SOIL SURVEY

Yakima County Washington

Series 1942, No. 15

Issued April 1958

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATION
and the
WASHINGTON STATE PLANNING COUNCIL

How to Use THE SOIL SURVEY REPORT

THIS report is about the soils of Yakima County, Washington. It describes each kind of soil and states how it can be used, how it responds to treatment, how to take care of it, and what yields you can expect. Maps in the back show the location and extent of each soil.

SOILS OF A FARM

If you want to know about the soils on a farm or other tract, first find the right place on the map. The map shows towns and villages, roads, streams, and other landmarks. Remember that an inch on the map is half a mile on the ground. Each soil is shown by a symbol, such as Ya, and the extent of each is shown by a boundary line. Color patterns also help you pick out the areas of different soils, although each color pattern is used for several soils that resemble each other in some way.

The map legend shows the soil symbols, arranged in order so you can find them easily, and the name of each soil. The symbol Ya, for example, is used for Yakima loam. All areas of this soil, wherever they appear on the map, are shown by this symbol and the same color. Soil names are listed in the table of contents, so you can turn easily to the right page in the section, Soils of Yakima County. This section first describes each soil series. Then, under the heading Soil Types and Phases, each soil shown on the map is described in detail and its management is discussed.

Yields that you can expect from common crops are given in table 8. Soils are listed in order in the left-hand column of this table; opposite each soil name you will find the yields that can be expected in average years. These estimates of yields give you a basis for comparing probable responses of different soils.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils is given in the section, Soil Associations. This section tells about the principal kinds of soils, where they are found, and how they are related. While reading this section, refer to the soil association map (fig. 2). The patterns shown on this map frequently indicate well-defined differences in type of farming, land use, and land use problems.

A newcomer to the county, especially if he considers buying land, will want to know about the climate; types and sizes of farms; principal farm products and how they are marketed; kinds and conditions of farm tenure; availability of water, roads, and railroads; and location of towns and population centers. Information about all these will be found in the sections, General Nature of the Area, and Additional Facts About Yakima County.

This publication on the soil survey of Yakima County, Wash., is a cooperative contribution from the—

SOIL CONSERVATION SERVICE

the

WASHINGTON AGRICULTURAL EXPERIMENT STATION

and the

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Series 1942, No. 15 Issued April 1958

SOIL SURVEY OF YAKIMA COUNTY, WASHINGTON

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United States Department of Agriculture in cooperation with the Washington Agricultural Experiment Station and the Washington State Planning Council

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[1] Field work for this survey was done when the Division of Soil Survey was part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

YAKIMA COUNTY is among the leading agricultural counties in the United States. Its inhabitants derive their livelihood mainly from farming the irrigated arid and semiarid lands of the Yakima Valley. In addition to these irrigated lands, part of the Horse Heaven plateau in the southeastern part of the county, and some other small upland areas, are dry-farmed. The remainder of the land is largely nonarable; it consists of arid to semiarid rangelands in the eastern part of the county and of forested mountain and foothill country in the west. A large area in the mountains is in national forests. The Yakima Indian Reservation occupies approximately the southwestern half of the county.

For a number of years, agriculture, which dates from about 1861, consisted almost entirely of livestock raising. After the Northern Pacific Railroad was completed in 1886, and after irrigation systems were built, agriculture became more diversified. Now, in the Yakima Valley as a whole, agriculture is highly diversified. Most of the individual farms are specialized, however, because under irrigation farming the various enterprises require specialized skills and special implements and adaptations to soil, location, and relief. Crops and farm enterprises must be adjusted frequently because of changing market demands and because of diseases, insect pests, and weeds.

Many different crops are grown on the irrigated lands. These include apples, pears, peaches, cherries, apricots, grapes, hops, alfalfa hay, and sugar beets. Asparagus, potatoes, and other vegetable and truck crops such as sweet corn and peas are important for canning, freezing, or dehydrating. The fruits, vegetables, hops, and beet sugar are shipped to all parts of the nation.

Dairying, grazing sheep on the range, and feeding sheep and beef cattle are all important in various parts of the county. Lack of good range is a serious handicap to livestock raising, however. In 1950 livestock and livestock products constituted less than a third of the total value of agricultural products sold.

To provide a basis for the best agricultural uses of the land, this cooperative soil survey was made by the United States Department of Agriculture, the Washington Agricultural Experiment Station, and the Washington State Planning Council. Field work was completed in 1942. Unless otherwise specifically indicated, all statements in this report refer to conditions in the county at that time.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Yakima County is located in south-central Washington (fig. 1). The county extends eastward for about 80 miles from the crest of the Cascade Mountains. The total area is 4,273 miles square, or 2,734,720 acres, of which 1,163,533 acres was covered by the survey. Yakima, the county seat and principal city, is 110 miles southeast of Seattle and 165 miles southwest of Spokane.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

PHYSIOGRAPHY

The higher western part of Yakima County lies in the middle section of the Cascade-Sierra Range (*3*).[2] Only a very small part of that section, however, is covered by this soil survey. The central and eastern parts of the county consist mostly of foothills, ridges, and basin valleys that flank the mountains and merge into the basin of the Columbia River. These central and eastern areas are in the Walla Walla Plateau section of the Columbia Plateau physiographic province (*3*). This province has diversified physiography and climate and strong relief.

Extrusive igneous (volcanic) rocks predominate in the county. Of these, Yakima or Columbia River basalt is by far the most extensive. The basalt flows are prominently exposed in stream canyons and on the crests and upper slopes of ridges. These areas of stony and very shallow land on the ridges are locally called "scabland." In the valleys the lava rock is as a rule buried beneath younger and softer rocks or unconsolidated materials. Among these covering materials are sandstones, shales, glacial lake sediments, windblown deposits, and the alluvium of river terraces and flood plains.

[2] Italic figures in parentheses refer to Literature Cited, page 142.

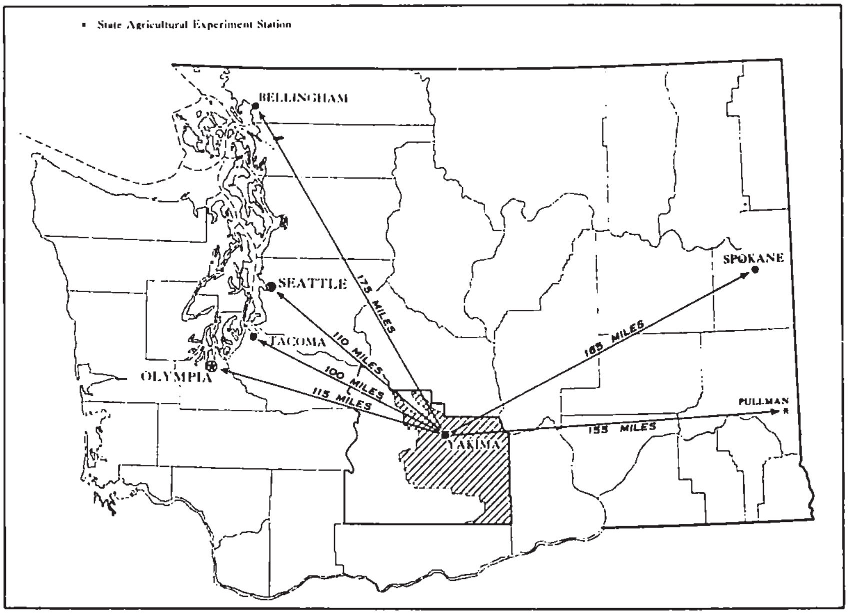

FIGURE 1.—Location of Yakima County in Washington.

The prominent topographic features of the county were formed as a result of slow earth movements, which in comparatively recent geologic time arched the mountains and their tributary ridges upward and folded the troughlike valleys downward. Six roughly parallel eastward-trending ridges and their intervening valleys occupy the central and eastern parts of the county.

The major landforms have been severely sculptured by erosion. Erosion has removed the softer formations from the higher lands and has stripped away many feet of the basalt. Aggressive stream action has cut many stream canyons into the hard rock.

RELIEF

Altitudes range from 425 feet above sea level along the Columbia River to 12,307 feet on the summit of Mount Adams. United States Highway 410 crosses the Chinook Pass at an altitude of 5,440 feet, and the peaks along the crestline of the Cascade Range are generally from 6,000 to 8,000 feet high. Several points on the ridges east of Yakima rise above 4,000 feet. The irrigated lands of the Yakima Valley have altitudes that range from around 700 feet at the Benton County line to more than 2,000 feet north of Tieton.

DRAINAGE

The Yakima River system drains all of the county except the extreme northeastern and southeastern corners, which slope toward the Columbia River, and about 850 square miles in the southwestern part of the county that lies in the drainage basin of the Klickitat River. The Yakima River is an antecedent stream that has maintained its course by cutting downward as ridges slowly rose in its path. It flows south and east across the northeastern part of the county. It traverses three structural basins and has worn through two mountain ridges to form steep-walled canyons or water gaps.

The smaller streams, for the most part, have formed after the main structural features of the county were established. Only those with sources in or near the mountains have a continuous flow. The Naches River is the largest tributary of the Yakima River within the county, and the Tieton River, branching off the Naches, is large. They furnish considerable water for irrigation.

The basin lands, with the bottom lands along streams and on adjoining terraces, alluvial fans, and lower uplands, are collectively called Yakima Valley. Those areas near Yakima are called locally the upper Valley, and those within the larger basin south and southeast of Union Gap, the lower Valley.

CLIMATE

In the settled areas of Yakima County, the arid to semiarid climate is healthful and pleasant; it is favorable for growing many irrigated crops common to the Temperate Zone. Although the climate is essentially continental because the county is located inland, the moderating effects of winds from the Pacific Ocean are felt. These ocean winds are not entirely shut off by the Cascade Mountains. The prevailing weather is not so mild and even as that of western Washington, nor is it so rigorous as that of the Rocky Mountain areas or the Great Plains. Table 1 gives climatic data for the United States Weather Bureau stations at Yakima and Sunnyside.

In Sunnyside extremes of temperature rarely occur and do not last long. Because of the dry atmosphere, they cause little discomfort. Occasionally winters are severe—temperatures are low, and snow lies on the ground for extended periods. Most winters are more moderate, however, and some are very mild and have little snow.

Blizzards and tornadoes rarely, if ever, occur in Yakima County. Severe electrical storms are more frequent in the mountains than in the inhabited valleys. Destructive hail and winds are rare.

Spring usually comes early in the valleys. In some years cool windy weather prevails until late in May, but spring plowing often begins late in February. Early crops are seeded in March. The summers are warm and exceedingly dry. The high daily temperatures, abundant sunshine, and long daylight favor rapid plant growth.

One or more hot spells that last 1 or 2 weeks are common during July and August. Farmwork is usually carried on in spite of discomfort. Some of the town people, however, move to summer homes, and many others spend weekends in the nearby mountain recreational areas.

Winter cold seldom interferes with work on the farms. Generally there is plenty of time to harvest all the crops and to complete fall plowing before hard freezes arrive. Occasionally, however, apples are frozen on the trees, and potatoes and other root crops are injured.

Of all the temperature effects that result from the climate, late spring frosts have the most important bearing upon the use of the land within the irrigated areas. At the present time, orchard fruits, and the less hardy varieties of grapes are grown only on the higher lands and in areas just below the water gaps where air drainage is favorable and protects from frost. Marked differences in frost hazard occur within short distances. Yakima, situated in the air draft through the Selah Valley, has an average growing season of 186 days. At Yakima the average date of the last frost in spring is April 17, and the average first frost in autumn is October 20. At Sunnyside, on the other hand, the average date of the last frost in spring is May 2, and the first in fall, October 10.

Differences in altitude result in a wide range of precipitation throughout the county. At Sunnyside, which has an altitude of 747 feet, the average annual precipitation is 6.56 inches; snowfall, 14.0 inches; temperature, 51.2°; and average frost-free period, 161 days. Along the crestline of the Cascade Range, at elevations of 5,000 to more than 12,000 feet, precipitation is much higher; ice and snow remain on the highest peaks throughout the year and frosts may occur on any night in the summer.

In the lower settled parts of the county, the most striking climatic characteristics are low precipitation and a dry atmosphere. These

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at two stations in Yakima County, Wash.*

[Yakima, elevation, 1,061 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average with totals	Total for the driest year	Total for the wettest year	Average snowfall with totals
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	30. 6	66	−24	1. 10	. 26	1. 34	7. 0
January	26. 9	60	−21	. 96	. 52	1. 52	8. 7
February	34. 2	66	−11	. 81	1. 19	. 86	3. 4
Winter	30. 6	66	−24	2. 87	1. 97	3. 72	19. 1
March	43. 7	82	13	. 46	. 20	. 29	. 1
April	51. 4	94	22	. 43	. 08	. 46	. 1
May	59. 1	98	28	. 47	. 41	2. 76	(3)
Spring	51. 4	98	13	1. 36	. 69	3. 51	. 2
June	65. 4	103	32	. 59	. 44	2. 10	0
July	71. 4	111	41	. 18	. 02	. 07	0
August	69. 5	102	36	. 22	(3)	. 44	0
Summer	68. 7	111	32	. 99	. 46	2. 61	0
September	61. 1	98	20	. 39	. 15	. 64	0
October	50. 6	89	12	. 62	. 24	. 27	(3)
November	38. 1	70	5	. 98	. 39	1. 12	2. 8
Fall	49. 9	98	5	1. 99	. 78	2. 03	2. 8
Year	50. 2	111	−24	7. 21	[4] 3. 90	[5] 11. 87	22. 1

See footnotes at end of table.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at two stations in Yakima County, Wash.*—Continued

[Sunnyside elevation, 747 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average with totals	Total for the driest year	Total for the wettest year	Average snowfall with totals
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	32. 4	69	−30	. 88	. 06	1. 31	3. 5
January	29. 7	70	−26	. 87	. 40	1. 70	6. 2
February	35. 9	70	−15	. 65	. 14	1. 07	2. 3
Winter	32. 7	70	−30	2. 40	. 60	4. 08	12. 0
March	44. 7	82	7	. 37	. 05	. 71	. 2
April	52. 4	96	17	. 38	. 05	. 38	(3)
May	59. 3	99	24	. 50	. 73	. 06	0
Spring	52. 1	99	7	1. 25	. 83	1. 15	. 2
June	66. 0	106	32	. 51	. 49	2. 30	0
July	71. 9	108	39	. 20	0	. 09	0
August	69. 9	108	36	. 23	. 07	0	0
Summer	69. 3	108	32	. 94	. 56	2. 39	0
September	61. 2	99	18	. 47	. 52	. 01	0
October	51. 6	88	14	. 57	. 11	2. 59	(3)
November	39. 8	76	−23	. 93	. 41	. 72	1. 8
Fall	50. 9	99	−23	1. 97	1. 04	3. 32	1. 8
Year	51. 2	108	−30	6. 56	[6] 3. 03	[7] 10. 94	14. 0

[1] Yakima: Average temperature based on a 45-year record, through 1954; highest and lowest temperatures on a 21-year record, through 1930. Sunnyside: Average temperature based on a 58-year record, through 1954; highest and lowest temperatures on a 35-year record through 1930.

[2] Yakima: Average precipitation and wettest and driest years based on a 45-year record, 1910–1954, based on a 21-year record, through 1930. Sunnyside: Average precipitation and wettest and driest years based on a 60-year record, 1895–1954; snowfall, based on a 34-year record, through 1930.

[3] Trace. [4] In 1930. [5] In 1948. [6] In 1898. [7] In 1950.

lower areas form a long narrow strip in the climatic shadow of the Cascade Mountains. In the lee of the mountains, which stand crosswise to the prevailing westerly winds, the dry downflowing air affects the soils and the vegetation. The driest areas are those at the lowest altitudes. Dryland wheat farming is limited chiefly to elevations above 1,700 feet. It is carried on the most successfully at altitudes of 2,500 to 3,000 feet and in areas where the air flows upward as it does near Bickleton (Klickitat County).

In the mountains the precipitation falls mainly as snow, and in the valleys, as rain. Precipitation is usually gentle and falls only for short periods. Local torrential summer rains strike occasionally on strips along the ridges. Damage from such rains is usually caused by floodwaters that rush down the coulees and wash out irrigation ditches along the margins of the valleys.

In the Yakima Valley and in its vicinity, effective precipitation falls only when prevailing weather conditions are reversed. During this reversal air currents are drawn toward the mountains by a low pressure area farther west. This happens chiefly in winter and early in spring. Frequently, however, enough rain falls early in summer to damage the cherry crop and to injure some of the first cutting of hay.

Prevailing winds are from the west. They blow strongest during spring. Velocities rarely reach 40 miles an hour, and damage to crops is usually slight. Soil blowing is serious if fields are worked to a fine mulch—in sandy areas spring crops are sometimes blown out. During the rest of the year, strong winds are rare and of short duration.

Strong sunlight is normal during the growing season. The long summer days common at this northern latitude stimulate plant growth. During June and July, the average time that the sun shines daily is 13 to 15 hours. Humidity is normally very low, and evaporation is excessive.

Rain in the summer is rare. When it does come, it may do as much harm as good on the irrigated lands. Rain does have the advantage of lowering the fire hazard in the mountain forests for a few days. The increased humidity helps the dryland wheat but has little effect on the arid rangelands. It is expected that soil moisture from winter will start the early crops. The winter moisture is often not enough for early growth of crops, so that they must be irrigated early in the growing season.

WATER SUPPLY

The water supplies of Yakima County come primarily from streams that are fed by the melting snow of the Cascade Mountains. In the Yakima Valley a great deal of water is used annually for irrigation. Much of this comes from the headwaters of the Yakima River in Kittitas County. Here, three large mountain lakes—the Cle Elum, Kachess, and Keechellis—have been made into storage reservoirs by constructing dams to augment the flow of the river late in summer and in fall. Three more mountain reservoirs in Yakima County—Tieton and Clear Lake Reservoirs on the Tieton River and the Bumping Lake on the Bumping River—add greatly to the flow of the Naches River. There is also a small reservoir located on Wenas Creek. The natural flow of the creeks is used to irrigate lands in their individual valleys.

Shallow wells predominate on the farms of the lower valley lands. These tap ground-water tables are fed by streams or by irrigation waters. Deep wells, some of which are artesian, supply water for a number of the towns and some of the farms. The artesian water zones are generally the axes of down-warped basins. Here deep-lying strata hold water derived from sources in the mountains. A number of artesian wells are scattered widely throughout the valleys; they flow naturally, or the water rises to within easy pumping distance of the surface.

A few large springs and many small ones are scattered along the flanks of the high ridges, but they are distributed unevenly. On many square miles of range, water must be hauled to sheep or the land grazed only in cool weather.

Mountain streams and lakes in the National and State forests provide exceptional opportunities for recreation. Public campgrounds and sites for summer homes adjoin the roads that follow the major streams in the national forests. Many miles of well-stocked streams, the reservoirs, and a large number of small remote mountain lakes are normally open for fishing.

WILDLIFE

Deer and elk are usually numerous in the mountain forests. In winter they often damage the haystacks and orchards on outlying ranches. Pheasants, partridges, and quail abound in the valleys and are hunted extensively during the open seasons. Ducks are also abundant each fall, and large blocks of marshland along the streams are leased to hunting clubs. In the mountains and valleys, game preserves have been set aside for the protection of wildlife.

VEGETATION

Because of variations in climate, the plants of Yakima County are of many different kinds and vary greatly in density of growth. The contrasting plant associations conform to the differences in elevation, exposure, and soil.

The effects of drying winds and direct sunlight are so pronounced that both the altitude and the direction of exposure to the sun are major factors that affect plant growth, even in areas under irrigation.

On west and south exposures, the native cover is sparse; most of the species that grow there are drought resistant. On these exposures erosion from wind and water has been the most severe. As a result the soils are generally shallow and are gravelly or stony in many places.

The plant cover on north and east slopes is more abundant, particularly at higher altitudes, where dense stands of trees are common. At lower drier altitudes, more grass grows on the north and east slopes, and the soils have correspondingly greater depth and a greater content of organic matter. Even the high-lying shallow soil, or scabland, on north and east slopes in the arid and semiarid rangelands is more desirable for grazing than the deeper soils of the lower lands that have a west or south exposure.

Most of the precipitation comes in the winter. Plants must depend mainly upon moisture stored in the soil, upon ground water, and upon water carried to them by streams. In the arid to semiarid eastern and central parts of the county, the normal annual precipitation is 6 to 12 inches but is generally nearer 6 inches than 12. At Sunnyside the precipitation was only 3.03 inches in the driest year recorded (see table 1).

Plants are able to grow in this extremely arid climate only because accumulated winter moisture allows a short growing period in spring. The annual plants get enough moisture because they mature early. The native perennial shrubs and grasses make their annual growth early in the summer and lie dormant through the long period when the soils are dry. Certain plants such as Russian-thistle, wild sunflower, and Jim Hill mustard, however, are able to grow into the early summer. The brief summer rains have little effect except to settle the dust and to increase humidity temporarily.

Shrubs and grasses of the semiarid and arid rangelands.—Big sagebrush and bunchgrasses predominate in the drier parts of the county. Big sagebrush became abundant after the original cover of bunchgrasses and smaller native perennial grasses was thinned out or destroyed by overgrazing. In places other semiarid shrubs such as rabbitbrush and hopsage grow on the shallow soils and southern exposures in the areas of lowest rainfall.

Antelope-brush, or bitterbrush, grows in the more humid areas; it attains a height of 4 to 8 feet in the moister coulees. Several other native shrubs grow around rock outcrops and on the scablands. White sage, or winterfat, a silvery gray plant that is important because of its forage value, grows on shallow soils overlying shale in the uplands. Intermingled with the arid and semiarid shrubs is a variable cover of grasses and herbs. This is scant on the lower levels but becomes more dense and increases in grazing value at higher altitudes as distances to water become greater for stock.

Downy chess, commonly called cheat or cheatgrass, is an annual grass introduced from southern Europe. It is by far the most abundant grass on the arid and semiarid ranges. Moisture is sufficient so that the seeds germinate in the fall, and the grass attains its growth in spring. This grass seeds profusely even under the most adverse conditions. In some years, however, it is infected with a smut that is suspected of poisoning cattle. Cheatgrass makes up the greater part of the spring forage for sheep. It must be grazed before the sharp-awned seeds are formed or after they shatter in the fall. During summers, after spring and fall moisture has been abundant, the dry cheatgrass becomes a serious fire hazard. It is also a serious pest in alfalfa and commonly lowers the quality of the first cutting.

Several species of plants, such as mustard and Russian-thistle, grow on the more arid ranges and furnish some forage for livestock. Tarweed, or fiddleneck, is the most serious pest on the range. It is prevalent in some districts, particularly on shallow soils, southern exposures, and severely overgrazed land. Hogs may die of poisoning if fed dryland wheat from fields infested with tarweed.

Vegetation of bottom lands.—A heavy cover of cottonwood, willow, hawthorn, wild rose, chokecherry, serviceberry, and many species of deciduous plants grow on the moist soils along the streams. Greasewood and saltgrass make up the principal native vegetation on the saline and alkali soils. Giant wildrye is common on low-lying, slightly saline soils, and it covered much of the nonsaline bottom land, as well, at the time the county was first settled.

Trees and shrubs of the foothills.—In the foothills, at altitudes that range from 1,800 feet in the canyons to 3,000 feet on exposed slopes, an interrupted and irregular line delineates the dry margin of the ponderosa (western yellow) pine forest that grows under an annual precipitation of 12 to 18 inches. Scabland and Smooth stony land and Stony and shallow soils predominate in these areas. This belt of transition from semiarid into subhumid conditions constitutes a zone of conflict between plants of the open lands and those of the forest. Many different plant associations occur. The plant cover, however, consists chiefly of the comparatively unpalatable pinegrasses, shrubs, herbs, and the cheatgrass, which can be grazed for only a short period.

At the lower eastern fringe of the forests, western yellow pine is the only large native tree that can live where precipitation is so low and where the soils are so stony and shallow in many places. The pine is in scattered groves or open stands. It grows in the most favorable locations. These are the north and east slopes, or the coulees and canyon bottoms in areas of open scabland, or on the prairies on the ridges and dry southern exposures. A few scattered trees cling to the rock outcrops on canyon walls. Some grow along streams, sometimes several miles out into the adjoining sagebrush-grass areas.

In many places, especially along large drainageways, scrubby Oregon oak grows up among the pines. These oaks are most abundant in the canyons but also grow high up on the rocky slopes.

The big, or common, sagebrush so abundant on lower lands thins out near the forests. The most abundant shrubs associated with the pines are antelope-brush, stocky laurel (snowbrush), chokecherry, wild cherry, wild currant, serviceberry, oceanspray, and mockorange.

The streams of the lower canyons are bordered with cottonwoods, aspens, several species of willows, small alders, small dogwoods (red-osiers), hawthorns, and many of the shrubs listed in the preceding paragraph. A short distance within the western yellow pine zone, Douglas-fir enters the association, chiefly in the cooler moist situations. Here, this widely distributed western tree is small and grows slowly.

Forests of high altitudes.—At higher altitudes to the west in the unsurveyed part of the county the ponderosa pine forests grade into denser mixed coniferous forests, high parklands, mountain meadows, and alpine snowfields. Because of the complex topography and range in temperature and moisture that result from differences in altitude and exposure, the plant associations in these areas are exceedingly varied and their distribution is interrupted and irregular. Few areas of equal size present such an array of plant species.

Four life zones occur in this part of the Cascade Mountains. They are, (1) the western yellow pine zone of the Arid Transition; (2) the Canadian; (3) the Hudsonian; and (4) the Arctic, or Alpine (*14*). In many places some plant associations are crowded out or intermingled with others because the zones are so narrow and the relief is so broken. Many plants that are indigenous to the Canadian zone are able to establish themselves in the cool moist areas within the Arid Transition zone. They also climb up southern exposures into the Hudsonian zone. Plants that are native to the west side of the mountains are also found in strategic locations comparable to those of their natural habitat.

Scientific names for some of the more common trees, shrubs, and grasses of the county are listed as follows:

FOREST TREES AND SHRUBS

Scientific name	*Common name*
Acer circinatum	Vine maple.
A. negundo	Boxelder.
Amelanchier florida	Serviceberry.
Berberis nervosa	Oregon-grape.
Ceanothus velutinus	Sticky laurel; buckbrush; snowbrush.
Cornus stolonifera	Small dogwood; red-osier.

FOREST TREES AND SHRUBS—Continued

Scientific name	*Common name*
Crataegus douglasii	Blackhaw.
Elaeagnus angustifolia	Russian-olive.
Holodiscus discolor	Indian arrow; oceanspray.
Juniperus occidentalis	Western juniper.
Philadelphus lewisii	Syringa; mockorange.
Pinus ponderosa	Ponderosa pine; western yellow pine.
Populus balsamifera	Balsam poplar.
P. tremuloides	Quaking aspen.
P. trichocarpa	Black cottonwood.
Prunus demissa	Chokeberry.
P. emarginata	Bittercherry.
Pseudotsuga menziesii	Douglas-fir.
Quercus garryana	Garry oak; Oregon oak.
Rhus glabra var. *occidentalis*	Sumac.
R. radicans	Poison-sumac; poison-ivy.
Ribes sp	Wild currant and gooseberry.
Rosa nutkana	Wildrose.
R. pisocarpa	Wildrose.
Salix sp	Willow.
Sambucus cerulea	Blue elderberry.

SHRUBS OF THE SEMIARID AND ARID RANGELANDS

Artemisia rigida	Scabland sagebrush.
A. tridentata	Big sagebrush; common sagebrush.
Chrysothamnus nauseosus	Rabbitbrush.
C. viscidiflorus	Rabbitbrush.
Eurotia lanata	Winterfat; white sage.
Grayia spinosa	Hopsage.
Purshia tridentata	Bitterbrush; antelope-brush.
Salvia dorrii subsp. *carnosa* (*Ramona incana*)	Mintbrush.
Sarcobatus vermiculatus	Greasewood.

GRASSES OF THE SEMIARID AND ARID RANGELANDS

Agropyron dasystachyum	Wheatgrass.
A. spicatum	Bluebunch wheatgrass; western bunchgrass.
Bromus mollis	Soft chess.
B. marginatus	A bromegrass.
B. racemosus	A bromegrass.
B. rigidus	Ripgutgrass.
B. secalinus	Chess.
B. tectorum	Downy chess; commonly called cheat or cheatgrass.
Distichlis stricta	Saltgrass.
Elymus canadensis	Canada wildrye.
E. condensatus	Giant wildrye.
Festuca idahoensis	Idaho fescue; bluebunch fescue.
Hordeum leporinum	Mouse barley.
Oryzopsis hymenoides	Indian ricegrass.
Poa secunda	Sandberg bluegrass.
Puccinellia distans	Alkaligrass.
Stipa comata	Needle-and-thread grass.
S. thurberiana	Thurber needlegrass.

HERBS AND FORBS OF THE SEMIARID AND ARID RANGELANDS

Abronia mellifera	Sand-verbena.
Achillea lanulosa	Yarrow.
Allium acuminatum	Wild-onion.
Amsinckia intermedia	Tarweed; fiddleneck.
A. tessellata	Tarweed.

HERBS AND FORBS OF THE SEMIARID AND ARID RANGELANDS—Continued

Scientific name	*Common name*
Aster canescens	Blue aster.
A. sp	Asters.
Astragalus sp	Rattleweed; locoweed; milkvetch; poisonvetch.
Atriplex patula	Spearorache; holy roller.
Balsamorhiza careyana	Balsamroot.
B. hirsuta var. *lagocephala*	Balsamroot.
B. hookeri	Balsamroot.
B. sagittata	Arrowleaf balsamroot.
Brodiaea douglasii	Blue brodiaea.
Calochortus nuttallii	Sego-lily.
Chenopodium sp	Lambsquarters.
Chrysopsis sp	Golden aster.
Cirsium undulatum	Thistle.
Cuscuta sp	Dodder on sagebrush.
Erigeron linearis	Fleabane.
Eriogonum elatum	Rush eriogonum.
E. heracleoides	Wyeth eriogonum; Indian-tobacco
E. nudum	Barestem eriogonum.
E. piperi	Piper eriogonum.
E. umbellatum	Sulfur eriogonum.
E. sp	Eriogonum.
Erodium cicutarium	Alfileria; filaree.
Euphorbia glyptosperma	Green splurge.
Franseria acanthicarpa	Sandbur.
Gaura parviflora	Crimson gaura.
Helianthella douglasii	Wild sunflower.
Iris missouriensis	Wild iris; wild-flag.
Lepidium apetalum	Pennycress.
L. perfoliatum	Shieldgrass.
Leptotaenia sp	Wild carrot.
Lewisia rediviva	Bitterroot.
Linum lewisii	Wild blue phlox.
Lithosperum ruderale	Stoneseed.
Lomatium sp	Indianroot; biscuitroot.
Lupinus sp	Lupine.
Lygodesmia sp	Skeletonweed.
Mentzelia albicaulis	Whitestem mentzelia.
M. laevicaulis	Blazingstar mentzelia.
Monardella odoratissima	Wild mint.
Nicotiana attenuata	Coyote tobacco.
Oenothera pallida	White evening-primrose.
O. strigosa	Evening-primrose.
Opuntia polyacantha	Pricklypear cactus.
Penstemon acuminatus	Penstemon.
P. glaber	Penstemon.
Perideridia gairdneri	Western false-caraway.
Phacelia leucophylla	Waterleaf.
P. linearis	Waterleaf.
Phlox canescens	Sage phlox.
P. longifolia	Sage phlox.
Rumex venosus	Sand dock.
Salsola koli var. *tenuifolia*	Russian-thistle.
Sida hederacea	Alkali-mallow.
Sisymbrium altissimum	Jim Hill mustard.
S. sophia	Wild mustard.
Sphaeralcea munroana	Crimson-mallow.
Zigadenus paniculatus	Foothill deathcamas.
Z. venenosus	Deathcamas.

SOIL SURVEY METHODS AND DEFINITIONS

The scientist who makes a soil survey examines soils in the field, classifies the soils in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map.

Field study.—The soil surveyor bores or digs many holes to see what the soils are like. The holes are not spaced in a regular pattern but are located according to the lay of the land. Usually they are not more than a quarter of a mile apart, and sometimes they are much closer. In most soils such a boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. Each layer is studied to see how it differs from others in the profile and to learn the things about the soil that influence its capacity to support plant growth.

Color is usually related to the amount of organic matter. The darker the surface soil, as a rule, the more organic matter it contains. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

Texture, or the content of sand, silt, and clay, is determined by the way the soil feels when rubbed between the fingers and is later checked by laboratory analysis. Texture determines how well the soil retains moisture, plant nutrients, and fertilizer and whether it is easy or difficult to cultivate.

Structure, which is the way the individual soil particles are arranged in larger grains, and the amount of pore space between grains, gives us clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture.

Consistence, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

Other characteristics observed in the course of the field study and considered in classifying the soil include the following: The depth of the soil to bedrock, cemented or compact layers, or loose gravel strata; the presence of gravel or stones in amounts that will interfere with cultivation; the steepness and pattern of slopes and the degree of erosion; the surface runoff of water, drainage through the soil, and occurrence of a high ground water table; nature of the underlying rocks or other parent material from which the soil has developed; acidity or alkalinity of the soil as measured by chemical tests; and whether the soil contains excess salts or alkali.

Simple chemical tests show how acid the soil may be.[3] The presence or absence of lime (free calcium carbonate) is detected by applying unheated dilute hydrochloric acid to the soil sample. Calcareous soils

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[3] The reaction of a soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. The degree of acidity or alkalinity is expressed in words and pH values as follows (*19*):

Extremely acid	Below 4. 5	Neutral	6. 6–7. 3
Very strongly acid	4. 5–5. 0	Mildly alkaline	7. 4–7. 8
Strongly acid	5. 1–5. 5	Moderately alkaline	7. 9–8. 4
Medium acid	5. 6–6. 0	Strongly alkaline	8. 5–9. 0
Slightly acid	6. 1–6. 5	Very strongly alkaline	9. 1 or higher

are those that contain sufficient calcium carbonate (often magnesium carbonate also) so that effervescence is visible to the naked eye when hydrochloric acid is added.

Noncalcareous soils are those that do not contain sufficient calcium carbonate to be detected by applying hydrochloric acid. A soil may contain an abundance of available calcium and yet not be calcareous according to the test with hydrochloric acid. The test indicates the presence of calcium carbonate (lime), not of calcium in other compounds.

A saline soil is one that contains enough soluble salts so distributed in the profile that they interfere with the growth of most crop plants. These are the neutral or nearly neutral salts, often called "white alkali," as well as the true alkali salts, called "black alkali," of which sodium bicarbonate and carbonate are the most common. The content of readily soluble salts is determined by using an electrolytic bridge. The conductivity of the saturation extract of saline soils is 4 millimhos or greater, and most saline soils contain 15 percent or more of soluble salts.

An alkali soil has so high a degree of alkalinity, pH 8.5 or higher, or so high a percentage of exchangeable sodium, 15 percent or higher, or both, that the growth of most crop plants is reduced.

A saline-alkali soil is one that has a harmful concentration of salts, a high alkalinity, or large amounts of exchangeable sodium, or both, and, as a result, is of reduced value for crop plants.

Classification.—On the basis of the characteristics observed by the survey team or determined by laboratory tests, soils are classified into phases, types, and series. The soil type is the basic classification unit. A soil type may consist of several phases. Types that resemble one another in most of their characteristics are grouped into soil series.

Soil type.—Soils similar in kind, thickness, and arrangement of soil layers are classified as one soil type.

Soil phase.—Because of differences other than those of kind, thickness, and arrangement of layers, some soil types are divided into two or more phases. Slope variations, frequency of rock outcrops, degree of erosion, depth of soil over the substratum, type of drainage (natural or artificial), and presence of excess soluble salts are examples of characteristics that suggest dividing a soil type into phases.

The soil phase (or the soil type if it has not been subdivided) is the unit shown on the soil map. It is the unit that has the narrowest range of characteristics. Use and management practices therefore can be specified for the soil phase more easily than for soil series or yet broader groups that contain more variation.

Soil series.—Two or more soil types that differ in surface texture but that are otherwise similar in kind, thickness, and arrangement of soil layers are normally designated as a soil series. In a given area, however, it frequently happens that a soil series is represented by only one soil type. Each series is named for a place near which the soil was first mapped. Thus, Cowiche is the name of a soil series that occurs over tuffaceous sandstones and shales in Yakima County. It was first recognized near Cowiche Mountain.

Miscellaneous land types.—Steep rocky mountainsides that have little or no true soil are not classified into types and series but are identified by descriptive names such as Steep broken and stony land.

Soil complex.—When two or more soils are so intricately associated in small areas that it is not feasible to show them separately on the soil map, they are mapped together and called a soil complex. The Quincy-Sagemoor-Marsh complex is a soil complex mapped in this county.

SOILS OF YAKIMA COUNTY

Yakima County, lying between the crest of the Cascade Range and the Columbia River, is a complex area characterized by diverse geology, physiography, and climate. The parent materials of the soils were derived from many kinds of rocks through the processes of weathering and wind and water erosion. In the more arid areas, particularly, wind and water have shifted, eroded, covered up, and otherwise altered the soils.

In spite of the diverse environment, some of the soils have certain characteristics in common. For example, there are large areas where the surface soils are pale brown, light brownish gray, or grayish brown and of a silt loam or loam texture. The similarity of the surface layers is often misleading, however. Beneath these similar surface layers are subsoils and substrata so different that suitability for different crops is vitally affected. These underlying, less evident, layers, so diverse and locally different, are especially important wherever irrigation is practiced.

The soils of the county most valuable for agriculture have formed on soft rocks or on deep deposits of unconsolidated medium-textured materials. Most of the agricultural soils of the county are developing from transported materials. Deposits of alluvium occur on the lower slopes of the ridges, on the benchlands, the stream terraces, alluvial fans, basin lowlands, and stream bottoms.

Basin areas in this county were once filled to depths of about 1,250 feet by glacial lake sediments consisting of light-gray, calcareous silt and sand. Remnants of these beds underlie important agricultural soils on the benchlands of the lower Yakima Valley.

Many of the better soils have formed partly from loess—deposits of windborne silt and very fine sand that once covered great areas in the intermountain region. Much of the loess deposit has been removed by erosion, but in protected areas and on the high, well-grassed plateaus enough remains to form deep soils. Several soil series of the uplands have a thin cover of loess over older materials.

Of the soils developed from weathering bedrock, those derived from tuffaceous sandstones and shales of the Ellensburg and related formations are best. The soft easily weathered rocks also have provided much material for the alluvial soils.

Basic lava flows underlie the entire eastern part of the county, and in high or exposed places they outcrop. This kind of rock weathers slowly in a dry climate, so on many of the ridges and upper slopes the soils are shallow and very stony. Scabland and Smooth stony land or Steep broken and stony land are mapped in such places. Nevertheless, where 10 inches or more of precipitation falls in protected places, appreciable areas of soils suitable for cultivation have developed in residuum weathered from hard rocks. These areas normally occur near or within the mountains. The basic lava rocks, rich in soil-forming minerals, have contributed considerable material to the fertile alluvial soils of the valleys.

Many soils on the terraces and valley floors are shallow, gravelly, and droughty because they overlie beds of gravel deposited by the swift waters of the Yakima River and its larger tributaries. In places, areas of sandy soil occur because the wind has worked exposed soils or soft sediments, blown away the fine particles, and left the sand. These sandy areas occur chiefly in the lower, drier parts of the valleys. For the most part, they are derived from the sandier beds deposited in glacial lakes.

Slow drainage during the period of soil formation has affected the soils of the lower lying lands. Because of restricted drainage, soluble salts or alkali have accumulated. Several soil series of this county owe their distinctive characteristics to the past influence exerted by saline ground water.

SOIL SERIES AND THEIR RELATIONS

The soils of the county vary in color, texture, consistence, structure, organic-matter content, reaction, parent material, depth, relief, natural fertility, moisture relations, content of soluble salts, erodibility, and stoniness. All of these things have an important effect on the suitability of the soils for farming.

The soils of the county have been placed in four main groups in order that their relationships may be more easily understood. These groups are: Soils of the semiarid uplands and terraces; soils of the arid uplands and terraces; soils of the bottom lands, alluvial fans, and low terraces; and miscellaneous land types. The grouping is made mainly on the basis of climate and physiography, but the fourth group, miscellaneous land types, consists of many kinds of land occurring on widely diverse topography.

The first three of the four groups have subgroups. The bases for separation into subgroups are kind of parent materials, degree of profile development or texture of the subsoil, natural drainage, and occurrence of alkali. Each subgroup has a distinguishing color pattern on the map, so its location and extent can be seen readily.

SOILS OF THE SEMIARID UPLANDS AND TERRACES

Soils of the semiarid uplands and terraces have been placed in three subgroups. The first subgroup consists of relatively dark-colored soils on loess or bedrock of the uplands, the second of light-colored soils on loess or bedrock of the uplands, and the third of light-colored soils on cemented gravel of the terraces.

RELATIVELY DARK COLORED SOILS ON LOESS OR BEDROCK OF THE UPLANDS

The soils of this subgroup are members of the Bickleton and Taneum series. They occur as disconnected areas on the higher uplands and plateaus. In that part of the county mapped in detail, they are normally at altitudes above 2,200 feet, but are somewhat below the drier lower edge of the ponderosa pine forests.

The soils are distinguished from other soils of the uplands and terraces by their darker colored surface soil. Higher effective precipitation and more abundant grass and other vegetation account for their darker color. The soils are in a climatic zone where much of the precipitation, 10 to 26 inches yearly, comes as snow. Summers are dry and somewhat cooler than at lower altitudes. The natural vegetation is predominantly bunchgrasses and big sagebrush, but bitterbrush grows in some areas.

Bickleton silt loam, the only member of the Bickleton series in the county, has a grayish-brown surface soil and a slightly compact subsoil. Normally, there is a slight to moderate accumulation of lime in the subsoil. The soil is shallow—2 to 4½ feet deep over basalt bedrock. The upper part of the soil has formed from loess, but the lower has been influenced to varying degrees by material derived from basalt.

Taneum soils have a surface soil slightly lighter colored than that of the Bickleton soil. The subsoil is compact, as in the Bickleton soil, but overlies tuffaceous sandstone or shale, not basalt. As a rule, little or no lime has accumulated. The upper layers may be derived from loess, or influenced by it, but the lower layers have developed from material that weathered from noncalcareous sedimentary rocks of the Ellensburg formation, or a similar formation. These sedimentary rocks are normally tuffaceous sandstones. Taneum soils are used mainly for dry-farmed wheat, because they occur above the present irrigation systems.

LIGHT-COLORED SOILS ON LOESS OR BEDROCK OF THE UPLANDS

The soils of this subgroup have formed on semiarid uplands and higher terraces. They consist of the members of the Cowiche, Renslow, Ritzville, Simcoe, and Tieton series. Because they lie at lower altitudes, they receive less effective precipitation than the relatively dark colored soils on loess or bedrock of the uplands. Also they are apparently lower in organic matter because they are in a warmer climate and have a less abundant growth of grasses and other plants.

Soils of this subgroup have formed under the influence of good drainage, a natural vegetation of bunchgrasses and big sagebrush, and a yearly precipitation of 7 to 13 inches. Most of the precipitation comes in winter.

According to the kind of parent material, the soils of this subgroup can be separated as soils on loess and soils on bedrock.

Soils on loess.—In this category are soils of the Renslow and Ritzville series. These upland soils occur on plateaus protected by north-facing slopes and on the more gently sloping foot slopes. In other words, they occur in places where natural erosion has not had a chance to remove the deposit of smooth, floury, windborne silty material that once may have formed a continuous blanket over the hills and valleys. These soils are distinguished from the other light-colored soils of this subgroup by lack of coarse sand grains, pebbles, or stones in their profile or in the underlying parent material.

Ritzville soils are widely distributed and cover a large acreage in the drier upland parts of the county. They reflect the influence of an arid to semiarid climate and a vegetation of big sagebrush and bunchgrasses. They have developed under an annual precipitation of 7 to 9 inches, most of which falls late in fall, in winter, and early in spring. They have a pale-brown, neutral to mildly alkaline, noncalcareous surface soil and a very friable silt loam or heavy loam subsoil. The subsoil has a slight to moderate accumulation of lime below depths of 2 to 3½ feet.

Renslow soils occur at slightly higher altitudes than the Ritzville, so they receive slightly more precipitation, or about 8 to 11 inches yearly. They have a slightly darker and browner, more granular, surface soil than the Ritzville soils because they developed under a more abundant cover of grass and sagebrush. The Renslow subsoil, slightly more compact and more distinctly subangular blocky than that of the Ritzville, has zones of slight lime accumulation at depths of 4 to 5 feet.

Renslow soils, like the Ritzville, are well suited to irrigation. Only the higher lying areas of either are suitable for dry farming, but the Renslow is normally better for this purpose than the Ritzville.

Soils on bedrock.—In this category are light-colored soils underlain by bedrock—members of the Cowiche, Simcoe, and Tieton series. These soils have grayish-brown to light grayish-brown, neutral, noncalcareous surface soils. Normally, the subsoil is compact, and in most places the lower part of it has a zone in which there is a slight to moderate accumulation of lime. In some places, however, the entire soil above the decomposing bedrock is noncalcareous.

Though they are underlain by bedrock, the upper parts of these soils were derived from or influenced by loess. The lower part of the Cowiche soils, and in some areas even the upper part, was formed from materials that weathered from tuffaceous sandstone, shale, or other sedimentary rocks of the Ellensburg formation. This is the formation that provides the parent material for the Taneum and Roza soils. Cowiche soils, however, are in a climatic zone intermediate between the climatic zones of the Taneum and Roza soils. The effect of climate is apparent in the Cowiche profiles. They contain more lime and less organic matter than the Taneum soils, but in comparison with the Roza soils are somewhat browner and deeper and contain more organic matter. A considerable part of the Cowiche acreage is irrigated; the areas above irrigation ditches are mainly used for grazing or dry-farmed wheat.

The Simcoe soil was derived mainly from basalt bedrock. The lower parts of its profile have developed from weathered basalt, and in places the entire profile was derived from that material. Included, however, are some areas on lower slopes and alluvial fans where the parent material of the Simcoe soil first weathered from fragments of basalt and was later washed down and deposited by swiftly moving waters. Only a small part of the Simcoe soil is irrigated; most of it is used for grazing or for dry-farmed wheat.

Tieton soils overlie andesite bedrock. The lower part of these soils is partly derived from materials weathered from this rock. Their upper part has formed predominantly from loess. Tieton loamy fine sand, however, has been considerably influenced by sandy materials reworked by wind. Most of the acreage of Tieton soils is irrigated and used for orchard fruits.

LIGHT-COLORED SOILS ON CEMENTED GRAVEL OF THE TERRACES

This subgroup contains only the Harwood soils, which occur on high dissected terraces and receive an annual precipitation of 7 to 10 inches. In most areas the upper part of the Harwood soils apparently was derived from loess, but possibly this has been mixed with old water-laid materials in some places. The lower part consists of older material—nearly impermeable layers of gravel, cobblestones, and sand that have been cemented by siliceous materials and frequently contain some lime.

The surface soil is typically grayish brown to light brownish gray, neutral, and noncalcareous. The subsoil above the cemented gravel is moderately permeable and slightly calcareous in many places. The nearly impermeable gravel is at depths of 1½ to 4 feet.

Harwood soils differ from the Burke soils principally in containing much less lime. In some areas they grade into the Cowiche soils. Most of the Harwood acreage is irrigated and used for orchard fruits and field crops. Some areas lie high enough for dry farming.

SOILS OF THE ARID UPLANDS AND TERRACES

In this group are light-colored soils of the uplands and moderate to high terraces. They occupy a large area in the eastern part of the county. The annual precipitation is 6 to 8 inches. The arid climate permitted only a sparse growth of big sagebrush and grass, so little organic matter accumulated in the soils. Drainage was good during the development of these soils. They have been placed in five subgroups according to the nature of their parent material or underlying bedrock.

SOILS ON BEDROCK OF THE UPLANDS

This subgroup is made up of Roza soils, which have developed mainly from light-colored, noncalcareous, acidic volcanic rocks. They occur on tuffaceous sandstones, volcanic ash, or conglomerate of the Ellensburg and associated sedimentary formations. Though their parent material weathered mainly from the underlying bedrock, the upper parts of the soils are in many areas derived from a mantle of loess, or have been considerably influenced by loess. The Roza soils vary considerably from place to place. They occupy only a small acreage within areas under irrigation and are of minor agricultural importance.

The surface layer of the Roza soils is typically light brownish gray to light gray, neutral to mildly alkaline, and noncalcareous. The subsoil is very compact, prismatic, dense, fine textured, and slowly to very slowly permeable. Lime occurs in the lower subsoil and in the upper part of the underlying decaying bedrock, which normally lies 1½ to 3 feet from the surface. Roza soils are normally lighter colored than the Cowiche, shallower, and lower in organic matter.

SOILS ON LIME OR SILICA HARDPANS OF THE UPLANDS AND TERRACES

This group is made up of Burke and Selah soils. They have a white, hard layer of lime or silica that generaly overlies gravel. Lower parts of the profile are derived mainly from water-laid materials, principally of basaltic origin, but in most places the upper parts have formed from a mantle of loess or have been influenced by loess. The surface soil is pale brown to light brownish gray, neutral to mildly alkaline, generally noncalcareous, and of medium to moderately coarse texture.

In the Burke soils, the subsoil that overlies the hardpan is very friable and of medium to moderately coarse texture. In the Selah soil, the subsoil above the hardpan is dense, compact, prismatic, and fine textured.

Both series generally have some accumulation of lime above the hardpan. In both the hardpan is nearly impermeable to very slowly permeable and 1½ to 4 feet from the surface.

SOILS ON LOOSE GRAVEL OR BEDROCK OF THE TERRACES

This subgroup consists of Ephrata and Prosser soils. Ephrata very fine sandy loam, the only Ephrata soil mapped in the county, occurs on terraces and overlies loose basaltic gravel and sand. Although it was generally derived from old water-laid materials of basaltic origin, the upper part of the Ephrata soil is more or less influenced by a mantle of loess. The Ephrata soil lacks the well-developed hardpan of the Burke soils and is rapidly to very rapidly permeable. It is distinguished from the Naches soils, which also occur over loose gravel on low terraces, by its lack of a finer textured subsoil, and by having a distinct lime coating in the upper part of the underlying gravel.

The Prosser soil occupies low terraces on the floor of the Yakima Valley and overlies a basaltic lava flow. It has developed under an annual precipitation of 6 to 7 inches. It formed under the influence of good drainage and a natural vegetation of sagebrush and grass.

The Prosser soil was derived principally from mixed alluvium, although in places it may have been influenced somewhat by a thin mantle of loess or by material weathered from the underlying basalt. It has a pale-brown, medium to moderately coarse textured surface soil. As a rule, the entire profile is noncalcareous and neutral to mildly alkaline, but in places the lower part is calacreous.

SOILS ON STRATIFIED SILTS AND SANDS OF THE TERRACES

This subgroup is made up of Sagemoor soils, which occur on high or moderately high terraces and have developed under the influence of good drainage. They overlie silty and sandy lake-laid materials. Though they were derived mainly from these underlying, mainly calcareous, lake-laid materials, the upper parts of some of the Sagemoor soils have been influenced by a mantle of loess, or have been derived from loess.

Sagemoor soils have a light brownish-gray to pale-brown surface soil of medium to moderately coarse texture. Some of them have a calcareous surface soil. The Sagemoor subsoil generally has accumulations of lime, and, in places, has layers somewhat more compact and finer in texture. The variations in subsoil texture result from differences in the kind of parent material deposited.

SOILS ON WINDBLOWN SANDS OF THE TERRACES

In this group are Quincy soils and a complex of Quincy, Sagemoor, and Marsh soils. The parent material—excessively drained, windblown sand—was derived mainly from sandy lake-laid deposits similar to those underlying some of the Sagemoor soils. In some areas, however, the parent material was blown from sandy alluvium. The finer particles were picked up by the wind from the lake deposits and alluvium and were carried away. The coarser particles were dropped and form the sandy parent material for the soils of this group. The areas of Quincy soils have a somewhat dunelike topography.

Quincy soils have a light brownish-gray to pale-brown, noncalcareous, sand or loamy fine sand surface soil. The lower layers consist of loose, or nearly loose, single-grained materials not appreciably different from the surface soil in texture or in degree of development. Stratified lakebeds of more compact silty or sandy calcareous materials normally underlie the soils at depths of 1 to 15 feet. In some places the layers overlying this compact material are slightly calcareous. Quincy soils differ from the associated Sagemoor soils in having a coarser texture, more rapid permeability, and a lower water-holding capacity.

SOILS OF THE BOTTOM LANDS, ALLUVIAL FANS, AND LOW TERRACES

This group consists of many soils of widely different characteristics. They occupy bottom lands of streams, shallow lake basins, or very low terraces on the valley floors or alluvial fans. Some of the fans extend for a considerable distance back into the hills. All the soils, however, have this in common: They were derived from materials deposited by water.

This group of widely different soils has been divided into several subgroups on the basis of natural drainage, degree of subsoil development or texture of the subsoil, nature of the underlying materials, and occurrence of alkali.

SOMEWHAT EXCESSIVELY DRAINED SOILS ON LOOSE GRAVEL OF THE BOTTOM LANDS

In this group are soils of the Beverly and Yakima series. They are somewhat excessively drained, are medium to coarse textured, and overlie loose gravel. Typically, they are noncalcareous, not affected by alkali, and moderately deep.

Beverly soils occur in the southeastern part of the valley along the Yakima River and receive a yearly rainfall of 5½ to 7 inches. They have a light brownish-gray, pale-brown, or light grayish-brown, medium-textured surface soil.

Yakima soils have developed under an annual precipitation of 6 to 16 inches. They have a grayish-brown to brown surface soil of medium to coarse texture.

Soils of both the Beverly and Yakima series have a natural cover consisting mainly of sagebrush and grass. Cottonwoods, willows, and shrubs grow along the streams.

WELL-DRAINED SOILS ON MEDIUM-TEXTURED OR SANDY ALLUVIUM OF THE BOTTOM LANDS

This subgroup consists of soils on loamy or sandy alluvium—members of the Cleman, Esquatzel, and Onyx series. They have good drainage and occupy bottom lands or alluvial fans.

These soils are developing from material that has been transported by water and deposited as alluvium in comparatively recent times. They are young soils that show only faint development of layers because soil-forming processes have acted on the alluvial sediments only a short time. In some places very slight compaction has formed in the subsoil, the iron compounds have oxidized somewhat, and some organic matter has accumulated in the surface soil.

The soils have become well populated by soil organisms, but no development of layers that differ from one another in texture or structure has taken place. Where differences in texture or structure do occur, they are the results of differences in the material that was laid down by water. The soils have undergone little leaching or loss of fertility. They are, in general, the most adaptable and productive soils of the Yakima Valley.

The parent materials for soils of this subgroup come from a large number of intermittent drainageways or dry coulees that cut across the upland slopes. These coulees enter the Valley from all sides. They vary a great deal in length, but many extend 10 to 20 miles from the Valley to their source. Some have channels that continue to the main streams; others empty out upon the terraces, lower slopes, or valley floor. Floodwaters rush down these coulees during heavy rains and deposit much soil material when they reach the Valley. The material is deposited as alluvial fans, some covering only a few acres and others several hundred. The larger creeks, and in one locality a channel of the Yakima River, have built up natural levees of very gently sloping recent alluvial sediments.

The alluvial deposits are irregularly and widely scattered throughout the Valley. The mineral composition and texture of the sediments and the resulting soils depend upon the source of the materials and on differences in the way they were deposited and stratified.

The Cleman soils are developing under an annual precipitation of 7 to 9 inches. Their parent material is alluvium derived principally from gray tuffaceous sandstone, light-colored shale, volcanic ash, or conglomerate of the Ellensburg formation and soils formed thereon. They have grayish-brown surface soil, the texture of which ranges from coarse sandy loam to clay loam. In most places Cleman soils are noncalcareous.

The Esquatzel soils occupy the largest area in this subgroup. They receive an annual precipitation of 6 to 9 inches. They are developing in medium to moderately coarse textured alluvium. This alluvium principally comes from loess but to considerable extent from materials washed from basaltic, water-laid, or lake-laid materials or from soils formed on these materials. To a large extent, the alluvium has washed from the drier uplands and benches. In some of the higher lying areas, the upper part of the soils may be derived from loess or is to some extent influenced by a thin mantle of loess.

The parent materials for Esquatzel soils resemble those of the Ahtanum, Kittitas, and Umapine soils, but Esquatzel soils are forming under the influence of better drainage and are generally less alkaline. They also lack the hardpan of the Ahtanum soils, are lighter colored than the Kittitas soil, and are less calcareous than the Umapine soil.

Esquatzel soils have light brownish-gray to pale-brown, generally noncalcareous, neutral to mildly alkaline surface soil. In most places their subsoil is calcareous and it often has a few lime veins.

Onyx soil occurs under higher precipitation (about 9 to 14 inches yearly) than the Esquatzel soils. It is generally noncalcareous and is slightly darker. The soil is forming in alluvium derived chiefly from basalt and loess, or from soils developed on these materials. Much of the material has been washed from areas where the precipitation is higher. The Onyx surface soil is grayish brown.

WELL-DRAINED SOILS WITH MODERATELY FINE TEXTURED SUBSOILS ON LOOSE GRAVEL OF THE LOW TERRACES

Naches soils, the only soils in this subgroup, occur on low terraces and have gravel at depths of 1½ to 3 feet. They have a brown to grayish-brown surface soil of moderately fine to moderately coarse texture. Their subsoil is brown to yellowish brown, noncalcareous, gritty or gravelly clay loam or heavy loam. In places the underlying gravel is slightly lime coated. The soils have formed principally from old water-laid alluvium that is mainly of basaltic origin. The upper parts, however, have been influenced by a thin mantle of loess. The annual rainfall is 5½ to 8 inches. The natural vegetation was sagebrush and grass.

IMPERFECTLY AND POORLY DRAINED SOILS WITH DENSE CLAY LAYERS OR HARDPANS OF THE BOTTOM LANDS AND LOW TERRACES

These older alkali soils—the Ahtanum, Fiander, Giffin, Scowlale, Wahtum, and White Swan—occupy low terraces or occur in basins. Their profile characteristics have resulted from a long and complex cycle of development under the influence of alkali. At some time in the past, they were subjected to high ground water tables. As a result excess soluble salts, including sodium carbonate or black alkali, accumulated in them. Their drainage improved as natural streams became entrenched, and dense clayey subsoil horizons, either continuous or scattered, developed in them.

Soils of this subgroup receive 6 to 7 inches of precipitation yearly, or slightly more for the White Swan soil. The vegetation for all the soils except the White Swan is sagebrush and saltgrass. For the White Swan, the vegetation is sagebrush and greasewood. All the soils of this subgroup have very low agricultural value.

Ahtanum soils are characterized by a light-colored surface soil and cemented strongly alkaline hardpan. The hardpan in these soils is not continuous; it occurs sporadically.

The Ahtanum soils were formed from parent materials similar to those of the Esquatzel, Kittitas, and Umapine soils. The Ahtanum soils are distinguished from these soils, however, by the sporadic occurrence of the hardpan. The Ahtanum soils are lighter colored than the Kittitas soil, more alkaline, and more affected by alkali. They are more poorly drained than the Esquatzel soils and are generally salty.

Fiander fine sandy loam, the only soil of the Fiander series mapped in Yakima County, has formed from old alluvial materials that resemble those for Naches soils. The underlying loose gravel, however, normally occurs at greater depths than in the Naches soils. The Fiander soil resembles the slick spots in the Naches soils.

The Fiander surface soil is light colored, generally noncalcareous, and mildly to very strongly alkaline. The upper subsoil is pale brown to brown, generally noncalcareous, very strongly alkaline, and very slowly permeable to water. The lower subsoil is calcareous. The Fiander soil differs from the Ahtanum, Giffin, and Umapine soils in having a comparatively dense clay loam, sandy clay loam, or silty clay loam upper subsoil of columnar or prismatic structure.

The light-colored Giffin soils are the youngest of the soils in this subgroup. In most places the whole upper part of these soils turns into a deflocculated and plastic mass when wet, although a definite somewhat clayey horizon occurs here and there. These soils have formed from mixed alluvium that is generally medium in texture. They commonly occupy slightly higher areas than the associated Beverly soils.

Scowlale loam is the only soil of the Scowlale series mapped in Yakima County. It is distinguished from the other soils of this subgroup by its dark-gray surface layer. It is distinguished from the associated dark-colored Toppenish soils by the dense blocky or somewhat prismatic structure of its clayey upper subsoil, which is slowly to very slowly permeable to water. Generally, the surface soil is noncalcareous and moderately to mildly alkaline. The subsoil is calcareous and strongly alkaline. The Scowlale soil was derived from old mixed alluvium. It occupies low terraces.

The Wahtum soils, like the Ahtanum soils, are characterized by a light-colored surface soil and cemented strongly alkaline hardpan that is not continuous. They differ principally from the Ahtanum soils in occupying slightly higher positions and in being better drained.

The Wahtum soils occur on nearly level to very gently sloping low terraces, second bottoms, or remnants of old alluvial fans. They have developed under an annual precipitation of 6 to 10 inches. In most places, the surface soil is noncalcareous and nonsaline or only slightly saline, and the subsoil above the hardpan consists of clay loam or heavy loam of subangular blocky structure. These soils are poorly to very poorly suited to irrigated crops. Their natural vegetation consists mainly of saltgrass and greasewood.

White Swan loam is the only soil of the White Swan series mapped in Yakima County. It is the oldest and the highest lying soil of this subgroup. It is characterized by a light-colored, neutral, noncalcareous, very friable, thin surface soil; a dense, prismatic, noncalcareous, clay upper subsoil; and a calcareous, strongly to very strongly alkaline lower subsoil in which there is a calcareous hardpan in most places. The parent material generally resembles that of the Sagemoor soils. It consists of a thin mantle of loess over lake-laid silty and sandy strata.

IMPERFECTLY AND POORLY DRAINED SOILS WITH MEDIUM-TEXTURED SUBSOILS OF THE BOTTOM LANDS AND LOW TERRACES

The soils of this subgroup belong to the Kittitas and Umapine series. They are characterized by medium-textured subsoils. They have formed from medium-textured alluvium derived mainly from loessial and basaltic materials. They have the same kind of parent materials as the Ahtanum and Esquatzel soils but they lack the hardpan of the Ahtanum, and are more affected by alkali and more calcareous in the upper parts than the Esquatzel.

Kittitas silt loam, the only soil of that series mapped in the county, has a dark surface soil. Its natural vegetation is grass, sagebrush, and herbaceous plants.

Umapine loam, the only soil of the Umapine series mapped in the county, has a light brownish-gray to light-gray surface soil, is more saline and calcareous than the Kittitas soil, and has a natural cover of saltgrass, greasewood, and rabbitbrush.

POORLY DRAINED SOILS WITH FINE-TEXTURED SUBSOILS ON GRAVEL OF THE BOTTOM LANDS

This group consists of Toppenish and Wenas soils, which have formed on bottom lands under the influence of poor drainage and an abundant cover of grass and herbaceous plants. In most places enough organic matter has accumulated to give the surface soils a dark-gray color.

The Toppenish soils have formed in drier regions where the annual precipitation is 6 to 8 inches. They are calcareous and in places are affected by excess soluble salts.

The Wenas soils have formed in the upper parts of the valleys under approximately 8 to 16 inches of precipitation yearly. They are normally noncalcareous and free of alkali.

Soils of both these series have fine-textured subsoil, mainly because of the kind of parent material deposited.

MISCELLANEOUS LAND TYPES

Marsh, Riverwash, Rough mountainous land, Scabland and Smooth stony land, Steep broken and stony land, and Stony and shallow soils are the miscellaneous land types mapped in Yakima County. They consist of loose coarse material in stream channels, dune sand, or steep rocky mountainsides, all of which have little or no true soil.

SOIL TYPES AND PHASES

In the following pages, the soil types and phases of Yakima County are described in detail and their use for agriculture is discussed. The acreage and proportionate extent of each soil are given in table 2. The location and distribution of all of the soils are shown on the soil map that accompanies this report.

TABLE 2.—*Approximate acreage and proportionate extent of the soils mapped in Yakima County, Wash.*

Soil	Acres	Percent
Ahtanum fine sandy loam	2, 814	0. 2
Ahtanum loam	14, 567	1. 2
Ahtanum silt loam	2, 124	. 8
Beverly loam	5, 542	. 5
Beverly silt loam	1, 043	. 1
Bickleton silt loam	4, 254	. 4
Burke fine sandy loam	3, 200	. 3
Burke loam	51, 956	4. 4
Cleman clay loam	1, 230	. 1
Cleman coarse sandy loam	412	(1)
Cleman loam	512	(1)
Cleman sandy loam	3, 117	. 2
Cowiche fine sandy loam	2, 489	. 2
Cowiche loam	4, 614	. 4
Rolling	1, 272	. 1
Ephrata very fine sandy loam	4, 075	. 3
Esquatzel fine sandy loam	10, 624	. 9
Esquatzel silt loam	39, 317	3. 4
Esquatzel very fine sandy loam	6, 073	. 5
Fiander fine sandy loam	1, 962	. 2

See footnote at end of table.

TABLE 2.—*Approximate acreage and proportionate extent of the soils mapped in Yakima County, Wash.*—Continued

Soil	Acres	Percent
Giffin loam	2, 286	. 2
Giffin silt loam	1, 937	. 2
Harwood loam	9, 871	. 8
Sloping	4, 150	. 4
Kittitas silt loam	5, 314	. 4
Marsh	5, 274	. 4
Naches loam	6, 053	. 5
Naches sandy loam	114	(1)
Naches soils	49, 714	4. 3
Onyx loam	9, 636	. 8
Prosser fine sandy loam	874	. 1
Quincy loamy fine sand	12, 666	1. 1
Quincy sand	7, 949	. 7
Quincy-Sagemoor-Marsh complex	694	. 1
Renslow silt loam	23, 116	2. 0
Ritzville and Renslow silt loams	47, 920	4. 1
Ritzville silt loam	74, 173	6. 4
Strongly sloping	5, 164	. 4
Riverwash	15, 136	1. 3
Roza clay loam	724	. 1
Roza gravelly loam	3, 475	. 3
Roza gritty loam	2, 270	. 2
Roza sandy loam	2, 981	. 3
Rough mountainous land	21, 368	1. 8
Sagemoor fine sandy loam	27, 131	2. 3
Sagemoor loam:		
Compact subsoil	62, 682	5. 4
Saline	3, 614	. 3
Sagemoor very fine sandy loam	27, 179	2. 3
Sloping	10, 106	. 9
Scabland and Smooth stony land	83, 254	7. 2
Scowlale loam	1, 690	. 1
Selah loam	3, 848	. 3
Simcoe clay loam	5, 481	. 5
Steep broken and stony land	297, 938	25. 6
Stony and shallow soils	64, 681	5. 5
Taneum loam	4, 031	. 3
Rolling	545	(1)
Tieton loam	7, 403	. 6
Tieton loamy fine sand	227	(1)
Toppenish clay	705	. 1
Toppenish clay loam	6, 094	. 5
Toppenish loam	9, 719	. 8
Umapine loam	11, 258	. 9
Wahtum fine sandy loam	880	. 1
Wahtum loam	9, 075	. 8
Wenas gravelly loam	990	. 1
Wenas loam	11, 738	1. 0
White Swan loam	3, 949	. 3
Yakima loam	16, 465	1. 4
Yakima sandy loam	5, 844	. 5
Yakima very gravelly sandy loam	6, 034	. 5
Water area	6, 916	. 6
Total	1, 163, 533	100. 0

[1] Less than 0.1 percent.

Ahtanum loam (0 to 1 percent slopes) (Ab).—This soil is strongly to moderately affected by soluble salts and alkali and has a strongly alkaline lime hardpan in its subsoil. It formed from medium to moderately coarse textured mixed alluvium, which was derived principally from loess but to some extent from basalt and soils formed on basalt.

Ahtanum loam occurs on low level areas on stream bottoms, in basins, on valley floors, and on low terraces. In these areas a high water table persisted for long periods, during which conditions favored accumulation of lime, soluble salts, and alkali. This is the most extensive soil on the bottom lands. The larger areas occur in the lower Ahtanum and Moxee valleys, in the central and southern parts of the Reservation valley, and in the Satus district. Most of this soil is in the Yakima-Esquatzel-Ahtanum soil association (fig. 2).

The parent material of Ahtanum loam is similar to that of the Umapine, Kittitas, and Esquatzel soils. Ahtanum loam, however, differs from the related Umapine loam in having a calcareous hardpan, although the pan is not continuous (pl. 1). Ahtanum loam is lighter in color than Kittitas silt loam, is more affected by salts and alkali, and has a hardpan that is more developed. It is distinguished from the Esquatzel soils by having poor drainage, by being more affected by alkali, and by having the hardpan, which does not occur in the Esquatzel soils.

The typical vegetation consists of saltgrass, greasewood, and other plants tolerant of alkali.

Profile description:

1. Pale-brown[4] to light brownish-gray loam that has a thin platy structure and breaks easily into a mass of very fine granules or single grains; dark grayish brown and very friable when moist; approximately 2 to 3 inches thick; in many places, when dry, soil is somewhat vesicular, has a slight salt crust at the surface and, under the crust, nearly loose material of very fine crumb structure.
2. Loam or silt loam similar to layer above in color; thick platy; generally not vesicular; 5 to 10 inches thick.
3. Soft or slightly hard loam or silt loam somewhat lighter and browner in color than layers above; somewhat massive or breaks into weak blocks that crush easily into weak granules and single grains; 7 to 30 inches thick.
4. Light brownish-gray to grayish-brown, strongly calcareous, weakly to strongly cemented water-table hardpan that contains veins of segregated white lime and a few small pores and fine channels; dark grayish brown to very dark grayish brown when moist; hardpan can generally be broken with the hands but in places it is too hard; where hardpan is well developed, its top is commonly coated by a film or very thin layer of very dense strongly cemented white limy material; in places a few roots penetrate; 2 to 12 inches thick.
5. Light brownish-gray, pale-brown, or light-gray soft or slightly hard loam or silt loam; very friable to friable when moist; in places contains hard or slightly hard lenses or thin layers of softly or weakly cemented material; 10 to 25 inches thick.
6. Material similar to layer above but generally somewhat mottled with yellowish-brown and very dark brown iron stains or other stains; very friable or friable when moist.

As a rule the alluvial parent material is deep. Occasionally, gravel beds occur at depths of 3 to 6 feet, but in most places medium to

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[4] Names of soil colors used in this report are those adopted by the Division of Soil Survey in 1948. The color is that of dry soil unless stated otherwise.

moderately coarse textured materials extend downward to undetermined depths. Occasionally, a layer of white volcanic ash occurs in the subsoil or substratum. In some areas in the Reservation valley, the surface soil overlies strata of silt and sands deposited by lakes; in other places, it overlies clay or clay loams.

The upper 5 layers of this soil are generally moderately to strongly calcareous and strongly to very strongly alkaline. Below 50 to 60 inches, the soil is noncalcareous or only slightly calcareous and mildly alkaline. Alkali and soluble salts are common in the hardpan and in the layers above. In some areas that have been reclaimed to varying degree, the content of alkali and soluble salts is considerably less.

The differentiation between profile layers in Ahtanum loam is variable and uneven, as is true of most older saline and alkali soils. The hardpan, or cemented horizon, occurs at depths that range from 1½ to 4 feet (pl. 1). This hardpan apparently indicates the level of the water table during the formation of the pan. In several places where there are two or more hardpan layers, there appear to have been sudden changes in a fluctuating former water table. In other places a sequence of thin bands of hardpan cementation that occurs throughout a 2- to 3-foot thickness of subsoil indicates a slower change in the water level.

The hardpan varies in thickness and hardness within short distances. In one place it may be a foot thick and stonelike, but a few yards away it may be only 2 or 3 inches thick and have soft fragmental cementation. In many places, sometimes within only a short distance of a well-developed hardpan, the pan is absent or consists of a few small lumps or thin plates.

The organic-matter content of Ahtanum loam is low. Surface runoff is very slow; internal drainage is medium to very slow, depending on the depth to the water table and the permeability of the hardpan, or cemented layer. Some areas are subject to seepage from irrigated areas. Many areas have a high water table.

Use and management.—The greater part of Ahtanum loam is in unimproved pasture that consists of saltgrass and greasewood. Most of the soil can be irrigated under existing systems, though some tracts do not have adequate water rights.

The results of a number of efforts that have been made to reclaim this soil indicate that it may have considerable potential value as cropland or as improved irrigated pasture. The chief factors that retard its reclamation are the very slow permeability of the hardpan, the alkalinity of the soil, insufficient water for irrigation, lack of adequate drainage by means of deep open ditches, and the cost and time involved to bring the reclaimed land into profitable production of cash crops. To reclaim this soil, it would be necessary to leach the soluble salts from the root zone by using liberal irrigation and to counteract the alkali by using amendments such as gypsum or sulfur.

This soil is like Umapine loam in being infertile for most crops when first put into cultivation. Several years of soil improvement are needed to make it normally productive.

This soil may be observed under cultivation along the Harrah Drain at the road leading to Fort Simcoe 14¼ miles west of Toppenish; in a field 1 mile north of White Swan; in fields along the road south of Satus; and in several fields in the lower Ahtanum district. A number of common crops are grown, including hops, alfalfa, and sugar beets. Both plant growth and yields are exceedingly variable. They depend upon the original character of and depth to the hardpan, on drainage, and on soil-improvement practices that have been followed. For many years a few bare spots or areas of uneven and stunted growth persist in most fields made up of this soil.

The hardpan is one of the most important factors in reclaiming and subsequently using this soil, for the hardpan limits internal drainage and the leaching of the salts. As a rule, however, the hardpan is not impermeable over any large area. Where the pan lies within 18 inches of the surface either by natural occurrence or as the result of leveling, bare patches occur. Where the pan occurs even at depths of 20 to 24 inches, growth is retarded for such deep-rooted plants as hops and sugar beets, although alfalfa, grasses, and clovers may not be affected. These bare spots persist; it is not yet known if the hardpan, even after leaching away the alkali, can ever be changed so that it will be favorable for root growth.

Slick spots of deflocculated surface soil develop in some areas when the land is irrigated. These occur most conspicuously in the virgin soil in areas along the Mud Lake Drain, 12 miles west of Toppenish. The reclamation of saline-alkali soils is discussed more fully in the section, Soluble Salts and Alkali.

Ahtanum fine sandy loam (0 to 1 percent slopes) (Aa).—Except for its somewhat coarser texture, this soil resembles Ahtanum loam in most respects. Most of it is in the Yakima-Esquatzel-Ahtanum soil association (fig. 2).

The soil is generally deep—rarely less than 4 feet—and as a rule it overlies gravel. In some areas in the Reservation valley, however, it overlies glacial lakebeds of silts and sands. In places the lower subsoil grades into or overlies clay loam or clay. Other variations in this soil are slight differences in texture of the surface soil and subsoil and in depth to the hardpan and in its thickness. The hardpan occurs as much as 4 feet below the surface; in many places it consists of only a few small lumps or thin softly cemented plates or lenses. A fluctuating water table occurs in some areas at depths of 3 to 10 feet. A layer of white volcanic ash is in the subsoil or substratum in some places. The content of soluble salts varies, but generally the soil is moderately to strongly affected by alkali.

Use and management.—Only small tracts of this soil have been reclaimed; the greater part is in unimproved saltgrass pasture. The suitability of the soil for crops and the management needed for successful reclamation are similar to those for Ahtanum loam. The coarser texture, however, gives slightly more rapid internal drainage, and the soil is somewhat easier to reclaim than Ahtanum loam.

Ahtanum silt loam (0 to 1 percent slopes) (Ac).—This is the least extensive soil in the Ahtanum series. Its finer texture distinguishes it from Ahtanum loam and Ahtanum fine sandy loam. Most of this soil is associated with areas of these other Ahtanum soils and with Esquatzel and Kittitas soils.

Ahtanum silt loam is generally calcareous throughout the entire profile and strongly to very strongly alkaline. In some areas, however, the lower part may be noncalcareous or only mildly calcareous and mildly alkaline. Also in areas that have been reclaimed to some extent, the upper part of the soil may be less alkaline. In some areas the soil below the hardpan is somewhat mottled with yellowish brown or very dark brown iron stains or other stains.

Depth to the hardpan, its thickness, and its degree of development vary greatly even within short distances. In many spots the hardpan is only slightly developed or is entirely absent.

In some areas the substratum consists of clay loam, clay, or other fine-textured material that impedes internal drainage greatly. Nevertheless, since the soil generally overlies silts, sandy loams, sands, or, in places, gravel beds, underdrainage is slow, but usually adequate if the soil is protected by intercepting drains. A layer of white, light-gray, or very pale brown volcanic ash occurs in the subsoil or substratum in some areas.

Use and management.—The use of this soil and the feasibility of reclaiming it depend to a great extent upon its location, drainage, and substratum. In general it is used in much the same way as Ahtanum loam.

Approximately a hundred acres on bottom land along Wenas Creek, and two areas of about 650 and 250 acres, respectively, in the vicinity of Moxee occur as low strongly saline areas that receive seepage from higher lands. Deep intercepting drains and considerable time and expense are needed to reclaim such areas (pl. 3*A*). Another body of about 700 acres, 12 miles west of Toppenish, is underlain by gravel at depths of 4 to 8 feet. Here, drainage into the Mud Lake Drain has allowed successful reclamation of the greater part. Crops are grown satisfactorily on this area except on the slick spots that may persist for many years.

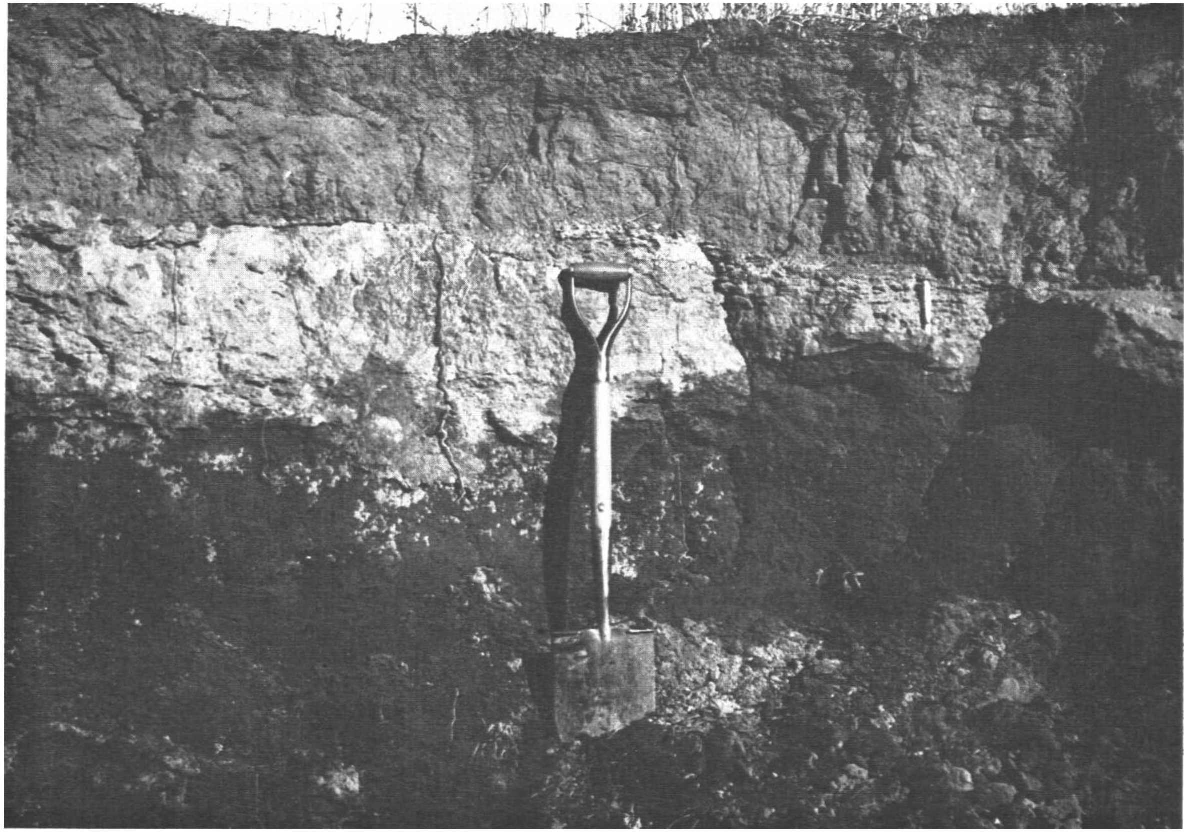
The texture of the surface soil and subsoil handicaps reclamation. The fine material becomes dispersed and puddled under irrigation. In many areas the hardpan lies at such depth that it does not much affect the value of the soil.

Beverly loam (0 to 2 percent slopes) (Ba).—This light-colored soil has formed from stratified medium-textured and coarse-textured alluvium that was derived from mixed materials that were recently or very recently deposited.

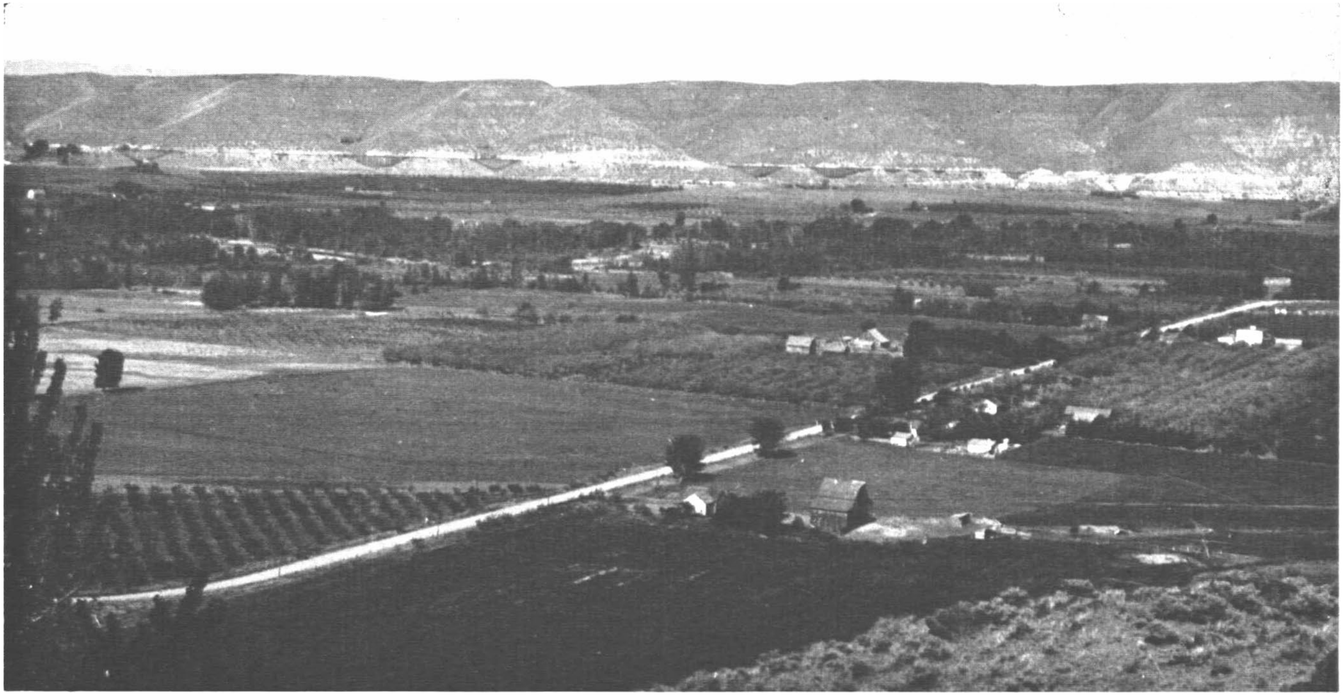
This soil generally occurs in the southeastern part of the Yakima-Esquatzel-Ahtanum soil association. Some small areas, however, occur on the first bottoms of the Yakima River near Union Gap in the upper Yakima Valley and have been mapped with Yakima loam.

Beverly loam is similar to the Beverly soil in the adjoining Benton County. As a rule, however, its depth to loose gravel is greater and it is more suitable for agriculture than the Benton County soil. Beverly loam is grayer and lighter in color than the Yakima soils.

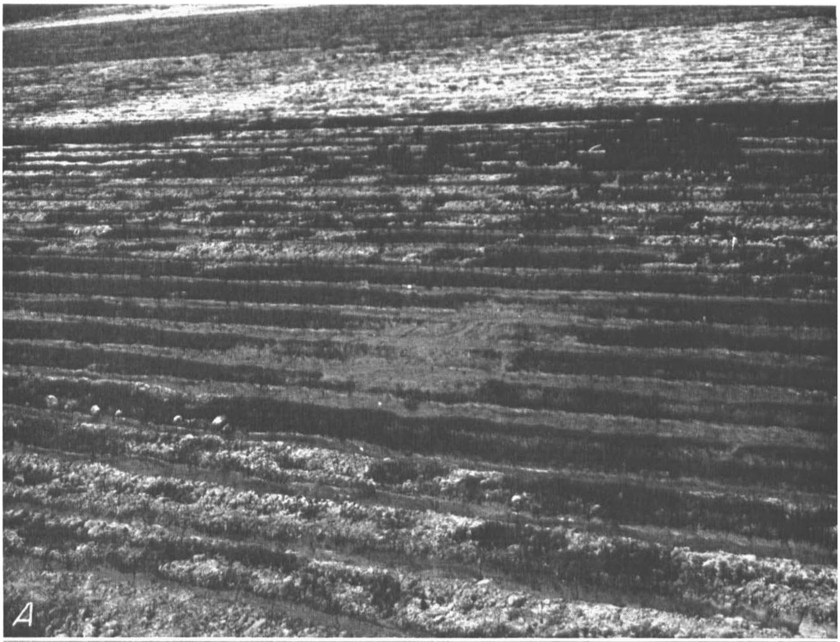
The relief is nearly level or slopes very gently with the gradient of the riverbed; the continuity of the land, however, is interrupted by abandoned or overflow channels of the river, low escarpments, or gravel bars. Most areas are occasionally overflowed. The water table is high in some areas, and as a rule subirrigation is variable. The natural vegetation on the lower lying areas that receive some subirrigation consisted of deciduous brush and cottonwoods and willows. Other somewhat higher, naturally open, areas have a cover of sagebrush and grass.



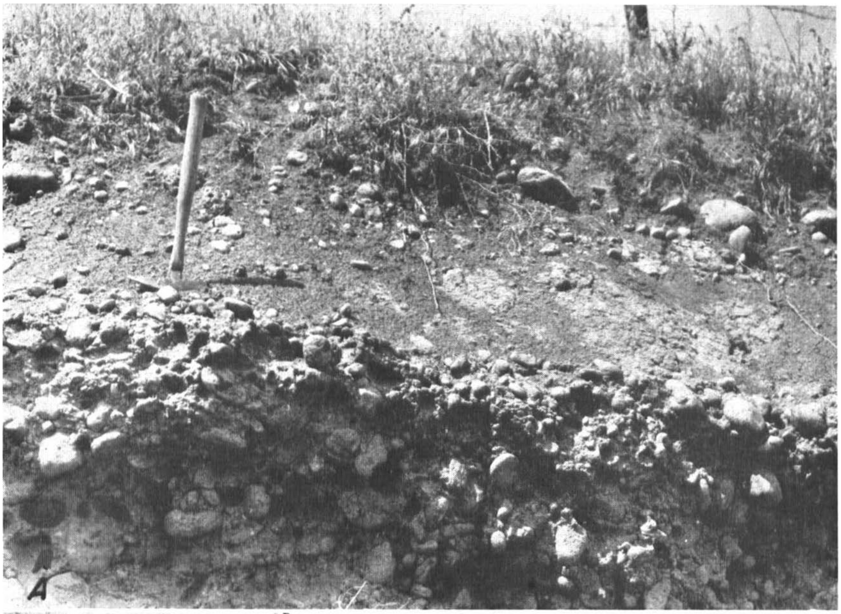
Exposure of Ahtanum loam showing pronounced and uneven development of hardpan.

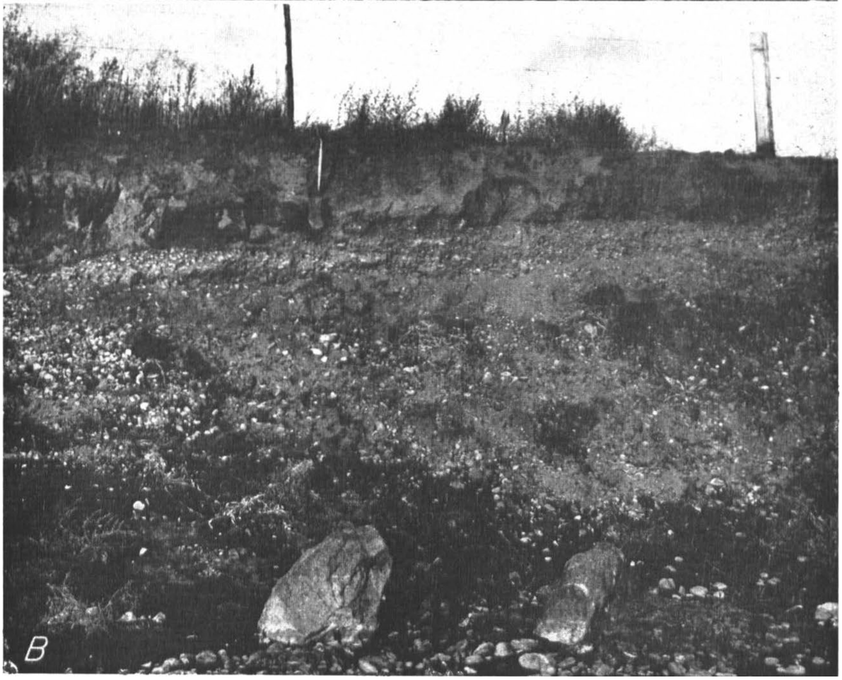


Naches Valley, southeast of Naches, traversed by Naches River: Naches soils on terrace bordering road in foreground, and Cleman soils on alluvial fans across the valley next to uplands.



A, Water standing on Ahtanum silt loam, a poorly drained soil difficult to leach of excess soluble salts.
B, Sugar beets, seriously affected by excess soluble salts, on Esquatzel silt loam east of Sunnyside. Alkaliweed in background.





A, Cut of Harwood loam, sloping, showing thin fine-textured layer over cemented gravel.
B, Exposure of Naches soils at edge of gravel pit; finer materials above loose gravel range from 1½ to 4 feet in thickness; alkaliweeds indicate soil contains excess soluble salts.

Profile description:

1. Light brownish-gray to pale-brown soft loam of weak fine granular structure; typically noncalcareous but mildly calcareous in places; contains a moderate number of fine pores; dark grayish brown and very friable when moist; 8 to 13 inches thick.
2. Light brownish-gray to pale-brown soft to slightly hard massive loam, silt loam, or fine sandy loam; somewhat mottled with yellowish brown or yellow, especially around root and other channels; contains a few to many fine pores; mildly calcareous in some places and generally stratified, or contains pockets and lenses of sand or sandy loam; 20 to 100 inches or more thick.
3. Noncalcareous, loose, well-rounded stream-laid gravel derived from many kinds of rocks.

Depth to gravel ranges from about 2½ to 15 feet. The soil is generally mildly alkaline throughout. Its content of organic matter is fairly low. Although the soil above the gravel is moderately permeable, the gravel is very rapidly permeable. The water-holding capacity of this soil ranges from low to moderate, depending mainly on the texture of the subsoil and the depth to gravel. Excess soluble salts are rarely present in injurious quantities.

Use and management.—Much of this soil is woodland or is covered by sagebrush, but some tracts have been cleared. Considerable areas of open and cleared land were once farmed without irrigation. The annual spring rise of the river subirrigated or flooded the land, and moderate yields of wild hay, alfalfa, grain, or corn, could be obtained. Most people living along the river no longer plant crops because they fear floods such as the one of 1933, which inundated all the first bottoms.

Since mountain reservoirs were built and the flow of the river has been controlled artificially, much of the land has been dry and has reverted largely to unimproved pasture. Only a small part is irrigated from ditches. Generally, since there are no water rights, irrigation water would have to be pumped from the river.

This soil is fertile and productive when properly irrigated and managed. Most of it, however, has unfavorable relief for irrigation. Irrigation could be extended to some areas so that they could be used for alfalfa or other crops. Where the soil is not irrigated, it provides good natural pasture.

Beverly silt loam (0 to 2 percent slopes) (Bb).—This soil is associated with Beverly loam. It occurs on low level areas or on long narrow shallow depressions; these areas are abandoned river channels that are nearly filled. The texture is rather variable, as is the depth to loose gravel. The soil is commonly stratified, and it shows very little or no difference in profile layers. Beverly silt loam differs mainly from Beverly loam in having a finer texture and a grayer and less brown color. It occupies lower positions than Beverly loam and is not so well drained. Beverly silt loam is not an extensive soil.

Most areas of this soil are subirrigated to some extent by a moderate to somewhat high fluctuating water table. Surface runoff is very slow, and the soil is occasionally overflowed. The content of organic matter is fairly low. The soil is generally mildly alkaline but is not materially affected by soluble salts or alkali. The material above the gravel is moderately permeable, and the gravel is very rapidly permeable.

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The water-holding capacity varies with the texture of the soil above the gravel and the depth to the gravel.

Use and management.—This soil is valuable as natural pasture. The wooded areas have cottonwoods that furnish wood for fuel, posts, and some logs for building. Most of the soil is subirrigated. Several of the larger areas, comprising about 200 acres on the bottoms 2 miles east of Satus, are subirrigated by means of dams in slough channels, and these areas provide good pasture. Small areas that are farmed produce good yields of oats and wheat without irrigation, provided the subirrigation is adequate. Irrigation would make some areas suitable for row crops and alfalfa.

Bickleton silt loam (2 to 6 percent slopes) (Bc).—This dark, well-drained soil occurs at altitudes of 2,800 to 3,100 feet. It occupies slightly dissected undulating to somewhat rolling upland plains or rather high plateaus near the county line in the southern part of the county. It is the most extensive soil of the Bickleton-Steep broken and stony land soil association (fig. 2) in the vicinity of upper Glade Creek, west of Bluelight.

This soil has developed under the influence of a fairly cool climate that provides a rather short growing season. The climate is controlled by winds rising from the gorge along the Columbia River, which reach their highest velocity in this area. The average annual precipitation is 10 to 12 inches, much of which falls as snow. The air is humid or subhumid until late in spring.

Bickleton silt loam has developed over a thin deposit of loess that overlies basalt bedrock. Most of the lower part of the soil was derived from, or was notably influenced by, material weathered from basalt. In some places a thin capping of quartzite-gravel conglomerate lies over the basalt and below the loess.

This soil is darker than the Renslow and Ritzville soils. It is related to the Gem soils mapped elsewhere in the semiarid areas of the Northwest, but it is more influenced by loess. The natural vegetation consisted of grass and some large sagebrush.

Profile description:

1. Dark grayish-brown, slightly hard, neutral silt loam of fine granular structure; very dark brown and very friable when moist; under grass sod, structure is disguised by many grass roots but in other places the top 2 to 3 inches is thin platy; 6 to 10 inches thick.
2. Material similar to layer above but slightly lighter in color and usually slightly more compact and finer in texture; neutral reaction; coarse granular structure; 5 to 8 inches thick.
3. Brown, noncalcareous, hard or slightly hard, neutral, slightly compact silty clay loam or fine-textured silt loam; breaks into subangular blocky aggregates ¼ to ½ inch across that contain a moderate number of fine pores and channels; very dark grayish brown and firm to friable when moist; in places contains a few small fragments of somewhat decayed basalt; 10 to 20 inches thick.
4. Pale-brown, light yellowish-brown, or brown, slightly or moderately compact silty clay loam or heavy silt loam; breaks into hard or slightly hard, rounded or subangular blocky aggregates ¼ to ½ inch across; moderate to few fine pores and channels; large to small amounts of segregated white lime occur as veins and splotches in cracks and fissures; dark brown and firm to friable when moist; in most places contains a few small fragments of basalt that is more or less decayed; 6 to 20 inches thick.
5. Basalt bedrock, or basalt fragments and some fine interstitial material

The surface soil of Bickleton silt loam has a moderate content of organic matter. The soil is moderately permeable, and its water-holding capacity is moderate to high, depending on depth to bedrock. The depth to free calcium carbonate ranges from about 16 to 48 inches, and the depth to bedrock from about 20 to 55 inches.

In places the subsoil is loam or silt loam apparently little influenced by material weathered from basalt. In other places the subsoil has a weak prismatic structure.

Mapped with Bickleton silt loam is some soil in which the surface layer is lighter in color and the subsoil is coarser in texture. This soil occurs along the eastern margin of Bickleton silt loam, where that soil is transitional to Renslow silt loam. On the divide north of the head of Glade Creek, this Renslow soil is transitional to small bodies of Simcoe clay loam, which was derived through the weathering of basalt.

Use and management.—Bickleton silt loam has long been used to grow dryland wheat, as the ranches on upper Glade Creek were taken up about 1888. The introduction of Baart spring wheat and of tractor-drawn diskplows has increased yields and made dry farming less hazardous. Fortyfold and other fall wheats are also grown. Wheat is alternated with summer fallow, and yields range from 12 to 25 bushels to the acre.

The soil is beginning to show the effects of this system of farming. Yields have dropped because supplies of organic matter and nitrogen have been depleted and the soil has deteriorated in structure or tilth. Dry farming could be made more permanent if a part of the land were retired for 8 to 10 years and seeded to crested wheatgrass or other grass. Rainfall is not sufficient to allow the use of legumes such as alfalfa in the rotation. Other legumes may be found, however, that are suited to the climate.

Cattle are raised on some ranches. They spend the summer on nearby forested areas and are returned to the wheatfields after harvest in the fall. They winter on stubble and straw that is left in windrows by combine harvesters. On several ranches hogs are kept to pick up waste grain in the fields. They are occasionally fattened on wheat if the market price of the wheat is low.

The more sloping areas are somewhat susceptible to water erosion. Simple erosion-control methods are needed on these areas to control surface runoff and to check further erosion.

Burke loam (1 to 7 percent slopes) (Be).—This soil is distinguished by a distinct, or well-developed, lime-and-silica hardpan at moderate to shallow depths. The surface soil and upper subsoil are light colored, medium textured, and slightly hard. The upper part of the soil, which is generally less than 4 feet thick, appears to have been derived mainly from loessial material that resembles the material from which the Ritzville soils were formed. The loess, however, has been influenced in varying degrees by old materials deposited by water. In most places the hardpan has formed on or in the upper part of old water-laid gravelly or cobbly deposits. Some areas overlie basalt bedrock, angular basalt fragments, tuffaceous sandstone or shale, or layers of silts and sands deposited by lakes, layers similar to those that underlie the Sagemoor soils. The soil has developed under the influence of an arid to semiarid climate, which has warm to hot, dry summers and an average annual precipitation of 5½ to 8 inches.

This is the most extensive soil in the Burke-Ritzville-Roza soil association (fig. 2). Large areas occur at midelevations on well-drained, gently to moderately sloping high terraces or benches and old alluvial fans. In many places Burke loam occupies mesalike remnants of ancient land surfaces. Many areas are in the uplands. The soil occurs very extensively north and east of the Yakima River in the drier eastern part of the county; it is the predominant soil in the eastern part of the valley along Selah Creek, in the Moxee Valley, and in places along the flanks of Rattlesnake Ridge north of Sunnyside.

Burke loam is distinguished from the associated Ritzville, Roza, and Sagemoor soils by its distinct hardpan; from the related Selah soil by its lack of a clayey layer above the hardpan; and from the related Harwood soils by its more limy, or calichelike, hardpan.

The native vegetation consisted principally of big sagebrush and a rather sparse growth of bunchgrasses.

Profile description:

1. Pale-brown soft loam; dark grayish brown to brown and very friable when moist; nearly bare of vegetation; when dry, the top ½ inch vesicular if undisturbed; structure of next lower 2 or 3 inches very thin platy; material below is massive and breaks into single grains and indistinct very fine granules; 5 to 8 inches thick.
2. Soft or slightly hard loam, silt loam, or very fine sandy loam of a color similar to or slightly lighter than that of the layer above; massive but falls into single grains and indistinct very fine granules; very friable when moist; 12 to 40 inches thick.
3. White, pinkish-white, and very pale brown strongly cemented or indurated lime-and-silica hardpan; in many places hardpan consists of rocklike caliche, but in some is slablike, and in others is fractured and more or less broken or lenslike; layer commonly contains rounded or angular pebbles or cobblestones; 6 to 20 inches thick.
4. Gravel and cobblestones, mainly basaltic; more or less cemented.

The average depth of the soil over the hardpan is about 2 feet, although the range is from 1½ to 4 feet. Areas that have a depth of less than 18 inches over the hardpan are usually mapped as Stony and shallow soils.

A thin fine-textured subsoil horizon similar to that of Selah loam occurs above the hardpan in a few places, but such areas are not extensive and are unimportant. Although the surface soil and the upper part of the subsoil are generally noncalcareous and neutral to mildly alkaline, in many places they contain small fragments of a lime hardpan or lime-coated pebbles or cobblestones. Evidently these pebbles and cobblestones were brought up and mixed with the soil by burrowing animals.

The organic-matter content of Burke loam is low to very low. The soil above the hardpan is moderately permeable to water and roots, and the hardpan ranges from impermeable to slowly permeable. In some areas the hardpan overlies basalt bedrock, angular basalt fragments, tuffaceous sandstones or shales, or stratified lake-laid silts and sands.

Use and management.—This soil must be irrigated before crops will grow on it successfully. The greater part of the soil occurs above the irrigation systems. It is moderately deep and is variable; it absorbs and holds water unevenly and does not make good cropland.

Generally the soil is droughty, but where the hardpan and cemented gravel are impermeable, it may waterlog. Where small areas of this soil have been used for apple orchards in the East Selah and Terrace Heights districts, growth of the trees has been uneven and generally unsatisfactory. Along the Roza Canal, where it is under irrigation, this soil is best suited to soft fruits, grapes, alfalfa, and irrigated pasture.

Because of the moderate depth of the soil, considerable care is needed in irrigating to avoid erosion. The more sloping areas are very susceptible to water erosion, and all areas are susceptible to wind erosion. Crops should be grown that will hold the soil and add to the content of organic matter and nitrogen. Orchards and vineyards should be kept under a cover crop of alfalfa or under some other legume or grasses. Row crops that need open tillage should not be grown until after ditchbanks have become sodded and stabilized or adequate equipment has been installed for water conveyance and turnout control. New land should not be broken out of the sagebrush or tilled and left open to wind erosion before water is available for irrigation.

Burke fine sandy loam (1 to 5 percent slopes) (Bd).—Except for its sandier texture, this soil generally resembles Burke loam. It is somewhat intermediate in character between Burke loam and Selah loam. In most places, however, it lacks the clayey subsoil of Selah loam and more nearly resembles the Burke soil. It was formed in an environment similar to that in which Burke loam was formed. Its sandier texture probably resulted from the upper part of the soil being derived from sandier old water-laid materials. This sandier material, however, may have been shifted or modified by wind, so that possibly the coarser texture resulted from the removal of the fine material by wind.

The surface soil and upper part of the subsoil are commonly noncalcareous and are neutral or mildly alkaline. In many spots they contain small fragments of lime hardpan or lime-coated pebbles evidently brought up from below and mixed with the soil by burrowing animals.

The content of organic matter in this soil is low to very low. The hardpan ranges from slow to nearly impermeable; average depth to the hardpan is about 2 feet, but the range is from about 1½ to 4 feet. The hardpan overlies gravel and cobblestones, tuffaceous sandstones and shales, basalt bedrock, or angular basalt fragments. In places there is a thin layer above the hardpan that is somewhat compact and finer in texture; it resembles or approaches the corresponding layer in the Selah soil.

Use and management.—Because of the small area that is irrigated, this soil is of little importance to the present agriculture. Several fields are irrigated by floodwater ditches that bring water from Wenas Creek; this is supplemented by water pumped from wells. Where depth to the hardpan is 3 feet or more and slopes are gentle, the soil is fairly well suited to most of the fruits and general farm crops grown in the area. If it is not held by vegetation, the soil is moderately susceptible to wind erosion, and the more sloping areas are easily eroded by flowing water. Careful irrigation is needed to keep erosion at a minimum.

Cleman sandy loam (1 to 6 percent slopes) (Cd).—This is a grayish-brown, gently sloping soil that developed under an average annual precipitation of 7 to 9 inches. It occupies well-drained recent alluvial fans and narrow bottom lands in coulees (pl. 2). These coulees head in eroded uplands or canyons where gray tuffaceous sandstones, beds of white ash, or light-colored shales of the Ellensburg formation are exposed or underlie the soils of the uplands. The soil contains a comparatively high proportion of small fragments from these light-colored acidic rocks.

Cleman sandy loam occurs in the Yakima-Esquatzel-Ahtanum soil association (fig. 2). Most areas are small; the largest one occurs on a series of short alluvial fans that extend for 6 miles along the southwestern margin of the Wenas Creek valley.

This soil somewhat resembles the Onyx and Esquatzel soils, but it is grayer and was formed from alluvium derived from more acidic rocks. The native plant cover consisted of sagebrush and the other shrubs, grasses, herbs, and weeds that are common in arid to semiarid areas.

Profile description:

1. Grayish-brown, soft to slightly hard sandy loam that contains some sharp coarse sand and fine gravel; nearly structureless but breaks easily into weak fine granules and single grains; very dark grayish brown and very friable when moist; 6 to 15 inches thick.
2. Grayish-brown to light brownish-gray, slightly hard to soft sandy loam that contains sharp coarse sand, fine gravel, and small subangular fragments of tuffaceous materials; nearly structureless; very dark grayish brown and very friable when moist; 8 to 20 inches thick.
3. Grayish-brown to pale-brown, slightly hard to soft sandy loam or coarse sandy loam that is single grained and contains considerable sharp fine gravel and small rock fragments as large as ¼ inch across; very friable when moist; layer may be stratified; 30 to 50 inches or more thick.

The texture of this soil is variable. It is usually coarser at the upper part of each fan and along the present drainageways and progressively finer toward the lower more nearly level lands. The soil contains little or no free lime and as a rule does not effervesce when dilute hydrochloric acid is applied; it is neutral to mildly alkaline. The organic-matter content is low. The soil is rapidly permeable, and its water-holding capacity is low. Salts and alkali are usually not present, and the water table is generally not high.

Use and management.—Most of the Cleman sandy loam that occurs in the Wenas Creek valley is irrigated by water brought from Wenas Creek by private ditches. This soil is planted to alfalfa and other farm crops. About 450 acres near Naches is almost entirely in orchards. Elsewhere in the county the soil occurs in small bodies rarely a hundred acres in extent. Where these areas are irrigated, they are used for many different crops.

This soil is fertile and productive. Although it is rather porous and droughty, it produces good to excellent yields if irrigated adequately and well managed. It is especially suitable for fruit, alfalfa, and potatoes.

Cleman coarse sandy loam (2 to 7 percent slopes) (Cb).—This soil is associated with Cleman sandy loam and was developed in a similar environment. It differs from Cleman sandy loam mainly in that it is coarser in texture, more rapidly permeable, and lies higher on the fans. Within each alluvial fan, the texture of the soil usually ranges from coarse gravelly sandy loam at the upper part of the fan to sandy loam at the lower margin.

Cleman coarse sandy loam is generally noncalcareous and is approximately neutral. Its content of organic matter is low, and it has a low capacity for holding water.

Use and management.—This soil is almost entirely in orchards. It is necessary to irrigate with large quantities of water, but the trees are thrifty and produce excellent fruit. Fruit trees, grapes, and early vegetables are fairly well suited to the soil if sufficient water is available. It is important to use cropping practices that will increase the amount of organic matter in the soil.

Cleman loam (1 to 4 percent slopes) (Cc).—This soil occurs under an environment similar to that of Cleman sandy loam. It differs from Cleman sandy loam chiefly in being finer textured and moderately permeable. As a rule the alluvial fans and bottom lands on which the soil occurs are gently sloping, and most areas of the soil are well drained. Except for the large amount of material derived from gray tuffaceous sandstone and shale, Cleman loam somewhat resembles Esquatzel silt loam.

Generally Cleman loam is noncalcareous, approximately neutral, and rather low in organic matter. It is moderately permeable and has a moderate water-holding capacity.

Use and management.—Most of this soil is irrigated. It is used for orchards and for crops common to the region. It is well suited to most of the crops grown, and high yields are obtained.

Cleman clay loam (0 to 3 percent slopes) (Ca).—The environment under which this soil was developed is similar to that of Cleman sandy loam. Cleman clay loam, however, is usually lower and farther out on the alluvial fans and has more gentle slopes. It has a finer texture than Cleman sandy loam and is more slowly permeable to water. Surface runoff is slower; occasionally on some areas the water table is high when irrigation is excessive.

In some places the texture of the surface soil deviates from clay loam and ranges from heavy loam to sandy clay. As a rule the entire profile is noncalcareous and neutral to mildly alkaline, but it includes some areas that have a calcareous subsoil. A few areas are slightly saline and have an occasional moderately high water table.

Cleman clay loam is moderately permeable to water. Its organic-matter content is rather low to moderate.

Use and management.—This soil is fertile; it is fairly well suited to most of the crops grown in the areas where it occurs. The soil puddles if irrigation water becomes ponded, however, and becomes hard to manage if clean cultivation is practiced excessively. Areas that are not so well drained are not well suited to orchard fruits and alfalfa. Some areas may need intercepting drains.

Cowiche loam (2 to 8 percent slopes) (Cf).—This soil has developed from material that overlies and is largely weathered from the gray tuffaceous sandstones or shales of the Ellensburg formation. A variable amount of loess or windborne silt generally occurs in the surface soil and sometimes in the upper part of the subsoil. Relief is gently sloping or undulating to rolling. The greater part of the soil is patchy and uneven.

This soil occurs on well-drained uplands and on lower slopes of the foothills at altitudes of 1,200 to 2,100 feet. It has developed under an average annual precipitation of 7 to 11 inches.

Most areas of Cowiche loam are in the Cowiche-Simcoe-Harwood soil association (fig. 2). The soil is generally associated with Tanoum loam, Steep broken and stony land, or Scabland and Smooth stony land on the upper side of the slopes, and with Ritzville, Selah, or Roza soils on the lower, more arid side. Cowiche loam is lighter in color and has more free lime than the related Tanoum loam. The natural vegetation consisted of big sagebrush and grass.

In most areas where this soil occurs, the tuffaceous sandstones and shales overlie basalt, but in the lower areas and in the old valleys, gravel deposits overlie the sandstone and shale. The Cowiche soils overlie this sandstone and shale; Simcoe clay loam overlies the basalt where the basalt is not covered by other materials; and Harwood loam overlies the gravelly deposits. Several areas of Cowiche loam occur along the margin between irrigated land and areas just beyond, where dryland cultivation is practiced. The larger areas occur near the towns of Tieton and Cowiche.

Profile description:

1. Grayish-brown to light brownish-gray, neutral, noncalcareous, slightly hard to soft loam of weak fine granular structure; very dark grayish brown and friable to very friable when moist; when dry, the upper 2 or 3 inches in many places has a strong thin platy structure, and the upper half-inch may be vesicular; lower part of the layer in places has a weak medium to coarse granular structure; layer has many fine pores and channels and varying numbers of roots and in places contains gritty sand grains or small pebbles; 8 to 17 inches thick.
2. Brown, neutral, noncalcareous, hard to very hard clay loam; breaks into strong subangular blocky aggregates ¼ to ½ inch across; contains some coarse sand and fine gravel, a few to moderate number of fine pores and channels, and a moderate number of roots; dark grayish brown to brown and firm to friable when moist; somewhat sticky and plastic when wet; ranges from sandy clay loam to clay loam or sandy clay and may be somewhat dense; in places has a more or less prismatic structure or breaks vertically into prisms about 1 to 2 inches across; 12 to 22 inches thick.
3. Material similar to that in layer above but has a moderate to large number of white lime veins, splotches, and soft concretions and somewhat more sand and small pebbles; 3 to 5 inches thick.
4. Pale-brown to light yellowish-brown, moderately to strongly calcareous, slightly hard to hard coarse clay loam, sandy clay loam, or sandy loam; contains moderate to large number of white lime veins, splotches, and soft concretions, a moderate number of fine pores and channels, and some coarse sand, fine gravel, and small angular fragments of sandstone or shale; yellowish brown and firm to friable when moist; 9 to 12 inches thick.
5. Pale-olive, pale-yellow, or very pale brown, decomposing, stratified sandstone or shale that generally contains tuffaceous material; upper few inches commonly have white lime in the cracks and between the strata, but layer grades downward into noncalcareous, less decomposed, semiconsolidated or consolidated bedrock.

This soil varies considerably in depth, development, and surface-soil color. In the lower, drier areas, the surface soil is lighter in color and the lower subsoil contains more lime. The higher areas farther west have a darker surface soil and less lime in the subsoil. In most places the depth to free lime ranges from about 20 to 35 inches and the depth to sandstone ranges from 36 to 45 inches. The soil in some places, especially in areas of higher rainfall, has little or no free lime above the decomposing bedrock. A few places have a thin layer just above or in the upper part of the decomposing bedrock that has been more or less cemented into a hardpan by lime and possibly silica.

The content of organic matter in the surface soil of Cowiche loam is moderately low. The soil is moderately permeable to water and roots. The decomposing bedrock is moderately permeable to very slowly permeable. The soil is not subject to a high water table or to excess soluble salts.

Use and management.—The larger areas occur near Tieton and Cowiche, where several hundred acres of irrigated Cowiche loam is largely in apple orchards. Other small scattered bodies are widely distributed in the orchard districts west of Yakima, on Selah Heights, and in the Wenas Creek country.

According to its depth, slope, exposure, and irrigability, this soil is somewhat similar to the Simcoe, Tieton, Renslow, and Ritzville soils in adaptation to crops and cultural practices. All of these soils need to be irrigated carefully. To maintain organic matter and nitrogen, legumes such as alfalfa should be used in the crop rotations or as a permanent cover crop in the orchards.

Several of the more sloping areas are somewhat eroded, and special irrigation and cultural practices should be used on them to prevent further loss of soil. Dryland wheat farming on some of the higher lying soil is marginal and of small extent and importance. Low yields are common.

Cowiche loam, rolling (8 to 20 percent slopes) (Cg).—Small patches of this soil occur throughout the orchard areas of the county in association with less sloping areas of Cowiche loam and with the soils associated with Cowiche loam. The largest area covers approximately 250 acres on a northeastern exposure northwest of Cowiche. It supports valuable apple orchards. Other areas of the soil are generally not more than 40 acres in size and as a rule occur on south or west slopes.

Surface runoff is considerably more rapid on this soil than on less sloping areas of Cowiche loam. Several of the areas have become somewhat eroded.

Except for its steeper slope, this soil resembles the more nearly level Cowiche loam. It is usually shallower to decomposing bedrock, however; has less lime, and has a less well developed subsoil.

Use and management.—Although apples are grown on the rolling phase of Cowiche loam, the soil is better suited to peaches or grapes than to apples. It needs careful irrigation. It should be kept in alfalfa or some other dense cover crop that will control erosion.

Cowiche fine sandy loam (2 to 10 percent slopes) (Ce).—This inextensive soil is of minor agricultural importance. Most of it occurs in the rangelands in Iowa Flat and on the upland slopes bordering Wenas Creek northwest of Iowa Flat. A little of it occurs below the present irrigation system, and the largest area of this is east of Selah.

The climatic environment and the range of surface relief of this soil and Cowiche loam are about the same. This soil, however, appears to have been derived from tuffaceous sandstone of coarser texture than that from which Cowiche loam originated.

The profile of Cowiche fine sandy loam closely resembles that of Cowiche loam in most of the significant characteristics. It is sandier, however; as a rule slightly lighter colored, and not so well developed in the subsoil. In several places the subsoil of this soil is slightly hard heavy loam or heavy fine sandy loam. The depth to free lime ranges from approximately 30 to 50 inches, but in places there is little or no lime above the decomposing sandstone. The depth to bedrock is 35 to 60 inches.

The content of organic matter is low in the surface soil. The soil is moderately permeable to water and roots.

Use and management.—Most of this soil is used for range. The largest area under the present irrigation, located east of Selah, is used for orchards and dry farming. The soil is fairly well suited to all fruits grown in the area. It must be carefully irrigated, and organic matter should be added by using legumes in the crop rotations.

Ephrata very fine sandy loam (1 to 6 percent slopes) (Ea).—This is not an extensive soil and is of minor agricultural importance in Yakima County. In part it adjoins soils mapped in the Ephrata series in adjoining Benton County (*8*). It occupies somewhat excessively drained undulating terraces or benches. These are near the Yakima River in the extreme eastern part of the county where the average annual precipitation is 6 to 8 inches. Some areas have an uneven relief of low ridges and intervening swales, and relief in general is undulating or billowy.

The upper layers of Ephrata very fine sandy loam are thin, light in color, and of medium texture. Below these layers is loose, poorly assorted gravel, cobblestones, and stones that in the upper part are strongly lime coated. The subsoil layers do not have distinct differences in texture and structure, but a definite zone of lime accumulation occurs in the upper part of the gravel.

The parent material, deposited by water, originated mainly from basalt. The upper part of the soil, however, may be influenced somewhat by loess or silty windborne materials.

This soil is distinguished from the Burke soils mainly by its lack of a well-developed hardpan and by more rapid permeability. It is distinguished from the Naches soils by its lack of a finer textured subsoil and by the distinct lime coating in the upper part of the gravel layer. The natural vegetation consisted of sagebrush and some grass.

Profile description:

1. Pale-brown, noncalcareous very fine sandy loam; weak platy in upper part but breaks easily into weak very fine granules and single grains; dark grayish brown and very friable when moist; 6 to 10 inches thick.
2. Noncalcareous soft very fine sandy loam or loam a little lighter in color than layer above; massive and breaks easily into single grains; very friable when moist; in places contains some pebbles as large as an inch across; 10 to 13 inches thick.
3. Light yellowish-brown, pale-brown, or light brownish-gray, slightly hard generally noncalcareous very fine sandy loam or loam that contains some gravel; massive and crumbles easily into single grains; dark grayish brown and very friable when moist; 10 to 25 inches thick.
4. Gravel coated unevenly with white lime and mixed with light brownish-gray or light-gray calcareous loamy or sandy material; 3 to 9 inches thick.
5. Poorly assorted loose pebbles and subangular cobblestones, some of which are lime coated on the lower side; mostly basaltic.

The soil material is generally shallow over gravel, but its depth varies. The texture of the upper part of the soil ranges from very fine sandy loam to loam. Much of this soil east of Mabton, however, has a surface soil and upper subsoil of fine sandy loam. In some areas along the road from Mabton to Euclid Flat, 2½ to 4 feet of fine sandy loam lies over the porous gravel. In places stones occur on the surface or are embedded in the soil. Such areas are shown on the soil map by soil symbols or are mapped as Stony and shallow soils.

Ephrata very fine sandy loam is generally moderately to rapidly permeable. The gravel is very rapidly permeable except in places where the upper part is cemented in varying degrees by lime. In places where it is strongly cemented, this layer stops penetration of roots and water. The water-holding capacity of the soil is low, and the organic-matter content is very low. The upper soil layers are generally neutral to mildly alkaline.

Use and management.—Ephrata very fine sandy loam is mainly in small farms that have had frequent change of occupants. Cultivation has been abandoned on tracts that are very shallow or stony or that have very unfavorable relief. The surface is largely undulating or billowy and unfavorable for irrigation. Some of the soil has been withdrawn from cultivation so that the irrigation water could be used on the better lands of the farm.

The soil is used for growing many kinds of crops and for many farm enterprises. In some instances comparatively high productivity has been maintained by hard work and good management. Water requirements are high—the soil needs 4½ acre-feet or more. Where it is dry and bare, the soil is moderately susceptible to wind erosion, and the more sloping areas are easily eroded by water. Although it is usually very easy to till, careful irrigation is necessary to prevent further erosion. Dry farming is unsuccessful on this soil.

It is necessary to use the best cropping practices possible to maintain supplies of organic matter, nitrogen, and phosphorus. Legumes must be used in the rotation, and manure is essential if the soil is farmed. Grapes are grown with considerable success on some of the poorest, droughty soils of the Valley, and it is suggested that they be grown here. Because it is so dry and excessively drained, this soil is well suited to poultry. An important storage point for dryland grain is located near Mabton, and feeding enterprises that would not depend upon extensive tillage could possibly be developed.

Some of this soil that has a deeper upper soil over the gravel occurs along the road from Mabton to Euclid Flat. In these areas the soil has smooth gentle slopes and lies favorably for irrigation; here the soil is in well-kept farms that are moderately productive.

Esquatzel silt loam (0 to 2 percent slopes) (Ec).—This light-colored, well-drained soil is one of the best in the county for general farm crops. It has developed under an average annual precipitation of 6 to 9 inches. It consists of medium-textured alluvium derived principally from loess. The alluvium is mixed, however, with considerable wash from basalt, or with mixed water-laid materials or soils formed thereon. To a large extent, this alluvium was washed from areas that have a semiarid to arid climate. In some of the higher lying areas, the upper part of the soil may be derived from or influenced to some extent by loess or windblown materials.

The parent material of Esquatzel silt loam is similar to that of the Ahtanum, Kittitas, and Umapine soils, but Esquatzel silt loam has better drainage and is typically nonsaline and less alkaline. It lacks the hardpan of the Ahtanum soils, is lighter colored than the Kittitas soil, and is less calcareous than the Umapine soil.

Esquatzel silt loam is one of the more extensive soils in the Yakima-Esquatzel-Ahtanum soil association (fig. 2). As a rule it is associated with the Ritzville, Sagemoor, Burke, Harwood, and Selah soils. In some places, however, it is associated with the Toppenish soils. Near the leveed banks of an abandoned stream channel at the Toppenish Longhouse, this soil grades into dark-colored Toppenish loam that was derived from similar alluvium, but developed in a naturally moist or wet environment.

Esquatzel silt loam occupies level, nearly level, or very gently sloping bottom lands, low terraces, valley floors, and fairly recent alluvial fans. Some areas on flood plains may be flooded occasionally, but overflows are less frequent since the streams have been brought under control for use in irrigation. In the vicinity of Toppenish is an area where distributary channels of a floodway from the river, called Wanity Slough, have spread alluvium over older sediments and older soils of the valley floor. Although a high water table was rare under natural conditions, irrigation has caused the ground water to rise moderately to fairly high in some flat bottoms that receive seepage from higher lying areas.

Most of Esquatzel silt loam occurs in small areas widely scattered in many parts of the Valley. Large areas that are important to farming occur near Wide Hollow School, in the vicinity of Toppenish, in the Satus district, and in several other localities. Elsewhere, 20-, 40-, or 80-acre tracts add greatly to the value of individual farms.

The natural vegetation consisted chiefly of sagebrush, some grasses, and associated plants. In virgin areas the sagebrush is usually large and abundant.

In texture there is practically no difference between the subsoil layers in this soil. In some areas, however, the subsoil has slight structural prominence. In most places lime has accumulated either in disseminated form or in veins.

Profile description:

1. Light brownish-gray to pale-brown, noncalcareous, slightly hard silt loam; breaks easily into weak very fine granules; dark grayish brown and friable to very friable when moist; where disturbed, structure of the upper 2 or 3 inches is platy; 5 to 10 inches thick.
2. Pale-brown to light brownish-gray, slightly hard to soft silt loam or loam; nearly structureless and crushes into weak very fine granules; noncalcareous in most areas; grayish brown to brown and friable to very friable when moist; 20 to 35 inches thick.
3. Pale-brown, mildly to moderately calcareous, slightly hard loam, silt loam, or fine sandy loam; in places, light yellowish brown in lower part; nearly structureless; crushes into weak very fine granules; brown to grayish brown and friable to very friable when moist; in some areas layer contains a few firm coarse granules that have a somewhat subangular blocky structure; in most places lime has accumulated as white small veins or channels; 15 to 40 inches thick.
4. Generally noncalcareous, soft to slightly hard, stratified coarse- to medium-textured alluvium.

This soil is neutral to mildly alkaline and low in organic matter. It generally is noncalcareous, but in places the surface soil and upper subsoil are calcareous. The soil is moderately permeable and has a moderately high water-holding capacity.

Esquatzel silt loam varies somewhat from place to place, depending upon the nature of the stratified sediments deposited by streams. Layers of variable textures occur. In some of the lower areas, the surface soil is finer textured and approaches a clay loam or silty clay loam. On the low terraces the surface of the soil may have widely spaced vertical cracks that form very large easily crushed prismatic aggregates. Occasionally, the soil is underlain by sandy loam, loose gravel, or sand at depths below 3 or 4 feet. As a rule the upper part of the soil is free from gravel except on the upper parts of the fans and along coulee channels. In places the soil overlies approximately 12 inches of nearly white, noncalcareous, very fine sandy or silty, pumiceous volcanic ash that occurs at a depth of about 3 feet. The lower part of the soil in some areas is mottled with gray and yellowish brown.

When the soil is irrigated, underdrainage is not always adequate. Where the soil occupies the low level bottoms of coulees, lateral seepage from irrigated higher lands renders many areas saline and nonproductive. Several such areas occur in the vicinities of Sunnyside and Outlook. The excess soluble salts are mainly neutral salts, or "white alkali," and consist chiefly of chlorides, sulfates, and nitrates of sodium, calcium, and magnesium. Some gypsum occurs in places. The areas that are moderately to strongly affected by salts are outlined on the map; those that are only slightly affected, or are spotty, are indicated by symbols.

Still another variation occurs along the lower course of Wanity Slough south of Toppenish. Here, the soil is naturally slightly to moderately saline. The salinity appears to have developed recently and has not significantly changed the soil profile or the potential productivity of the soil. The soil can be reclaimed easily, but only a small part has been cultivated, because it is undulating and broken by many channels.

Areas of this soil that occur in the western part of the county and that receive more rainfall are transitional to Onyx loam; that is, they are somewhat darker colored and contain less lime and more basaltic materials.

Use and management.—Esquatzel silt loam is one of the better agricultural soils of the county. Most of it is irrigated. It is used for all the crops grown in the Yakima Valley. Alluvial fan areas that are comparatively free of forest, and narrow terraces such as those near Donald, are used for orchards. The larger areas that occur on favorable relief are in demand for sugar beets, truck crops, and hops. Yields in most areas are high. Generally the soil is easily worked and irrigated. Erosion is negligible.

Although the better areas of this soil are among those more adaptable and consistently productive in the Valley, continuous cropping depletes the soil. The best soils are cropped the most intensively and are being depleted the most rapidly; the poorer soils are used for pasture or alfalfa and in many places are being improved. It is as necessary to rotate crops properly on this soil, and on others like it, as it is to rotate them on areas of poorer soil, and it is also necessary to grow legumes, add manure, and apply phosphorus fertilizer. The better soils need good management as much as the poorer soils. Good management is particularly needed by this and other Esquatzel soils in the eastern part of the Valley.

In some places this soil receives accumulated ground water from higher irrigated areas. This soil, like others composed largely of loess or silty materials, has a marked tendency to become saline wherever a high water table develops. This tendency is evident even though the water table is at depths of 5 to 8 feet. Apparently the uniform texture and the arrangement of the soil particles favor the capillary rise of water. The water rises to the surface and evaporates, and the soluble salts it carries accumulate (pl. 3, *B*). Fortunately most Esquatzel silt loam is drained adequately and is not affected by soluble salts or is only slightly affected. Considerable areas of this soil that have become saline since irrigation was begun have been mapped with the associated Umapine soil.

Saline areas of Esquatzel silt loam can be reclaimed by establishing adequate drainage and then leaching the soil. If possible the water table should first be lowered by establishing deep ditches or tile drains. Then large amounts of water can be applied to leach most of the salts down below the root zone. This leaching may be done in winter. If enough water is applied just before germination, a good stand will often be obtained in spite of some salt and a high water table.

Esquatzel very fine sandy loam (0 to 2 percent slopes) (Ed).—Areas of this soil under irrigation are not extensive. Approximately 2 square miles of it occurs in the upper Valley in areas ranging from 30 to 320 acres in size. These areas are in the Ahtanum, Cowiche Creek, and Moxee valleys and east of Selah. Somewhat larger areas, totaling about 6 square miles, occur in the eastern part of the Moxee valley, in the Black Rock valley, and along upper Selah Creek. These areas are far out in the semiarid or arid rangelands and well above the present limits of irrigation.

This soil differs from Esquatzel silt loam principally in having a coarser texture and in slightly more rapid permeability. It was derived from similar materials and was formed under a similar environment.

Like Esquatzel silt loam, this soil varies somewhat from place to place. The differences depend to a large extent on the character of the stratified sediments deposited by the streams; layers of variable textures may be present at any depth in the profile.

Esquatzel very fine sandy loam has a low organic-matter content and is normally neutral to mildly alkaline. In places it is entirely noncalcareous, but in some areas it is weakly calcareous in the upper part. It is moderately permeable and has a moderate water-holding capacity.

Use and management.—Most of this soil occupies positions higher than the present irrigation systems. It is therefore used principally for grazing. Its grazing value is somewhat greater than that of other soils of the semiarid to arid uplands.

Under irrigation this soil is productive and well suited to many kinds of crops. Field crops, truck crops, orchard fruits, and hops are grown, and yields are comparatively high. The soil is similar to Esquatzel silt loam in suitability for crops but has a slightly lower water-holding capacity.

In level low-lying areas this soil is like Esquatzel silt loam in being subject to rise of capillary moisture and accumulation of soluble salts where there is a high water table. Saline areas are generally of minor extent. Some areas that have become saline since irrigation was begun have been mapped with the associated Ahtanum soils. Where feasible, ditches to intercept seepage water from higher areas would benefit the saline areas considerably.

Esquatzel fine sandy loam (0 to 2 percent slopes) (Eb).—This soil developed under an environment similar to that of Esquatzel silt loam and Esquatzel very fine sandy loam, but it is somewhat coarser in texture and more rapidly permeable. These differences may have been caused by the parent material having been derived more from basaltic and mixed water-laid materials and less from loess.

The soil is only moderately extensive. The larger areas that are locally important to farming cover about 500 acres near Wide Hollow School, 900 acres in the southern part of the Satus district, 1,200 acres near Sunnyside, and 400 acres 3 miles east of Mabton. Elsewhere, there are widely scattered, isolated areas, small and of little importance.

Esquatzel fine sandy loam occurs chiefly in the Yakima-Esquatzel-Ahtanum soil association (fig. 2). It is better drained, less alkaline, and generally lacks the hardpan typical of the related and associated Ahtanum fine sandy loam.

The profile varies somewhat from place to place, mainly because of differences in the kind of alluvium deposited by the streams. The soil is commonly stratified. Various medium- to coarse-textured layers occur in the subsoil and especially in the lower part of the profile. In several places, especially in some of the narrow coulee bottoms, loose gravel or sands underlie the soil at fairly shallow depths. The surface soil in some places is a very fine sandy loam that ranges to loamy fine sand or sandy loam.

Esquatzel fine sandy loam is generally neutral to mildly alkaline. As a rule the entire profile is noncalcareous, but in places the surface soil is calcareous. In some areas the subsoil has only a slight structural development, exhibited by the soil breaking into firm subangular blocky aggregates. The soil is moderately to rapidly permeable and has a moderate water-holding capacity. The lower part of the soil is in places mottled with gray and yellowish-brown stains.

Like Esquatzel silt loam, some of the lower areas now have a somewhat high fluctuating water table caused by seepage from higher irrigated areas. Excess soluble salts have accumulated in many of these lower areas.

Use and management.—The use of Esquatzel fine sandy loam is similar to that of Esquatzel silt loam and Esquatzel very fine sandy loam. Although it has a slightly coarser texture and needs more water, it is suited to the same crops, and management is similar. Yields on Esquatzel fine sandy loam are slightly lower, however, and the soil is somewhat more difficult to irrigate.

Fiander fine sandy loam (0 to 1 percent slopes) (Fa).—This light-colored soil has a moderate to strong concentration of alkali and a dense clayey subsoil. It occurs on nearly level terrain on the floor of the Reservation valley; it lies only a little higher than the bottom lands along Toppenish Creek. Surface runoff is very slow.

The soil appears to have developed under conditions of poor or imperfect drainage where the water table was high; consequently, excess soluble salts, including sodium salts, have accumulated in it. Its profile characteristics stem from a long and complex development under the influence of saline-alkali conditions and an average annual precipitation of between 6 and 7 inches.

Fiander fine sandy loam originated from fairly old alluvium derived mainly from basalt and loess and soils formed on these materials. A gravelly layer commonly occurs in the lower part. Although in Fiander fine sandy loam the underlying gravel usually occurs at a greater depth than in the Naches soils, the parent material resembles that of the Naches soils; the slick spots in the Naches soils are actually small areas of Fiander soil.

Most areas have a cover of greasewood and saltgrass, but bare spots intervene. Part of the surface soil that has been shifted by the wind has accumulated under the greasewood clumps to form low mounds on which cheatgrass grows.

The soil has moderate to somewhat strongly developed texture and structure in the upper subsoil layer. The surface soil has been worked or shifted by wind in many places. This soil is designated as fine sandy loam because the sandy material that has accumulated as mounds under the greasewood has been leveled, and the surface soil that results has a fine sandy loam texture. The bare places between the mounds are of variable texture, and in places the fine-textured subsoil is at the surface. This soil in many places is a complex of Fiander soils of various textures.

This soil differs from the Giffin, Umapine, and Ahtanum soils in having a rather dense, fine-textured upper subsoil. It differs from White Swan loam in parent material, and it has a more strongly alkaline surface soil.

Profile description:

1. Brown, grayish-brown, or pale-brown, noncalcareous, soft nearly structureless fine sandy loam that crushes readily to single grains; dark grayish brown and very friable when moist; top 2 or 3 inches in places may be weak thin platy; 5 to 16 inches thick.
2. Pale-brown to brown, somewhat dense clay loam, sandy clay loam, or silty clay loam; breaks into slightly round-topped columns 1 to 2 inches across and into darker coated distinct very hard angular to subangular blocky aggregates ¼ to ½ inch across; dark grayish brown to dark yellowish brown and firm when moist; upper part of this layer commonly noncalcareous but white lime veins, splotches, and coatings in cracks and channels occur in lower part; 3 to 7 inches thick.
3. Light yellowish-brown to pale-brown, moderately calcareous light clay loam or sandy clay loam that contains white lime veins and splotches; breaks into hard subangular blocky aggregates ¼ to ½ inch across; dark yellowish brown and friable to firm when moist; 7 to 18 inches thick.
4. Light-gray, calcareous, massive loam, silt loam, or fine sandy loam mottled with light yellowish brown; 10 to 60 inches or more thick.
5. Beds of brown-stained, loose rounded gravel, principally basaltic.

This soil varies somewhat in profile characteristics, depending upon the extent of modification by wind and the kind of parent materials. Where it has been shifted by the wind, the surface soil has accumulated around the greasewood to depths of as much as 18 inches. The bare areas among the brush have little or no original surface soil and are of clay loam texture. In places that are not greatly modified by wind, the surface soil is loam, very fine sandy loam, or silt loam. When dry, the top inch or so of the surface soil in those places not worked by wind is generally distinctly vesicular; the next lower 2 or 3 inches has a distinct thin platy structure. Under the greasewood, the surface soil is nearly structureless.

The dense fine-textured subsoil varies somewhat in texture, thickness, and degree of structural development. A weakly lime-cemented hardpan occurs at a depth of 2 or 3 feet in some places. The depth to the gravel layer ranges from 2½ to 8 feet or more.

The surface soil of Fiander fine sandy loam is calcareous in places and is mildly to very strongly alkaline. The subsoil is generally very strongly alkaline. The content of organic matter in the surface soil is very low. The soil is very slowly permeable to water, and a high water table affects most areas.

Use and management.—Fiander fine sandy loam is of little value for agriculture. It is used principally for grazing, but its value for this use is low.

Because of the very slowly permeable subsoil and the type of alkali concentrations, this soil is difficult to reclaim. In many places the surface soil is scarcely of plow depth. Although danger of water erosion is negligible, the soil is susceptible to wind erosion if it is not protected by vegetation.

Giffin loam (0 to 1 percent slopes) (Ga).—The structure of this soil has been affected adversely by excess soluble salts and alkali. A definite somewhat dense clayey horizon occurs in places, but generally the whole upper part of the soil becomes a dispersed and plastic mass when wet.

The soil occurs on second bottoms or low terraces near the Yakima River and about 10 to 20 feet higher than the river. It is level to very gently undulating, but the continuity is interrupted by many partly filled abandoned channels. Oxbow bends, once river channels, are now sloughs or shallow lakes. Areas occupied by this soil apparently were a poorly drained flood plain during a stage in the development of the Valley. Because of the high water table then prevailing, excess soluble salts have accumulated in the soil. Later these areas were partly drained by natural processes and partly leached of salts.

The plant cover consists principally of stunted greasewood and saltgrass. In most places the brush is widely spaced and the soil appears barren.

Giffin loam originated from mixed alluvium that is generally medium in texture and was derived from basalt, loess, and mixed water-laid materials and soils formed thereon. The parent materials resemble those of the Umapine, Ahtanum, Esquatzel, and Beverly soils. Giffin loam is associated with the Beverly soils but occurs at slightly higher elevations.

Profile description:

1. Light brownish-gray, calcareous loam that breaks into soft thin plates in the upper part and thicker plates or fine granules in the lower part; dark grayish brown, dispersed, and plastic when wet; 4 to 8 inches thick.
2. Light brownish-gray, calcareous, slightly hard to hard loam that is plastic and sticky when wet; becomes puddled when wet; 6 to 12 inches thick.

3. Light brownish-gray, hard to slightly hard massive loam, silt loam, or light clay loam; generally noncalcareous but in places calcareous; 30 to 45 inches thick.
4. Medium- to coarse-textured sediments of unknown depths that are generally stratified.

The soil is generally only slightly affected by excess soluble salts, but the content varies. In most places the upper part is strongly to very strongly alkaline. The organic-matter content is low. Drainage is very slow throughout the soil. The upper part of the soil becomes puddled when wet, and water penetration is greatly restricted.

The above profile is typical of most Giffin loam, but a somewhat dense, clayey, columnar subsoil similar to that of Fiander fine sandy loam occurs in a few places. Also included are areas in shallow swales on the terrace 2 miles south of Emerald. These swales are believed to be nearly filled river channels. The soils in the swales are older, and in some places they have a clayey subsoil. In other places the surface soil is darker in color and somewhat resembles that of the Toppenish soils.

Use and management.—Most Giffin loam is pastured. The areas that are generally grazed are strips of subirrigated land along the sloughs and lakes. Several tracts are leased to gun clubs.

As a rule the soil is unfit for crops when it is first cultivated. It runs together and puddles under irrigation, is low in organic matter and nitrogen, and is not suitable for most farm crops. Nevertheless, its potential value is much greater than that of the other soils that have been affected by alkali. Areas that have relief favorable for irrigation may sometimes be used profitably for permanent pasture. The strip-flooding method of irrigating is suggested.

Alkaliweeds, foxtail, or other plants that come in during the initial stages of reclamation should be left on the ground. Grass and legume seedlings will become established on such dispersed soil only if protected by a growth of hardy weeds that act as primary invaders. The grass or legumes will normally become established the second year if the land is irrigated frequently. Applications of sulfur or gypsum should be used to reduce the alkalinity.

Giffin silt loam (0 to 1 percent slopes) (Gb).—This soil has developed under an environment somewhat similar to that of Giffin loam. More areas occur on old partly filled stream channels, swales, or other low-lying areas. Surface runoff is very slow.

The soil is distinguished from Giffin loam, with which it is associated, by its somewhat finer texture and slower permeability. Use and management of Giffin silt loam are similar to those of Giffin loam.

Harwood loam (1 to 5 percent slopes) (Ha).—This light-colored soil differs from Burke loam in having much less lime. Its weakly to moderately developed subsoil overlies comparatively impermeable cemented gravel at shallow to moderate depths. The upper part of the soil in most areas was derived from silty windborne material, possibly mixed with materials deposited by water. Except for some areas to the west near Tampico, which receive slightly more precipitation, the soil developed under an average annual precipitation of 7 to 10 inches.

The gravel underlying this soil is generally cemented by siliceous materials mixed with some lime. This gravel layer is older than the upper part of the soil. As a rule the soil above the gravel is moderately deep. Many areas, however, have little or no soil over the cemented gravel. Such areas, especially numerous and extensive to the west, have been mapped as Scabland and Smooth stony land.

Harwood loam is the predominant soil in the Harwood-Steep broken and stony land soil association (fig. 2). Some areas are associated with Cowiche loam. Harwood loam occurs on the dissected remnants of a high terrace that extends from the foothills east nearly to Yakima. It also occurs on a similar but much smaller and lower terrace that extends from the vicinity of Tieton southeast to the forks of Cowiche Creek. The larger terrace west of Yakima is deeply entrenched by several V-shaped valleys, by very shallow drainageways, and by level or slightly depressed areas that occur where surface drainage is very slow. Relief in general is nearly level to gently sloping or undulating.

The natural vegetation consisted mostly of sagebrush, grasses, and associated herbaceous plants.

Profile description:

1. Grayish-brown to light brownish-gray, noncalcareous, slightly hard to soft loam that breaks into fine granules; very dark grayish brown and friable to very friable when moist; 6 to 10 inches thick.
2. Pale-brown to light brownish-gray, noncalcareous, slightly hard loam or heavy loam that contains a moderate number of fine pores; breaks into weak subangular blocky aggregates about ¼ inch across; dark brown to dark grayish brown and friable when moist; 10 to 18 inches thick.
3. Pale-brown, light brownish-gray, or brown, intermittently calcareous, slightly hard heavy loam, sandy clay loam, or coarse-textured clay loam that contains a moderate number of fine pores and a few small pebbles; weak subangular blocky structure; dark brown to dark grayish brown and friable to firm when moist; in many places veins or small splotches of white lime occur, especially in the lower part.
4. Pale-brown to brown dense, indurated or strongly cemented sand, gravel, and some cobblestones; contains lenses that are white or pinkish white; cementing material appears to be principally siliceous, although some lime is commonly present, and lenses or coatings of lime occur on or in the hardpan in places; 6 to 15 inches thick.
5. Gravel, sand, and some cobblestones less strongly cemented than in layer above; material generally noncalcareous and principally of basaltic origin.

Generally the soil is neutral in the upper part and mildly alkaline in the lower part. The surface soil is low in organic matter. The material above the hardpan is moderately permeable; the hardpan is impermeable to very slowly permeable. The soil above the hardpan averages about 3 feet in thickness, although it ranges from 1½ to 4 feet.

Several areas that in varying degrees resemble the Manastash soils of Kittitas County are mapped as Harwood loam. These areas were developed under a little higher precipitation, mainly in the western part of the county near Cowiche Mountain and Tampico. They have a slightly darker surface soil; a brown, noncalcareous, firm or very firm, compact sandy clay, clay, or clay loam subsoil; and a cemented gravel, sand, and cobblestone hardpan that is noncalcareous in most places. Depth to the hardpan is somewhat less than in the typical soil.

Use and management.—Harwood loam is important for growing fruit. Large areas west of Yakima and near Cowiche and Tieton are under irrigation in the Tieton division. Apple orchards have been planted on much of this soil. Because of the shallow depth to cemented gravel and the impaired internal drainage, apple trees are smaller in size and shorter lived than on deeper soils. The fruit, though smaller than on better soils, has good quality and especially good color. The trees commonly become sick or die if the surface is level or surface drainage is so deficient that the soil waterlogs. Some small depressional areas are marshy and subject to frosts.

The soil should be irrigated lightly and frequently so as to prevent waterlogging. Pears or other soft fruits probably will be planted as the apple orchards become overage and are removed. Where spray residue has accumulated in quantities toxic to tree fruits, grapes may prove a better crop.

Harwood loam, sloping (5 to 10 percent slopes) (Hb).—This soil is associated with areas of Harwood loam but occurs on the slopes of V-shaped valleys that traverse the benchlands. The slopes range mainly from 5 to 10 percent but in places reach 15 percent. The soil resembles Harwood loam in profile characteristics and in parent material. Except for its greater slope, it formed under a similar environment. Surface runoff and susceptibility to water erosion are greater, however.

The soil is more variable than Harwood loam in texture and in depth to the cemented gravel (pl. 4*A*). It is normally shallower, and in places scarcely a foot deep to the gravelly layer. Most of it has a limited number of pebbles or cobblestones on the surface. The subsoil, compared to the corresponding layer in Harwood loam, more frequently consists of moderately compact clay loam, gravelly clay loam, or other fine-textured material and, consequently, is more slowly permeable. Exposures of the stiff clayey subsoil are common.

Use and management.—Some areas of Harwood loam, sloping, were planted to apple and other fruit trees during the time when orchards were set out extensively. The apple trees do not make an even, thrifty growth. The soil is fair to poor for peach trees or grapes. In a few small areas, water seeping from higher areas has caused accumulation of excess soluble salts. The soil is difficult to irrigate, and special management is needed to prevent excessive runoff. Sprinkler irrigation is more suitable for the sloping areas. The soil is best suited to permanent irrigated pasture consisting of mixed grasses and legumes.

Kittitas silt loam (0 to 1 percent slopes) (Ka).—This soil occupies level to nearly level bottom lands, low alluvial fans, or low terraces. It is subirrigated by streams that flow abundantly in the spring but go nearly dry late in summer. The soil covers a comparatively small total acreage. It occurs as small isolated patches, chiefly on the bottom lands of Wenas, Ahtanum, and Toppenish Creeks and on the flats west of Brownstown.

The soil developed under an annual precipitation of 5½ to 8 inches. It was derived mainly from loess, but to a lesser extent from basalt and from soils derived from loessial and basaltic material.

Organic matter from an abundant growth of grass and herbaceous plants imparts a dark color to the surface soil. The dark color is partly caused by black alkali that dissolves the organic matter and causes a dark staining on, and in, the soil.

The parent material resembles that of the associated Esquatzel and Ahtanum soils. This soil, however, is darker and generally is more alkaline and calcareous than the Esquatzel soils. It is darker than the Ahtanum soils, less affected by alkali, and generally does not have their lime hardpan. It differs from the Toppenish soils in being lighter in color, better drained, and more permeable.

Where this soil is moist and only slightly or moderately saline or alkaline, a mixed plant cover of both salt-tolerant species and plants that are not salt tolerant will grow. Giant wildryegrass, sagebrush, wildrose, lupines, and wild flags are typical of the plants growing on virgin areas of the soil.

Profile description:

1. Dark grayish-brown to grayish-brown slightly hard silt loam; breaks into fine granules when disturbed and is generally slightly to moderately calcareous; very dark brown and friable to very friable when moist; 4 to 8 inches thick.
2. Dark grayish-brown, slightly hard, slightly to moderately calcareous silt loam, heavy silt loam, or loam; breaks into indistinct granules when disturbed; very dark brown and friable to very friable when moist; upper part is in many places streaked with dark or black alkali stains; normally contains white lime veins and a moderate number of fine pores; 22 to 45 inches thick.
3. Grayish-brown to light brownish-gray slightly hard silt loam, loam, or light silty clay loam that is massive, very dark grayish brown, and friable to very friable when moist; 25 to 50 inches thick; generally noncareous and in places stratified and slightly mottled with gray and yellowish brown.
4. Stratified, noncalcareous sediments of silt, sand, or gravel deposited by water.

The upper part of the soil normally is strongly alkaline and very slightly to moderately affected by excess soluble salts. In places, however, it is strongly affected. The lower part of the soil generally is neutral. The organic-matter content of the surface soil is moderate. The soil is moderately permeable but subject to seepage. The water table becomes high if this soil lies below higher irrigated land.

This soil varies from place to place because of differences in the alluvial parent material, in moisture, and in salt and alkali that influenced its development. The surface soil, darker than the rest of the profile, is 12 inches or more in thickness in some areas, and its texture ranges from loam to silty clay loam. The subsoil is generally moderately permeable but in places consists of silty clay loam or clay loam. The depth to the very rapidly permeable substrata of sand or gravel is 3 to 8 feet. Generally, but not always, there is little or no development of the limy ground-water hardpan so characteristic of the closely related Ahtanum soils. Nevertheless, some hard lumps or lenses of an incipient hardpan occur in places.

A dark-colored soil that has a pronounced, almost stonelike, hardpan covers approximately 360 acres on the bottom lands along Toppenish Creek both east and west of the Powerhouse road, 12 miles southwest of Toppenish. This area has been mapped with Kittitas silt loam because it is too small to map separately.

Use and management.—Kittitas silt loam is farmed only in the Ahtanum valley east of Ahtanum and in the vicinity of White Swan. Elsewhere it is chiefly in unimproved pasture. Although only a small part is tilled, the soil is fairly easy to reclaim if adequate underdrainage can be obtained. The organic matter in the surface soil minimizes the toxicity of the soluble salts. Yields of common field crops should be moderate to good after the first year of thorough irrigation. A mild kind of slick spot appears in some areas but is much less pronounced and persistent than on the lighter colored soils.

Marsh (0 to 1 percent slopes) (Ma).—This soil occurs mainly as small isolated areas on bottom lands along streams. It is very poorly drained. In some places the poor drainage results from the low position of the soil, but more frequently it is caused by seepage or waste water moving from higher irrigated areas. The soil normally does not have a definite profile, as the materials are exceedingly varied.

Most of the soil occurs as long narrow bodies in abandoned channels of fresh-water streams or sloughs. These areas have a dense growth of cattails, tules, and other marsh plants. A few areas are affected by saline waters and have a saltgrass cover.

Use and management.—Marsh is used to some extent for pasture. Several areas near Selah have been used to raise frogs for market. The larger areas along Toppenish Creek serve as a refuge for ducks and geese. Most of them are leased by gun clubs for controlled shooting, and probably this is their best immediate use.

Naches loam (0 to 2 percent slopes) (Nb).—This is a moderately deep, light-colored, well-drained soil; its subsoil is slightly to moderately developed and overlies loose gravel. The soil originated from fairly old alluvium, which washed mainly from basalt but partly from granite and from loess and sedimentary materials. The soil developed under an annual precipitation of 5½ to 8 inches. The natural vegetation consisted principally of big sagebrush and grass.

Naches loam occurs mainly in the Naches soil association (fig. 2). Most of it is on rather low terraces, but a smaller acreage is on alluvial fans. Some of these fans are probably remnants of old materials deposited by streams during the last part of the glacial period. The soil is in positions slightly higher than those occupied by the Yakima soils, and it is distinguished from them by its more compact, browner subsoil.

The soil is nearly level to gently undulating and slopes very gently toward the valleys. On the terraces, particularly in the large area west of Wapato, the continuity of the surface is interrupted by many abandoned and partly filled stream channels. In some places the relief is unfavorable for irrigation; it is necessary to use small odd-shaped tracts that have head ditches running in several directions.

This soil is poorly suited to leveling for irrigation because its depth to underlying gravel varies within short distances, and gravel bars and shallow gravelly areas are common.

Profile description:

1. Brown to grayish-brown, slightly hard to soft gritty loam; contains some pebbles; breaks readily into fine granules; very dark grayish brown to dark brown and friable to very friable when moist; where undisturbed, upper 2 or 3 inches generally has a platy structure; 5 to 9 inches thick.
2. Brown gritty or sandy clay loam, gravelly clay loam, or heavy loam that contains pebbles; breaks into hard or slightly hard subangular blocky aggregates about ¼ inch across; dark brown to very dark grayish brown and friable to firm when moist; 8 to 14 inches thick.

3. Brown to yellowish-brown gravelly clay loam, gravelly loam, or gravelly sandy loam; breaks into slightly hard subangular blocky aggregates and single grains; very friable when moist; 5 to 13 inches thick.
4. Loose or nearly loose gravel and some coarse to medium-textured materials; contains cobblestones in some places; chiefly noncalcareous, but in many spots the pebbles in the upper few inches are coated with lime; materials principally basaltic, but to some extent granitic; pebbles in upper foot or so are stained brown.

The organic-matter content in the surface soil is low. The surface soil and subsoil are typically noncalcareous, approximately neutral, and moderately permeable to water and roots. The gravel normally permits very rapid penetration of water, so the soil has a very low water-holding capacity. The depth to loose gravel ranges from about 1½ to 3 feet and varies within short distances. Patches of gravelly soil are common, and spots of very gravelly soil are included.

A considerable area of this soil on the higher and older terraces near Harrah varies somewhat from the typical. The surface soil is mostly loam or light clay loam but, in places, is lighter colored and a silt loam. The different texture may indicate an admixture of loess. Locally, white segregations of lime occur in the lower subsoil, or lime coats the underlying gravel. Most of the soil on the Harrah terrace is from 2½ to 3 feet deep to gravel, or deeper than is usual for Naches loam. No slick spots were observed on this terrace.

The areas in the upper Wenas Creek valley and near Tampico have a darker surface soil that contains more organic matter. The soil in these areas is less alkaline.

Use and management.—Although Naches loam is only moderately deep and in many places gravelly and droughty, it is moderately fertile and important to crop production in the Yakima Valley. Most of it has been planted intensively to cash crops for many years.

Much of this soil is used for irrigated crops. Practically all of the crops are grown that are common to the Valley, including hops and sugar beets. In the upper Valley and just below Union Gap, large acreages that are not so subject to frost are in orchards. Where it is not too shallow, the soil is fairly suitable for most fruits and is especially suitable for short-lived, soft fruit trees. Under intensive management even the shallow gravelly areas in many places support good orchards. Soft fruits now predominate in most areas, and many apple orchards have been removed. As a rule other crops have been established successfully on the tracts formerly used for apple orchards. The effects of poisonous spray residue appear to be less severe on the Naches soils that contain abundant iron.

The iron-bearing compounds that are produced in the weathering of dark-colored igneous rocks impart the brown or rusty-brown color to Naches loam and to other soils derived principally from basalt or andesite. These compounds appear to have a distinct value in helping to maintain good soil tilth and fertility. For this reason Naches loam has been able to withstand considerable clean cultivation and excessive irrigation. It was observed, however, that when the granular structure of the soil breaks down, the surface soil becomes somewhat dense and intractable.

The subsoil is moderately permeable to water and roots. When exposed by leveling, it becomes granular and makes a good surface soil. It must be protected, however, and its content of organic matter and nitrogen increased by planting alfalfa or other suitable legume crops for 3 or 4 years before beginning clean tillage.

The moderate soil depth, a disadvantage on the well-drained terraces of the upper Valley, is a distinct asset on the more nearly level areas in the Reservation valley, where drainage is a major problem. Here the gravel substratum allows the free lateral movement of ground water to large open drains. In most places the gravel is well above the water table. In an apple orchard west of Wapato, it was noted that the trees that were the least thrifty grew on the deepest soil, which was in contact with the water table. Excessive moisture prevailed in the root zone of these trees. Trees that grew on the higher, shallower, and more droughty areas were healthy.

The larger areas of Naches loam not in orchards are mainly used for general farm crops grown in rotation with alfalfa, truck crops, sugar beets, and hops. Yields are moderate in most places but are declining on some land that has been cropped intensively without proper management. Considerable areas of leased Indian land and other tenant holdings have been planted to cash crops for many years without using alfalfa often enough in the rotation or without applying manure or other fertilizer properly. Often the alfalfa was baled and sold as a cash crop, and the stubble was pastured to the ground before the soil was plowed. Thus, the alfalfa instead of improving the soil, depleted the nitrogen and organic matter and the natural supply of phosphorus.

The areas in the upper Wenas Creek valley and near Tampico are used to some extent for dry-farmed grain and are mainly planted to wheat. Yields are fair.

Naches sandy loam (0 to 2 percent slopes) (Nc).—This soil resembles Naches loam in most significant respects. Its texture is sandier; and as a result, it has more rapid internal drainage and lower water-holding capacity. Generally it occupies higher, shallower, more gravelly positions. Some of this soil contains only a little more fine material than the associated Yakima very gravelly sandy loam. In most areas narrow strips and small areas of this soil are intermingled with Naches loam.

Originally coarse gravel and cobblestones were scattered on top of the ground and in the surface layer in many places. These have been cleared from some fields. The areas in which gravel definitely interferes with tillage are indicated on the soil map by gravel symbols.

The reaction, organic matter content, and variability of this soil are similar to those of Naches loam. Generally, however, loose gravel occurs at a somewhat shallower depth.

Use and management.—If irrigated, this soil produces fair to good yields of a number of crops. Even the shallow gravelly areas are fairly well suited to fruits if favorable moisture is maintained by using frequent light irrigations. Outside the fruit districts, the areas of shallow gravelly soil are often used to grow cantaloups, other melons, and tomatoes, but elsewhere they are farmed with adjacent soils and are planted to the same crops as the adjacent soils.

Plant growth and yields vary according to the moisture and fertility that are maintained. The finer soil material in the upper part of the underlying gravel adds to the moisture-holding capacity; it is not sufficient, however, to form a productive root zone if the upper soil is removed. Many of the more droughty and nonproductive areas in fields are the result of leveling.

Naches soils (0 to 2 percent slopes) (Nd).—This mapping unit consists of undifferentiated areas of Naches soils of various textures and depths to loose gravel. From place to place the areas included vary so much in the texture of the surface layer, development of the subsoil, and thickness of the surface soil and subsoil that it was impractical to show these differences on a map of the scale used (pl. 4*B*).

The principal soils in the mapping unit are Naches loam and Naches sandy loam, each of which is described elsewhere in this part of the report. Areas of Naches loam are the most extensive by far, but the sandy loam soils are important in some areas. The soil in many areas contains some gravel. Areas that contain enough gravel to affect the workability and fertility of the soil materially are indicated on the soil map by symbols. The subsoils in these gravelly areas generally are more rapidly permeable to water and have a lower water-holding capacity than in other areas. The soil in some small areas is so gravelly and loose that it resembles Yakima very gravelly sandy loam.

In many places these various soil types are associated closely in a pattern that evidently was formed by winding streams as they dropped sediments of various textures. The channels of those streams still remain. In most places the profiles of the soils have been so changed by deep plowing and leveling that it is not possible to identify the texture of the original surface soil. Depth to gravel varies within short distances, and areas of gravelly and shallow soil are common.

These soils are normally not affected by salts or alkali. Small somewhat saline areas near Parker are included, however, and also some soils affected more or less by salts or alkali that do not belong to the Naches series. These alkali soils commonly occur as small patches in complex association with typical Naches soils. They actually are a complex made up of Naches soils and varying, but minor, areas of Fiander soil or other saline-alkali soils. Such areas are located south of Parker. They are small and infrequent in the northern part of the Naches soils areas but are more extensive in the southern extension of the Naches soils, or in other words, where Naches soils grade into the Fiander fine sandy loam southwest of Toppenish.

Where the surface soil is finer textured, the alkali-affected soils commonly form slick spots or areas of deflocculated soil. Such spots range from a few feet across to several acres. Generally they are barren and intractable. They are easily seen on fall-plowed fields after the surface has become dry in the spring. These slick spots appear to have developed where the soil material once contained salts that have been partially leached away. Deflocculation and some solonization resulted. In the leaching process, considerable exchangeable sodium was released in the soil. It caused the fine clay particles to become dispersed and separated into grains. It formed a gluey mass that puddles when wet and tends to bake hard when dry. Slick spots are designated on the soil map by a symbol shown in the map legend.

Use and management.—The use, suitability for crops, and management needs of the various Naches soils in this mapping unit are discussed in the descriptions of Naches loam and Naches sandy loam.

The use and management needs of the slick spots are discussed under the description of the Fiander fine sandy loam and in the section, Soluble Salts and Alkali.

Onyx loam (0 to 3 percent slopes) (Oa).—This is one of the more productive soils for most crops, but its total acreage is small. Most areas are in the Stony and shallow soils-Simcoe-Onyx soil association (fig. 2). The soil mainly occurs on nearly level to gently sloping alluvial fans. Some areas, however, occur on the level floors of coulees or on small flood plains along creeks or rivers. Natural drainage is good.

The soil developed under an annual precipitation that on most areas is between 9 and 14 inches. The natural vegetation on Onyx loam consisted mainly of sagebrush and grass.

Onyx loam was formed from recent or young alluvium that was derived chiefly from basaltic and loessial materials and soils formed thereon. Typically there is very little or no difference in texture and structure among the layers below the surface soil. Much of the alluvial material was washed from areas where precipitation was greater and where the material was mainly basaltic. This alluvium is fertile soil material, not yet changed appreciably by its environment. The soil contrasts strikingly with the older Naches soils that have finer textured subsoils, and with the solonized and somewhat infertile Fiander, Scowlale, and Giffin soils, and the alkaline and infertile Umapine and Ahtanum soils. All of these latter soils are older soils that have developed from alluvial sediments. Onyx loam differs from Esquatzel silt loam in being principally noncalcareous, in having a darker colored surface soil, and in occurring under a higher precipitation.

Profile description:

1. Grayish-brown, soft to slightly hard, very fine granular loam; very dark grayish brown and very friable when moist; where undisturbed, upper 2 or 3 inches normally is platy; 6 to 8 inches thick.
2. Soft to slightly hard, massive loam of a color similar to, or slightly lighter, than the layer above; when disturbed, breaks into single grains and soft granules; very friable when moist; 20 to 40 inches thick.
3. Brown, light yellowish-brown, or grayish-brown, slightly hard to soft fine sandy loam, or other stratified, moderately coarse alluvium.

Generally the entire profile is noncalcareous and neutral to mildly alkaline. In small areas, however, the lower part of the soil is slightly calcareous. The supply of organic matter in the surface soil is low to moderate. Except on the upper part of the fans and along coulee channels, the soil ordinarily contains little or no gravel. The soil material is deep, or more than 4 feet on the average. Underdrainage is favorable except in level coulee bottoms that receive seepage from higher irrigated land. The soil is moderately permeable to water and roots and has moderate capacity for holding water available to plants.

In some areas a clay loam subsoil is slightly more prominent than is normal for Onyx loam. A small acreage mapped with this soil has a fine sandy loam surface texture but is similar in other respects.

Use and management.—Many kinds of crops are grown under irrigation on Onyx loam. Some areas are in orchards, and a few are used for dry-farmed wheat.

The irrigated soil is well suited to many crops and highly productive under good management. It maintains good structure and tilth under continued cropping and excessive irrigation and tillage. Most areas are very easy to work. The erosion hazard is slight or is negligible.

Prosser fine sandy loam (0 to 5 percent slopes) (Pa).—This soil of minor agricultural importance occupies low terraces where the floor of the Yakima Valley rests upon basaltic lava flows. Here the river enters a channel entrenched in the basaltic rock. This channel eventually deepens to a canyon. The soil developed under an annual precipitation of 6 to 7 inches.

This soil is arable but occurs in association with outcrops of basalt. It appears to have been derived from shallow mixed material deposited by water over basalt bedrock. Possibly the water-laid deposit was modified later by windblown material. The lower part of the soil is derived from, or influenced by, basalt residuum or is mixed with basalt fragments. Solid rock underlies the soil at depths of a few inches to 3 feet or more. Stones or smaller fragments of basalt are strewn over the surface or in some places are embedded in the soil. The areas that have bedrock near the surface resemble the associated scabland.

Relief is varied; many places are nearly level, but some are undulating or gently rolling and have complex slopes unfavorable for irrigation. The lower parts of a few small depressions that have no outlet are poorly drained. The natural drainage of most areas is adequate, but some areas become poorly drained if irrigated. The natural vegetation consisted principally of sagebrush and some bunchgrass.

Profile description:

1. Pale-brown, soft, nearly structureless fine sandy loam; breaks into single grains and indistinct fine granules; dark grayish brown and very friable when moist; where undisturbed, upper 2 or 3 inches has a platy structure; 7 to 12 inches thick.
2. Pale-brown to light yellowish-brown, soft or slightly hard fine sandy loam or loam contains many small decomposing basalt fragments; nearly structureless and breaks into single grains and indistinct granules; brown and friable to very friable when moist; 8 to 25 inches thick.
3. Basalt bedrock.

In most places the entire soil is noncalcareous and neutral to mildly alkaline; the lower part may be slightly calcareous. The organic-matter content is low to very low. The soil is moderately permeable, but the bedrock prevents free underdrainage. The imperfectly drained areas that result from excessive irrigation or seepage from higher lying irrigated land may have an accumulation of soluble salts.

In places the subsoil appears to have been influenced considerably by material weathered from the basalt fragments. It is a light yellowish-brown, yellowish-brown, or pale-brown slightly compact clay loam that breaks into weakly developed subangular blocky aggregates.

In slightly depressed areas, the surface soil is a light brownish-gray loam; the lower part of the soil is a calcareous friable loam slightly lighter in color; bedrock occurs at depths of 4 to 5 feet.

Use and management.—Prosser fine sandy loam is mainly in small farms where crops are generally grown for home use. A number of crops are grown under irrigation. The rainfall is too low for dry farming to be successful. Frost is too much of a hazard for most tree fruits. The shallow depth to bedrock limits root penetration, and the water-holding capacity is such that the soil is best suited to hardy grapes, potatoes, and shallow-rooted crops. Where depth to bedrock is 3 feet or more, relief is favorable, and drainage is adequate, the soil is fairly well suited to most of the commonly grown field crops, and yields are fairly good. Some areas need better underdrainage or intercepting drains to prevent soluble salts from accumulating. Some acreage is in unimproved pasture of low grazing value.

Quincy loamy fine sand (1 to 7 percent slopes) (Qa).—This light-colored soil developed under an annual precipitation of 6 to 7 inches. It was derived from sandy materials that mainly came from beds of sandy alluvium deposited in lakes. This material has been modified and redistributed by wind. The finer particles were carried away by the wind, and the coarser particles accumulated as sand.

Quincy loamy fine sand apparently has been only moderately shifted by wind. The finer material has not been removed completely. As a rule at depths of 1½ to 5 feet the sandy surface soil is underlain by unconsolidated stratified silty and sandy materials similar to those that underlie the Sagemoor soil. In areas in the Moxee Valley, however, the surface soil is underlain by sandy alluvium.

With few exceptions the areas of windblown sands occupy positions on the lower terraces in the drier eastern part of the county. These areas are arid; the sparse vegetation is similar to that on the soils and sand dunes near the Columbia River.

Windworking has gained entrance to the soil mainly in two kinds of physiographic situations: (1) Where vertical riverbanks or bluffs of soft sediments are exposed to the west winds; and (2) where floodwaters from large coulees have dropped masses of sandy sediments as they spread out over flat terrain. The fresh sandy sediments covered the vegetation, then dried out and became subject to wind action before new plant growth could stabilize them. Animal trails leading to water may also have started wind action in some places.

Once windworking has begun, it may continue to extend east for a considerable distance. The first type of windworking extends eastward from the river bluffs between Zillah and Granger. It also occurs immediately southwest of Emerald and on the bluff north of Mabton. The second type occurs near Outlook, south and east of Sunnyside, in the Satus district, and both west and east of Mabton.

Most Quincy loamy fine sand is in the Quincy-Sagemoor soil association (fig. 2). It occurs mainly where relief is fairly level, gently to moderately sloping, or undulating. Many areas, however, have low dunes or hummocks rising ½ to 1½ feet high. The native cover of sagebrush and grasses is nearly as dense as that on adjacent finer textured soils. The vegetation on unplowed land is predominnatly big sagebrush and cheatgrass, though rabbitbrush, hopsage, other desert shrubs, and scattered bunchgrasses, including Indian ricegrass, grow in places.

Profile description:

1. Light brownish-gray to pale-brown noncalcareous, loose loamy fine sand; falls into incoherent single grains under very gentle pressure; dark grayish brown to grayish brown, loose to very friable, and very slightly coherent

when moist; if undisturbed upper 2 or 3 inches has a weak platy structure in some places; 15 to 35 inches thick.

2. Loose to soft slightly calcareous loamy fine sand slightly lighter in color than layer above; falls into single grains under very gentle pressure; loose to very friable and slightly coherent when moist; in places texture is fine sandy loam; a few white lime veins occur; 5 to 15 inches thick.
3. Strata of gray to light brownish-gray, calcareous sandy and silty lake-laid deposits at depths of 1½ to 5 feet; silty and sandy materials ordinarily are in alternate layers, but in places the material is principally sandy; silty layers are slightly compact, more or less hardened, and thinly laminated.

In places a few boulders of granite or of a number of other kinds of rocks are embedded in the underlying strata. These are near the surface or may be exposed in the hollows between the mounds. They originated from old underlying lake-laid deposits.

In the upper Valley, an area of about 2½ square miles of sandy soils that were formed from windworked alluvial flood deposits are mapped with this soil. They extend for more than 4 miles along the big wash southeast of Moxee. These soils are related to Esquatzel fine sandy loam; they contain fragments derived from basalt and are browner than the typical Quincy soil that overlies beds of material deposited by lakes. These included soils overlie loessial or alluvial deposits at depths ranging from 2 to 4 feet. In places they are noncalcareous, but in some areas the lower part is calcareous. The largest area, however, is saline and predominantly calcareous; it has a lime accumulation of considerable extent in the subsoil.

The upper part of the Quincy loamy fine sand is generally mildly alkaline, and the lower stratified layers are somewhat more strongly alkaline. In places the upper part of the soil is calcareous because some of the underlying calcareous material has been brought up by burrowing animals. The content of organic matter is very low.

Little water runs off this soil during rains. The upper part of the soil is very rapidly permeable to water and has a very low capacity for holding water. The underlying strata are moderately to rapidly permeable and have a higher water-holding capacity.

Use and management.—Much of Quincy loamy fine sand is irrigated. Its agricultural value is limited, however, by its droughty sandy texture and by the difficulty of maintaining its productivity. Organic matter is broken down and dissipated more rapidly in such sandy soils, and plant nutrients are leached away by excessive irrigation. This soil is somewhat difficult to irrigate uniformly without causing erosion. It blows badly when dry if it is exposed to the wind. Also, the grass sandbur is a great problem. Nevertheless, most of this soil that can be reached by irrigation systems has been allotted water and put into cultivation.

Nearly all Quincy loamy fine sand occurs in the Sunnyside district. This soil has been the cause of more controversy over the duty and allotment of water than any other soil mapped in this survey. Various tracts have been allotted 3½, 4, 4½, and 5 acre-feet of water, respectively, by reclassification surveys. Quantities in excess of these amounts must be purchased as excess water. In 1936 it was found that of 1,751 farms of the Sunnyside Valley Irrigation District, 885 used more than 5 acre-feet, 135 used more than 8 acre-feet, and 21 farms used more than 11 acre-feet of water per acre irrigated. It may be assumed that the soil on many of the farms that used the larger quantities of water was Quincy loamy fine sand. The average charge per irrigated acre for operation and maintenance was much higher on the 21 farms than on 807 farms that used an average of 3.73 acre-feet an acre and obviously had finer textured soils.

Where depth to a more compact substratum is not more than 3 feet, loss of water by deep percolation normally is not great. Nevertheless, the depth of the sand and the porosity of the substratum vary greatly within short distances. Most fields have areas where water is lost rapidly by deep percolation. Such areas need large quantities of water and are hard to irrigate.

Except for hops and sugar beets, practically all the crops common in the Sunnyside district are grown on Quincy loamy fine sand. Problems of soil management are much the same for all crops. Profitable yields can be obtained only where favorable moisture is maintained and supplies of organic matter and nitrogen are maintained or increased. A legume cover crop or green manure crop is especially valuable. After a few years of cropping, applications of phosphorus are needed.

Effective irrigation on this soil requires short runs and carefully maintained flumes, pipelines, or other structures. Large streams of water, if turned into long rill ditches, will cause erosion, uneven distribution of water, and greater loss of water through the soil.

Under careful management, good yields of most crops can be obtained on the better tracts of Quincy loamy fine sand, but most of these tracts are used for raising livestock or large flocks of turkeys. In most places these better areas are a part of holdings that include other more valuable land, so farming does not depend entirely upon this droughty soil. Many other holdings, however, consist entirely or partly of the droughty soil, have unfavorable relief, have a south or west exposure, or are open to the wind. Such areas cannot be farmed economically.

On some tracts of this soil, turkeys are raised to advantage. Small areas on the better strips of soil are irrigated and planted to sunflowers and sudangrass or legumes. The sunflowers provide shade for the turkeys, and the sudangrass or legumes serve as pasture. Sandy areas that dry quickly after irrigation are suitable for turkey runs. Other uses that do not depend upon extensive cultivation possibly may be devised for submarginal sandy tracts.

The orchards in the more productive areas consist chiefly of soft fruits. They are limited to a few small tracts on higher slopes. Grapes are grown extensively and appear to be one of the better crops for this soil. Concord grapes will yield as much as 10 tons to the acre. Good growth and high yields of Zinfandel and other wine grapes are obtained.

Asparagus produces well in protected areas, but the plantings will be blown out if exposed directly to the wind on south and west slopes. Asparagus has the disadvantage of needing clean cultivation during the windy spring months and should be protected by windbreaks. Drifting sand injures the young shoots; it causes the tips to curl over to the windward, and the quality is impaired.

In the less droughty patches, alfalfa can be grown. It is one of the better crops for improving the soil, as it furnishes much needed nitrogen and organic matter if used properly. Corn is one of the better crops to follow alfalfa; it can well be planted on fields where large flocks of turkeys have been raised, as it will benefit from the droppings.

Quincy loamy fine sand is a problem soil that can be improved in a short time, or it can be depleted very rapidly. Its productivity can be maintained only through the best of management and careful planning. During years when there is a shortage of irrigation water, it presents a critical problem. Only the better tracts, therefore, should be used as farmland, and the rest should be retired from cultivation. If unimproved its grazing value is low.

Quincy sand (1 to 10 percent slopes) (Qb).—This soil is coarser than Quincy loamy fine sand, less coherent, and normally deeper to silty and sandy strata deposited by lakes. It is also more rapidly permeable, more droughty, and more dunelike.

The relief is undulating to rolling. Low rounded dunes and ridges 5 to 15 feet high are common, and depressions occur that resemble potholes. In these the soil has been blown away so that the underlying compact beds of glacial lake formation, or porous sandy and gravelly glacial outwash or river terrace deposits, are exposed. In many of these depressions, boulders or smaller rock fragments of ice-rafted origin occur erratically. Some depressions are filled with water. The dunes have been partly or almost completely stabilized by a cover of rabbitbrush, big sagebrush, hopsage, desert herbs, and scattered bunches of Indian ricegrass. Low marginal fringes and small level areas near irrigated lands are poorly drained and are mainly saline.

Quincy sand occurs extensively between lower Satus Creek and Mabton. State highway No. 3a passes through the two largest areas. Elsewhere the areas are mostly small. They are associated with Quincy loamy fine sand where the wind has reworked that soil most extensively.

The sand in this soil commonly rests upon beds of gray or light brownish-gray glacial lake deposits that consist of sandy and slightly compact calcareous silts. These generally occur at depths of 3 to 5 feet or more, but the depth may range from a few inches in the depressions to 15 feet in the higher dunes or ridges. In places the sand rests upon sandy or gravelly alluvium or old alluvial deposits.

The upper part of this soil is low in organic matter and is generally mildly alkaline. The underlying silts and sands deposited in lakes are more strongly alkaline. Like Quincy loamy fine sand, this soil contains granite boulders or fragments of other rocks, as well as calcareous material brought up from the underlying strata by burrowing animals.

Little or no water from rain runs off this soil. The sand is very rapidly permeable and has a very low water-holding capacity. The underlying lake-laid strata are less rapidly permeable.

Quincy sand varies in color and texture from place to place because of differences in the materials from which it was derived. The small area on the bluff north of Mabton and an area southwest of Emerald have a high proportion of medium and coarse sand that consists of black basalt fragments; these fragments were derived from beds of black sand that occur in the lower parts of the lake-laid beds. The sands are the color of ordinary black pepper. Because of their small total area, these areas are not mapped separately.

Use and management.—Quincy sand is of little agricultural value. It is used almost entirely as rangeland. Only the small areas occurring within tracts of Quincy loamy fine sand have been leveled and farmed. In such places the soil blows badly and is very difficult to irrigate. Grapes are the only crop that will thrive on this soil.

This soil has very low value as range. The Indian ricegrass makes good forage, but it is sparse and scattered. The arid shrubs afford some browse for sheep, and the low wet areas make fair pasture.

Quincy-Sagemoor-Marsh complex (0 to 15 percent slopes) (Qc).—This complex is not extensive. It consists of dunelike mounds and low ridges of Quincy sand and Quincy loamy fine sand, and some patches of Sagemoor fine sandy loam. The intervening low flats and pothole depressions are either marshy or are filled with water most of the year. There are several permanent ponds.

The margins of the Marsh soil are saline and are covered by saltgrass and greasewood. The dry areas are mostly covered by cheatgrass, rabbitbrush, and weeds. Russian-olive, evidently derived from seeds carried by birds, has become well established over a considerable area. It is widely scattered and occurs as a close-set fringe that borders depressions.

Use and management.—This complex has little value for crops but is used as unimproved pasture. One tract is used as range for goats that browse on the low-spreading Russian-olive trees. Some tracts are used for bird refuges or for raising muskrats.

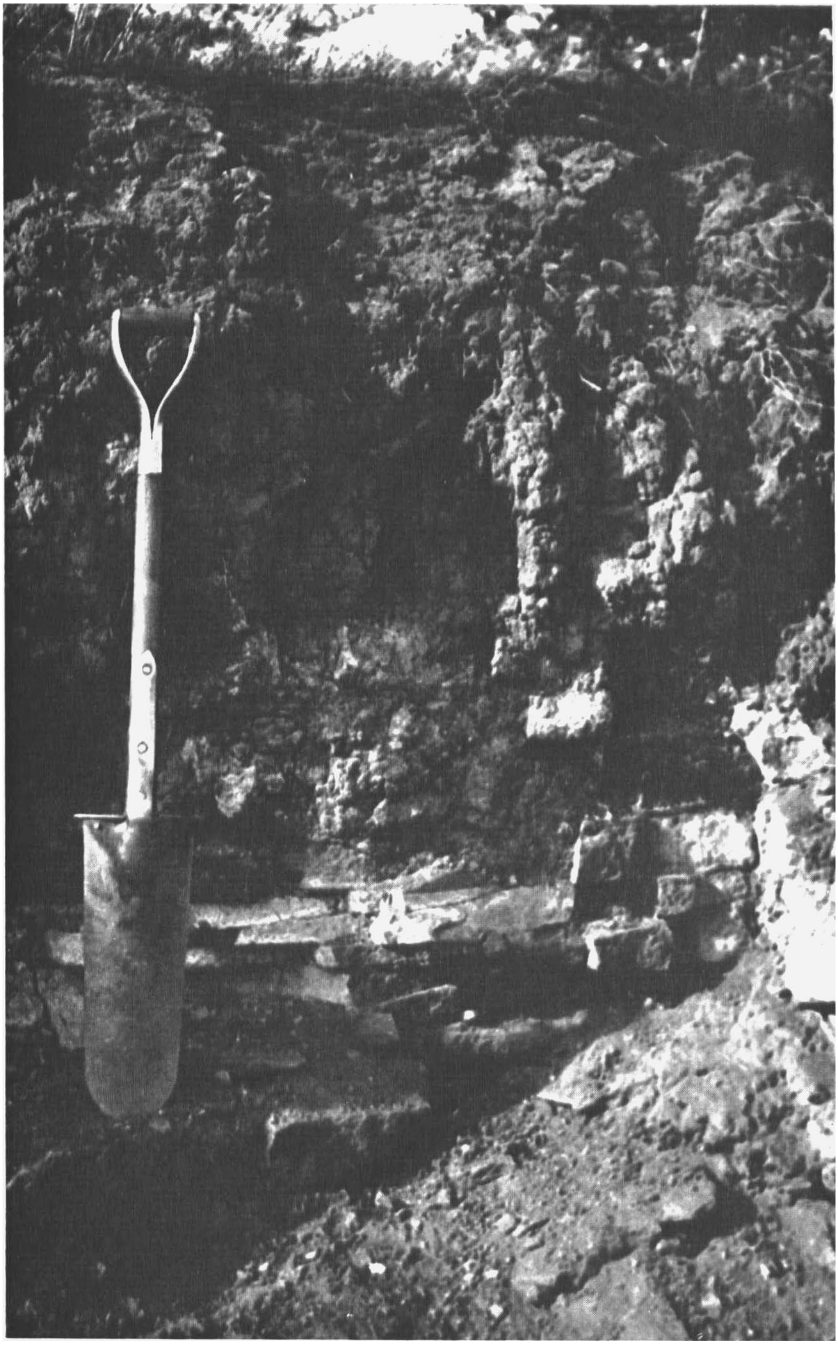
Renslow silt loam (1 to 8 percent slopes) (Ra).—This light-colored, well-drained soil has developed in the western or northwestern extensions of the same blanket of silty windborne material from which the Ritzville soils were derived. The average annual precipitation was 8 to 11 inches. The soil differs very little from Ritzville silt loam. Its surface layer is slightly darker and has a more granular structure and its subsoil is slightly more compact. As a rule the depth to the horizon of lime accumulation is greater also.

This soil is distributed irregularly on the uplands, plateaus, and flanks of the ridges. Most areas occur in the Renslow-Simcoe-Onyx soil association (fig. 2). The areas are dissected by coulees, steep slopes, and bodies of Stony and shallow soils or scabland. They are widely separated by intervening ridges and valleys. The relief is undulating to gently rolling. The natural vegetation was mainly big sagebrush and some grasses.

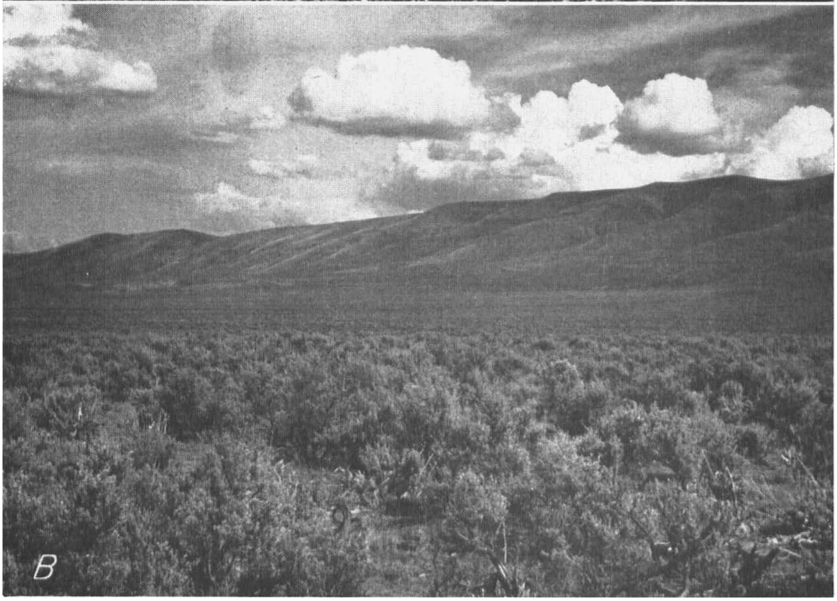
Profile description:

1. Brown, pale-brown, or light brownish-gray, noncalcareous, slightly hard to soft silt loam that crushes into weakly developed granules and single grains; very dark grayish brown to dark grayish brown and very friable when moist; top ½ inch in virgin soil is distinctly vesicular; the next lower 2 inches is very thin platy, and the next lower 2 or 3 inches is thick platy; 6 to 9 inches thick.
2. Brown to pale-brown, noncalcareous, slightly hard silt loam; nearly structureless and breaks into single grains and indistinct very fine granules; dark grayish brown and friable to very friable when moist; 8 to 12 inches thick.
3. Brown to yellowish-brown, noncalcareous, slightly compact to heavy silt loam that breaks into hard to slightly hard, subangular blocky aggregates about ¼ to ½ inch across; contains a moderate number of fine pores; dark brown and friable to firm when moist; lower part may be harder and the structure less distinct; 20 to 35 inches thick.

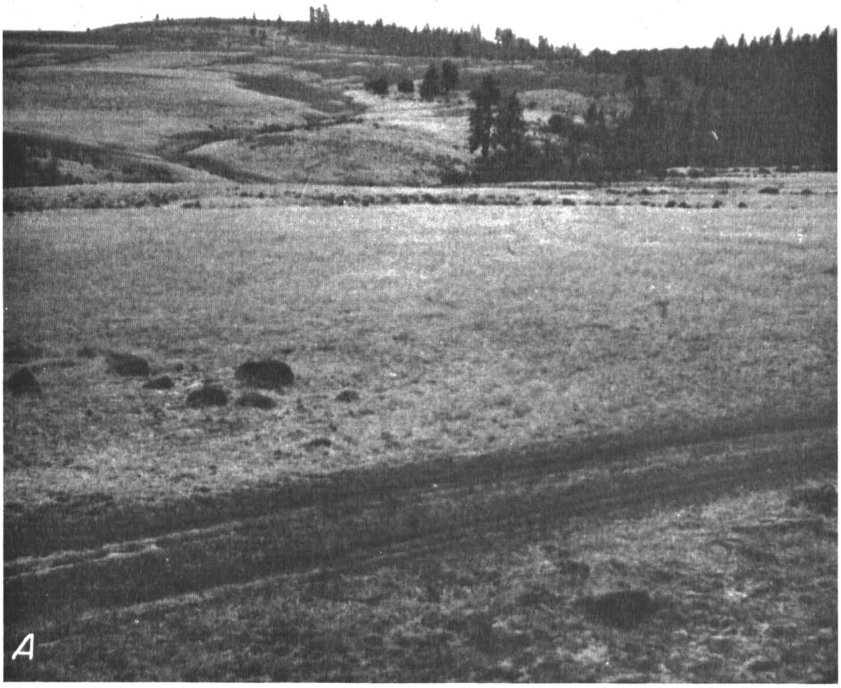
Cut in Ritzville soil, on Horse Heaven plateau south of Mabton, showing silt loam over loess.



Cut in Tieton loam on Naches Heights shows moderately developed profile over andesite bedrock.



A, Sugar beets and orchard on Naches soils south of Wapato; hop ranch in right background.
B, Sagebrush on Renslow silt loam southeast of White Swan; Stony and shallow soils, and Steep broken and stony land on slopes of Toppenish Ridge in background.



A, Scabland and Stony and shallow soils overlying basalt; irregular growth of pines in background borders these miscellaneous land types.
B, Apple orchard on Tieton loam in Naches Heights district; hillocks in background consist of jumbled piles of andesite lava rock, called scabland.

4. Pale-brown to light yellowish-brown, hard to slightly hard silt loam or loam, contains a small to moderate number of white lime veins; friable when moist; 6 to 12 inches thick.
5. Pale-brown to light yellowish-brown, noncalcareous slightly hard, loessial parent material of silt loam or loam texture; variable thickness.

The upper part of Renslow silt loam is generally neutral, and the lower part generally mildly alkaline. In places the soil is noncalcareous to the underlying substratum, or is calcareous below a depth of about 3 feet. The surface soil has a moderately low content of organic matter. The soil above the underlying substratum is moderately permeable to water and roots.

Like Ritzville silt loam, the principal variations that occur in Renslow silt loam are in depth of the loessial material and in the formations it overlies. The underlying strata in some places consist of caliche or lime-coated old gravel, sandstones, or other sedimentary beds, deposited by water, or of basalt, which is more common at the higher altitudes. The soil is generally 3 feet or more in depth and is not affected greatly by the rocks it overlies. The texture of the surface soil ranges from silt loam to very fine sandy loam. In profile characteristics this soil grades to Ritzville silt loam, and the boundaries between them are arbitrarily drawn.

Use and management.—Although Renslow silt loam is one of the more desirable and more fertile upland soils, it occurs in the semiarid rangelands and dry-farming areas entirely above irrigation systems. Wheat can be grown successfully only on the higher lying plateau areas. Most of the rest of the soil is used for unimproved pasture, but its value for grazing is moderate.

Most of this soil that occurs on the smoother parts of the plateau between Naches River and Wenas Creek is dry farmed. Although it occurs at altitudes that range from 1,700 to 2,200 feet, the areas are subject to the drying effect of downflowing air from the nearby mountains. Yields of 8 to 10 bushels of wheat an acre are normally obtained. Winter rye is a more dependable crop.

The larger and more productive areas of Renslow silt loam cover about 6 square miles. They occur in a transitional zone between the more arid Ritzville silt loam soils and the darker colored Bickleton silt loam on the plateau in the upper Glade Creek district. This area has been successfully dry farmed for many years. Farming practices are similar to those used on the associated Ritzville soils. Both winter and spring wheats are grown, and yields of 15 to 20 bushels to the acre are ordinarily obtained.

Ritzville silt loam (1 to 8 percent slopes) (Rc).—This light-colored, well-drained soil is agriculturally the most important soil in the more arid part of the uplands. Its relief is generally nearly level, gently undulating, or rolling, but some areas are hilly.

The soil was developed under an annual precipitation of 7 to 9 inches. It was derived from silty windborne material, or loess, which forms a mantle over much of the uplands (pl. 5). This uniform windborne deposit apparently originated from a great variety of rocks and minerals.

In Yakima County, as in much of the semiarid and arid country west of the Columbia River, the loessial cover appears to have been thinner originally than on areas east of the river. Under the sparse

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vegetation common to the more arid parts of the Northwest, much of the surface soil has been removed by natural erosion, but over large areas it is still several feet thick.

Areas of Ritzville silt loam are the most extensive on smooth plateaus at higher altitudes and on north slopes of the ridges where a more abundant vegetation has protected the surface from erosion. It is the principal soil in the Ritzville-Stony and shallow soils-Esquatzel soil association (fig. 2). It also occurs on large areas in the Burke-Ritzville-Roza soil association.

This soil is more arid than areas of Renslow silt loam that have developed from similar parent materials. Surface runoff ranges from slow to rapid. The natural vegetation consisted principally of big sagebrush and some bunchgrasses and other grasses.

Profile description:

1. Pale-brown, noncalcareous, soft to slightly hard silt loam or loam; breaks into single grains, indistinct very fine granules, or a dustlike mass; dark grayish brown and very friable when moist; when dry, the top ½ to 1 inch of the virgin soil is generally distinctly vesicular; next lower 2 inches is very thin platy; 5 to 7 inches thick.
2. Pale-brown to light yellowish-brown, noncalcareous, soft to slightly hard silt loam or loam; nearly structureless and breaks into single grains, indistinct very fine granules, or a dustlike mass; dark grayish brown to brown and very friable when moist; commonly has a small to moderate number of fine pores and roots; 20 to 32 inches thick.
3. Light yellowish-brown to pale-brown, mildly to moderately calcareous, soft to slightly hard silt loam or loam; nearly structureless and breaks into single grains, indistinct very fine granules, or a dustlike mass; dark grayish brown and very friable when moist; in most places lime is segregated to some extent as fine white veins; small to moderate number of fine pores; 18 to 30 inches thick.
4. Light yellowish-brown, very pale brown, or pale-brown, soft, massive silt loam, loam, or very fine sandy loam; crushes into a single-grained powderlike mass; in places calcareous, but the lime is disseminated; various thicknesses.

Typically the upper part of Ritzville silt loam is neutral to mildly alkaline, and the lower part, mildly alkaline. The surface soil has a low organic-matter content. A characteristic of this soil is its ability to stand vertical when cut by ditches, roads, and other excavations. Also in such cuts, vertical cracks are quite noticeable; they are spaced about 3 to 8 inches apart and extend 2 to 3 feet downward from the surface. The soil is permeable to water and roots, and perched water tables are rare. The fairly uniform medium texture and depth of this soil are very favorable for retaining available water.

The principal variations in this soil are in depth, slopes, and character of the underlying rocks or deposits. In many places at the lower limits in altitude, the loessial parent material overlies beds of compact glacial lake deposits. The areas where the layer of loessial material is less than 3 feet thick are mapped as Sagemoor loam, compact subsoil.

Higher on the flanks of the ridges, the minimum depth of Ritzville silt loam is about 3½ feet. Here it occurs on smoother or more protected places in association with the Harwood, Selah, Burke, or Roza soils; it overlies cemented gravel, basalt fragments, buried soils, caliche, conglomerate, sandstone, or shale.

On the higher slopes and plateaus, the loessial material overlies basalt bedrock at depths that range from a few inches to many feet.

In these areas Ritzville silt loam is the predominant arable soil; it occurs in association with Stony and shallow soils, Scabland and Smooth stony land, and the steep rocky slopes along coulees and canyons. In many areas of this soil there are patches where the depth of the loess is less than 3½ feet. In a few places, reworking of the loess by wind has produced a very fine to fine sandy loam surface soil.

In several places, especially where the soil is shallower, the subsoil or lower subsoil is slightly harder and more compact and has a weakly developed subangular blocky structure somewhat resembling that of the subsoil of Renslow silt loam. Also, in some similar locations, the subsoil has a greater accumulation of lime than is typical.

Use and management.—Most Ritzville silt loam lies above irrigation ditches. Important areas are irrigated, however, in the orchard districts west and north of Yakima, in the vicinity of Moxee, under the Indian Ditch south of Ahtanum Creek, and in several places under the Roza Canal in the lower Valley. Many of the irrigated areas are nearly level to gently sloping. Such areas occur in the vicinity of Moxee and west of Yakima and are very productive.

If irrigated this soil is well suited to all of the fruits and other crops grown in the Valley. It needs legumes in crop rotations (*20*) and manure to keep up the supply of organic matter and nitrogen (*17*). The older farmlands need phosphorus fertilizers.

Ritzville silt loam that lies above irrigation systems covers a large area of arid and semiarid rangelands. It is the predominant soil of the dry-farming areas on the Horse Heaven plateau and along Glade Creek. Here, in common with large areas east of Columbia River, it is one of the most arid soils used for dryland wheat farming. The average annual precipitation is the lowest known to support wheat production. It is possible to grow wheat because the winters are mild and comparatively short, and the deep uniform medium texture of the soil absorbs and holds the winter moisture. Summer-fallowing is essential, as it is necessary to use the moisture accumulation of two winters and the nitrification of two summers to produce one crop (*11*).

Although this soil occurs at altitudes of 1,000 to 2,500 feet, the differences in profile characteristics are slight. Successful dryland wheat production, however, is possible only on plateau areas that are generally at altitudes above 1,700 feet (*18*). Wheat is chiefly confined to the Horse Heaven and Glade Creek country. Past attempts to dry-farm lower areas were soon abandoned. The rainfall is greater at the higher altitude. The better growth of wheat on the higher land, however, can be attributed partially to cooler temperatures, higher humidity, which results in less evaporation, and longer retention of the moisture into the growing season.

The land to be summer-fallowed should be broken as early as possible in spring with a diskplow. This leaves the soil rough and does not bury the stubble. The roughness and stubble protect the soil from blowing, which is a considerable hazard to dry farming. Rod-weeders that leave clods and stubble on the surface are in common use.

This friable medium-textured soil is easy to till. Using modern tools, an exceptionally large acreage can be farmed per man employed. Since small modern tractors were developed and the wheatland type diskplow came into use, tillage has been accomplished much faster.

The introduction of early Baart spring wheat has added to the security and permanence of dry farming.

As a result of several years of favorable moisture and abnormally high yields of 20 to 25 bushels to the acre, wheat raising has been extended back to a fringe of drier marginal land where cultivation was once abandoned. It should be recognized that such yields will not continue. As the organic matter and nitrogen are depleted, or as a cycle of drier years and wind erosion comes, the yields will decrease. The normal yield is judged to be in the range of 5 to 15 bushels an acre every second year. The actual yield in any specific location will depend on altitude, relief, exposure, and weather.

Ritzville silt loam, strongly sloping (8 to 15 percent slopes) (Rd).—This soil is mapped within the irrigated districts of the upper Yakima Valley or closely adjacent to them. It occurs in small patches normally on the north, east, or southeast side of the slopes. Natural erosion has generally removed much of the loessial material from the south and west slopes. Areas 2 miles northwest of Yakima are shallow, but in most places this soil is of average depth. North- and east-facing slopes are most protected from sun, wind, and excessive evaporation. These slopes have more abundant vegetation to protect the surface soil from erosion, and in these places the soil commonly has greatest depth and fertility.

Use and management.—Ritzville silt loam, strongly sloping, is not well suited to intertilled crops because it is difficult to irrigate it without causing erosion. It is best used for permanent plantings that permit a close-growing crop to be grown. All tree fruits are suited to it, and they allow planting of cover crops between the rows. Some of the more thrifty and productive orchards are on steeper north- and east-facing slopes. Careful irrigation is essential, and pipelines or good flumes are needed to insure water delivery. Where controlled streams are trickled down the rills through a thick mat of alfalfa or well-established perennial cover crop, there is little evidence of erosion.

Ritzville and Renslow silt loams (1 to 8 percent slopes) (Rb).—Large areas of these soils occur in the northeastern part of the county, particularly on Yakima Ridge, on the Rattlesnake Hills, or in adjacent areas. These soils are mapped in somewhat less detail than those on the irrigated areas. They are classified as Ritzville and Renslow silt loams. Some areas are very similar to Ritzville silt loam, but others resemble Renslow silt loam. Many areas are transitional between these two soil types. These soils were derived from loess. They have developed under an annual precipitation of 8 to 11 inches.

Generally the soils at the lower altitudes are similar to Ritzville silt loam; those at the higher altitudes more nearly resemble Renslow silt loam. The soils that occur at higher altitudes have very slightly darker and slightly more granular surface soils, harder and more strongly subangular blocky subsoils, and greater depth to calcareous material. Also the soils that have more extensive north and northeast slopes more nearly resemble the Renslow soil. In contrast, those that have south and southwest slopes have more of the characteristics of the Ritzville soils. Practically all areas of these soils occur in the upland range areas covered by sagebrush and grass. They are well above any foreseeable irrigation system. For this reason many transitional variations were not mapped separately.

Ritzville and Renslow silt loams generally have undulating to gently rolling relief, but some areas are steeper. Many areas are interrupted by dissecting coulees, steep slopes, or bodies of Stony and shallow soils or scabland.

Use and management.—Practically all areas of Ritzville and Renslow silt loams are used as sagebrush-and-grass range, but a few are planted to grain and are dry farmed. The prevailing practices, crop adaptations, and management needs resemble those of either the Ritzville or Renslow soils.

Riverwash (0 to 1 percent slopes) (Re).—This miscellaneous land type occurs along all of the perennial streams. It occupies large areas bordering the Yakima, Naches, and Tieton Rivers. It consists of recent deposits of fairly loose cobblestones, gravel, and sand, and of areas of silt. Originally it was subject to periodic floods. Since streams have been controlled by storage reservoirs and water has been diverted for irrigation, the land is no longer flooded every year. It has a very low water-holding capacity.

Some areas of Riverwash occur on the level bottoms of coulees, and others around margins of the valleys of intermittent streams, where floodwaters have spread out upon the smooth terrain. In some of these areas, a fairly large quantity of finer alluvial soil material is mixed with the coarser sand, gravel, and cobblestones, and the wash is less droughty. Most of these areas are small, and some are covered by sagebrush and grasses.

Use and management.—There is an extensive growth of cottonwoods, willows, and brush along the rivers, but much of this land consists of open gravel and bare sandbars. The wooded areas supply fuel and logs and poles for building sheds and corrals. The brush is of some value as a winter cover for livestock.

Riverwash is used for pasture because sweetclover and grass grow where small areas of soil material are subirrigated by the streams. In the Yakima Valley, practically all of the sand and gravel used for concrete work is taken from deposits along the Yakima River.

Rough mountainous land (Rf).—This miscellaneous land type covers a comparatively small area and occurs only in the higher northwestern part of the county. Most of it is at altitudes greater than 2,500 feet. It occurs mainly on higher foothills and mountains that rise above the valleys along the upper reaches of the Naches and Tieton Rivers and Wenas Creek. The rainfall supports a growth of ponderosa (western yellow) pine and an undergrowth of bitterbrush, grass, and herbaceous plants. The trees vary considerably in size and density of stand because of differences in altitude and exposure. No trees grow on the exposed ridgetops or on slopes that face south. Dense groves of fairly large trees grow on protected north and east slopes.

The lower boundary of this land type is along the lower, drier, eastern extension of the scattered growth of pines. At this boundary it generally grades to Steep broken and stony land. The chief differences between the two land types is that Rough mountainous land occurs at higher altitudes and has a cooler, moister climate and a more extensive forest cover.

Rough mountainous land consists mainly of forested mountains and steep and broken foothills. Much of it is precipitous cliffs and talus slopes. The gradient of most slopes exceeds 20 percent, but some areas on small ridgetops and benches and in valleys are not so steep.

This land is predominantly stony and shallow over bedrock, which is mainly basalt, andesite, or tuffaceous sandstones, shales, and conglomerates. In protected places and on the gentle slopes, particularly on the northern and eastern exposures, the soils are commonly deeper and less stony. In the more open areas where the predominant vegetation is grass, shrubs, and herbaceous plants, some of the deeper soils that overlie basalt resemble Simcoe clay loam (*1*) (*7*), and some resemble the Underwood soils mapped in southwestern Washington (*10*).

Use and management.—Because it is so steep and stony, this land is unsuitable for either irrigated or dryland farming. It is used mainly for forestry and grazing and its value for these purposes varies considerably. The cliffs have little value for either use. In general, except under the denser forests, this land supports an abundant growth of grasses, herbaceous plants, and shrubs, which in grazing value is much superior to the growth farther east in the more arid regions. Most areas, however, have been overgrazed.

Roza gritty loam (2 to 20 percent slopes) (Rk).—This soil is of only minor importance agriculturally. Areas are small and widely distributed. It has developed under an annual precipitation of 6 to 8 inches. Surface drainage is slow to rapid.

Roza gritty loam occurs chiefly in the Burke-Ritzville-Roza soil association (fig. 2). It generally occupies the flanks of the larger ridges and other uplands, where the relief is complex and rugged. The underlying Tertiary sedimentary beds were derived principally from light-colored acidic volcanic rocks. These beds consist of soft, easily weathered, very light gray tuffaceous sandstones of varied textures, white volcanic ash, gray shales, and conglomerates composed of well-rounded pebbles worn from light-colored lava fragments. Beds of well-rounded, light-brown quartzite gravel occur in some places.

The beds are folded in conformity with the general structure of the prominent landforms. On the naturally dissected flanks of the ridges, the dip of the strata in some places conforms approximately to the land surface, or in others the strata drop away at a steep angle. Thus, a soil area overlies a single bed or the edges of many different beds; some areas consist of so many soils of various textures and stages of development that it was not feasible to separate them on a map of the scale used.

Although Roza gritty loam was derived predominantly from material weathered from underlying tuffaceous sandstone and shale, the upper part in many areas was formed from or influenced considerably by a mantle of loess or silty windborne material deposited over the underlying residuum.

This soil has formed from materials similar to those underlying Cowiche and Taneum soils. It occurs generally in a drier climate, however, has a lighter colored surface soil, is shallower, and generally has a more strongly developed subsoil. Where it occurs on gentle slopes, Roza gritty loam normally has a strongly differentiated profile. The very compact clayey subsoil is somewhat similar to that of the Selah soil.

Profile description:

1. Light brownish-gray to light-gray, noncalcareous, slightly hard to soft gritty loam or light sandy clay loam; moderately or strongly developed very thin platy structure when undisturbed; dark grayish brown and very friable when moist; when dry, the top ½ to 1 inch is distinctly vesicular, but it is softer and less vesicular in bare places under each clump of sagebrush; 3 to 4 inches thick.
2. Material much like that above but generally of thicker platy structure in the upper part and weaker fine granular structure in lower part; 3 to 6 inches thick; abrupt transition to lower layer.
3. Pale-brown to brown, noncalcareous, very compact sandy clay or gritty clay; weak to moderate prismatic structure; breaks into very hard, dense, subangular blocky or blocky aggregates ¼ to ¾ inch across that have a lacquerlike colloidal coating; brown and very firm when moist; plastic and sticky when wet; 6 to 13 inches thick.
4. Pale-brown, light yellowish-brown, or pale-yellow, hard, compact sandy clay loam or clay loam; grades into heavy sandy loam; contains a few pebbles and fragments of light-colored tuffaceous rock, as well as veins, streaks, and splotches of white lime; structure is weak blocky to massive; firm to friable when moist; 6 to 12 inches thick.
5. Decomposing tuffaceous sedimentary rocks presumed to be of the Ellensburg formation; mainly semiconsolidated sandstone; calcareous principally in vertical cracks and between strata in upper part.

The upper part of the soil is neutral to mildly alkaline, and the lower part mildly alkaline. The content of organic matter in the surface soil is low to very low. The subsoil is very slowly to slowly permeable to water, and the capacity of the soil for holding water available to plants is low.

Soils that have various characteristics are mapped with Roza gritty loam. These soils formed over alternating beds of sandstone and shale. In places they were influenced by a mantle of loessial or sandy local alluvial material. Most areas of Roza gritty loam actually consist of a complex of soils having various textures and other characteristics. The texture of the surface soil ranges from sandy loam to clay loam within short distances, and the profile characteristics vary according to relief. The above profile is only one of several profiles included in this soil as mapped, but it is the predominant one.

Soils mapped with Roza gritty loam have less prominent profile layers. In places they have a thin surface layer of silt loam derived from loessial material or a surface layer of sandy loam that evidently originated from local alluvial deposits. On stronger slopes, the soils are shallower, show less development, consist mainly of decomposing sandstone or shale, and are gravelly in places. Here, outcrops of the parent rock are common.

Generally depth to the decomposing bedrock is shallow, as a rule only about 20 to 30 inches. In places little or no lime has accumulated above the decomposing rock strata. In places a thin lime-cemented hardpan occurs just above the bedrock.

Use and management.—Roza gritty loam that occurs in the orchard districts north and northwest of Selah is almost entirely under irrigation. The rest of this soil is used chiefly for range, which has low grazing value.

This soil is difficult to till and to irrigate properly. As a rule the bottoms of the furrows lie in the clay subsoil and water does not soak in readily. The erosion hazard on the more sloping areas is fairly high. Such areas are not well suited to clean cultivation of intertilled crops but may be used for permanent plantings of short-lived fruit trees or grapes. A mixed pasture of legumes and grasses will thrive on the shallow areas if they are irrigated frequently, their organic-matter content is improved, and the subsoil is made more permeable.

Roza clay loam (2 to 20 percent slopes) (Rg).—This soil is distinguished from Roza gritty loam principally by its finer texture and by the difference in parent material. It was derived principally from material weathered from light greenish-gray, purplish-gray, or pinkish-gray, noncalcareous very fine grained shales. It has developed under an environment similar to that of Roza gritty loam, and it occurs also in the Burke-Ritzville-Roza soil association (fig. 2). Areas are small and scattered. Most of this soil occurs on the hills north of Selah and is under irrigation.

The reaction and organic-matter content of Roza clay loam resemble that of Roza gritty loam, but it is more slowly permeable to water, especially in its upper part. A number of soils that have profiles that deviate from the predominant one are included in this mapping unit. The chief variations are differences in shades of grayish color and in the character of the underlying shale. In places a thin layer of loam or sandy loam surface soil, which is rarely more than 4 inches thick, overlies the clay loam or sandy clay surface layer. The texture of the surface soil ranges from sandy clay loam to clay.

Use and management.—Roza clay loam is difficult to till and to irrigate. It has little agricultural value. Most of it that lies below an irrigation system is left idle. On exposed slopes on the arid and semi-arid rangelands, however, it is well suited to winterfat (or white sage), a small shrub of considerable forage value.

Roza gravelly loam (2 to 20 percent slopes) (Rh).—This soil has formed under an environment somewhat similar to that of Roza gritty loam. It is coarser textured or more gravelly than Roza gritty loam, slightly more permeable, and more variable from place to place. Some areas occur where beds of conglomerate cap mesalike remnants of an ancient land surface; others occupy slopes where gravel from outcrops of conglomerate are scattered through the surrounding soil. This soil occurs chiefly on the rough southern flanks of the Rattlesnake Hills.

The areas that occupy the mesalike remnants of a higher land surface as a rule are gently sloping, except near their edges where the tableland breaks away to steep escarpments. Other areas occur on low ridges, gently rounded low hills, or on a foot-slope fringe below Steep broken and stony land. Some of the more shallow and gravelly areas are mapped with Stony and shallow soils.

Use and management.—Roza gravelly loam is of little importance agriculturally, as only a few hundred acres could be irrigated. The greater part of the irrigated acreage consists of hilly areas that lie below the new Roza Canal north of Buena. Other small scattered areas are north and west of Selah. As the soil is shallow and gravelly, it is better suited to soft tree fruits or grapes grown along with permanent cover crops. The more sloping areas are difficult to irrigate and highly erodible.

Roza sandy loam (2 to 20 percent slopes) (Rl).—This soil has formed mainly from residual material weathered from the coarse gray tuffaceous sandstones abundant in the Ellensburg formation. It has developed under an environment similar to that of the associated Roza gritty loam. Except for its coarser texture and slightly more rapid internal drainage, it resembles that soil in most of its significant characteristics.

The depth to bedrock is 1 to 3 feet or more, but the soil is predominantly rather shallow. In some places the bedrock is hard and in others 4 feet or more of it may be softened sandstone. The texture of the surface soil ranges from fine sandy loam to coarse sandy loam. In places a few pebbles or small cobblestones are on the surface or occur throughout the soil.

In some of the smoother areas, a thin, weakly or strongly cemented, lime-and-silica hardpan lies over the decomposing sandstone at a depth of about 2½ feet. In other places, especially on the stronger slopes, the subsoil consists of slightly sticky coarse sandy or gravelly clay loam that is more permeable than elsewhere. Locally the soil is noncalcareous except for streaks of it in cracks and between layers of the decomposing bedrock.

Use and management.—Most of the Roza sandy loam occurs above the present irrigation systems. It provides range grazing of rather low value. Its use and suitability for irrigated crops resemble those of Roza gritty loam. It is not well suited to intertilled crops but is more suitable for grapes and short-lived fruit trees such as peaches. The soil is difficult to irrigate properly, and the erosion hazard on the more sloping areas is fairly high.

Sagemoor very fine sandy loam (1 to 7 percent slopes) (Sd).—This light-colored, well-drained soil is important to the agriculture of Yakima Valley. Because of its peculiar profile and high lime content, it presents unusual problems of use and management. The soil occurs principally in the Sagemoor-Esquatzel and the Quincy-Sagemoor soil associations (fig. 2). It covers most of the "Island," an isolated remnant of benchland 12 miles west of Toppenish. It is the predominant soil along the Sunnyside Canal between Zillah and Sunnyside and in the vicinities of Grandview and Outlook.

Sagemoor very fine sandy loam generally occupies nearly level, gently sloping, or moderately sloping benchlands or terraces, some of which are rather low. The continuity of the surface commonly is interrupted by many intermittent drainageways, locally called coulees, that cross the terraces. Some of these are deeply entrenched and bordered by escarpments.

This soil has developed under an annual precipitation of 6 to 7 inches. The natural vegetation was principally big sagebrush and some grasses.

The soil overlies and was partly or entirely derived from beds of light-gray, calcareous, water-laid materials. Evidently these beds are glacial outwash or lake deposits. The sediments are well sorted and, in greater part, stratified as thin alternating layers of fine sandy loam and silt loam. In high banks these layers look like the annual rings of a tree. The material appears to be mainly glacial rock flour. This rock flour was ground by the continental ice sheet that lay in the drainage basin of the Columbia River to the north and was washed into the basins east of the Cascades at some period in midglacial time. It was deposited when the river passage through the mountains was blocked.

In general Sagemoor very fine sandy loam occurs at middle or lower altitudes where the beds, deposited in lakes, are more sandy, less silty, less compact, and more permeable. In this respect it differs from Sagemoor loam, compact subsoil, which occurs chiefly on the higher parts of these lake-laid beds where the more compact and silty strata are more pronounced.

Occasionally large boulders and smaller fragments of granite and other hard rocks foreign to the drainage basin of the Yakima River occur in this soil. The kind of rock fragments and their being at altitudes up to 1,200 or 1,300 feet indicate that they probably were picked up by ice in the upper drainage basin of the Columbia River, carried by ice floating in a glacial lake, and finally dropped in their present positions. Apparently the sedimentary deposits once filled the basins to an altitude of approximately 1,250 feet. Definite beach lines have been obliterated by erosion or covered by loess. They are indicated only by the upper limits of the sedimentary beds and by erratic boulders.

After the Yakima River and other major streams had reestablished their valleys in the soft lake sediments, deposits of loess gave the land a new surface cover. In many areas the upper part of this soil is influenced in varying degrees by loess or is derived from it. The influence of loessial material is less than for the Sagemoor loams.

Profile description:

1. Light brownish-gray to pale-brown, noncalcareous, soft to slightly hard very fine sandy loam or loam; dry virgin soil has a thin platy structure under a vesicular layer in the upper ½ inch; dark grayish brown or olive brown and very friable when moist; 2 or 3 inches thick.
2. Noncalcareous, soft to slightly hard very fine sandy loam similar in color or slightly lighter than layer above; nearly structureless and falls easily into a mass of single grains and indistinct very fine granules; very friable when moist; lower part, in places, slightly calcareous; 10 to 20 inches thick.
3. Light-gray, moderately to strongly calcareous, slightly compact, slightly hard to hard loam or silt loam; distinct very thin platy structure; contains a few fine pores and has many small white lime veins and coatings in cracks and channels and between strata; grayish brown to light olive brown and friable to firm when moist; 4 to 8 inches thick.
4. Light-gray to light brownish-gray, moderately to strongly calcareous, soft very fine sandy loam; nearly structureless or weak thin platy; generally breaks into single grains; grayish brown or light olive brown and very friable when moist; lime is not segregated or only faintly segregated; 4 to 8 inches thick.
5. Alternating layers of light-gray, light brownish-gray, or light olive-gray fine sandy, loamy, or silty unconsolidated deposits, each layer generally only a few inches thick; layers of very fine sandy loam, fine sandy loam, and loamy very fine sand predominate, but layers of slightly compact loam or silt loam are common, especially in the upper part; finer textured material is calcareous, and the lime generally disseminated; some of the coarser material is not calcareous.

The surface soil has a low to very low organic-matter content and is generally neutral to mildly alkaline. The lower layers are mildly to moderately alkaline. The soil is moderately permeable. The capacity for holding water available is moderate. In some of the lower and more nearly level areas, seepage from higher areas and excessive irrigation may produce a high ground water table and result in the accumulation of excess soluble salts.

Sagemoor very fine sandy loam is somewhat variable in texture, subsoil compactness, and in depth to the silty or sandy layers. Small areas that have a surface soil of fine sandy loam, loam, or silt loam are mapped with the Sagemoor very fine sandy loam. The surface soil in some places is more a light yellowish brown. The depth to the light-gray laminated layers of silt loam or loam ranges from about 12 to 42 inches. In places, however, on the slopes bordering coulees, erosion has reduced this depth to a few inches and the light-gray limy material is turned to the surface when the land is plowed. Where the soil adjoins Sagemoor loam, compact subsoil, the subsoil is somewhat more compact in places and less permeable than normal.

Use and management.—Most of Sagemoor very fine sandy loam is used for irrigated crops. The rest is chiefly in range pasture. The climate is too dry to grow dry-farmed wheat successfully.

Although there are local differences in frost hazard, underdrainage, salt accumulation, and supply of irrigation water, this soil is well suited to most fruits and to the usual crops grown in the Yakima Valley. Generally the underdrainage is adequate, and little seepage or salt accumulation occurs except in low-lying level areas such as the one at Outlook. Even here the soil is moderately permeable, and the salts could easily be leached out and the land reclaimed if deep, well-placed drains were installed to lower the water table.

This soil produces high yields of many different crops. It is naturally so low in organic matter and nitrogen, however, that virgin areas will scarcely produce one cash crop if nitrogen fertilizer is not used or a legume grown first. In the past the common practice was to grow alfalfa for several years and then to maintain the nitrogen supply by including alfalfa in short crop rotations. Alfalfa is the common cover crop in orchards and should be planted to protect the soil when young trees are first set out.

Grapes have been grown recently without a cover crop. Legumes that are suitable as a cover crop for vineyards must be found soon or the soil will become depleted. Cropping continuously without adding organic matter injures the soil structure and tilth. Applications of as much as a hundred pounds of ammonium sulfate to an acre can be used safely where cornstalks, heavy stubble, or weeds are plowed under. Straw, strawy manure, and old stack bottoms may be fortified with ammonium sulfate or other fertilizer containing nitrogen and spread upon the soil.

Organic matter is depleted when irrigated crops are grown on this soil, because the growing season is long and the climate is warm and arid. Building up or maintaining organic matter at a high level is difficult. A high content is not necessary for continued productivity, but a moderate amount of decomposing plant material must be kept in the soil so that a small day-to-day supply of nitrogen and other plant nutrients will be released for growing plants. Careful irrigation is needed to prevent erosion. Supplies of organic matter, nitrogen, and phosphorous must be maintained by using proper crop rotations, fertilizers, and cropping methods. The Sagemoor soils, if intensively cropped, are the first to show phosphorus deficiency. Probably the original content of phosphorus was lower in these soils, or the abundant lime in the lower part has tied up part of the phosphorus in a form not available to plants.

Livestock farms and areas liberally manured generally do not show phosphorus deficiency. Areas that have been cash-cropped, particularly those where alfalfa hay has been grown commercially for a long time, respond markedly to fertilizers that contain phosphorus. Phosphates, chiefly treble superphosphate, have come into general use on the Sagemoor soils. Many farms need more phosphate than they have received. Phosphates can be applied in several ways. For alfalfa 100 to 200 pounds of treble superphosphate to the acre, or its equivalent, applied in winter is suitable. Similar amounts are suggested for permanent pastures in older farming areas, as they should increase the growth and improve the nutritive quality of the forage. Phosphorus is not leached away; the part not used by the first crop remains for crops that follow.

In old apple orchards, the Sagemoor soils, grayish in color, retain more of the toxicity of lead arsenate spray than do the Tieton, Cowiche Harwood, Naches, and other soils of brownish color. This possibly may have resulted from differences in soil properties.

Sagemoor very fine sandy loam is especially suited to alfalfa and tame grasses. It is well suited to asparagus, and the acreage of this crop has increased greatly recently. Soft fruits produce well in areas free of frost. Grapes are now grown extensively on the sloping areas. Wine grapes of good quality and sugar content are produced on southern exposures. Under good management hops grow well. Following alfalfa, heavy manuring, or turkey raising, high yields of wheat and corn are common. Yields of other suitable crops are comparable.

Where the surface soil is distinctly calcareous because of erosion, deep plowing, or other causes, some fruit trees, especially peaches and pears, show pronounced chlorosis, or yellowing, of the leaves. This is more common in orchards that have greater slopes. In such areas the surface soil is more often calcareous, or a high concentration of lime frequently occurs at very shallow depths. The cause and remedy for chlorosis are not fully understood. Chlorosis appears to be caused by the lime in the upper part of the soil, but similar yellowing of leaves may result from other causes.

Sagemoor very fine sandy loam, sloping (7 to 15 percent slopes) (Se).—This soil is distinguished from Sagemoor very fine sandy loam principally by greater slope, which results in greater surface runoff and variability in the soil profile. It is associated with the Sagemoor very fine sandy loam and with Sagemoor loam, compact subsoil. It occurs chiefly on short slopes that grade from the smoother terraces down to the intermittent drainageways and coulee bottoms that cut through the terraces. Some areas that have slopes as great as 18 to 20 percent are mapped with this soil. The more sloping areas resemble Steep broken and stony land.

The profile is similar to that of Sagemoor very fine sandy loam but is more variable. The variability is caused by the short slopes, which start down across the nearly horizontal stratified layers of sand and silt that underlie the terraces. Thus the texture of the surface soil, as well as that of the subsoil and lower soil, ranges from loamy fine sand to silt loam within comparatively short distances. The texture depends on the texture of the strata that crop out on the slope but is predominantly a very fine sandy loam.

Free lime occurs nearer to the surface than in the less sloping soil. In many places the surface soil is calcareous. Also erratic boulders and stones are somewhat more common, but they do not materially interfere with tillage.

Use and management.—A large part of the sloping phase of Sagemoor very fine sandy loam, especially in the Sunnyside irrigation district, is irrigated and used mainly for pasture and alfalfa. It is not well suited to intertilled crops; it is difficult to use some of the large farm machinery on the steeper slopes. The unirrigated areas are used chiefly as range, but their value for grazing is low.

It is hard to irrigate soil properly without causing excessive surface runoff. The soil erodes easily where it is not protected by close-growing vegetation. Sprinkler irrigation is more efficient than other types, especially where intertilled crops, orchard fruits, or grapes are grown. The soil should remain in grass-and-legume pasture or other close-growing crops as much of the time as possible. Other management requirements are the same as for Sagemoor very fine sandy loam.

Chlorosis, or the yellowing, of the leaves of some trees, especially of peaches and pears, is more common on the sloping phase of Sagemoor very fine sandy loam than on the less sloping areas. It appears to be associated with the many spots on the slopes where lime is in the surface soil or at very shallow depths.

Particularly where it is associated with Sagemoor loam, compact subsoil, this sloping phase of Sagemoor very fine sandy loam contains excess soluble salts. The accumulation generally results from lateral movement of salt-bearing water from Sagemoor loam, compact subsoil, to this soil. The water emerges on the slopes, where it evaporates and leaves the salts. Deep subsoiling, particularly in the smoother areas above the slopes, and careful irrigation probably would prevent the salts from accumulating.

Sagemoor fine sandy loam (1 to 5 percent slopes) (Sa).—This soil occurs on the lower terraces in the drier eastern part of the lower Yakima Valley. It is associated with the Quincy soils and with Sagemoor very fine sandy loam. Its texture may be the result of the slight reworking of a very fine sandy loam surface soil by wind, which removed the finer material. The soil could also have been derived from coarser strata of the lake-laid beds. It developed under an environment similar to that of Sagemoor very fine sandy loam. It was derived from similar or somewhat coarser parent material, influenced very little or none by loess. Although generally the relief is similar to that of Sagemoor very fine sandy loam, the soil forms faint low dunes in places.

Sagemoor fine sandy loam varies in texture of the surface soil and in the sequence of layers in the lower part. The glacial lake deposits lie horizontally; therefore strata of varying texture and consistence crop out at different points on the slopes. In places the underlying strata have been plowed up and mixed with the surface soil so that the present plow layer is grayer than it was formerly. Where low dunes have been leveled and spread, the texture approaches or is a loamy fine sand or a loamy very fine sand that resembles Quincy loamy fine sand. In other places the surface soil is a very fine sandy loam. The depth to the underlying strata ranges from about 12 to 42 inches.

Use and management.—More than half of Sagemoor fine sandy loam is irrigated; it is planted chiefly to general field crops and asparagus. Small acreages on the higher slopes are in orchards and vineyards. The soil is well suited to all of the common crops grown and is very responsive to good management. Like Sagemoor very fine sandy loam, however, it needs organic matter, nitrogen, and phosphorus to produce high yields. On general farms short rotations should be used in which alfalfa is grown for a third to a half of the time. From 100 to 200 pounds of treble superphosphate to the acre should be added annually for good soil maintenance. Orchards generally are kept under an alfalfa cover crop and are given smaller applications of phosphorus. In the past grapes have been grown under clean cultivation, and little concern has been given to fertility of the soil. To maintain the soil, however, it is essential that a suitable legume cover crop be introduced.

Where hops, asparagus, and other frequently tilled crops are grown, the maintenance of soil fertility is a critical problem. Manure is applied heavily where it is available. As the supply of plant nutrients is depleted in Sagemoor fine sandy loam, it will probably be necessary to grow winter cover crops and green-manure crops to furnish organic matter and to use more and more commercial nitrogen and phosphorus. Legume green-manure crops must be planted and phosphorus applied early in the fall when water and labor are usually short. Moreover, the legumes have not made enough growth to be ready to be plowed under until the middle of May or late May. Winter rye can be sowed late, makes much of its growth from the winter precipitation, and matures early in the spring. When treated with nitrogen and phosphorus fertilizers, rye is a good substitute for the more valuable legumes as a green-manure crop.

In the low level marginal areas, poor drainage caused by a high water table, may occur in some areas because lateral outlets are not adequate. Such areas can be reclaimed only by large, deep, intercepting drains that lower the water table.

Sagemoor loam, compact subsoil (1 to 5 percent slopes) (Sb).—This is one of the more important irrigated soils in the Yakima Valley. It occupies higher positions than Sagemoor very fine sandy loam and Sagemoor fine sandy loam. Large areas of it occur on upper benches or terraces around the margins of the lower Valley. It covers part of the north and south benches of Reservation valley. It is the predominant soil along the Parker Heights Ditch and along the Sunnyside Canal and above it from the headgate to Zillah. Most of the arable land of the Roza division within the lower Valley consists of Sagemoor loam, compact subsoil.

This soil has formed under an environment similar to that of Sagemoor very fine sandy loam and from somewhat similar parent materials. It overlies the upper members of the glacial lake deposits, however, which are composed mainly of alternating layers of compact silty material and soft very fine sandy sediments. The upper silty layers are compact, dense, and slowly permeable.

Although the parent material of Sagemoor loam, compact subsoil, may have been more or less dense, very thin cemented layers or lenses of lime and siliceous materials have formed on the uppermost layer and, in most places, on some of the lower layers. Where well developed the lime crusts stop root penetration and are nearly impermeable to water. Mats of roots form just above the crusts. The crusts are not continuous for any great distance, however, and they vary greatly in degree of hardness, cementation, and development. This is evidenced by the fact that mats of roots occur above successively lower crusts. The coarser textured strata permit easy downward or lateral movement of water. The subsoil and lower lying strata favor the formation of local perched water tables. This water generally moves laterally and, where it seeps out on slopes, salts generally accumulate.

This soil varies somewhat in degree of development, in texture, in depth to the compact subsoil, and in permeability of the compact layers and lime crusts. In some areas the surface soil is a very fine sandy loam; in others it is a silt loam. In places its color grades toward light yellowish brown. Occasional boulders or stones occur in some places, as they do in Sagemoor very fine sandy loam. In some spots the subsoil is less compact and the lime crusts are absent or only faintly developed. In such places the soil resembles, or is essentially the same as, Sagemoor very fine sandy loam. The depth to the compact layers ranges from about 1 to 3½ feet. Where the soil is shallow, tillage may mix fragments of calcareous materials with the surface soil. The soil, where it is deep, closely resembles the Ritzville soils.

Use and management.—Except for the problem of underdrainage and salt accumulation caused by the compact, less permeable underlying strata, the problems of use and management are the same as for Sagemoor very fine sandy loam.

Where different amounts of irrigation water have been used within the lower Valley, striking contrasts can be noted. On the benches in the Reservation, a great deal of soil has become saline and nonproductive. Under the Wapato project of the Indian Reservation, the benchlands have been alloted 4½ acre-feet of water, and in the past 6 acre-feet or more was delivered to some of the land. Overirrigation of these higher lands has resulted in the accumulation of a local perched water table in many places, and much of the soil on the slopes is now seeped and salinized because of the lateral movement of water.

In contrast, east of this area just across the river in Parker Heights and throughout the areas within the Sunnyside division, a general shortage of irrigation water has been the rule. Here, in most places, 3 acre-feet or less has been allotted. Only minor areas have been affected by seepage because the crops use most of the irrigation water before it can escape from the root zone. No doubt crops have suffered from the lack of water at times, but the soil has not been affected by excess salts. Three acre-feet is believed to be a safe allotment of water for irrigating this soil.

In many orchards the compact layers were dynamited before the trees were set. Deep subsoiling would help to improve the downward penetration of water and roots and to prevent the accumulation of salts.

In a few spots, and especially on slopes, chlorosis of fruit trees particularly of peaches and pears, has occurred. Chlorosis appears to, occur where lime or a moderately strong concentration of alkali is near the surface of the soil.

Sagemoor loam, saline (0 to 2 percent slopes) (Sc).—This soil occupies basins in the western part of Reservation valley. Limited areas occur elsewhere, that is, wherever Sagemoor loams were briefly influenced by a saline water table. The salinity developed before natural drainageways were established. The soil always occurs on low terraces. It is not extensive and is not important agriculturally. Attempts to reclaim it have shown variable, but generally unsatisfactory results. With sufficient leaching and the kind of farming that would build up organic matter and fertility, the soil probably could be brought to a level of productivity equal to that of the other Sagemoor soils. The soil is covered by greasewood and sagebrush.

Scabland and Smooth stony land (1 to 15 percent slopes) (Sf).—This miscellaneous land type consists of areas of Scabland and Smooth stony land mapped together. The areas are very shallow and stony and nearly level to sloping or rolling.

In central Washington the term scabland commonly applies to all nearly level, sloping, or rolling, very shallow and stony land that is underlain by lava flows of basalt or andesite and has bedrock outcrops. In this report, the term covers several different kinds of land.

Predominantly Scabland and Smooth stony land consists of comparatively smooth, gentle to moderately sloping land on the flanks and tops of the upland ridges. On the Horse Heaven plateau, however this land occurs as long strips between the soil areas and the steep breaks of entrenched canyons.

As a rule, the nearly bare surface layer—a brown gritty loam or clay loam derived from weathered basalt—occurs chiefly as interstitial material in a pavement of basalt fragments. In many places small islandlike mounds of irregular small areas of soil comparatively free of rocks are interspersed with the scabland. These patches evidently were derived from a shallow layer of loess deposited over basalt residuum. They appear to be remnants of a once continuous soil mantle that has been eroded away. In other places soil materials several feet deep support considerable plant growth, but so many angular blocks of basalt occur that a hole cannot be dug without using a crowbar.

Outcropping ledges and piles of broken rock commonly occur along the crests of the ridges and breaks of the coulees. This kind of scabland occurs extensively on the ridges in the arid and semiarid rangelands. It occupies only a very small total area in the irrigated districts. Small patches break the continuity of fields in the dry-farmed areas on the Horse Heaven plateau. It also occurs extensively in association with dry-farmed areas on the slopes west of Cowiche.

On Naches Heights there is a long tonguelike lava plateau composed of nearly black andesite scabland. This plateau consists chiefly of islandlike piles and ridges of large blocks and ledges of rock that crop out in areas of Tieton soils. Here, the land is very similar to the stony, broken "malpais" form of land that occurs on recent lava flows. These outcrops occupy about a third of the surface in this important orchard district. They interfere greatly with the use of the land and with the construction of canals and roads.

Bordering the Yakima River, between the bridge near Euclid Flat and Byron, is a body of channeled or valley type of basalt scabland that is 2½ miles square. This area has relief very similar to that of the channeled scablands of eastern Washington, as it is on ledges, low ridges, and hillocks where basalt outcrops and in intervening narrow valleys and potholes that are filled with fine soil material.

Smooth stony land consists principally of nearly bare exposures of the beds of cemented coarse rounded gravel and cobblestones that underlie the Harwood soils. Locally it is also called scabland. It differs little from the typical scabland, except that it is underlain by cemented gravel instead of by lava. It is associated with Harwood loam and covers considerable areas on the benchlands that extend from Wide Hollow School westward to Tampico. Comparatively small areas occur near Cowiche. This is the predominant land above the irrigated areas west of the Tieton Canal toward Cowiche Mountain.

Use and management.—Except for small patches that are generally too small for cultivation, Scabland and Smooth stony land is nonarable. Some areas within the settled districts are used for building sites, for barnlots, or for stacking grain or hay. The outcrops of basalt are used in many places as a source of crushed rock for roadbuilding. The massive blocks of andesite in the Naches Heights district have some potential value as building stone, but so far they have been used to only minor extent for fireplaces, retaining walls, and rock gardens. Several hundred acres south of the bridge near Euclid Flat is used as a dump ground for the town of Grandview and the surrounding thickly settled area.

As rangeland this mapping unit varies widely in value. The natural vegetation in most areas is mainly sagebrush with some grasses. Usually, except for a brief period in the spring, there is only a scant plant cover of value for forage. At higher elevations, however, some areas support a stand of grass comparable to that of the adjacent soils. In general this mapping unit offers little obstacle to travel by horseback or to driving livestock.

Many areas of this land on Horse Heaven plateau are so smooth and bare that emergency airplane landings could be made without difficulty except when the land is wet. Other areas might well serve as landing fields if scattered slabes of rock were cleared away.

Smooth stony land that is underlain by cemented gravel has little value. In most places scarcely 6 inches of finer soil material lies above the gravel. The soil material normally occurs in spaces between the pebbles, cobblestones, and stones. Small, scattered, islandlike mounds and patches of soil 1 to 2½ feet deep support the grasses that furnish most of the grazing on this land type.

Scowlale loam (0 to 3 percent slopes) (Sg).—This dark-colored soil was evidently formed first on grass-covered creek bottoms where the moisture supply was high because of subsurface water and occasional floods. The soil now occupies high bottom lands and low terraces, that is, slightly higher areas than the soils affected by ground water or overflow by the streams. Scowlale loam was derived from mixed alluvial materials, principally of basaltic and loessial origin. It was developed under an annual rainfall of 6 to 8 inches.

The surface is very gently sloping, or undulating in places. It is traversed by small winding abandoned stream channels. Greasewood and a sparse growth of saltgrass are predominant. The surface is bare between the shrubs.

Profile description:

1. Dark-gray, noncalcareous, slightly hard to soft loam; distinct very thin platy structure when dry and undisturbed; breaks to granules below the ½-inch surface layer of vesicular material; black and friable to very friable when moist; 11 to 15 inches thick.
2. Light-gray, calcareous, hard clay loam; generally massive; 4 to 7 inches thick.
3. Light brownish-gray, compact clay loam to sandy clay loam; breaks into hard prisms; has white lime coatings and splotches; 9 to 14 inches thick.
4. Light brownish-gray, noncalcareous, slightly hard loamy fine sand, somewhat mottled with brown and gray; 15 to 20 inches thick.
5. Small waterworn gravel, mainly basaltic, that is in places unevenly stained with brown.

This soil varies chiefly in color, texture, and depth of surface soil over the clayey horizons. In some areas the surface soil consists of clay loam, silty clay loam, or sandy clay loam. Small areas of an overwash phase have been included. These occur near the adjoining hills, where pale-brown to light brownish-gray local alluvium, 2 inches to 1 foot or more in depth, has been deposited over the older soil.

The reaction of the Scowlale loam varies considerably, but in most places the surface soil is moderately to mildly alkaline and the subsoil is strongly alkaline. The surface soil has a fairly high content of organic matter. The soil is slowly to very slowly permeable.

Use and management.—This soil is mostly outside of irrigation districts and is used almost entirely for range grazing. Its value for grazing is very low. The soil is difficult to reclaim because it is slowly to very slowly permeable. Possibly flood irrigation and applying sulfur or gypsum would reclaim it to the point where it would produce grass-and-clover pasture.

Selah loam (2 to 7 percent slopes) (Sh).—This soil has developed under an annual precipitation of 7 to 9 inches. It has a dense, fine-textured subsoil over a white lime-silica cemented hardpan. Its lower layers were derived from old water-laid materials, of which the lower part was gravel. In most places the upper part of the soil was derived from, or materially influenced by, loess. Possibly the fine-textured subsoil and the hardpan were formed to a considerable extent before the loess mantle was deposited. The old soil, in places, may have lost its surface horizons through erosion and later received deposits of loess.

This well-drained soil covers a small area but is important because it occurs in highly developed orchard areas. Most of it is on the uplands and high terraces north and west of Selah. A few small scattered bodies occur west of Yakima. Most areas are gently to moderately sloping. Where normal erosion has been more severe, the soil is associated with the Roza soils and with Steep broken and stony land. It is associated with the Ritzville soils in the more protected areas where the most loess material remains. The natural vegetation consisted mainly of big sagebrush and grasses.

Profile description:

1. Pale-brown to light brownish-gray, noncalcareous, slightly hard to soft loam; thin platy when dry and undisturbed but breaks to granules; dark grayish brown and friable when moist; 2 to 4 inches thick.
2. Noncalcareous, slightly hard loam similar to or slightly lighter colored than surface layer; nearly structureless or breaks into single grains and weak fine granules; friable when moist; 7 to 18 inches thick.
3. Brown, noncalcareous, compact, prismatic gritty clay or sandy clay; breaks into very hard, dense, subangular blocky or blocky aggregates about ½ to ¾ inch across; lacquerlike colloidal coating on aggregates; dark brown and very firm when moist, plastic and sticky when wet; 5 to 10 inches thick.
4. Yellowish-brown to brown, compact gritty clay or clay loam; breaks into hard subangular blocky aggregates; contains white veins and splotches of lime; firm when moist; 3 to 10 inches thick.
5. White, pink, or pinkish-white, strongly cemented or indurated, platy or slablike hardpan cemented by silica and lime; embedded pebbles or cobblestones in some places; 8 to 20 inches thick.
6. Compact, partially cemented gravel of undetermined thickness.

The surface soil ranges from silt loam to very fine sandy loam in texture. In some areas it contains pebbles or cobblestones. It varies in thickness because of wind or water erosion or because of variations in the depth of the loessial mantle. The development of the hardpan and clay horizons is not uniform. In some places the clay subsoil horizon is absent. In these the loessial material directly overlies the hardpan, and the soil is similar to Burke loam, which is mapped extensively in the basin uplands east of the Yakima River. It is distinguished from the Burke loam, however, by its dense fine-textured layer above the hardpan. In places the hardpan is fractured or is not so well developed as is typical.

The surface soil of Selah loam has a low content of organic matter and is generally mildly alkaline or neutral. The lower layers are mildly to moderately alkaline. Drainage through the subsoil is slow to very slow; the hardpan is very slowly permeable to impermeable.

Use and management.—Most Selah loam is irrigated, and a large part of it is in orchards. Because of its unevenly developed profile and the variable moisture supply, it is not well suited to apples. Orchards grow unevenly. Usually the trees are unthrifty or dead where the soil has waterlogged over the clay subsoil and indurated hardpan. In places the surface soil is too shallow to provide a sufficient root zone. Where the soil must be kept in orchards, the best crops are short-lived soft fruits or grapes. The soil is also fairly well suited to alfalfa and grass-and-legume pasture.

Careful irrigation of this soil is important. Excessive irrigation waterlogs the soil above the hardpan and injures deep-rooted crops. The soil on the more sloping areas is very susceptible to erosion if not covered by a close-growing crop.

Simcoe clay loam (2 to 20 percent slopes) (Sk).—This well-drained soil has developed under an annual precipitation of 8 to 13 inches. Much of it came from basalt that was bedrock weathered in place, or from basalt stones and angular rock fragments that were transported a short distance and dropped on old colluvial foot slopes or on alluvial fans. In places an admixture or definite overlay of loessial material occurs in the surface soil.

Patches of Simcoe clay loam occupy foothills and plateaus below the irregular lower margin of the forests. The topography ranges from very gently sloping to strongly rolling. The soil occupies only a small total area within that part of the county mapped in detail. Most areas are in the Stony and shallow soils-Simcoe-Onyx, the Renslow-Simcoe-Onyx, and the Cowiche-Simcoe-Harwood soil associations (fig. 2).

The winter moisture penetrates this soil fairly deeply. The soil dries out quickly in the spring, however, and as a result the grass is not luxuriant. Bunchgrasses, once a considerable part of the natural cover, have been thinned or destroyed by overgrazing. They have been replaced largely by big sagebrush, cheatgrass, and other semiarid herbs and shrubs. Bitterbrush grows in some areas.

Simcoe clay loam is lighter in color and has less organic matter than Bickleton silt loam, which developed under a denser growth of native grasses.

Profile description:

1. Grayish-brown, slightly hard gritty clay loam or heavy loam; thin platy when undisturbed but breaks out as fine granules; dark grayish brown and friable when moist; in many places contains basalt fragments; layer 3 to 5 inches thick.
2. Material similar to that in layer above; weak fine granular structure; 3 to 8 inches thick.
3. Brown, somewhat compact, gritty clay or heavy clay loam; breaks into very hard to hard subangular blocky aggregates about ½ inch across; dark brown and firm to very firm when moist; in most places contains angular basalt fragments; 15 to 30 inches thick.
4. Brown to yellowish-brown, slightly compact, hard gritty clay loam; weak subangular blocky structure; contains moderate number of basalt fragments; in many places the lower part contains some white veins or splotches of lime; 6 to 20 inches thick.
5. Partly decomposed basalt bedrock or fragments; lime coatings occur in places.

The upper part of Simcoe clay loam is neutral and the lower part is mildly alkaline. The organic-matter content of the surface soil is moderate to low. Drainage is slow in the soil above the bedrock.

This soil varies a great deal because it has different kinds of relief and is widely distributed in small areas. The depth to underlying rock ranges from 1½ to 5 feet. The most common variation has a silt loam surface soil slightly lighter in color and a subsoil not so well developed as typical. This variation is a transition to Renslow silt loam. Another variant lacks the typical subsoil and occupies small islandlike patches in the scabland areas. This variant may have been derived from wind-shifted parent material. In some areas stones on and in the soil materially interfere with tillage. Such areas are shown on the map by stone symbols.

Use and management.—Simcoe clay loam is not important for crops. A number of small predominantly shallow and stony areas west of Yakima are irrigated and partly planted to orchard fruits. Because the areas are sloping, shallow, or stony, they are better for peaches than for apples. The soil is inherently fertile. If it is not excessively stony, 3 feet or more deep, and on favorable relief, it is well suited to all the commonly grown crops. The larger areas of favorable depth and surface relief, east and northeast of Fort Simcoe, are farmed under supplemental irrigation. Good crops of alfalfa and grain are grown if the soil is well managed and irrigated.

Considerable acreages of Simcoe clay loam occur far out on the rangelands of the Indian reservation. Several thousand acres covered by sagebrush and grass, extending out of the area, are on the undulating plateaus between Satus Creek and Logy Creek and along the tributary canyons. Other areas are associated with scabland and the dry margins of the ponderosa pine forest. The rangelands have moderate to rather low carrying capacity. Some areas are used for dry-farmed wheat.

Steep broken and stony land (20 to 70 percent slopes) (Sl).—Except in the smoother areas of the Valley, this miscellaneous land type is distributed widely in Yakima County. On the terraces it consists of the steep slopes of escarpments and entrenched coulees. The steep areas are associated with all the soils of the uplands and occupy the greater part of the mountain ridges. Though the slopes of most areas range from 20 to 70 percent, the slope of some precipitous walls of canyons is steeper.

The soil materials are exceedingly variable, depending on the location. In Steep broken and stony land, outcrops of practically all the kinds of deposits and rock formations of the uplands occur. Except on high north and east exposures, where loessial materials and Ritzville or Renslow soils occur in places on steep relief, there is little semblance to a soil profile or to a definite or consistent soil. This land is generally stony or gravelly except where it is associated with the Sagemoor soils and where sandstones and shales of the Ellensburg formation crop out in many places.

Use and management.—Steep broken and stony land is unsuitable for either irrigated or dryland farming. The plant cover varies but generally consists of sagebrush and other semiarid or arid shrubs, remnants of the native grass vegetation, and most abundant, the cheatgrass that was introduced. The vegetation is sparse on south and west exposures and generally more abundant elsewhere. It is of less value for grazing than the vegetation on smoother lands. The growth of the grass is governed largely by the moisture supply, which is determined by altitude and exposure and the degree of grazing to which the grass has been subjected. Steep north and east slopes, especially at higher elevations, have the best grass cover in the rangelands.

Stony and shallow soils (2 to 15 percent slopes) (Sm).—This miscellaneous land type occurs on uplands that have comparatively favorable relief. The land is of low or marginal value for agriculture because it is so shallow or stony. It occurs in many parts of the county, generally distributed around the margins of the valleys on the flanks of the ridges. Within the irrigated districts, it occurs more frequently in the upland orchard districts of the upper Valley. The more extensive areas are in the arid and semiarid rangelands east of Yakima above a source of water for irrigation.

The soil materials overlie various upland materials and rock formations. Predominantly the soil is less than 18 inches deep, and most of it is stony. The soils consist principally of shallow or stony phases of the Selah, Burke, Roza, Ritzville, and Renslow soils, with which they are associated. The larger areas in the rangelands east of Selah and Moxee consist mainly of shallow Burke loam that has 6 to 18 inches of soil over a lime hardpan. Around the margins of the Reservation valley, especially in Medicine Valley and near Fort Simcoe, considerable areas of stony alluvial fans have been mapped with this land type.

Use and management.—Small areas of Stony and shallow soils are under cultivation and are chiefly in orchards. These occur in the Selah district and in the Terrace Heights district across the river and east of Yakima. There, a golf course is situated on this land, and a satisfactory turf of lawngrass is maintained by sprinkling frequently. The trees in nearby apple orchards are unthrifty, and their growth and production is uneven because of the shallow depth to the hardpan and the cemented coarse gravel.

Stones can be removed, but the depth of the soil is sufficient for only shallow-rooted and very hardy crops. Frequent light irrigations are needed. Grapes and short-lived stone fruits, such as peaches, are grown fairly successfully on the deeper areas. Mixed grass-legume pasture is one of the better uses. Other uses that do not depend primarily upon cultivation may be devised that will utilize the small areas that occur in the thickly settled irrigated districts.

In the semiarid and arid rangelands, the Stony and shallow soils are used principally for grazing. They have a lower grazing value than the adjacent deeper soils or ones that are not so stony.

Taneum loam (2 to 7 percent slopes) (Ta).—This well-drained rather dark colored soil was formed on the uplands under a somewhat more effective precipitation than occurs on most of the uplands in the part of the county mapped in detail. It was developed under an average annual precipitation of 11 to 16 inches. Most of it occurs above an altitude of 2,200 feet. Most areas are undulating to gently rolling.

The total area of Taneum loam is rather small. The soil occurs mainly in the Taneum-Steep broken and stony land soil association (fig. 2). The natural vegetation consisted mainly of grasses, bitterbrush, sagebrush, and rabbitbrush.

Taneum loam was derived principally from material weathered from tuffaceous sandstone bedrock, but in places the upper part is influenced by, or derived from, loessial material. It is distinguished from Cowiche loam chiefly by a darker surface soil and a smaller content of lime; it occurs under a higher effective precipitation, which has resulted in a denser plant cover.

Profile description:

1. Grayish-brown, slightly hard loam or gritty loam; thin platy structure when undisturbed; very dark grayish brown to very dark brown and very friable when moist; 2 to 3 inches thick.
2. Slightly hard loam or gritty loam similar to layer above in color but slightly lighter; breaks into weakly developed fine granules; very friable when moist; 6 to 10 inches thick.
3. Brown, slightly hard, light or gritty clay loam or heavy loam; breaks into weakly developed subangular blocky aggregates ¼ to ½ inch across, contains some fine pores; friable when moist; 7 to 16 inches thick.
4. Brown, somewhat compact clay loam or sandy clay; contains some fine pores; breaks into hard subangular to blocky aggregates ¼ to ½ inch across; friable to firm when moist; 10 to 20 inches thick.

5. Brown to light yellowish-brown slightly hard light clay loam, sandy clay loam, or gritty loam; in places has a few white lime veins and splotches in the lower part; 10 to 15 inches thick.
6. Light yellowish-brown, pale-yellow, or pale-olive, weathered tuffaceous sandstone; grades downward to bedrock; in places upper part has some white lime veins or coatings in the cracks.

The upper part of the Taneum loam is noncalcareous and is neutral in reaction, but the lower part is slightly calcareous in places and is generally mildly alkaline. The surface soil has a moderate content of organic matter. Drainage through the soil is slow.

Some areas that have a lighter colored surface soil and resemble Cowiche loam are mapped with the Taneum loam. The surface soil consists of fine sandy loam in a few places. Near the margins of some of the areas, the tuffaceous sandstone thins out and the underlying basalt outcrops.

Use and management.—Nearly all of Taneum loam lies above the present irrigation systems. A few areas are used for range grazing, for which the soil has a higher than average value. Most of the soil is in dry-farmed wheat. It is fairly well suited to that use, and yields are fairly high. Erosion control practices should be used on the more sloping areas that are subject to erosion.

Taneum loam, rolling (7 to 18 percent slopes) (Tb).—Except for its greater slope, this soil resembles Taneum loam in most of the significant profile characteristics and in its environment. As a result of its greater slope, surface runoff is more rapid, the soil is more susceptible to erosion, the surface layer is thinner, and the subsoil is slightly more variable and thinner. The total area is very small.

Use and management.—The use of this soil is similar to that of Taneum loam, except that a smaller part is used for wheat than for grazing. Wheat yields are somewhat lower. Special measures are needed to control erosion on the stronger slopes.

Tieton loam (2 to 7 percent slopes) (Tc).—This important soil occurs in the Naches Heights orchard district. It has developed over and, in a large part, was derived from material weathered from dark-colored andesitic lava (pl. 6). In most places, however, the upper part of the soil was derived from loess, or influenced to a considerable degree by that material. The soil is distinguished from the somewhat similar Simcoe clay loam principally by its different parent material.

Tieton loam occupies most of the arable part of Naches Heights, where it overlies the Tieton andesite lava flows. The continuity of the soil is broken by many ridges and islands of outcropping rock, which consists of huge piles of angular stones of nearly black andesite over bedrock. The plateau that this soil occupies is about 12 miles long and 2 miles wide and occurs at an altitude of 1,500 to 2,200 feet. The soil has developed under an annual precipitation of 7 to 10 inches.

The surface is generally very gently undulating to rolling, but in a few areas the slopes exceed 7 percent. The natural vegetation consisted chiefly of big sagebrush and grasses and some rabbitbrush and associated plants.

Profile description:

1. Grayish-brown slightly hard loam or silt loam; thin platy structure when undisturbed; very dark grayish brown to very dark brown and friable to very friable when moist; 2 to 4 inches thick.

2. Grayish-brown to brown slightly hard loam or silt loam; weak fine granular structure; dark grayish brown and friable to very friable when moist; 5 to 12 inches thick.
3. Brown clay loam or heavy loam; breaks into weak to moderately developed, hard to slightly hard, subangular blocky aggregates ¼ to ½ inch across; aggregates have a slightly darker colloidal staining but may be yellowish brown when crushed; aggregates have a few to moderate number of fine pores, friable when moist; 11 to 22 inches thick.
4. Brown, slightly compact clay loam that in most places contains a few decomposing andesite fragments and some white lime veins or splotches; breaks into moderately distinct hard subangular blocky aggregates; the aggregates commonly have a slightly darker colloidal staining and a few fine pores and may be yellowish brown when crushed; firm to friable when moist; 12 to 25 inches thick.
5. Decomposing andesite rock, in most places lime coated; grades downward to andesite bedrock.

The surface soil has a low content of organic matter and as a rule is neutral. Decomposing andesite in some areas occurs at depths of 2 to 5 feet, but the soil is generally deep except where it is close to the islandlike piles of outcropping rock. Drainage through the soil to the bedrock is medium.

The soil has a high water-holding capacity. It is fertile and productive where the nitrogen supply is maintained by planting alfalfa in the rotation or by using it as a cover crop in orchards.

The flow of the andesitic lava is so recent that the regional drainage is not fully established, and imperfectly drained basins with flat bottoms occur in places.

A variant soil, which has a grayish clay subsoil, occurs on a few acres in the lower places. The largest of these basins is 2 miles northeast of Tieton. In places, particularly along the northeastern margin of the plateau, most of the soil consists of loam or silt loam derived from loess.

Use and management.—Nearly all of the Tieton loam is irrigated and cropped. The area is irrigated under the Tieton division and is highly developed for apple and pear orchards.

The soil is especially well suited to tree fruits of all kinds. Fruits in the area are for the most part seldom injured by frosts. They come into bloom about 2 weeks later than in the lower Yakima Valley. This results in their escaping late frost.

Tieton loamy fine sand (2 to 7 percent slopes) (Td).—This soil occurs in the northern part of the Naches Heights plateau where the wind is strong much of the time. The upper part of the soil has been shifted by winds. The finer material has blown away, and the sandy material has been left. This soil occurs only in several small areas. Except for its coarser surface soil, it is very similar to the associated Tieton loam.

Use and management.—Tieton loamy fine sand is used in much the same way as Tieton loam. Where sufficient water can be applied, it is well suited to all of the fruits common to the area. It should be protected from blowing by maintaining a close cover crop of alfalfa.

Toppenish loam (0 to 1 percent slopes) (Tg).—This nearly level, dark-colored, poorly drained soil of the bottom lands is important agriculturally. It is interesting because it has developed on nonsaline or only slightly saline wet meadows that are subject to flooding, although they are in a dry climate. The soil now ranges from nonsaline to strongly saline, but the salts have probably accumulated since the natural environment was disturbed.

The soil appears to have been flooded by streams nearly every spring and then to have been subirrigated to a considerable degree during the rest of the growing season. The downward leaching evidently nearly balanced the rise and accumulation of soluble salts from the ground water, for the soil supported an abundant grass and herbaceous growth and became dark in color. The periodic flooding in most places has been cut off by various manmade structures. Some areas have become saline as a result of being subjected to high water tables. These water tables are caused by seepage from the irrigated surrounding land.

Toppenish loam is widely distributed in the Reservation part of the lower Valley. Areas important in the present irrigated agriculture occur near Toppenish, in the Satus district, and west of Buena.

The soil was developed under an annual precipitation of 6 to 8 inches. It has formed from alluvium derived from a variety of sources, but principally from basalt and loess. It is darker and naturally more poorly drained than the related Kittitas, Esquatzel, and Umapine soils. It differs from Wenas loam in being calcareous.

Profile description:

1. Dark-gray, calcareous, slightly hard loam; when undisturbed, thin platy in the upper few inches and fine granular in the lower part of layer; very dark gray to very dark brown and friable to very friable when moist; in most places slightly affected by soluble salts and moderately to strongly alkaline; 9 to 14 inches thick.
2. Grayish-brown to gray, strongly to moderately calcareous, mildly to moderately alkaline, slightly hard light clay loam or loam; massive but breaks into indistinct fine granules and in most places contains a few small white lime veins and many fine pores; very dark grayish brown to very dark brown and very friable to friable when moist; 9 to 18 inches thick.
3. Mottled pale-brown, light brownish-gray, and light yellowish-brown, noncalcareous, neutral to mildly alkaline clay loam or heavy loam; contains many fine pores and breaks into indistinct granules; friable to very friable when moist; 15 to 40 inches thick.
4. Noncalcareous loose gravel, sand, or other coarse-textured, water-laid deposits.

The texture of the surface soil, although generally a slightly hard loam, ranges from loam to clay loam. In some places the soil is somewhat stratified throughout. In a few places it contains layers of silty clay loam or clay. The depth to gravel, sand, or other coarse-textured deposits ranges from 3 to 8 feet. The content of lime and soluble salts and the reaction vary considerably from place to place.

The organic-matter content of the surface soil of Toppenish loam is high. Except when retarded by a periodically high water table, drainage through the soil to the coarse-textured layers is slow.

Use and management.—Toppenish loam is reclaimed easily for crops if it is drained artificially and provided with adequate irrigation water. It is one of the most productive soils in the Yakima Valley. It is well suited to small grains, corn, alfalfa, sugar beets, and asparagus. Hops are grown on several of the better drained areas. Old abandoned stream channels or nearly level areas that have patches of higher land are hard to irrigate, especially if the furrow method is used. Most Toppenish loam has nearly level relief, however, and is very easy to irrigate. Unfortunately many small isolated areas are associated with other soils of lower value, so they remain in unimproved pasture.

Toppenish clay loam (0 to 1 percent slopes) (Tf).—Except for its finer texture, this soil resembles Toppenish loam in most of its significant characteristics. It has formed under a similar environment. It occupies low nearly level bottom lands subject to periodic overflow.

The chief variations are in depth of the dark-colored upper layers and in the stratification of the materials. In some places the dark-colored horizons are only 6 to 8 inches thick, but in others they are 2 to 2½ feet thick. Some small ponded areas of gray clay or clay loam have been mapped with the Toppenish clay loam. The content of lime and soluble salts and the reaction of the soil vary considerably from place to place.

The dark-colored soil layers of Toppenish clay loam have a high to very high content of organic matter. Drainage through the soil above the gravel is generally slow and in places may be further retarded or prevented by a high water table. The greater part of this soil is nonsaline or only slightly affected by excess soluble salts.

Use and management.—Toppenish clay loam is used in much the same way as Toppenish loam, but sugar beets are not grown so generally. Some areas along the creeks that are still overflowed are used for pasture or to grow native hay. Where irrigated, the soil is best suited to wheat, oats, and pasture. It produces high yields of grain and good pasture if the soil is properly managed. In most areas it can be irrigated by flooding.

Toppenish clay (0 to 1 percent slopes) (Te).—This soil is somewhat a variant from the Toppenish series because of its finer texture and lighter colored surface soil. It was formed, however, under a somewhat similar environment. It occupies an area, once covered by Mud Lake, that is in an ancient stream valley near Brownstown. Originally, Mud Lake was filled periodically by the natural overflow of floodwaters from Toppenish Creek. The soil of this old lakebed is drained more or less by the Mud Lake drain and is available for cropping.

Use and management.—Most of the Toppenish clay is in pasture or hay, including some alfalfa. Because the clay is so intractable, it is not well suited to ordinary tilled crops or alfalfa. Its best use is for grass-and-legume pasture. Where drainage is not adequate, strawberry clover is the best pasture plant available.

Umapine loam (0 to 2 percent slopes) (Ua).—Under the influence of a high ground water table, this light-colored soil has become strongly or moderately affected by soluble salts and alkali. In many areas the water table has been lowered by natural entrenchment of streams or by artificial drainage. The land in these areas is now dry, but the salts have been only slightly leached from the surface soil by the small amount of rain.

This soil occupies level or very gently sloping areas on the floor of the Reservation valley. It occurs chiefly in areas somewhat like islands that are slightly raised above the surrounding flood plains. Most places are smooth, but some slight mounds or hummocks occur around the brush. The soil generally is not subject to overflow. Salt-tolerant native plants form a variable, but sparse, cover on the virgin soil. The cover consists principally of saltgrass but includes greasewood, giant wildrye, rabbitbrush, and a little stunted sagebrush.

Umapine loam has developed under an annual precipitation of 6 to 7 inches. In general it was formed from mixed medium-textured alluvium, derived principally from basaltic, loessial, and stratified lake-laid materials. The alluvial material resembles that from which the Esquatzel, Kittitas, and Ahtanum soils were formed. Umapine loam differs from the Esquatzel soils in being calcareous in the upper part and in being more strongly alkaline. It is lighter colored than the Kittitas soil and in most places lacks the hardpan of the Athanum soils.

Profile description:

1. Light brownish-gray to light-gray, moderately to strongly calcareous, strongly to very strongly alkaline, soft to slightly hard loam; dark grayish brown and very friable when moist; in the dry virgin soil, topmost ½ to 1 inch is distinctly vesicular over a 2- to 4-inch layer, which has a distinct very thin platy structure; the material below mainly structureless or has a very weak to very fine granular structure; 8 to 20 inches thick.
2. Light-gray, calcareous, strongly to moderately alkaline, slightly hard loam or silt loam; commonly contains many fine pores; generally nearly structureless, or weakly developed subangular blocky in places; grayish brown and very friable when moist; in some places the lower part is noncalcareous and in others some of the lime is segregated into small white veins; 15 to 30 inches thick.
3. Somewhat mottled light-gray, noncalcareous, slightly hard loam or clay loam; friable when moist; some areas contain pebbles; layer is 15 to 30 inches thick.
4. Loose, waterworn, noncalcareous gravel, mostly basaltic and generally stained with brown.

Although the greater part of the soil has a loam surface layer, the texture of the surface soil ranges from very fine sandy loam to silt loam. Depth to gravel ranges from 2 to 5 feet, often within short distances. In a few places, the surface soil contains gravel.

A grayish surface soil that is high in lime is a distinguishing feature of Umapine loam. The organic-matter content is very low.

Some areas occupy swales or depressions slightly lower than the usual location. In these areas the soil is darker and higher in organic matter than is typical of Umapine loam. The soil in these areas resembles the Toppenish soils. In other places the soil is less calcareous and not so strongly alkaline and resembles the Esquatzel soils. The concentration of soluble salts, alkali, and lime varies considerably. In places an efflorescence, or crust, of salts occurs on the surface when the soil is dry. As a rule the content of exchangeable sodium in the upper layers is high. The lower layers are generally weakly calcareous, but the soil in some areas is noncalcareous below a depth of about 20 inches. Drainage through the soil above the gravel, if not retarded by a high water table, is often slow. Drainage, however, is variable, depending upon the degree of dispersion caused by the alkali.

Use and management.—About a fourth of the Umapine loam has been reclaimed to some extent and is used for alfalfa, sugar beets, hops, and other crops. The rest is in unimproved pasture, for which it has moderate value.

Because soluble salts and alkali have been in this soil a long time, it has become almost unsuitable for crops. To make it more suitable, the ground water table should be lowered in those places where it is too high. Chemical amendments such as gypsum or sulfur should be applied to the soil to help reduce the effects of salt and alkali. Following applications of these, the soil should be flooded by irrigation water to leach out the excess salts.

The first crops raised on Umapine loam are invariably poor, and unsatisfactory productivity will persist for a long time on the reclaimed soil. Even in fields that have been well managed for as much as 20 years, plant growth and yields are lower than on nearby Esquatzel, Naches, or Toppenish soils. The virgin soil is very low in organic matter and nitrogen. It is benefited by manure and plowing under a cover crop such as sweetclover or alfalfa.

Wahtum loam (0 to 3 percent slopes) (Wb).—This soil occurs on nearly level to very gently sloping low terraces, second bottoms, or remnants of old alluvial fans. It is imperfectly drained and has a strongly aklaline, strongly calcareous hardpan. Soluble salts have accumulated in the soil, apparently as a result of its original poor drainage. Since the drainage has been improved in most areas by deepening the stream channels the excess salts have been partly leached from the soil. In most places the surface soil is now nonsaline or is only slightly saline and is noncalcareous.

Wahtum loam has developed under an annual precipitation of 6 to 10 inches; the areas near White Swan have the most rainfall. The soil has formed from old mixed alluvium that washed mainly from loess and basalt but, to some extent, from tuffaceous sandstone, shale, and lake-laid materials. It is distinguished from the Ahtanum soils principally by its higher position, better drainage, and the greater development of its subsoil above the hardpan.

The natural plant cover in areas near the Yakima River is mainly greasewood. Near White Swan the cover consists mainly of thrifty sagebrush, native grasses, and cheatgrass. Some greasewood and saltgrass grow in places, and some bare spots and small areas, still affected by salts or alkali, are covered predominantly by the greasewood and saltgrass.

Profile description:

1. Light brownish-gray to pale-brown, noncalcareous, mildly to moderately alkaline, slightly hard to soft loam; very weak fine granular structure; very dark grayish brown and friable when moist; in places layer is weakly calcareous; dry undisturbed areas have thin platy structure in upper 2 or 3 inches; 10 to 15 inches thick.
2. Pale-brown, mildly to strongly alkaline, hard subangular blocky clay loam or loam; grayish brown to brown and friable to firm when moist; in places contains weakly cemented aggregates and may be weakly calcareous; 4 to 7 inches thick.
3. Light-gray, strongly calcareous, strongly to very strongly alkaline, weakly to strongly cemented hardpan; breaks into irregular fragments of various sizes and generally contains some white lime veins and coatings; 4 to 10 inches thick.
4. Light brownish-gray to pale-brown, moderately calcareous, moderately to very strongly alkaline, slightly hard to hard loam or clay loam; somewhat subangular blocky structure and slightly mottled in places; contains some white lime veins; 10 to 25 inches thick.
5. Stratified alluvium, chiefly of medium or moderately coarse texture.

The soil varies considerably. The depth to the hardpan ranges from about 1 to 4 feet. Approximately a third of this soil that lies between Emerald and the Mabton-Sunnyside road, is shallow to the hardpan, stays saline, and is covered by saltgrass and greasewood. East of the Mabton-Sunnyside road the hardpan occurs mainly at depths of 2½ to 3 feet. The surface soil in these areas is very low in organic matter. The surface drainage is slow in most areas; internal drainage is slow to very slow because it is restricted by the cemented hardpan.

Some of the areas mapped with Wahtum loam have developed under a somewhat higher rainfall and at a higher altitude than is usual for this soil. Some of these areas, especially in the vicinity of White Swan, have a slightly darker surface soil and a browner, softer, less continuous hardpan. The parent material in these places evidently was old alluvium derived largely from basalt. Soluble salts that formerly may have been present have been leached from the upper part of the soil in most places.

Use and management.—Use and management of Wahtum loam vary according to the location. About one-third of the soil between Emerald and the Mabton-Sunnyside road is covered by saltgrass and greasewood because it is shallow to the hardpan and is affected materially by soluble salts. The rest of the soil in this locality is used for farming. Alfalfa and general farm crops are grown, and yields range from poor to good. Low yields are partly the result of lack of proper soil maintenance. Bare spots, however, and areas of poor growth caused by shallowness to the hardpan or by other inherent soil conditions, also limit production.

The soil east of the Mabton-Sunnyside road is mostly of better quality. The hardpan occurs at depths of 2½ to 3 feet. Crops yield nearly as well as on adjacent soils that are not affected by the hardpan.

Some of the better areas of Wahtum loam that occur in Medicine Valley and in the vicinity of White Swan are farmed in a limited way. They are planted to hay, grain, and other crops. A scant and often irregular supply of irrigation water is diverted from the creeks for these areas. The yields from several tracts now irrigated indicate that areas favorable to irrigation would be worth reclaiming if ample water could be provided. Yields are nearly as large as on the nonsaline soils of the area that have the hardpan 2 feet or more below the surface.

Wahtum fine sandy loam (0 to 3 percent slopes) (Wa).—This soil occupies a very small total area in association with Wahtum loam. Except for its fine sandy loam surface soil and slightly coarser textured subsoil, it resembles Wahtum loam. In most places the soil above the hardpan is deep enough to provide an adequate root zone. The soil is of some importance 2½ miles north of Mabton and eastward to the Euclid Flat road. Crop yields are fair but depend largely upon how well the fertility of the soil is maintained.

Wenas loam (0 to 2 percent slopes) (Wd).—This dark-colored soil occurs on bottom lands along the perennial streams that flow from the mountains and foothills. It lies along all such streams except Satus Creek. The stream valleys are narrow, and both the individual areas and the total area of this soil are small.

The surface relief is nearly level. In many places, however, the soil is broken by interlacing stream channels, gravel bars, and small areas of marsh. Much of the soil is flooded occasionally both by the main streams and by waters from the lateral intermittent drainageways that spill out upon the bottoms. A considerable part of this soil is subirrigated and has a fairly high water table.

The original plant cover on Wenas loam consisted of abundant grass and herbaceous growth and clumps of deciduous brush. This abundant vegetation, supported by natural irrigation, produced a dark-colored soil high in organic matter.

The soil was formed from fairly recent materials derived from alluvial flood plains and fans. These materials were washed to a considerable extent from regions of higher precipitation. They are principally from basaltic materials but include a mixture of some loessial, sedimentary, and crystalline rock materials.

Wenas loam differs from the associated Yakima soils in having a darker surface soil, a grayer and finer textured subsoil, and poor drainage. It differs from the Toppenish soils in being generally noncalcareous, less alkaline, and shallower to gravel.

Profile description:

1. Dark-gray, slightly hard loam that is crumbled easily into fine granules; very dark brown to black and very friable when moist; 3 to 7 inches thick.
2. Dark-gray to gray slightly hard loam or light clay loam; very faintly mottled with yellowish brown or light yellowish brown; breaks into coarse or medium granules; very dark brown, very dark gray, or black and friable when moist; 7 to 18 inches thick.
3. Gray to grayish-brown, hard clay loam, sandy clay loam, or silty clay loam; mottled with brown, reddish yellow, or light yellowish brown; massive to weak subangular blocky structure; when moist, mottled very dark gray or grayish brown and friable to firm; 15 to 25 inches thick.
4. Loose gravelly alluvium, mostly basaltic.

The entire soil is typically noncalcareous and approximately neutral. Drainage through the soil layers above the gravel is slow if it is not retarded by a high water table.

The color, texture, and organic-matter content vary somewhat from place to place. In some areas the surface soil is fine sandy loam or clay loam. Stratified layers of various textures may occur at any place in the profile. Some areas contain gravel or cobblestones. The depth to loose gravel ranges from about 2 to 5 feet. A few spots are slightly affected by excess soluble salts.

Use and management.—This Wenas soil and others of its series were the first and, for a time, the only soils settled by the pioneers. These soils could be farmed with little or no irrigation. Wenas loam is fertile and is used to grow grains, wild hay, and tame hay. It is also used for native pasture, for which it is excellent. Near Tampico, where it is better drained, hops are grown on the creek bottoms.

This soil is not well suited to most fruits, because of the frost hazard and the impaired drainage. Drainage varies considerably, but in most places the slope of the stream valleys is sufficient to allow some artificial drainage by ditching or by straightening the stream channels.

Wenas gravelly loam (0 to 2 percent slopes) (Wc).—This soil is very similar to Wenas loam. It contains variable quantities of gravel, however, and in some places cobblestones occur on its surface and throughout the profile. It occupies creek bottoms and has a dark surface soil derived through decay of an abundant growth of grass and herbaceous plants. It has formed under an environment similar to that of Wenas loam and was derived from similar but more gravelly materials.

This soil is of minor importance. In some places it is cropped or used for gardens. Most of it is too gravelly to till and is best used for hay and pasture.

White Swan loam (0 to 2 percent slopes) (We).—This soil is among the oldest and highest lying of the alkali soils of the Valley. It has developed at altitudes of 850 to 1,050 feet under an annual precipitation of 6 to 10 inches. In most places it was developed in a thin mantle of loessial material that was deposited over glacial lake-laid strata similar to those underlying the Sagemoor soils.

This soil occupies low nearly level to very gently sloping terraces that consist of remnants of a basin-floor plain in the western end of the Reservation valley. Apparently at a certain stage in the formation of the valley, the soil occupied a poorly drained basin and received excess soluble salts. It was later drained to some extent by the entrenchment of local streams. Then, over a long period, the accumulated soluble salts were gradually leached away by the rainfall and the soil became dispersed and alkaline.

This soil is associated with Sagemoor loam, compact subsoil, but it occurs at somewhat lower altitudes. Nearly all of it is owned by the Indians. The natural vegetation consists of a sparse cover of small sagebrush and greasewood. Between a third and a half of the areas between the shrubs is bare.

Profile description:

1. Brown to pale-brown, noncalcareous, neutral, soft to slightly hard loam; very dark grayish brown and very friable when moist; deepest around brush and shallowest in bare spots; upper 1 to 3 inches of the dry virgin soil is distinctly vesicular, that in the next lower 2 to 5 inches distinct very thin to thin platy; 2 to 14 inches thick.
2. Pale-brown to light brownish-gray, noncalcareous, mildly alkaline, soft to slightly hard, loam or silty clay loam; very fine to fine platy structure; dark grayish brown and friable when moist; ½ to 1 inch thick.
3. Pale-brown to brown, noncalcareous, mildly to moderately alkaline clay; breaks into distinct flat-topped prisms ½ to 1½ inches across, which break into dense or very dense, very hard, blocky aggregates ¼ to ½ inch across; blocky aggregates have a lacquerlike colloidal coating; grayish brown to dark yellowish brown and very firm when moist; 4 to 9 inches thick.
4. Pale-brown to light yellowish-brown, calcareous, strongly to very strongly alkaline, very hard to extremely hard silty clay loam; contains some white lime veins; weakly cemented in many places but breaks into weakly developed, slightly dense, subangular blocky aggregates ¼ to ½ inch across; dark grayish brown to dark yellowish brown and firm to very firm when moist; 3 to 11 inches thick.
5. Light brownish-gray to light-gray, calcareous, moderately to very strongly alkaline, hard to slightly hard silt loam; layer generally somewhat laminated and contains white lime veins; grayish brown to olive gray and firm to friable when moist; 4 to 10 inches thick.
6. Stratified, calcareous, glacial lake sediments, mainly silt loam, very fine sandy loam, and fine sandy loam.

The surface soil is very low in organic matter, and it generally does not contain excess soluble salts. When dry it is generally vesicular and is filled with spherical holes like those in coarse bread or cheese.

The areas may have two or more textures. In many places materials in the surface soil have been shifted by the wind and small mounds or hummocks have accumulated around the shrubs. The surface soil under the sagebrush is as deep as 15 inches and is more friable, less vesicular, and not so platy as elsewhere. It is very thin in the bare spots between the brush. Occasional granite boulders or other stones occur on or in the soil.

The cemented layer, which resembles a hardpan, varies in cementation, hardness, and depth below the surface. In places it is dense enough to stop root penetration, and a brown mat of roots forms on its top. In other places it is absent or only faintly cemented. Drainage through the soil is very slow.

Use and management.—White Swan loam is used almost entirely for unimproved range, but its value for that purpose is low. It is of very little value for crops. The shallow depth of the soil over the dense clayey layers and over the horizon that resembles a hardpan affords an unsatisfactory root zone for most crop plants. The bare patches are very unproductive.

This soil waterlogs easily. Attempts to use it for irrigated crops were disappointing. The results may be seen at the Christian Mission 2 miles south of White Swan.

In most places this soil occupies relief favorable to irrigation. Should it ever become necessary to use the soil, its best use will probably prove to be mixed grass-legume pasture. The most satisfactory method of irrigating is to use light, frequent strip-flooding between low borders 3 to 6 feet apart. Alkaliweed makes satisfactory forage and will grow on the barren spots if they are irrigated.

Yakima loam (0 to 2 percent slopes) (Ya).—This soil occurs on the bottom lands along the Yakima River and some of its larger tributaries, including several creeks that flow from the mountains. It is the most extensive soil in the Yakima-Esquatzel-Ahtanum soil association (fig. 2).

The surface is generally nearly level or slopes very gently with the gradient of the streams. In places it is very gently undulating and is interrupted by very low escarpments, abandoned stream channels, or gravel bars. Only areas in the lower bottoms are occasionally overflowed. Most areas are somewhat excessively drained and are not influenced by a ground water table.

The soil was derived from recent alluvium. This alluvium was washed principally from basalt and from soils formed on basalt that to a large extent occur in areas of higher precipitation. In places the alluvium is mixed somewhat with materials from sedimentary rock or from loess. This soil is browner and darker than the Beverly soils, not so well developed as the Naches soils, and lighter colored and better drained than the Wenas soils.

Yakima loam is characterized by stratified layers and beds of very rapidly permeable waterworn gravel or sand that occur at shallow depths. Gravel in the surface soil is common. The soil in many places is a complex consisting of very shallow gravelly areas and intervening bodies of greater depth that have a surface soil free of gravel.

Unplowed areas are usually covered by big sagebrush and cheatgrass, as the native grasses have been destroyed by overgrazing.

Cottonwoods, willows, and deciduous shrubs fringe many of the abandoned stream channels and grow on narrow strips along the main streams.

Profile description:

1. Grayish-brown to brown, slightly hard to soft loam or gritty loam; breaks into weakly developed fine granules; very dark grayish brown to very dark brown and very friable when moist; 4 to 10 inches thick.
2. Material similar to that in layer above or slightly lighter colored; in many places contains some pebbles; 10 to 18 inches thick.
3. Brown to slightly yellowish brown, soft, gritty loam or sandy loam; mainly massive and generally contains pebbles; very dark grayish brown and very friable when moist; 10 to 20 inches thick.
4. Brown, grayish-brown, or yellowish-brown, loose waterworn gravel, gravelly sand, or other coarse-textured alluvium.

The surface soil of Yakima loam has a low content of organic matter. Typically the entire profile is noncalcareous, nonsaline, and approximately neutral. Drainage through the soil is medium, and it is very rapid in the very porous gravel or coarse-textured substratum material.

Several areas of soil that deviate from the typical Yakima loam profile in texture, depth, and color were included with this mapping unit because there was so much variation within short distances. The texture of the surface soil ranges from loam to fine sandy loam, gravelly loam, or clay loam. The depth to the the loose gravelly or coarse-textured material ranges from about 1½ to 4 feet. Shallow gravelly areas are common, and the more gravelly ones are indicated by gravel symbols on the soil map. As geological stratification dominates the profile, layers of various textures may occur at any depth. Fine-textured layers are not common. In the Ahtanum Creek valley that extends from Wiley City west to Tampico, some areas with deeper soils similar to Onyx loam are included. Areas that have darker colored soils closely related to the Wenas soils are also included.

Yakima loam shows little or no difference in profile layers. Some areas are included, however, that are at higher elevations and slightly older. These are transitional to soils of the Naches series. In places the boundary between this soil and the Naches soils is not distinct. Some areas mapped as Naches soils include bodies of Yakima soil.

Use and management.—Because it occurs in low places, Yakima loam is almost entirely under irrigation. A considerable part of it is supplied with adequate low-cost water from pioneer ditches. The soil is productive in spite of the fact that it is patchy and shallow and spotted by gravelly areas and gravel bars. Underdrainage through the gravel is an asset, and saline areas rarely occur.

This soil is planted to orchards only in the areas where air drainage is most favorable, such as near Naches and below Union Gap. It is best suited to truck gardening and general farm crops. Dairy farming is especially suitable on this soil if adjacent bottom lands along sloughs or rivers can be used for pasture. Where the soil is 2½ to 4 feet deep over gravel, it is nearly as suitable for farm crops as Onyx loam and about as productive. The soil needs drainage, phosphorus fertilizers, and crop rotations that furnish nitrogen and organic matter. In short, it should be managed in about the same way as Onyx loam.

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Yakima sandy loam (0 to 2 percent slopes) (Yb).—This soil resembles Yakima loam but is more sandy and more rapidly permeable. The depth to the loose gravel varies considerably. In many places the soil is 2 to 3 feet deep over the gravel, but numerous areas have a gravelly surface soil. The more gravelly spots are shown by gravel symbols on the soil map. This soil, as mapped, is like Yakima loam in that it includes other soils.

Use and management.—Yakima sandy loam is used in much the same way as Yakima loam. It is suitable for the same crops. Because of its coarser texture, however, it is somewhat less productive and needs more frequent irrigation. Its water-holding capacity is low.

Yakima very gravelly sandy loam (0 to 3 percent slopes) (Yc).—This soil resembles Yakima loam and Yakima sandy loam but is coarser and contains considerably more waterworn gravel and, in places, cobblestones. The amount of gravel is extremely variable from place to place. In most areas gravel interferes seriously with tillage and greatly lowers the waterholding capacity and productivity of the soil. Areas of this soil contain many patches or very low ridges that consist mainly of gravel bars and have little or no vegetation. Other intermingled areas contain less gravel. Many areas are a complex mixture of Yakima soils of various textures and of an older and higher riverwash that is no longer overflowed. The surface of Yakima very gravelly sandy loam in many places is made uneven by very low ridges, short terrace escarpments, or abandoned stream channels.

This soil covers a considerable area in the Reservation valley. Near Wapato a large acreage consists of cobbly gravel bars. Much of the southern part of the city of Yakima is built upon this soil.

Use and management.—Yakima very gravelly sandy loam has little value in itself, and in many fields it interrupts the continuity of better soils. It also causes extensive seepage loss from ditches and interferes with efficient irrigation. A few areas are used as sites for barnlots, haystacks, and beestands. The greater part, at present, can be put to no profitable use. Some areas could be used for feedyards or for poultry raising, but this would mean that much-needed manure would be left on this nonarable soil.

PRODUCTIVITY AND MANAGEMENT OF YAKIMA COUNTY SOILS

PRODUCTIVITY

Table 3 lists the soils of Yakima County alphabetically and gives for each one the estimated average acre yields that may be expected over a period of years.

These yields are based on the management most farmers in the county were using in 1942, the time when field work for this survey was completed. All yields are for crops grown under irrigation.

If they are well drained, the deep, uniform medium-textured soils generally are the most productive and desirable. Nevertheless, in lowland areas that have limited drainage, comparatively shallow soils underlain by porous gravel may be of greater value than deep medium-textured soils on the same lowlands. In orchard areas, furthermore, the site, relief, and direction of exposure so much affect air drainage and temperature that they are more important than small differences in soil characteristics.

A crop should not be attempted on a soil very poorly suited, or entirely unsuited, to that crop. It is generally not practical to grow a crop commercially on a soil poorly suited to it, but some success can be had by using special management, or by growing the crop on a noncommercial basis, as for example, in a home garden.

SOIL MANAGEMENT

Two main kinds of farming are practiced in this county, irrigation and dryland. The problems of management met in irrigation farming are much different from those met in dry farming, so the two are discussed separately.

MANAGEMENT OF IRRIGATED AREAS

It has long been a popular belief that soils of arid or semiarid areas are very fertile, and that their fertility lasts indefinitely after they are irrigated. This is not true. Irrigated soils can be depleted rapidly, or their fertility can be maintained or improved. The choice is made by the operator.

Before irrigation, soils of the Yakima Valley are much like those in other dry regions. They are generally neutral or alkaline. They have fair structure and good supplies of some of the minerals plants need, particularly calcium, potassium, magnesium, and sulfur. But they are low in organic matter, low in nitrogen, and may have only a limited supply of phosphorus in forms that plants can use.

Poor soil management, either on irrigated or nonirrigated soils causes depletion of the soils. Crops taken off remove nitrogen and other plant nutrients and cultivation reduces the supply of organic matter. Loss of organic matter causes deterioration of soil structure. As soil structure becomes less favorable, the soils absorb less water, are harder to work, and are more likely to erode.

In irrigation farming, the effects of poor management are not limited to those just mentioned. Improperly applied irrigation water carries away plant nutrients, erodes the soils, causes high water tables, and frequently encourages accumulation of salts and alkali harmful to crops. These and other important problems of irrigation management are discussed in the following pages, and some desirable practices are suggested.

Use of irrigation water.—In the past applying excessive irrigation water has damaged many soils. Using too much water is wasteful, but that is only part of the story. The excess water causes seepage and accumulation of harmful salts in the soils that lie at lower levels. Too much water on a soil with poor internal drainage waterlogs the root zone and will injure or kill crops or fruit trees. It leaches plant nutrients from the soils that allow rapid percolation of moisture. On droughty Quincy soils and the shallow Yakima, Naches, and Ephrata soils, use of too much water will leach the soils so rapidly that it will be difficult to keep the soils fertile enough to produce crops profitably.

Good use of irrigation water is discussed in the section, Irrigation and Drainage.

TABLE 3.—*Estimated average acre yields to be expected over a period of years on the soils of Yakima County, Wash.*

[Yield estimates are based on the management used by most farmers in the county at the time of survey (1942); unless otherwise indicated by footnotes, all yields are for irrigated soils; absence of data indicates crop specified is not suited to the soil, or its acreage is so small that average yields under irrigation could not be determined]

Soil	Corn	Oats	Wheat	Barley	Alfalfa hay	Mixed hay	Pasture	Potatoes	Sugar beets	Hops	Apples	Peaches	Pears
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Ahtanum fine sandy loam [1]					2.5	1.2	3.0	6.6	15.0	1,500			
Ahtanum loam [1]					2.5	1.3	3.0	6.6	15.0	1,500			
Ahtanum silt loam [1]					2.5	1.3	3.0	6.7	15.0	1,500			
Beverly loam	40	50	25	25	3.0	1.3	3.0	6.0	16.0				
Beverly silt loam	45	55	28	28	3.2	1.3	3.2	6.5	17.0				
Bickleton silt loam [2]													
Burke fine sandy loam	35	40	25	20	3.5	1.2	3.5	11.0	17.0	1,600	12,000	9,200	11,000
Burke loam	35	45	28	23	3.5	1.3	3.7	11.0	17.0	1,600	12,500	9,500	11,500
Cleman clay loam	50	60	30	30	3.5	1.4	3.7	9.0	18.0		15,000	9,500	
Cleman coarse sandy loam	35	45	20	20	2.8	1.1	3.0	8.0			11,500	7,800	
Cleman loam	45	60	30	30	3.5	1.4	3.5	10.0	18.0		15,500	11,000	
Cleman sandy loam	40	50	25	25	3.0	1.2	3.5	10.0	16.5		14,000		
Cowiche fine sandy loam	40	55	35	35	3.5	1.4	3.5	9.0	18.0	2,000	16,700	8,400	11,300
Cowiche loam	45	60	35	35	3.5	1.4	3.7	9.5	18.0	2,000	17,500	9,000	12,500
Rolling	35	50	30	30	3.3	1.2	3.3				15,000	7,500	10,500
Ephrata very fine sandy loam	50	50	35	32	3.8	1.4	3.4	9.5	16.0	1,900	13,500	12,000	10,000
Esquatzel fine sandy loam	75	80	50	45	4.5	2.0	5.0	12.0	20.0	2,000	18,000	12,000	14,500
Esquatzel silt loam	80	90	55	48	4.5	2.5	5.5	12.5	22.0	2,200	18,500	12,500	15,000
Esquatzel very fine sandy loam	80	90	55	48	4.5	2.5	5.0	12.5	21.0	2,200	18,000	12,500	15,000
Fiander fine sandy loam [1]					2.5	1.0	3.0						
Giffin loam [1]						1.0	3.0						
Giffin silt loam [1]						1.2	3.0						
Harwood loam	45	55	28	25	3.3	1.2	3.2	8.5	15.0	1,600	15,500	8,000	11,000
Sloping	35	40	20	20	3.0	1.1	3.0				12,500	6,000	8,500
Kittitas silt loam [1]	60	70	35	30	3.5	1.3	3.8	10.0	20.0	1,700			
Marsh													
Naches loam	50	65	35	30	3.7	1.5	3.3	10.5	18.0	1,900	21,500	13,000	11,500
Naches sandy loam	45	60	35	28	3.2	1.2	3.3	10.0	17.0	1,800	18,000	11,500	10,800
Naches soils	45	60	33	27	3.3	1.2	3.3	10.0	16.0	1,600	18,500	11,200	9,800
Onyx loam	75	80	50	45	4.5	2.0	5.5	12.5	21.0	2,000	21,500	12,500	15,000
Prosser fine sandy loam	40	50	25	25	3.0	1.1	3.0	6.0	12.0	1,400		8,500	
Quincy loamy fine sand	30	40	20	20	2.5	1.0	2.5	6.0		1,200	12,000	8,800	
Quincy sand							(3)						
Quincy-Sagemoor-Marsh complex							(3)						
Renslow silt loam [2]													
Ritzville silt loam	60	75	38	33	4.0	1.5	4.5	10.5	20.0	1,800	23,500	13,500	16,000
Strongly sloping	55	70	35	32	4.0	1.4	4.5	10.0	18.0	1,700	22,500	13,000	15,500
Ritzville and Renslow silt loams [2]			(4)				(4)						
Riverwash							(5)						
Rough mountainous land							(5)						
Roza clay loam	35	40	25	20	3.0	1.2	2.8				12,000	9,000	11,200

Roza gritty loam	33	38	25	20	3.0	1.2	2.7				12,000	9,000	11,000
Roza gravelly loam	32	37	24	19	2.9	1.1	2.6				11,500	8,500	11,000
Roza sandy loam	32	36	23	18	2.8	1.1	2.5				11,500	8,500	11,000
Sagemoor very fine sandy loam	50	60	36	35	4.1	1.5	4.0	10.7	20.0	1,800	25,500	13,500	21,000
Sloping	45	55	33	32	3.8	1.2	3.8	7.0	15.0	1,600	24,000	13,000	20,500
Sagemoor fine sandy loam	50	60	36	35	4.0	1.5	4.0	10.8	20.0	1,800	25,000	13,000	16,500
Sagemoor loam:													
Compact subsoil	45	40	28	28	3.8	1.3	3.8	9.5	18.0	1,600	22,500	10,800	14,000
Saline [1]						1.1	3.0						
Scabland and Smooth stony land							(5)						
Scowlale loam [1]						1.0	2.5						
Selah loam	42	55	35	35	3.7	1.3	3.5	9.0	20.0	1,800	21,500	12,800	16,200
Simcoe clay loam [6]		35	25	20	2.0	1.0	2.0						
Steep broken and Stony land							(5)						
Stony and shallow soils							(3)						
Tancum loam [2]													
Rolling [2]													
Tieton loam	40	55	35	35	3.5	1.5	4.0	9.0	18.0	2,000	25,200	13,500	15,500
Tieton loamy fine sand	30	40	25	20	3.0	1.3	3.3	7.5	15.0	1,600	20,800	12,000	12,500
Toppenish clay [1]	35	50	20	20		1.3	3.0						
Toppenish clay loam [1]	40	60	25	25		1.3	3.5						
Toppenish loam [1]	40	60	25	25	3.0	1.3	3.6	8.0	16.0	1,600			
Umapine loam [1]	25	40	20	20	2.5	1.0	2.8	6.5	14.0	1,500			
Wahtum fine sandy loam [1]	35	45	25	25	3.2	1.2	3.5	7.0	15.0	1,500			
Wahtum loam [1]	35	45	25	25	3.3	1.3	3.5	7.0	15.0	1,600			
Wenas gravelly loam	55	65	45	40	3.8	1.8	4.5	9.5	20.0	1,750			
Wenas loam	60	70	50	45	4.0	2.0	4.5	10.0	21.0	1,800			
White Swan loam [6]	35	50	25	30	3.5	1.4	3.5	7.0	14.0				
Yakima loam	50	70	35	35	3.5	1.3	4.0	9.0	17.0	1,800			
Yakima sandy loam	45	65	33	32	3.5	1.2	4.0	9.0	16.5	1,700			
Yakima very gravelly sandy loam						1.0	2.5						

[1] Yields extremely variable depending on soil depth, management, and degree of reclamation.
[2] Soil is dry farmed; not irrigated.
[3] Used to some extent for dryland range pasture.
[4] Fair for dryland wheat at higher elevations; fair for dryland range pasture.
[5] Affords variable amounts of dryland range pasture.
[6] Irrigated from small streams only; water shortage acute; fertile enough to produce higher yields if well managed.

Erosion.—Soils in the Yakima Valley are subject to wind and water erosion. The coarser textured soils on exposed south and west slopes are normally the only irrigated soils seriously affected by drifting. Because they are susceptible to drifting, Quincy loamy fine sand, Ephrata very fine sandy loam, Sagemoor very fine sandy loam, and Sagemoor fine sandy loam on south and west slopes are better for vineyards, alfalfa, or other soil-binding crops than for row crops. Asparagus should not be planted on south and west slopes, because the drifting sand injures the tender shoots.

Irrigation rills on sloping land become gullies if they carry too much water. The irrigator needs to give constant attention to his job. A weed may blow into a ditch, lodge, and cause an overflow that will cut a gully overnight, or a gopher can cause the same thing by tunneling, or a head ditch or a flume may break.

Water erosion and gullying on steeper slopes can be held to a minimum by establishing a dense stand of grass and legumes. Irrigation still will have to be done carefully, but the slopes will require much less attention than if they were in row crops.

Spray residue.—Accumulation of lead arsenate residue is a critical problem in old orchards. The spray, used extensively on apples and pears to combat the codling moth, accumulates in slightly soluble form in the top 4 to 6 inches of the soil. Only a few parts per million of the lead arsenate go into the soil solution, but this is toxic to most crop plants that germinate and feed in the surface soil. The residue does not seem to affect old trees that have roots below the zone of accumulation, but alfalfa or other cover crops that are needed to maintain fertility of the soil die out and fail to grow when reseeded.

When an old orchard is taken out, spray residues limit the use of the soil. Recently, use of improved sprays has checked accumulation of spray residue. The problem is therefore limited to the older orchard sites.

Organic matter.—Virgin soils in arid areas have a low supply of organic matter. Successful farming of these soils requires that the supply be built up, or at least, maintained.

In the Yakima Valley, intensive growing of cash crops has been the most important cause of soil deterioration. Large areas of desirable soils not subject to seepage or erosion have lost their productivity because they have been cropped intensively. Soils less desirable have been less used for crops, and, consequently, have retained a larger share of the original productivity.

Organic matter is depleted if crops are sold off the land, and in irrigated areas farmers are strongly tempted to do this. Their costs per acre are high, so they are inclined to grow row crops that produce large yields per acre. They are not inclined to keep livestock, because doing this requires growing of feed crops or purchase of feed. Without livestock, they do not have manure to restore at least part of the organic matter removed in the cash crops. They can quickly replace the nitrogen and other plant nutrients by applying commercial fertilizer, but restoring the organic matter needed for good tilth and lasting productivity requires time and careful management.

Organic matter can be restored by applying barnyard manure, growing winter cover crops and plowing them under, or by growing legume-grass sod in rotation with row crops. Each method has advantages and disadvantages.

Green-manure crops and even barnyard manure make it possible to continue cropping in areas that would otherwise be unsuitable, but grass-legume sods are better sources of organic matter. Plant residues break down rapidly in soils under irrigation, and the humus soon dissipates. The residue from a green-manure crop or a dressing of barnyard manure is exhausted after 1 or 2 years of cropping. The plant material breaks down so rapidly that it exists in the soil mainly as interstitial, crude organic matter. Little of it becomes humus, which is the stable colloidal form of organic matter that fixes itself as a film, or coating, around the soil particles.

Humus, the better and more permanent form of organic matter, accumulates naturally in soils that are under an undisturbed cover of grass and herbs. The semiarid soils of the Yakima Valley are natural grassland and, if irrigated, are also well suited to legumes. Bacteria on the roots of legumes take nitrogen from the air. When the legume is plowed, the roots decay and supply both organic matter and nitrogen for the soil. Grass-legume sods are the best source of humus and need to be a part of the rotation if the productivity of irrigated soils is to be maintained or improved.

Green-manure crops grown in winter, vetch for example, supply organic matter and nitrogen at lower cost than manure. It may be necessary to use them in vineyards and hopyards because the supply of manure has become low. These crops must be planted in September, however, a time when water is usually short and there is a press of other work. The crops, furthermore, should be plowed under late in May, which is too late to allow planting of most cash crops.

Most farmers prefer rye to legumes because the seed is low priced and because the crop has a short growing period and is winter-hardy. Rye used alone is of low value as green manure. It can be used instead of legumes if nitrogen fertilizer is applied.

Alfalfa benefits the soil if properly managed, but it will deplete the soil if the hay is sold off the farm, the stubble is pastured, and the plants are plowed out and removed when the stand becomes poor. Frequently, farmers in this county crown the alfalfa, that is, plow it 3 or 4 inches deep; replow 6 or 8 inches deep; harrow out most of the crowns; and then rake the crowns off after they have dried. This process leaves scarcely enough nitrogen and organic matter for 1 year, but farmers often grow row crops 3 to 6 years before planting alfalfa again.

Under practices such as those just mentioned, Toppenish clay and similar soils have lost their flocculent structure and have become dense, difficult to till, and hard to soak with irrigation water. Other soils, such as the Renslow and Ritzville silt loams, have become less productive. Small-seeded crops do not make good stands on them, and grow poorly. Also the soils need to be irrigated more frequently.

Maintenance of organic matter in the soils requires use of all available supplies. Weeds, stack bottoms, and strawpiles should be composted and returned to the soil, not burned. Barnyard manure should be used, if available, and cover crops grown. The late growth of alfalfa should be turned under as green manure. Finally, accumulation of the permanent form of organic matter vital to continued productivity must be encouraged by growing grass-legume sods, even if they are not needed for pasture.

Plant nutrients.—The soils of the Yakima Valley are most often deficient in nitrogen and phosphorus. Need for minor elements has not been studied enough to permit accurate predictions. Also, the effect of excess lime salts, and alkali on the soils has not been defined in terms of plant nutrition.

Nitrogen can be returned to the soil by growing legumes in the crop rotation, planting green-manure crops, applying barnyard manure, and using commercial fertilizer.

Use of commercial fertilizer as the only source of nitrogen is not advisable. Nitrogen is unstable unless organic matter and micro-organisms are in the soils to hold it and release it slowly.

A commercial nitrogen fertilizer such as ammonium sulfate can be used to fortify weeds, straw, and cornstalks made into compost and plowed under. Rye is much more effective as a winter cover and green manure if 100 pounds of ammonium sulfate per acre is applied. Barnyard manure also can be fortified.

Phosphorus, in good supply, stimulates plants to grow extensive root systems early in the season and causes them to mature earlier and to produce more seed. Phosphorus, unlike nitrogen, rarely injures plants or causes abnormality in growth if too much is applied. It is fairly stable in the soil, so if a large application is made, the amount not used by the first crop will benefit crops that follow.

Some soils of the Yakima Valley, particularly those that have been cash-cropped for a long time, have become deficient in phosphorus. Soils used to grow alfalfa for cash market are among those depleted, for alfalfa is a heavy user of phosphorus. The Sagemoor soils in the Sunnyside division are particularly deficient in phosphorus because of cash cropping.

Phosphorus deficiency is not easy to detect. If the soil is extremely low in phosphorus, plants develop a purplish color. This is not a sure sign, however, for the purplish color may result from other causes. Soil tests are the best way of determining need for phosphorus. Livestock may develop serious nutritional disorders if fed crops from soils low in phosphorus.

Farmers generally apply superphosphate. Small quantities are applied to orchards, although it is not recommended. From 100 to 150 pounds per acre is used annually on sugar beets. Alfalfa and pasture plants have shown marked increase in yield and definitely better feeding value where phosphorus has been applied.

Potassium is apparently abundant in the soils of the Yakima Valley.

Lime is apparently not needed for any of the soils under irrigation in the Yakima Valley. Some soils, especially the Sagemoor and Umapine, contain too much lime. The lime reduces the availability of other plant nutrients.

The Simcoe, Cowiche, Tieton, Harwood, and Naches soils contain no free lime, or only small quantities. Nevertheless, these soils are neutral or nearly neutral. The irrigation water alone contains enough soluble calcium to meet the needs of plants and to keep the soils neutral in reaction. Analyses of irrigation water show that 75 to 200 pounds of calcium is carried to each acre every year. A 100-bushel corn crop needs only about 50 pounds of calcium per acre (*2*).

Minor elements are necessary to plant growth, but little information is available concerning need for these elements in the Yakima Valley. Some of the soils have a short supply of available iron, zinc, and manganese.

MANAGEMENT OF DRYLAND

The nonirrigated soils of the county are used for grazing or production of small grains. Generally speaking these uses account for all of the agricultural land outside the Yakima Valley.

Dry Farming.—None of the soils suitable for dry farming receive enough rainfall to produce crops every year. Some of them are summer-fallowed every other year (*18*). Others are planted only when there is some prospect that enough moisture will be available, and, consequently, they may lie idle several years between plantings.

The soils are plowed as early in spring as possible. A diskplow is preferred because it leaves the soil rough and buries only part of the stubble. The straw, roots, and other trash left at the surface protect the soil from blowing, which is always a hazard in dry farming. Rodweeders are often used, as they leave clods and trash at the surface.

Modern tractors, the wheatland diskplow, and Early Baart spring wheat have made dry farming a less hazardous enterprise. The limited moisture available is better used because tractors permit early completion of field work and because the wheat matures earlier. The diskplow, as already mentioned, provides protection from wind erosion.

The soils are beginning to show the effects of dry farming. Yields are decreasing because supplies of organic matter and nitrogen are being depleted. Soil tilth and structure are impaired. This process of deterioration can be checked by putting part of the dryland into grass for 8 to 10 years. Crested wheatgrass is suggested. Alfalfa or similar soil-improving legumes are not suitable for dryland because they need more moisture than can normally be expected in this climate.

Grazing.—Many thousands of cattle, sheep, and horses grazed the native grasses in this area in the early days of settlement. Sheep raising became important in 1885. Overstocking greatly depleted the range. Cheatgrass invaded, and sagebrush became more abundant. Cheatgrass now furnishes most of the forage. Sheep graze the cheatgrass early in spring and often graze it again late in fall after the sharp, three-awned seeds have shattered out. The stand of cheatgrass depends on the amount of rainfall and the time it comes. Fall rains are needed to sprout the seeds. When precipitation is high in winter, the cheatgrass grows luxuriantly the following spring and becomes a serious fire hazard when it dries out in summer.

In addition to cheatgrass, there are drought-tolerant weeds, mostly in abandoned fields and along drainageways, that provide some forage. Sheep will eat Russian-thistle, lambsquarter, Jim Hill mustard, tansymustard, and shieldcress. They will also eat small quantities of sagebrush. In fall and winter, livestock relish whitesage (winterfat) that grows on shallow soils that have south and west exposures.

Fiddleneck, locally called tarweed, is the most obnoxious plant on the dry ranges. It is unpalatable, if not actually poisonous, and the coarse stinging hairs discourage livestock from grazing other plants nearby. Tarweed is abundant on soils that have been severely overgrazed.

Improved management of rangelands would benefit the agriculture of the whole county. The depleted range does not provide grazing for enough animals to give irrigation farmers a good local market for feed crops. If the carrying capacity of the range were improved, irrigation farmers would be able to grow grass-legume mixtures in their crop rotations, feed range livestock on their farms in winter, and in this way limit the soil-depleting practice of growing crops for sale on outside markets. One of the major problems on irrigation farms is restoration of organic matter removed by cropping. Feeding of livestock on the farm will provide much of the needed organic matter.

The rangelands can be improved mainly by controlling grazing and, in the badly overgrazed areas, by reseeding to native perennial plants. Few perennial grasses are hardy enough to grow in this dry climate. The Great Plains grasses are poorly suited because in their normal climate they get most of their rainfall in summer. In Yakima County most of the moisture comes in winter. Crested wheatgrass produces desirable forage but it is successful only on soils where dryland grain can be grown.

Interest in range management has increased recently. Many stockmen now control grazing, and overgrazing has been reduced on the Indian Reservation. The stand of native grasses has noticeably increased in many places where grazing has been reduced. Some areas, however, are so badly overgrazed that they will recover only if they are reseeded and protected from livestock until the new growth is established.

Ranchers need to consider both range site and range condition as they plan their grazing programs. A range site is one kind of soil, or a group of soils, able to produce about the same kind and amount of forage per acre. Range condition can be excellent, good, fair, or poor, depending on the relative numbers of different plants and their origin. Ranges can be brought to good or excellent condition by good grazing practices.

CAPABILITY GROUPS OF SOILS

The capability grouping is arrangement of soils according to their relative suitability for crops, grazing, forestry, or wildlife. The estimate of this suitability is a consensus of several persons who know the soils and work with them. Soils that are nearly level, well drained, free from overflow, fairly fertile, and not otherwise limited are placed in capability class I. They are widely adaptable and the user of them has many choices open to him. He can use his class I soils for crops, without special practices, and can choose one of several cropping systems; or he may, if he wishes, use the soil for pasture or for some other purpose.

Soils are placed in class II if they are a little less widely adaptable, and thus more limited than those in class I. A gently sloping soil, for example, must be farmed on the contour, or kept covered with vegetation more of the time, or managed in some other way to control runoff and erosion; it is more difficult to irrigate than a soil in class I. Other soils of class II are limited and require special management because they have excess water, because they are sandy or shallow and have low moisture-holding capacity, or because they are where the climate is not favorable.

Soils are placed in capability class III if they are still less adaptable or have more stringent management requirements than those in class II, and yet can be used satisfactorily for long-term cropping. Soils even less adaptable and therefore more limited than those in class III, but usable for tilled crops part of the time or with special precautions, are in class IV.

Soils not suitable for cultivation are in classes V, VI, VII, or VIII. Class V contains the soils not subject to erosion but unsuitable for cultivation because of standing water or some other limitation. Class VI contains the soils, many of them steep, that yield fairly good amounts of forage or of forest products but as a rule should not be cultivated. Some of them can with safety be disturbed just enough to prepare them for orchards, or other trees, or for extremely long-time pastures.

Soils in class VII are more limited than those in class VI, are not suitable for any cultivation, and usually give only fair or poor yields of forage or wood products. Soils in class VIII are so severely limited that they produce little useful vegetation. They may make attractive scenery, or may be parts of useful watersheds. Some have a little value as a refuge for wildlife.

Classes I and V do not occur in Yakima County.

SUBCLASSES: Most of the capability classes include soils that differ greatly from one another. It is convenient to recognize capability subclasses, based on the dominant kind of limitation. As many as four subclasses may be recognized, according to dominant limitations: These are risk of erosion (e), excess water (w), shallow or droughty soil (s), and hazardous climate (c). Subclasses are denoted by a small letter following the class number, such as IIe or IIw. Subclasses "e" and "s" occur in this county.

The capability class and subclass for each soil are shown in the following list:

Name	*Capability class and subclass*
Ahtanum fine sandy loam (Aa)	IIs.
Ahtanum loam (Ab)	IIs.
Ahtanum silt loam (Ac)	IIs.
Beverly loam (Ba)	IIs.
Beverly silt loam (Bb)	IIs.
Bickleton silt loam (Bc)	IIe.
Burke fine sandy loam (Bd)	IIIe.
Burke loam (Be)	IIe.
Cleman clay loam (Ca)	IIe.
Cleman coarse sandy loam (Cb)	IVs.
Cleman loam (Cc)	IIe.
Cleman sandy loam (Cd)	IIs.
Cowiche fine sandy loam (Ce)	IIe.
Cowiche loam (Cf)	IIe.
Rolling (Cg)	IVe.
Ephrata very fine sandy loam (Ea)	IIe.
Esquatzel fine sandy loam (Eb)	IIs.
Esquatzel silt loam (Ec)	IIe.
Esquatzel very fine sandy loam (Ed)	IIe.
Fiander fine sandy loam (Fa)	IVs.
Giffin loam (Ga)	IIIs.
Giffin silt loam (Gb)	IIIs.

Name	*Capability class and subclass*
Harwood loam (Ha)	IIe.
Sloping (Hb)	IIIe.
Kittitas silt loam (Ka)	IIe.
Marsh (Ma)	VIII.
Naches loam (Nb)	IIs.
Naches sandy loam (Nc)	IIs.
Naches soils (Nd)	IVe.
Onyx loam (Oa)	IIc.
Prosser fine sandy loam (Pa)	IIs.
Quincy loamy fine sand (Qa)	IIIe.
Quincy sand (Qb)	IVe.
Quincy-Sagemoor-Marsh complex (Qc)	VIIs.
Renslow silt loam (Ra)	IIIe.
Ritzville and Renslow silt loams (Rb)	IIIc.
Ritzville silt loam (Rc)	IIe.
Strongly sloping (Rd)	IVe.
Riverwash (Re)	VIII.
Rough mountainous land (Rf)	VIIe.
Roza clay loam (Rg)	IIs.
Roza gravelly loam (Rh)	IVs.
Roza gritty loam (Rk)	IIIs.
Roza sandy loam (Rl)	IIIs.
Sagemoor fine sandy loam (Sa)	IIe.
Sagemoor loam, compact subsoil (Sb)	IIIe.
Saline (Sc)	IVs.
Sagemoor very fine sandy loam (Sd)	IIe.
Sloping (Se)	IIIe.
Scabland and Smooth stony land (Sf)	VIs.
Scowlale loam (Sg)	IVs.
Selah loam (Sh)	IIIe.
Simcoe clay loam (Sk)	IIe.
Steep broken and stony land (Sl)	VIIe.
Stony and shallow soils (Sm)	VIe.
Taneum loam (Ta)	IIIe.
Rolling (Tb)	IVe.
Tieton loam (Tc)	IIe.
Tieton loamy fine sand (Td)	IIIe.
Toppenish clay (Te)	IIs.
Toppenish clay loam (Tf)	IIs.
Toppenish loam (Tg)	IIs.
Umapine loam (Ua)	IIs.
Wahtum fine sandy loam (Wa)	IIs.
Wahtum loam (Wb)	IIs.
Wenas gravelly loam (Wc)	IVs.
Wenas loam (Wd)	IIe.
White Swan loam (We)	IVs.
Yakima loam (Ya)	IIs.
Yakima sandy loam (Yb)	IIs.
Yakima very gravelly sandy loam (Yc)	IVs.

SOLUBLE SALTS AND ALKALI

Concentration of water-soluble salts harmful to crops occur in some soils in arid climates where the rainfall is too low to leach them away. The effects of salts on plants are determined by the kinds of salts, the amount present, and the moisture conditions of the soils.

Soil areas in this county that were affected by salts at the time of the survey are outlined, or shown by symbol, on the soil map. Determination of specific salt content was not made for these areas because:

1. The concentrations and proportions of salts vary from place to place and within short distances.

2. The salinity changes from season to season.
3. Some salty areas are reclaimed and others grow larger.
4. Salts accumulate in new places as irrigation is extended.

Source of soluble salts.—Salts come from the soil materials, from irrigation waters, or from seepage waters.

In this county the soils themselves are the most important source of salts. Ground water from irrigated areas is charged with salts dissolved from the soils and the underlying strata. The discharge water in many drains contains only 300 to 800 parts per million (p. p. m.) of salts, but in some drains the concentration ranges up to 2,000 p. p. m. In many places seepage waters contain 3,000 p. p. m. of salt, and in one instance the water had 148,470 p. p. m. of salt (*21*).

The Yakima Valley is irrigated by water from perennial streams that flow from the mountains. The water is relatively free of salts. The salt content varies in different streams, at different points along the same stream, and at different seasons. Salt content is normally highest in fall and lowest in spring when the streams are swollen by melting snow.

The analyses of irrigation water available indicate that the salt content ranges from 50 to 200 p. p. m. These waters are low in salt. Some irrigation waters used in the West contain as much as 2,000 parts of salt per million.

The foregoing discussion of salt concentration in ground water is only indicative of the range to be expected in the Yakima Valley. Exact information on the amount of salts in the ground water is not important. It is important that salts in the ground water, within a rather wide range of concentration, may cause toxic accumulation of salts in the surface soil. This occurs wherever the ground water is allowed to rise to the surface and evaporate for several years.

Some of the older soils in the Yakima Valley have become strongly charged with salts because they have been subirrigated for a long time by streams containing a low concentration of soluble salts.

Drainage and concentration of salts.—Well-drained soils, even in arid areas, normally have low concentrations of salts, and the salts are diffused throughout the profile. In contrast poorly drained soils in a dry climate frequently have strong concentrations of salts. The salts, furthermore, are often in the root zone of crops. The ground water prevents leaching of the salts and, instead, brings the dissolved salts near the surface. When the water evaporates, the salts are left in the root zone.

In this county the areas affected by salts now have a high water table or have had one in the past. Obviously, reclamation of the salt-affected soils cannot be accomplished unless drainage can be improved.

Kinds of soluble salts.—The two main kinds of salty soils are popularly called "white alkali" and "black alkali." Soils may be saline, or alkaline, or both. In this report, soils affected by soluble salts are classified as follows:

SALINE: Soil has a concentration of salts so distributed in the profile that the growth of most crops is retarded.

ALKALI: Soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the exchangeable bases) that the growth of most crops is reduced.

SALINE-ALKALI: Soil has a combination of harmful quantities of neutral salts and either high alkalinity or high exchangeable sodium, or both, so distributed in the profile that growth of most crops is retarded.

The salts normally most abundant in soils of the Yakima Valley are neutral salts. Sodium sulfate and sodium chloride are dominant. Appreciable amounts of calcium sulfate, calcium chloride, and magnesium bicarbonate are present. Nitrates occur in some areas of the Ahtanum and Kittitas soils. In the saline areas of the Esquatzel and Sagemoor soils, nitrates may be abundant, or even the dominant salts (*9*).

The salts just named do not make the soil strongly alkaline. Excessive concentrations of these salts are commonly referred to as "white alkali." Soils affected only by these neutral salts normally can be reclaimed by providing good drainage and leaching with large amounts of irrigation water.

Some soils in the Yakima Valley contain appreciable quantities of sodium bicarbonate, and a few small areas have sodium carbonate. These salts are strongly alkaline in reaction and are commonly called "black alkali."

In soils that contain a high proportion of sodium salts, the tiny clay particles, or colloids, hold part of the sodium on their surface. The soils stay flocculated, or fluffy, so long as they contain a high concentration of salts. But when water is applied and the excess salts are removed, the water reacts with the sodium that stays on the clay particles and forms sodium hydroxide, or lye. This makes the soil highly alkaline and causes the clay particles to disperse easily in water. Then the soil becomes puddled and slowly permeable and, on drying, "freezes up" into a hard or cloddy mass.

Reclamation of soils that contain sodium requires good drainage, application of very large amounts of water without giving the soil a chance to dry out, and use of chemical amendments such as sulfur.

Lime (calcium carbonate) and gypsum (calcium sulfate) occur in many places along with soluble salts. The lime and gypsum are only slightly soluble and, if not present in excessive amounts, usually benefit rather than harm the soils.

Lime is most abundant in the subsoil layers of older well-drained soils. The soil layer is said to be calcareous if it effervesces, or bubbles, when dilute hydrochloric acid is applied.

Excessive amounts of gypsum are not common in soils of the Yakima Valley. Gypsum does not effervesce when hydrochloric acid is applied; its presence in the soil is determined by laboratory tests. If a soil that contains sodium salts also contains gypsum, the harmful effect of the sodium is partly prevented. A sodium-affected soil that contains gypsum will not lose its permeability so readily after leaching.

LABORATORY STUDIES OF SALINE AND ALKALI SOILS

Chemical and physical characteristics of several saline and alkali soils of Yakima County were determined by laboratory analyses after field work had been completed. The results, shown in table 4, help us understand these soils, the methods that can be used to reclaim them, and the probable degree of success if reclamation is attempted.

Salinity of the soils was determined by measuring the electrical conductivity of the saturation extract; that is, the flow of electricity through water extracted from a sample of saturated soil. Reference to table 4 will show a wide range in electrical conductivity for the various samples.

Data obtained by Scofield (*16*) and the U. S. Regional Salinity Laboratory (*15*) will help in interpreting these conductivity ranges in terms of crop production. A conductivity of less than 4 millimhos per centimeter (mmho./cm.) indicates that common field crops will grow. At a conductivity between 4 and 8, crops more sensitive to salts will not thrive, but salt-tolerant crops will do well. At a conductivity between 8 and 15, yields of even the salt-tolerant crops will be low. If the conductivity is more than 15, none of the ordinary field crops will do well.

Information concerning the kinds of soluble salts in the various soils sampled were obtained by making detailed chemical analyses. If exchangeable sodium was present, the capacity for cation exchange was determined, and the percentage of exchangeable sodium was calculated. A percentage of exchangeable sodium greater than 15 is considered excessive for plant growth.

The soils sampled were also tested for effervescence with dilute hydrochloric acid (HCl), amount of water held when saturated, and pH of the saturated soil paste. Samples from upper layers of the soils were tested to determine their permeability, to obtain information concerning dispersion of the soil particles, and to judge how successfully they could be leached of salts under field conditions.

Ahtanum loam.—This soil was sampled at two sites as shown in table 4. Conductivity of the saturation extract and the percentage of salt on a dryweight basis show high concentrations of soluble salts in the upper layers. Lower layers contained relatively little salt at the time of sampling, but it is apparent that the amount of salts in the root zone is enough to adversely affect the growth of most crops. Sodium nitrate, sodium chloride, and sodium sulfate are the principal salts present. Although not determined, appreciable quantities of bicarbonate and carbonate ions are no doubt present.

The samples studied have high percentages of exchangeable sodium; the pH of all samples is 8.6 or higher. Because of the large percentage of exchangeable sodium, the soil is highly dispersed and very slowly permeable.

Reclaiming this soil would require drainage, applications of large amounts of water to leach it, and the addition of chemicals to replace the sodium. The presence of lime in the soil permits use of sulfur as an amendment to enable calcium to replace the exchangeable sodium.

Esquatzel silt loam.—Three saline areas of Esquatzel silt loam were sampled at the sites shown in table 4. The sites had shown poor to fair response to cropping but, at the time of sampling, were idle because of excess salt content.

Both the conductivity of the saturation extract and the percentage of salt calculated on a dry-weight basis show strong concentrations

TABLE 4.—*Chemical analyses of saline*

Soil type, site number, and location	Depth	Lime test [3]	Water content at saturation	pH of saturated paste	Electrical conductivity of saturation extract	Percent salt dry-weight basis	Soluble cations in saturation extract: Ca	Mg	Na	K	Sum of cations
	Inches		*Percent*		*Mmho./cm.*	*Percent*	*Me./l.*	*Me./l.*	*Me./l.*	*Me./l.*	*Me./l.*
Ahtanum loam: Site 16 (SW¼ sec. 29, T. 13 N., R. 18 E.)	0-6	1	38.4	8.9	22.1	0.65	11	5	212	16	244
	6-12	2	36.2	8.6	10.1	.24	-----	-----	104	-----	-----
	12-24	3	39.0	8.6	4.3	.12	-----	-----	35	-----	-----
Site 16a (About 300 feet from site 16)	([4])	0	31.2	9.9	15.7	.34	-----	-----	-----	-----	-----
	0-6	2	31.3	9.4	22.0	.54	11	3	250	14	278
	12-18	3	32.8	8.0	2.4	.06	-----	-----	23	-----	-----
	18-20	3	37.7	9.1	([5])	([5])	-----	-----	19	-----	-----
Esquatzel silt loam (saline area): [6] Site 11 (SW¼ sec. 3, T. 11 N., R. 18 E.)	([4])	[7] 2	44.0	8.2	113.0	6.37	-----	-----	3,532	-----	-----
	0-6	0	35.4	7.6	23.6	.63	140	84	76	3	303
	6-12	0	36.4	7.4	22.0	.58	-----	-----	84	-----	-----
	12-24	0	34.4	7.5	10.9	.24	-----	-----	47	-----	-----
	24-36	0	35.5	7.6	10.6	.23	-----	-----	46	-----	-----
	36-48	0	36.8	7.6	6.8	.16	-----	-----	38	-----	-----
Site 11a (about 60 feet from site 11)	0-6	[7] 1	41.1	7.5	24.2	.77	-----	-----	107	-----	-----
	6-12	1	41.1	8.0	9.1	.24	-----	-----	50	-----	-----
	12-18	1	42.0	7.9	6.6	.18	-----	-----	44	-----	-----
Site 12 (SE¼ sec. 5, T. 11 N., R. 18 E.)	0-6	[7] 1	39.1	7.9	10.9	.56	84	60	103	2	249
	6-12	1	40.0	7.8	8.0	.21	-----	-----	40	-----	-----
	12-24	0	43.1	7.4	12.9	.37	-----	-----	60	-----	-----
	24-36	0	41.8	7.8	4.1	.13	-----	-----	25	-----	-----
	36-48	0	40.7	7.4	26.2	.84	100	80	119	1	300
Site 12a (About 50 feet from site 12)	0-1½	0	34.6	7.1	121.0	5.54	620	780	964	12	2,376
	1½-3	0	37.0	7.5	52.0	2.00	-----	-----	317	-----	-----
Site 18 (SE¼ sec. 30, T. 10 N., R. 23 E.)	0-6	[7] 1	38.7	8.6	47.9	1.94	30	62	668	3	763
	6-12	1	38.8	8.5	35.0	1.12	-----	-----	426	-----	-----
	12-24	1	36.6	8.2	17.0	.43	-----	-----	174	-----	-----
	24-36	2	40.5	8.0	13.7	.38	-----	-----	114	-----	-----
Fiander fine sandy loam: Site 4 (SE¼ sec. 20, T. 10 N., R. 19 E.)	0-6	1	45.4	7.6	([5])	([5])	-----	-----	11	-----	-----
	6-12	3	55.5	9.1	5.9	.22	-----	-----	60	-----	-----
Kittitas silt loam: Site 13 (SW¼ sec. 25, T. 11 N., R. 17 E.)	([4])	0	36.8	9.8	138.0	7.71	-----	-----	3,612	-----	-----
	0-6	3	40.6	10.2	43.4	1.60	0	1	524	30	555
	6-12	3	40.1	9.7	18.8	.54	-----	-----	188	-----	-----
	12-24	3	42.5	8.7	20.1	.63	3	3	195	18	219
	24-36	3	53.1	9.2	6.3	.22	-----	-----	60	-----	-----
	36-48	1	44.5	8.5	2.9	.10	-----	-----	25	-----	-----
Sagemoor loam, compact subsoil (salted area): [6] Site 14 [9] (NE¼ sec. 31, T. 11 N., R. 18 E.)	([4])	[10] 1	29.9	8.0	159.0	6.84	1	424	5,160	66	5,651
	([4])	[10] 1	37.8	7.8	13.0	.32	-----	-----	64	-----	-----
	0-6	[10] 1	36.2	8.4	34.2	1.05	35	45	363	5	448
	6-12	1	34.1	8.3	17.8	.43	-----	-----	181	-----	-----
	12-24	3	38.3	8.7	14.2	.38	-----	-----	143	-----	-----
	24-36	3	36.9	8.7	7.7	.18	-----	-----	71	-----	-----
	36-48	[10] 3	38.7	8.3	5.4	.14	-----	-----	50	-----	-----
Site 15 [11] (SW¼ sec. 13, T. 11 N., R. 17 E.)	0-6	[10] 2	46.5	8.0	12.0	.37	37	34	79	0	150
	6-12	3	45.3	8.0	6.2	.19	-----	-----	34	-----	-----
	12-24	3	46.2	8.4	2.2	.08	-----	-----	12	-----	-----
	24-36	3	42.0	8.3	1.5	([5])	-----	-----	8	-----	-----
	36-48	3	42.9	8.5	1.5	([5])	-----	-----	9	-----	-----
Umapine loam: Site 1 [12] (NE¼ sec. 22, T. 10 N., R. 20 E.)	0-6	3	60.5	9.5	5.6	.22	2	1	59	4	66
	6-12	3	61.9	9.2	2.8	.13	2	1	28	2	33
	12-24	3	63.0	8.3	3.5	.15	4	3	24	1	32
	24-36	3	62.5	8.4	5.3	.23	5	4	39	1	49

See footnotes at end of table.

or alkali soils in Yakima County, Wash.[1]

Soluble anions in saturation extract						Cation exchange capacity	Exchangeable sodium	Exchangeable sodium percentage	Permeability		Remarks
CO_3	HCO_3	SO_4	Cl	NO_3	Sum of anions				Initial	Final	
Me./l.	*Me./l.*	*Me./l.*	*Me./l.*	*Me./l.*	*Me./l.*	*Me./100 gm. of soil*	*Me./100 gm. of soil*	*Percent*	*Inches/hour*	*Inches/hour*	
(3)	(3)	24	38	50		22	12	56	0.04	0.01	Sugar beets failed to grow; water table at 24 inches.
						22	8	37	.06	.01	
						20	4	18			
											Sugar beets failed to grow; hardpan at 18 inches.
(3)	(3)	10	95	110		17	9	54			
						20	6	31			
						20	9	45			
0	4	29	85	106	284		1		.29	.08	Sugar beets failed to germinate; water table at 42 inches.
							1		.24	.04	
							2				
							1				
							2				
							1				Large beets but a poor stand.
							2				
							2				
0	3	46	80	106	235		2		.44	.22	Fair stand of sugar beets but good growth; water table at 36 inches.
							2		.34	.11	
							3				
							2				
0	1	7	83	200	291		2				
0	10	36	620	1,630	2,296		1				Sugar beets failed to germinate.
							1				
0	13	524	180	50	767	16	6	38	.60	.53	Formerly cultivated but now idle covered by salt-tolerant weeds; water table at 36 inches.
						17	6	35	.34	.39	
						18	6	33			
						23	5	23			
							2				Idle land; dense B horizon at 6 inches.
						33	23	70			
(3)	(3)	189	110	170		30	15	52	.08	.02	Sugar beets failed to grow; water table at 42 inches.
						28	14	49	.06	.02	
0	9	11	60	114	194	29	12	41			
						37	24	63			
						36	12	33			
0	32	2,400	2,680	425	5,537						No sugar beets.
											Good sugar beets.
0	5	222	152	80	459	17	7	39	.18	.10	Sugar beets failed to germinate.
						18	6	31	.11	.03	
						16	6	39			
						14	5	38			
						13	5	36			
0	7	62	47	32	148		1		.15	.08	Sugar beets failed to germinate; compact layer at 12 inches.
							1		.17	.11	
							1				
							1				
							1				
(3)	(3)	34	5	0		30	16	53	.10	.11	Partially reclaimed field; poor alfalfa.
(3)	(3)	14	3	0		32	13	39	.22	.25	
0	3	15	14	0	32	29	4	15			
0	3	19	17	0	39	29	5	19			

TABLE 4.—*Chemical analyses af saline*

Soil type, site number, and location	Depth	Lime test [2]	Water content at saturation	pH of saturated paste	Electrical conductivity of saturation extract	Percent salt dry-weight basis	Soluble cations in saturation extract				
							Ca	Mg	Na	K	Sum of cations
	Inches		*Percent*		*Mmho. /cm.*	*Percent*	*Me. /l.*	*Me. /l.*	*Me. /l.*	*Me. /l.*	*Me. /l.*
Site 1a [13] (Near site 1)	0–6	3	64.1	8.7	5.0	.22	2	2	41	4	49
	6–12	3	62.0	8.6	3.1	.14	4	2	25	2	33
	12–24	3	64.8	8.3	1.3	(5)	4	1	7	0	12
	24–36	3	61.3	8.5	(5)	(5)	4	1	6	0	11
Site 2 (SE¼ sec. 28, T. 10 N., R. 20 E.)	0–6	3	46.9	9.1	20.4	.70	2	0	188	42	232
	6–12	3	43.7	9.6	12.7	.37	1	1	122	12	136
	12–24	3	48.4	8.7	7.6	.23	4	3	75	3	85
	24–36	3	52.2	8.1	3.0	.12	16	4	12	0	32
Site 3 (NW¼ sec. 28, T. 10 N., R. 20 E.)	0–6	2	47.9	9.7	7.0	.23	2	1	81	6	90
	6–12	2	51.7	8.6	(5)	(5)	2	1	8	1	12
	12–24	1	51.8	8.5	(5)	(5)	1	1	6	1	9
	24–36	0	50.4	7.7	(5)	(5)	2	1	3	0	6

[1] Soil samples obtained and laboratory analyses performed by, or under the direction of, C. A. Bower and Milton Fireman, U. S. Regional Salinity Laboratory, Riverside, Calif.: sampling was done between September 8 and 12, 1945, inclusive. See Diagnosis and Improvement of Saline and Alkali Soils (*15*) for methods used.

[2] Based on effervescence when dilute hydrochloric acid added; 0, noncalcareous; 1, slightly calcareous; 2, moderately calcareous; and 3, strongly calcareous.

[3] Determination not possible because extract contained large quantities of dispersed organic matter.

[4] So-called "salt crust." A thin crusted layer at surface.

[5] Salt concentration in saturation extract less than 1,700 p.p.m. Percentage salt not computed but very small.

of soluble salts. The salts are most abundant in the upper layers and would adversely affect the growth of even the most salt-tolerant crops. The salts in the Esquatzel soils are mainly the nitrates, chlorides, and sulfates of sodium, magnesium, and calcium.

Detailed analyses of the saturation extract of a sample taken at site 18 show gypsum in the 0- to 6-inch layer. Supplementary analyses show the gypsum content of the 0- to 6-inch layer to be 2.1, and that of the 6- to 12-inch layer to be 1.7.

Tests show that exchangeable sodium is not abnormally high at sites 11, 11a, and 12, but at site 18 the exchangeable sodium ranges from 23.2 to 37.6 percent of the exchangeable bases. The pH of the Esquatzel soil, at all locations, was less than 8.5.

Laboratory determinations show considerable variation in permeability at the various sites. Soil samples from site 18, though high in exchangeable sodium, had moderate permeability. At the conclusion of the permeability test, the samples from site 18 were analyzed. It was found that calcium from the gypsum had replaced practically all the exchangeable sodium. This exchange accounted for the moderate permeability of the samples.

Samples from sites 11 and 12 had high permeability at first, but the rate decreased markedly after the soluble salts were leached out.

From the foregoing it can be said that the saline areas of Esquatzel silt loam probably can be reclaimed by drainage and leaching. The sample at site 18, though high in exchangeable sodium, could be reclaimed because the sodium will not persist after leaching.

or alkali soils in Yakima County, Wash.—Continued

Soluble anions in saturation extract						Cation exchange capacity	Exchangeable sodium	Exchangeable sodium percentage	Permeability		Remarks
CO_3	HCO_3	SO_4	Cl	NO_3	Sum of anions				Initial	Final	
Me./l.	*Me./l.*	*Me./l.*	*Me./l.*	*Me./l.*	*Me./l.*	*Me./100 gm. of soil*	*Me./100 gm. of soil*	*Percent*	*Inches/hour*	*Inches/hour*	
0	6	24	18	0	48	25	7	26	.22	.22	Fair alfalfa.
0	6	13	11	0	30	30	6	20	-------	-------	
0	3	5	5	0	13	26	3	10	-------	-------	
0	4	1	2	0	7	26	3	11	-------	-------	
0	16	131	93	0	240	22	9	39	.05	.05	Virgin area covered by salt-tolerant vegetation.
0	17	69	52	0	138	22	12	56	.08	.08	
0	5	62	23	0	90	22	5	23	-------	-------	
0	3	31	4	0	38	23	2	9	-------	-------	
[3]	[3]	49	14	0	-------	26	15	56	.03	.02	Partially reclaimed field about one-fourth mile from site 2; poor alfalfa.
0	8	0	2	0	10	28	4	14	.16	.06	
0	6	0	2	0	8	30	3	9	-------	-------	
0	4	1	1	0	6	30	1	4	-------	-------	

[6] Normally Esquatzel soils not affected by excess salts or alkali.
[7] In most areas the surface soil of Esquatzel silt loam is noncalcareous.
[8] In most areas the upper parts of Sagemoor loam, compact subsoil, are not affected by excess alkali salts.
[9] The soil samples were taken from a gently sloping area.
[10] In most areas of Sagemoor loam, compact subsoil, the surface soil is noncalcareous.
[11] The soil samples were taken from a sloping area.
[12] The upper part of this soil is somewhat darker than typical Umapine loam.

Fiander fine sandy loam.—This is a Solonetz soil. At the site sampled the surface soil has a pH of 7.6 and has very little soluble and exchangeable sodium. The subsoil, at depths of 6 to 12 inches, has a pH value of 9.1 and contains only a slight concentration of soluble salts but has a very high percentage of exchangeable sodium.

The laboratory tests show the soil to be very slowly permeable. After 3 days, water penetrated the soil to a depth of only 1½ inches.

On the basis of laboratory tests, Fiander fine sandy loam is so slowly permeable and so high in exchangeable sodium that reclamation would not be practicable.

Kittitas silt loam.—Analyses of the Kittitas soil shows that it is similar to the Ahtanum but contains somewhat more salt and exchangeable sodium and less soluble calcium and magnesium. Reclaiming this soil, as for the Ahtanum soil, will require drainage, leaching, and the addition of chemical amendments.

Sagemoor loam, compact subsoil.—Samples of this soil were taken from two sloping areas where plants failed to germinate or grow because salts were excessive. Tests show that the samples are slightly to strongly calcareous and have pH values of 7.8 to 8.7. The conductivity of the saturation extract at site 14 shows strong concentrations of salts, especially in the surface layers.

For site 15 appreciable salt is shown only above the compact layer, which is at a depth of 12 inches. The salts in Sagemoor silt loam, compact subsoil, consist mainly of the sulfates, chlorides, and nitrates of sodium, calcium, and magnesium.

At site 14 the Sagemoor soil has a high percentage of exchangeable sodium.

In laboratory tests, the permeability of the Sagemoor samples is slow. Supplementary analyses showed 0.7 percent gypsum in the 0- to 6-inch layer at site 14. After leaching, practically all of the exchangeable sodium in this layer had been replaced by calcium.

The 6- to 12-inch layer at site 14 contains only a trace of gypsum. This layer, after leaching, still retains most of its exchangeable sodium. Because it retains the sodium, this layer becomes markedly less permeable after leaching.

The water table is normally at a considerable depth in the Sagemoor soils, but salts tend to accumulate in some places because the compact subsoil restricts vertical drainage. The excess water moves down the slopes laterally and seeps out where the compact layer is near the surface. The salts accumulate where the water reaches the surface and evaporates.

Reclamation of these soils probably could be achieved by first breaking up the subsoil with a chisel and then leaching. The areas that contain excessive exchangeable sodium, and not enough gypsum to replace the sodium during leaching, may need gypsum and sulfur.

Umapine loam.—Samples analyzed were taken from both cultivated and virgin sites. Except for the 24- to 36-inch layer at site 3, all the samples were calcareous. Conductivity of the saturation extract and the percentage of salts show that all the sites have appreciable quantities of salts in the 0- to 6-inch layer. At sites 1 and 2, amounts of salts were appreciable to depths of at least 36 inches. In contrast, at sites la and 3, the layers were low in salts.

Analyses of the saturation extracts show that the principal salts in Umapine soils are sodium sulfate and sodium chloride. These samples, in marked contrast to other samples, contained no nitrate salts.

All samples of the Umapine soil that were examined have a high percentage of exchangeable sodium, especially in the surface layers. Where sodium makes up more than 30 percent of the exchangeable bases, or thereabout, the pH is greater than 9.0.

Laboratory permeabilities were slow for all samples except for the sample of the 6- to 12-inch layer at site 1, and for the 0- to 6-inch layer at site la.

The Umapine samples are unusual in that their permeability does not decrease markedly with time. Most soils having a high percentage of exchangeable sodium become much less permeable with time.

Sites 1 and la are adjacent, and at the time of sampling were planted to alfalfa. The stand was poor on site 1 but fair on site la. The differences in permeability and exchangeable sodium percentages in the 0- to 6-inch layer at these two sites probably account for the difference in the growth of alfalfa.

Reclaiming the Umapine soil will require leaching and application of chemical amendments to replace the exchangeable sodium. The lime in the soil will aid in reclamation and permit the use of sulfur to replace the sodium.

IRRIGATION AND DRAINAGE

According to the Federal census, Yakima County had a larger acreage of irrigated land in 1949 than any other county in the State of Washington. Most of the crops grown in the county are grown under irrigation. Irrigation water has often been used improperly or excessively, however, so that drainage has become a major problem. Many areas, once well drained, can no longer be used for agriculture.

IRRIGATION

The first white settlers began to irrigate the land in Yakima Valley soon after they arrived. They dug ditches to bring water from rivers and creeks to small tracts of land. The county's growth depended directly upon the expansion of irrigation. Consequently, larger ditches were built, and canals and storage reservoirs were constructed in the mountains.

It will not be feasible to extend irrigation to many additional areas. Construction would be costly because of the broken terrain of the higher lands. Furthermore, there is not enough water. Little public interest has been shown in reclaiming poorly drained soils and alkali areas or in improving lands that have low productivity, although they are already irrigated.

Since 1906 the larger systems have been built by the Federal Government. Irrigation on the Yakima Indian Reservation is controlled by the government (*13*), but many smaller systems are owned and controlled locally. The main ditches and canals of the larger projects are shown on the soil map.

The following tabulation gives data on irrigation in Yakima County for 1950:

Irrigated land in farms	acres	[1] 266, 460
Type of enterprise:		
U. S. Bureau of Reclamation	acres	23, 131
U. S. Bureau of Indian Affairs	acres	114, 478
Nonfederal irrigation enterprises	acres	[2] 167, 059
All irrigation enterprises	number	753
Irrigation works:		
Reservoirs	number	20
Total capacity of the 17 reservoirs reporting	acre-feet	237, 344
Length:		
Main canals and ditches	miles	2, 377
Pipelines and siphons	miles	[3] 425
Tunnels	feet	56, 839
Pumping plants	number	267
Pumped wells	number	216
Irrigation pumps	number	715
Flowing wells	number	13

[1] In 1949.
[2] Nonfederal irrigation enterprises are single farm, mutual, and district.
[3] Does not include pipelines in farm-distribution systems.

Of the 6,959 farms in Yakima County in 1950, about 95.1 percent, or 6,620, were irrigated farms. Most irrigated land in farms, 266,460 acres in 1949, was in the Yakima Valley. Irrigation in the Yakima Valley is complete, not supplemental to the natural rainfall. Rainfall may help to germinate early planted seeds, but it supplies practically no moisture for growth. Often the ground is so dry in the spring that seeds will not germinate unless the land is irrigated before planting.

Crops are irrigated 2 to 14 times, depending upon the soil, the crop, and the water available. On most general farms, some soils must be planted to small grains, corn, or other crops that do not need so much moisture. Otherwise, there would not be enough water for alfalfa, sugar beets, late potatoes, and other crops that must be irrigated throughout the season.

Water rights, amounts delivered, and charges.—Methods of distributing water in Yakima County are complex. Separate units or districts are numerous, and farms receive water under many different water rights or contracts. In regard to water right, lands are of varied status, even within the federal projects. Different amounts of water are allotted to different lands at various charges per acre. In the Sunnyside division (*12*), many types of water rights exist. This division is divided into a number of districts. In these various districts the quantities of water delivered and charges per acre vary widely.

Total amounts of water are figured in acre-feet. Running water is usually measured in cubic feet per second, or c. f. s., (commonly shortened to second-feet), and in tenths of hundreds thereof (*22*). Some of the older systems, such as the Kennewick at the upper end of the Sunnyside Canal, have a submerged orifice that is still used to measure water, and the unit of measurement used is the miner's inch or share. The State of Washington has no legal statute that defines a miner's inch. The miner's inch varies from 1/50 second-foot, flowing through a 1-inch orifice under a 4-inch head, to 1/40 second-foot under a 6-inch head.

The person who is irrigating should be familiar with the units of measurement. He can then measure the amount of water he is using and determine the amount that flows over his own weirs (*4*). Wright (*21*) suggests the irrigator can learn ways of conserving water by carefully measuring the water he uses and keeping records on the results. Overirrigation, however, is not the only cause of unsatisfactory yields or soil conditions. Careful measuring of water against yields and tilth may show that past unsatisfactory results are caused by some practice other than overirrigation.

The quantity of water delivered to irrigated farms varies considerably. Less than 2 acre-feet is delivered to some areas under creek ditches. One part of the Indian Reservation, and on a few droughty areas in the Sunnyside division, 10 or 11 acre-feet is used. The minimum amount adequate for full crop production is generally about 3 acre-feet for soils that retain moisture well. About 2½ acre-feet is needed for alfalfa.

Most of the farms receive ample amounts of water. In fact, in some districts, deliveries are excessive. The lands under creek rights are those that most often do not have enough water. Water rights in the Wenas Creek valley are classified into many grades of priority. Lands that have low priority receive only floodwaters from the creeks for a few weeks in the spring. Consequently, they are irrigated inadequately. In the Ahtanum Valley, conditions are somewhat similar. Some bottom lands in that valley have no water rights of any value.

Water costs are separated into (1) construction charges, and (2) operation and maintenance charges. Maintenance and operation charges must be paid each year, but construction charges are apportioned over a period of years. In addition, special assessments are often levied against the land.

Construction charges have been completely paid on most of the older developments, and operation and maintenance costs are $1.00 an acre or less. Charges are usually much higher for recent or more costly systems. For some systems, costs range up to $15 or even $20 an acre for operation and maintenance, and several hundred dollars an acre for construction. On the acres irrigated in the county in 1949, costs were apportioned as shown in the following:

Cost per acre	*Acres irrigated*
Less than $1.00	24, 298
$1.00 to $1.99	3, 563
$2.00 to $4.99	138, 318
$5.00 to $9.99	104, 272
$10.00 and over	34, 217

Anyone who wishes to buy, lease, or rent land in the Yakima Valley should obtain accurate information about the water costs, water rights, and charges for irrigation and drainage construction that apply to the land in which he is interested.

Distributing water on the land.—Water is delivered to farms through earthen or concrete-lined ditches, canals, laterals, flumes, or pipelines (*22*). The water is generally turned through locked headgates into still boxes. From the still boxes the allotted amount is measured to specific tracts over Cipoletti or trapezoidal weirs. Water is generally delivered to the highest point on each 40-acre tract. One or several separate heads of water may be delivered to different places on a farm. The farm may receive water under more than one water right or contract, each allowing different amounts of water at different costs per acre.

Water is distributed in the Yakima Valley mainly by the row, or rill, or what is commonly called the corrugation method. Irrigation systems are designed accordingly, and water is delivered in small heads, chiefly in a continuous flow. In some districts farms rotate in using water. In most districts a continuous stream of water, which must be tended every few hours throughout the growing season, runs on some part of the farm. In the Sunnyside division, water is in the ditches from early in April until late in October.

The rill system has several objectionable features. It is costly and time consuming and is detrimental to the soil. The frequent ditching, irrigation, cultivating, and reditching overtill the soil. Consequently, organic matter oxidates rapidly, and the soil loses productivity and tilth, or structure. Nonetheless, the rill irrigation is the best system for use on the uniform soils and sloping uneven terrain of most of the Yakima Valley. Orchards, vineyards, hopyards, and asparagus beds are irrigated by using rill ditches, as are small grains, alfalfa, and pasture. Length of runs, width between rills, and the time and interval between applications of water vary according to the crop, soil, and slope. Methods of rill irrigation also vary because of the shape of the field, which is governed, in turn, by the boundaries fixed by land ownership and topography.

If the slope is gentle and uniform, head ditches are generally of earth. Wooden flumes are used in many fields that have steep or compound slopes. Considerable time and labor is required to shovel out head ditches and repair flumes. Underground concrete-tile pipelines that have various types of risers are used in many orchards and on some well-improved farms. These pipelines are permanent and allow surface tillage, but they are too expensive for most general farms. A cheaper and more suitable means of conveying water is one of the greatest needs in the Yakima Valley.

Except to leach out soluble salts or alkali, water should not be allowed to seep out of the root zone. If seepage occurs, water is wasted. The waste water leaches plant nutrients out of the soil and adds to drainage problems on lower lying lands. Irrigation that barely saturates the root zone is ideal. It is rarely accomplished because the water must run in the upper part of the rill for some time before it reaches the lower end.

To distribute irrigation water properly requires skill and experience. Familiarity with the soils and the lay of the land are particularly important. One of the main reasons that some irrigation in Yakima Valley is not efficient is that farm tenure changes so frequently the farm operator cannot become well acquainted with his soils.

Ordinarily, irrigation water is run straight down slopes. It penetrates the steep slopes slowly and causes erosion that may be severe in bare loose soils. If small well-controlled streams are used, little erosion occurs in grass pasture, alfalfa fields, or orchard protected by cover crops. Steep slopes should be kept under a permanent cover, as they are poorly suited to intertilled crops under irrigation.

Contour irrigation is not generally used in the Yakima Valley. Most fields have compound or uneven slopes unsuitable for contour rows and ditches. Contour irrigation requires head ditches, flumes, or pipelines that run down the slope. These would be too expensive for most farmers. It also requires ditches of uneven and abnormal depth. Gophers would prevent successful use of contour irrigation, because one gopher can dig a hole that will cause several ditches to break. When ditches break, a deep gully may form on the slope.

Some nearly level pastures and fields of hay or grain are irrigated by flooding, but only a few farms irrigate in this way. These flood-irrigated farms are mainly on the Indian Reservation where larger heads of water are available. Flood irrigation is desirable if it is feasible.

A system of stripflooding has been tried on a few farms. Water is run down the slopes between low border ridges spaced 2 to 6 feet apart. This method is desirable, especially in permanent pastures where ordinary ditching is not practical.

DRAINAGE

Irrigation has impaired drainage in many parts of the Yakima Valley. The underlying rock and the general topography have caused ground water to seep out on slopes and to accumulate on coulee bottoms, even in some of the higher areas of the uplands. In large areas of lowlands, a high water table is permanent. This table causes soluble salts to accumulate unless the water is held at a safe level by digging drainage ditches.

Hurd and Hollands (*5*, *6*) state that drainage is the cause of many important differences among farms. Some irrigated soils in Yakima

Valley have good natural drainage. Others are only poorly drained and are so alkaline as to be worthless for agriculture. As larger amounts, sometimes excessive amounts, of water have been applied, seepage from the canal has become greater and the water table has continued to rise. In some areas water now stands on the surface where, 40 years ago, the water level was at depths of 50 to 100 feet.

Some of the soils that originally were the most productive are now in alkali pasture or are wasteland. Some areas were abandoned because it was too difficult to build satisfactory drainage systems. In other areas the cost of constructing drainage systems outweighed the returns from agriculture that would result.

State laws provide for establishing drainage districts. Scores of these districts have been organized in the Yakima Valley. The district sells bonds and constructs drainage systems where necessary.

Once, drainage ditches could be dug easily and cheaply if the land to be irrigated were near a river. The cost of drainage increased in proportion to distance from the rivers. But as drainage systems were extended, costs for drainage became higher for farmers on the lower lands, as the common practice was to assess costs in proportion to the benefits received.

When higher lands in new irrigation projects were brought under irrigation they needed little, if any, artificial drainage. The lower lands, which had been farmed for a number of years, needed better drainage if they were to continue to be farmed. Some of these lower lands had become alkaline.

Farmers in many areas did nothing about improving drainage until drainage problems became so acute that they could no longer be ignored. Drainage projects now overlap so that some tracts are in several drainage districts or subdistricts, sometimes in as many as four. This overlapping was caused by the way in which the area was settled and by the failure to adopt adequate measures before the need became acute.

The following tabulation shows drainage facilities in Yakima County for 1950:

Drainage enterprises (including irrigation enterprises having their own drainage) .... number	90
Land drained (net)[1] .... acres	186, 806
By drainage enterprises (organized separately from irrigation enterprises) .... acres	58, 158
By irrigation enterprises .... acres	128, 648
Land with good drainage (no loss of cultivated crops) .... acres	[2] 47, 511
Land with fair drainage (frequent loss of cultivated crops) .... acres	[2] 6, 239
Land with poor drainage (unfit for cultivation) .... acres	[2] 4, 408
Open ditches completed prior to 1940 [3] .... miles	276. 8
Tile drains completed prior to 1940 [3] .... miles	146. 8

[1] Total of 18,868 acres included in two or more enterprises (overlapped).
[2] In 1949.
[3] Information not available for years from 1940 to 1950, inclusive.

Artificial drainage has been attempted in most of the important poorly drained areas in the Yakima Valley. The main drains in the Yakima Valley are large open ditches 6 to 12 feet deep. These open ditches have some objectionable features but are the cheapest and usually the most satisfactory. They allow ground water and waste water to enter freely, and they can be cleaned or deepened easily.

Systems used are of two kinds: (1) Intercepting drains—drains placed at the foot of slopes to intercept the flow of ground water; and (2) direct drains—drains that cross the lowest ground to carry off surface water and prevent flooding. Intercepting drains keep the ground water table from rising, but the direct drains are ineffective for that purpose.

Intercepting drains have been used to drain areas of Naches, Yakima, and other soils underlain by porous gravel beds. In fact, the largest areas drained successfully consist of areas of such soils that have smooth slopes, which make it possible to build shallow straight intercepting drains.

In many places in the Sunnyside division, the relief and the fine texture of the substratum make it too difficult or too costly to build effective intercepting drains. In areas where relief has made it possible to build these drains, the ditches that have been built are inadequate. This is true also in the Moxee district. Considerable sums of money have been spent for drainage systems from which little benefit has been derived.

Direct drains are used in some low areas of the Yakima Valley. These drains carry water away that has seeped into them after it has passed through the soil. Direct drains are predominant in the Sunnyside division, but they are not effective in protecting the soils from the high ground water table. In many places the ground water table is 2 to 4 feet from the surface, although a deep drainage ditch may be only a hundred feet away.

In areas of Sagemoor loam, compact subsoil, that occur on the dissected rolling benchlands of the Yakima Indian Reservation, seepage and salts have appeared on the slopes. Drainage ditches are impractical in these areas. Seepage can be stopped only by changing irrigation methods, using less water, or possibly by using deep subsoiling. The smooth terraces should receive light irrigations through frequent short runs to avoid wasting water and its accumulating in the underlying strata. The frequent light irrigations have been successful on areas of Sagemoor loam, compact subsoil, which has similar relief. These areas are under the pump districts of the Sunnyside division, where less water is received.

SOIL ASSOCIATIONS

A soil association is a group of defined and named taxonomic soil units, regularly associated in a defined, proportional, geographic pattern. Each soil association consists predominantly of soils of one or more series, and the names of predominant series are included in the name for the association. The Yakima-Esquatzel-Ahtanum soil association, for example, consist principally of various soils of the Yakima, Esquatzel, and Ahtanum series, but a number of minor soils are included. The same is true of other soil associations. Figure 2 shows the soil associations in that part of Yakima County mapped in detail.

The soils in each soil association area are generally distributed in a characteristic pattern, but in some areas the pattern is less definite than in others. These patterns can be determined from the detailed soil map. Soils that are associated in a geographic pattern may or may not be similar in characteristics or in their suitability for agri-

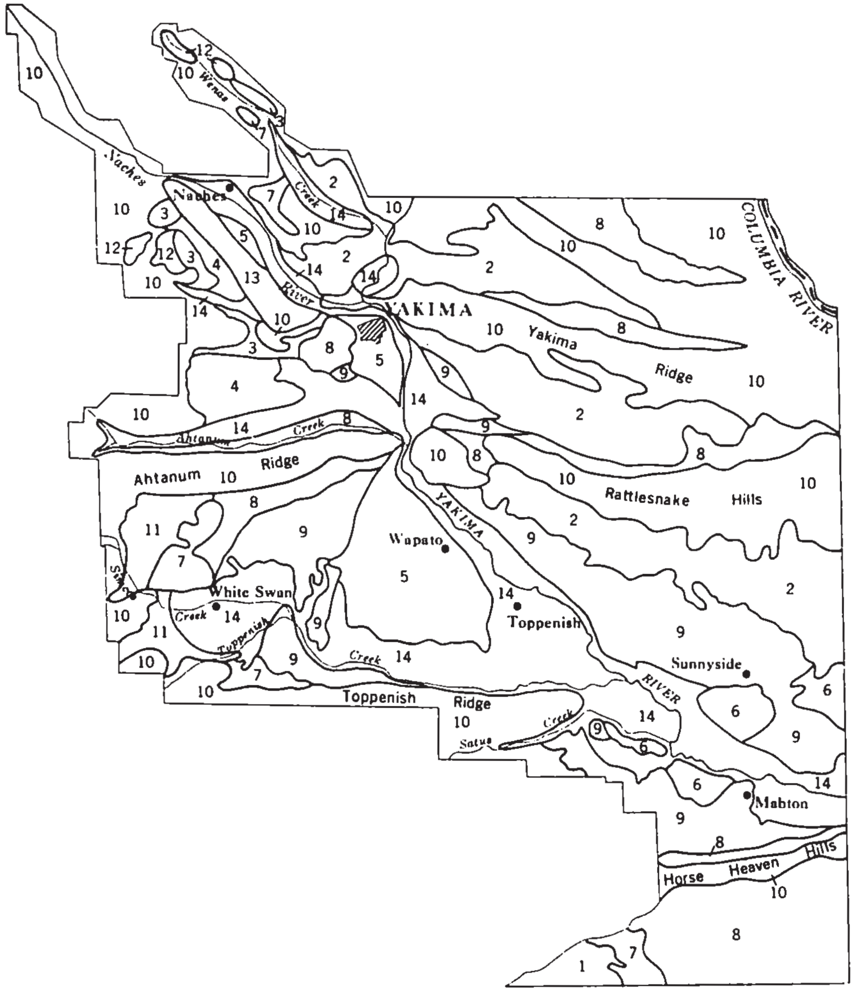

FIGURE 2.—Soil associations of Yakima County, Wash.

1. Bickleton-Steep broken and stony land.
2. Burke-Ritzville-Rozn.
3. Cowiche-Simcoe-Harwood.
4. Harwood-Steep broken and stony land.
5. Naches.
6. Quincy-Sagemoor.
7. Renslow-Simcoe-Onyx.
8. Ritzville-Stony and shallow soils-Esquatzel.
9. Sagemoor-Esquatzel.
10. Steep broken and stony land—Stony and shallow soils.
11. Stony and shallow soils-Simcoe-Onyx.
12. Taneum-Steep broken and stony land.
13. Tieton-Scabland.
14. Yakima-Esquatzel-Ahtanum.

cultural use. Some members of an association differ greatly, others only slightly.

The present use and the potential use of a given soil, and its importance to the agriculture of the area, will often be determined by the other soils with which it is associated. Small bodies of soils suited to irrigated crops, surrounded by soils suited only to grazing, for example, will often be used to grow the feed crops needed for the livestock supported by the grazing land. If these same small areas were associated with other soils also suitable for irrigated crops, they likely would be used very differently, perhaps for sugar beets or other cash crops.

Hence, it is important to know how soils are associated geographically, as well as to know their individual characteristics and physical suitability for various uses. Knowledge of the soil associations is also useful in identifying the soils of an area, understanding their distribution and interpreting and predicting their relation to agriculture.

A brief discussion of each soil association follows. More detailed information on the soils of each association can be obtained from the section, Soils of Yakima County.

BICKLETON-STEEP BROKEN AND STONY LAND

The Bickleton-Steep broken and stony land association is one of the smallest in the county. Most of it is made up of Bickleton silt loam, the only Bickleton soil mapped in the county. This soil occurs on high uplands, has developed over basalt bedrock, and receives a comparatively large amount of effective precipitation. Steep broken and stony land is the principal land type on the steep slopes along streams that flow through the uplands in this association, but small areas of Scabland and Smooth stony land occur.

This association occurs south and west of the Horse Heaven Hills in the southern part of the county. All of it lies above irrigation systems. The farms are very large, and the area is sparsely populated. The Bickleton soil is used mainly for dry-farmed wheat. The other soils and land types are generally used for grazing.

BURKE-RITZVILLE-ROZA

The Burke-Ritzville-Roza soil association occupies the higher terraces and uplands on the flanks of mountain ridges and hills in the eastern and northeastern parts of the county. It is the second largest soil association in the county. Burke and Ritzville soils predominate; they occupy areas of about equal size. The Burke soils occur on high terraces and on some uplands where a lime hardpan has developed. The Ritzville soils occur on more level uplands and terraces or on protected slopes where a sufficient mantle of loess remains.

Roza soils, on only a comparatively small total acreage, occur in many areas. They occupy gently undulating to rolling uplands that have little or no loess over the weathered tuffaceous sandstones, shales, and conglomerates. Minor soils in this association are Selah loam, which occurs on uplands and dissected terraces near the town of Selah north of Yakima; Scabland and Smooth stony land, and Stony and shallow soils; and the Esquatzel soils, which occupy bottom lands. The pattern of this association is more broken than that of some of the other associations. The total area is large.

Most of the acreage in this soil association lies above irrigation systems. Part of it is irrigated, however, and the rest is used chiefly for range pasture. Most of it is too arid to be dry-farmed successfully. The suitability of the soils for irrigated crops varies. The variation depends considerably on soil characteristics and relief. The irrigated areas are thickly populated, but few people live in the range areas.

COWICHE-SIMCOE-HARWOOD

The Cowiche-Simcoe-Harwood soil association occurs mainly on uplands in the highly developed orchard areas west and northwest of Yakima. The predominant soils in the association, by far, are the Cowiche, which are undulating to rolling and have developed mainly from weathered sandstones and shales. In some areas of the association basalt rock lies near the surface, and Simcoe clay loam, the only Simcoe soil mapped in the county, was derived from it. In some places, old cemented gravel caps both the sandstones and basalt, and on this the Harwood soils developed. Small areas of Ritzville soils, Scabland and Smooth stony land, Steep broken and stony land, and possibly other soils are included in the association. The soils vary in use suitability, but most of them are well suited or fairly well suited to irrigated orchards and to some crops. Although the soils are largely in orchards, minor areas are in dry-farmed wheat or are used for range grazing. In the densly populated irrigated areas, the farms are small.

HARWOOD-STEEP BROKEN AND STONY LAND

The Harwood-Steep broken and stony land soil association occupies high dissected terraces underlain by cemented gravel. The association occurs in the highly developed orchard areas west and northwest of Yakima.

Harwood soils are by far predominant. They occupy parts of terraces where slopes are not so steep. On the steeper breaks of the terraces are areas of Steep broken and stony land. A few areas of Scabland and Smooth stony land, and some of Cowiche, Burke, and Ritzville soils, are associated with the Harwood soils.

The soils of more level areas are mainly in irrigated orchards. Where the soils have sufficient depth, they are well suited to irrigated farming. Farms are small, and areas where this association occurs are thickly populated.

NACHES

The Naches soil association is approximately the sixth largest in the county. A large area occurs west of Wapato and Toppenish, and two smaller ones are near Yakima and Naches. The association consists largely of the Naches soils on nearly level to very gently undulating low terraces, but minor areas of Yakima and Esquatzel soils are also included.

Practically all of this association is in crops or orchards that are under irrigation (pl. 7*A*). Generally, the soils are only fair for irrigation farming. Air drainage and depth to loose gravel greatyl affect their suitability for orchards. Most of the farms are of moderate size.

QUINCY-SAGEMOOR

The Quincy-Sagemoor soil association occurs on terraces in the southeastern part of the lower valley. It consists predominantly of Quincy soils, which formed from windblown sands. The sandier soils of the Sagemoor series occupy a smaller acreage where the wind action has been less severe. The Quincy soils are poor or very poor for irrigation farming, but the Sagemoor soils are well suited or fairly well suited.

RENSLOW-SIMCOE-ONYX

The Renslow-Simcoe-Onyx soil association ranks about seventh in total area. It occurs in areas that receive slightly higher effective precipitation than the areas of the Ritzville-Stony and shallow soils-Esquatzel association. Renslow silt loam, on the uplands, the only Renslow soil mapped in the county, is by far the predominant soil in the association (pl. 7, *B*). It occurs where the loess mantle is comparatively thick. The Simcoe soil occurs where the loess mantle is thin or missing and where the soil materials weathered from the underlying basalt. The bottoms and alluvial fans are occupied mainly by Onyx loam.

Soils in this association are mainly above irrigation systems. At the higher altitudes, they are used for dry-farmed wheat, and the farms are very large. The lower areas are used chiefly for grazing.

RITZVILLE-STONY AND SHALLOW SOILS-ESQUATZEL

The Ritzville-Stony and shallow soils-Esquatzel soil association is approximately fifth in extent. It occurs mainly on the plateau south of the Horse Heaven Hills and on the smoother flanks of some of the mountain ridges and hills. Ritzville soils predominate. They occur mainly on the less sloping areas in the uplands where the mantle of loess is deepest. Areas where the loess mantle is shallow consist mainly of Stony and shallow soils and to a lesser extent of Scabland and Smooth stony land. Soils on bottom lands that cross the uplands are chiefly Esquatzel soils. Steep broken and stony land occupies most of the steeper areas that slope to the dissecting streams.

The Ritzville and Esquatzel soils are predominantly very well suited to irrigated crops, and to orchards in those places where air drainage is favorable. Most of the association, however, lies above irrigation systems. The Ritzville soils in the dry climate of the Horse Heaven plateau are used mainly for dry-farmed wheat. Farms are large and houses are far apart. Other unirrigated areas are used chiefly for range, and the population is very sparse.

SAGEMOOR-ESQUATZEL

The Sagemoor-Esquatzel soil association, although about the fourth in total area, is the largest area used for crops. It occurs on dissected terraces that nearly surround the bottom lands and lower terraces of the central part of the lower Valley, and to minor extent it occurs in the central part of the upper Yakima Valley. The various Sagemoor soils occupy most of this association. Many intermittent streams or coulees cross the terraces, and these coulee bottoms of various widths are occupied chiefly by Esquatzel soils or, in a few places, by Riverwash. A few areas of Burke and Quincy soils and of Steep broken and stony land are intermingled on the terraces.

Most of the Sagemoor soils are nearly level to very gently rolling. The various crops grown on them, and in places the orchards, are generally irrigated. For the most part, the soils are fairly well suited to well suited to irrigation farming. The edges of the terraces and the breaks along the coulees are more sloping. They are not used for crops so extensively and are poorly suited or unsuited to irrigated crops.

The Esquatzel soils are level to very gently sloping. They are generally very well suited to most field and truck crops except where they are drained inadequately or are saline as a result of irrigation seepage. Their suitability for orchards is affected greatly by air drainage. The area is too dry for dry farming. In irrigated areas, the population is moderately dense and the farms are small to moderate in size.

STEEP BROKEN AND STONY LAND-STONY AND SHALLOW SOILS

The Steep broken and stonly land and Stony and shallow soils association occupies the largest total area in the county but is the least important for crops. It occurs on mountain ridges and hills in the various parts of the county (pl. 8*A*). The greater part consists of Steep broken and stony land. Areas of smoother relief on ridgetops, on the lower slopes, and in the valleys consist mainly of Stony and shallow soils but include many areas of Scabland and Smooth stony land.

Only very minor areas of this association are irrigated or used for harvested crops. Most of the association is in unimproved range. Hardly any of the area is suited to harvested crops or is very poorly suited to them. The land occurs above irrigation facilities. In general it is best used for grazing. Very few people live in the area bounded by this soil association.

STONY AND SHALLOW SOILS-SIMCOE-ONYX

The Stony and shallow soils-Simcoe-Onyx soil association is somewhat similar to the Renslow-Simcoe-Onyx association, but its loess mantle is thinner. Much of it consists of old stony alluvial fans occupied mainly by Stony and shallow soils. The Simcoe soil occurs on alluvial fans that are not so stony and on areas of deeper soil material in the uplands. The bottoms and alluvial fans that are not so stony or that contain no stones consist mostly of Onyx loam, the only Onyx soil mapped in Yakima County. Most of this association is used for range grazing, but a little is dry-farmed. The population is rather sparse.

TANEUM-STEEP BROKEN AND STONY LAND

The Taneum-Steep broken and stony land association has the smallest total acreage of the associations mapped in the county. It occupies uplands at higher altitudes in the northwestern part of the county. The effective precipitation is greater than for the associations at lower altitudes.

The Taneum soils, developed over tuffaceous sandstones, occupy far the greater part of the association. Steep broken and stony land is on the stronger slopes that extend down from the Taneum soils to the streams that dissect the association. The Taneum soils are used mainly for dry-farmed wheat, and the other soils of the association are used for grazing. Farms are very large, and the population is sparse.

TIETON-SCABLAND

The Tieton-Scabland association occurs on the Naches Heights plateau. It is a highly developed orchard area underlain by andesite (pl. 8, *B*). Tieton soils, comprising much of the association, are associated with islandlike areas of andesite rock outcrops or scabland.

The Tieton soils are well suited to orchard fruits and to crops but are used mainly for irrigated orchard fruits. The scabland is nonarable. Farms are small, and the areas are densely populated.

YAKIMA-ESQUATZEL-AHTANUM

The Yakima-Esquatzel-Ahtanum soil association is approximately the third largest of all the associations in the county. It occupies bottom lands, basins, low terraces, and floors of the larger valleys. Although many soils that differ in characteristics are included, all of the soils are level to very gently sloping and were derived from water-laid materials.

The largest acreage is made up of soils of the Yakima series. The Yakima soils occur mainly on the upper parts of the valleys on the bottoms along or near streams.

The Esquatzel soils, second largest in total area, occur principally on bottoms farther back from the streams or where the sediments are not so coarse. Soils of the Yakima and Esquatzel series are naturally well drained.

The Ahtanum soils make up a considerable part of the acreage in which drainage is naturally imperfect or poor. They are moderately or strongly affected by alkali. Other associated alkali soils that occur on smaller areas are the Umapine, White Swan, Fiander, Giffin, Scowlale, and Kittitas. Poorly drained, dark-colored Toppenish and Wenas soils occupy the lowest areas on the bottoms, and areas of Riverwash, Onyx, Beverly, and Cleman soils are also mapped in this association.

These soils are varied in their uses and in suitability for use. Most lie below the irrigation systems. The Esquatzel, Yakima, Cleman, Onyx, and Toppenish soils are generally planted to field crops or truck crops and to a minor extent are used for orchard fruits. They are predominantly very well suited or fairly well suited to such use. The alkali soils are generally very poorly suited to irrigated crops and are used mainly for grazing. Houses are not numerous in most of this association.

ADDITIONAL FACTS ABOUT YAKIMA COUNTY

ORGANIZATION AND POPULATION

The first settlers came into the Yakima Valley from The Dalles and Goldendale in the 1860's. They settled on bottom lands along the Ahtanum, Cowiche, and Wenas Creeks and along the Yakima River, where they could cut wild hay and grow crops on the subirrigated land. They were of typical pioneer stock; their principal occupation was raising cattle and much of their time was spent fighting the Indians. In 1865 the county was organized under the Washington Territorial Government.

The Northern Pacific Railroad was completed in 1886. It stimulated settlement by bringing transportation to the Valley. The area became well known for its abundant crops irrigated from small ditches. More settlers soon came to the Valley. From the early days to the present time, irrigation agriculture has expanded almost without interruption.

Defense work during World War II and postwar activity brought more people into the area so that the population of the county increased considerably between 1940 and 1950. According to the 1950 census, the population was 135,723. Except for the Indians, American-born people of European ancestry make up most of the population. Some small settlements are mainly of French and Dutch origin. Most of the people live on the irrigated lands of the Yakima Valley and depend either directly or indirectly upon agriculture for a livelihood.

Yakima is the county seat and largest city in central Washington. It had a population of 38,486 in 1950. Toppenish, located in the lower Yakima Valley, had a population of 5,265 in 1950, and Wapato, a population of 3,185. These are the two principal towns of the Yakima Indian Reservation. Other important towns are Selah, Naches, and Tieton, which are fruit-packing centers in the orchard districts; Moxee, located in a hop-growing area southeast of Yakima; and Union Gap, located directly north of the water-gap of the same name. Union Gap is an important fruit and vegetable mart and truckloading center.

Parker, Harrah, Brownstown, and White Swan are minor trading points. In the Sunnyside division northeast of the Yakima River, are Sunnyside, which had a population of 4,194 in 1950, and Grandview and Zillah. These are fruit-packing centers and shipping points. Granger, Mabton, and Buena are among the smaller communities.

TRANSPORTATION AND PUBLIC FACILITIES

The main line of the Northern Pacific Railroad passes through the entire length of the Yakima Valley. One branch line serves the towns of the Sunnyside district, and others serve the orchard districts above Yakima. A branch line of the Union Pacific parallels the Northern Pacific to Yakima. Interstate buses carry a considerable part of the passenger traffic. The county has many federal highways, country roads, mountain roads, and trails through the forests.

In all but the most remote places, children are transported by bus to consolidated schools. Sixteen high schools are in the county, and a junior college is located at Yakima.

Trunk powerlines, which include the line that connects the Bonneville and Grand Coulee Dams, cross the county. Rural electrification has expanded rapidly. In 1950, 6,694 farms of the 6,959 in the county used electricity. Buildings, equipment, and the standards of living vary greatly in the rural areas. Fine estates and well-equipped farms are often located next to farms that have simple houses and poor equipment.

INDUSTRIES

Sawmills are located at Yakima and at Naches. A brickyard and several plants for making concrete pipe are located at Granger. The major industry of the county, however, is packing and processing fruits, vegetables, and other farm products. Several dehydration and fruit-evaporating plants are located in the county, and many of the

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towns have large packing and cold-storage warehouses. There are vinegar factories at Yakima, and wineries at Yakima, Sunnyside, and Grandview.

AGRICULTURE

EARLY DEVELOPMENT

Agriculture in this county dates from 1861–62, when the first permanent white settlers came into the Yakima Valley. The Indians who lived there had depended chiefly upon roots, berries, salmon, and deer and other game for food. They dug breadroot, wild potatoes, blue camas, and bitterroot, and gathered black-pine moss for food. They dried salmonberries, huckleberries, serviceberries, and chokecherries for winter use. If corn or other crops were planted, they were not grown extensively. Salmon was the abundant staple food along the Columbia River and its tributaries.

Grass was the greatest resource. Horses had been in the region for at least a hundred years, and during times of privation were used as food. As early as 1813, fur traders reported that the Yakima Indians possessed great herds of horses; the Indians still cherish horses as a sign of wealth.

The first cattle of the area were owned by the Indians. About 1840 they obtained a few longhorns from the Hudson's Bay Company. These were brought into the Valley from Fort Vancouver and Nisqually House. By 1855 many Indians owned cattle.

After the treaty of Walla Walla in 1855, which defined the Yakima Indian Reservation, and following the Yakima war of 1857, the tribes were soon dispossessed of most of their lands. White men began to settle the area.

The principal occupation of the early white settlers was cattle raising. Native forage was more abundant at that time, and dry mature grass furnished grazing most of the year. Low-lying lands were irrigated to some extent by means of easily constructed ditches. Gardens and grain were grown for home use, and hay was produced for winter feed. It was soon found that the climate and soil were such that many different crops could be grown.

At first, interest was centered in growing hops, but later it switched to fruit. Hops were first grown in 1872. A short time later, they were planted extensively in the Ahtanum Valley and "Parker Bottoms." After they were dried and baled, they were hauled to The Dalles to be shipped down the Columbia River and around Cape Horn.

When the Northern Pacific Railroad was extended into Yakima, a period of immigration began. By 1890 most of the easily irrigated lands in the white man's part of the Yakima Valley had been settled. The increase in population and depletion of the rangelands by overstocking forced both the whites and Indians to turn more and more to irrigation. By 1885 cattle had been replaced largely by sheep. These, together with large bands of half-wild horses, continued to overgraze the ranges, and hay was needed for winter feeding.

A time of canal building and a boom period followed. Expensive, sometimes ill-advised, schemes of irrigation were planned and promoted. Orchards became popular and were pushed beyond the limits of adaptation. Plantings were made on poor or inadequately drained soils or in areas subject to frost, and these orchards were sold to misinformed investors. This was not an unmitigated evil, however, as it led to greater knowledge of the soil and to readjustments in land use.

The first ditches were built by groups of landowners or promoting companies. A number of them are still operated but are now organized under State irrigation laws. The largest and most important are the Naches Selah, the Selah Moxee, the Ahtanum and Union Gap systems, and the Congdon Ditch.

Federal irrigation projects were begun in the Yakima Valley about 1906 (*5*). Federal and privately financed irrigation has continued to expand. In 1950, 266,460 acres was under irrigation.

CROPS

An unusually large number of crops are grown commercially in the Yakima Valley. Table 5 gives the acreage of principal crops and the number of fruit trees and grapevines of bearing age in Yakima County for stated years. Under favorable conditions and the best cultural methods, yields of crops are high.

FRUITS

Fruit is generally grown only on the upland slopes and terraces. Exceptions are the bottom lands in the vicinity of Naches, Yakima, Parker, and Wapato, where air drainage through the canyons makes the temperatures favorable for orchards. Extensive orchards are in the Tieton division and the Naches-Selah district. Elsewhere, orchards cover much of the land on Terrace Heights, between Parker Heights and Granger, on the flanks of Snipes Mountain, and at Grandview.

Apples are, and have always been, the most important fruit in the county. Winesap, Delicious, Red Delicious, Jonathan, and Rome Beauty are the principal varieties grown. The apple orchards, which played so important a part in the development of Yakima, are now less profitable. The codling moth has increased spraying costs and lowered the yield of salable apples. The land has been made less productive because lead-arsenate spray has accumulated in it. The demand for apples has now raised prices to a profitable level, but for many years there was little profit. Many apple orchards have been pulled out. In many places where the accumulation of lead-arsenate is not too great, the old apple trees have been pulled out and the orchard replanted to soft fruits.

Pears are less extensively grown than apples. Much of the crop is shipped to canneries. Bartlett is the variety demanded for canning. Some orchards consisting of table-variety pears have been pulled out recently. Pears can be grown on lower and less adequately drained areas than most varieties of apples, and they need to be sprayed less frequently.

Peach orchards are scattered throughout the fruit-growing areas. Yields and prices fluctuate greatly. Often a peach crop that is only fair brings a greater net profit than a good crop of other fruit. Some of the main varieties have been Elberta, J. H. Hale, and Gold Medal, but recent plantings include several other varieties. If irrigated

TABLE 5.—*Acreage of principal crops and number of bearing fruit trees and grapevines of bearing age in Yakima County, Wash., in stated years.*

Crop	1929	1939	1949
	Acres	*Acres*	*Acres*
Corn for all purposes	7,873	10,246	10,827
Small grains threshed or combined:			
Barley	5,031	7,178	7,635
Oats	3,539	8,778	8,386
Wheat	47,369	21,616	33,219
Rye	531	567	384
All hay	81,342	[1] 73,618	[2] 63,114
Alfalfa	73,663	64,568	53,546
Clover and timothy, alone or mixed	706	1,332	1,020
Small grains cut for hay	5,707	5,229	4,409
Wild hay cut	1,266	2,489	4,139
Sugar beets	105	10,489	11,361
Hops	2,172	4,242	12,740
Potatoes, Irish or white	15,502	6,605	[3] 8,213
Mint for oil	156	16	2,235
Vegetables harvested for sale:			
Asparagus	292	2,075	4,578
Cantaloups and muskmelons	901	[4] 898	1,056
Corn, sweet	205	982	6,877
Lima beans, green	(5)	10	1,252
Onions, dry	551	877	380
Peas, green	39	99	2,074
Tomatoes	540	737	1,454
Alfalfa seed harvested	6	295	5,439
Clover seed harvested	1,250	1,128	[6] 632
	Number	*Number*	*Number*
Apple trees	1,763,981	1,200,600	1,113,413
Apricot trees	107,195	133,343	192,496
Cherry trees	80,774	149,690	155,377
Peach trees	358,915	403,508	660,791
Pear trees	920,766	1,000,666	988,870
Plum and prune trees	170,367	136,580	205,185
Grapevines	437,874	512,526	1,729,519

[1] Exclusive of sorghums.
[2] Exclusive of sorghums, soybeans, cowpeas, and peanuts cut for hay.
[3] Does not include acreage on farms with less than 10 bags harvested.
[4] Includes honeydews and other melons.
[5] Figure not available.
[6] Red clover only.

carefully, peaches can be grown on some of the fine-textured soils and on shallow and stony land. Because little spraying or other attention is needed, the trees on steep land can be managed much more easily than apples.

Cherries are grown throughout the orchard districts, and in most years they are next to pears in value. Bing, Royal Ann, and Lambert are the principal varieties. Although a late frost in spring or a rain at ripening time occasionally ruins a crop, cherries are usually profitable.

Apricots, prunes, and plums are increasing in acreage and importance. This increase is brought about by the demands of canneries and processing plants and the need to replace apples with soft fruits.

After prohibition was repealed, larger areas were set in grapes. This stimulated the building of wineries and distilleries in the county. Large acreages, chiefly on the Sunnyside division, have been planted to vineyards. Grapes can be cared for successfully on steeply sloping land. They are apparently more tolerant of the spray residues in the soil of old orchards than most plants.

Concord and Campbell Early, grown for juice and table use, are American varieties that are winter hardy and yield well. Niagara, White Diamond, Red Delaware, Thompson Seedless, Muscat, Blue Portugese, Zinfandel, and several other varieties are grown for wine. The more tender varieties must be taken down and mulched to prevent winterkilling.

VEGETABLES

Many kinds of vegetables that have excellent quality are grown in the Yakima Valley. The acreage of the principal vegetables is shown in table 5. Acreages depend almost entirely upon available markets but are becoming larger as new methods of preserving vegetables are developed. In recent years sweet corn, asparagus, green peas, tomatoes, green lima beans, and melons have been grown the most extensively. Squash was grown for market and for stockfeed until 1940, but since that time it has been driven out of production almost completely by a blight disease carried by the common squash bug.

Sweet corn is processed at a cannery in Toppenish and at a quick-freeze plant at Zillah. Corn earworm causes considerable damage, particularly to sweet corn grown for table use. The percentage of injury in small plantings can be reduced considerably by treating with oil and pyrethrum or DDT.

Asparagus is grown in the lower valley. It is planted on the deeper medium-textured or moderately coarse textured soils, chiefly those of the Sagemoor series. The rust-resistant Mary Washington is the standard variety. Green peas have been grown to a great extent in recent years, although the growing season is often unfavorable for them. They are generally frozen or shipped to canneries. Tomatoes are canned locally or are shipped fresh to markets throughout the State to be used for home canning.

Cantaloups and watermelons are grown in the lower valley. Melons ripen too late in this area to command prices that will justify extensive planting under the usual market conditions. Nevertheless, their acreage has increased somewhat during the past few years.

Onions are grown for local use or are shipped to markets throughout the Northwest, but they are not grown so extensively as in former years. Carrots are grown to some extent. They are dehydrated and are shipped to local markets or used for stockfeed. The Chantenay is the chief variety grown.

POTATOES

For a number of years potatoes were an important and profitable crop. In 1934 when wireworm and potato beetles were the only serious pests to attack potatoes, 17,563 acres was harvested. Since then the county has become infested by two types of flea beetles, and by 1950 potato acreage had dropped to less than half that of 1934. Some fair crops are still obtained on the older farms. The best potatoes, however, are grown in a crop rotation and follow alfalfa. These good potatoes are grown on the newer soils that are deep, moderately coarse textured, and free from disease and wireworms.

Netted Gem is the principal variety grown. White Rose and Irish Cobbler are early varieties.

HOPS

Although hops have been grown to some extent in the Yakima Valley since 1872, few yards were maintained through the prohibition years. Extensive plantings during the past 20 years have made this one of the most important crops. The best-quality hops are grown in the vicinity of Tampico, but the acreage is small because of the lack of good soil. The bulk of the crop is produced in the Moxee district, where several thousand acres are in hopyards. Other large acreages are west of Toppenish, near Sunnyside, and at Mabton.

SUGAR BEETS

Sugar beets have been grown extensively in the Yakima Valley since 1937. At that time the sugar factory at Toppenish was reopened because a blight-resistant strain of beets had been developed. Sugar beets tolerate moderate salinity but need deep, medium-textured, well-drained soils, and gentle slopes to produce well. In this regard sugar beets compete with hops for low-lying lands of uniformly good quality. They are generally rotated with alfalfa and are fertilized by adding phosphorus and manure. This is done to obtain the largest yields possible.

ALFALFA

Alfalfa has long been one of the most important and useful crops in the irrigated districts. The warm dry seasons and plentiful lime in the soils favor its growth. It is of great value for hay; it is fed to all types of livestock and poultry, and it improves the soil when used in crop rotations.

When the Valley lands were first farmed, alfalfa was used as a cover crop for orchards. It normally produced 6 to 8 tons an acre of good quality hay when grown alone. Since that time it has declined in importance. In orchards it has been subjected to poisonous spray residues, and it has been used on depleted soils and forced to compete with weeds and disease. On many farms it has been sold off the land continuously as a cash crop. When used as a cash crop, it slowly depletes the soil's supplies of phosphorus and potassium and probably removes some of the minor plant nutrients.

On new land and on old fields where productivity has been maintained, alfalfa will still make 3 good cuttings and yield a total of 6 to 8 tons an acre. In many places a liberal application of treble superphosphate to older fields has markedly increased yield, resistance to disease, and quality of the hay.

In short rotations that keep a stand of alfalfa for only 3 to 4 years, northern-grown common is the usual variety. Where a stand is to last a longer period, winter-hardy, wilt-resistant varieties should be grown.

CEREAL CROPS

Wheat is the most important cereal crop in the county. It is grown to a minor extent in the irrigated districts, chiefly on the general-farming lands of the lower Valley. Soft white wheats, such as Pilcraw and Jenkin's Club, are the leading varieties for irrigated land. This wheat is used locally for livestock feed.

All of the wheat of milling quality is grown on the dryland wheat farms. These are on the arable land at the higher elevations where annual rainfall is 8 inches or more. Most of this land is on the Horse Heaven plateau in the extreme southeastern corner of the county. Small dry-farmed areas are located also on the hills west of Tieton, east of Naches, and along upper Wenas Creek. Wheat is generally the only crop grown, and the land is summer-fallowed every other year. In some of the drier areas, the land is left idle most of the time and is cropped occasionally when there is some prospect of sufficient moisture. Baart is the spring wheat commonly grown. Turkey and Fortyfold are the chief winter varieties.

Oats, barley, and rye are not grown so extensively as wheat on irrigated lands. Markton, the leading variety of oats, yields up to 130 bushels. Leading varieties of barley are Trebi, Blue, and Beldi Giant. Winter rye needs less moisture than wheat and for this reason is grown to a small extent on the dryland grain farms. It is also grown on a few isolated tracts in the arid eastern end of the county. It is cut for hay and is used as winter range for livestock.

Corn is grown mainly on the general farms of the lower Valley. Its acreage and popularity have increased since hybrid seed came into use. The crop is used locally to feed livestock.

MINOR CROPS

Many minor crops are grown commercially or experimentally in the Yakima Valley. Some of these are sweet sorghum for sirup, green beans (snap, string, or wax), carrots, broccoli, walnuts (English or Persian), and nursery products.

PERMANENT PASTURES

Permanent irrigated pastures are of vital importance to the Yakima Valley for they are a practical means of improving the soil and controlling weeds. The present acreage in seeded pasture is proportionately small. As a rule only the poorer soils, seeped or saline soils, or areas of uneven relief are put in pasture. The pastures are usually overgrazed, weedy, and receive only waste water and such time and care as can be spared from other crops. In recent years, however, farmers have become more interested in using fertilized and well-managed mixed grass-legume pasture as a part of a crop rotation. This improves the soil and utilizes the saline land.

Where water is supplied, the arid lands are naturally well suited to grass and to many of the valuable forage legumes. If favorable moisture is maintained and the soil is undisturbed, grasses and clovers come in without seeding. They form a permanent vegetation under which animal life such as earthworms can live. Organic matter increases with the increased growth of vegetation, and the soil becomes more friable. When an old fence is removed or a ditch is plowed up and made part of a cropped field, the greater plant growth made on the strip that was formerly in grass is very evident.

Many kinds of grass are available for pasture mixtures. Orchardgrass and smooth brome, when well established, will withstand considerable drying out on the higher spots in a field. Perennial ryegrass and Kentucky bluegrass are excellent for intermediate positions, and meadow fescue, sheep fescue, redtop, and several of the bentgrasses do well in low wet situations. Big bluegrass and Canada wildrye are other useful grasses. Common whiteclover and Ladino clover are commonly used in pasture mixtures. Strawberry clover, however, will withstand more salinity and excessive moisture. When grown alone in short rotations, sweetclover makes the highest forage yield.

Pastures need frequent light irrigations, and they are irrigated in several different ways. Where they are nearly level, it is the general practice to flood them. On sloping land irrigated by a rill or corrugation system, the frequent ditching necessary to distribute the water properly, has been neglected because of the time and labor involved. The more satisfactory practice of stripflooding between low borders 3 to 6 feet apart is coming into favor. Stripflooding is preferred to ditching, especially where saline land is being reclaimed. The land must be smoothed and the borders built before seeding.

Whether pastures will be extended in order to maintain the soil depends directly upon whether livestock is kept and the profits derived from it. There has been a considerable increase in acreage of irrigated pastures during the past 10 years, but economic pressure on the land—the need to produce cash crops—keeps a greater increase of pasture in check.

LIVESTOCK AND LIVESTOCK PRODUCTS

Livestock raising is a secondary enterprise in this county. Sheep are raised on a few large ranches, and purebred cattle, on several farms. There are a few specialized dairy farms. Table 6 lists the number of livestock on the farms of Yakima County in 1940 and 1950.

TABLE 6.—*Number of livestock and beehives on farms of Yakima County, Wash., in stated years*

Livestock	1940	1950
	Number	*Number*
Cattle	[1] 56,200	90,788
Horses	[1] 14,630	8,300
Mules	[1] 770	223
Hogs	[2] 22,987	16,540
Sheep	[3] 76,496	89,838
Chickens	[2] 214,645	[4] 205,143
Turkeys	[2] 9,558	[4] 15,888
Beehives	7,672	10,434

[1] Over 3 months old on April 1.
[2] Over 4 months old on April 1.
[3] Over 6 months old on April 1.
[4] Over 4 months old on hand.

The range cattle, Herefords and Shorthorns, are grazed along the margin of the timber and in the mountain meadows of the Indian Reservation. The Indians have been encouraged to replace their horses with beef cattle. One fine herd of purebred Angus cattle is kept near Yakima. Several ranchers along Toppenish and Satus Creeks and the Yakima River run small herds of beef cattle of good grade on native grass pasture. Cattle feeding has been done near Toppenish and Sunnyside since the sugar factory was reopened. Beet pulp and locally grown hay and grain are fed.

The number of dairy cattle has increased slightly in recent years. They are mostly of Guernsey, Holstein, and Jersey breeds. Many small dairies are distributed throughout the Yakima Valley. Most milk, cream, and butter is used locally. Several large creameries are located in Yakima, and cream stations are located in all the smaller towns. A large plant at Sunnyside produces condensed milk.

The number of hogs has declined greatly during the last few years. They are raised mainly on the general farms and are sold on local markets. Duroc-Jersey, Poland China, and Chester White are the leading breeds.

Horses are not important in this county. Many belong to the Indians and run wild on the reservation. The rest, for the most part, are ordinary farm work animals.

Raising of sheep on the open range is an important enterprise. The Yakima Valley is the center of operations for sheepmen who graze their bands in several States. The sheep graze widely and are difficult to count on the range, so figures on the number of sheep in Yakima County are likely to be confusing and inaccurate.

Sheep raising in this county and the rest of central Washington depends upon production of high-quality lambs for early market. Bands of Rambouillet-Lincoln ewes, cross-bred to Hampshire bucks, are wintered in the Yakima Valley. The ewes are placed in sheds for lambing, which begins late in January and continues through the first part of February. The bands are taken out of the Valley as early as possible, so that they can graze the spring growth of cheatgrass on the arid ranges. In April or May the bands are trailed toward summer pasture. As the snow melts, the bands move upward on the slopes of the Cascades or the Okanogan Highlands.

In July or August, the lambs are shipped to midwestern markets, mostly to Chicago. The ewes are returned to the Valley in October or November for flushing on fall pasture. They graze on hay and grain fields and on sugar-beet tops.

Although raising of lambs for early market has long been the practice, there is some variation in the marketing pattern. Heavier lambs are now tolerated on the market, so some lambs born late in the lambing season may be brought back to the Valley and fattened. A large sheep-feeding establishment located at Granger fattens lambs brought in from Oregon. The feeding is done in well-equipped sheds late in fall and in winter.

A few farms specialize in chickens, but most of the chickens are raised in small barnyard flocks. Several turkey farms are located in the lower Valley. A number of farms in the vicinity of Sunnyside, Mabton, and Grandview keep several thousand birds.

Conditions in the Yakima Valley favor poultry raising. The droughty soils are especially suitable because they dry quickly and are therefore freer from organisms that cause poultry diseases. Soils suitable for poultry are abundant, and feed is plentiful. Poultry raising is chiefly limited by the cost of equipment, housing, and specially prepared feeds. The Washington Cooperative Egg and Poultry Association handles much of the poultry.

FARMING METHODS

On the irrigated lands, the soil is normally plowed deep with a heavy two-way moldboard plow. As much of the plowing as possible is done late in fall and in winter. The soil is then ready for early spring planting, which is essential for many crops. It is hard to get a good stand if small-seeded crops are sown late in the season. Early seeding is especially needed on the saline soils, on soils that contain slick spots, and on soils so intensively cropped that they have been depleted of fertility and made difficult to work.

Planting depends upon the time that spring arrives. In some seasons it is possible to plow and prepare the land in February and to plant small grains, alfalfa, clover, grass, and hardy vegetables early in March. Sugar beets are planted before mid-April; corn, tomatoes, and other less hardy crops soon follow. The early cantaloups, other melons, and cucumbers are planted under translucent paper caps that protect them from frost.

Considerable tillage and a great deal of hand labor are needed throughout the growing season. Ditching and irrigating start soon after planting is completed. The soils are sometimes so dry in spring that some crops must be irrigated to bring up the young plants. The crops have to be irrigated, tilled, and hoed frequently.

Orchards are pruned and sprayed late in winter and early in spring. Apple and pear orchards must be sprayed throughout the summer. Alfalfa should be cultivated both ways across the field with a heavy spring-tooth harrow to kill cheatgrass. Grapes, hops, potatoes, sugar beets, and all of the other crops need a great deal of care. Most of them need to be dusted or sprayed with insecticides.

Harvesting begins when the asparagus is cut in April. It continues through haying, fruitpicking, and until the potatoes and sugar beets are harvested. The dry climate is a great advantage during harvest. Hay can be stacked in the open, and grain can be combined or it can be threshed from windrows or shocks. Only rarely does a freeze come so early that the harvest of root crops is delayed. Fall frosts seldom come when the apples are still on the trees.

The soil used for crops is packed down by tractors and heavy implements because ditching and frequent tillage are necessary. As a rule, only the orchard crops and pasture leave the soil undisturbed a long enough time to recover from the bad effects of tillage. A crop rotation is normally used, but the average cycle is too short to allow much recovery of soil structure. Alfalfa, grown for 3 or 4 years, is depended upon to restore nitrogen and organic matter and improve structure. Many farmers, however, sell the alfalfa off the farm, and it is then of little value to the soil. Sugar beets or other tilled crops sometimes have been grown continuously for 7 or 8 years, and only manure is added to maintain productivity. Hops and grapes are generally clean cultivated. Hops are heavily fertilized with manure if it is available.

Not enough manure is produced on the irrigated lands. Extensive plantings of hops and asparagus increase the demand for manure. For several years, until the supply ran low, manure was hauled to the hopyards from grounds far out on the range where sheep had been bedded. Now hop growers have turned to legumes. A suitable legume is stripplanted in the hopyards to furnish organic matter and to provide shade for the vines. Except where it has been killed out by the poisonous spray residues applied to apple trees, alfalfa has proved a successful legume for orchards. Winter rye has been used extensively as a winter cover crop or as a green-manure crop. Winter vetch has been grown in a few places for these purposes. Shortage of water and the press of work during the proper planting time in September have kept down the acreage of winter crops.

Turkey raising has increased to such extent that it has at least a small effect on the supply of manure. The productivity of the soil normally increases where several thousand turkeys have been kept on a farm and fed concentrated rations that were produced elsewhere.

Extensive use of commercial fertilizer dates from 1937, when the beet-sugar industry returned to the Yakima Valley. Since that time, most beet fields have received 100 to 200 pounds of treble superphosphate an acre. The results show that most of the soils on the older farms are deficient in phosphorus. Phosphorus is now applied to many crops, but most commonly to sugar beets, asparagus, and alfalfa. A few farmers, particularly dairymen, apply it to permanent pasture. The phosphorus improves the pasture and the health of their livestock.

Nitrogen fertilizers have not been used so much as phosphorus, because alfalfa has been grown so generally in the crop rotations. Ammonium sulfate is generally preferred. Sodium nitrate is considered detrimental to soil structure. Mixed fertilizers—mostly those containing small percentages of nitrogen, phosphorus, and perhaps, some potassium—have been bought from local dealers in the Valley.

So far, there is no evidence that the irrigated soils in the Yakima Valley need lime. Soils should be tested before lime is applied.

FARM EQUIPMENT

Irrigated farming demands efficient use of machinery. Power equipment is used on all the larger orchards, hopyards, and fields. Most of the farmers have invested large sums of money in machinery.

Modern tillage implements and tractors have replaced horse-drawn machinery to a great extent. In 1950, 7,057 tractors of all kinds were reported on the 6,959 farms in the county. Small- or medium-sized wheel tractors are used for most of the tillage on irrigated farms. Tractor-drawn, medium-sized to large combines are used for harvesting. On the dryland farms, medium- or large-sized wheel or caterpillar tractors pull wide hookups of tillage and seeding implements. Tractor mowers are used generally. Power-driven buckrakes, overshot stackers, and pickup hay balers are used to put up hay.

Horses are still used on many of the smaller farms and in the small orchards, vineyards, asparagus fields, and hayfields. Much of the plowing and other heavy work on these small places is contracted to operators who own tractor-drawn implements.

Tractor power, the disk, or wheatland plow, and the introduction of Baart wheat have been responsible for extending large-scale farming in the drier areas. When plowing or summer fallowing had to be done by horse-drawn implements, the work often took until the 4th of July. This was far too late for seeding or for preparing land for summer fallow. The same work can now be done in 2 weeks if tractors are run 24 hours a day. The earlier completion of work conserves spring moisture. The diskplow, furthermore, reduces wind erosion by leaving the ground rough and the stubble exposed.

In 1950, 5,413 trucks were reported on the farms of the county. Considerable amounts of money are invested in spraying equipment for orchards, in picking machines and balers for hopyards, and in haying implements and stackers on general farms. Electric motors and centrifugal pumps are major items on farms that must pump irrigation water from wells or canals.

FARM INVESTMENTS

Land values in Yakima County vary according to the amount of improvement. Raw land in sagebrush is of little value except for range grazing. The value of the irrigated land, other than the quality of the soil, lies in the water rights, the equity in an irrigation system, and the facilities for distributing water within its boundaries.

The investments in improvements on the land are generally greater than the combined cost of the raw land and the paid-up construction charges. Often the cost of pipelines, flumes, and other irrigation structures, earth ditches, and leveling of fields exceeds the combined cost of the land and the water rights.

The average cost of buildings and fences is fairly high in this county because of the number of small farms and because of the comparatively high cost of some of the rural dwellings. Hop kilns constitute a considerable investment on some farms.

Buildings are inadequate on many farms, and housing is sometimes below a standard that is desirable. Large well-equipped barns are common only on the dairy farms and specialized stock farms. Since the climate is so dry, farming can be carried on without providing much shelter for equipment. Adequate machine sheds are rare, and most equipment and farm machinery are left in the open.

The major investments on the dryland grain farms, which range in size from 1 to several square miles, are in land and machinery.

TYPES OF FARMS

Considering the Yakima Valley as a whole, the irrigation farming is diversified. On individual farms, however, the farming is specialized. Even in irrigated areas where general farming is the rule, the farmer must choose the enterprises best suited to the farm, the operator, and the equipment.

Orchards are dominant in the Tieton division because the soils, location, relief, high land values, and high water costs all favor the growing of tree fruits.

The farms on the Indian Reservation are mainly in annual cash crops because the system of tenure favors this kind of enterprise.

Most of the farms, though allotted to the Indians, are now farmed by non-Indians who lease on a short-time cash basis.

In the Sunnyside division the type of farm and the kind of tenure both vary.

In 1950 there were 6,959 farms in the county, and of this total, 1,555 were not classified by principal source of income. The remaining farms were classified as follows:

	Number of farms
Fruit-and-nut farms	2, 040
Field-crop farms other than fruit-and-nut farms	902
Cash grain	183
Other field crops	719
General farms	749
Dairy farms	600
Vegetable farms	468
Livestock farms other than dairy and poultry	424
Poultry farms	221

SIZE, NUMBER, AND TENURE OF FARMS

Table 7 shows, for the period 1930–50, the changes that have taken place in total area of land in farms, in number of farms, and in farm tenure. In that period acreage of land in farms and the acreage per farm have both increased.

Most of the farms are small. Of the 6,959 farms in the county in 1950, 16 percent were less than 10 acres in size. Slightly more than half were 10 to 49 acres in size. Only 2.4 percent of the farms had more than 500 acres. The number of larger farms has increased somewhat during the past few years, as some of the smaller holdings have been eliminated.

LAND USE

In 1950, 41.1 percent of the county was land in farms. The total area of land in farms was 1,123,749 acres. In 1949 this farmland was divided, according to use, as follows:

	Acres
Cropland harvested	237, 438
Irrigated	212, 168
Not irrigated	25, 270
Cropland used only for pasture	50, 906
Cropland not harvested and not pastured	55, 352
Cultivated summer fallow	26, 935
Other	28, 417
Woodland pastured	124, 458
Woodland not pastured	5, 912
Other pasture (not cropland and not woodland)	596, 721
Other land (house lots, roads, wasteland, etc.)	52, 962

FARM LABOR

Much of the farmwork in the Yakima Valley is seasonal. For many years the growers of fruits, hops, and sugar beets have depended upon a large supply of cheap transient labor. An annual migration of workers begins in early summer and reaches a peak at hop picking time in September. For this short period thousands of laborers are needed in the Valley. The harvest ceases abruptly the first week of November, and most of the migrant workers move on.

Housing facilities for the migratory farmworkers are inadequate, and their living conditions are far from desirable. Many live in tents,

TABLE 7.—*Number of farms, area in farms, and farm tenure in Yakima County, Wash., for stated years*

Year	Total number farms	Total area in farms	Average per farm	Farms operated by—		
				Full or part owners	Tenants	Managers
	Number	*Acres*	*Acres*	*Percent*	*Percent*	*Percent*
1930	6, 806	598, 366	87. 9	71. 8	24. 5	3. 7
1940	6, 606	932, 495	141. 2	71. 3	25. 9	2. 8
1950	6, 959	1, 123, 749	161. 5	83. 7	15. 2	1. 1

in the open along the river, or wherever space can be found. Every available hut and tourist cabin is occupied. Two federally built labor camps provide shelter for a small number.

Much of the handwork for sugar beets and truck crops is done by Mexicans and Filipinos who are paid a fixed rate per acre. Many of the laborers who perform other kinds of work, however, are paid by the hour or by the day. Board and lodging are rarely provided. Nearly all fruit-picking and the subsequent packing are paid for as piecework, and only the highly skilled make good wages during normal times. Many Indians help to pick the hops. Hop picking is considered a sort of outing or festival and is done by all classes.

Even most of the smaller farms need to hire help for short periods, but help is hired by the month or by the year only on the larger farms, hopyards, and orchards. On a few places, hired men who have families are provided with a house and garden plot.

So much work is involved in operating an irrigated farm that labor even at low wages is often the largest factor in the cost of producing the crop. Often labor costs absorb all the profit. Many attempts have been made to save labor. Several new laborsaving devices are of some use, but as most irrigated fields are small, large machinery is not suitable. Hop-picking machines have been used in some yards for several years, and use of machines to harvest sugar beets is practical in large fields.

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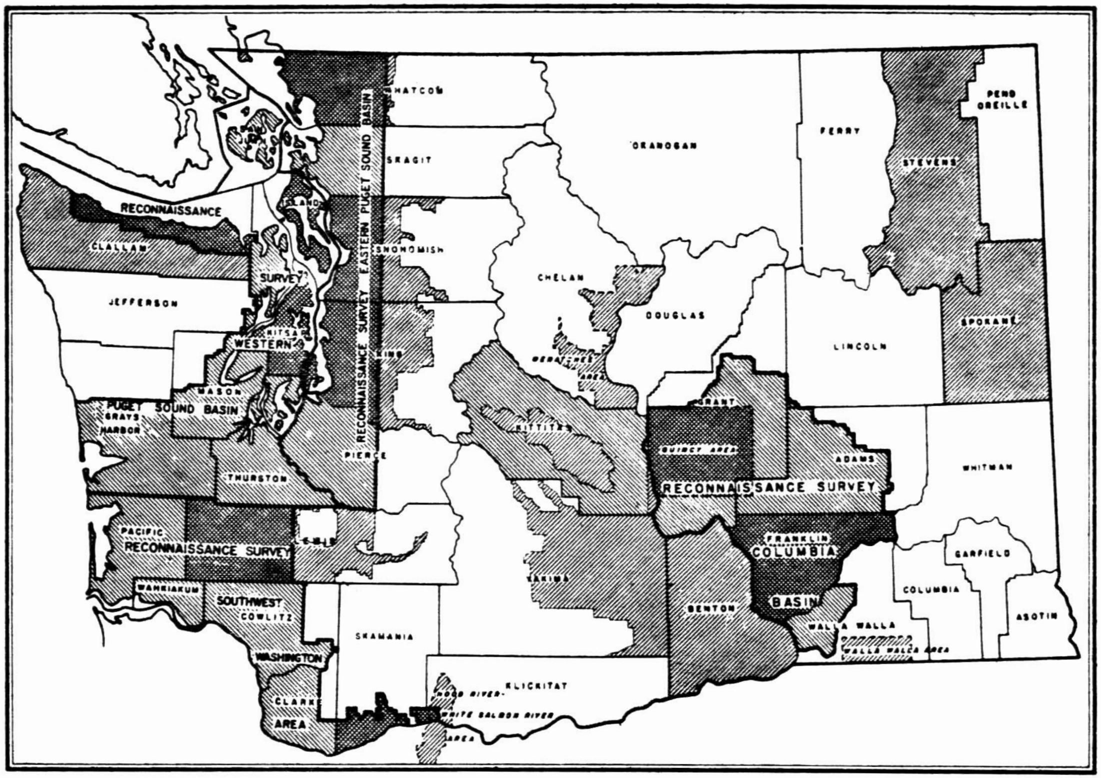

Areas surveyed in Washington: Reconnaissance surveys shown by the northwest-southeast hatching; detailed surveys, by northeast-southwest hatching; areas surveyed both ways, by crosshatching.

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