SOIL SURVEY OF KING COUNTY AREA, WASHINGTON

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THE KING COUNTY AREA covers 445,500 acres in the western part of King County (fig. 1). For this part of the county, this survey replaces a soil survey of the entire county published in 1952 (12).

Seattle was first settled in 1851, and the Green River Valley south of Seattle in about 1853. The major commercial ventures during the first years following settlement were in the lumbering industry. Lumbering is still a major industry in the Area.

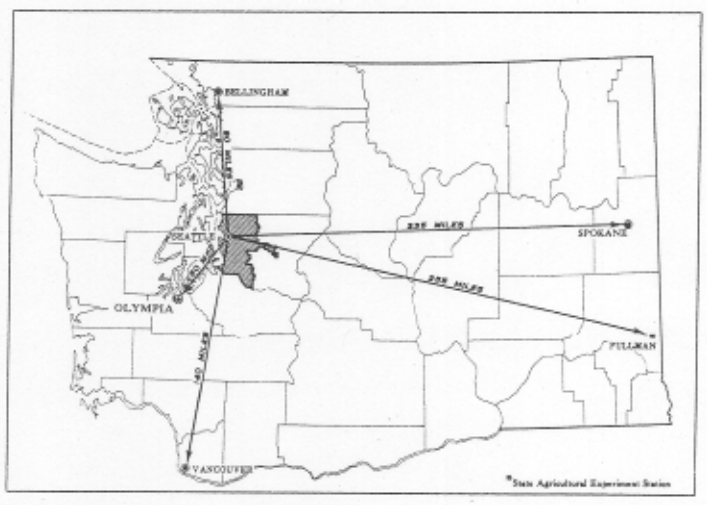


Figure 1.--Location of the King County Area in Washington.

The first cultivated crops were produced almost exclusively for home consumption. Farming, however, became productive enough that many carloads of fresh vegetables were exported from the county. Also, numerous manufacturing enterprises were established.

The large increase in population associated with industrial activity has increased the demand for residential and commercial sites. The demand has been so great that during the period 1954 to 1966, farmland was converted to other uses at the rate of about 3,900 acres per year. Fresh vegetables are now imported from other States (24). The rapid conversion of farmland to urban uses is significant because only about 9 percent of the county, outside of the National Forest, is considered suitable for farming.

Major limitations to use of the soils are erosion on sloping farmland and in urban developments, wetness that affects homesites and onsite sewage disposal, and the high slippage potential of some soils. Flooding has been controlled along a number of the major rivers in the county, but it remains a hazard in the Snoqualmie Valley. In the Green River area near Kent and Auburn, water stands on many soils that have restricted permeability even though the flood hazard has been greatly reduced by the Howard Hanson Dam and by construction of dikes along the river.

Soil scientists made this survey to learn what kinds of soil are in the King County Area, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants and crops, the kinds of rock, and many facts about the soils. They dug 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 into the parent material that has not been changed much by leaching or by the action of plant roots.

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 nationwide, uniform procedures. The soil series and the soil phase are the categories of soil classification most used in a local survey.

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 observed and mapped. Alderwood and Renton, 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 those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Kitsap silt loam, 2 to 8 percent slopes, is one of several phases within the Kitsap series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the development of urban areas and the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. 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 phase. These scattered bits are referred to as inclusions.

Some mapping units are made up of soils of different series or of different phases within one series. Three such kinds of mapping units are shown on the soil map of the King County Area: soil complexes, soil associations, and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Everett-Alderwood gravelly sandy loams, 6 to 15 percent slopes.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Ragnar-Indianola association, sloping, is an example,

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Alderwood and Kitsap soils, very steep, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Coastal beaches is a land type in the King County Area.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to he organized in such a as to be readily useful to different groups of users, among them farmers, managers of woodland, engineers, urban planners, appraisers, and homeowners.

On the basis of performance, yield and practice tables, and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists,

urban planners, engineers, and others, and then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management,

GENERAL SOIL MAP

The general soil map at the back of this survey shows, in color, the soil associations in the King County Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The seven soil associations in the King County Area are described in the following pages.

1. Alderwood Association

Moderately well drained, undulating to hilly soils that have dense, very slowly permeable glacial till at a depth of 20 to 40 inches; on uplands and terraces

This association occurs as large tracts on uplands and terraces in both the northern and southern parts of the survey area. It is about 8S percent .Alderwood soils, 8 percent Everett soils, and 7 percent less extensive soils (fig. 2). This association occupies about 52 percent of the survey area.

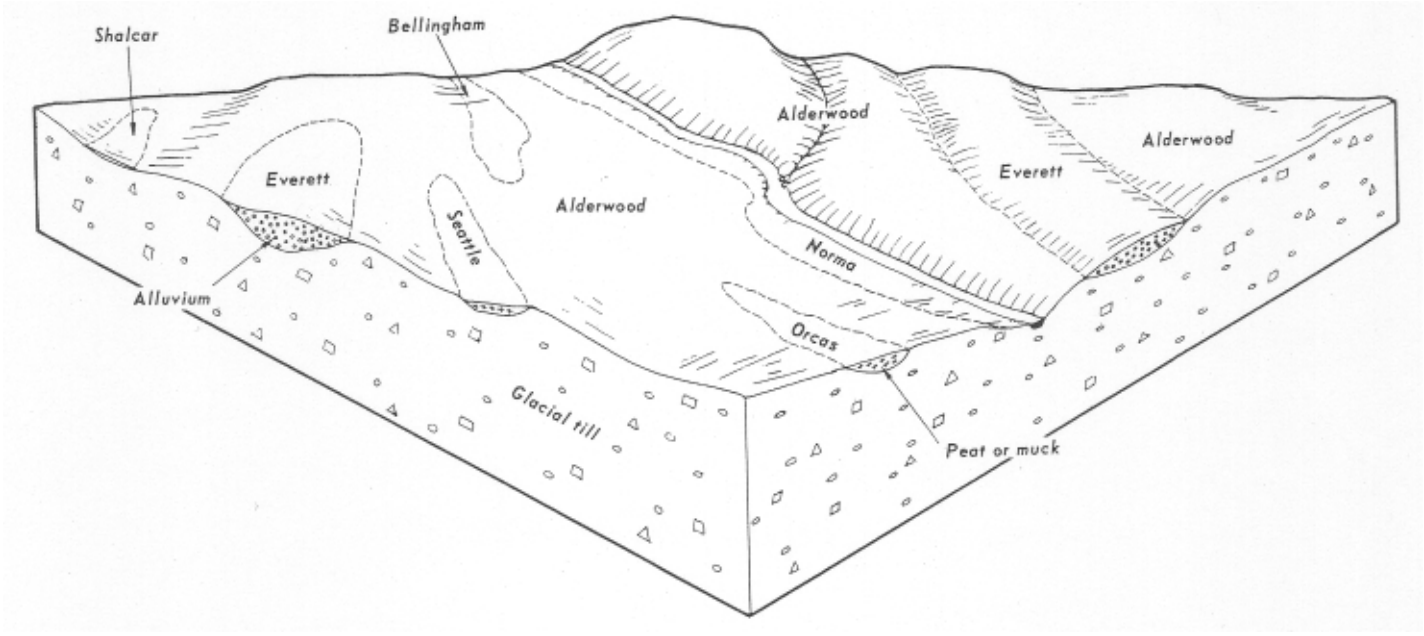


Figure 2.--Pattern of soils and parent material in soil association 1.

Alderwood soils are moderately well drained gravelly sandy loamy that are 24 to 40 inches deep over consolidated glacial till. They have convex slopes. Slopes are dominantly 0 to 30 percent, but range to as much as 70 percent. Slopes of more than 15 percent are generally no more than 200 feet long.

Everett soils are nearly level and undulating to moderately steep. They are on terraces and terrace fronts.

The less extensive soils in this association are in depressions or on terraces along small streams. These soils, mostly the Norma, Bellingham, Orcas, Shalcar, and Seattle soils, have impeded drainage and are subject to flooding. There are significant acreages of Kitsap soils, which have a silty substratum, in the major valleys and around Lake Washington and Puget Sound.

The soils of this association are well suited to pasture and timber production but are poorly suited to cultivated crops. Urban development is occurring rapidly. Limitations for homesites are moderate and slight on most of this association, but are severe on Kitsap soils.

2. Oridia-Seattle-Woodinville Association

Somewhat poorly drained and very poorly drained, nearly level soils; in major stream valleys

This association is in major stream valleys or nearby level areas in both the southern and northern parts of the survey area. It is about 17 percent Oridia soils, 13 percent Seattle soils, and 10 percent Woodinville soils. About 60 percent is soils of small extent, mainly Briscot, Edgewick, Newberg, Nooksack, Pilchuck, Puget, Puyallup, Renton, Si, Sultan, Snohomish, Shalcar, and Tukwila soils. This association occupies about 11 percent of the survey area.

Oridia soils are somewhat poorly drained, stratified silt loamy. Briscot, Edgewick, Newberg, Nooksack, Puget, Renton, Si, and Sultan soils, which are similar to Oridia soils, are stratified, well-drained to poorly drained sandy loams, silt loams, and silty clay loams. Most are subject to flooding.

Seattle, Shalcar, and Tukwila soils are very poorly drained deposits of peat and muck. Pilchuck soils are sandy, excessively drained, and subject to flooding.

Woodinville and Snohomish soils are poorly drained silt loamy that contain layers of peat.

Most soils in this association are well suited to row crops, but a few are better suited to pasture and forage crops. In general, these are the most desirable soils for farming in the survey area. Site preparation for urban development is more costly on this association than on most of the other associations. Limitations are moderate and severe for residential and commercial sites.

3. Buckley-Alderwood Association

Poorly drained and moderately well drained, nearly level to rolling soils that have dense, slowly permeable and very slowly permeable glacial till at a depth of 20 to 40 inches; on glacial till plains and uplands

This association is on glacial till plains and uplands in the southeastern part of the survey area. It is about 60 percent Buckley soils and 35 percent Alderwood soils (fig. 3). The rest is soils of minor extent. This association occupies about 7 percent of the survey area.

Buckley soils are nearly level, poorly drained silt loams and gravelly loams. They have a very dense substratum.

Alderwood soils are undulating to rolling, moderately well drained gravelly sandy loams. Their substratum is consolidated glacial till.

Among the minor soils are level, poorly drained peat and muck soils of the Seattle, Tukwila, and Shalcar series and moderately steep Beausite soils that have bedrock at a depth of 20 to 40 inches.

Most of the farms on this association are dairy farms. Seasonal wetness and gravelly soils are the main limitations for row crops.

Residential development on this association is of moderate extent and has been mostly on Alderwood soils. Alderwood soils have moderate limitations for homesites, and Buckley soils have severe limitations. Both have severe limitations for septic tank filter fields. Seattle, Shalcar, and Tukwila soils have severe limitations for homesites and septic tank filter fields.

4. Everett Association

Somewhat excessively drained, gravelly, gently undulating soils underlain by sand and gravel; on terraces

This association is dominantly on terraces in the southeastern part of the survey area; smaller areas are scattered throughout the northern half. The association occupies about 14 percent of the survey area. It is about 70 percent Everett soils, 15 percent Neilton soils, 7 percent Alderwood soils, and 8 percent less extensive soils (fig. 4).

Everett soils are gravelly sandy loam to a depth of 18 to 36 inches. They are underlain by very gravelly sand. Slopes are dominantly 0 to 15 percent, but are as steep as 30 percent on terrace fronts.

Neilton soils also are on terraces. They are gravelly loamy sand to a depth of 18 to 30 inches.

Alderwood soils have consolidated glacial till in the substratum. These soils are rolling and hilly. Slopes range up to 30 percent.

Less extensive in this association are the Indianola, Seattle, and Norma soils. Indianola soils are somewhat excessively drained and sandy. Slopes

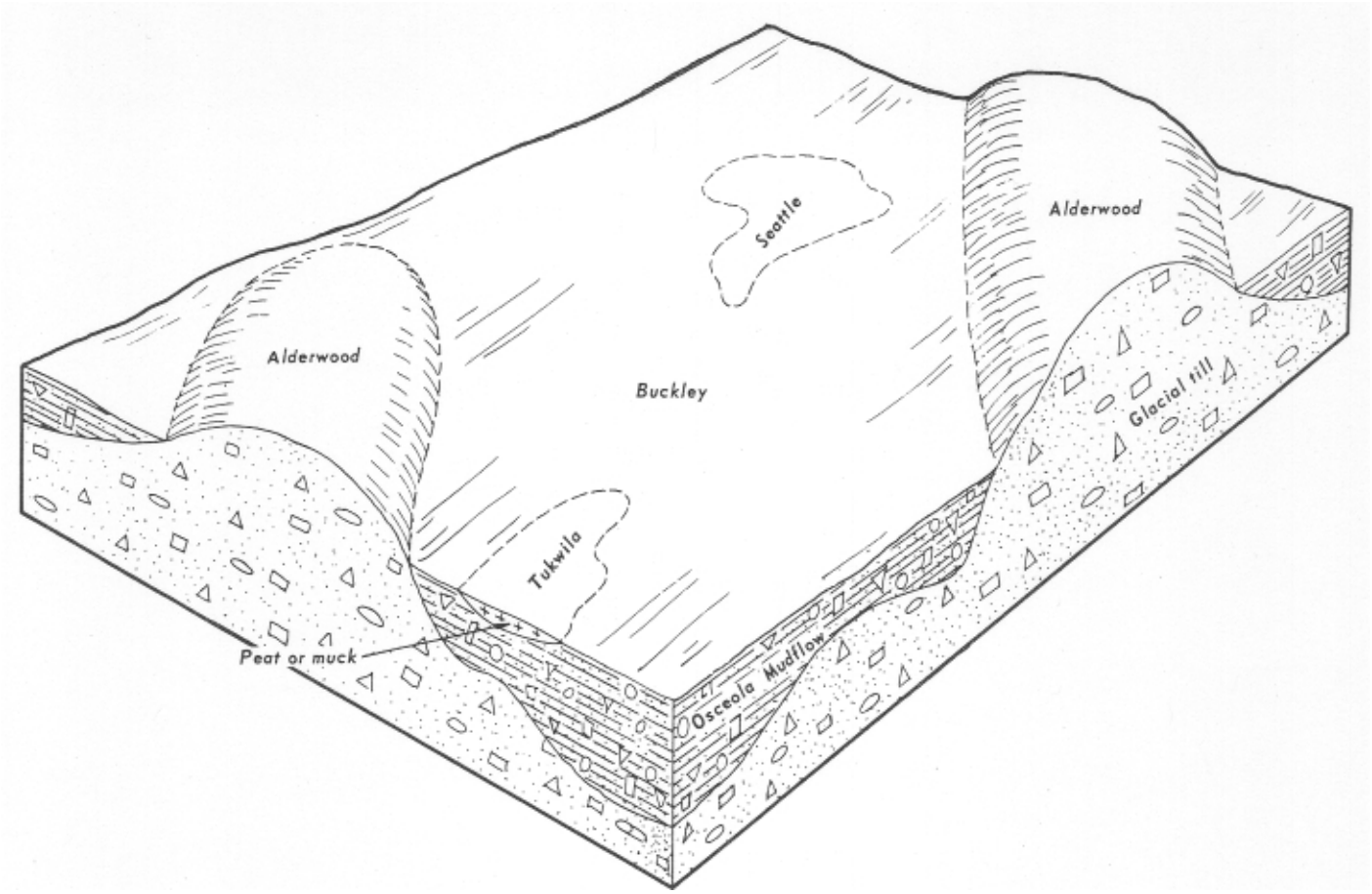


Figure 3.--Pattern of soils and parent material in soil association 3.

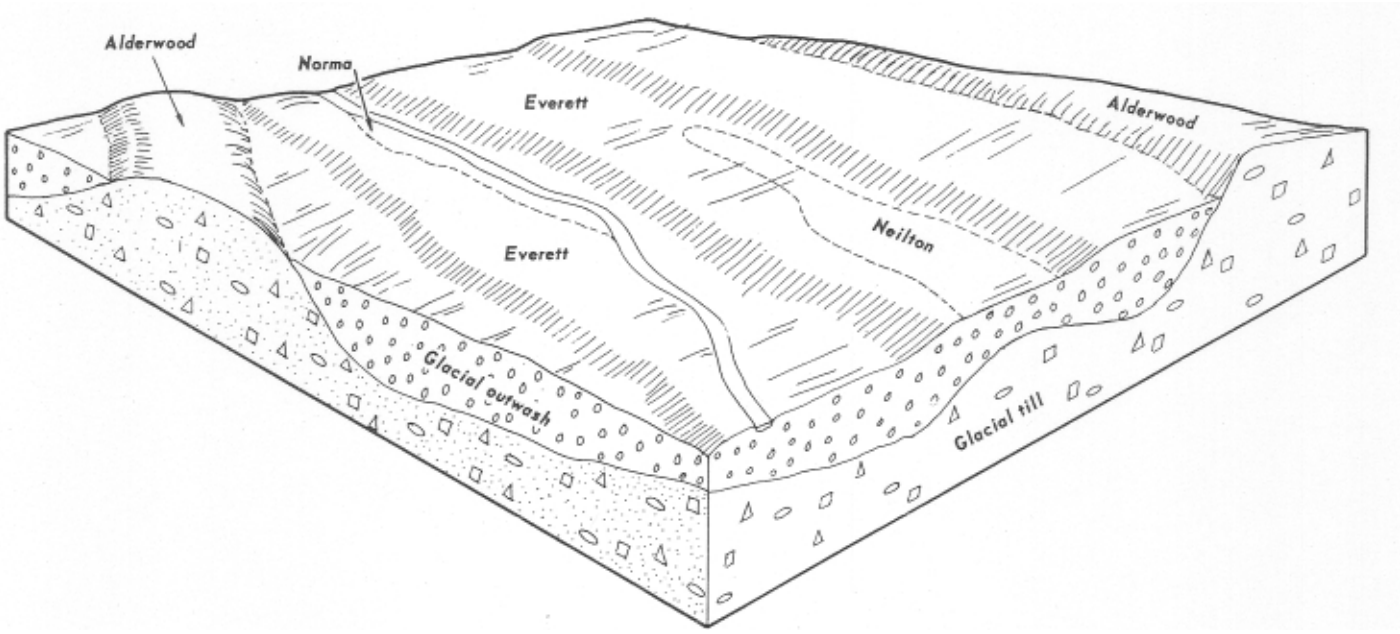


Figure 4.--Pattern of soils and parent material in soil association 4.

are mostly 2 to 15 percent. Seattle muck and Norma sandy loam are very poorly drained and poorly drained. They are in depressions and on flat terraces adjacent to small streams.

The soils of this association are poorly suited to farming but are moderately well suited to timber production. Everett soils have the fewest limitations for residential and industrial development of any soils in the survey area.

5. Beausite-Alderwood Association

Well drained and moderately well drained, gently rolling to very steep soils that have sandstone or shale or dense, very slowly permeable glacial till at a depth of 20 to 40 inches; on uplands

This association is in the central and eastern parts of the survey area. It is about 55 percent Beausite soils, 30 percent Alderwood soils, 10 percent Ovall soils, and 5 percent less extensive soils (fig. 5). This association occupies about 9 percent of the survey area.

Beausite soils are rolling gravelly sandy loams that have sandstone at a depth of 24 to 40 inches. Slopes are mostly 15 to 30 percent but in some areas are as steep as 75 percent.

Alderwood soils also are rolling gravelly sandy loams and have consolidated glacial till at a depth of 24 to 40 inches. Slopes are 6 to 30 percent in most places.

Ovall soils are rolling to hilly gravelly loams that have strongly weathered andesite at a depth of 20 to 40 inches. Slopes are dominantly 6 to 25 percent, but are as much as 75 percent in some areas.

Soils of minor extent are mostly the poorly drained Norma, Bellingham, and Tukwila soils. All are in depressions on the uplands or on terraces adjacent to small streams.

The soils of this association are well suited to timber production but poorly suited to farming. The gently rolling areas are moderately well suited to pasture. Limitations for residential and commercial sites are moderate to severe. In most places limitations for septic tank filter fields are severe.

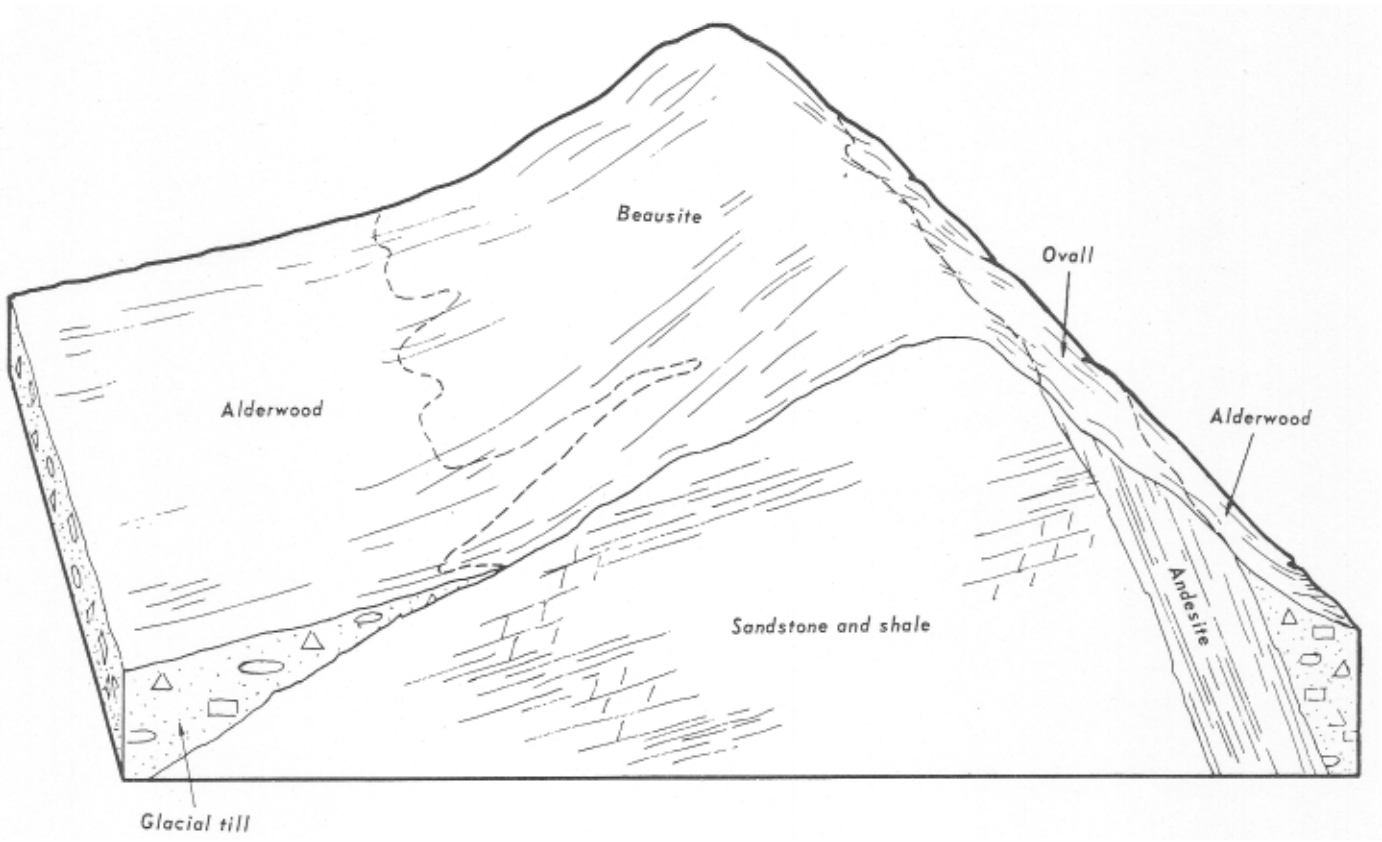


Figure 5.--Pattern of soils and parent material in soil association 5.

6. Alderwood-Kitsap-Indianola Association

Moderately well drained, nearly level to steep soils that have very slowly permeable glacial till or glacial lake deposits at a depth of 16 to 40 inches, and somewhat excessively drained, rolling, deep sandy soils; on uplands and terraces

This association occurs as three scattered areas in the northern half of the survey area. It is about 50 percent Alderwood soils, 30 percent Kitsap soils, 15 percent Indianola soils, and 5 percent other soils (fig. 6). This association occupies about 5 percent of the survey area.

Alderwood soils are rolling soils on uplands and terraces. They have consolidated glacial till in the substratum. Slopes are dominantly 6 to 15 percent but range from 1 or 2 percent to as much as 30 percent where the upland plains break into the ravines and major valleys.

Kitsap silt loams have silty, platy lake sediment in the substratum. Slopes are dominantly 8 to 30 percent. Generally the steeper soils are on terrace fronts that face the major valleys and drainageways.

Indianola soils are sandy and 60 inches or more deep. Slopes are 15 to 30 percent in many places on terrace fronts adjacent to the steeper Kitsap soils. On terraces northeast of Juanita, slopes are mostly 3 to 8 percent.

Less extensive in this association are somewhat excessively drained very gravelly soils, poorly drained silty soils, and very poorly drained peaty soils.

The suitability of the soils in this association for farming ranges from fair to poor. Most of the soils are well suited to timber production. Limitations are slight to severe for residential and commercial sites.

7. Puget-Earlmont-Snohomish Association

Poorly drained and somewhat poorly drained, nearly level soils that have layers of peat within a few feet of the surface; in major stream valleys

This association occurs as three distinct areas in the Sammamish and Snoqualmie Valleys in the northern half of the survey area. It is about 25 percent Puget soils, 25 percent Earlmont soils, 20 percent Snohomish soils, and 30 percent soils of minor extent. This association occupies about 3 percent of the survey area. Slopes do not exceed 2 percent.

Puget soils are mostly silty clay loams that formed in alluvium. Earlmont soils are mostly silt loams that formed in diatomite. Snohomish soils are silt loams that have peat or muck in the substratum.

Most of the soils of this association are well suited to farming and are among the more productive soils in King County for truck crops. The soils have a seasonal high water table and are subject to flooding except where flood protection structures have been installed. The high water table and high compressibility of these soils cause moderate to severe limitations for residential and commercial sites and for septic tank filter fields.

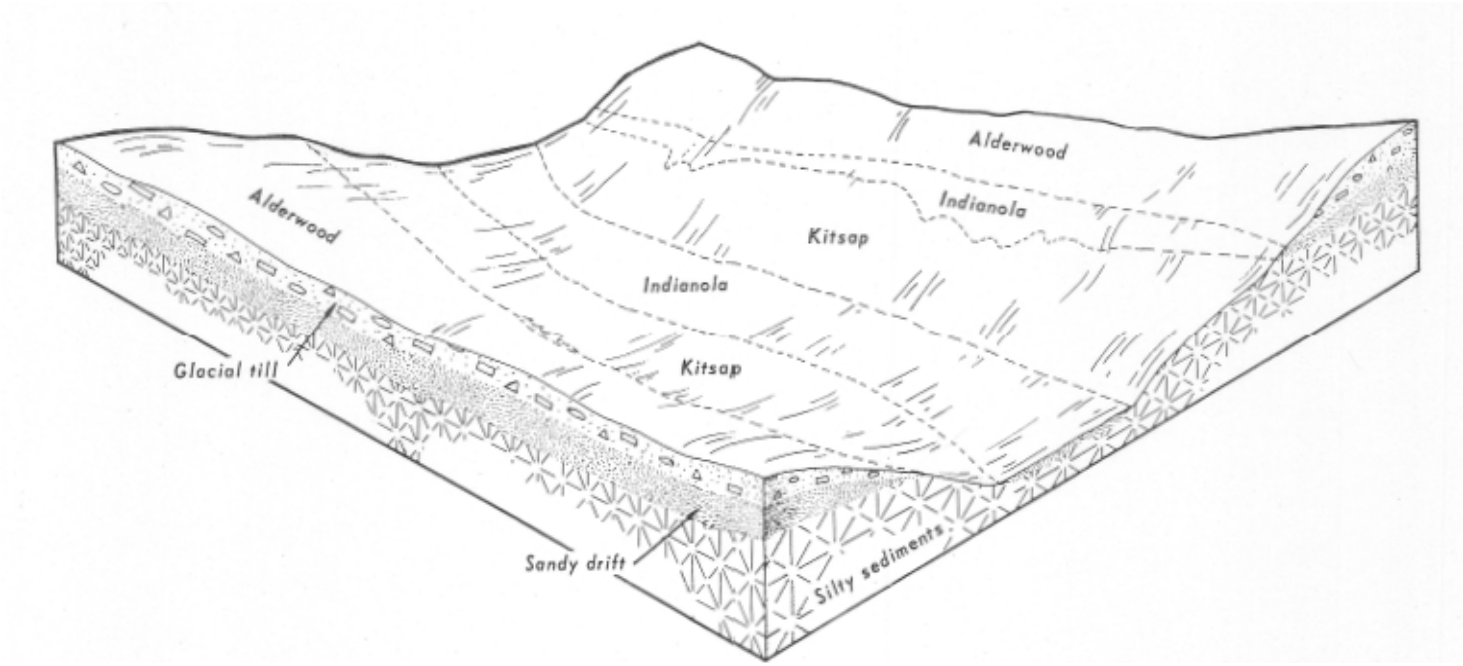


Figure 6.—Pattern of soils and parent material in soil association 6.

This section describes the soil series and mapping units in the King County Area. Each soil series is described and then each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Unless it is otherwise stated, the colors given in the descriptions are those of a moist soil.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Urban land, for example, does not belong to a soil series, but nevertheless, is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a 5Ymbol in parentheses. This 5Ymbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and woodland group in which the mapping unit has been placed. The woodland designation and the page for the description of each capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (19).

Alderwood Series

The Alderwood series is made up of moderately well drained soils that have a weakly consolidated to strongly consolidated substratum at a depth of 24 to 40 inches. These soils are on uplands. They formed under conifers, in glacial deposits. Slopes are 0 to 70 percent. The annual precipitation is 35 to 60 inches, most of which is rainfall, between October and May. The mean annual air temperature is about 50° F. The frost-free season is 150 to 200 days. Elevation ranges from 100 to 800 feet.

In a representative profile, the surface layer and subsoil are *very* dark brown, dark-brown, and grayish-brown gravelly sandy loam about 27 inches thick. The substratum is grayish-brown, weakly consolidated to strongly consolidated glacial till that extends to a depth of 60 inches and more.

Alderwood soils are used for timber, pasture, berries, row crops, and urban development. They are the most extensive soils in the survey area.

Alderwood gravelly sandy loam, 6 to 15 percent slopes (AgC).--This soil is rolling. Areas are irregular in shape and range from 10 to about 600 acres in size.

Representative profile of Alderwood gravelly sandy loam, 6 to 15 percent slopes, in woodland, 450 feet east and 1,300 feet south of the north quarter corner of sec. 15, T. 24 N., R. 6 E.:

A1--0 to 2 inches, very dark brown (10YR 2/2) gravelly sandy loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; slightly hard, friable, nonsticky, nonplastic; many roots; strongly acid; abrupt, wavy boundary. 1 to 3 inches thick.

B2--2 to 12 inches, dark-brown (10YR 4/3) gravelly sandy loam, brown (10YR 5/3) dry; moderate, medium, subangular blocky structure; slightly hard, friable, nonsticky, nonplastic; many roots; strongly acid; clear, wavy boundary. 9 to 14 inches thick.

B3--12 to 27 inches, grayish-brown (2.5Y 5/2) gravelly sandy loam, light gray (2.5Y 7/2) dry; many, medium, distinct mottles of light olive brown (2.5Y 5/6); hard, friable, nonsticky, nonplastic; many roots; medium acid; abrupt, wavy boundary. 12 to 23 inches thick.

IIC--27 to 60 inches, grayish-brown (2.5Y 5/2), weakly to strongly consolidated till, light gray (2.5Y 7/2) dry; common, medium, distinct mottles of light olive brown and yellowish brown (2.5Y 5/6 and 10YR 5/6); massive; no roots; medium acid. Many feet thick.

The A horizon ranges from very dark brown to dark brown. The B horizon is dark brown, grayish brown, and dark yellowish brown. The consolidated C horizon, at a depth of 24 to 40 inches, is mostly grayish brown mottled with yellowish brown. Some layers in the C horizon slake in water. In a few areas, there is a thin, gray or grayish-brown A2 horizon. In most areas, this horizon has been destroyed through logging operations.

Soils included with this soil in mapping make up no more than 30 percent of the total acreage. Some areas are up to 3 percent the poorly drained Norma, Bellingham, Seattle, Tukwila, and Shalcar soils; some are up to 5 percent the *very* gravelly Everett and Neilton soils; and some are up to 15 percent Alderwood soils that have slopes more gentle or steeper than 6 to 15 percent. Some areas in Newcastle Hills are 25 percent Beausite soils, some northeast of Duvall are as much as 25 percent Ovall soils, and some in the vicinity of Dash Point are 10 percent Indianola and Kitsap soils. Also included are small areas of Alderwood soils that have a gravelly loam surface layer and subsoil.

Permeability is moderately rapid in the surface layer and subsoil and very slow in the substratum. Roots penetrate easily to the consolidated substratum where they tend to mat on the surface. Some roots enter the substratum through cracks. Water moves on top of the substratum in winter. Available water capacity is low. Runoff is slow to medium, and the hazard of erosion is moderate.

This soil is used for timber, pasture, berries, and row crops, and for urban development. Capability unit IVe-2; woodland group 3d1.

Alderwood gravelly sandy loam, 0 to 6 percent slopes (AgB).--This soil is nearly level and undulating. It is similar to Alderwood gravelly sandy loam, 6 to 15 percent slopes, but in places its surface layer is 2 to 3 inches thicker. Areas are irregular in shape and range from 10 acres to slightly more than 600 acres in size.

Some areas are as much as 15 percent included Norma, Bellingham, Tukwila, and Shalcar soils, all of which are poorly drained; and some areas in the vicinity of Enumclaw are as much as 10 percent Buckley soils.

Runoff is slow, and the erosion hazard is slight.

This Alderwood soil is used for timber, pasture, berries, and row crops, and for urban development. Capability unit IVe-2; woodland group 3d2.

Alderwood gravelly sandy loam, 15 to 30 percent slopes (AgD).--Depth to the substratum in this soil varies within short distances, but is commonly about 40 inches. Areas are elongated and range from 7 to about 250 acres in size.

Soils included with this soil in mapping make up no more than 30 percent of the total acreage. Some areas are up to 25 percent Everett soils that have slopes of 15 to 30 percent, and some areas are up to 2 percent Bellingham, Norma, and Seattle soils, which are in depressions. Some areas, especially on Squak Mountain, in Newcastle Hills, and north of Tiger Mountain, are 25 percent Beausite and Ovall soils. Beausite soils are underlain by sandstone, and Ovall soils by andesite.

Runoff is medium, and the erosion hazard is severe. The slippage potential is moderate.

This Alderwood soil is used mostly for timber. Some areas on the lower parts of slopes are used for pasture. Capability unit VIe-2; woodland group 3d1.

Alderwood and Kitsap soils, very steep (AkF).-This mapping unit is about 50 percent Alderwood gravelly sandy loam and 25 percent Kitsap silt loam. Slopes are 25 to 70 percent. Distribution of the soils varies greatly within short distances.

About 15 percent of some mapped areas is an included, unnamed, very deep, moderately coarse textured soil; and about 10 percent of some areas is a very deep, coarse-textured Indianola soil.

Drainage and permeability vary. Runoff is rapid to very rapid, and the erosion hazard is severe to very severe. The slippage potential is severe.

These soils are used for timber. Capability unit VIIe-1; woodland group 2dl.

Arents, Alderwood Material

Arents, Alderwood material consists of Alderwood soils that have been so disturbed through urbanization that *they* no longer can be classified with the Alderwood series. These soils, however, have many similar features. The upper part of the soil, to a depth of 20 to 40 inches, is brown to darkbrown gravelly sandy loam. Below this is a grayishbrown, consolidated and impervious substratum. Slopes generally range from 0 to 15 percent.

These soils are used for urban development.

Arents, Alderwood material, 0 to 6 percent slopes (AmB).--In many areas this soil is level, as a result of shaping during construction for urban facilities. Areas are rectangular in shape and range from 5 acres to about 400 acres in size.

Representative profile of Arents, Alderwood material, 0 to 6 percent slopes, in an urban area, 1,300 feet west and 350 feet south of the northeast corner of sec. 23, T. 25 N., R. 5 E.:

0 to 26 inches, dark-brown (10YR 4/3) gravelly sandy loam, pale brown (10YR 6/3) dry; massive; slightly hard, very friable, nonsticky, nonplastic; many roots; medium acid; abrupt, smooth boundary. 23 to 29 inches thick.

26 to 60 inches, grayish-brown (2.5Y 5/2) weakly consolidated to strongly consolidated glacial till, light brownish gray (2.5Y 6/2) dry; common, medium, prominent mottles of yellowish brown (10YR 5/6) moist; massive; no roots; medium acid. Many feet thick.

The upper, very friable part of the soil extends to a depth of 20 to 40 inches and ranges from dark grayish brown to dark yellowish brown.

Some areas are up to 30 percent included soils that are similar to this soil material, but either shallower or deeper over the compact substratum; and some areas are 5 to 10 percent very gravelly Everett soils and sandy Indianola soils.

This Arents, Alderwood soil is moderately well drained. Permeability in the upper, disturbed soil material is moderately rapid to moderately slow, depending on its compaction during construction. The substratum is very slowly permeable. Roots penetrate to and tend to mat on the surface of the consolidated substratum. Some roots enter the substratum through cracks. Water moves on top of the substratum in winter. Available water capacity is low. Runoff is slow, and the erosion hazard is slight.

This soil is used for urban development. Capability unit IVe-2; woodland group 3d2.

Arents, Alderwood material, 6 to 15 percent slopes (AmC).--This soil has convex slopes. Areas are rectangular in shape and range from 10 acres to about 450 acres in size.

Some areas are up to 30 percent included soils that are similar to this soil material, but either shallower or deeper over the compact substratum; and some areas are 5 to 10 percent very gravelly Everett soils and sandy Indianola soils.

Runoff is medium, and the erosion hazard is moderate to severe.

This soil is used for urban development. Capability unit IVe-2; woodland group 3d2.

Arents, Everett material (An).--This is a level to gently sloping, dark-brown gravelly or very gravelly sandy loam. It is very similar to Everett gravelly sandy loam (see Everett series), but it has been disturbed and altered through urban development. Multicolored very gravelly coarse sand is at a depth of 8 to 40 inches. Areas are commonly rectangular in shape, and range from 1 to 120 acres in size.

Representative profile of Arents, Everett material, in a homesite, 440 feet west and 100 feet north of the center of sec. 11, T. 24 N., R. 6 E.:

0 to 8 inches, dark-brown (7.5YR 3/4) gravelly sandy loam, brown (7.5YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; 30 percent gravel content; slightly acid; clear, smooth boundary. 8 to 14 inches thick.

8 to 60 inches, grayish-brown and light olive-brown (2.5Y 5/2 and 5/4) very gravelly coarse sand, light gray and light yellowish brown (2.5Y 7/2 and 6/4) dry; single grain; loose, nonsticky, nonplastic; few roots; 55 percent gravel and 10 percent cobblestone content; medium acid.

The upper part of the soil ranges from dark brown to olive brown and from gravelly sandy loam to very gravelly loamy sand. The substratum ranges from black to olive brown.

This soil is somewhat excessively drained. The effective rooting depth is 60 inches or more. Permeability is rapid, and available water capacity is low. Runoff is slow, and the erosion hazard is slight.

This soil is used for urban development. Capability unit IVs-1; woodland group 3f3.

Beausite Series

The Beausite series is made up of well-drained soils that are underlain by sandstone at a depth of 20 to 40 inches. These soils formed in glacial deposits. They are rolling to very steep. Slopes are 6 to 75 percent. The vegetation is alder, fir, cedar, and associated brush and shrubs. The annual precipitation is 40 to 60 inches, and the mean annual temperature is about 50° F. The frost-free season ranges from 160 to 190 days. Elevation is 600 to 2,000 feet.

In a representative profile, the surface layer and the upper part of the subsoil are dark-brown to dark yellowish-brown gravelly sandy loam that extends to a depth of about 19 inches. The lower part of the subsoil is olive-brown very gravelly sandy loam. Fractured sandstone is at a depth of about 38 inches.

Beausite soils are used for timber and pasture. Some areas have been used for urban development.

Beausite gravelly sandy loam, 6 to 15 percent slopes (BeC).--Areas of this soil are 20 acres or more in size. Slopes are long and convex.

Representative profile of Beausite gravelly sandy loam, 6 to 15 percent slopes, in woodland, 570 feet south and 800 feet east of the northwest corner of sec. 29, T. 24 N., R. 6 E.:

O1--2 inches to 1/2 inch, undecomposed leaf litter.

O2--1/2 inch to 0, black (10YR 2/1) decomposed leaf litter.

A1--0 to 6 inches, dark-brown (10YR 3/3) gravelly sandy loam, brown (10YR 5/3) dry; weak, fine, granular structure; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; clear, wavy boundary. 5 to 7 inches thick.

B21--6 to 19 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam, light yellowish brown (10YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; clear, irregular boundary. 10 to 15 inches thick.

B22--19 to 38 inches, olive-brown (2.5Y 4/4) very gravelly sandy loam, light yellowish brown (2.5Y 6/4) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; medium acid; abrupt, irregular boundary.

IIR--38 inches, fractured sandstone; medium acid.

The A horizon ranges from very dark grayish brown to very dark brown and dark brown. The B horizon ranges from dark grayish brown to dark yellowish brown and olive brown. It is gravelly and very gravelly sandy loam and gravelly loam. Depth to sandstone ranges from 20 to 40 inches.

Some areas are up to 20 percent included Alderwood soils, which have a consolidated substratum, and Ovall soils, which are underlain by andesite; some are up to 5 percent the wet Norma and Seattle soils; some are up to 5 percent Beausite soils that have a gravelly loam surface layer and subsoil; and some are up to 10 percent soils that are similar to Beausite soils, but are more than 40 inches deep over sandstone.

Roots penetrate easily to bedrock and enter a few cracks in the bedrock. Permeability is moderately rapid. Available water capacity is low. Runoff is medium, and the hazard of erosion is moderate.

This soil is used for timber and pasture and for urban development. Capability unit IVe-2; woodland group 3d2.

Beausite gravelly sandy loam, 15 to 30 percent slopes (BeD).--Areas of this soil are 40 acres or more in size. Slopes are long. On the east side of Squak Mountain, south of Issaquah, and on the north side of Tiger Mountain, east of Issaquah, slopes are as steep as 50 percent.

Some areas are up to 20 percent included Alderwood soils, which have a consolidated substratum, and Ovall soils, which are underlain by andesite; some are up to 5 percent the wet Norma and Seattle soils; some are up to S percent Beausite soils that have a gravelly loam surface layer and subsoil;
and some are up to 10 percent soils that are similar to Beausite soils, but are more than 40 inches deep over sandstone. On the east side of Squak Mountain, south of Issaquah, and on the north side of Tiger Mountain, east of Issaquah, are included areas where slopes are as steep as 50 percent.

Runoff is rapid and the hazard of erosion is severe.

This soil is used for timber and pasture. Capability unit VIe-2; woodland group 3d1.

Beausite gravelly sandy loam, 40 to 75 percent slopes (BeF).--This soil is similar to Beausite gravelly sandy loam, 6 to 15 percent slopes, but is commonly shallower over sandstone. The depth to sandstone is commonly 20 to 30 inches, but in places is as much as 40 inches. Slopes are convex. Areas are irregularly shaped and range from 100 to about 600 acres in size.

Soils included with this soil in mapping make up no more than 40 percent of the total acreage. Some areas are up to 10 percent Alderwood soils, which have a consolidated substratum; some are up to 10 percent Ovall soils that are 20 to 40 inches deep over weathered andesite and have slopes of 30 to 75 percent; some isolated areas are up to 25 percent rock outcrop; and some are up to 20 percent Beausite soils that have milder slopes.

Runoff is very rapid, and the hazard of erosion is very severe.

This soil is used for timber. Capability unit VIIe-1; woodland group 3d1.

Bellingham Series

The Bellingham series is made up of poorly drained soils that formed in alluvium, under grass and sedges. These soils are nearly level and are mostly in depressions on the upland glacial till plain. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile the surface layer is very dark brown silt loam about 11 inches thick. The subsoil is mottled gray silty clay loam about 49 inches thick.

Bellingham soils are used chiefly for pasture and occasionally for row crops.

Bellingham silt loam (Bh).--Areas of this soil are somewhat rounded and elongated and range from 1 to 40 acres in size. Slopes are less than 2 percent.

Representative profile of Bellingham silt loam, in pasture, 600 feet north and 650 feet east of the south quarter corner of sec. 10, T. 24 N., R. 6 E.:

Ap--0 to 11 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry; common, fine, distinct mottles, brownish yellow (10YR 6/6) dry; moderate, medium, crumb structure; hard, friable, slightly sticky, slightly plastic; many roots; medium acid; abrupt, smooth boundary. 12 to 20 inches thick.

B1--11 to 14 inches, olive-gray (5Y 5/2) loamy sand, light gray (5Y 7/2) dry; massive; hard, very friable, nonsticky, nonplastic; common roots; medium acid; clear, smooth boundary. 0 to 3 inches thick.

B2g--14 to 60 inches, gray (N 5/0) silty *clay* loam; many, medium and large, prominent, strong brown mottles, light gray (5Y 7/1) and yellow (10YR 7/8) dry; massive; hard, firm, sticky, plastic; few roots; neutral.

The A horizon ranges from black to very dark grayish brown. The B horizon is grayish brown, olive gray, or gray. It is mostly silty clay loam and heavy silt loam. There are a few thin layers of loamy sand and sandy loam.

Included in mapping were small areas of Alderwood, Everett, and Seattle soils. Total inclusions do not exceed 15 percent of the total acreage.

Permeability is slow. In drained areas, roots penetrate to a depth of 60 inches and more. In undrained areas, effective rooting depth is restricted because the seasonal water table is near the surface during the rainy season. The available water capacity is high. Runoff is slow, and the hazard of erosion is slight.

This soil is used mostly for pasture. A few areas are used for row crops. Capability unit IIIw-2; woodland group 3w2.

Briscot Series

The Briscot series is made up of somewhat poorly drained soils. These soils formed in alluvium, under conifers and grass in river valleys. Slopes are less than 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about sea level to 85 feet.

In a representative profile, the surface layer is dark Grayish-brown silt loam about 9 inches thick. The subsoil is mottled grayish-brown and dark-gray, stratified fine sandy loam, silt loam, and fine sand to a depth of 60 inches or more.

Briscot soils are used for row crops and seeded grass pasture and for urban development.

Briscot silt loam (Br).--Areas of this soil are irregularly shaped and range from 5 to more than 80 acres in size.

Representative profile of Briscot silt loam, cultivated, 1,000 feet north and 1,410 feet east of the southeast corner of sec. 25, T. 22 N., R. 4 E.:

Ap--O to 9 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) dry; moderate, medium, granular structure; slightly hard, friable, sticky, plastic; many roots; neutral; abrupt, smooth boundary. 8 to 10 inches thick.

B21g--9 to 17 inches, grayish-brown (2.5Y 5/2) silt loam, light brownish gray (2.5Y 6/2) dry; many, large, prominent, dark-brown (7.5YR 4/4 and 3/4) mottles, brownish yellow (10YR 6/6) dry; weak, very coarse, prismatic structure; slightly hard, friable, sticky, plastic; common roots; neutral; abrupt, wavy boundary. 7 to 9 inches thick.

B22--17 to 44 inches, grayish-brown (2.5Y 5/2) lenses of fine sandy loam, silt loam, and fine sand, light brownish gray (2.5Y 6/2) dry; many, large, prominent, dark-brown (7.5YR 4/4) mottles, yellowish brown (10YR 5/6) and light yellowish brown (10YR 6/4) dry; massive; slightly hard, very friable, slightly sticky, nonplastic; few roots; neutral; diffuse, smooth boundary. 25 to 28 inches thick.

B23g--44 to 60 inches, dark-gray (5Y 4/1) lenses of fine sandy loam, silt loam, and fine sand, grayish brown (2.5Y 5/2) dry; many, large, prominent, dark-brown (7.5YR 4/4) and dark-red (2.5YR 3/6) mottles, brown (7.5YR 5/4) and yellowish brown (10YR 5/6) dry; massive; very friable, slightly sticky, nonplastic; few roots; neutral. Many feet thick.

The A horizon ranges from dark *gray* to dark grayish brown and from silt loam to very fine sandy loam. The B horizon is grayish brown to olive gray mottled with dark brown. It is mostly fine sandy' loam but is stratified with fine sand and silt loam.

Some areas are up to 5 percent included Puyallup soils, which are well drained and are on natural stream levees, and Newberg soils, which also are well drained and are in stream valleys; some areas are up to 2 percent the poorly drained Puget and Woodinville soils; and some are up to 5 percent Oridia and Renton soils.

Permeability is moderate. In winter the seasonal water table is within a depth of 1 to 2 feet. In drained areas, roots penetrate easily to a depth of 60 inches or more. In undrained areas, effective rooting depth is restricted. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a moderate hazard.

This soil is used for row crops and seeded grass pasture and for urban development. Capability unit IIw-2; woodland group 3wl.

Buckley Series

The Buckley series consists of poorly drained soils. These soils formed in the Osceola mudflow on the nearly level plain between the Green and White Rivers near Enumclaw and Buckley. The annual precipitation is about 48 inches, and the mean annual air temperature is about 50° F. The frost-free season is 190 to 205 days. Elevation ranges from 500 to 700 feet.

In a representative profile, the surface layer is black silt loam and very dark grayish-brown gravelly loam about 16 inches thick. The subsoil is grayish-brown gravelly sandy clay loam mottled with brown and strong brown to a depth of 60 inches or more.

Many areas of Buckley soils have been cleared and drained and are used for seeded grass pasture and hay.

Buckley silt loam (Bu).--This level soil occurs as slightly concave tracts that are irregular in shape and range from 5 acres to more than 100 acres in size.

Representative profile of Buckley silt loam, in pasture, 1,550 feet west and 300 feet south of the east quarter corner of sec. 20, T. 20 N., R. 6 E.:

Ap--0 to 10 inches, black (10YR 2/1) silt loam, very dark brown (10YR 2/2) dry; weak, fine, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; 15 percent gravel; many roots; medium acid; abrupt, smooth boundary. 10 to 14 inches thick.

A1--10 to 16 inches, very dark grayish-brown (10YR 3/2) gravelly loam, grayish brown (10YR 5/2) dry; few, fine, prominent strong-brown (7.5YR 5/6) mottles; weak, medium, granular structure; slightly hard, friable, slightly sticky, slightly plastic; common roots; slightly acid; clear, broken boundary. 0 to 8 inches thick.

B--16 to 60 inches, grayish-brown (2.5Y 5/2) gravelly sandy clay loam, white (2.5Y 8/2) dry; many, medium and coarse, prominent, brown and strong-brown (7.5YR 5/4 and 5/6) mottles and many, medium, distinct and common, fine, prominent mottles of yellow and reddish yellow (2.5Y 7/6 and 7.5YR 6/8) dry; massive; hard, very firm, slightly sticky, slightly plastic; few roots; slightly acid. Several feet thick.

The B horizon is gray to grayish brown mottled with brown and strong brown. It is sandy clay to gravelly sandy clay loam. Depth to the B horizon ranges from 16 to 30 inches.

Some areas are up to 4 percent included Alderwood soils on the higher knobs, and some areas are about 6 percent the poorly drained Seattle and Tukwila soils in depressions.

Permeability is moderate in the surface layer and slow in the subsoil. There is a seasonal water table at or near the surface in winter. In drained areas, roots penetrate with difficulty to a depth of 60 inches or more. In undrained areas, the rooting

depth is restricted. The available water capacity is high. Runoff is slow, and the erosion hazard is slight.

This soil is used for seeded pasture and hay. Capability unit IIIw-2; woodland group 4w1.

Coastal Beaches

Coastal beaches (Cb) are long, narrow areas of sand and gravel along Puget Sound. Small areas of tidal marsh are included. These beach areas are above mean tide but are swept by storm waves. Capability unit VIIIw-1; no woodland classification.

Earlmont Series

The Earlmont series is made up of somewhat poorly drained soils that formed in diatomaceous material. These nearly level soils are on flood plains. Slopes are less than 1 percent. The annual precipitation is 45 to 50 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation is about 40 feet.

In a representative profile, the surface layer is dark grayish-brown silt loam about 9 inches thick. The subsoil is grayish-brown, light brownish-gray, and brown silt loam and silty clay loam about 35 inches thick. The substratum is stratified very fine sandy loam, muck, and diatomite. It extends to a depth of 60 inches or more.

Earlmont soils are used for row crops and grass pasture.

Earlmont silt loam (Ea).--This nearly level soil occurs as long, narrow areas that range from 30 to 40 acres in size.

Representative Profile of Earlmont silt loam, cultivated, 930 feet west and 250 feet north of the east quarter corner of sec. 27, T. 26 N., R. 5 E.:

Ap--0 to 9 inches, dark grayish-brown (10YR 4/2) silt loam, white (10YR 8/1) dry; moderate, coarse and very coarse, granular structure; slightly hard, friable, nonsticky, nonplastic; many roots; strongly acid; abrupt, smooth boundary. 7 to 11 inches thick.

B21--9 to 25 inches, grayish-brown (10YR 5/2) silt loam, white (10YR 8/1) dry; common, fine, prominent dark-brown (7.5YR 4/4) mottles, and many, large, distinct, yellowish-brown (10YR 5/6) mottles on ped faces; common, fine, prominent mottles of brownish yellow (10YR 6/6) and yellow (10YR 7/6) dry; medium, very coarse, prismatic structure; hard, firm, slightly sticky, slightly plastic; common roots; very strongly acid; gradual, smooth boundary. 13 to 16 inches thick.

B22--25 to 41 inches, light brownish-gray (2.5Y 6/2) silty clay loam, white (N 8/0) dry; common, fine, prominent, yellowish-red (5YR 4/8) mottles in root casts, yellow (10YR 7/6 and 8/6) dry; moderate, very coarse, prismatic structure; hard, firm, sticky, plastic; common roots; very strongly acid; clear, smooth boundary. 16 to 20 inches thick.

B23--41 to 44 inches, brown (10YR 5/3) and light brownish-gray (10YR 6/2) silt loam, white (N 8/0) dry; common, fine, prominent, yellowish-brown (10YR 5/6) mottles, light yellowish brown (10YR 6/4) and brownish yellow (10YR 6/6) dry; moderate, very coarse, prismatic structure; hard, firm, slightly sticky, slightly plastic; common roots; very strongly acid; abrupt, smooth boundary. 2 to 4 inches thick.

IIC--44 to 46 inches, very pale brown (10YR 7/3) very fine sandy loam and silt loam, white (10YR 8/1) dry; common, fine, prominent, strong-brown (7,5YR 5/8) mottles, faint and pale brown (10YR 6/3) dry; massive; hard, firm, nonsticky, nonplastic; common roots; very strongly acid; abrupt, smooth boundary. 0 to 3 inches thick.

IIIOa--46 to 48 inches, black (10YR 2/1) and very dark brown (10YR 2/2) muck, dark grayish brown (10YR 4/2) streaked with light gray (10YR 7/1) dry; massive; hard, firm, slightly sticky, slightly plastic; few roots; very strongly acid; abrupt, smooth boundary. 0 to 3 inches thick.

IVC--48 to 60 inches, very dark brown (10YR 2/2) and light-gray (10YR 7/2) laminations of diatomite and muck, white (N 8/0) and grayish brown (10YR 5/2) dry; common, medium, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles in the diatomite, very pale brown (10YR 8/4) dry; weak laminar structure; hard, firm, slightly sticky; slightly plastic; few roots; very strongly acid. Laminated material similar to this horizon extends downward many feet.

The A horizon ranges from gray to dark gray or dark grayish brown. The B horizon ranges from gray and light gray to brown. Below this is stratified diatomite, peat, muck, and volcanic ash. Peat and muck are below a depth of 40 inches; gravel is below a depth of 48 inches in some places.

Some areas are as much as 10 percent the somewhat poorly drained Snohomish, light colored variant, soils; and some areas are 1 percent the poorly drained Seattle and Tukwila soils in depressions.

Permeability is moderate. There is a seasonal water table at a depth of 2 to 3 feet. In drained areas, roots penetrate easily to a depth of 60 inches and more. In undrained areas, root penetration is limited. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. This soil is subject to flooding.

This soil is used for grass pasture and row crops. Capability unit IIw-2; woodland group 3w2.

Edgewick Series

The Edgewick series is made up of well-drained soils. These soils formed in alluvium, under conifers

and grass on valley floors in the vicinity of North Bend. Slopes are 0 to 3 percent. The annual precipitation is 70 to 80 inches, and the mean annual temperature is about 50° F. The frost-free season is about 150 days. Elevation ranges from 400 to 500 feet.

In a representative profile, the surface layer is very dark grayish-brown to dark grayish-brown fine sandy loam that extends to a depth of about 34 inches. The underlying layers are black gravelly sand and gravelly sandy loam that extend to a depth of 60 inches or more.

Edgewick soils are used for pasture.

Edgewick fine sandy loam (Ed).--This soil is slightly convex or level. Areas are irregular in shape and range from 5 acres to more than 300 acres in size. Slope is less than 3 percent.

Representative profile of Edgewick fine sandy loam, in pasture, 1,430 feet east and 1,000 feet south of the west quarter corner of sec. 15, T. 23 N., R. 8 E.:

Ap--0 to 9 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, very friable, nonsticky, nonplastic; many roots; strongly acid; abrupt, smooth boundary. 8 to 11 inches thick.

C1--9 to 34 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) fine sandy loam, grayish brown (2.5Y 5/2) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; medium acid; abrupt, smooth boundary. 24 to 30 inches thick.

IIC2--34 to 60 inches, black (5Y 2/2), stratified gravelly sand and gravelly sandy loam, grayish brown (2.5Y 5/2) dry; massive; soft, very friable, nonsticky, nonplastic; neutral.

The C horizon ranges from dark grayish brown to olive brown. The content of gravel is as much as 10 percent in places in the A horizon and the Cl horizon. The IIC horizon, at a depth below 32 to 40 inches, ranges from dark grayish brown to black and from stratified sand to fine sandy loam that has gravel in some places.

Soils included with this soil in mapping make up no more than 15 percent of the total acreage. Some areas are up to 10 percent Nooksack and Si soils; some are up to 5 percent Pilchuck soils, which occupy the natural levees along streams and the higher swells and undulations; some areas are up to 2 percent the poorly drained Puget soils; and some are 1 percent the poorly drained Seattle soils.

Permeability is moderately rapid. The effective rooting depth is restricted by the gravelly sand substratum. There is a seasonal high water table at a depth of 3 to 4 feet. Available water capacity is moderately high. Runoff is slow, and the erosion hazard is slight. The hazard of stream overflow is moderate to severe.

This soil is used for pasture. Capability unit IIIw-1; woodland group 2o1.

Everett Series

The Everett series is made up of somewhat excessively drained soils that are underlain by very gravelly sand at a depth of 18 to 36 inches. These soils formed in very gravelly glacial outwash deposits, under conifers. They are on terraces and terrace fronts and are gently undulating and moderately steep. Slopes are 0 to 30 percent. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the surface layer and subsoil are black to brown, gravelly to very gravelly sandy loam about 32 inches thick. The substratum extends to a depth of 60 inches or more. It is multicolored black to gray very gravelly sand (pl. I, left).

Everett soils are used for timber and pasture and for urban development.

Everett gravelly sandy loam, 0 to 5 percent slopes (EvB).--This nearly level to very gently undulating soil is on terraces. Areas are irregular in shape and range from 5 acres to more than 200 acres in size.

Representative profile of Everett gravelly sandy loam, 0 to 5 percent slopes, in forest, 450 feet west and 250 feet north of the southeast corner of sec. 30, T. 22 N., R. 7 E.:

01--l to 3/4 inch, undecomposed roots, twigs, and moss; abundant roots. 1 to 2 inches thick.

02--3/4 inch to 0, black (10YR 2/1),decomposed organic matter; abundant roots. 3/4 of an inch to 1 1/2 inches thick.

A1--0 to 1 1/2 inches, black (10YR 2/1) sandy loam, gray (10YR 5/1) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; abrupt, distinct boundary. 0 to 1 1/2 inches thick.

B2ir--l 1/2 to 17 inches, dark-brown (7.5YR 3/4) gravelly sandy loam, yellowish brown (10YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; clear, smooth boundary. 10 to 18 inches thick.

B3--17 to 32 inches, brown (10YR 4/3) very gravelly sandy loam, pale brown (10YR 6/3) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; medium acid; clear, wavy boundary. 8 to 18 inches thick.

IIC--32 to 60 inches, black and dark grayish-brown (10YR 2/1 and 4/2) very gravelly coarse sand, gray, grayish brown, and brown (10YR 5/1 and 5/3) dry; single grain; loose, nonsticky, nonplastic; few roots; medium acid.

The A horizon ranges from black to dark gray. The Bir horizon ranges from dark brown and brown to dark yellowish brown and the B3 horizon from brown to dark brown. The IIC horizon ranges from black and very dark brown to olive brown, and from very

gravelly coarse sand to very gravelly loamy sand. Depth to the IIC horizon ranges from 18 to 36 inches.

Some areas are up to 5 percent included Alderwood soils, on the more rolling and undulating parts of the landscape; some are about 5 percent the deep, sandy Indianola soils; and some are up to 25 percent Neilton very gravelly loamy sands. Also included in mapping are areas where consolidated glacial till which characteristically underlies Alderwood soils, is at a depth of 5 to 15 feet.

Permeability is rapid. The effective rooting depth is 60 inches or more. Available water capacity is low. Runoff is slow, and the erosion hazard is slight.

This soil is used for timber and pasture and for urban development. Capability unit IVs-1; woodland group 3f3.

Everett gravelly sandy loam, 5 to 15 percent slopes (EvC).--This soil is rolling. Areas are irregular in shape, have a convex surface, and range from 25 acres to more than 200 acres in size. Runoff is slow to medium, and the erosion hazard is slight to moderate.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 5 percent Alderwood soils, which overlie consolidated glacial till; some are up to 20 percent Neilton very gravelly loamy sand; and some are about 15 percent included areas of Everett soils where slopes are more gentle than S percent and where they are steeper than 15 percent.

This Everett soil is used for timber and pasture and for urban development. Capability unit VIs-1; woodland group 3f3.

Everett gravelly sandy loam, 15 to 30 percent slopes (EvD).--This soil occurs as long, narrow areas, mostly along drainageways or on short slopes between terrace benches. It is similar to Everett gravelly sandy loam, 0 to 5 percent slopes, but in most places is stonier and more gravelly.

Soils included with this soil in mapping make up no more than 30 percent of the total acreage. Some areas are up to 10 percent Alderwood soils, which overlie consolidated glacial till; some are up to 5 percent the deep, sandy Indianola soils; some are up to 10 percent Neilton very gravelly loamy sand; and some are about 15 percent included areas of Everett soils where slopes are less than 1S percent.

Runoff is medium to rapid, and the erosion hazard is moderate to severe.

Most of the acreage is used for timber. Capability unit VIe-1; woodland group 3f2.

Everett-Alderwood gravelly sandy loams, 6 to 15 percent slopes (EwC).--This mapping unit is about equal parts Everett and Alderwood soils. The soils are rolling. Slopes are dominantly 6 to 10 percent, but range from gentle to steep. Most areas are irregular in shape and range from 15 to 100 acres or more in size. In areas classified as Everett soils, field examination and geologic maps indicate the presence of a consolidated substratum at a depth of 7 to 20 feet. This substratum is the same material as that in the Alderwood soils.

Some areas are up to 5 percent included Norma, Seattle, and Tukwila soils, all of which are poorly drained.

Runoff is slow to medium, and the erosion hazard is slight to moderate.

Most of the acreage is used for timber. Capability unit VIs-1; woodland group 3f3.

Indianola Series

The Indianola series is made up of somewhat excessively drained soils that formed under conifers in sandy, recessional, stratified glacial drift. These undulating, rolling, and hummocky soils are on terraces. Slopes are 0 to 30 percent. The annual precipitation is 30 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to 210 days. Elevation ranges from about sea level to 1,000 feet.

In a representative profile, the upper 30 inches is brown, dark yellowish-brown, and light olivebrown loamy fine sand. This is underlain by olive sand that extends to a depth of 60 inches or more (pl. I, right).

Indianola soils are used for timber and for urban development.

Indianola loamy fine sand, 4 to 15 percent slopes (InC).--This undulating and rolling soil has convex slopes. It is near the edges of upland terraces. Areas range from 5 to more than 100 acres in size.

Representative profile of Indianola loamy fine sand, 4 to 15 percent slopes, in forest, 1,000 feet west and 900 feet south of the northeast corner of sec. 32, T. 25 N., R. 6 E.:

01--3/4 inch to 0, leaf litter.
B21ir--0 to 6 inches, brown (10YR 4/3) loamy fine sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; clear, smooth boundary. 4 to 8 inches thick.
B22ir--6 to 15 inches, dark yellowish-brown (10YR 4/4) loamy fine sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; slightly acid; clear, smooth boundary. 6 to 15 inches thick.
C1--15 to 30 inches, light olive-brown (2.5Y 5/4) loamy fine sand, yellowish brown (10YR 6/4) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; slightly acid; gradual, smooth boundary. 12 to 17 inches thick.
C2--30 to 60 inches, olive (5Y 5/4) sand, light brownish gray (2.5Y 6/2) dry; single grain; loose, nonsticky, nonplastic; few roots; slightly acid. Many feet thick.

There is a thin, very dark brown A1 horizon at the surface in some places. The B horizon ranges

from very dark grayish brown to brown and dark yellowish brown. The C horizon ranges from dark grayish brown to pale olive and from loamy fine sand to sand. Thin lenses of silty material are at a depth of 4 to 7 feet in some places.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 10 percent Alderwood soils, on the more rolling and undulating parts of the landscape; some are up to 8 percent the deep, gravelly Everett and Neilton soils; some are up to 15 percent Kitsap soils, which have platy lake sediments in the subsoil; and some are up to 15 percent Ragnar soils, which have a sandy substratum.

Permeability is rapid. The effective rooting depth is 60 inches or more. Available water capacity is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for timber and for urban development. Capability unit IVs-2; woodland group 4s3.

Indianola loamy fine sand, 0 to 4 percent slopes (InA).--This soil occupies smooth terraces in long narrow tracts adjacent to streams. Areas range from about 3 to 70 acres in size.

Soils included with this soil in mapping make up no more than 20 percent of the total acreage. Some areas are up to 5 percent Alderwood soils, on the more rolling and undulating parts of the landscape; some are about 10 percent the deep, gravelly Everett and Neilton soils; some are up to 10 percent Indianola loamy fine sand that has stronger slopes; and some areas are up to 10 percent the poorly drained Norma, Shalcar, Tukwila soils.

Runoff is slow, and the erosion hazard is slight. This soil is used for timber. Capability unit IVs-2; woodland group 4s3.

Indianola loamy fine sand, 15 to 30 percent slopes (InD).--This soil is along entrenched streams.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 10 percent Alderwood soils; some are about 5 percent the deep, gravelly Everett and Neilton soils; some are up to 15 percent Kitsap soils, which have platy, silty lake sediments in the subsoil; and some are up to 15 percent Indianola loamy fine sand that has milder slopes.

Runoff is medium, and the erosion hazard is moderate to severe.

This soil is used for timber. Capability unit VIe-1; woodland group 4s2.

Kitsap Series

The Kitsap series is made up of moderately well drained soils that formed in glacial lake deposits, under a cover of conifers and shrubs. These soils are on terraces and strongly dissected terrace fronts. They are gently undulating and rolling and moderately steep. Slopes are 2 to 70 percent. Platy, silty sediments are at a depth of 18 to 40 inches. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to more than 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the surface layer and subsoil are very dark brown and dark yellowishbrown silt loam that extends to a depth of about 24 inches. The substratum is olive-gray silty clay loam. It extends to a depth of 60 inches or more.

Kitsap soils are used for timber and pasture.

Kitsap silt loam, 2 to 8 percent slopes (KpB).-This undulating soil is on low terraces of the major valleys of the Area. Areas range from 5 acres to more than 600 acres in size and are nearly circular to irregular in shape. Some areas are one-eighth to a half mile wide and up to 3 or 4 miles long.

Representative profile of Kitsap silt loam, 2 to 8 percent slopes, in pasture, 820 feet west and 330 feet south of east quarter corner of sec. 28, T. 25 N., R. 7 E.:

Ap--0 to 5 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; slightly hard, very friable, nor-sticky, nonplastic; many roots; medium acid; abrupt, smooth boundary.

B2--5 to 24 inches, dark yellowish-brown (10YR 3/4) silt loam, brown (10YR 5/3) dry; 2 percent iron concretions; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; slightly acid; abrupt, wavy boundary. 18 to 21 inches thick.

IIC--24 to 60 inches, olive-gray (5Y 5/2) silty clay loam, light gray (5Y 7/2) dry; many, medium and coarse, prominent mottles of dark yellowish brown and strong brown (10YR 4/4 and 7.5YR 5/8); moderate, thin and medium, platy structure; hard, firm, sticky, plastic; few roots to a depth of 36 inches, none below; strongly acid.

The A horizon ranges from very dark brown to dark brown. The B horizon ranges from dark yellowish brown to dark brown and from silt loam to silty clay loam. The platy IIC horizon ranges from grayish brown to olive gray and from silt loam to silty clay loam that has thin lenses of loamy fine sand in places. Brownish mottles are common in the upper part of the IIC horizon.

Some areas are up to 10 percent included Alderwood gravelly sandy loam; some are up to 5 percent the *very* deep, sandy Indianola soils; and some are up to 5 percent the poorly drained Bellingham, Tukwila, and Seattle soils.

Water flows on top of the substratum in winter. Permeability is moderate above the substratum and very slow within it. The effective rooting depth is about 36 inches. Available water capacity is moderate to moderately high. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for timber and pasture. Capability unit IIIe-1; woodland group 2d2.

Kitsap silt loam, 8 to 15 percent slopes (KpC).--Areas of this soil are commonly less than 50 acres in size.

Some areas are up to 10 percent included Alderwood gravelly sandy loam; some are up to 5 percent the very deep, sandy Indianola soils; and some are up to 5 percent the poorly drained Bellingham, Tukwila, and Seattle soils.

Runoff is medium, and the erosion hazard is moderate to severe. The slippage potential is moderate (pl. II, top and bottom).

This Kitsap soil is used for timber and pasture. Capability unit IVe-1; woodland group 2d2.

Kitsap silt loam, 15 to 30 percent slopes (KpD).-This moderately steep soil is similar to Kitsap silt loam, 2 to 8 percent slopes, but the platy substratum generally is at a depth of about 40 inches.

Soils included with this soil in mapping make up no more than 30 percent of the total acreage. Some areas are up to 15 percent Alderwood gravelly sandy loam; some are up to 15 percent the very deep, sandy Indianola soils; and some are up to 2 percent the poorly drained Bellingham, Seattle, and Tukwila soils.

Runoff is rapid, and the erosion hazard is severe. Slippage potential is severe.

This soil is used for timber and pasture. Capability unit VIe-2; woodland group 2d1.

Klaus Series

The Klaus series is made up of somewhat excessively drained soils that formed under conifers, in very gravelly glacial outwash. These soils are on terraces in the vicinity of North Bend. Slopes are 6 to 15 percent. Annual precipitation is about 80 inches, and the mean annual air temperature is 48° or 49° F. The frost-free season is about 150 days. Elevation ranges from 500 to 600 feet.

In a representative profile, the surface layer is gray loamy sand about 1 1/2 inches thick. The subsoil is dark reddish-brown and dark-brown gravelly loamy sand and very gravelly loamy sand about 24 inches thick. The substratum is dark grayish-brown and olive-brown very gravelly sand that extends to a depth of 60 inches or more.

Klaus soils are used for timber and pasture.

Klaus gravelly loamy sand, 6 to 15 percent slopes (KsC).--This soil is strongly sloping or rolling and is mostly convex. Areas are irregular in shape and range from 10 acres to about 50 acres in size.

Representative profile of Klaus gravelly loamy sand, 6 to 15 percent slopes, in forest, 300 feet east and 1,000 feet north of the southwest corner of sec. 7, T. 23 N., R. 9 E.:

02--1/2 inch to 0, black (N 2/1), decomposed leaf litter; massive.

A2--0 to 1 1/2 inches, gray (10YR 5/1) loamy sand, light gray (10YR 6/1) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; extremely acid; abrupt, irregular boundary. 0 to 2 1/2 inches thick.

B21hir--1 1/2 to 3 inches, dark reddish-brown (2.5YR 2/3 and 3/4) gravelly loamy sand, dark brown (7.5YR 4/4) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; extremely acid; abrupt, irregular boundary. 0 to 6 inches thick.

B22ir--3 to 13 inches, dark reddish-brown (5YR 3/4) very gravelly loamy sand, brown (7.5YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; very strongly acid; gradual, irregular boundary. 5 to 15 inches thick.

B3--13 to 25 inches, dark-brown (7.5YR 4/4) very gravelly loamy sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; strongly acid; abrupt, wavy boundary. 5 to 15 inches thick.

C--25 to 60 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) very gravelly sand, light brownish gray (2.5Y 6/2) dry; single grain; loose, nonsticky, nonplastic; few roots; medium acid.

In many places the thin, gray A2 horizon has been destroyed by logging operations. The upper part of the B horizon ranges from dark gray to dark reddish brown.

The lower part of the B horizon ranges from dark brown or very dark brown to dark yellowish brown and olive brown. Depth to the very cobbly or very gravelly sand C horizon is 18 to 36 inches.

Some areas are as much as 6 percent included Norma and Seattle soils, which are in depressions.

Permeability is rapid to very rapid. The effective rooting depth is 60 inches or more. Available water capacity is low. Runoff is slow, and the erosion hazard is slight.

This soil is used for timber and pasture. Capability unit VIs-1; woodland group 3f1.

Mixed Alluvial Land

Mixed alluvial land (Ma) consists of a variety of alluvial soils in areas that are too small and too closely associated to map separately at the scale used. Texture ranges from sand and gravelly sand to silty clay loam. This land is well drained to very poorly drained. Slopes are commonly 2 percent and less. The hazard of stream overflow is severe.

Mixed alluvial land is used mostly for timber and pasture. Capability unit VIw-2; woodland group 2o1.

Neilton Series

The Neilton series is made up of excessively drained soils. These undulating and rolling soils formed under conifers, on terraces, in stratified, very gravelly glacial outwash deposits. Slopes are 2 to 15 percent. The annual precipitation is 35 to 55 inches, and the mean annual temperature is about

50° F. The frost-free season ranges from 145 to 210 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the soil is dark-brown and dark yellowish-brown *very* gravelly loamy sand to a depth of about 18 inches. The substratum is dark grayish-brown very gravelly sand to a depth of 60 inches and more.

Neilton soils are used for timber and for urban development.

Neilton very gravelly loamy sand, 2 to 15 percent slopes (NeC).--This undulating and rolling soil is in irregularly shaped areas that range from 5 acres to about 200 acres in size.

Representative profile of Neilton very gravelly loamy sand, 2 to 15 percent slopes, in woodland, 1,100 feet east and 150 feet north of the southwest corner of sec. 28, T. 21 N., R. 5 E.:

01--1 to 1/8 inch, undecomposed organic matter; abrupt, smooth boundary. 1 to 2 inches thick.
02--1/8 inch to 0, black (10YR 2/1), decomposed organic matter. 1/8 to 1/4 inch thick.
B21ir--0 to 6 inches, dark-brown (10YR 3/3) very gravelly loamy sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, non-plastic; many roots; strongly acid; clear, smooth boundary. 6 to 8 inches thick.
B22ir--6 to 18 inches, dark yellowish-brown (10YR 3/4) very gravelly loamy sand, yellowish brown (10YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; medium acid; abrupt, wavy boundary. 10 to 14 inches thick.
IIC--18 to 60 inches, dark grayish-brown (2.5Y 4/2) very gravelly sand, light brownish gray (2.5Y 6/2) dry; single grain; loose, nonsticky, non-plastic; few roots; medium acid (pH 5.6). Many feet thick.

The B horizon ranges from dark brown to dark yellowish brown. The IIC horizon ranges from grayish brown to dark grayish brown.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 5 percent Alderwood soils, on the more rolling and undulating parts of the landscape; some are about 3 percent the deep, sandy Indianola soils; some are up to 1 percent the poorly drained Norma soils; some areas are about 1 percent the poorly drained Seattle soils in depressions; and some are up to 20 percent Everett very gravelly sandy loam.

Permeability is very rapid. The effective rooting depth is 60 inches and more. The available water capacity is low. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for timber and for urban development. Capability unit VIs-1; woodland group 3f3.

Newberg Series

The Newberg series is made up of well-drained soils that formed in alluvium in the stream valleys, under grass, hardwoods, and conifers. Slopes are 0 to 2 percent. The annual precipitation is 35 to 45 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the surface layer is very dark grayish-brown silt loam and very fine sandy loam about 20 inches thick. It is underlain, to a depth of 60 inches or more, by stratified very fine sandy loam, loamy very fine sand, loamy sand, and silt loam.

Newberg soils are used for row crops and are among the best soils in the Area for that use. They are also used for pasture and for urban development.

Newberg silt loam (Ng).--This soil is in long, narrow areas that range from 5 to more than 100 acres in size. Slopes are less than 2 percent and are mostly convex.

Representative profile of cultivated Newberg silt loam, 500 feet west and 575 feet north of the east quarter corner of sec. 36, T. 23 N., R. 4 E.:

Ap--0 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; medium acid; abrupt, smooth boundary. 8 to 10 inches thick.
A1--10 to 20 inches, very dark grayish-brown (10YR 3/2) very fine sandy loam, grayish brown (10YR 5/2) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; slightly acid; clear, smooth boundary. 9 to 12 inches thick.
C1—20 to 36 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (2.5Y 4/2) very fine sandy loam and loamy very fine sand, grayish brown (10YR 4/2) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; neutral; abrupt, wavy boundary. 12 to 16 inches thick.
C2--36 to 46 inches, dark grayish-brown (2.5Y 4/2) and gray (5Y 5/1) very fine sandy loam, light brownish gray (2.5Y 6/2) dry; common, large, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; massive; soft, very friable, nonsticky, nonplastic; common roots; neutral; abrupt, wavy boundary. 10 to 13 inches thick.
C3--46 to 47 inches, dark grayish-brown (2.5Y 4/2), yellowish-brown (10YR 5/4), yellowish-red (5YR 4/6), and dark reddish-brown (5YR 3/3) loamy sand and silt loam, light gray (2.5Y 7/0), reddish brown (5YR 4/4), and yellowish red (5YR 4/8) dry; massive; very hard, very friable to very firm, slightly sticky, slightly plastic; few roots; neutral; abrupt, wavy boundary. 1 to 2 inches thick.
C4--47 to 60 inches, gray (5Y 5/1) very fine sandy loam, light gray (5Y 7/1) dry; many, fine, prominent, yellowish-brown (10YR 5/4) mottles and few, fine, prominent, yellowish-red (5YR 4/8) and red (2.5YR 4/6) mottles, light yellowish brown (10YR 6/4) and yellowish red (5YR 4/8)

dry; massive; slightly hard, very friable; nonsticky, nonplastic; few roots; neutral.

The A horizon ranges from very dark grayish brown to very dark brown. The C horizon consists of layers of silt loam, very fine sandy loam, sandy loam, loamy sand, and sand; the thickness of each layer varies. Mottles occur at a depth below 30 to 40 inches in some places.

Some areas are up to 25 or 30 percent inclusions of somewhat poorly drained Briscot, Oridia, and Woodinville soils; and some are up to 10 percent the poorly drained Puget soils. Total inclusions do not exceed 30 percent.

Permeability is moderate. The effective rooting depth is 60 inches or more. A seasonal water table is at a depth of 3 to 4 feet in places. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. The hazard of stream overflow is slight to severe, depending on the amount of flood protection provided.

This soil is used mostly for row crops. Capability unit IIw-1; woodland group 2o1.

Nooksack Series

The Nooksack series is made up of well-drained soils that formed in alluvium in river valleys, under a cover of grass, conifers, and hardwoods. Slopes are 0 to 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 190 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the soil is very dark grayish-brown, dark grayish-brown, and grayishbrown silt loam to a depth of 60 inches or more.

Nooksack soils are used for row crops and pasture and for urban development.

Nooksack silt loam (Nk).--This nearly level soil is in long, narrow areas that range from 5 to about 300 acres in size. Slopes are less than 2 percent.

Representative profile of cultivated Nooksack silt loam, 1,800 feet east and 500 feet south of the west quarter corner of sec. 4, T. 24 N., R. 7 E.:

Ap1--0 to 2 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few, fine, faint, dark yellowish-brown (10YR 4/4) mottles; weak, thin, platy structure; slightly hard, very friable, nonsticky, nonplastic; many roots; slightly acid; abrupt, smooth boundary. 2 to 3 inches thick.

Ap2--2 to 11 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, coarse, prismatic structure; slightly hard, very friable, nonsticky, nonplastic; common roots; slightly acid; abrupt, smooth boundary. 8 to 10 inches thick.

B2--11 to 29 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) dry; weak, medium, prismatic structure and weak, medium, subangular blocky structure; hard, friable, slightly sticky, slightly plastic; common roots; medium acid; clear, smooth boundary. 17 to 21 inches thick.

C1--29 to 42 inches, dark grayish-brown. (10YR 4/2) and grayish-brown (2.5Y 5/2) silt loam and thin lenses of very fine sandy loam, light brownish gray (2.5Y 6/2) dry; massive; slightly hard, very friable, nonsticky, nonplastic; common roots; slightly acid; clear, smooth boundary. 10 to 15 inches thick.

C2--42 to 60 inches, grayish-brown (2.5Y 5/3) silt loam, light brownish gray (2.5Y 6/2) dry; massive; hard, friable, sticky, plastic; common roots; medium acid.

The B and C horizons are mostly silt loam and very fine sandy loam and have lenses of silty clay loam and fine sandy loam. The C horizon is dark grayish brown, grayish brown, or dark brown.

Some areas are up to 5 percent included poorly drained Puget soils; and some are 10 to 15 percent the somewhat poorly drained Oridia and Briscot soils. Also included with this soil in mapping are areas of the poorly drained Woodinville silt loam and a few areas of a Woodinville silty clay loam. Included soils make up no more than 15 percent of the total acreage.

Permeability is moderate. The effective rooting depth is 60 inches or more. A seasonal water table is at a depth of 3 to 4 feet in places. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a moderate to severe hazard.

This soil is used for row crops and pasture and for urban development. Capability unit IIw-1; woodland group 2o1.

Norma Series

The Norma series is made up of poorly drained soils that formed in alluvium, under sedges, grass, conifers, and hardwoods. These soils are in basins on the glaciated uplands and in areas along the stream bottoms. Slopes are 0 to 2 percent. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to 200 days. Elevation ranges from about sea level to 600 feet.

In a representative profile, the surface layer is black sandy loam about 10 inches thick. The subsoil is dark grayish-brown and dark-gray sandy loam and extends to a depth of 60 inches or more.

Norma soils are used mainly for pasture. If drained, they are used for row crops.

Norma sandy loam (No).--This soil occurs as strips 25 to 300 feet wide. Slopes are less than 2 percent. Areas are level or concave and range from 1 to about 100 acres in size.

Representative profile of Norma sandy loam, in a pasture, 725 feet east and 50 feet north of the south quarter corner of sec. 31, T. 20 N., R. 7 E.:

Ap--0 to 10 inches, black (10YR 2/1) sandy loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; slightly acid; abrupt, smooth boundary. 10 to 12 inches thick.

B21g--10 to 30 inches, dark grayish-brown (2.5Y 4/2) sandy loam, light brownish gray (2.5Y 6/2) dry; many, medium, prominent, yellowish-red (5YR 4/8) and brown (7.5YR 4/4) mottles, very pale brown (10YR 7/4) and reddish yellow (7.5YR 6/8) dry; thin platy structure; hard, very friable, nonsticky, nonplastic; few roots; slightly acid; clear, wavy boundary. 19 to 24 inches thick.

B22g--30 to 60 inches, dark-gray (5Y 4/1) sandy loam, light gray (5Y 7/1) dry; common, fine, prominent, strong-brown (7.5YR 5/6) and reddish-yellow (7.5YR 6/6) mottles, yellowish brown (10YR 5/8) and pale brown (2.5Y 7/4) dry; massive; slightly hard, very friable, nonsticky. nonplastic; few roots; slightly acid.

The A horizon ranges from black to very dark brown and is as much as 15 percent gravel. The B horizon commonly is sandy loam that in places is stratified with silt loam and loamy sand. It is as much as 35 percent gravel in some places. The B horizon is mottled gray, dark gray, and dark grayish brown.

Some areas are up to 5 percent included Seattle, Tukwila, and Shalcar soils; and some are up to 5 percent Alderwood and Everett soils, at the slightly higher elevations. In the area northwest of Auburn, in the Green River Valley, there are areas of Norma soils that have an organic surface layer as thick as 12 inches in some places. Also included are small areas of Norma soils that have a silt loam surface layer.

Permeability is moderately rapid. The seasonal water table is at or near the surface. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is moderately high to high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a severe hazard in places.

This soil is used mostly for pasture. Drained areas are used for row crops. Capability unit IIIw-3; woodland group 3w2.

Orcas Series

The Orcas series is made up of very poorly drained organic soils that formed in sphagnum moss and small amounts of Labrador tea and cranberry plants. These soils are in basins on the undulating, rolling glaciated uplands. Slopes are 0 to 1 percent. Annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season is 160 to 180 days. Elevation ranges from 100 to 500 feet.

In a representative profile, the surface layer is dark reddish-brown sphagnum peat about 6 inches thick. The next layer is yellowish-red sphagnum peat that extends to a depth of about 60 inches. Orcas soils are used mostly as wildlife habitat.

Orcas peat (Or).--This level or slightly concave soil is in irregularly shaped areas that range from 2 to about 10 acres in size. Slopes are less than 1 percent.

Representative profile of Orcas peat, under wild cranberries, 600 feet north and 650 feet west of the east quarter corner of sec. 8, T. 24 N., R. 6 E.:

Oi1--0 to 6 inches, dark reddish-brown (5YR 3/2) sphagnum peat, very pale brown (10YR 7/3) dry; soft, spongy; many roots; extremely acid; clear, smooth boundary. 6 to 8 inches thick.

Oi2--6 to 60 inches, yellowish-red (5YR 5/6, 4/6, 4/8) sphagnum peat, very pale brown (10YR 7/4) dry; soft, spongy; few roots; extremely acid.

The Oi1 horizon ranges from dark reddish brown to reddish black. Only slight decomposition has occurred. The Oi2 horizon is uniformly sphagnum peat that ranges from dark reddish brown through yellowish red to very pale brown.

Some areas mapped are up to 20 percent included Seattle and Tukwila mucks, and some are up to 5 percent the wet Bellingham soils.

Permeability is very rapid. There is a water table at or close to the surface for several months each year. In areas where the water table is controlled, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is high. Runoff is ponded, and there is no erosion hazard.

This soil is used mostly as wildlife habitat. Capability unit VIIIw-1; no woodland classification.

Oridia Series

The Oridia series is made up of somewhat poorly drained soils that formed in alluvium in river valleys. Slopes are 0 to 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about 0 to 85 feet.

In a representative profile, the surface layer is dark grayish-brown silt loam about 9 inches thick. The subsoil is grayish-brown, dark grayish-brown, and gray silt loam and silty clay loam that extends to a depth of 60 inches or more.

Oridia soils are used for row crops and pasture and for urban development.

Oridia silt loam (0s).--This gently undulating soil is in irregularly shaped areas. Slopes are less than 2 percent. Areas range from 10 to more than 200 acres in size.

Representative profile of Oridia silt loam, in pasture, 850 feet north, 620 feet east of the southwest corner of sec. 12, T. 22 N., R. 4 E.:

Ap--O to 9 inches, dark grayish-brown (10YR 4/2) heavy silt loam, light brownish gray (2.5Y 6/2) dry; few, fine, prominent, strong-brown (7.5YR 5/6) mottles, reddish yellow (7.5YR 7/6) dry; moderate, medium, granular structure; hard, friable, sticky, plastic; many roots; medium acid; abrupt, smooth boundary. 9 to 11 inches thick.

B21g--9 to 17 inches, grayish-brown (2.5Y 5/2) heavy silt loam, light gray (2.5Y 7/2) dry; many, medium, prominent, brown (7.5YR 4/4) mottles, strong brown (7.5YR 5/6) and very pale brown (10YR 7/3 and 7/4) dry; moderate, medium and coarse, subangular blocky structure; hard, friable, sticky, plastic; many roots; slightly acid; clear, wavy boundary. 6 to 10 inches thick.

B22g--17 to 42 inches, dark grayish-brown (2.5Y 4/1) silt loam and fine sand, white (2.5Y 8/2) dry; fine sand is light gray (10YR 6/1) dry; mottles are many, large, prominent, brown (7.5YR 4/4) and strong brown (7.5YR 5/6) and medium, prominent, *very* pale brown (10YR 7/4) and reddish yellow (7.5YR 6/6) dry; silt loam is massive, hard, friable, sticky, plastic; fine sand is single grain; loose, nonsticky, nonplastic; common roots; neutral; abrupt, smooth boundary. 23 to 26 inches thick.

B23--42 to 54 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, light gray (5Y 7/2) dry; mottles are many, large, prominent, strongbrown (7.5YR 5/6) and medium, prominent, yellow (10YR 7/6) and brownish yellow (10YR 6/6) dry; a discontinuous strong-brown (7.5YR 5/6) and dark-brown (7.5YR 3/4) ortstein layer 1/4 inch thick; massive; hard, friable, sticky, plastic; few roots, neutral; abrupt, wavy boundary. 9 to 15 inches thick.

B24g--54 to 64 inches, gray (5Y 5/1) heavy silt loam, gray (5Y 6/1) dry; few, medium, prominent, darkbrown (7.5YR 4/4) mottles; massive; hard, friable, sticky, plastic; few roots; very strongly acid.

The B horizon is mottled dark *gray* and dark grayish brown to olive gray. It is dominantly silt loam but contains layers of silty clay loam, fine sand, loamy fine sand, and very fine sandy loam. The sandy lenses commonly occur below a depth of 20 inches.

Some areas mapped are up to 10 percent inclusions of poorly drained Puget and Woodinville soils; and some are up to 10 percent the well-drained Newberg and Puyallup soils.

Permeability is moderate to moderately slow in the subsoil. The seasonal high water table is at a depth of 1 to 2 feet. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. The flood hazard is moderate.

This soil is used for row crops and seeded grass pasture and for urban development. Capability unit IIw-2; woodland group 3w1.

Ovall Series

The Ovall series is made up of well-drained soils that overlie weathered andesite breccia at a depth of 20 to 40 inches. These soils formed in glacial deposits on uplands. Slopes are 0 to 75 percent. The annual precipitation is 45 to 65 inches, and the mean annual air temperature is about 52° F. The frost-free season is about 150 days. Elevation ranges from S00 to 1,000 feet.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown loam and gravelly loam about 11 inches thick. The subsoil is dark-brown gravelly loam about 25 inches thick. Weathered andesite is at a depth of about 36 inches. Ovall soils are used for timber and pasture.

Ovall gravelly loam, 0 to 15 percent slopes (OvC).--This gently sloping to rolling soil is on uplands. Areas are somewhat rounded to nearly rectangular in shape and range from 40 to more than 160 acres in size.

Representative profile of Ovall gravelly loam, 0 to 15 percent slopes, in forest, 1,500 feet west and 2,200 feet south of the northeast corner of sec. 5, T. 26 N., R. 7 E.:

O1--2 inches to 0, leaf litter; abundant roots.

A11--0 to 4 inches, very dark brown (10YR 2/2) gravelly loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; soft, very friable, sticky, plastic; many roots; strongly acid; clear, smooth boundary. 3 to S inches thick.

A12--4 to 11 inches, very dark grayish-brown (10YR 3/2) gravelly loam, grayish brown (10YR 5/2) dry; moderate, medium, granular structure; slightly hard, very friable, sticky, plastic; many roots; strongly acid; abrupt, wavy boundary. 5 to 13 inches thick.

B21--11 to 24 inches, dark-brown (10YR 3/3) gravelly loam, grayish brown (10YR 5/2) dry; weak, fine, subangular blocky structure; slightly hard, very friable, sticky, plastic; common roots; slightly acid; clear, wavy boundary. 6 to 13 inches thick.

B22--24 to 36 inches, dark-brown (10YR 3/3) gravelly loam, brown (10YR 5/3) dry; weak, fine, subangular blocky structure; slightly hard, friable, sticky, plastic; few roots; slightly acid; abrupt, irregular boundary. 6 to 18 inches thick.

IIR--36 inches, weathered andesite.

In places there is a thin loam surface layer. The B horizon is loam or gravelly loam that ranges from dark brown to dark yellowish brown. Depth to the weathered andesite ranges from 20 to 40 inches within very short distances. The andesite is commonly soft and fractured in the upper 3 to 10 inches.

Some mapped areas are up to 30 percent included Alderwood gravelly sandy loam, and some are up to 5 percent the poorly drained Norma, Tukwila, and

Shalcar soils in depressions. Some areas in the vicinity of section 9, T. 26 N., R. 7 E. are as much as 20 percent deep silty clay loams that have a very dark brown surface layer and a reddish-yellow to olive-yellow subsoil.

Permeability is moderate. Roots penetrate easily to the bedrock. Available water capacity is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This Ovall soil is used for timber and pasture. Capability unit IVe-2; woodland group 3dl.

Ovall gravelly loam, 15 to 25 percent slopes (OvD).--This hilly soil is on uplands. Areas are irregular in shape and range from 40 to about 160 acres in size.

Some mapped areas are up to 20 percent included Alderwood gravelly sandy loam, and some are up to 10 percent Beausite gravelly loam.

Runoff is medium, and the erosion hazard is severe.

This soil is used for timber. Capability unit VIe-2; woodland group 3d1.

Ovall gravelly loam, 40 to 75 percent slopes (OvF).--This soil is very steep and mostly convex. The areas are irregular in shape and range from 50 to about 300 acres in size. This soil is similar to Ovall gravelly loam, 0 to 15 percent slopes, except that depth to the underlying andesite averages 30 to 40 inches.

Some areas on the lower slopes are up to 15 percent included Alder wood gravelly sandy loam; some are up to 15 percent Ovall soils that have slopes of less than 40 percent; and some are up to 10 percent Beausite gravelly sandy loam.

Runoff is rapid to very rapid, and the erosion hazard is severe.

This soil is used for timber. Capability unit VIIe-1; woodland group 3d1.

Pilchuck Series

The Pilchuck series is made up of excessively drained soils that formed in alluvium on low stream terraces, under a cover of hardwoods and conifers. Slopes are 0 to 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is 160 to 200 days. Elevation ranges from 20 to 800 feet.

In a representative profile, layers of very dark gray, dark grayish-brown, and dark-gray fine sand and loamy fine sand extend to a depth of about 38 inches. Below this is black gravelly sand that extends to a depth of 60 inches or more.

Pilchuck soils are used for pasture and, to a limited extent, for timber.

Pilchuck loamy fine sand (Pc).--This nearly level soil is on terraces adjacent to streams. The areas are long and narrow and range from 2 to slightly more than 60 acres in size. Slopes are less than 2 percent.

Representative profile of Pilchuck loamy fine sand, in woodland, 650 feet north and 800 feet west of the southeast corner of sec. 28, T. 21 N., R. 5 E.:

C1--O to 20 inches, very dark gray (10YR 3/1) loamy fine sand, dark gray (2.5Y 4/1) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; neutral; clear, smooth boundary. 15 to 23 inches thick.

C2--20 to 25 inches, dark grayish-brown (2.5Y 4/2) loamy fine sand, gray (10YR 5/1) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; neutral; abrupt, wavy boundary. 4 to 9 inches thick.

C3--25 to 30 inches, very dark gray and dark-gray (10YR 3/1 and 4/1) fine sand, dark gray (10YR 4/1) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; neutral.; abrupt, wavy boundary. 4 to 7 inches thick.

C4--30 to 38 inches, dark-gray (10YR 4/1) loamy fine sand, grayish brown (10YR 5/2) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; slightly acid; abrupt, wavy boundary. 6 to 9 inches thick.

C5--38 to 60 inches, black (10YR 2/1) gravelly sand, very dark gray (10YR 3/1) dry; single grain; loose, nonsticky, nonplastic; few roots; neutral. Many feet thick.

The C horizon ranges from very dark gray to dark gray and grayish brown. It is loamy fine sand to fine sand that is up to 15 percent gravel. A few layers are more than 15 percent gravel or cobblestones.

Some mapped areas are up to 15 percent inclusions of Riverwash; some are up to 20 percent Pilchuck fine sandy loam; and some are up to 1S percent Briscot, Puyallup, and Oridia soils.

Permeability is rapid. The effective rooting depth is 60 inches or more. A seasonal high water table is at a depth of 2 to 4 feet in places. Available water capacity is low, and runoff is slow. Stream overflow is a severe hazard. The hazard of erosion and deposition by stream overflow is moderate to severe.

This soil is used for timber and pasture. Capability unit VIw-1; woodland group 2s1,

Pilchuck fine sandy loam (Pk).--This nearly level soil is adjacent to streams. It is in long, narrow areas that range from 4 to about 150 acres in size. The surface layer is fine sandy loam or sandy loam that is very dark grayish brown to very dark gray and 8 to 14 inches thick.

This soil is used for timber and pasture. Capability unit IVw-l; woodland group 2s1.

Puget Series

The Puget series is made up of poorly drained soils that formed in alluvium, under sedges and grass, in small depressions of the river valleys. Slopes

are 0 to 1 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 190 days. Elevations range from 10 to 650 feet.

In a representative profile, the soil is dominantly mottled dark grayish-brown and grayish-brown silty clay loam to a depth of about 45 inches. The substratum is gray silty clay that extends to a depth of 60 inches or more.

Puget soils are used for row crops and pasture.

Puget silty clay loam (Pu).--Puget soils are in nearly round or elongated tracts that range from 3 to 110 acres in size. Slopes are less than 1 percent.

Representative profile of Puget silty clay loam, in pasture, 800 feet east of the west quarter corner of sec. 21, T. 25 N., R. 7 E.:

A11--0 to 1 inch, very dark grayish-brown (2.5Y 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate, thin, platy structure; hard, firm, slightly sticky, slightly plastic, many roots; medium acid; abrupt, smooth boundary. 1 to 2 inches thick.

A12--1 to 7 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, light gray (5Y 7/2) dry; common, fine, prominent, dark-brown (7.5YR 4/4) mottles; moderate, very coarse, prismatic structure; hard, firm, sticky, plastic; many roots; medium acid; clear, smooth boundary. 5 to 7 inches thick.

B21g--7 to 17 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, light gray (2.5Y 7/2) dry; common, medium, prominent, strong-brown (7.5YR 5/6, 5/8) mottles; moderate, medium, prismatic structure; hard, firm, sticky, plastic; many roots; slightly acid; clear, smooth boundary. 5 to 12 inches thick.

B22g--17 to 25 inches, grayish-brown (2.5Y 5/2) silty clay loam, light olive gray (5Y 6/2) dry; many, medium, prominent, yellowish-red (5YR 5/8, 4/8) mottles; strong, very coarse, prismatic structure; very hard, firm, sticky, plastic; common roots; slightly acid; abrupt, smooth boundary. 6 to 12 inches thick.

B23g--25 to 26 1/2 inches, dark-gray (5Y 4/1) medium sand, light grayish brown (2.5Y 6/2) dry; few, medium, prominent, yellowish-red (5YR 5/8) mottles; single grain; loose, nonsticky, nonplastic; few roots; slightly acid; abrupt, smooth boundary. 1 to 2 inches thick.

B24g--26 1/2 to 31 inches, grayish-brown (2.5Y 5/2) silty clay loam, light gray (5Y 7/2) dry; many, medium, prominent, yellowish-brown (10YR 3/6) mottles; moderate, medium, angular blocky structure; hard, firm, sticky, plastic; few roots; medium acid; abrupt, wavy boundary. 3 to 6 inches thick .

B25g--31 to 40 inches, grayish-brown (2.5Y 5/2) silty clay loam, light gray (5Y 7/1) dry; common, fine, prominent, yellow, brownish-yellow (10YR 7/6, 6/6), and strong-brown (7.5YR 5/8) mottles; strong, very coarse, prismatic structure; hard, firm, sticky, plastic; few roots; medium acid; clear, smooth boundary. 8 to 10 inches thick.

C1g--40 to 45 inches, greenish-gray (5GY 5/1) silty clay loam, light gray (5Y 7/1) dry; common, fine, prominent, strong-brown (7.5YR 5/6) mottles; massive; hard, firm, sticky, plastic; medium acid; clear, smooth boundary. 4 to 6 inches thick.

C2g--45 to 60 inches, gray (5Y 5/1) silty clay, light gray (5Y 7/1) dry; few, medium, prominent, yellowish-red (5YR 4/8, 5/8) mottles, yellowish brown (10YR 5/8) dry; and common, medium, distinct, light olive-brown (2.5Y 5/4) mottles, light yellowish brown (2.5Y 6/4) dry; massive; very hard, firm, sticky, plastic; medium acid.

The A horizon ranges from silty clay loam to silt loam. The B horizon is dominantly silty clay loam stratified with silt loam, silty clay, and fine sand.

Some areas mapped are up to 10 percent inclusions of Woodinville and Snohomish soils.

Permeability is slow. The seasonal high water table is at or near the surface. In drained areas, roots penetrate with difficulty to a depth of 60 inches or more. In undrained areas the effective rooting depth is restricted. The available water capacity is high. Runoff is slow to ponded, and the erosion hazard is slight. Stream overflow is a severe hazard.

This soil is used for row crops and pasture. Capability unit IIIw-2; woodland group 3w2.

Puyallup Series

The Puyallup series is made up of well-drained soils that formed in alluvium, under grass, hardwoods, and conifers. These soils are on the natural levees adjacent to streams in the river valleys. Slopes are 0 to 2 percent. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 160 to 200 days. Elevation ranges from 20 to 500 feet.

In a representative profile, very dark grayishbrown and dark grayish-brown fine sandy loam and very fine sandy loam extend to a depth of about 34 inches. The substratum, at a depth of 60 inches or more, is very dark grayish-brown, dark grayishbrown, and dark-brown medium sand, loamy sand, and sand.

Puyallup soils are used mostly for row crops and pasture. They are among the soils that are well suited to farming. Urban development is occurring in many areas.

Puyallup fine sandy loam (Py).--This nearly level soil is on natural levees in the valley bottoms. Areas are long and narrow or somewhat rounded and

range from 2 to about 50 acres in size. Slopes are less than 2 percent and are slightly convex.

Representative profile of Puyallup fine sandy loam, in pasture, 1,030 feet east and 1,000 feet north of center of sec. 21, T. 21 N., R. 5 E.:

All--O to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, brown (10YR 3/3) dry; weak, fine, granular structure; soft, very friable, nonsticky, nonplastic; many roots; neutral; clear, smooth boundary. 6 to 10 inches thick.
A12--8 to 14 inches, very dark grayish-brown (10YR 3/2) very fine sandy loam, brown (10YR 5/3) dry; moderate, medium and coarse, granular structure; soft, very friable, slightly sticky slightly plastic; many roots; neutral; abrupt, smooth boundary. 4 to 8 inches thick.
C1--14 to 34 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, brown (10YR 5/3) dry; weak, medium, platy structure; slightly hard, *very* friable, slightly sticky, slightly plastic; many roots; slightly acid; abrupt, wavy boundary. 18 to 24 inches thick.
C2--34 to 45 inches, very dark grayish-brown and dark grayish-brown (10YR 4/2 and 3/2) medium sand, grayish brown (10YR 5/2) dry; single grain; loose, nonsticky, nonplastic; plentiful roots; neutral; gradual, smooth boundary. 9 to 13 inches thick.
C3--45 to 51 inches, dark-brown (10YR 3/3) loamy sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; slightly acid. 4 to 7 inches thick.
C4--5l to 60 inches, dark grayish-brown (2.5Y 4/2) sand, dark gray and gray (10YR 4/1 and 6/1) dry; single grain; loose, nonsticky, nonplastic; few roots; neutral.

The A horizon ranges from very dark grayish brown to very dark brown and from fine sandy loam to very fine sandy loam and silt loam. The C horizon ranges from very dark grayish brown to olive brown. The upper part of the C horizon is dominantly very fine sandy loam. Commonly layers of sand, fine sand, and loamy fine sand are in the lower part of the C horizon. Mottles occur below a depth of 30 to 40 inches in places.

Some areas are up to 15 percent inclusions of Briscot, Newberg, Nooksack, Oridia, and Renton soils; and some are up to 10 percent the poorly drained Woodinville and Puget soils.

Permeability is moderately rapid. The effective rooting depth is 60 inches or more. The seasonal water table is at a depth of 4 to 5 feet. Available water capacity is moderately high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a slight to severe hazard, depending on the amount of flood protection provided.

This soil is used for row crops and pasture and for urban development. Capability unit IIw-1; woodland group 2o1.

Ragnar Series

The Ragnar series is made up of well-drained, gently sloping to strongly rolling soils on dissected glacial outwash terraces. The vegetation is mostly conifers. Slopes are 2 to 25 percent. The annual precipitation is 35 to 65 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to 210 days. Elevation ranges from 300 to 1,000 feet.

In a representative profile, very dark grayish-brown, dark yellowish-brown, and yellowish-brown fine sandy loam extends to a depth of about 27 inches. The substratum is olive-brown loamy sand. It extends to a depth of 60 inches or more.

Ragnar soils are used for timber and for urban development.

Ragnar fine sandy loam, 6 to 15 percent slopes (RaC).--This undulating to rolling soil is on glacial terraces. It is in irregularly shaped tracts that range from 5 to more than 300 acres in size.

Representative profile of Ragnar fine sandy loam, 6 to 15 percent slopes, in forest, 300 feet north and 230 feet east of the center of sec. 3, T. 21 N., R. 5 E.:

O1--1 1/2 inches to 0, black (10YR 2/1) leaves and twigs; abundant roots; abrupt, smooth boundary. 1 to 2 inches thick.
A1--0 to 4 inches, very dark grayish-brown (10YR 3/2) and very dark-gray (10YR 3/1) fine sandy loam, grayish brown (10YR 5/2) dry; massive; slightly hard, very friable, nonsticky, nonplastic; many roots; medium acid; abrupt, wavy boundary. 3 to 9 inches thick.
B21--4 to 17 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) fine sandy loam, brown (10YR 5/3) dry; massive; slightly hard, very friable, nonsticky, nonplastic; many roots; medium acid; clear, smooth boundary. 5 to 13 inches thick.
B22--17 to 27 inches, yellowish-brown (10YR 5/4) fine sandy loam, brown (10YR 5/3) dry; massive; slightly hard, very friable, nonsticky, nonplastic; common roots; medium acid; clear, smooth boundary. 6 to 12 inches thick.
IIC--27 to 60 inches, olive-brown (2.5Y 4/4) loamy sand, yellowish brown (10YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; very few roots; medium acid. Material similar to this horizon extends downward many feet and has numerous, very thick silty layers.

The A horizon ranges from black to very dark grayish brown. The B horizon is sandy loam and fine sandy loam that is dark yellowish brown to brown. The IIC horizon, below a depth of 20 inches, is very dark grayish brown to olive brown. Lenses of loam and silt loam occur below a depth of 36 to 40 inches in many places. Any one horizon can be as much as 15 percent gravel.

Some areas are up to 15 percent inclusions of the very deep, sandy Indianola soils; some are up to 15 percent the very gravelly Everett and Klaus soils; and some are up to 10 percent Alderwood gravelly sandy loam.

Permeability is moderately rapid in the upper part of this soil and rapid in the substratum. Silty layers in the substratum are slowly permeable. The effective rooting depth is 60 inches or more. Available water capacity is moderately high. Runoff is medium, and the erosion hazard is moderate.

This soil is used for timber and for urban development. Capability unit IVe-3; woodland group 4s1

Ragnar fine sandy loam, 15 to 25 percent slopes (RaD).--This soil is similar to Ragnar fine sandy loam, 6 to 15 percent slopes, but it is on long narrow terrace fronts between terraces or adjacent to streams. Underlying silty layers are common. Areas range from 5 to 100 acres in size.

Some areas mapped are up to 10 percent inclusions of the very gravelly Everett and Klaus soils; some are up to 15 percent the very deep, sandy Indianola soils; and some are up to 10 percent Alderwood gravelly sandy loam. Inclusions total less than 25 percent of the acreage.

Runoff is medium to rapid, and the erosion hazard is severe.

This Ragnar soil is used for timber. Capability unit VIe-2; woodland group 4s1.

Ragnar-Indianola association, sloping (RdC).-This association is about equal parts Ragnar fine sandy loam and Indianola loamy fine sand. Slopes are 2 to 15 percent and are mostly convex. Areas are irregular to somewhat rounded in shape and range from 30 to about 300 acres in size. Both soils occupy similar parts of the landscape and have similar vegetation.

Some areas are up to 15 percent inclusions of the very gravelly Everett and Klaus soils.

These soils are used for timber. Ragnar soil in capability unit IVe-3, woodland group 4sl; Indianola soil in capability unit IVs-2, woodland group 4s3.

Ragnar-Indianola association, moderately steep (RdE).--This association is nearly equal parts Ragnar fine sandy loam and Indianola loamy fine sand. Slopes are 15 to 25 percent and convex to concave. Areas are irregular in shape and range from 10 to 40 acres in size.

Some areas are up to 20 percent inclusions of the very gravelly Everett soils; some are up to 15 percent Alderwood gravelly sandy loam; and some are up to 10 percent Kitsap silt loam.

These soils are used for timber. Ragnar soil in capability unit VIe-2, woodland group 4s1; Indianola soil in capability unit VIe-1, woodland group 4s2.

Renton Series

The Renton series is made up of somewhat poorly drained soils that formed in alluvium in river valleys. Slopes are 0 to 1 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from near sea level to 85 feet.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 6 inches thick. The subsoil is mottled dark grayish-brown very fine sandy loam and fine sandy loam about 10 inches thick. The substratum is mottled black sand to a depth of 60 inches or more.

Renton soils are used for row crops and seeded grass pasture and for urban development.

Renton silt loam (Re).--This soil is nearly level to very gently undulating. Slopes are 0 to 1 percent. Areas are irregular in shape and range from 2 to nearly 300 acres in size.

Representative profile of cultivated Renton silt loam, 470 feet west and 1,050 feet north of the east quarter corner of sec. 23, T. 22 N., R. 4 E.:

Ap--0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; moderate, medium and coarse, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; medium acid; abrupt, wavy boundary. 6 to 8 inches thick.

B21--6 to 11 inches, dark grayish-brown (2.5Y 4/2) very fine sandy loam, grayish brown (2.5Y 5/2) dry; many, medium, prominent, dark-brown (7.5YR 4/4) mottles, yellow (10YR 7/6) dry; massive; slightly hard, very friable, slightly sticky, slightly plastic; many roots; neutral (pH 6.6); clear, wavy boundary. 3 to 12 inches thick.

B22--11 to 16 inches, dark grayish-brown (2.5Y 4/2) fine sandy loam and thin lenses of fine sand, grayish brown (2.5Y 5/2) dry; many, medium, prominent, dark-brown (7.5YR 4/4) mottles, reddish yellow (7.5YR 6/6 and 7/6) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; slightly acid; abrupt, irregular boundary. 3 to 12 inches thick.

IIC--16 to 60 inches, black (10YR 2/1) sand, dark grayish-brown (10YR 4/2) dry; common, medium, prominent, strong-brown (7.5YR 5/6) mottles, reddish yellow (7.5YR 7/6) and strong brown (7.5YR 5/6) dry; single grain; loose, nonsticky, nonplastic; few roots; slightly acid.

The A horizon ranges from dark grayish brown to very dark grayish brown. The B horizon ranges from mottled dark gray to grayish brown or dark grayish brown and from silt loam to fine sandy loam. The IIC horizon is mottled, ranges from black to dark

grayish brown, and is sand or loamy sand. Depth to the IIC horizon ranges from 15 to 30 inches. Thick, silty layers occur in the IIC horizon in some places.

Some mapped areas of this soil are up to 2 percent inclusions of the well-drained Puyallup soils on natural stream levees; some are up to 2 percent the poorly drained Puget and Woodinville soils; and some are up to 5 percent the somewhat poorly drained Briscot and Oridia soils. Total inclusions do not exceed 10 percent.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the substratum. There is a seasonal high water table at a depth of 1 to 2 feet. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is moderate to moderately high. Runoff is slow, and the erosion hazard is slight. Flood protection is provided. Thus, the hazard of stream overflow is slight. Capability unit IIIw-1; woodland group 3w1.

Riverwash

Riverwash (Rh) consists of long, narrow areas of sand, gravel, and stones along channels of the larger streams. Some areas are barren of vegetation, and others support scattered cottonwoods, willows, and other trees and shrubs. Overflow and alteration by severe erosion and deposition are frequent. Capability unit VIIIw-1; no woodland classification.

Salal Series

The Salal series is made up of well-drained soils that formed under grass, in alluvium, on flood plains. Slopes are 0 to 2 percent. The annual precipitation is 70 to 80 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 150 days. Elevation ranges from 400 to 500 feet.

In a representative profile, black and very dark grayish-brown silt loam extends to a depth of 60 inches or more.

Salal soils are used for row crops and pasture.

Salal silt loam (Sa).--This soil is in one irregularly shaped area of about 500 acres, west of North Bend. Slopes are less than 2 percent and are mostly convex.

Representative profile of Salal silt loam, in a cultivated field, 1,550 feet east and 1,500 feet north of the southwest corner of sec. 4, T. 23 N., R. 8 E.:

Ap--0 to 11 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; soft, very friable, slightly sticky, slightly plastic; many roots; strongly acid; abrupt, smooth boundary. 9 to 11 inches thick.

A1--11 to 18 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; medium acid; abrupt, wavy boundary. 5 to 11 inches thick.

C1--18 to 33 inches, very dark grayish-brown (2.5Y 3/2) silt loam, grayish brown (2.5Y 5/2) when dry; massive; slightly hard, very friable, slightly sticky, slightly plastic; common roots within a depth of 25 inches, few below; medium acid; clear, wavy boundary. 12 to 18 inches thick.

C2--33 to 50 inches, very dark grayish-brown (2.5Y 3/2) silt loam, light brownish gray (2.5Y 6/2) dry; massive; slightly hard, very friable, slightly sticky, slightly plastic; few roots; medium acid; clear, *wavy* boundary. 14 to 20 inches thick.

C3--50 to 60 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) dry; common, fine, distinct, olive-brown (2.5Y 4/4) mottles, very pale brown (10YR 7/4) dry; weak, fine, granular structure; hard, friable, slightly sticky, plastic; very few roots; medium acid.

Faint mottles occur below a depth of 40 inches in some places. The C horizon is mostly silt loam but has lenses of fine sandy loam or silty clay loam in places.

Included in mapping, and making up as much as 10 percent of some areas, are Nooksack, Si, and Edgewick soils.

Permeability is moderate. The effective rooting depth is 60 inches and more. The seasonal high water table is at a depth of 3 to 4 feet. The available water capacity is high.

Runoff is slow, and the hazard of erosion is slight. Stream overflow is a slight hazard. Capability unit IIw-1; woodland group 2o1.

Sammamish Series

The Sammamish series is made up of somewhat poorly drained soils that formed in alluvium in stream valleys. Slopes are 0 to 2 percent. The annual precipitation is about 50 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about sea level to 50 feet.

In a representative profile, the soil is very dark grayish-brown, dark grayish-brown, and olivegray, stratified silt loam, loamy sand, and fine sandy loam to a depth of 60 inches or more.

Sammamish soils are used for row crops and pasture.

Sammamish silt loam (Sh).--This nearly level soil is in long, irregularly shaped areas that range from 10 to about 200 acres in size. It is near Issaquah and North Bend.

Representative profile of Sammamish silt loam, in pasture, 350 feet north and 50 feet east of the center of sec. 21, T. 24 N., R. 6 E.:

Ap--0 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate, medium, crumb structure; slightly hard, very friable, nonsticky, nonplastic; many roots; strongly acid; abrupt, smooth boundary. 10 to 12 inches thick.

B21--12 to 30 inches, dark grayish-brown (2.5Y 4/2) silt loam and loamy sand, light brownish gray (2.5Y 6/2) dry; many, medium, prominent, brown (7.5YR 4/4), strong-brown (7.5YR 5/6), and dark-brown (7.5YR 3/2) mottles, strong brown (7.5YR 5/6) dry; massive; slightly hard, friable, nonsticky, nonplastic; common roots; neutral; clear, smooth boundary. 16 to 20 inches thick.

B22--30 to 60 inches, olive-gray (5Y 4/2) fine sandy loam and silt loam, grayish brown (2.5Y 5/2) dry; many, medium and fine, prominent, yellowish-red (5YR 4/8) mottles, yellowish red (5YR 5/6, 5/8, 4/6) dry; massive; slightly hard, very friable, nonsticky, nonplastic; very few roots; slightly acid.

The A horizon ranges from black to very dark grayish brown. The B horizon is stratified with silty clay loam, silt loam, fine sandy loam, and loamy sand.

Some areas of this soil are up to 5 percent inclusions of Puget soils; and some are up to 10 percent Bellingham soils. Also included are small areas of Sammamish soils where the surface layer is fine sandy loam and other small areas where it is silty clay loam.

Permeability is moderately slow. There is a seasonal high water table at a depth of 1 to 2 feet. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. Flooding is a hazard.

This soil is used for row crops and pasture. Capability unit IIw-2; woodland group 3w1.

Seattle Series

The Seattle series is made up of very poorly drained organic soils that formed in material derived primarily from sedges. These soils are in depressions and valleys on the glacial till plain and also in the river and stream valleys. Slopes are 0 to 1 percent. The annual precipitation is 35 to 50 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to 250 days. Elevation ranges from about sea level to 1,000 feet.

In a representative profile, the surface layer is black muck about 11 inches thick. It is underlain by dark reddish-brown, black, very dark brown, and dark-brown muck and mucky peat that extends to a depth of 60 inches or more.

If drained, Seattle soils are used for seeded grass pasture, hay, blueberries, and truck crops.

Seattle muck (Sk).--Areas of this nearly level soil are somewhat circular or long and narrow and range from 1 to about 500 acres in size. Slopes are less than 1 percent.

Representative profile of Seattle muck, in pasture, 200 feet east and 500 feet north of the center of sec. 2, T. 24 N., R. 5 E.:

Oa1--O to 11 inches, black (5YR 2/1) muck, black (10YR 2/1) dry; strong, fine, granular structure; hard, very friable, nonsticky, nonplastic; many roots; strongly acid; clear, smooth boundary. 10 to 13 inches thick.

Oe1--11 to 17 inches, dark reddish-brown (5YR 2/2) mucky peat, black (10YR 2/1) with dark-brown (10YR 4/3) fibers dry; laminar structure; very hard, very friable, nonsticky, nonplastic; common roots; strongly acid; clear, smooth boundary. 6 to 8 inches thick.

Oa2--17 to 21 inches, black (5YR 2/1) muck, black (5YR 2/1) dry; massive; very hard, very friable, slightly sticky, slightly plastic; few roots; very strongly acid; clear, wavy boundary. 3 to 6 inches thick.

Oe2--21 to 35 inches, very dark brown (7.5YR 2/2) mucky peat, very dark grayish brown (10YR 3/2) and pale brown (10YR 6/3) dry; massive; very hard, very friable, nonsticky, nonplastic; few roots; medium acid; clear, smooth boundary. 12 to 17 inches thick.

Oe3--35 to 60 inches, dark-brown (7.5YR 3/4) mucky sedge peat, very dark brown (10YR 2/2) and brown (10YR 5/3) dry; massive; very hard, very friable, nonsticky, nonplastic; few roots; medium acid. Several feet thick.

The subsurface layers are stratified mucky peat, muck, and peat that formed mostly from sedges. Where these soils adjoin mineral soils, some layers are 25 percent wood fragments. Thin lenses of mineral soil a half inch to 2 inches thick occur at any depth below 15 inches in some places, but they make up no more than 5 percent of the soil mass.

Some areas are up to 30 percent inclusions of Tukwila soils, which are deep mucks, and Shalcar soils, which are shallow over a mineral substratum; and some areas are up to 15 percent inclusions of the wet Bellingham and Norma soils. Total inclusions do not exceed 30 percent.

Permeability is moderate. There is a seasonal high water table at or near the surface. If the water table is controlled, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is limited. The available water capacity is high. Runoff ponds, and there is little or no erosion hazard.

This soil is used for seeded grass pasture, hay, blueberries, and truck crops. Capability unit IIw-3; no woodland classification.

Shalcar Series

The Shalcar series is made up of very poorly drained organic soils that are stratified with mineral soils and overlie mineral soil material at a depth of 16 to 30 inches. These soils formed in deposits of sedge peat and alluvium in the stream valleys and on rolling, glaciated uplands. Slopes

are 0 to 1 percent. The annual precipitation is 35 to 80 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from 25 to 750 feet.

In a representative profile, the surface layer is very dark brown muck about 14 inches thick. Below this is 5 inches of grayish-brown silt loam and dark-gray very fine sandy loam. The next 5 inches is black and very dark brown muck. The underlying material is mottled grayish-brown, dark-gray, black, and very dark grayish-brown silt loam to loamy sand that extends to a depth of 60 inches or more.

Shalcar soils are used for row crops and pasture.

Shalcar muck (Sm) .--This nearly level soil is in rounded and irregularly shaped areas that range from 1 to about 30 acres in size. Slopes are less than 1 percent.

Representative profile of Shalcar muck, in pasture, 280 feet east and 1,220 feet north of center of sec. 35, T. 22 N., R. 4 E.:

Oa1--O to 9 inches, very dark brown (10YR 2/2) muck, grayish brown (2.5Y 5/1) dry; many, large, prominent, strong-brown (7.5YR 5/6) mottles dry; moderate, medium, granular structure; slightly hard, very friable, sticky, plastic; many roots; medium acid; abrupt, smooth boundary. 9 to 11 inches thick.

Oa2--9 to 14 inches, very dark brown (10YR 2/2) muck and pockets of silt loam; muck is black (10YR 2/1), very dark brown (10YR 2/2), and brown (10YR 4/3) dry; silt loam is light gray (10YR 7/2) dry; moderate, thin, platy structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; *very* strongly acid; abrupt, smooth boundary. 3 to 5 inches thick.

C1--14 to 16 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) dry; many, medium, prominent, brown (7.5YR 4/4) and strong-brown (7.5YR 5/6) mottles, brown (7.5YR 4/4) and reddish yellow (7.5YR 7/6) dry; massive; hard, firm, sticky, plastic; few roots; extremely acid; clear, smooth boundary. 0 to 2 inches thick.

C2--16 to 23 inches, dark-gray (5Y 4/1) fine sandy loam, gray (5Y 6/1) dry; many, medium, prominent, dark-brown (7.5YR 3/2) and dark reddishbrown (5YR 3/4) mottles, yellowish brown (10YR 5/8) and brownish yellow (10YR 6/6) dry; massive; slightly hard, very friable, nonsticky, nonplastic; few roots; extremely acid; clear, wavy boundary. 0 to 10 inches thick.

Oa3--23 to 28 inches, black (10YR 2/1) and very dark brown (10YR 2/2) muck and 25 percent dark-gray (5Y 4/1) fine sandy loam, gray (5Y 6/1 and 5/1) dry; common, medium, prominent mottles of yellowish brown (10YR 5/8) dry; moderate, thin, platy structure; slightly hard, very friable, slightly sticky, slightly plastic; few roots; very strongly acid; clear, wavy boundary. 4 to 6 inches thick.

C3--28 to 60 inches, very dark grayish-brown (2.5Y 3/1) loamy sand, gray (5Y 5/1) dry; common, medium, prominent, dark yellowish-brown (10YR 4/4) mottles and few, medium, prominent mottles of yellowish brown (10YR 5/6 and 5/8) dry; massive; soft, very friable, nonsticky, nonplastic; few roots; very strongly acid.

The muck and mucky peat layers range in color from black to very dark brown, have a combined thickness of 16 to 28 inches, and occur within a depth of 32 inches. Thin layers of mineral soil material also occur within this depth in places. The mineral C horizon is loamy sand to silty clay loam and is mottled very dark grayish brown, gray, and olive gray.

Some areas are up to 30 percent inclusions of the very deep muck and mucky peat Tukwila and Seattle soils; and some areas are up to 15 percent the poorly drained Norma, Bellingham, Puget, and Snohomish soils. Inclusions make up no more than 30 percent of the total acreage.

Permeability is moderate in the organic layers and moderate to rapid in the lower part of the profile. There is a seasonal high water table at or near the surface. If the water table is controlled, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is high. Runoff is ponded. There is no erosion hazard.

This soil is used for row crops and pasture. Capability unit IIw-3; no woodland classification.

Si Series

The Si series is made up of moderately well drained soils that formed under grass and hardwoods, in alluvium on stream terraces near North Bend. Slopes are 0 to 2 percent. The annual precipitation is 70 to 80 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 150 days. Elevation ranges from 400 to 500 feet.

In a representative profile, the surface layer and upper part of the subsoil are dark grayish-brown silt loam about 25 inches thick. The lower part of the subsoil, to a depth of 60 inches or more, is mottled dark grayish-brown, very dark gray, and olive-gray stratified silt loam, loamy sand, and very fine sandy loam.

Si soils are used for row crops and pasture.

Si silt loam (Sn).--This soil is on stream terraces. Slopes are mostly less than 2 percent and convex. Areas range from 2 to about 100 acres in size.

Representative profile of Si silt loam, in pasture, 1,650 feet south and 100 feet west of the north quarter corner of sec. 34, T. 24 N., R. 8 E.:

Ap--0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) dry; weak, medium, crumb structure; hard, very friable, slightly sticky, slightly plastic; many roots; medium acid; clear, smooth boundary. 6 to 9 inches thick.

B1--7 to 25 inches, dark grayish-brown (2.5Y 4/2) silt loam, grayish brown (2.5Y 5/2) dry; massive; slightly hard, very friable, slightly sticky, slightly plastic; many roots; medium acid; clear, smooth boundary. 16 to 20 inches thick.

B21g--25 to 40 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) dry; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles, faint light yellowish brown (2.5Y 6/4) dry; massive; slightly hard, very friable, slightly sticky, slightly plastic; common roots; medium acid; clear, wavy boundary. 13 to 18 inches thick.

B22g--40 to 46 inches, very dark gray (5Y 3/1) loamy sand, grayish brown (2.5Y 5/2) dry; common, medium, distinct, dark yellowish-brown (10YR 3/4) mottles; massive; soft, very friable, nonsticky, nonplastic; few roots; slightly acid; clear, wavy boundary. 3 to 8 inches thick.

B23--46 to 60 inches, olive-gray (5Y 4/2) silt loam and very fine sandy loam, light brownish gray (2.5Y 6/2) dry; common, medium, prominent, dark yellowish-brown (10YR 4/4) mottles, yellowish brown (10YR 5/6) and light yellowish brown (10YR 6/4) dry; massive; slightly hard, very friable, nonsticky, nonplastic; few roots; slightly acid.

The A horizon ranges from dark grayish brown to very dark grayish brown. The B horizon ranges from dark grayish brown and dark gray to very dark gray and olive gray, and from silt loam to very fine sandy loam. In places it contains thin lenses of fine sand, loamy sand, and sandy loam. The number and prominence of mottles increase below a depth of 20 inches.

Some areas are up to 15 percent inclusions of a deep, stratified Edgewick sandy loam; some are up to 5 percent the sandy Pilchuck soils; and some are up to 5 percent the wet Bellingham, Seattle, and Tukwila soils.

Permeability is moderate. The effective rooting depth is 60 inches and more. The seasonal high water table is at a depth of 2 to 4 feet. The available water capacity is high. Runoff is slow, and the hazard of erosion is slight. Stream overflow is a moderate hazard.

This soil is used for row crops and pasture. Capability unit IIw-1; woodland group 201.

Snohomish Series

The Snohomish series is made up of poorly drained soils that formed in alluvium in stream valleys. Slopes are 0 to 2 percent. Annual precipitation is 35 to 50 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from about sea level to 300 feet.

In a representative profile, the surface layer and subsoil are very dark grayish-brown and grayish brown silt loam and clay loam about 17 inches thick. Below this is black mucky peat about 10 inches thick. The substratum is dark-gray loamy fine sand that extends to a depth of 60 inches or more.

Snohomish soils are used for row crops, pasture, and hay.

Snohomish silt loam (So).--This nearly level soil is in areas that are irregular in shape and range from 2 to about 400 acres in size.

Representative profile of Snohomish silt loam, in pasture, 1,050 feet east and 500 feet south of the northwest corner of sec. 24, T. 21 N., R. 4 E.:

Ap--O to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, light grayish brown (10YR 6/2) dry; few, fine, distinct, yellowish-brown (10YR 5/6) mottles, brownish yellow (10YR 6/6) dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky, plastic; many roots; medium acid; abrupt, smooth boundary. 6 to 8 inches thick.

A1--8 to 11 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; medium acid; abrupt, wavy boundary. 1 to 3 inches thick.

B2g--11 to 17 inches, grayish-brown (2.5Y 5/2) clay loam, light gray (2.5Y 7/2) dry; black (10YR 2/1) mucky peat, very dark gray and dark gray (10YR 3/1 and 4/1) dry; many, medium, prominent mottles of reddish brown and yellowish red (5YR 4/4 and 5/6), common, fine, prominent mottles of brownish yellow (10YR 6/6 and 6/8) dry; moderate, medium, granular structure; hard, firm, sticky, plastic; few roots; medium acid; abrupt, wavy boundary. 6 to 26 inches thick.

IIOe--17 to 27 inches, black (10YR 2/1) moist, mucky peat, very dark brown (10YR 2/2) dry; massive; hard, very friable, nonsticky, nonplastic; few roots; medium acid; abrupt, wavy boundary. 10 to 25 inches thick.

IIICg--27 to 60 inches, loamy fine sand, dark gray (N 4/0) moist; gray (5Y 5/1) dry; few, fine, distinct mottles of light brownish gray (2.5Y 6/2) dry; massive; soft, very friable, non-sticky, nonplastic; few roots; medium acid.

The A horizon ranges from very dark grayish brown to dark brown. The B horizon ranges from very dark grayish brown to gray and from silt loam to silty clay loam and loamy sand. Depth to layers of peaty material ranges from 13 to 36 inches. The peaty layers are black to reddish black and are 10 inches or more thick. Layers of silty clay loam to loamy sand occur within and below the peaty layers.

Some areas are up to 20 percent included Woodinville soils; and some are up to 5 percent Seattle, Tukwila, and Shalcar soils.

Permeability is moderate in the upper part of the profile and moderately rapid in the lower part. There is a seasonal high water table at or near the surface. In drained areas, the effective rooting depth is 60

inches or more. In undrained areas, rooting depth is restricted. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a severe hazard.

This soil is used for row crops, pasture, and hay. Capability unit IIw-2; woodland group 3w2.

Snohomish Series, Thick Surface Variant

Snohomish series, thick surface variant, is made up of somewhat poorly drained soils that formed in alluvial deposits of diatomaceous material on the flood plain of the Sammamish Valley. Slopes are 0 to 2 percent. The annual precipitation is 45 to 50 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about sea level to 40 feet.

In a representative profile, the surface layer is very dark brown silt loam about 10 inches thick. The next layers are very dark grayish-brown and lightgray silt loam and very fine sandy loam about 19 inches thick. Below this is black muck that extends to a depth of 60 inches or more.

These soils are used for row crops, hay, or pasture.

Snohomish silt loam, thick surface variant (Sr).--This soil is nearly level. Areas are irregular in shape and range from 1 acre to nearly 200 acres in size.

Representative profile of cultivated Snohomish silt loam, 820 feet north and 250 feet east of the west quarter corner of sec. 26, T. 26 N., R. 5 E.:

Ap--O to 10 inches, very dark brown (7.5YR 2/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine and coarse, crumb structure; soft, very friable, nonsticky, slightly plastic; common roots; slightly acid; abrupt, wavy boundary. 10 to 12 inches thick.

C1--10 to 18 inches, very dark grayish-brown (10YR 3/2) and brown (10YR 5/3) silt loam, light gray (2.5Y 7/2) dry; few, fine, prominent (10YR 7/6 and 6/8) mottles in root casts; moderate, *very* coarse, prismatic structure; hard, friable, slightly sticky, slightly plastic; common roots; medium acid; abrupt, wavy boundary. 4 to 12 inches thick.

IIC2--18 to 20 inches, light-gray (10YR 7/2) and dark yellowish-brown (10YR 4/4) very fine sandy loam (volcanic ash), white (10YR 8/1) and very pale brown (10YR 7/4) dry; massive; slightly hard, friable, nonsticky, nonplastic; common roots; slightly acid; abrupt, wavy boundary. 3/4 inch to 2 inches thick.

IIIC3--20 to 29 inches, very dark grayish-brown (10YR 3/2) and light brownish-gray (10YR 6/2) silt loam, light brownish gray (10YR 6/2) and very pale brown (10YR 7/4) dry; moderate, very coarse, prismatic structure that parts to very coarse platy structure; slightly hard, friable, nonsticky, slightly plastic; few roots; medium acid; clear, smooth boundary. 4 to 14 inches

IVOa--29 to 60 inches, black (5YR 2/1) muck, black (5YR 2/1) dry; moderate, very coarse, prismatic structure; slightly hard, very friable, nonsticky, nonplastic; few roots; very strongly acid. Several feet thick.

The mineral layers above the muck range from very dark brown to very dark grayish brown. The lower part of the mineral layer commonly ranges from light brownish gray to very dark brown. Layers of very fine sandy loam volcanic ash commonly occur in the lower half of the mineral layer. The depth to muck ranges from 20 to 40 inches.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 25 percent the very deep Earlmont silt loam; and some are up to 15 percent the very deep Tukwila muck.

Permeability is moderate. There is a seasonal high water table at a depth of 2 to 3 feet. In drained areas, the effective rooting depth is 60 inches or more. Available water capacity is high. Runoff is very slow, and the erosion hazard is slight. This soil is subject to occasional flooding.

This soil is used for row crops, pasture, and hay. Capability unit IIw-2; woodland group 3w2.

Sultan Series

The Sultan series is made up of moderately well drained soils that formed in alluvium, under grass and hardwoods, in the major stream valleys. Slopes are 0 to 2 percent. The annual precipitation is 35 to 50 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from about sea level to 85 feet.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 9 inches thick. The subsoil extends to a depth of 60 inches or more. It is mottled yellowish-brown, light olivebrown, grayish-brown, and olive-gray, stratified silty clay loam, silt loam, very fine sandy loam, and medium sand.

Sultan soils are used for row crops and pasture.

Sultan silt loam (Su).--This gently undulating soil is on bottom land. Slopes are less than 2 percent. Areas are irregular in shape and range from 2 to about 200 acres in size.

Representative profile of Sultan silt loam, in pasture, 500 feet east, 250 feet east and 250 feet north of the south quarter corner of sec. 9, T. 25 N., R. 7 E.:

Ap--O to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; moderate, medium, granular structure; hard, firm, sticky, and plastic; many roots; slightly acid; abrupt, smooth boundary. 6 to 10 inches thick.

B21--9 to 21 inches, yellowish-brown (10YR 5/4) silty clay loam, pale brown (10YR 6/3) dry; moderate, fine, subangular blocky structure;

hard, friable, sticky, and plastic; many roots; slightly acid; clear, wavy boundary. 10 to 14 inches thick.

B22g--21 to 24 inches, light olive-brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) dry; many, medium, prominent, yellowish-brown (10YR 5/8) mottles, brownish yellow (10YR 6/8) dry; moderate, medium, subangular blocky structure; hard, very friable, slightly sticky, slightly plastic; common roots; neutral; clear, wavy boundary. 2 to 5 inches thick.

B23g--24 to 48 inches, grayish-brown (2.5Y 5/2) silty clay loam, white (2.5Y 8/2) dry; many, medium, prominent, yellowish-brown (10YR 5/8) mottles, yellow (10YR 7/8) dry; moderate, medium, prismatic structure; slightly hard, very friable, sticky, plastic; few roots; neutral; clear, wavy boundary. 20 to 30 inches thick.

B31--48 to 66 inches, olive-gray (5Y 5/2) very fine sandy loam stratified with medium sand, light gray (2.5Y 7/2) dry; many, coarse, prominent, yellowish-red and strong-brown (5YR 5/8 and 5YR 5/6) mottles, strong brown (7.5YR 5/8) dry; massive; slightly hard, very friable, nonsticky and nonplastic; few roots; neutral; clear, wavy boundary. 12 to 20 inches thick.

B32--66 to 72 inches, olive-gray (5Y 5/2) very fine sandy loam, light olive gray (5Y 6/2) dry; common, fine, prominent, yellowish-red (5YR 4/6) mottles, strong brown (7.5YR 5/8) dry; massive; slightly hard, very friable, nonsticky, nonplastic; very few roots; *very* strongly acid.

The A horizon ranges from very dark grayish brown to dark grayish brown. The B horizon ranges from dark grayish brown to olive gray and has brownish mottles. It is mostly silt loam and silty clay loam but in places contains a thin stratum of sand, loamy sand, or very fine sandy loam.

Some areas of this soil are up to 40 or 50 percent inclusions of Puget, Sammamish, and Oridia soils. Also included are small areas of Sultan silty clay loam.

Permeability is moderate. The effective rooting depth is 60 inches or more. A seasonal high water table is at a depth of 2 to 3 feet. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a severe hazard in some areas.

This soil is used for row crops and pasture. Capability unit IIw-1; woodland group 3w1

Tukwila Series

The Tukwila series is made up of very poorly drained organic soils that formed in decomposing sedges, rushes, grasses, and shrubs. These soils are in wet basins of upland depressions and on stream bottoms. Slopes are 0 to 1 percent. The annual precipitation ranges from 35 to 80 inches, and the mean annual temperature is about 50° F. The frost-free season is 150 to 200 days. Elevation ranges from 25 to 750 feet.

In a representative profile, dominantly black to very dark brown muck extends to a depth of 60 inches or more.

If drained, Tukwila soils are used for row crops. They are also used for pasture.

Tukwila muck (Tu).--This nearly level soil is in nearly circular and elongated areas that range from 1 to about 60 acres in size. Slopes are less than 1 percent.

Representative profile of Tukwila muck, in pasture, 320 feet west and 1,140 feet south of the center of sec. 4, T. 21 N., R. 5 E.:

Oa1--O to 10 inches, black (10YR 2/1) muck, dark gray (10YR 4/1) dry; moderate, coarse, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; extremely acid; abrupt, smooth boundary. 8 to 12 inches thick.

Oa2--10 to 16 inches, black (10YR 2/1) muck, brown (10YR 5/3) dry; ped exterior is dark gray (10YR 4/1) dry; moderate, very coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; very strongly acid; clear, smooth boundary. 6 to 9 inches thick.

Oa3--16 to 19 inches, black (10YR 2/1) muck, dark brown (10YR 3/3) dry grading to pale brown (10YR 6/3) in lower part; dark reddish-brown (5YR 3/3) ped interior; moderate, very coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; very strongly acid; abrupt, wavy boundary. 2 to 4 inches thick.

Ldi--19 to 21 inches, strong-brown (7.5YR 5/6) and very pale brown (10YR 7/3) silt loam (diatomite), light yellowish brown (10YR 6/4) dry; massive; slightly hard, very friable, nonsticky, nonplastic; many roots; very strongly acid; abrupt, smooth boundary. 1 to 3 inches thick.

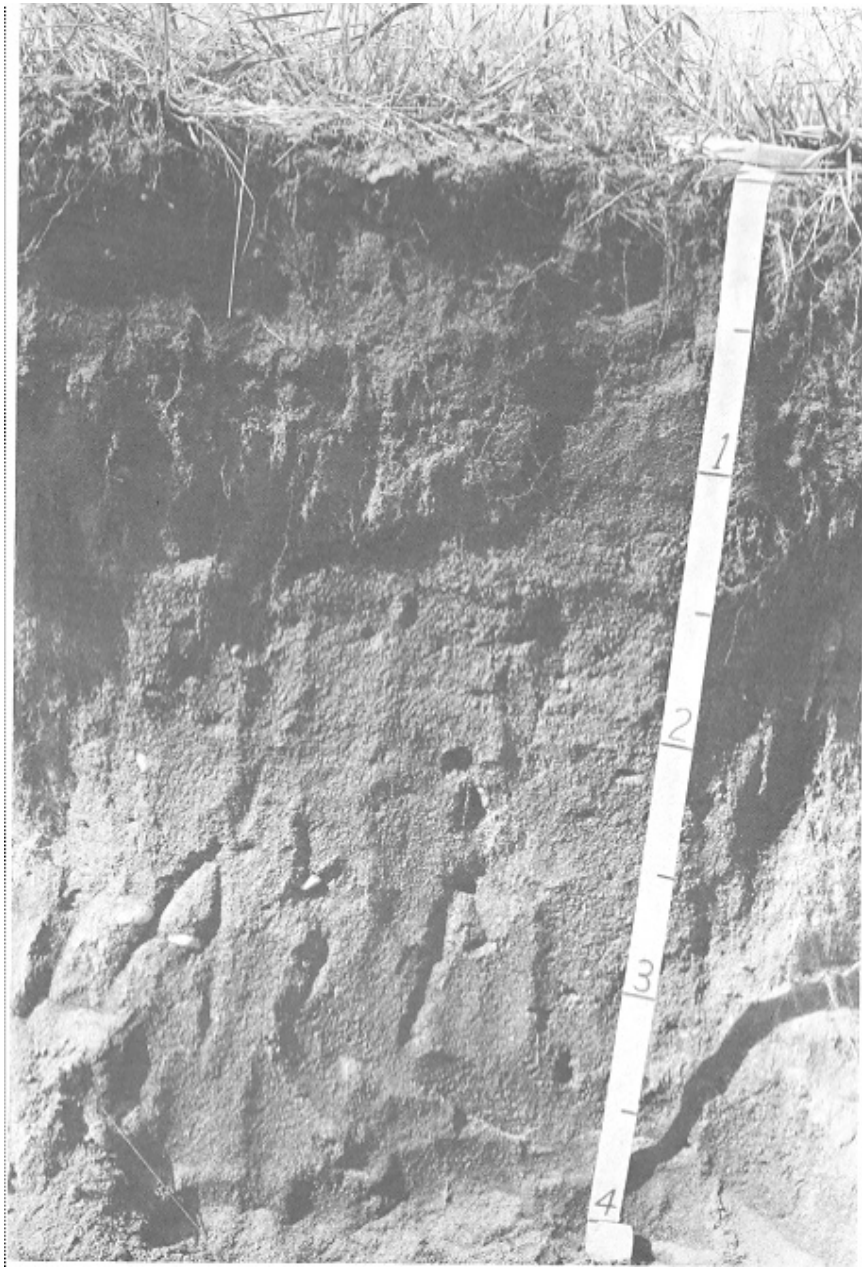
Oa4--21 to 60 inches, very dark brown (10YR 2/2) muck that is S to 10 percent woody stems, dark brown (10YR 2/2) dry; massive; slightly hard, very friable, slightly sticky, slightly plastic; common roots to a depth of 30 inches, few roots below; very strongly acid. Several feet thick.

The underlying organic layers are strong-brown to very dark brown muck, peaty muck, and in places layers of diatomite 1 to 10 inches thick.

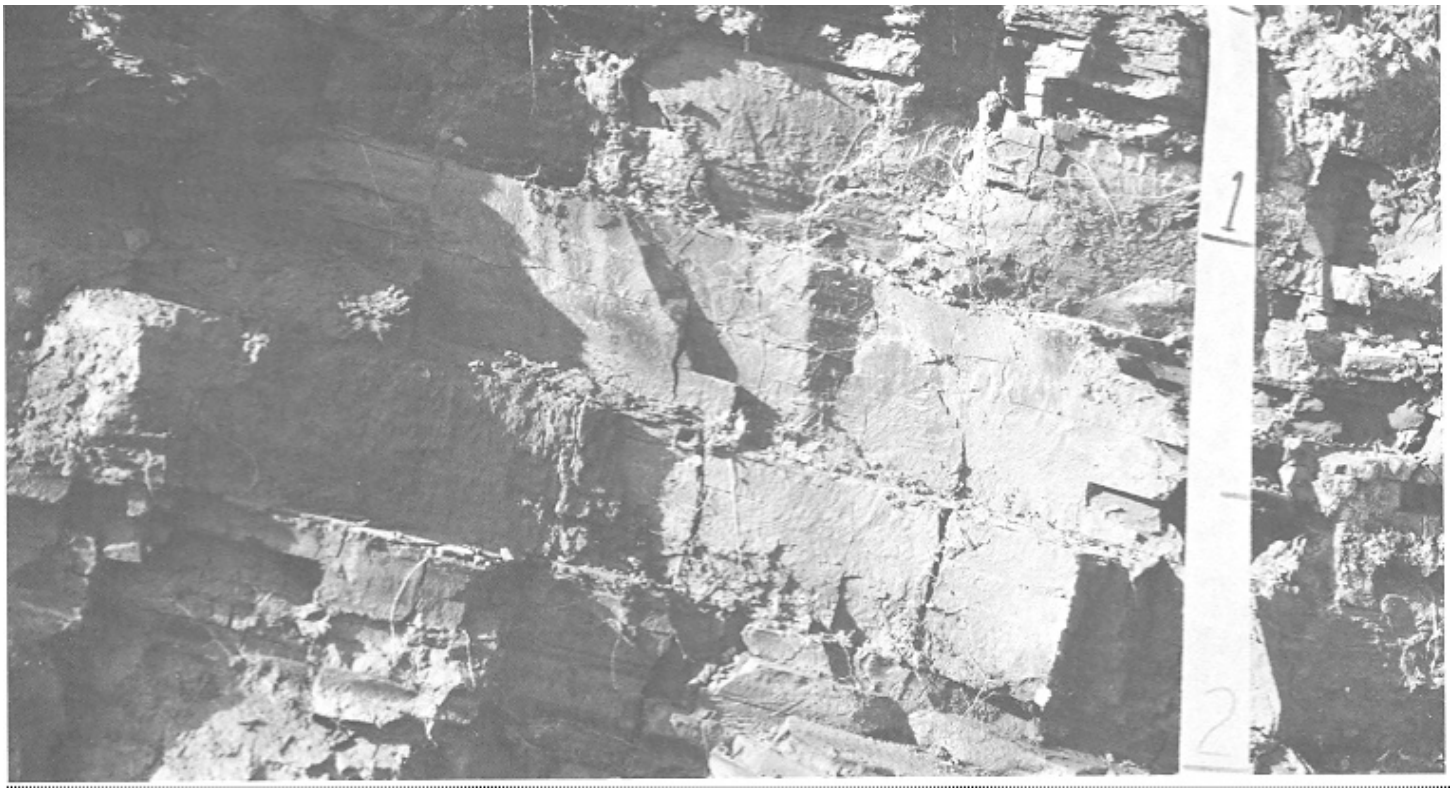
Some areas of this soil are up to 30 or 40 percent Seattle soils; and some are up to 5 percent the poorly drained Bellingham and Norma soils.

Permeability is moderate. There is a seasonal high water table at or near the surface. If the water table is controlled, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. Available water capacity is high. Runoff is ponded, and the erosion hazard is slight.

Profile of Everett gravelly sandy loam, 0 to 5 percent slopes. This somewhat excessively drained soil has few limitations for residential and industrial development. Limitations for farming are severe.



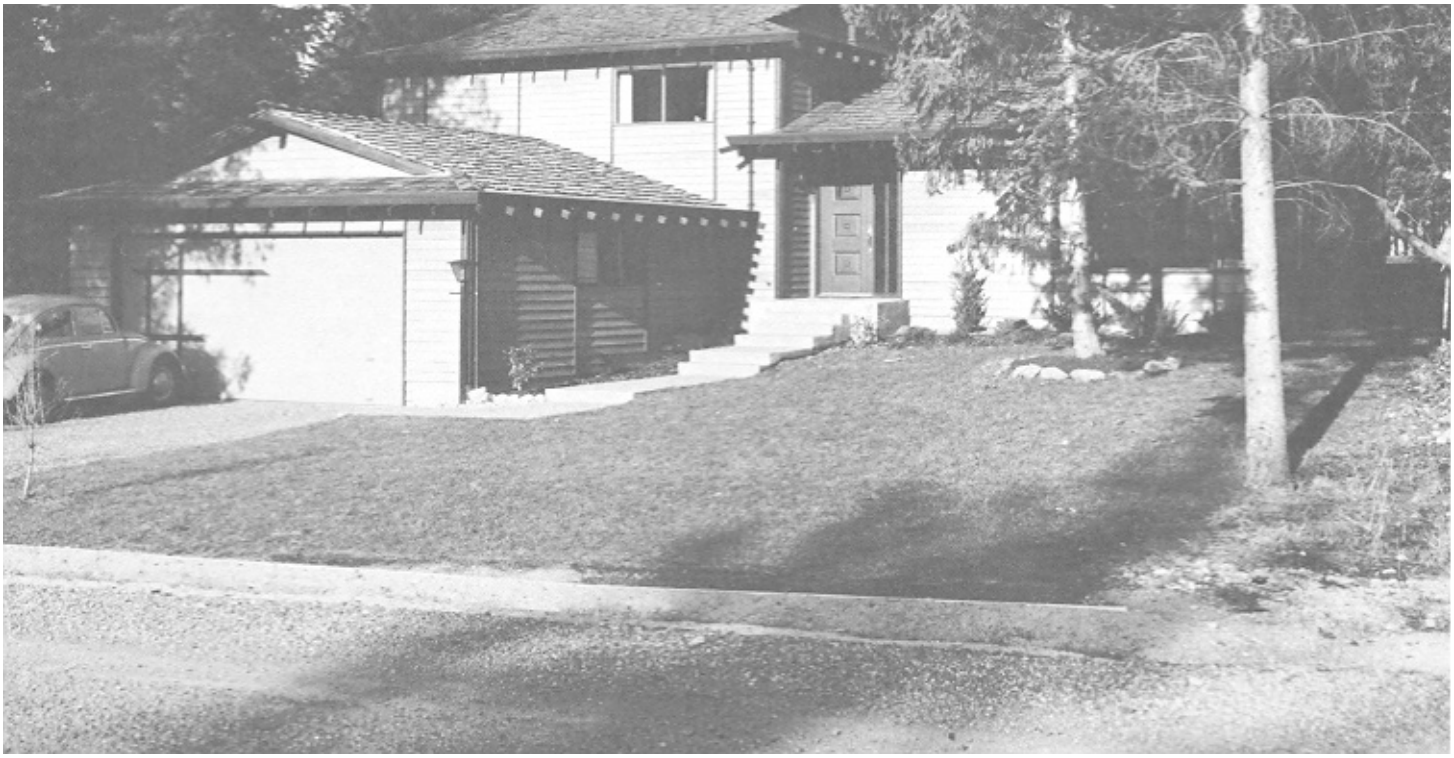
Profile of Indianola loamy fine sand, 4 to 15 percent slopes. Loose, olive sand underlies the massive subsoil.



Platy lake sediments in substratum of Kitsap silt loam, 8 to 15 percent slopes. Slippage potential is moderate.

Soil slip in Kitsap silt loam. Slippage commonly occurs where soils are disturbed during construction.

Ponding on Woodinville silt loam. Water commonly stands on this soil in winter. Flooding is a hazard, and permeability is restricted.



Gentle slopes and no drainage limitations make this Everett soil a desirable residential and industrial site.

If drained, this soil is used for row crops. It is also used for pasture. Capability unit IIw-3; no woodland classification.

Urban Land

Urban land (Ur) is soil that has been modified by disturbance of the natural layers with additions of fill material several feet thick to accommodate large industrial and housing installations. In the Green River Valley the fill ranges from about 3 to more than 12 feet in thickness, and from gravelly sandy loam to gravelly loam in texture.

The erosion hazard is slight to moderate. No capability or woodland classification.

Woodinville Series

The Woodinville series is made up of nearly level and gently undulating, poorly drained soils that formed under grass and sedges, in alluvium, on stream bottoms. Slopes are 0 to 2 percent. The annual precipitation ranges from 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 190 days. Elevation ranges from about sea level to about 85 feet.

In a representative profile, gray silt loam, silty clay loam, and layers of peaty muck extend to a depth of about 38 inches. This is underlain by greenish-gray silt loam that extends to a depth of 60 inches and more.

Woodinville soils are used for row crops, pasture, and urban development.

Woodinville silt loam (Wo).--This soil is in elongated and blocky shaped areas that range from 5 to nearly 300 acres in size. It is nearly level and gently undulating. Slopes are less than 2 percent.

Representative profile of Woodinville silt loam, in pasture, 1,700 feet south and 400 feet west of the north quarter corner of sec. 6, T. 25 N., R. 7 E.:

Ap1--O to 3 inches, gray (5Y 5/1) silt loam, grayish brown (10YR 5/2) dry; common, fine, prominent, dark reddish-brown (5YR 3/4) and reddish-brown (5YR 5/4) mottles; moderate, medium, crumb structure; hard, friable, sticky, plastic; many fine roots; medium acid; clear, smooth boundary. 2 to 4 inches thick.

Ap2--3 to 8 inches, gray (5Y 5/1) silty clay loam, light brownish gray (2.5Y 6/2) dry; many, fine, prominent, dark reddish-brown (5YR 3/3 and 3/4) mottles and common, fine, prominent mottles of strong brown (7.5YR 5/6) and reddish yellow (7.5YR 6/6) dry; moderate, fine and very fine, angular blocky structure; hard, friable, sticky, plastic; common fine roots; medium acid; abrupt, wavy boundary. 4 to 6 inches thick.

B21g--8 to 38 inches, gray (5Y 5/1) silty clay loam, gray (5Y 6/1) dry; common, fine, prominent, brown (7.5YR 4/4) mottles and medium, prominent mottles of brownish yellow (10YR 6/6) dry; 25 percent of matrix is lenses of very dark brown (10YR 2/2) and dark yellowish-brown (10YR 3/4) peaty muck, brown (7.5YR 4/2) dry; massive; hard, firm, sticky, plastic; few fine roots; medium acid; clear, smooth boundary. 30 to 40 inches thick.

B22g--38 to 60 inches, greenish-gray (5BG 5/1) silt loam, gray (5Y 6/1) dry; few, fine, prominent mottles of brownish yellow (10YR 6/6) dry; massive; hard, very friable, slightly sticky, slightly plastic; strongly acid.

The A horizon ranges from dark grayish brown to gray and from silt loam to silty clay loam. The B horizon ranges from gray and grayish brown to olive gray and greenish gray and from silty clay loam to silt loam. In places there are thin lenses of very fine sandy loam and loamy fine sand. Peaty lenses are common in the B horizon. These lenses are thin, and their combined thickness, between depths of 10 and 40 inches, does not exceed 10 inches.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 15 percent Puget soils; some are up to 10 percent Snohomish soils; and some areas are up to 10 percent Oridia, Briscot, Puyallup, Newberg, and Nooksack soils.

Permeability is moderately slow. There is a seasonal high water table at or near the surface. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is high. Runoff is slow, and the hazard of erosion is slight. Stream overflow is a severe hazard unless flood protection is provided (pl. III, top).

This soil is used for row crops, pasture, and urban development. Capability unit IIw-2; woodland group 3w2.

USE AND MANAGEMENT OF THE SOILS

This section explains how the soils of the King County Area can be used for engineering, nonfarm, urban, and recreational purposes, and how they can be managed for woodland, crops and pasture, and wildlife habitat. Features that affect the specific uses of soils are described. Table 6 shows estimated yields of wood crops, and table 7 estimated yields of hay and pasture crops.

Soils and Engineering

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. Among the properties most important to engineers are permeability, shear strength, drainage, consolidation characteristics, texture, plasticity, shrink-swell potential, and soil reaction. Depth to bedrock, or other consolidated material and topography are also important.

Information concerning these and related soil properties is given in tables 2 and 3. The estimates and interpretations in these tables can be used to-

1. Make studies that will aid in selecting and developing industrial, commercial, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils in planning drainage systems, farm ponds, irrigation systems, terraces, waterways, and diversion terraces.
3. Make preliminary evaluations of soil conditions that will aid in selecting sites for highways, airports, pipelines, and cables and in planning detailed investigations at selected locations.
4. Locate probable sources of gravel, sand, and other construction material.
5. Correlate performance of soil mapping units to develop information that will be useful in planning engineering practices and in designing and maintaining engineering structures.
6. Determine the suitability of soils for crosscountry movement of vehicles and construction equipment.
7. Supplement other publications, such as maps, reports, and aerial photographs, that are used in preparation of engineering reports for a specific area.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The engineering interpretations reported here do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or excavations deeper than the depths reported (ordinarily about 5 feet). Even in these situations, however, the soil map is useful in planning more detailed field investigations and in indicating the kinds of problems that may be expected.

Some of the terms used by soil scientists have special meanings in soil science that may not be familiar to engineers. These terms are defined in the Glossary.

Engineering Classification Systems

The two systems most commonly used in classifying soils for engineering are the systems approved by the American Association of State Highway Officials (AASHO) and the Unified system.

The AASHO system (1) is used to classify soils according to those properties that affect use in highway construction. In this system all soil material is classified in eight principal groups. The groups range from A-1, which consists of soils that have the highest bearing strength and are the best soils for subgrade, to A-7, which consists of soils that have the lowest strength when wet. Organic soils are in group A-8.

In the Unified system (22) soils are classified according to their texture and plasticity and their performance as engineering construction material. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of finegrained soils, identified as ML, CL, OL, M3, CH, and OH; and one class of highly organic soils, identified as Pt. GP and GW are clean gravels, and GM and GC are gravels that include, respectively, an appreciable amount of nonplastic and plastic fines. SP and SW are clean sands. SM and SC are sands that include fines of silt and clay. ML and CL are silts and clays that have a low liquid limit, and M3 and CH are silts and clays that have a high liquid limit. Soils on the borderline between two classes are designated by symbols for both classes; for example, SP-SM.

Soil scientists use the USDA textural classification (19). In this, the texture of the soil is determined according to the proportion of soil particles smaller than 2 millimeters in diameter, that is, the proportion of sand, silt, and clay. Textural modifiers, such as gravelly, stony, shaly, and cobbly, are used as needed.

Table 2 shows the estimated classification of all the soils in the Area according to all three systems of classification.

Estimated Properties

Table 2 gives estimates of some of the significant properties and the classifications of soils in the King County Area. Estimates are given for each significant layer of a typical profile. The paragraphs that follow explain some of the columns in table 2.

The depth to bedrock is not given in table 2 because only three soils in the survey area have bedrock or noncompressible material within a depth of 5 feet. Beausite and Ovall soils have sandstone and weathered andesite at a depth of 20 to 40 inches. Alderwood soils have consolidated glacial till at a similar depth.

Depth to seasonal high water table refers to the highest level at which the ground water stands for a significant period of time.

Depth from surface indicates the thickness of significant layers of a typical profile. The thickness of the horizons differs somewhat among mapping units of the same soil series.

Percentage passing sieve refers to the percentage of dry soil material that will pass sieves of the indicated sizes.

Permeability refers to the rate at which water moves downward through undisturbed soil. It depends largely on the texture, structure, porosity, and density of the soil.

Available water capacity represents the maximum amount of water that plants can obtain from the soil

Reaction refers to the acidity or alkalinity of the soil, expressed in terms of pH. A pH of 7.0 is neutral. Values less than 7.0 indicate acidity, and values more than 7.0 indicate alkalinity.

Shrink-swell potential is an indication of the volume change that can be expected with a change in moisture content. It depends largely on the amount and type of clay in the soil. In general, soils classified as CH or A-7 have a high shrink-swell potential, and soils classified as SP, GM, or A-1 have a low shrink-swell potential.

Corrosivity refers to the deterioration of concrete or untreated steel pipelines as a result of exposure to oxygen and moisture and to chemical and electrolytic reactions.

Engineering Interpretations

Table 3 rates the soils as a source of topsoil and road fill. It also indicates features that adversely affect the suitability of a soil for highway location, dikes and levees, reservoirs, embankments, drainage and irrigation systems, and grassed waterways. The features designated in the table should be considered in planning, designing, constructing, and maintaining the specified engineering project.

The ratings in table 3 are based on estimates of physical and chemical properties given in table 2, on field observations of the soil, and on experience with the same kinds of soil in other survey areas. The ratings are not a substitute for onsite investigation.

The soils are not rated for suitability as a source of sand and gravel in table 3. Soils of the Indianola and Pilchuck series are good sources of sand, and soils of the Everett and Klaus series are good sources of gravel. Limited amounts of sand are in the substratum of Ragnar and Renton soils and in some areas of Mixed alluvial land. No other soil in the survey area is a good source of sand and gravel.

The paragraphs that follow explain some of the terms used in table 3.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material and preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments also affect suitability.

Road fill is soil material used in road embankments. Suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, (2) the relative ease of excavating the material at borrow points, and (3) its stability when used as surfacing material for unpaved roads.

Soil properties that most affect highway location are the load-supporting capacity and stability of the soil when it is used as subgrade and the workability and quantity of cut and fill material available. The AASHO and Unified classifications of soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and the amount of cut and fill needed to establish an even grade. Susceptibility of the soil material to frost action and the erodibility of roadbanks are important to the stability and ease of maintenance of the highway.

Embankments, dikes, and levees require soil material that resists seepage and piping and has favorable stability, shrink-swell potential, shear strength, and compatibility. Stones or organic material in a soil are among the features that are unfavorable.

Reservoir areas hold water behind a dam or embankment. Soils suitable for this use have low seepage. The degree of seepage is related to the permeability of the soil and the depth to fractured or permeable bedrock or other permeable material.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to rock or other layers that affect the rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion or soil blowing; soil texture; content of stones; depth of the root zone; rate of water intake at the surface; permeability of soil layers that restrict movement of water; the amount of water held available to plants;
the need for drainage; and depth to water table or bedrock.

Grassed waterways are natural or constructed waterways or outlets shaped or graded and established in suitable vegetation as needed for the safe disposal of runoff from a field, diversion, terrace,

or other structure. They are affected by such features as slope, erosion, available water capacity, flooding, texture and depth of soil, amount of gravel, ease of growing needed plants, natural soil drainage, and potential for siltation of channels.

Town and Country Planning

The King County Area, traditionally a lumbering and farming area, experienced a rapid population growth in the years following World War II. Suburban areas spread rapidly throughout the western part of the Area. One result of this growth has been an increasing demand for information about soil conditions that affect nonfarm uses; for example, information about the limitations of soils for disposal of sewage effluent from septic tank systems, and information about the limitations of soils for use in building foundations, shallow excavations, and sewage lagoons.

Table 4 shows the limitations of each soil in the survey area for specific nonfarm uses. Limitations are rated as none to slight, moderate, or severe. If a soil has more than one limiting quality, it is given the rating of the most severe. A rating of severe for a particular use does not mean that the soil cannot be used for the stated purpose. For example, a soil that is severely limited for use in building foundations because it has a highly compressible subsoil can still be used if the foundation can be modified at a cost the developer is willing to accept.

The following paragraphs explain what properties limit the suitability of a soil for each of the uses specified in table 4.

Foundations for low buildings.--Ratings are for undisturbed soils that are evaluated for single family dwellings and other structures having similar foundation requirements. Buildings of more than three stories and other buildings having foundation loads in excess of those equal to three story build ings are excluded. Drainage, seasonal wetness, susceptibility to flooding, slope, shrink-swell po tential and depth to bedrock are the properties considered. Location and accessibility, factors that can he important in selecting a site, are not con sidered. Ratings are based on the characteristics of undisturbed soil to a depth of 5 feet. The de grees of limitation are defined as follows:

None to slight. For buildings with basements, this rating indicates that the soil has all of the following features. Natural drainage is good, somewhat excessive, or excessive. Seasonal high water table is below a depth of 60 inches. There is no flood hazard. Slopes are less than 8 percent. Shrink-swell potential is low. Depth to bedrock is more than 60 inches.

For buildings without basements, a rating of none to slight indicates that the soil has all of the following features. Natural drainage is moderately good, good, somewhat excessive, or excessive. Seasonal high water table is below a depth of 30 inches. There is no flood hazard. Slopes are less than 8 percent. Shrink-swell potential is low. Depth to bedrock is more than 40 inches.

Moderate. For buildings with basements, this rating indicates that the soil has one or more of the following features. Natural drainage is moderately good. Seasonal high water table is at a depth of 30 to 60 inches. There is no flood hazard. Slopes are 8 to 15 percent. Shrink-swell potential is moderate. Depth to bedrock is 40 to 60 inches.

For buildings without basements, a rating of moderate indicates that the soil has one or more of the following features. Natural drainage is somewhat poor or moderately good. Seasonal high water table is at a depth of 20 to 30 inches. There is no flood hazard. Slopes are 8 to 15 percent. Shrink-swell potential is moderate. Depth to bedrock is 20 to 40 inches.

Severe. For buildings with basements, this rating indicates that the soil has one or more of the following features. Natural drainage is very poor, poor, or somewhat poor. Seasonal high water table is within a depth of 30 inches. Flooding is occasional to frequent. Slopes are 15 percent or more. Shrink-swell potential is high. Depth to bedrock is less than 40 inches.

For buildings without basements, a rating of severe indicates that the soil has one or more of the following features. Natural drainage is very poor or poor. Seasonal high water table is within a depth of 20 inches. Flooding is occasional to frequent. Slopes are 15 percent or more. Shrink-swell potential is high. Depth to bedrock is less than 20 inches.

Shallow excavations.--The ratings for excavations apply to soil uses that require excavating or trenching to a depth of 6 feet or less. Such uses include underground utility lines, pipelines, sewers, cables, basements, and open ditches. The ratings are based on soil properties, such as depth to bed rock. Shrink-swell potential and corrosivity are not considered even though they must be assessed when evaluating a site for the installation of a buried pipeline. The degrees of limitation for shallow excavations are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Natural drainage is excessive, somewhat excessive, or good. Seasonal high water table is below a depth of 60 inches. There is no flooding. Slopes are less than 8 percent. Material within the depth to be excavated is fine sandy loam, sandy loam, loam, silt loam, or sandy clay loam. Depth to bedrock is 60 inches or more.

Moderate. This rating indicates that the soil has one or more of the following features. Natural drainage is moderately good. Depth to the seasonal high water table is 30 to 60 inches. Flooding is rare. Slopes are 8 to 15 percent. Material within the depth to be excavated is silt, clay loam, or sandy clay, and all gravelly soils. Depth to bed rock is 40 to 60 inches.

Severe. This rating indicates that the soil has one or more of the following features. Natural

drainage is somewhat poor, poor, or very poor. Seasonal high water table is at a depth of 30 inches or less. Flooding is occasional to frequent. Slopes are 15 percent or more. Material within the depth to be excavated is clay, silty clay, sand, loamy sand, organic, or very gravelly. Depth to bedrock is less than 40 inches.

Septic tank filter fields.--A septic tank filter field is an area in which a subsurface system of tile drains is laid in such a way that effluent from the septic tank is distributed uniformly into the soil. Criteria used for rating soils are based on the ability of the soil to absorb effluent. It is assumed that the minimum depth of soil material over the tile lines is 12 inches and-that the minimum diameter of the lines is 4 inches. It is also assumed that the minimum depth of the filter material over the lines is 2 inches and that the minimum depth of the filter material under the lines is 6 inches.

Percolation rate may be used to evaluate soils for septic tank filter fields. However, a rapid percolation rate does not necessarily indicate an acceptable site. Adjoining soils that have a very slow percolation rate or proximity to streams or ponds can make the installation of a septic tank filter field inadvisable. Filter fields should be placed where they cannot contaminate water supplies. Although soils that have a rapid or very rapid percolation rate do not impede movement of effluent from the tile drains, they may permit the effluent to contaminate nearby water supplies. In many parts of the King County Area, soils that have a rapid percolation rate to a depth of 4 or 5 feet meet the minimum requirements established by health codes. These soils are in the Everett, Indianola, Neilton, or Ragnar series. However, impervious layers of consolidated glacial till or platy silty materials occur at a depth of 5 to 15 feet in some areas. Effluent can readily move downward through the sand and gravelly layers of these soils, but it moves laterally over the impervious layers and may come to the surface in the yard of a neighbor or in a ditch along the road. The degrees of limitation for septic tank filter fields are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Hydraulic conductivity (Uhland core procedure) is more than 1 inch per hour, and percolation rate (auger hole method) is faster than 45 minutes per inch. Depth to seasonal water table is more than 6 feet. There is no flooding. Slopes are less than 8 per cent. Depth to bedrock or consolidated

Moderate. This rating indicates that the soil has one or more of the following features. Hydraulic conductivity (Uhland core procedure) is 1.0 to 0.63 inches per hour, and percolation rate (auger hole procedure) is 45 to 60 minutes per inch. Depth to seasonal high water table is 4 to 6 feet.

Flooding is rare. Slopes are 8 to 15 percent. Depth to bedrock or consolidated glacial till is 4 to 6 feet.

Severe. This rating indicates that the soil has one or more of the following features. Hydraulic conductivity (Uhland core procedure) is less than 0.63 inch per hour, and percolation rate (auger hole procedure) is slower than 60 minutes per inch. Depth to seasonal high water table is less than 4 feet. Flooding is occasional to frequent. Slopes are more than 15 percent. Depth to bedrock or consolidated glacial till is less than 4 feet.

Sewage lagoons.--A sewage lagoon is a shallow embanked pond used to hold sewage for the time required for bacterial decomposition. The soil serves as an impoundment area, and as material for constructing the embankment. The requirements are the same as those for other embankments designed to impound water. Table 3 rates the soils for embank ments. Table 4 rates the soil for use as a floor for the sewage lagoon. The degrees of limitation for sewage lagoons are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Permeability is less than 0.63 inch per hour. Depth to bedrock is 60 inches or more. Slope is less than 2 percent. Unified soil classification is GC, SC, CL, or CH. Soil is less than 20 percent gravel and cobblestones one-eighth inch to 6 inches in diameter, in the soil, and less than 3 percent of the soil surface is covered with cobblestones and stones more than 6 inches in diameter. Content of organic matter is less than 2 percent. There is no flooding.

Moderate. This rating indicates that the soil has one or more of the following features. Permeability is 0.63 to 2.0 inches per hour. Depth to bedrock is 40 to 60 inches. Slope is 2 to 7 percent. Unified soil classification is GM, ML, SM, or MH. Soil is 20 to 50 percent gravel and cobblestones one-eighth inch to 6 inches in diameter, and 3 to 15 percent of the surface is covered with cobblestones and stones more than 6 inches in diameter. Content of organic matter is 2 to 15 percent. Flooding occurs no more than once in 25 years.

Severe. This rating indicates that the soil has one or more of the following features. Permeability is more than 2 inches per hour. The depth to bedrock is less than 40 inches. Slope is more than 7 percent. Unified soil classification is GP, GMV, SP, SW, OL, OH, or Pt. Soil is more than 50 percent gravel and cobblestones one-eighth inch to 6 inches in diameter, and more than 15 percent of the soil surface is covered with cobblestones and stones more than 6 inches in diameter. Content of organic matter is more than 15 percent. Flooding occurs more than once each 25 years.

Sanitary land fill.--No ratings are shown in table 4 for use of the soils as sanitary land fill areas.

Sanitary land fills are for underground burial of garbage and trash. Soil limitation ratings are based on soil features to a depth of 5 feet. Onsite

geologic investigations of material below that depth are needed before final determination of the site limitations can be made.

The degree of limitation is based on soil properties and qualities. Soil limitations for trenchtype land fill, area-type land fill, and cover material are defined in the following paragraphs.

Trench-type land fill. The trench type sanitary land fill is a dug trench in which refuse is buried. The refuse is covered with at least a 6-inch layer of compacted soil material daily, or more frequently if necessary. Soil material excavated in digging the trench is used for this purpose. A final cover of soil material at least 2 feet thick is placed on the land fill when the trench is full.

All the soils in the survey area are severely limited for use as trench-type land fills for one or more of the following reasons: seasonal high water table within a depth of 6 feet; bedrock within a depth of 6 feet; slopes more than 25 percent; permeability rate more than 2 inches per hour; flooding; peat, muck, gravel, sand, clay, or silty clay texture.

Area-type land fill. In an area-type land fill, refuse is placed in successive layers on the surface of the soil. Cover material must be imported daily because generally no trenches are dug except for the purpose of obtaining cover material. A final cover of soil material at least 2 feet thick is placed over the fill.

The soil at the proposed site of an area land fill should be investigated to determine whether substances dissolved in water that percolates through the soil can pollute ground water supplies. Land fills generally are so large that it would not be practical to remove the refuse if a pollution hazard should develop. Consequently, a thorough evaluation of site hydrology is essential to land fill design.

Beausite gravelly sandy loam, 6 to 15 percent slopes, has a moderate limitation for area-type land fills because of slope. Ovall gravelly loam, 0 to 15 percent slopes, has a slight limitation where slopes are 0 to 8 percent and a moderate limitation where slopes are 8 to 15 percent. Salal silt loam has a moderate limitation for area-type land fills because the water table fluctuates between depths of 40 and 60 inches. All other soils in the soil survey have severe limitations for area-type land fills because of one or more of the following characteristics: seasonal high water table within a depth of 40 inches; flooding; permeability rate more than 2 inches per hour; slopes more than 15 percent.

Cover material for area-type land fill. Because an area-type land fill generally is covered with borrow material, nearby soils should be rated for suitability as a source of cover material. Soil characteristics relevant to both daily and final cover material are nearly enough alike for one rating to suffice for both uses.

Suitability for cover is based on slope, wetness, thickness of the borrow material, and workability, or the ease of digging, moving, and spreading the soil material over the refuse during both wet and dry periods.

Soils rated as a good source for area-type land fills not only have favorable properties, but the borrow area must be reclaimable. Some damage to the borrow area is to be expected, but if vegetation and erosion control are too difficult to reestablish, the soil should be rated as a poor source for daily cover material.

Kitsap silt loam, 2 to 8 percent slopes, and the Briscot, Earlmont, Newberg, Nooksack, Oridia, Renton, Salal, Sammamish, Si, and Sultan soils are rated as a good source of cover material.

The following soils are rated as a fair source of cover material: Alderwood gravelly sandy loam, 0 to 6 percent slopes; Alderwood gravelly sandy loam, 6 to 15 percent slopes; Arents, Alderwood material, 0 to 6 percent slopes; Arents, Alderwood material, 6 to 15 percent slopes; Edgewick fine sandy loam; Kitsap silt loam, 8 to 15 percent slopes; Puyallup fine sandy loam; Ragnar fine sandy loam, 6 to 15 percent slopes; and Ragnar-Indianola association, sloping.

All other soils in the survey area are rated as a poor source for one of the following reasons: slopes more than 15 percent] poor or very poor drainage; more than 35 percent gravel, cobblestones, or stones; silty clay, clay, muck, peat, or sand texture; cover material less than 20 inches thick; material *very* firm or extremely firm when moist.

Recreation

Limitations of the soils for use as playgrounds, camp areas, picnic areas, and paths and trails are shown in table 5. Limitations are rated none to slight, moderate, or severe. The following paragraphs explain what properties limit the suitability of a soil for each of the uses specified in table 5.

Playgrounds.--The ratings for playgrounds apply to the intensive use of soils for baseball, football, soccer, and other similar organized games. These areas are subject to heavy foot traffic by humans.

The degree of limitation shown in table 5 is based on soil properties and qualities. It does not apply to other factors that may be important in selecting a site. The need for topdressing is not considered even though the surface texture should be suitable for growing and maintaining grass. The degrees of limitation are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Natural drainage is excessive, somewhat excessive, or good. There is no flooding during the season of use. Slope is less than 2 percent. Surface layer is sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam. Depth to bedrock or consolidated glacial till is more than 40 inches.

In the original manuscript, there was a table in this space.
All tables have been updated and are available from http://soildatamart.nrcs.usda.gov.

Less than 1 percent of the soil surface is covered with gravel or cobblestones.

Moderate. This rating indicates that the soil has one or more of the following features. Natural drainage is moderately good or somewhat poor. Flooding may occur once in 2 years during the season of use. Slope is 2 to 6 percent. Surface layer is clay loam, sandy clay loam, silty clay loam, or loamy sand. Depth to bedrock or consolidated glacial till is 20 to 40 inches. Up to 20 percent of the surface is covered with gravel or cobblestones.

Severe. This rating indicates that the soil has one or more of the following features. Natural drainage is poor or very poor. Flooding occurs more than once during the season of use. Slope is more than 6 percent. Surface layer is sandy clay, silty clay, clay, sand, or organic material. Depth to bedrock or consolidated glacial till is less than 20 inches. More than 20 percent of the soil surface is covered with gravel or cobblestones.

Camp areas.--Camp areas are used intensively for tents, small camp trailers, and the accompanying activities of outdoor living. It is assumed that little site preparation will be done other than shaping and leveling for tent and parking areas.

The degree of limitation is based on soil properties and qualities. The soils should be suitable for heavy foot traffic by humans and for limited vehicular traffic. Soil suitability for growing and maintaining vegetation is not considered here, but it is a factor to consider in final evaluation of a site. The degrees of limitation are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Natural drainage is excessive, somewhat excessive, or good. There is no flooding. Slope is less than 8 percent. Surface layer is sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam. Gravel or cobblestones cover less than 20 percent of the soil surface.

Moderate. This rating indicates that the soil has one or more of the following features. Natural drainage is moderately good or somewhat poor. No flooding occurs during the season of use. Slope is 8 to 15 percent. Surface layer is clay loam, sandy clay loam, silty clay loam, loamy sand, or sand. Gravel or cobblestones cover 20 to 50 percent of the soil surface.

Severe. This rating indicates that the soil has one or more of the following features. Natural drainage is poor or very poor. Flooding occurs during the season of use. Slope is more than 15 percent. Surface layer is sandy clay, silty clay, clay, loose sand, or organic material. Gravel or cobblestones cover more than 50 percent of the soil surface.

Picnic areas.--The ratings for picnic areas apply to soils considered for intensive use as park-type picnic areas. It is assumed that most vehicular traffic will be confined to designated roads. Suit ability of soils for growing vegetation is not considered in the ratings, but it is a factor to consider in final evaluation of a site.

The degree of limitation is based on soil properties and site features. The degrees of limitation are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Natural drainage is excessive, somewhat excessive, good, or moderately good. There is no flooding during the season of use. Slope is less than 8 percent. Surface layer is sandy loam, fine

sandy loam, very fine sandy loam, loam, or silt loam. Gravel or cobblestones cover less than 20 percent of the soil surface.

Moderate. This rating indicates that the soil has one or more of the following features. Natural drainage is somewhat poor. Flooding of the site may occur once or twice for short periods during the season of use. Slope is 8 to 15 percent. The surface layer is clay loam, sandy clay loam, silty clay loam, or loamy sand. Gravel or cobblestones cover 20 to 50 percent of the soil surface.

Severe. This rating indicates that the soil has one or more of the following features. Natural drainage is poor or very poor. Flooding of the site occurs more than twice during the season of use. Slope is more than 15 percent. The surface layer is sandy clay, silty clay, clay, sand, or organic material. Gravel or cobblestones cover more than 50 percent of the soil surface.

Paths and trails.--The ratings for paths and trails apply to soils to be used for local and cross-country footpaths and trails and for bridle paths. It is assumed that these areas will be used as they occur in nature and that little or no soil will be excavated or used as fill material. Trafficability, dustiness, and soil features that affect the design and maintenance of trafficways are given special emphasis.

The degree of limitation is based on soil properties and site features. The degrees of limitation are defined as follows:

None to slight. This rating indicates that the soil has all of the following features. Natural drainage is excessive, somewhat excessive, good, or moderately good. There is no flooding of the areas during the season of use. Slope is less than 15 percent. The surface layer is sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam. Gravel or cobblestones cover less than 20 percent of the soil surface.

Moderate. This rating indicates that the soil has one or more of the following features. Natural drainage is somewhat poor. Flooding of the areas may occur once or twice for short periods during the season of use. Slope is 15 to 25 percent. The surface layer is clay loam, sandy clay loam, silty clay loam, or loamy sand. Gravel or cobblestones cover 20 to 50 percent of the soil surface.

Severe. This rating indicates that the soil has one or more of the following features. Natural drainage is poor or very poor. Flooding of the areas occurs more than twice during the season of use. Slope is more than 25 percent. The surface layer is sandy clay, silty clay, clay, sand, or organic material. Gravel or cobblestones cover more than 50 percent of the soil surface.

Woodland [2/]

About 60 percent of the King County Area is woodland. Most of this acreage is privately owned. Small areas of woodland are held for residential and recreational sites and investment purposes. A few areas are managed primarily for wood crops. Although the soils of the Area have a high potential for production of wood crops, there is little intensive management of the woodland.

The Area has several large and a number of small sawmills. Logs are sold for processing into a variety of wood products, including dimension lumber, furniture, pulp, plywood, utility poles, and fence posts. Large quantities of logs are also used for fireplace wood.

Although the native stands of trees were primarily conifers, at least half the woodland is now deciduous. Douglas-fir is the dominant conifer; western hemlock and western redcedar grow in smaller but significant numbers. The dominant deciduous tree is red alder, and there are small stands of big leaf maple. Black cottonwoods grow near streams. Red alder commonly invades logged-off areas and becomes dominant unless intensive management is applied or unless soil conditions are unfavorable for its establishment.

Woodland Groups and Production of Wood Crops

The soils of the King County Area. are grouped in table 6 according to their suitability for wood crops (15, 16). There are 15 groups. Each group consists of soils that are about the same in productivity of trees and have soil-related limitations that require about the same woodland management.

Table 6 gives, in summary form, the estimates of productivity and the relative severity of the soil-related limitations for each of the 15 woodland groups of soils.

Explanations of the ratings in table 6 follow:

Potential productivity is an indication of the amount of a given woodland crop that a given soil can produce under a specified level of management. It is expressed as the site index, which is the average height in feet that the dominant trees of a given species will reach, growing on a given soil for a specified number of years. To obtain the average site index for a tree species on a given soil, the average total ages and heights of dominant and codominant trees are determined on a number of soil plots. Site index, based on this height-age relationship, is then determined from formulas or tables developed for this purpose (3, 11, 25). The site index averages and ranges shown in table 6 are based on the average height of Douglas-fir and codominant trees at 100 years of age. The table also gives the average yearly growth in cubic feet and

2/ Prepared by DAVID L. HINTZ, forestry specialist, and DALE E. SNYDER, soil scientist, Soil Conservation Service.

board feet, calculated from the site index. Part of the yield data was taken from the work of Schlots and Quam (15, 16).

Seedling mortality refers to the expected loss of seedlings as a result of unfavorable soil characteristics or topographic features. Even if healthy seedlings of suitable species are correctly planted or occur naturally in adequate numbers, some will not survive if conditions are unfavorable. The degrees of seedling mortality shown in table 6 are based on mortality of seedlings among the numbers normally planted for adequate stocking. The rating of slight indicates a loss of less than 25 percent of the seedlings; moderate indicates a loss of 25 to 50 percent; and severe indicates a loss of more than 50 percent.

Plant competition refers to the rate of invasion of unwanted trees, shrubs, and vines when openings are made in the tree canopy. Competition is slight if it does not prevent adequate natural regeneration and early growth or interfere with the normal development of planted seedlings. Competition is moderate if it delays the establishment and slows the growth of seedlings, either naturally occurring or planted, but does not prevent the eventual development of a fully stocked, normal stand. Competition is severe if it prevents adequate restocking, either natural or artificial, without intensive preparation of the site and without special maintenance practices, including weeding.

Equipment limitation refers to soil characteristics and topographic features that restrict or prohibit the use of conventional equipment for planting and harvesting wood crops, for constructing roads, for controlling unwanted vegetation, and for controlling fires. The limitation is slight if there is little or no restriction on the type of equipment that can be used or the time of year that equipment can be used. The limitation is moderate if the use of equipment is restricted by one or more unfavorable characteristics, such as slope, stones or other obstructions, seasonal wetness, instability, or risk of injury to the roots of trees. The limitation is severe if special equipment is needed or if the use of such equipment is severely restricted by one or more unfavorable soil characteristics.

Erosion hazard is rated according to the risk of erosion in woodland. The hazard is slight if there is no special problem. It is moderate if there would be a moderate loss of soil where runoff is not controlled and the vegetative cover is not adequate for protection. The hazard is severe or very severe if steep slopes, rapid or very rapid runoff, and past erosion make the soil highly susceptible to erosion, and intensive management, including special equipment and methods of operation that minimize soil deterioration are needed.

Windthrow hazard, or wind firmness, is rated according to the ability of the soil to support trees during periods of strong winds. A rating of slight indicates that trees are not expected to be blown down in commonly occurring winds. Moderate indicates that most trees are stable except during short periods of excessive wetness and strong winds. Severe indicates that the soil and tree roots do not give enough stability to keep many trees from blowing over during moderate or strong winds and periods of excessive wetness.

Each woodland group in table 6 is identified by a symbol, for example, 2o1. The first element of the symbol is a number that indicates potential productivity by site class. The site class is based on the site index.

The numeral 1, denoting site class 1, indicates a site index of 185 or higher.
The numeral 2 indicates a site-index range of 155 to 184.
The numeral 3 indicates a site-index range of 125 to 154.
The numeral 4 indicates a site-index range of 95 to 124.
The numeral 5 indicates a site-index range of 65 to 94.
The numeral 6 indicates a site index of 64 or lower.

The second element of the symbol is a letter that denotes the subclass or the kind of soil limitation be expected in woodland use and management.

The letter c denotes clay.
The letter d, rooting depth.
The letter f, gravel.
The letter r, slope.
The letter s, sand.
The letter w, wetness.
The letter x, stones or rocks.
The letter o denotes no limitation.

The third element of the symbol is a numeral that designates specified soils, within a subclass, that are suited to about the same kinds of trees.

Soils that are very poorly drained, subject to severe stream or tidal flooding, very gravelly or cobbly, or used for urban purposes are not assigned to woodland groups.

Areas mapped as Urban land (Ur) will support Douglas-fir, red alder, western redcedar, and lodgepole pine. Productivity varies but is similar to that of site class IV for Douglas-fir.

Areas mapped as Mixed alluvial land (Ma) will support black cottonwood, willow, and red alder, and are generally unsuited to Douglas-fir. Mixed alluvial soils are fairly productive of black cottonwood if they are subirrigated. The hazards of erosion, flooding, and deposition are severe.

Areas mapped as Coastal beaches (Cb) , Orcas peat (Or), Seattle muck (Sk) , Shalcar muck (Sm) , and Tukwila muck (Tu) can produce limited amounts of willow, western redcedar, western hemlock, red alder, and lodgepole pine. Douglas-fir is generally unsuited to these soils. Plant competition, equipment limitations, and windthrow hazard are all severe limitations to the use and management of these soils for woodland.

Crops and Pasture

This section explains the system of rating the suitability of soils for most kinds of field crops,

describes the capability units in the King County Area, and gives estimated yields of crops and pasture plants.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils' does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or for engineering purposes.

In the capability system, all kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are described in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (None in this survey area)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, woodland, or wildlife habitat. (None in this survey area)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that restrict their use to recreation, wildlife habitat, water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class. They are designated 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 shows that water in or on the soil interferes 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 United States, shows 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 limitations. Class V can contain, at the most, only the subclasses indicated by w, s, and c because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are 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 for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIw-1 or IVe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in the King County Area are described and suggestions for the use and management of the soils are given. The soil series represented in each unit are named, but this does not mean that all the soils of the series are in the unit. To find the unit in which a given soil has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

Capability Unit IIw-1

This unit consists of well drained and moderately well drained silt loams and fine sandy loams of the Newberg, Nooksack, Puyallup, Salal, Si, and Sultan series. Slopes are 0 to 2 percent. Annual precipitation is 35 to 80 inches, and the frost-free season is 150 to 200 days. Most of the soils are moderately permeable; the Puyallup soil is rapidly permeable below a depth of 30 to 34 inches. Runoff is slow, and the erosion hazard is slight. The available water capacity is moderately high to high. The effective rooting depth is 60 inches or more. The seasonal water table is at a depth of 0 to 5 feet. Most of these soils are subject to occasional flooding, but Nooksack and Sultan soils are subject to moderate or severe flooding.

These soils are used mostly for hay and pasture. If protected from flooding, they are well suited to vegetables, vegetable seed, strawberries, small grain, hay, and pasture.

These soils generally do not require drainage. The seasonal water table drops below the rooting depth during the growing season. Soil productivity and structure can be maintained under continuous cropping by applying fertilizer and growing crops for winter cover and green manure. An example of a suitable cropping system is hay and pasture for 3 or 4 years followed by strawberries for 3 or 4 years. Another is hay and pasture for 5 to 10 years followed by a row crop for 1 or 2 years. A winter cover crop should be grown between consecutive years of a row crop. Crops respond well to supplemental irrigation during dry periods in summer.

Capability Unit IIw-2

This unit consists of somewhat poorly drained and poorly drained silt loams of the Briscot, Earlmont, Oridia, Sammamish, Snohomish, and Woodinville series, and of a variant of the Snohomish series. Also in this unit are the Earlmont soils that formed from diatomite. Slopes are 0 to 3 percent. Precipitation is 35 to 55 inches, and the frost-free season is 150 to 200 days. Most of the soils are moderately slowly to moderately permeable. The Snohomish soil has moderately rapid permeability in the lower part. Runoff is very slow or slow, and the hazard of erosion is slight. The available water capacity is high. The effective rooting depth is 60 inches or more if the soil is adequately drained. The seasonal water table is at a depth of 0 to 3 feet. Some of the soils are subject to seasonal flooding.

These soils are used for pasture, hay, and row crops. If protected from flooding and adequately drained, they are well suited to corn, peas, broccoli, hay, and pasture. Unless drained, they are better suited to hay and pasture.

Drainage can be provided by tile or open drains if outlets are available. If adequately drained and protected from flooding and if fertilizer, winter cover crops, and green manure are used, these soils can be used for continuous cropping. An example of a suitable cropping system is grasses and legumes for 4 to 10 years followed by small grain for 1 or 2 years. Another is grasses and legumes for 5 to 10 years followed by a row crop of corn, peas, or broccoli for 1 or 2 years. A winter cover crop should be grown between successive years of a row crop.

Capability Unit IIw-3

This unit consists of very poorly drained muck soils of the Seattle, Shalcar, and Tukwila series. Slopes are 0 to 1 percent. Annual precipitation is 35 to 80 inches, and the frost-free season is 150 to 250 days. Most of the soils are moderately permeable. The Shalcar soil is rapidly permeable in the lower part. Runoff is ponded, and the hazard of erosion is slight. The available water capacity is high. The effective rooting depth is 60 inches or more. The seasonal water table is at or near the surface.

These soils are used for hay and pasture, blueberries, and truck crops. If adequately drained, they are well suited to vegetables, forage crops, hay, and pasture. Unless drained, they are suited to hay and pasture.

The drainage system must permit regulation of the water table throughout the year. If the water table is carefully controlled, and if fertilizers and winter cover crops are used, these soils can be adequately maintained for continuous cropping.

Capability Unit IIIe-1

Kitsap silt loam, 2 to 8 percent slopes, the only soil in this unit, is moderately well drained. Annual precipitation is 35 to 60 inches, and the frost-free season is 150 to 200 days. This soil is very slowly permeable. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The available water capacity is moderate to moderately high. The effective rooting depth is about 36 inches. Water moves along the top of the substratum in winter.

This soil is used for pasture and timber. If adequately protected from erosion, it is well suited to vegetables, strawberries, small grain, forage crops, grasses, legumes, and wood crops.

Adequate protection against accelerated erosion and maintenance of soil structure and soil productivity can be provided by growing grass and legume cover crops for 4 or 5 years followed by 1 to 4 years of a row crop. A winter cover crop should be grown between consecutive years of a row crop. Other suitable cropping systems are hay and pasture for 3 or 4 years followed by strawberries for 3 or 4 years, or hay and pasture for 5 to 10 years followed by a row crop for 1 or 2 years. Row crops should be planted across the slope approximately on the contour. Crops respond well to barnyard manure and fertilizer applied as needed.

Capability Unit IIIw-1

This unit consists of well-drained and somewhat poorly drained fine sandy loams and silt loams of the Edgewick and Renton series. Slopes are 0 to 3 percent. Annual precipitation is 35 to 80 inches, and the frost-free season is about 150 to 200 days. Permeability is moderately rapid and very rapid. Runoff is slow, and the hazard of erosion is slight. The available water capacity is moderate to moderately high. The effective rooting depth is 32 to 60 inches if the soils are adequately drained. The Renton soil has a seasonal water table at a depth of 1 to 2 feet. Both soils are subject to flooding.

These soils are used for row crops and pasture. If protected from flooding and adequately drained,

they are well suited to grasses, legumes, alfalfa, pole beans, sweet corn, strawberries, and cane berries. Unless protected from flooding, they are better suited to hay and pasture.

Drainage for the Renton soil can be provided by tile or open drains if outlets are available. In areas that are adequately drained and protected from flooding, soil productivity and protection can be maintained by continuous row cropping if a winter cover crop is grown between consecutive years of row crops. An example of another suitable cropping system is grasses and legumes for 4 to 10 years followed by 1 to 4 years of a row crop and a winter cover crop between consecutive years of the row crop Other suitable cropping systems are grasses and legumes for 5 to 10 years followed by strawberries for 3 or 4 years, or grasses and legumes for 5 to 10 years followed by cane fruits and winter cover crops for 7 to 10 years. Irrigation during periods of low rainfall promotes continued crop growth. Crops respond well to barnyard manure and fertilizer applied as needed.

Capability Unit IIIw-2

This unit consists of poorly drained silt loams and silty clay loams of the Bellingham, Buckley, and Puget series. Slopes are 0 to 2 percent. Annual precipitation is 35 to 55 inches, and the frost-free season is 150 to 205 days. Permeability is slow. Runoff is slow, and the hazard of erosion is slight. The available water capacity is high. The effective rooting depth is about 40 to 60 inches or more where the soils are adequately drained. The seasonal water table is at or near the surface. Some areas are subject to ponding and flooding.

These soils are used mostly for pasture. If adequately drained, they are suited to row crops, small grain, grasses, and legumes. Unless adequately drained, they are better suited to hay or pasture.

Drainage can be provided by tile or open drains if outlets are available. Soil productivity and protection can be maintained in a continuous row cropping system by applying fertilizer and growing a winter cover crop between consecutive years of a row crop or by a grass or legume crop for 4 to 10 years followed by 1 to 4 years of a row crop. A winter cover crop should be grown between consecutive years of the row crop.

Capability Unit IIIw-3

Norma sandy loam, the only soil in this unit, is poorly drained. Slopes are 0 to 2 percent. Annual precipitation is 35 to 60 inches, and the frost-free season is 150 to 200 days. Permeability is moderately rapid. Runoff is slow, and the hazard of erosion is slight. The available water capacity is moderately high to high. The effective rooting depth is 60 inches or more where the soil is adequately drained. The seasonal water table is at or near the surface. This soil is subject to flooding in places.

This soil is used mostly for pasture. If protected from flooding and if adequately drained, it is well suited to corn for silage, grasses, and legumes. Some drained areas are used for row crops.

Drainage can be provided by tile or open drains if outlets are available. In areas adequately drained and protected from flooding, soil productivity can be maintained under a cropping system that consists of grasses and legumes for 5 to 10 years followed by small grain or a row crop and then a grass or legume crop for 1 or 2 years. Crops respond to fertilization and supplemental irrigation.

Capability Unit IVe-1

Kitsap silt loam, 8 to 15 percent slopes, the only soil in this unit, is moderately well drained. Annual precipitation is 35 to 60 inches, and the frost-free season is 150 to 200 days. Permeability is very slow in the substratum. Runoff is medium, and the hazard of erosion is moderate to severe. The available water capacity is moderate to moderately high. The effective rooting depth is about 36 inches. Water moves along the top of the substratum in winter.

This soil is used for pasture and timber. If erosion is adequately controlled, it is suited to small grain, grasses, and legumes.

The hazard of erosion and sedimentation can be controlled and soil tilth can be improved under a cropping system that consists of grasses and legumes for 5 to 10 years followed by small grain for 1 year as a cleanup crop before reestablishing grasses and legumes. The small grain crop should be planted across the slope approximately on the contour. Crops respond well to applications of manure and fertilizer. Sprinkler irrigation is suitable for this soil.

Capability Unit IVe-2

This unit consists of well drained and moderately well drained gravelly sandy loams and gravelly loams of the Alderwood, Beausite, and Ovall series and of the Arents, Alderwwood material. Slopes are 0 to 15 percent. Annual precipitation is 35 to 65 inches, and the frost-free season is about 150 to 200 days. Permeability is moderate to moderately rapid. Alderwood soils are very slowly permeable in the substratum. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The available water capacity is low to moderate. The effective rooting depth is 20 to 40 inches. In winter, water moves along the top of the substratum of Alderwood soils and Arents, Alderwood material.

These soils are used for pasture, timber, and urban development. If erosion is adequately controlled, they are well suited to grasses, legumes, small grain, and row crops.

The hazards of erosion and sedimentation can be controlled and soil tilth can be maintained under a cropping system that consists of grasses and legumes for 5 to 10 years followed by small grain for 1 year

as a cleanup crop before reestablishing desired grasses and legumes. The small grain crop should be planted across the slope approximately on the contour. Crops respond well to applications of manure and fertilizer and to supplemental irrigation.

Capability Unit IVe-3

This unit consists of well-drained fine sandy loams of the Ragnar series. Slopes are 6 to 15 percent. Annual precipitation is 35 to 65 inches, and the frost-free season is 150 to 200 days. Permeability is moderately rapid in the upper part of the soil and rapid in the lower part. Runoff is medium, and the hazard of erosion is moderate. The available water capacity is moderately high. The effective rooting depth is 60 inches or more.

These soils are used for timber and urban development. If erosion is adequately controlled, they are suited to grasses, legumes, small grain, potatoes, strawberries, and cane fruits.

Soil structure and productivity can be maintained under a crop rotation system that consists of grasses and legumes for 5 to 10 years followed by 1 year of small grain as a cleanup crop before reestablishing grass or legume crops, or grasses and legumes for 5 to 10 years followed by 1 year of oats as a cleanup crop, then strawberries for 3 to 4 years. Other suitable cropping systems are grasses and legumes for 5 to 10 years followed by cane fruits for 7 to 10 years and an annual cover crop grown between the rows of cane fruits, or grasses and legumes for 5 to 10 years followed by small grain for 1 year as a cleanup crop, then potatoes or vegetables for I or 2 years. The row and small grain crops should be planted across the slope approximately on the contour. Crops respond to fertilization.

Capability Unit IVw-1

Pilchuck fine sandy loam, the only soil in this unit, is excessively drained. Slopes are 0 to 2 percent. Annual precipitation is 35 to 55 inches, and the frost-free season is 160 to 200 days. Permeability is rapid. Runoff is slow, and the hazard of erosion from stream overflow is moderate to severe. The available water capacity is low. The effective rooting depth is 60 inches or more. The seasonal water table is at a depth of 2 to 4 feet in some areas in winter.

This soil is used for pasture and timber. If protected from flooding, it is suited to grain, peas, corn, silage, grasses, and legumes.

If the soil is protected from flooding, the cropping system needed to maintain soil productivity is grasses and legumes for 5 to 10 years followed by peas or silage corn for 1 or 2 years before reestablishing grass or legume crops. Crops respond to fertilization and supplemental irrigation.

Capability Unit IVs-1

This unit consists of somewhat excessively drained gravelly sandy loams of the Everett series and the Arents, Everett material. Slopes are 0 to 5 percent. Annual precipitation is 35 to 60 inches, and the frost-free season is 150 to 200 days. Permeability is rapid. Runoff is slow, and the hazard of erosion is slight. The available water capacity is low. The effective rooting depth is 60 inches or more.

These soils are used for timber, pasture, and urban development. They are suited to grasses, legumes, small grain, strawberries, and cane fruits.

Soil structure and productivity can be maintained by a cropping system of grasses and legumes for 5 to 10 years followed by 1 year of small grain as a cleanup crop before reestablishing grasses and legumes. Other suitable cropping systems are grasses and legumes for 5 to 10 years followed by oats for 1 year as a cleanup crop, then strawberries for 3 or 4 years; grasses and legumes for 5 to 10 years, followed by cane fruits for 7 to 10 years with an annual cover crop grown between the rows of cane fruits; or grasses and legumes for 5 to 10 years followed by small grain for 1 year as a cleanup crop, then potatoes or vegetables for 1 or 2 years. Crops respond to fertilization and supplemental irrigation.

Capability Unit IVs-2

This unit consists of somewhat excessively drained loamy fine sands of the Indianola series. Slopes are 0 to 15 percent. Annual precipitation is 30 to 55 inches, and the frost-free season is 150 to 210 days. Permeability is rapid. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Available water capacity is low. The effective rooting depth is 60 inches or more.

The soils in this unit are used mostly for timber. They are suited to grasses, legumes, and small grain.

These soils can be protected against erosion by a cropping system of grasses and legumes for 5 to 10 years followed by 1 year of small grain before reestablishing grasses and legumes. The small grain crop should be planted across the slope approximately on the contour on slopes greater than 4 percent. Supplemental irrigation in droughty periods is beneficial. Crops respond to fertilization.

Capability Unit VIe-1

This unit consists of somewhat excessively drained gravelly sandy loamy and loamy fine sands of the Everett and Indianola series. Slopes are 15 to 30 percent. Annual precipitation is 30 to 60 inches, and the frost-free season is 150 to 210 days. Permeability is rapid. Runoff is medium to rapid,

and the hazard of erosion is moderate to severe. The available water capacity is low. The effective rooting depth is 60 inches or more.

The soils in this unit are used mostly for timber. If cleared, they are suited to grasses and legumes for pasture and hay.

These soils should be cultivated only to the extent necessary to establish or reestablish grass and legume crops. Because of erosion and droughtiness, they are better suited to permanent vegetation, woodland, wildlife habitat, and recreational use than to crops. Grasses and legumes respond to fertilization.

Capability Unit VIe-2

This unit consists of well drained and moderately well drained silt loams, gravelly loams, fine sandy loams, and gravelly sandy loams of the .Alderwood, Beausite, Kitsap, Ovall, and Ragnar series. Slopes are 15 to 30 percent. Annual precipitation is 35 to 65 inches, and the frost-free season is 150 to 210 days. Permeability is moderately rapid to very slow. In winter, water moves along the top of the substratum of Alderwood and Kitsap soils. The substratum of the Ragnar soil is rapidly permeable. Runoff is medium to rapid, and the hazard of erosion is severe. The available water capacity is low to moderately high, and the effective rooting depth is 20 to 60 inches.

The soils in this unit are used mostly for timber. If cleared, the soils are suited to grasses and legumes. Continuous grass, legumes, or woodland cover is necessary to protect the soils adequately against the hazards of severe erosion and sedimentation to maintain the quality of water in streams, and to control runoff. These soils should be cultivated only to the extent necessary to reestablish grass and legume crops. Grasses and legumes respond to fertilization.

Capability Unit VIw-1

Pilchuck loamy fine sand, the only soil in this unit, is excessively drained. Slopes are 0 to 2 percent. Annual precipitation is 35 to 55 inches, and the frost-free season is 160 to 200 days. Permeability is rapid. Runoff is slow, and the hazard of erosion from stream overflow is severe. The available water capacity is moderate. The effective rooting depth is 60 inches or more. The seasonal water table is at a depth of 2 to 4 feet in some areas.

This soil is used for timber and pasture. It is suited to wildlife habitat and recreational use, and it is well suited to cottonwood trees. Trees are most effective in stabilizing the soil against streambank erosion and channeling. Areas protected by levees are suited to grasses and legumes for hay and pasture. Grasses and legumes should remain as permanent cover crops on the soil until renovation is necessary. Grasses and legumes respond to fertilization.

Capability Unit VIw-2

Only Mixed alluvial land, a well-drained to very poorly drained sand or gravelly sand to silty clay loam, is in this unit. Slopes are 0 to 2 percent. Stream overflow is a severe hazard.

Mixed alluvial land is used for timber and pasture. It is suited to wildlife habitat and recreational use, and it is well suited to cottonwood trees. Trees are most effective in controlling streambank erosion and channeling. Areas protected by levees are suited to grasses and legumes for hay and pasture. Grasses and legumes should remain as permanent cover crops until renovation is necessary.

Capability Unit VIs-1

This unit consists of somewhat excessively drained and excessively drained gravelly sandy loamy, gravelly loamy sands, and very gravelly loamy sands of the Everett, Klaus, and Neilton series. Slopes are 2 to 15 percent. Annual precipitation is 35 to 80 inches, and the frost-free season is 150 to 200 days. Permeability is moderately rapid to very rapid. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The available water capacity is low. The effective rooting depth is about 60 inches or more.

The soils in this unit are used mostly for timber. If cleared, they are moderately well suited to grasses and legumes, and they are well suited for use as wildlife habitat and recreational areas.

These soils respond well to fertilization and to supplemental irrigation. Trees or permanent cover crops of grasses or legumes protect these soils against erosion.

Capability Unit VIIe-1

This unit consists of well drained and moderately well drained silt loams, gravelly loamy, and gravelly sandy loamy of the Alderwood, Beausite, Kitsap, and Ovall series. Slopes are 25 to 75 percent. Annual precipitation is 35 to 65 inches, and the frost-free season is 150 to 200 days. Permeability is moderately rapid to very slow. Water moves along the top of the substratum of the Alderwood and Kitsap soils in winter. Runoff is rapid to very rapid, and the hazard of erosion is severe to very severe. The available water capacity is low to moderate. The effective rooting depth is 20 to 40 inches.

These soils are used mostly for timber. They are too steep for farming. They are well suited to use as wildlife habitat and recreational areas.

Capability Unit VIIIw-1

This unit consists of very poorly drained Orcas peat, Riverwash, and Coastal beaches. Riverwash and Coastal beaches are subject to stream and tidal flooding. All are used mostly for recreation and wildlife food and cover.

Estimated Yields

Table 7 shows the estimated average yields per acre for pasture grass, silage, and hay. Absence of a yield figure indicates the soil is not commonly used for the given crop or its use is not recommended because of the severe hazard of erosion. Yields shown are for a moderately high level of management.

The yields shown in table 7 can be obtained by-

1. Growing suitable crop varieties.
2. Renovating the hay and pasture plantings when the stand declines in vigor or becomes in fested with weeds, rotating with grain or an adapted till crop to help control weeds, and planting a deep-rooted crop to improve per- meability in tight soils.
3. Growing a legume in the crop rotation to maintain or improve fertility.
4. Returning manure to the fields and applying fertilizer if a soil test indicates nutrients should he brought into proper balance, and adding lime as indicated by soil tests.
5. Controlling weeds, diseases, and insects.
6. Using supplemental irrigation.
7. Draining the soil if required.
8. Rotating cattle grazing on the pastures.

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All tables have been updated and are available from http://soildatamart.nrcs.usda.gov.

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The estimated yields given in table 7 are not presumed to be the maximum yields attainable. Rather, they are practical goals that can be attained by most farmers. It is recognized that differences in the weather, in the varieties of crops grown, and in the numbers and kinds of insects, diseases, and weeds present cause differences in yields on the same soil. Past management is also a factor. Although the indicated tonnage of hay can be obtained, the weather frequently is such that proper curing does not occur. Rain or high humidity favor molding and loss of the nutritive value.

Yields of vegetable crops have not been included in table 7 because of the small acreage used for vegetables in the Area. The acreages of principal commercial crops grown in all of King County in 1968 were as follows (24): snap beans, 950 acres; sweet corn, 700 acres; lettuce, 570 acres; and cabbage, 500 acres. The average yields for all soils were: snap beans, 3.9 tons per acre; sweet corn, 4 tons per acre; lettuce, 2 tons per acre; and cabbage, 14 tons per acre. Since 1968, the acreage of cropland has been reduced by urbanization. In 1969 only 870 acres was used for strawberries and cane fruits in all of King County.

Wildlife

King County has a number of unique features that provide desirable habitat for many species of fish and wildlife. These features include Puget Sound, a multitude of lakes and streams, coastal beaches, upland plains and hills, and high mountains to the east. The mild climate, the many sparsely populated areas, and the diversity of habitat are favorable to a variety of fish, shellfish, and wildlife.

The principal resident freshwater fish are rain bow, cutthroat, brook, and lake trout; dolly garden char; whitefish; kokanee; largemouth, smallmouth, and rock bass; bluegill; crappie; pumpkinseed; brown bullhead; and yellow perch.

Several kinds of salmon, steelhead, and searun cutthroat are the principal anadromous fish. Puget Sound contains several marine fish, such as cod, dogfish, skate, lingcod, flounder, herring, halibut,

smelt, sole, and rockfish. Several of these are sold nationally and internationally.

Beaches and estuaries are noted for their shellfish resources. Valued by fisherman are varieties of oysters, clams, crabs, scallops, abalone, and shrimp.

Each soil in the survey area has a potential for providing food, cover, or water for some species of wildlife. Rarely does one soil provide all things needed for a single species. Some soils support grass, others woody shrubs, others trees, and others are commonly adjacent to water. Where these soils occur in proper relationship, they compliment each other in supplying food and shelter for wildlife.

Each of the seven soil associations in the survey area is a combination of topographic features, soils, and plants that is suitable for one or more species of wildlife.

Pheasant are most abundant in the major stream valleys of the Oridia-Woodinville-Seattle association and part of the Alderwood association southeast of Renton.

Waterfowl are mostly in the Oridia-Seattle-Wood-inville and the Puget-Earlmont-Snohomish associations. They also frequent areas near Soos Creek in the Alderwood and the Buckley-Alderwood associations.

Deer are most abundant in the eastern part of the survey area in the Alderwood, the Buckley-Alderwood, the Everett, and the Beausite-Aldenwood associations.

Small animals, such as rabbit, fox, mountain beaver, and squirrel, inhabit most of the associations. Fur-bearing animals live near the streams in all associations.

The principal big game animals, black-tailed deer and black bear, provide excellent hunting. Blue and ruffed grouse, ring-necked pheasant, California quail, band-tailed pigeon, and mourning dove are the significant upland game birds. Cottontail rabbit is the only significant upland small game animal .

The Area supports beaver, muskrat, mink, river otter, weasel, skunk, bobcat, red fox, coyote, raccoon, and other valuable fur bearers. Harvest opportunities are excellent, and many fur animals are trapped each season.

The major waterfowl are mallard, pintail, canvasback, ruddy, bluebill, and wood duck; redhead; bufflehead; widgeon; goldeneye; green-winged teal; shoveler; Canada, lesser Canada, snow cackling, and white-fronted geese; and black brant. Merganser, scoter, common snipe, American coot, and whistling swan also occur. Waterfowl harvest is significant.

Shorebirds of many species frequent marine waters and tidal flats. Other kinds of wildlife in the area are herons and grebes; mountain beavers and marmots; hawks and owls; seals; and crows and starlings.

FORMATION AND CLASSIFICATION OF THE SOILS

This section tells how each of the five soilforming factors has affected the soils of the King County Area. It gives the classification of the soils according to both the current classification system (17, 21) and the 1938 system (2, 18) and decribes each of the suborders represented in the survey.

Factors of Soil Formation

Soil is a result of the interaction of soilforming processes on materials deposited by geologic agents. The properties of the soil at any given place are determined by five factors: (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) living organisms on and in the soil; (4) the topography, or lay of the land; and (5) the length of time the forces of soil formation have acted on the soil material. These factors, as they occur in the survey area, are described in the following paragraphs.

Parent Material

Most of the soils of the survey area formed in material deposited by the most recent glaciers. Many of the soils formed in glacial till, and a lesser, but significant, number of soils formed in recessional outwash deposits. The mineralogy of both the till and outwash is mixed.

Soils of the Alderwood and Beausite series are examples of soils that formed in Vashon glacial till. These soils are well graded sandy loams and learns that are about 30 percent gravel. Consolidated lodgement till is at a depth of 24 to 40 inches in the Alderwood soils. The dense, very hard characteristic of the lodgement till is probably largely due to consolidation caused by the weight of the glacier that occupied the Area about 13,500 to 15,000 years ago (5). The maximum thickness of that glacial ice in the Seattle area is estimated to have been about 3,500 feet, thus providing the probable consolida-- ting force. The till is compacted and partly cemented, particularly in the upper part (12). Examination of the thin section reveals a very close packing of soil particles and thin, discontinuous isotropic stringers between some particles. Compounds of iron and possibly silica are the probable cementing agents.

Shale and sandstone underlie Beausite soils. The Vashon Glacier incorporated these relatively soft rocks into the till, producing soil material of somewhat finer texture than that of the Alderwood soils. Very gravelly recessional outwash from the glacier is the material in which Everett soils formed.

The Osceola mudflow from Mount Ranier covered a large area in the south-central part of King County (6). It is relatively well graded and dense below a depth of 2 to 3 feet. Buckley soils formed in mudflow sediments.

Alluvial deposits in the stream valleys are mostly silty. Puget, Puyallup, and Oridia soils formed in this silty alluvial material. Pilchuck soils formed in sandy alluvial sediments.

The Kitsap soil formed in stratified and laminated, very slowly permeable silty lacustrine sediments. Soils that formed in lacustrine sediments are strongly sloping and occur mostly in small areas in the major valleys and around Lake Washington.

Climate

Precipitation and temperature are the main climatic factors that have influenced soil formation in the survey area. Annual precipitation ranges from 35 inches near Puget Sound to about 80 inches in the vicinity of North Bend. This difference in precipitation has had only a slight effect on soil formation.

Soils on uplands in the western part of the Area have a faintly expressed A2 horizon but those in the eastern part have a distinct A2 horizon. Examples are soils of the Everett and Klaus series. Upland soils in the eastern part of the survey area tend to be slightly more acid and show more leaching of bases than those in the western part.

Differences in precipitation produce few if any differences in the soils of the valleys from one part of the Area to another. Moderate to high precipitation has caused base saturation of less than 50 percent in all soils but those of the Newberg, Nooksack, and Puyallup series.

There is a well-defined dry season in summer and a rainy season in winter. Maritime air modifies temperatures throughout the year. The mean annual temperature is about 52° F. at Seattle and about 50° F. at Snoqualmie Falls. Soils are seldom frozen below a depth of 3 or 4 inches. More information about the climate of the King County Area is given in the section "Climate."

Living Organisms

Plants, micro-organisms, earthworms, and other forms of life on or in the soil are active in soilforming processes. They provide organic matter, help to decompose plant residue, affect the chemistry of the soil, and hasten soil formation. Living organisms also help to convert plant nutrients to a form that is more readily available to plants. Animals, such as mountain beaver, retard horizon formation by churning or mixing the soil.

Vegetation has affected formation of the soils in the King County Area. Soils formed under conifers generally have a thin, dark-colored A1 horizon and a faint to distinct A2 horizon. Alderwood and Klaus soils are examples. Logging operations have destroyed the thin, faint A2 horizon in most of the Alderwood soils in the Area. Soils that formed under deciduous trees have a somewhat thicker and lighter colored Al horizon but no trace of an A2 horizon. Examples are soils of the Nooksack and Puyallup series. Sedges, rushes, and grasses in open areas of the valley bottoms and on terraces have helped form a thick, very dark brown or black Al horizon in some soils, for example, in Bellingham, Buckley, and Norma soils. The Salal soil formed under grass and has an Al horizon, about 18 inches thick, that is black in the upper part.

Topography

Topography affects runoff and drainage and thereby the amount of water that enters the soil. In a level or nearly level area where water neither runs off nor accumulates, all of the rainwater, except that lost through evaporation or transpiration, enters the soil. In a depression where water accumulates, the amount of water that enters the soil is greater than in a level area that receives the same amount of rainfall; on a slope where water runs off, the amount is less. In general, the greater the amount of water that enters the soil, the greater is the depth to which the soil is leached and weathered.

The topography of the King County Area ranges from nearly level to very steep. Depressions occur in places. Soils in depressions show characteristics associated with wetness, namely gray and bluish mottles. Examples are soils of the Bellingham and Puget series. Soils formed on the highest mounds of the valley bottoms are well drained. Sloping soils on the upland terraces and in very steep mountainous areas are well drained and moderately well drained and have bright colors in most of the profile. The hazard of erosion generally increases with increasing steepness of topography.

Time

Time is necessary for the formation of soils from parent material. Generally, old soils have more strongly expressed horizons than young soils. Most soils in the survey area do not have strongly expressed horizons.

In most of the survey area, soil-forming processes have been acting on parent material since the glaciation, about 12,000 years ago. Since then alluvium has periodically accumulated in the stream valleys. Soil-forming processes have acted on these sediments for a shorter period of time.

Enough time has elapsed for easily recognizable horizons to form in most of the soils. Soils on the uplands have dark-colored A and B horizons that are significantly redder than the parent material. Examples are soils of the Everett and Klaus series. Soils in depressions on the upland terraces and in the valleys commonly have features associated with wetness, such as darkened A and B horizons that have pale colors and mottles. Buckley and Puget soils are examples. Some soils of the bottom land have

only weakly expressed horizons. For example, Nooksack soils have a thick, dark-colored A horizon, but the B horizon is recognizable only by structure and not by an increase in chroma. Pilchuck soils have not formed an A or B horizon.

Classification of the Soils

The classification of soils consists of an orderly grouping according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge to specific tracts of land. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories in order that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years, The older system was adopted in 1938 (2) and revised later (18). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (17) and adopted in 1965 (21). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 8 gives the classification of each soil series of the King County Area by family, subgroup, suborder, and order, according to the current system. It also shows one category--the great soil group-of the 1938 system.

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All tables have been updated and are available from http://soildatamart.nrcs.usda.gov.

ENTISOLS: Entisols have few, if any, clearly expressed genetic characteristics. They either lack genetic horizons or have only the beginning of horizons. Entisols in the King County survey area are divided into four suborders, the Psamment, Aquent, Fluvent, and Orthent.

Psamment suborder.--Entisols in this suborder have a texture of loamy fine sand or coarser throughout the 10- to 40-inch zone. Indianola and Pilchuck soils are representative.

Orthent suborder.--Entisols in this suborder have a texture of very gravelly sand and textures finer than loamy fine sand between depths of 10 and 40 inches. Neilton soils are representative.

Aquent suborder.--Entisols in this suborder have characteristics associated with wetness. Briscot, Earlmont, Oridia, Renton, Snohomish, and Woodinville soils are representative.

Fluvent suborder.--Entisols in this suborder have a texture of loamy very fine sand or finer between depths of 10 and 40 inches and do not have characteristics associated with wetness. Si and Sultan soils are representative.

INCEPTISOLS: This order is made up of soils that show only slight evidence of soil formation. The horizons are weakly expressed. In general, the soils in this order have weaker horizonation and are less strongly weathered and leached than those of any other order except the Entisol.

The Inceptisols of this Area formed in parent materials of mixed mineralogy deposited both by glacial and stream action. Soils in the Inceptisol order have drainage classes ranging from moderately well drained to poorly drained. The vegetation is mainly deciduous and coniferous trees on the moderately well drained soils and sedges, grasses, and rushes on the poorly drained soils. The Inceptisols of this survey area are divided into three suborders, the Aquepts, Ochrepts, and Umhrepts.

Aquept suborder.--Soils in this suborder are saturated at some period of the year unless they have been artificially drained. Bellingham, Buckley, Norma, Puget, and Sammamish soils are in this suborder.

Ochrept suborder.--Soils in this suborder have a slightly darkened A horizon and a weakly expressed B horizon. Alderwood, Beausite, Everett, Kitsap, and Ragnar soils are in this suborder.

Umbrept suborder.--Soils in this suborder have a very dark colored A horizon and either no B horizon or one that is weakly expressed. Edgewick, Ovall, and Salal soils are in this suborder.

MOLLISOLS: Soils in this order have a thick, dark-colored surface layer that is at least 1 percent organic matter and has more than 50 percent base saturation. The Mollisols in the survey area all formed in alluvial sediments of mixed mineralogy. The native vegetation was grass, shrubs, and deciduous trees. Mollisols in the survey area are in the Xeroll suborder.

Xeroll suborder.--Soils in this suborder are seasonally dry between depths of 7 and 20 inches. Newberg, Nooksack, and Puyallup soils are in this suborder.

SP0DOSOLS: The soils in this suborder have a horizon in which iron and aluminum oxides have accumulated at or near the surface, along with some organic carbon, but with little or no additional clay. This horizon is called a spodic horizon. It is about equivalent to a Bir horizon. The native vegetation was a coniferous forest. The one Spodosol in the survey area is in the Orthod suborder.

Orthod suborder.--Klaus soils are in this suborder.

HISTOSOLS: This order is made up of soils that have a large amount of organic matter. They are commonly very poorly drained or poorly drained. Three Histosol suborders are represented in the survey area, the Fibrist, Hemist, and Saprist.

Fibrist suborder.--Soils in this suborder have a very large amount of fibre that is well preserved and readily identifiable as to botanical origin. Orcas soils are in this suborder. They formed in sphagnum peat.

Hemist suborder.--Soils in this suborder have organic material that is partly decomposed but still has some recognizable plant parts. Seattle soils are in this suborder.

Saprist suborder.---Soils in this suborder have organic material that is mostly decomposed and in which only few if any plant parts are identifiable. Shalcar and Tukwila soils are in this suborder.

Laboratory Data

The chemical properties of soils of the Buckley, Klaus, Nooksack, and Snohomish series are given in table 9. The representative profile of each series is described in the section "Descriptions of the Soils." The data in table 9 can be used by soil scientists to classify soils, develop concepts of soil genesis, and to estimate the response of soils to applications of fertilizer and lime. Additional laboratory data are available for the Alderwood, 3/ Everett, and Klaus series (20).

All of the samples analyzed were taken from carefully selected pits. The samples are considered representative of the soil material that is made up of particles less than three-fourths of an inch in diameter. The soil material was rolled, crushed, and sieved by hand to remove fragments more than 2 millimeters in diameter.

The following laboratory methods were used. Extractable calcium and magnesium were determined by extraction with neutral normal ammonium acetate (4).

3/ BRACKETT, MICHAEL H. Alderswood Soil Series. 1966. [Unpublished master's thesis. Copy on file Dept. of Agron., Wash. State Univ. Pullman]

Extractable sodium and potassium were determined by flame photometry after extraction with ammonium acetate (7). Exchange acidity was determined by leaching with barium chloride and back titrating with 0.2N hydrochloric acid (13). Cation-exchange capacity was determined by displacement with ammonium acetate (13, 27). Exchangeable aluminum was extracted with potassium chloride (10, 14), and titration was done with potassium fluoride (26). Organic carbon was determined by the modified Walkley technique (13, 23). Reaction was determined in water, potassium chloride, and sodium fluoride. Iron and aluminum were extracted with a sodium pyrophosphate-sodium dithoinite solution (8).

CLIMATE [4/]

Most of the air masses that reach the survey area originate over the Pacific Ocean. The maritime air influences the climate throughout the year. The prevailing wind is from the southwest in fall and winter and gradually shifts to the northwest late in spring and in summer. There is a well-defined dry season in summer and a rainy season in winter. Annual precipitation increases from 35 inches in lowlands adjacent to Puget Sound to 150 inches or more on the wettest slopes of the Cascade Mountains. Snowfall ranges from less than 20 inches near Puget Sound to 400 inches on the higher slopes in the eastern part of the Area. Fifty percent of the annual precipitation falls from October through January and 75 percent from October through March. Total rainfall for July and August is less than 5 percent of the annual.

During the warmest months in summer, afternoon temperatures over the lowlands are in the 70's, decreasing to the 60's in the mountains. Temperatures can be expected to decrease 3 or 4 degrees with each increase of 1,000 feet in elevation. Maximum temperatures reach 85° to 90° F. on 5 to 15 days, and 100° F. has been recorded in the lowlands. The hottest weather and lowest relative humidity generally occur during brief periods when easterly winds blow.

In summer, the average relative humidity ranges from about 90 percent at sunrise to 50 percent in midafternoon. In winter, it ranges from 90 percent to 75 percent. Occasionally it may drop to 30 percent or less when dry easterly winds blow.

In winter, afternoon temperatures over the lowlands range from the lower 30's to the lower 40's and minimums from the mid-20's to the mid-30's. Below freezing temperatures are recorded on 30 to 90 nights depending on air drainage, distance from the Sound, and elevation (table 10). Almost every winter, minimums ranging from 10° to 20° F. are reported on a few nights, and below zero readings have been recorded in some localities. In the mountains, temperatures are below freezing on most nights between mid-October and April. The coldest weather occurs when the Pacific Northwest is under the influence of air from over the interior of the continent.

Maritime air that reaches the Washington coast late in fall and in winter is moist and is about the temperature of the ocean's surface. Orographic lifting and cooling of air masses moving inland causes cloudiness and variable precipitation (table 11). In the drier areas, annual precipitation 1 year in 10 has ranged from less than 25 to more than 40 inches, and on the wetter slopes of the Cascades, from less than 80 to more than 130 inches. Measurable precipitation (0.01 inch or more) is recorded on 4 to 8 days each month in summer, 10 to 15 days in fall and spring, and 20 to 25 days in winter.

During the wet season, rainfall is usually of light to moderate intensity and continuous over a period of time, rather than heavy downpours for brief intervals. Thunderstorms occur on 5 to 10 days each year, mostly in summer.

Most winter precipitation falls as rain at elevations below 1,500 feet, as rain or snow between 1,500 and 2,500 feet, and as snow at the higher elevations. Near the crest of the Cascades, snow can be expected in October, and it will remain on the ground from November until July. Snowfall ranges in depth from 10 to 30 inches over the lowlands, from 30 to 60 inches in valleys near the mountains and in the foothills, and from 300 to 400 inches on the higher ridges. In the mountains, density of the winter season snowpack increases from about 30 percent water early in winter to 45 percent in April. Snow depths at the higher elevations range from 75 to 150 inches in an average winter; it increases to 200 inches or more in seasons of heavier snowfall.

There are generally two periods of high stream flow each year. The major one occurs in fall and winter, coinciding with the season of heavy precipitation, and the other late in spring as the snowpack melts. Streams may rise above flood stage several times each rainy season.

The number of clear or only partly cloudy days each month is 4 to 7 in winter, 10 to 15 in spring and fall, and 20 or more in summer.

Winds in this Area are influenced to some extent by topography. In general, the prevailing wind is from the south or southwest in winter and the west or northwest in summer. The strongest winds are from the southwest and occur as the more intense winter storms move inland. Extreme winds at 30 feet above the ground can be expected to exceed 55 miles per hour once in 2 years, 80 miles per hour once in 50 years, and 90 miles per hour once in 100 years.

Depth of frost in the soil is quite variable. In an average winter, frost reaches a depth of 4 to 8 inches and may penetrate 15 inches or more during

4/ By EARL PHILLIPS, climatologist for Washington, National Weather Service, U.S. Department of Commerce.

prolonged cold periods with no snow cover. Soils under the mountain snowpack are usually free of frost unless they are frozen before snow starts accumulating.

In the lowlands, the longest growing season, 190 to 220 days, is near the Puget Sound. The shortest, 145 to 175 days, is in valleys separated from the Sound by ridges and in the foothills.

Annual evaporation is estimated at 25 to 35 inches. In an average season, the monthly evaporation is 2 to 3 inches in April, 5 to 7 inches in July, and 3 to 4 inches in September.

Evapotranspiration is the combined loss of water to the atmosphere through evaporation and through transpiration from plants. Techniques developed by Palmer-Havens for the application of the Thornthwaite method were used to estimate the potential evapotranspiration, or the theoretical maximum amount of water that could be used under ideal conditions (table 11). Assuming that soils have an available water capacity of 6 inches, estimates also have been made of the actual evapotranspiration.

Potential evapotranspiration in midsummer exceeds actual evapotranspiration by approximately 2 inches in the drier areas and by 1 inch on the wetter slopes of the Cascades.

GEOLOGY

The soils and land types of the King County Area formed largely in deposits of glacial drift laid down during the Vashon period of the Fraser glaciation (5) late in the Pleistocene. The major kinds of material left by the glacier are till, recessional outwash, and pro-glacial lacustrine and outwash sediments. Following deglaciation, alluvium accumulated in the valleys, and a mudflow from Mount Ranier covered a large area in the vicinity of Enumclaw. Figure 7 shows the general location of the major geologic material in the Area. See page 96.

The Vashon till consists of very dense, consolidated lodgement till that ranges in thickness from about 5 feet to nearly 100 feet and has a mantle of ablation till about 3 feet thick. The ablation till is loose, and it is in this material that soils of the Alderwood series formed. The Vashon till is the most extensive of the geologic material in the survey area. The till plain is undulating, and slopes are mostly 6 to 15 percent. In some areas slopes are less than 6 percent, and numerous slopes on terrace fronts to the valleys are more than 15 percent. Many poorly drained closed depressions punctuate the landscape. Organic soils of the Seattle series and wet mineral soils of the Bellingham and Norma series are in these depressions.

As the Vashon glacier receded, large quantities of meltwater were discharged from it. The meltwater sorted material in its path and left very gravelly and sandy sediments that range in thickness from 4 or 5 feet to 80 or 100 feet on the upland terraces. Major delta deposits are several hundred feet thick. The recessional, very gravelly sediments are loose and porous, and it is in these sediments that soils of the Everett series formed. Indianola soils formed in the sandy recessional deposits. The outwash terraces and plains are nearly level but have terrace escarpments as steep as 35 to 40 percent.

A northwest-trending ridge in the central part of the survey area is an uplift of shale, sandstone, conglomerate, and some carbonaceous shale and coalbeds (9). Andesite, tuff, and breccia also occur on the ridge from place to place. The Vashon glacier rode over the highest parts of the ridge, picked up some of the country rock, and left a mantle of debris about 3 feet thick in most places over the ridge. The terrain is fairly steep and has some slopes as steep as 75 to 80 percent. Soils of the Beausite series overlie the sedimentary rock, and soils of the Ovall series overlie the volcanic material.

Pro-glacial lacustrine and sandy outwash sediments are exposed mostly on the strong slopes that extend into the major valleys, such as the one near Kent and Auburn, around Lake Washington and Lake Sammamish, and in the Patterson Creek and Snoqualmie River Valleys. Soils of the Kitsap series formed in the silty lacustrine sediments, and soils of the Indianola series formed in the sandy outwash sediments.

About 5,000 years ago, a mudflow came from the north side of Mount Ranier, down the valley of the White River, and covered a large area in the vicinity of Enumclaw. It is known as the Osceola mudflow (6). The mudflow was so fluid that it flowed around most of the knobs of the Vashon till plain and left many of their drumlin-shaped tops exposed. The surface of the mudflow material is nearly level, which restricts drainage. The mudflow sediments are gravelly loam that is loose in the upper 18 to 30 inches because of weathering and soil formation and very dense and impervious below. Stones and gravel are principally andesite and basalt from the Cascade Mountains to the east. The clay mineral montmorillonite is abundant, but Vashon drift has stones and gravel mostly of granitic origin, and the dominant clay minerals are illite and chlorite. Soils of the Buckley series formed in the Osceola mudflow.

Alluvium accumulated in the valleys in postglacial times. In the valleys of the Green, Sammamish, and Snoqualmie Rivers, the sediments are many tens of feet thick, are mostly silty, and have lenses of sand and peat in some places. Soils of the Puget, Puyallup, Sultan, and Seattle series formed in this alluvium.

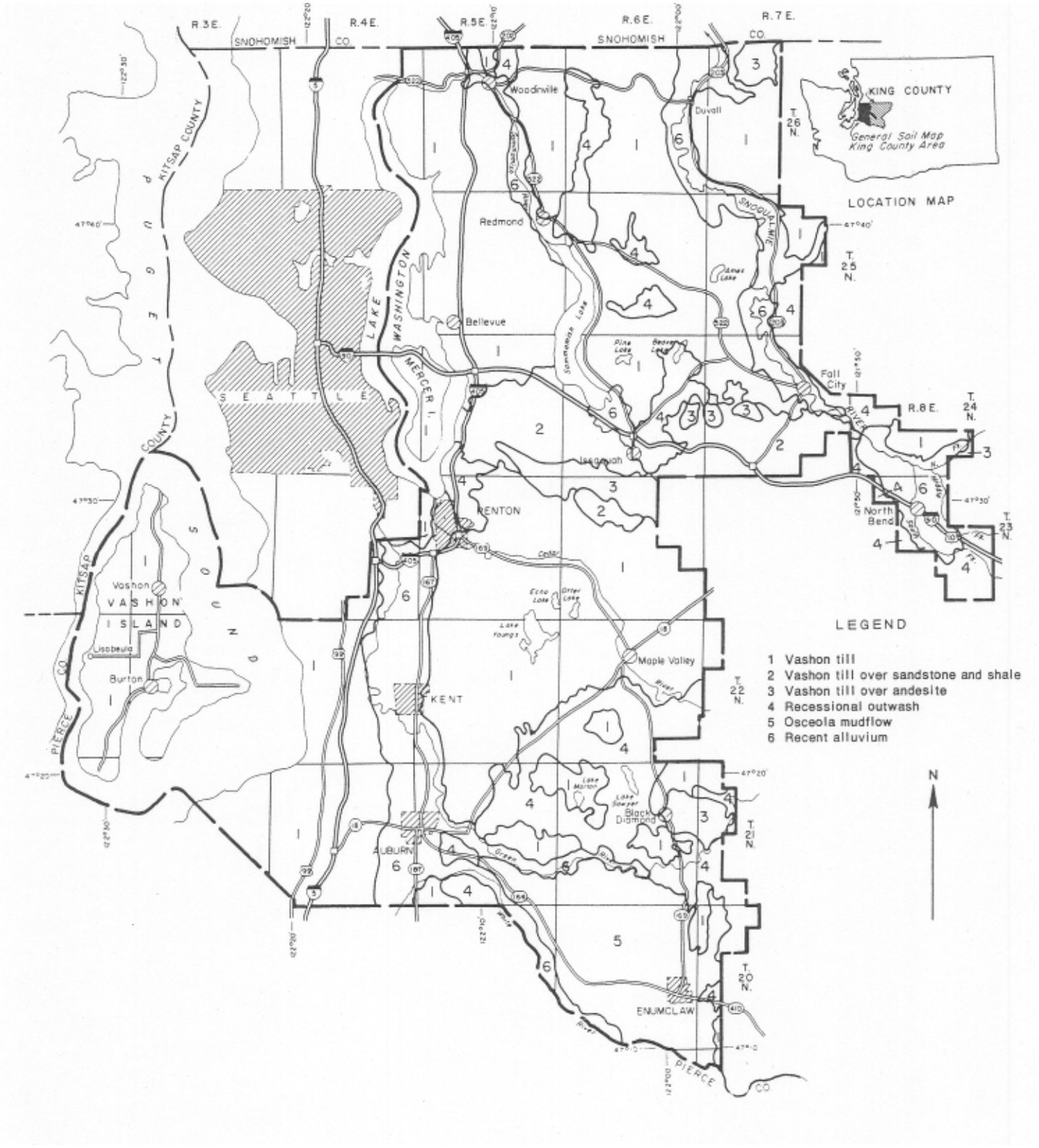

Figure 7.--Geologic material in the King County Area.

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GLOSSARY

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bottom land. Low land formed by alluvial deposits along a stream or in a lake basin; a flood plain.

Clay, As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Cobblestone. A rounded or partly rounded fragment of rock, 3 to 10 inches in diameter. A single piece is either a cobblestone or small stone. Cobbly soils contain 15 to 50 percent cobble--stones by volume.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are-

Loose.--Noncoherent when dry or moist; does not hold together in a mass.

Friable.--When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.--When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic-When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.--When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.--When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.--When dry, breaks into powder or individual grains under very slight pressure.

Cemented.--Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and in Podzolic soils commonly have mottling below 6 to 16 inches, in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion. The wearing away of the land surface by wind (sandblast), running water, or other geological agents.

Glacial till (geology). Unassorted, nonstratified glacial drift, consisting of clay, silt, sand, and boulders transported and deposited by glacial ice. Ablation till settles out of the melting ice and commonly is friable. Lodgement till is material over which the glacier has passed and is commonly dense and hard.

Gravel. Rounded and semi-rounded fragments of rocks one-eighth inch to 3 inches in diameter. A single piece is a pebble. Gravelly soils con tain 15 to 50 percent gravel, by volume.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

0 horizon.--The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.--The mineral horizon at the surface or just below an 0 horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accu- mulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and alumimum oxides).

B horizon.--The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.--The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.--Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance--few, common, and many; size--fine, medium, and coarse; and contrast--faint, distinct, and prominent. The size measurements are these: fine, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; medium, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and coarse, more than 15 milli meters (about 0.6 inch) in diameter along the greatest dimension.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter. If the organic matter is undecomposed and can be identified, the soil is peat. If the organic matter is decomposed, the soil is muck. Muck and peat usually accumulate where drainage is very poor.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil that enables water and air to move through it. Terms used to describe permeability are:

Term	Inches per hour
Very slow	Less than 0.06
Slow	0.06 - 0.20
Moderately slow	0.20 - 0.63
Moderate	0.63 - 2.00
Moderately rapid	2.00 - 6.30
Rapid	6.30 - 20.0
Very rapid	More than 20.0

Profile, soil. A vertical section of the soil through all its horizon and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Runoff. The water that is removed by flow over the surface of the soil. The rapidity of runoff and the amount of water removed are affected by slope; by the texture, structure, and porosity of the surface layer; by the vegetation; and by the prevailing climate. Relative degrees of runoff are as follows:

Ponded. None of the water runs off the soil. The water either moves through the soil or evaporates.

Very slow. Water is on the surface for long periods or enters the soil immediately. Very little water is removed as runoff.

Slow. Water covers the soil for significant periods or enters the soil. Only a small amount is removed as runoff.

Medium. A moderate amount of water enters the soil profile, and free water is on the sur face only for short periods. The loss of

water through runoff does not reduce seriously the supply available for plant growth.

Rapid. Most precipitation moves rapidly over the soil, and a small part moves through the soil profile.

Very rapid. A very large amount of water runs off the soil, and a very small part moves through the profile.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist 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.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are-platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are (1) single grain (each grain by itself, as in dune sand) or (2) massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.,

Substratum. Technically the part of the soil below the solum.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Volcanic ash. Small, ashy particles of solid or porous obsidian or pumice ejected by volcanic activity.