, nonsticky and nonplastic; pH 5.6; clear, wavy boundary.

9 to 9½ inches, light-gray (N 7/0) silt loam, white (N 8/0) when dry (essentially ash); single grain; loose, very friable, nonsticky and nonplastic; pH 5.6; abrupt, smooth boundary.

9½ to 30 inches, black (5YR 2/1) muck, very dusky red (2.5YR 2/2) when dry; weak, very fine, granular structure; loose, very friable, nonsticky and nonplastic; pH 5.6.

30 to 48 inches, dark reddish-brown (5YR 2/2) muck with a few observable remnants of partly disintegrated sedges, dark reddish brown (5YR 3/2) when dry; weak, very fine, granular structure; very friable, nonsticky and nonplastic; pH 5.3.

48 to 60 inches, dark reddish-brown (5YR 2/2), mixed sedimentary and sedge peat, black (5YR 2/1) when dry; hard, nonsticky, nonplastic; pH 6.6; gradual, wavy boundary.

60 to 72 inches, dark reddish-brown (5YR 3/3) sedimentary peat, black (5YR 2/1) when dry; hard, nonsticky, nonplastic; pH 7.0; gradual, wavy boundary. 8 to 20 inches thick.

72 to 84 inches +, dark reddish-brown (5YR 3/2) sedimentary peat containing a few small shells, black (5YR 2/1) when dry; hard, nonsticky, nonplastic; pH 7.6.

Range in characteristics.—The depth of Semiahmoo muck, as mapped in the San Juan Islands, ranges from 60 inches or more of decomposed organic materials to decomposed organic materials that are considerably less deep. This soil also includes areas in which decomposed sedges overlie raw sedges and disintegrated sedges.

ALLUVIAL SOILS

Alluvial soils developed from transported and relatively recently deposited material (alluvium). Their parent material is characterized by a weak modification, or none, of the original material by soil-forming processes.

In San Juan County, only one series, the Neptune, is in this great soil group.

Neptune Series.—The Neptune soils are on old beaches that are not covered by tidal waters. The soils formed in sand in which numerous marine shells are embedded. The native vegetation was mainly grass, but it included a few shrubs and trees.

The Neptune soils have a surface layer of dark grayish-brown to black gravelly sandy loam. The surface layer is underlain by dark gray to very dark gray, loose gravelly coarse sand. The substratum is gray, loose sand and gravel that contains numerous marine shells. The soil is alkaline throughout.

General Information About the County

In the following section the physiography, drainage, relief, and climate of San Juan County are discussed. General information is also given about the vegetation and water supplies in the county and about the settlement and population, industries, transportation and markets, and community and recreational facilities.

Physiography, Drainage, and Relief

San Juan, Orcas, Lopez, and Shaw Islands form the core of San Juan County. A few of the smaller islands in the county are Blakely, Waldron, Decatur, Stuart, Henry, Spieden, Patos, Crane, Johns, Center, McConnell, Double, Yellow, O'Neal, Blind, Posey, Matia, Clark, and Barnes. The last three islands are not inhabited.

Orcas, the largest of the islands, has a total area of 57 square miles. San Juan, the second largest, occupies a total area of 55 square miles; Lopez, 29 square miles; and Shaw, 8 square miles. There are 84 other islands no larger than one-fourth acre in size and 343 islands and reefs that occupy less than one-fourth acre (*5*).

The islands of San Juan County represent the highest points of a submerged mountain range. This mountain range formerly connected Vancouver Island with the mainland. Historians report that relics have been found indicating that the San Juan Archipelago may have been an ancient overland trade route between the Orient and what is now the continent of North America.

In most places the shorelines of the islands are elevated. They are rocky and are deeply indented by many sheltered coves and inlets. Orcas Island is nearly cut in two by the harbor known as East Sound, which resembles a fiord. The channels between the islands are commonly narrow. They are U-shaped as the result of glacial action. These channels are 600 to 1,000 feet deep. The water that flows in and out of the Strait of Georgia to the north of San Juan County must pass through the channels surrounding the islands. Consequently, there are heavy riptides in many places.

The surface of the islands is marked by abrupt differences in elevation. The glaciated part of the islands has low relief; that is, glacial plains and gently rolling and basinlike areas. There are only a few deeply entrenched drainageways. The islands are drained mainly by short, intermittent streams. Lopez Island has a larger proportion of nearly level land than any of the larger islands.

Numerous rocky knobs extend above the present glacial plain. There are 15 mountain peaks on the islands that exceed 1,000 feet in elevation. The highest is Mount Constitution on Orcas Island, which rises to an altitude of 2,409 feet. Mount Pickett, to the east of Mount Constitution, rises to an altitude of 1,889 feet. Glacial scouring of the bedrock indicates that glaciers once covered even the highest peaks on the islands (*5*).

Climate

San Juan County has a mild climate that is modified by westerly winds from the ocean. The summers are cool and dry, and the winters are mild and moist with frequent high overcast. The days of sunshine are above average for counties in the western part of the State. The average annual precipitation is 28.98 inches at Olga, on Orcas Island. It ranges from 20 to 29 inches on the rolling glacial plains. Data concerning temperature and precipitation, compiled from records of the U.S. Weather Bureau at the Olga station, are given in table 13.

Variations in precipitation within short distances have been noted in studies made on San Juan Island. These studies show that precipitation is as low as 19 inches on

TABLE 13.—*Temperature and precipitation at Olga Station, San Juan County, Wash.*

[Elevation, 80 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1929)	Wettest year (1917)	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	41.2	61	9	4.68	4.08	13.88	0.8
January	39.1	65	−8	3.75	1.11	4.62	2.9
February	41.0	65	0	2.77	.85	2.09	2.4
Winter	40.4	65	−8	11.20	6.04	20.59	6.1
March	44.3	74	19	2.43	2.57	2.50	1.0
April	48.6	78	28	1.83	.95	3.72	.1
May	53.2	81	32	1.58	.68	1.05	(3)
Spring	48.7	81	19	5.84	4.20	7.27	1.1
June	57.0	87	37	1.34	.51	3.52	0
July	59.7	92	40	.75	.13	.29	0
August	59.8	89	40	.88	.51	.50	0
Summer	58.8	92	37	2.97	1.15	4.31	0
September	56.3	87	32	1.85	.31	1.31	(3)
October	50.6	76	26	2.80	1.38	1.33	(3)
November	44.7	65	14	4.32	2.01	3.08	.6
Fall	50.5	87	14	8.97	3.70	5.72	.6
Year	49.6	92	−8	28.98	15.09	37.89	7.8

[1] Average temperature based on a 64-year record, through 1955; highest temperature based on a 61-year record; and lowest temperature based on a 60-year record, through 1952.

[2] Average precipitation based on a 66-year record, through 1955; wettest and driest years based on a 66-year record, in the period 1890–1955; snowfall based on a 58-year record, through 1952.

[3] Trace.

Cattle Point and that the amount of precipitation increases progressively to a high of 29 inches at Roche Harbor, a distance of 14 air miles. Precipitation is mainly in the form of gentle rains and showers. Occasionally, snow that lasts only a few days falls in winter. Precipitation is infrequent during the summer.

As summer approaches, evapotranspiration increases sharply, and the supply of moisture in the soil is rapidly depleted. In summer and early in fall, many of the soils are deficient in available water for plants to grow.

Weather records indicate a growing season throughout most of the agricultural area of about 226 days. The experience of home gardeners shows that frostpockets occur in low areas, and that in these pockets frosts in July often kill young plants.

Vegetation

The vegetation in San Juan County consists dominantly of conifers, but deciduous trees grow on some of the more poorly drained areas. Grasses occupy the drier sites, and various kinds of cactuses dominate the vegetation on the driest areas.

Douglas-fir (*Pseudotsuga menziesii*) grows under many different conditions. The drainage of the soils on which it grows ranges from somewhat excessive to imperfect. In areas at the highest elevations, Douglas-fir grows in mixed stands with western hemlock (*Tsuga heterophylla*), white fir (*Abies grandis*), Sitka spruce (*Picea sitchensis*), and western white pine (*Pinus monticola*). At lower elevations, it grows in pure stands or in stands where it is mixed with lodgepole pine (*P. contorta*).

Lodgepole pine grows in areas ranging in drainage from very poor (in bogs) to somewhat excessive. It grows best, however, on the better drained sites. Western redcedar (*Thuja plicata*) grows well on soils ranging in drainage from well drained to poorly drained, but it grows best on the soils that are moist in summer. Western redcedar rarely grows on soils that are somewhat excessively drained.

Several kinds of deciduous trees grow in association with the conifers throughout the county. They are more abundant on the moist or wet sites. On the moist or wet sites, red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) are dominant in the vegetation that comes in following logging. They give serious competition to the conifers (fig. 20). On the well-drained, black prairie soils, there are scattered Douglas-firs and Oregon white oaks (*Quercus garryana*). Vegetation on the somewhat excessively drained soils is dominated by Douglas-fir. Associated species include lodgepole pine, bigleaf maple, and Pacific madrone (*Arbutus menziesii*).

The somewhat excessively drained, black prairie soils have a cover of plants consisting of annual and perennial grasses and weeds. These include ripgutgrass (*Bromus rigidus*), soft chess (*B. mollis*), downy chess (*B. tectorum*), velvetgrass (*Holcus lanatus*), California oatgrass (*Danthonia Californica*), filaree (*Erodium* sp.) and soap olallee (*Shepherdia canadensis*), also called buffaloberry.

Cactus grows on Cattle Point of San Juan Island, and on Henry Island and other small islands. The soils there are coarse textured, and effective rainfall is low.

The understory, in many places, consists of a dense tangle of many different kinds of plants. On the bog soils and on other poorly drained soils in basins the vegetation in the understory is dominated by spirea, or hardhack (*Spiraea douglasii*). It also includes grasses (*Gramineae*) that tolerate water, sedges (*Carex* sp.), tule, skunkcabbage, rushes (*Juncus* sp.), and cattails (*Typha* sp.). In the acid peat bogs made up of sphagnum moss, there is Labrador-tea (*Ledum groenlandicum*) and cranberry (*Vaccinium oxycoccus*).

Figure 20.—A 12-year-old stand of alders on an Alderwood gravelly sandy loam.

Other understory vegetation that grows in this county under a wide range of moisture conditions includes oceanspray (*Sericotheca discolor*), salal (*Gaultheria shallon*), Oregongrape (*Berberis aquifolium*), snowberry (*Symphoricarpos racemosus*), red elder (*Sambucus callicarpa*), western thimbleberry (*Rubus parviflorus*), trailing blackberry (*R. macropetalus*), evergreen blackberry (*R. laciniatus*) (also called cutleaf blackberry), salmonberry (*R. spectabilis*), wild rose (*Rosa nutkana*), and devilsclub (*Fatsia horrida*). These plants are associated with many different kinds of mosses and ferns. The swordfern (*Polystichum munitum*) grows under dense timber. Brackenfern (*Pteridium aquilinum* var. *pubescens*) grows under less dense stands of timber and in open areas.

Water Supplies

In San Juan County the best aquifers for water are the Pleistocene glacial sands and gravel. Compacted glacial till, commonly called hardpan, is not a good aquifer, and it is sometimes necessary to drill through the glacial till to reach water. For example, a well northeast of East Sound, drilled to a depth of 47 feet through the compacted glacial till and into the fine sand, has a flow of 60 gallons per minute. Only low yields of water have been obtained in areas underlain by consolidated rock. The towns of Friday Harbor, East Sound, Olga, and Doebay have municipal water systems.

Supplemental irrigation is used by a few farmers, primarily during July and August. The water for irrigation is taken from lakes and small reservoirs on the farm. Only a small part of the acreage used for agriculture is irrigated, but the size of the irrigated acreage increases each year.

Settlement and Population

Until 1872, the area that is now San Juan County was claimed both by the United States and Great Britain. Military forces of both countries occupied it jointly until October 1872 when it became a part of the United States. The peak population was reached in 1920, and the population has decreased slightly since that time. In 1950, the county had a population of 3,245.

The development of the county has centered around a mixed type of farming consisting of dairying and the raising of beef cattle, sheep, and poultry. Costly and time-consuming transportation has been a handicap to greater agricultural development in the county. Many farms are operated on a part-time basis. Logging, fishing, and working at the lime quarries at Roche Harbor supplement the farm income.

Industries

Many people in San Juan County depend upon fishing for their livelihood. For some, this is a full-time occupation, but for others it is a means of supplementing their farm income. In past years the fish caught by commercial fishermen were processed at Friday Harbor and Deer Harbor, but part of the processing is now done on the mainland. One plant is used to can fish and is also used to can peas that are grown locally.

Slaughterhouses are located at Lopez and Friday Harbor. They are used to process a major part of the beef, sheep, and hogs that are raised in the county. Much of the meat is used locally, but part is used to supply a few stores on the mainland. A plant where milk is processed is located in Friday Harbor.

For many years, limestone quarries, located at Roche Harbor and Orcas Island, produced good-quality limestone. The limestone was used to supply paper and smelter industries of the Puget Sound area. The quarry facilities at Roche Harbor are now being remodeled to provide accommodations for a resort and yacht basin.

Transportation and Markets

Approximately 248 miles of county and State highways traverse the islands. These highways have all-weather blacktop and gravel surfaces. Access to points outside the county, for the purpose of getting supplies and marketing agricultural products, is by water. San Juan, Orcas, Lopez, and Shaw Islands are served by the Washington State Ferries, which provide transportation to Anacortes. The other islands depend upon freightboats and barges for transportation.

Regular air service is available between Friday Harbor and Seattle, East Sound, and Bellingham. Air taxi service is available, on call, from Friday Harbor, East Sound, and Lopez.

Community and Recreational Facilities

Public schools are located on San Juan, Orcas, Lopez, and Shaw Islands, and bus service is provided for the outlying districts. There are public schools also on Waldron, Decatur, and Stuart Islands, but sessions are held only when there are enough children of school age to warrant their operation.

Churches of several denominations are located on San Juan, Orcas, and Lopez Islands. There are no churches on Shaw Island, but two congregations hold services in the community hall.

Five fraternal organizations and American Legion Posts with their fraternal and post auxiliaries are represented on San Juan, Orcas, and Lopez Islands.

The islands of San Juan County are desirable for recreation because of their picturesque scenery. From the peak of Mount Constitution, which is 2,409 feet high, one can see the many islands, the Cascade Mountains, the Olympic Mountains, and Vancouver Islands.

The many coves and inlets and the waters surrounding the islands are ideal for cruising. Permanent residences and summer homes occupy many of the beach areas. Resorts are located at Point Lawrence, Doebay, Olga, East Sound, Deer Harbor, Roche Harbor, and False Bay, and there are camping facilities on Cascade Lake in Moran State Park. A Boy Scout Camp is located on San Juan Island, and a Y.M.C.A. camp, on Orcas Island. San Juan International Camps for boys and girls is located on Lopez Island.

Fishing and hunting attract many people to the county. Salmon fishing is a main tourist attraction in summer and fall. Deer, domestic rabbits, Chinese pheasants, ducks, and geese provide abundant hunting for the many sportsmen who visit the islands.

Agriculture

Agricultural development reached its peak in San Juan County in 1920. Since that time, the acreage in farms has decreased. The soils formed on glacial till and glacial drift have been the principal ones taken out of use for crops or pasture rather than the more productive basin soils. The high cost of transporting crops to the mainland has made it desirable to grow crops that have a high cash value.

The following section gives information about the agriculture in San Juan County. The statistics used are from reports published by the U.S. Bureau of the Census.

Land Use and Size of Farms

Approximately 41 percent of the total acreage in San Juan County, or 45,499 acres, was in farms in 1954. The acreage in farms has decreased during the past few years. In 1940, 68,017 acres was in farms, but there was a decrease to 56,716 acres in 1950. The following shows how land in farms was used in 1954.

	Acres
Cropland harvested	7, 108
Cropland not harvested and not pastured	2, 514
Cropland used only for pasture	11, 063
Woodland pastured	9, 853
Woodland not pastured	9, 441
Other pasture (not cropland and not woodland)	3, 389
Other land (house lots, roads, wasteland, etc.)	2, 131

The acreage in cropland harvested has decreased somewhat since 1939, when crops were harvested from 10,342 acres. A total of 24,305 acres was in pasture in 1954, and a total of 19,294 acres was in woodland.

Many of the farms in the county are small. About 37 percent of them are less than 70 acres in size.

Crops

Table 14 gives the acreage and yields of the major crops grown in San Juan County in stated years. The crops grown the most extensively are small grains and crops grown for hay and forage. The small grains are grown both in mixtures and alone. Clover and timothy are the most important hay crops, but alfalfa is grown extensively. The crops are used mainly to feed livestock that are raised on the farms.

Vegetables and fruits are now grown mainly for local use rather than for markets on the mainland. Peas grown for processing were an important crop on San Juan and Lopez Islands for a number of years. Because of extensive damage done by pea moths, farmers ceased growing the crop in 1937. In 1956, however, peas for processing again became an important crop, and the pea moth was controlled by dusting.

TABLE 14.—*Acreage of the principal crops and number of fruit and nut trees of bearing age in stated years*

Crop	1939	1949	1954
Small grains threshed or combined:			
Small grains grown together and threshed as a mixture	194	206	214
Winter wheat threshed or combined	814	301	229
Oats, grown alone, threshed or combined	644	954	788
Barley threshed or combined	204	668	752
Dry peas and beans harvested	2, 255	15	2
Hay and forage crops:			
Small grains cut for hay	535	104	168
Alfalfa and alfalfa mixtures cut for hay	997	1, 418	1, 041
Clover, timothy, and mixtures of clover and grasses cut for hay	2, 069	1, 662	2, 022
Wild hay cut	171	570	320
Other hay cut	1, 126	310	346
Field seed crops:			
Alfalfa seed harvested	16	25	0
Red clover seed harvested	20	190	93
Irish potatoes	61	(1)	(1)
	Number [2]	*Number* [2]	*Number*
Apple trees	10, 763	5, 059	3, 396
Peach trees	31	105	66
Pear trees	6, 020	1, 821	996
Cherry trees	4, 521	1, 019	396
Plum and prune trees	1, 951	922	477
Filbert and hazelnut trees	552	110	57

[1] Does not include acreage for farms with less than 10 bags harvested.
[2] One year later than year at head of column.

Livestock and Livestock Products

Approximately 85 percent of the income derived from the sale of farm products in 1954 was derived from the sale of livestock and livestock products. Table 15 gives the number of livestock on farms in stated years.

The number of horses and mules has decreased, as power equipment has gradually replaced those animals as a source of power. The numbers of cattle, hogs, and sheep have varied as the result of fluctuations in prices and in demand. The numbers of cattle, hogs, and sheep have increased slightly since 1940. The number of chickens more than 4 months old decreased slightly after 1940.

TABLE 15.—*Livestock on farms in stated years*

Livestock	1940	1950	1955
Horses and mules	[1] 499	257	85
Cattle	[1] 3, 223	3, 806	3, 970
Hogs	[2] 591	1, 256	1, 028
Sheep	[3] 7, 395	11, 742	8, 620
Chickens [2]	26, 861	20, 123	24, 285

[1] More than 3 months old.
[2] More than 4 months old.
[3] More than 6 months old.

Farm and Home Improvements

Most of the farms in the county have telephone and electrical service. Of the 295 farms in the county in 1954, 291 had telephone service and most had electricity. Telephone communication between the islands and to Bellingham on the mainland is supplied by cable. A dial system is in operation on San Juan and Orcas Islands.

Electrical power is supplied to Orcas, Lopez, San Juan, Decatur, and Shaw Islands by cable from Fidalgo Island. Standby power plants are located at Friday Harbor and East Sound.

Television reception is generally good on the islands from the Seattle, Bellingham, and Vancouver stations. The Bellingham station, KVOS, is on Mount Constitution.

A mailboat brings mail daily from Anacortes to San Juan, Orcas, Shaw, and Lopez Islands. The outlying islands receive biweekly deliveries of mail.

Farm Tenure

As the acreage in farms in the county, as well as the number of farms, has decreased, the number of farmers who own their farms has also decreased. In 1954, 245 farmers owned a total of 30,407 acres as compared to 364 farmers in 1940 who owned 42,970 acres. There were 42 part owners in 1954, operating 12,376 acres, as compared to 61 in 1940, operating 14,126 acres. The proportion of tenancy decreased sharply from 14.1 percent in 1940 to 2.4 percent in 1954.

There is an increasing trend for farmers to earn part of their income by working off the farm. In 1954, 212 farmers reported that they had earned income other than from the sale of farm products. In contrast, 195 operators reported that they had earned money from working off the farm in 1944.

Glossary

AC soil. A soil that has a profile containing only A and C horizons and no clearly defined B horizon.
Acidity. See Reaction, soil.
Aggregate (of soil). A mass, or cluster, of primary soil particles held together by internal forces to form a granule, clod, block, or prism.
Available moisture. That part of the moisture in the soil that can be taken up by plants at rates significant to their growth.
Bedrock. The solid rock underlying soils or other earthy surface formations.
Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that contains 40 percent or more clay, less than 45 percent of sand, and less than 40 percent of silt.

Claypan. A layer or horizon of accumulation, or a stratum of dense, compact, and relatively impervious clay.

Cobbles (cobblestones). Rounded fragments of rock 3 to 10 inches in diameter.

Colluvium (colluvial deposits). Mixed deposits of rock fragments and coarse soil materials near the bases of steep slopes. The deposits have accumulated as the result of soil creep, slides, or local wash.

Consistence, soil. The nature of soil material expressed by the resistance of the individual particles to separating from one another (cohesion) or by the ability of a soil mass to undergo a change in shape without breaking (plasticity). The consistence varies with the content of moisture. Thus, a soil aggregate or clod may be hard when dry and plastic when wet. Some of the terms used to describe consistence are as follows:

Friable. When moist, easily crushed by hand and coheres when pressed together. Friable soils are easily tilled.

Firm. When moist, crushes under moderate pressure, but resistance is distinctly noticeable. Firm soils are likely to be difficult to till.

Hard. When dry, moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.

Soft. When dry, weakly coherent and fragile; breaks to powder or individual grains under slight pressure.

Loose. Noncoherent when moist or dry. Loose soils are generally coarse textured and are easily tilled.

Plastic. When wet, retains an impressed shape and resists being deformed; plastic soils are high in clay and are difficult to till.

Drainage, soil. The rapidity and extent of the removal of water from the soil, in relation to additions, especially by runoff; by flow through the soil to underground spaces; or by a combination of both processes. As a condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation or partial saturation. Terms used in describing soil drainage classes are *very poorly drained, poorly drained, imperfectly or somewhat poorly drained, moderately well drained, well drained, somewhat excessively drained,* and *excessively drained.*

Erosion. The detachment and movement of the solid material of the land surface by wind, moving water, or ice, and by such processes as landslides and creep.

Field capacity. The moisture content of a soil, expressed as percentage of ovendry weight, after the gravitational or free water has been allowed to drain, usually for 2 or 3 days. The field moisture content 2 or 3 days after a soaking rain.

Glacial drift. Rock and earth materials that have been transported and deposited by glaciers and by the streams and lakes associated with glaciers. It includes both glacial till and glacial outwash.

Glacial outwash. Coarse-bedded gravel, sand, silt, and clay deposited by melt water as it flows from glacial ice.

Glacial till. The unsorted clay, silt, sand, and boulders transported and deposited by glaciers.

Granular. See Structure, soil.

Gravel. Rounded or angular fragments of rock greater than ½ inch but less than 3 inches in diameter.

Horizon, soil. A layer of soil, approximately parallel to the soil surface, with characteristics produced by soil-forming processes. The relative positions of the principal soil horizons in the soil profile and their nomenclature are given below—

Horizon A. The master horizon consisting of (1) one or more mineral horizons of maximum organic accumulation; or (2) surface or subsurface horizons that are lighter in color than the underlying horizon and that have lost clay minerals, iron, and aluminum with resultant concentration of the more resistant minerals; or (3) horizons belonging to both categories.

Horizon B. The master horizon of altered material characterized by (1) an accumulation of clay, iron, or aluminum, with accessory organic material; or (2) blocky or prismatic structure together with other characteristics, such as stronger colors, unlike those of the A horizon or the underlying horizons of nearly unchanged material; or (3) characteristics of both these categories. Commonly, the lower limit of the B horizon corresponds to the lower limit of the solum, or true soil.

Horizon C. A layer of unconsolidated material, relatively little affected by the influence of organisms and presumed to be similar in chemical, physical, and mineralogical composition to the material from which at least a part of the overlying solum has developed.

Horizon D. Any stratum underlying the C, or the B if no C is present, which is unlike the C, or unlike the material from which the solum has formed.

Infiltration. The downward entry of water into soil or other material. The rate of infiltration is the rate at which water is penetrating the surface of the soil at any given instant, usually expressed in inches per hour. The rate may be limited either by the infiltration capacity of the soil or by the rate at which water is applied to the surface of the soil.

Lacustrine deposits. Materials deposited in the waters of lakes and exposed by the lowering of the water level or by the elevation of the land.

Microclimate. Local climatic conditions, brought about by the modification of general climatic conditions by local differences in elevation and exposure.

Mineral soil. Soil composed mainly of inorganic (mineral) material with a relatively low content of organic material. Its bulk density is generally greater than that of organic soil.

Morphology, soil. The physical constitution of the soil including the texture, structure, consistence, color, and other physical and chemical properties of various soil horizons that make up the soil profile.

Mottling, soil. Color patches that vary in contrast, abundance, and size. Descriptive terms are as follows: Contrast—*faint, distinct,* and *prominent;* abundance—*few, common,* and *many;* and size—*fine, medium,* and *coarse.* The size measurements are the following: *Fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Organic matter, soil. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that have already passed through the stage of rapid decomposition.

Paleosol. A paleosol is a fossil soil formed on a landscape during the geologic past. Because sedimentation subsequent to pedogenesis buried and preserved the profile, this kind of a paleosol is a buried soil. Erosive stripping of the protective mantle of sediments in many places has resulted in the exposure of the paleosolic profile so that now the paleosol is on the modern surface. Because it is foreign to its present environment, the soil must continue to be designated as a paleosol, although it no longer is a buried soil *(6, 9).*

Percent slope. The gradient of a slope expressed in terms of percentage—the difference in elevation in feet for each 100 feet horizontal, for example, 15 percent slope is a slope that drops or rises 15 feet in 100 feet.

Permeability, soil. The quality of the soil that enables it to transmit air and water. Moderately permeable soils transmit air and water readily. Such conditions are favorable for the growth of roots. Slowly permeable soils allow water and air to move so slowly that the growth of roots may be restricted. Rapidly permeable soils transmit air and water rapidly and the growth of roots is good.

pH. A term used to indicate the acidity and alkalinity of soils. See also Reaction, soil.

Porosity, soil. The percentage of the soil (or rock) volume that is not occupied by particles of soil, including all pore spaces filled with air and water.

Reaction, soil. The degree of acidity or alkalinity of the soil, expressed in pH values or in words, as follows:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline.	9.1 and higher.
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Runoff. The water removed by flow over the surface of the soil. The amount and rapidity of runoff is closely related to slope and is also affected by factors, such as texture, structure, and porosity of the surface soil; the vegetative covering; and the prevailing climate. Terms used to express degrees of runoff are *ponded, very slow, slow, medium, rapid,* and *very rapid.*

Sand. Individual rock or mineral fragments having diameters ranging from 0.05 millimeter (0.002 inch) to 2.0 millimeters (0.079 inch). Grains of sand consist chiefly of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay. See also Texture, soil.

Sedimentary rock. Rock derived from the deposition of sediments, such as sandstone, shale, and limestone.

Shrink-swell potential. This refers to how much the soil expands or contracts when it becomes either wet or dry.

Silt. (1) Individual mineral particles of soil that range in diameter between the upper size of clay, 0.002 millimeter, and the lower size of very fine sand, 0.05 millimeter. (2) Soil of the textural class called silt contains 80 percent or more of silt and less than 12 percent of clay. (3) Sediments deposited from water in which the individual grains are approximately the size of silt, although the term is sometimes applied loosely to sediments containing considerable sand and clay.

Soil. The natural medium for the growth of land plants. A soil is a natural, three-dimensional body on the surface of the earth, unlike the adjoining bodies.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying parent material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Stratified. Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geological materials. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of the primary soil particles into lumps, granules, or other aggregates. Structure is described by grade—*weak, moderate,* or *strong,* that is, the distinctness and durability of the aggregates; by the size of the aggregates—*very fine, fine, medium, coarse,* or *very coarse*; and by their shape—*platy, prismatic, columnar, blocky, granular,* or *crumb.* A soil is described as structureless if there are no observable aggregates. Structureless soils may be massive (coherent) or single grain (noncoherent).

Blocky, angular. Aggregates are shaped like blocks; they may have flat or rounded surfaces that join at sharp angles.

Blocky, subangular. Aggregates have some rounded and some flat surfaces; upper sides are rounded.

Columnar. Aggregates are prismatic and are rounded at the top.

Crumb. Aggregates are generally soft, small, porous, and irregular, but tend toward a spherical shape, as in the A_1 horizon of many soils. Crumb structure is closely related to granular structure.

Granular. Individual grains grouped into spherical aggregates with rounded sides. Highly porous granules are commonly called crumbs.

Platy. Aggregates are flaky or platelike.

Prismatic. Aggregates have flat, vertical surfaces, and their height is greater than their width.

Texture, soil. The relative proportions of the various size groups of individual soil grains in a mass of soil; specifically, the proportions of sand, silt, and clay. The soil textural classes, in increasing order of the content of the finer separates, are as follows: *Sand, loamy sand, sandy loam, loam, silt loam,* and *clay.* These classes may be modified according to the relative size of the coarser particles; for example, *fine sand, loamy fine sand, fine sandy loam, very fine sandy loam, coarse sandy loam, gravelly sandy loam, gravelly loam, cobbly loam, sandy clay, stony clay,* and *stony loam.*

Tidal flats. Areas of nearly flat, bare mud, periodically covered by tidal waters. Normally these materials have an excess of soluble salt. A miscellaneous land type.

Tile, drain. Pipe made of burned clay, concrete, or similar materials, in short lengths, usually laid with open joints to collect and carry excess water from the soil.

Topsoil (engineering or landscape gardening). Presumably fertile soil material used to topdress roadbanks, gardens, and lawns.

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GUIDE TO MAPPING UNITS

[Table 1, p. 4, shows the acreage and proportionate extent of the soils, and table 2, p. 30, gives estimated yields of crops. For information about uses for woodland, see the section "Uses of Soils for Woodland." Descriptions of the woodland suitability groups begin on page 32. For information about the engineering properties of the soils, see the section "Engineering Properties of Soils"]

Map symbol	*Mapping unit*	*Capability unit*		*Woodland suitability group*	
		Page		*Page*	*Number*
Ad	Active dune land	4	VIIIs-1	29	(1)
AgB	Alderwood gravelly sandy loam, 3 to 8 percent slopes	5	IVs-3	27	2
AgC	Alderwood gravelly sandy loam, 8 to 15 percent slopes	5	IVs-3	27	2
AgD	Alderwood gravelly sandy loam, 15 to 30 percent slopes	5	VIs-7	29	2
AmB	Alderwood gravelly loam, 3 to 8 percent slopes	5	IIIs-2	25	2
AmD	Alderwood gravelly loam, 15 to 30 percent slopes	5	VIs-7	29	2
AsB	Alderwood stony loam, 3 to 8 percent slopes	6	VIs-7	29	2
AsC	Alderwood stony loam, 8 to 15 percent slopes	6	VIs-7	29	2
AsD	Alderwood stony loam, 15 to 30 percent slopes	6	VIs-7	29	2
Bc	Bellingham clay loam	6	IIw-1	22	4
Be	Bellingham silt loam	6	IIw-1	22	4
BgA	Bow gravelly silt loam, 0 to 3 percent slopes	7	IIIw-2	24	2
BgB	Bow gravelly silt loam, 3 to 8 percent slopes	7	IIIw-2	24	2
BgD	Bow gravelly silt loam, 8 to 30 percent slopes	8	VIs-7	29	2
BoA	Bow silt loam, 0 to 3 percent slopes	8	IIIw-2	24	2
BoB	Bow silt loam, 3 to 8 percent slopes	8	IIIw-2	24	2
BsB	Bow stony silt loam, 3 to 8 percent slopes	8	VIs-7	29	2
Cb	Coastal beaches	8	VIIIs-1	29	(1)
CoA	Coveland gravelly silt loam, 0 to 3 percent slopes	9	IIw-3	23	(1)
CoB	Coveland gravelly silt loam, 3 to 8 percent slopes	9	IIw-3	23	(1)
CsA	Coveland silt loam, 0 to 3 percent slopes	8	IIw-3	23	(1)
CsB	Coveland silt loam, 3 to 8 percent slopes	9	IIw-3	23	(1)
CtC	Coveland stony silt loam, 0 to 15 percent slopes	9	VIs-6	28	(1)
EgB	Everett gravelly sandy loam, 3 to 8 percent slopes	10	VIs-2	27	3
EgD	Everett gravelly sandy loam, 8 to 30 percent slopes	10	VIs-2	27	3
EsD	Everett stony sandy loam, 8 to 30 percent slopes	10	VIs-3	28	3
Ho	Hovde loam	10	VIw-1	27	(1)
InC	Indianola sandy loam, 0 to 15 percent slopes	11	VIs-2	27	3
IrB	Indianola-Roche complex, 0 to 8 percent slopes	11	VIs-7	29	2, 3
IrD	Indianola-Roche complex, 8 to 30 percent slopes	11	VIs-7	29	2, 3
Ng	Neptune gravelly sandy loam	12	VIs-8	29	(1)
Nm	Norma loam	12	IIIw-1	23	4
No	Norma loam, moderately deep	12	IIIw-1	23	4
Op	Orcas peat	13	VIIIw-1	29	(1)
PrD	Pickett-Rock outcrop complex, 0 to 30 percent slopes	13	VIs-7	29	1
PrE	Pickett-Rock outcrop complex, 30 to 70 percent slopes	14	VIIe-1	29	1
RgA	Roche gravelly loam, 0 to 3 percent slopes	15	IIIs-2	25	2
RgB	Roche gravelly loam, 3 to 8 percent slopes	14	IIIs-2	25	2
RgC	Roche gravelly loam, 8 to 15 percent slopes	15	IVe-1	26	2
RgD	Roche gravelly loam, 15 to 30 percent slopes	15	VIs-7	29	2
RhB	Roche gravelly sandy loam, 3 to 8 percent slopes	16	IVs-3	27	2
RoA	Roche loam, 0 to 3 percent slopes	15	IIIs-2	25	2
RoB	Roche loam, 3 to 8 percent slopes	15	IIIs-2	25	2
RoC	Roche loam, 8 to 15 percent slopes	16	IVe-1	26	2
RsB	Roche stony loam, 3 to 8 percent slopes	16	VIs-7	29	2
RsC	Roche stony loam, 8 to 15 percent slopes	16	VIs-7	29	2
RsD	Roche stony loam, 15 to 30 percent slopes	16	VIs-7	29	2
RtC	Roche stony sandy loam, 8 to 15 percent slopes	16	VIs-7	29	2
RxD	Roche-Rock outcrop complex, 8 to 30 percent slopes	16	VIs-7	29	2
RxE	Roche-Rock outcrop complex, 30 to 70 percent slopes	17	VIIe-1	29	2
Ry	Rock land, rolling	17	VIIe-1	29	(1)
Rz	Rock land, steep	17	VIIe-1	29	(1)
SaB	San Juan gravelly sandy loam, 0 to 8 percent slopes	17	VIs-4	28	(1)
SaD	San Juan gravelly sandy loam, 8 to 30 percent slopes	18	VIs-4	28	(1)
SdB	San Juan gravelly sandy loam, moderately deep, 0 to 8 percent slopes	18	IIIs-2	25	(1)
SdC	San Juan gravelly sandy loam, moderately deep, 8 to 15 percent slopes	19	IVe-1	26	(1)
SmC	San Juan loam, moderately deep, 0 to 15 percent slopes	19	IIIs-2	25	(1)
SsD	San Juan stony loam, moderately deep, 8 to 30 percent slopes	19	VIs-6	28	(1)
StC	San Juan stony sandy loam, 3 to 15 percent slopes	18	VIs-5	28	(1)
StD	San Juan stony sandy loam, 15 to 30 percent slopes	18	VIs-5	28	(1)
Sm	Semiahmoo muck	19	IIw-2	22	(1)
Ss	Semiahmoo muck, shallow	20	IVw-2	27	(1)
Ta	Tanwax peat, alkaline variant	20	IVw-4	27	(1)
Tm	Tidal marsh	20	VIIIw-1	29	(1)

[1] Not suited to trees or not used extensively as woodland.

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