U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

# SOIL SURVEY OF BENTON COUNTY, WASHINGTON.

BY

A. E. KOCHER, IN CHARGE, AND A. T. STRAHORN.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1916.]

WASHINGTON:
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1919.

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# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
*Washington, D. C., May 20, 1918.*

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of Benton County, Washington, and to request that they be published as advance sheets of the Field Operations of the Bureau of Soils, 1916, as authorized by law.

Respectfully,

MILTON WHITNEY,
*Chief of Bureau.*

Hon. D. F. HOUSTON,
*Secretary of Agriculture.*

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# SOIL SURVEY OF BENTON COUNTY, WASHINGTON.

By A. E. KOCHER, In Charge, and A. T. STRAHORN.—Area Inspected by MACY H. LAPHAM.

## DESCRIPTION OF THE AREA.

Benton County, Wash., lies about 100 miles west of the southeastern corner of the State. It is bounded on the north, east, and south by the Columbia River, which separates it on the north from Grant County, on the east from Franklin and Walla Walla Counties, and on the south from the State of Oregon. On the west it is bounded by Yakima and Klickitat Counties. Its greatest length from north to south is 57 miles, and its greatest width from east to west 44 miles. The county has an area of 1,720 square miles, or 1,100,800 acres.

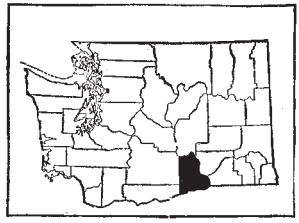

FIG. 1.—Sketch map showing location of the Benton County area, Washington.

Benton County lies east of the Cascade Range and occupies a peninsula-like position in one of the larger bends of the Columbia River. The principal physiographic features are the Yakima Valley, the Rattlesnake Hills, the Yakima Range, the Horse Heaven Hills, the Horse Heaven Plateau, and the Columbia River Plains.

The Yakima River flows in an easterly direction across the central part of the county. Its valley is from 2 to 4 miles in width, and consists of smooth terraces lying 20 to 100 feet above the stream. From the west county line to a point a few miles above Benton City, these terraces merge imperceptibly on the north into the slopes of the Rattlesnake Hills. For about 8 miles below Benton City the valley is walled in on the north and west by perpendicular walls of basalt or by steep slopes of the Rattlesnake Hills. Near the north side of township 10, range 27, the river makes a sharp bend, commonly known as the "Horn," and from this point flows in a southeasterly direction through the Columbia River Plains to the Columbia River.

The crest of the Rattlesnake Hills, in the northern part of the county, extends in a general southeast direction from the west county line. They range from 3,000 to more than 3,500 feet above sea level, the highest point being near the east side of township 11, range 25.

The slope southward from the crest is long and gentle, but on the north it is short and steep. The hills narrow toward the east and terminate in a point near Vista. The Yakima River follows a gorge through the range of hills at Benton City and divides it into two unequal parts. East of the river it consists of a steep-sided ridge about 3 miles in width and 12 miles in length. It might be assumed that the Yakima River once occupied the valley to the south of this ridge, but such is probably not the case, for the material in the coulée here consists of old valley-filling deposits seemingly lake laid or wind laid.

A few miles beyond the west county boundary the Rattlesnake Hills merge with the Yakima Range, the latter being an outlying spur of the Cascade Range. The Yakima Range extends northward to the Columbia River and includes about one and one-half townships in the northwestern corner of the county. The greater part of this range has a rather steep but uniform slope toward the east. On the north, however, along the Columbia, the slope is short and precipitous, with a fall of 2,000 feet to the mile.

The Horse Heaven Hills rise abruptly along the south side of the Yakima Valley from the western boundary of the county to Kiona, from which point they swing in a southeasterly direction to the Columbia River. West of the vicinity of Badger the slope is only 1½ to 2 miles long and is steep, the fall being about 1,400 feet. East of Badger the slopes are about 6 miles in length and many of them are smooth enough for cultivation.

Sloping south and east from the Horse Heaven Hills, and extending from the Columbia River on the east to the wooded foothills of the Cascades on the west, is the extensive region commonly known as the Horse Heaven Plateau. This plateau occupies about 500 square miles in Benton County. Viewed from certain positions a large part of this extensive area appears nearly level, though there is always a gradual slope toward the south and east. The elevation ranges from 1,500 to 2,000 feet above sea level along the north side to 700 to 1,000 feet along the south side, so that the average fall is approximately 100 feet to the mile. A number of deep draws or ravines extend southward across the plateau to the Columbia River, in all of which streams flow only during the period of melting snow or for a few hours following heavy rains. The draws lie 50 to 500 feet below the level of the upland. Along the lower margin of the plateau they frequently consist of deep, narrow canyons shut in by vertical walls of basalt.

In the northern, eastern, and southern parts of the county are extensive areas of the Columbia River Plains. The largest area, comprising about 425 square miles, lies north and east of the Rattlesnake Hills. In general this is a sandy, desertlike region consisting

mainly of old terraces, with dunes, rocky eminences, and very narrow strips of first-bottom lands. The terraces consist of comparatively level areas separated by rather steep slopes and lying 50 to 400 feet above the normal level of the Columbia River. A considerable part of T. 11 N., Rs. 27 and 28 E., of T. 12 N., Rs. 25 to 28, inclusive, E., and parts of Ts. 13 and 14 N., Rs. 27 and 28 E., have a very uneven surface, consisting of dunes and ridges varying in height from a few feet to more than 60 feet. The ridges usually are parallel and extend in an east-west direction. On the windward side the slope is gradual and smooth but on the opposite side there is frequently an abrupt drop of 20 to 60 feet.

A prominent ridge of basalt extends east from the Yakima Range through the center of T. 13 N., Rs. 25, 26, and 27 E., and terminates within 1 mile of Hanford. The eastern part of this ridge, known as Gable Mountain, rises abruptly to an elevation of more than 600 feet above the plains. Its rocky sides are steep and rough.

In the vicinity of Hover the Horse Heaven Hills approach the Columbia, and from this point to Tomar the river flows through a narrow gorge about 1,000 feet below the level of the upland. From Tomar the Columbia River Plains gradually widen out to about 6 miles at the southwestern corner of the county, where they are interrupted by Crow Butte, a rugged mass of basalt rising abruptly 400 feet above the river, and Canoe Ridge. The latter is a steep-sided ridge which has an elevation of 500 to 700 feet above the river and parallels the stream for about 8 miles. Here the basaltic walls have been cut through, forming the deep canyon of Glade Creek, and beyond this point the smoothly rounded slopes of Paterson Ridge extend in a northeasterly direction for a number of miles. From the crest of the ridge the land slopes gently southward and merges into a series of terraces. On the north side the slope is steep and leads down to a filled-in valley made up of wind-blown sands. From this point northward to the Horse Heaven Plateau the surface is billowy and choppy.

The drainage of the entire county reaches the Columbia River. The Yakima River, which joins the Columbia near Richland, drains only a very narrow strip on the south, as the north slopes of the Horse Heaven Hills are short and the south half of the county slopes mainly toward the south. The Yakima River receives the drainage from the Rattlesnake Hills, the drainage from the north slope reaching it through Cold Creek, which occupies an old glacial channel. There are a few small springs on the north side of the hills, but the waters of only one, Rattlesnake Springs, succeed in reaching the valley. This water is used to irrigate about 65 acres of land, and is lost in the sands at the lower side of the field. There are a

number of small drainage ways in nearly every part of the county which carry water only after heavy rains or after the snow thaws in the spring. The most poorly drained areas are in the sandy regions of the Columbia River Plains, between the Horn of the Yakima River and Hanford. Under dry farming drainage is of minor importance, but if any considerable area is ever put under irrigation there are a number of places that will require a complete system of artificial drainage.

Both the Columbia and Yakima Rivers are swiftly flowing. The Yakima Valley lies 1,000 to 1,400 feet below the upland on the south, and in places the Columbia flows through gorges 1,000 to 2,000 feet below the adjoining highlands. The beds of the streams are usually in basalt, and the process of cutting is still going on. At the northwestern corner of the county the elevation of the Columbia River is 440 feet and at the southwestern corner 230 feet above sea level, showing a fall of 210 feet in about 130 miles. Much of this fall occurs at various rapids, the most important of which is Coyote Rapids, a few miles above White Bluffs. At this point considerable water power is available. Power has been developed at Priest Rapids, 2 miles above the northwestern corner of the county.

Benton County was formed in 1905 from parts of Yakima and Klickitat Counties. Some sections, particularly in the vicinity of Prosser, were settled some time prior to this date. The early population consisted almost entirely of native white settlers who took up homesteads or desert claims. While nearly every State is represented in the present population, the greater part is from Minnesota, Iowa, and other central States. According to the 1910 census, 21.6 per cent of the population is of foreign or mixed parentage, and 12.3 per cent foreign born. Of the latter, Canadians, Germans, and English, in the order named, predominate. At the present time about 50 per cent of the total population of the county is concentrated in small towns, while not more than 5 per cent live outside the Columbia and Yakima Valleys. All the population is classed by the census as rural, and the average density of settlement is 4.7 persons to the square mile. The most thickly settled sections are the narrow valleys in the vicinity of Prosser, Kennewick, and Richland, and the most thinly settled the Columbia River Plains in the northern and southern parts of the county, the Rattlesnake Hills, and the Horse Heaven Plateau. In 1910 the population of the county was 7,937. Prosser, with a population of 1,298, is the largest town and the county seat. Kennewick had a population of 1,219 in 1910, and Richland, Hanford, and White Bluffs about 300 each. Other towns of 100 or more inhabitants are Benton City, Kiona, Finley, and Hover. In addition to these twons there are a number of small shipping points.

Transportation facilities are good. Railroad lines extend from east to west across the northern, central, and southern parts of the county. The Yakima Valley is traversed east and west by the transcontinental line of the Northern Pacific Railway and by a line of the Oregon-Washington Railroad & Navigation Co. Main lines of this system and of the Spokane, Portland & Seattle Railroad follow the Columbia River to Portland. A new branch of the Northern Pacific Railway leaves the main line at Gibbon and connects with the Sunnyside Branch at Grandview, 1 mile west of the county line. The Hanford Branch of the Chicago, Milwaukee & St. Paul Railroad extends up the Columbia from Hanford and joins the main line of the system near Beverly. Southward over the Rattlesnake Hills the distance between this road and those in the Yakima Valley is about 27 miles, while from the Yakima Valley southward over the Horse Heaven Plateau the distance between railroads is about 22 miles.

With the opening of the Celilo Canal at Dalles in 1915 the Columbia River was made navigable from the ocean to Priest Rapids. Steamers are now regularly operated between Portland, Kennewick, and intermediate points, and occasional trips are made to Hanford and White Bluffs. In addition to steamer service, daily mail and passenger service is maintained by gasoline launch between Kennewick, Richland, and Hanford.

The county road system is adequate for the present distribution of population. Many of the roads, however, have had practically no improvement. In the Horse Heaven region and in the valleys the roads follow section lines. Throughout the regions of deep sand south of Hanford and north of Carley and Whitcomb there are extensive areas without roads of any kind. In general the roads are good throughout the greater part of the year, but during the early fall they become badly cut up from the hauling of wheat, and many of the main highways are strawed. Sagebrush is also used with good results on roads through deep sand, and in this way many roads have been made passable for automobiles. A good oiled road extends from Hanford to White Bluffs and another down the river from Kennewick. The Inland Empire Highway crosses the county from east to west, and from the west side of the county to Kiona there is a good hard-surfaced road.

Prosser and Kennewick are the principal local markets. Much of the alfalfa produced in the county is used locally for feeding sheep. Portland, Seattle, Tacoma, and Spokane are important markets for fruit, and large quantities are also marketed in Chicago, New York, and other eastern cities and in South America, Australia, and Alaska.

## CLIMATE.

Benton County lies within the intermountain, arid region of the State and has a climate entirely different from that along the coast. Being east of the Cascade Mountains in the comparatively low Columbia River basin, it is practically shut off from the moderating effects of the winds from the ocean, while it lacks the protection of the Cascade Range from the extremes of heat and cold that characterize the climate of the continental interior. It is therefore subject to high summer and low winter temperatures, but on account of the low relative humidity of the air the extremes are not so oppressive as in moister climates. The rainfall is very low, as the region depends on the moisture-laden winds from the Pacific Ocean for its supply of rain and snow. These winds, in crossing the Cascade Mountains, are cooled to such an extent that they lose most of their moisture on the high western slopes, and in descending the eastern slopes they are warmed by the increase in pressure consequent to the lower elevation. As their moisture-holding capacity is thereby increased, they frequently pass eastward over the Columbia River basin as warm, dry winds capable of absorbing moisture rather than of precipitating it.

The mean annual precipitation at Kennewick, according to the records of the Weather Bureau station, is only 6.34 inches. The greatest rainfall recorded for any one year was 9.92 inches in 1899, and the least was 3.58 inches in 1898. The precipitation varies somewhat in different parts of the county, being slightly heavier in the Rattlesnake Hills and slightly lighter in the low interior valleys. The rainfall is greatest during the winter months and least in the summer, when only 0.62 inch falls, mainly in the form of local thunder showers. The snowfall varies considerably with elevation, ranging from a few inches in the Columbia and Yakima River valleys to 2 feet or more in the Rattlesnake Hills. As a rule the valleys are covered with snow for only a few days at a time during the coldest weather, but the hills usually are covered for several weeks. The greatest snowfall recorded for any one year at Kennewick is 19.5 inches.

The mean annual temperature at Kennewick is reported as 54.3° F. The average for January, the coldest month, is 31.2° and for July, the warmest month, 77.6°. The lowest temperature recorded at Kennewick is —21° and the highest 115°. Following even the hottest days in the summer the nights usually are cool, and clear days prevail during the coldest winter weather.

Killing frost has occurred at Kennewick as early in the fall as September 25 and as late in the spring as May 25, but the average

dates are October 15 and April 28, respectively. This gives an average growing season of 170 days, which is ample for maturing the grains and fruits commonly grown. Ordinarily stock may be grazed throughout the year, though short periods of feeding are necessary when the ground is covered with snow.

The prevailing winds are from the southwest and are strongest during the late spring and early summer, when they may continue for several days at a time, and frequently reach 30 or 40 miles an hour. These dry winds cause high evaporation, so that thorough cultivation is necessary to conserve sufficient moisture for dry-land crops and to prevent the rise and accumulation of alkali in the irrigated fields. The winds also cause extensive sand drifts in the areas of lighter soils.

The climate of Benton County is too dry for best results in farming without irrigation. With irrigation it is well suited to the production of fruit, grain, hay, and vegetables.

The following table is compiled from the records of the Weather Bureau station at Kennewick:

*Normal monthly, seasonal, and annual temperature and precipitation at Kennewick.*

| Month. | Temperature. | | | Precipitation. | | |
|---|---|---|---|---|---|---|
| | Mean. | Absolute maximum. | Absolute minimum. | Mean. | Total amount for the driest year (1898). | Total amount for the wettest year (1899). |
| | °F. | °F. | °F. | *Inches.* | *Inches.* | *Inches.* |
| December | 36.6 | 71 | −8 | 1.06 | 0.23 | 1.02 |
| January | 31.2 | 74 | −21 | .94 | .73 | 1.65 |
| February | 37.8 | 74 | −10 | .74 | .52 | 1.22 |
| Winter | 35.2 | 74 | −21 | 2.74 | 1.48 | 3.89 |
| March | 46.8 | 85 | 10 | .41 | .14 | .25 |
| April | 54.7 | 91 | 21 | .26 | .21 | .38 |
| May | 63.2 | 105 | 26 | .50 | .37 | .30 |
| Spring | 54.9 | 105 | 10 | 1.17 | .72 | .93 |
| June | 69.1 | 108 | 38 | .28 | .34 | .13 |
| July | 77.6 | 111 | 44 | .13 | .00 | .05 |
| August | 75.2 | 115 | 41 | .21 | .15 | 1.42 |
| Summer | 74.0 | 115 | 38 | .62 | .49 | 1.60 |
| September | 64.3 | 102 | 26 | .31 | .05 | .44 |
| October | 53.6 | 87 | 15 | .57 | .10 | 1.69 |
| November | 42.0 | 78 | −12 | .93 | .74 | 1.37 |
| Fall | 53.3 | 102 | −12 | 1.81 | .89 | 3.50 |
| Year | 54.3 | 115 | −21 | 6.34 | 3.58 | 9.92 |

## AGRICULTURE.

Agriculture has been carried on in Benton County for a comparatively short time. Prior to 1890 the region was considered too dry and barren for farming and the only settlements were those of stockmen, who lived in the valleys and grazed their stock on the uplands. The first settlements were in the Yakima Valley near Prosser and at various points on the Columbia River. The grazing of horses and cattle continued as the principal occupation until after 1900. There was a dense growth of nutritious bunch grass in the Horse Heaven country, and large numbers of horses and cattle were annually shipped from this region and from the Rattlesnake Hills.

During the early nineties a few small areas in the vicinity of Prosser and Kennewick were put under irrigation, and from that time the irrigated acreage has rapidly increased. From the beginning the principal irrigated crops have been alfalfa and fruit. About 1902 a considerable influx of settlers began, and during the next few years a large part of the Horse Heaven Plateau was taken up by homesteaders. During the next decade many thousand acres of bunch-grass land were plowed and seeded to wheat. The rapidity of development is indicated by the fact that in 1907, a year of low yields, nearly 500,000 bushels of wheat were shipped from Benton County.

Owing to the low rainfall the fields must be summer fallowed every other year, so that a harvest is returned only once in two years. Even with this precaution crop failures have been common. In view of these trying conditions and of the difficulty of obtaining underground water, so that water for all stock and domestic purposes had to be hauled long distances, many settlers, after acquiring title to their homesteads, immediately abandoned them. About 1909 a pronounced exodus began, and by 1913 there were only a few houses occupied on the Horse Heaven Plateau. At the present time, however, a considerable acreage is still in cultivation, as the farmers remaining work a number of homesteads. The continued success of all the better farmers has demonstrated that wheat can be profitably grown where proper attention is given to seed selection and to the details of cultivation.

There were 77,508 acres in wheat in 1909, producing 384,230 bushels. Alfalfa was grown on 3,632 acres, with a production of 16,976 tons. There were 4,278 acres in tame or cultivated grasses, producing 18,959 tons of hay, and 4,179 acres in grains cut green, producing 1,591 tons. Potatoes occupied a total of 505 acres and produced 49,311 bushels; corn, 118 acres, producing 4,272 bushels; and timothy and clover, alone or mixed, 639 acres, producing 979 tons. Hops were grown on 57 acres, producing 95,370 pounds.

There were 281 acres of vegetables, 702 acres of barley, and 12 acres of rye. Strawberries occupied 198 acres, with a production of 199,331 quarts; blackberries and dewberries 14 acres, with 19,311 quarts; and raspberries and loganberries 13 acres, with 12,085 quarts. There were 18,649 apple trees in the county, 69,193 grapevines, 22,331 peach trees, and 58 nut trees, principally Persian, or English, walnuts. A total of 884 cattle and calves, 665 horses and mules, 2,144 hogs, and 1,014 sheep and goats are reported sold or slaughtered in 1909. There were 798 cows on farms reporting dairy products.

The total value of all farm products for 1909 is given in the census as $945,063. Of this amount, $356,214 is for cereals, $106 for other grains and seeds, $236,742 for hay and forage, $53,471 for vegetables, $38,770 for fruits and nuts, and $27,454 for all other crops. Animals sold or slaughtered were valued at $100,297; dairy products, exclusive of those used at home, at $38,294; poultry and eggs at $77,581; and wool, mohair, and goat hair at $16,134.

In general the agriculture of Benton County consists of the production of wheat and fruit for sale, the growing of hay and vegetables for sale and for home use, hog raising, dairying, and the winter grazing and feeding of sheep. The principal crops are wheat, alfalfa, apples, peaches, pears, cherries, strawberries, and grapes, the first three named being by far the most important.

The following table, compiled from information furnished by the various transportation lines, shows the volume of agricultural products shipped from the principal stations within the county during the year 1915:

*Shipments of products in 1915 from principal stations in Benton County.*

| Town. | Apples. | Peaches. | Pears. | Cherries. | Grapes. | Strawberries. | Vegetables. | Wheat. |
|---|---|---|---|---|---|---|---|---|
| | *Boxes.* | *Boxes.* | *Boxes.* | *Boxes.* | *Boxes.* | *Boxes.* | *Boxes.* | *Bushels.* |
| Kennewick | 11,062 | 193,192 | 15,280 | 27,454 | 9,494 | 57,084 | 12,996 | 4,311 |
| Prosser | 25,939 | 36,005 | 12,874 | 7,874 | 21,585 | 1,009 | 6,994 | 103,786 |
| North Prosser | 4 | 97 | 8 | 805 | 704 | 620 | ..... | ..... |
| Kiona | 1,699 | 2,411 | 113 | 199 | 447 | 612 | 236 | 36,181 |
| Benton City | 18 | 320 | 13 | 9 | 7 | 996 | ..... | ..... |
| Hanford | 9,750 | 144,000 | ..... | ..... | ..... | ..... | ..... | ..... |
| White Bluffs | 2,641 | 18,000 | 642 | ..... | ..... | ..... | ..... | ..... |
| Badger | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 64,097 |
| Paterson | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 15,389 |
| Total | 51,113 | 394,025 | 28,127 | 36,341 | 32,237 | 60,321 | 19,426 | 223,764 |

Grand total, boxes of fruit and vegetables, 621,590.

In addition to the above there are ten or more small shipping points within the county for which figures were not obtained.

The production of wheat has remained about stationary for several years. The greatest advance has been in the production of fruit, owing largely to the rapidly increasing acreage placed under irrigation. A number of young orchards are just coming into bearing. Wheat, however, is still of first importance and the chief money crop of the county.

Alfalfa is the second most important crop, and one of the most dependable products. It is grown only in the irrigated valleys and occupies many of the older orchards. Considerable shipments are made to Seattle and other coast points, and a large part of the crop is sold in the stack to sheepmen and fed on the place. Some of the alfalfa is used for feeding work stock and dairy cattle and as pasturage for hogs.

Fruit growing is confined to the irrigated valleys near the towns. During the last four years there have been few orchards planted. A large proportion of the trees have not yet reached their greatest bearing stage. At present the third crop in importance in Benton County is apples. The leading varieties are the Winesap, Rome Beauty, Winter Banana, and Jonathan. Yields vary greatly, but many of the better cared for orchards at 10 years of age are producing as much as 800 boxes per acre. According to the leading growers, the cost of harvesting, exclusive of growing, is about 35 cents a box. Clean cultivation costs $12 to $14 an acre each year; the cost of pruning, spraying, thinning, and irrigating is quite variable.

Peaches are a very important crop, especially on the lighter soils about Kennewick and Hanford. The fruit from these districts ripens early and is the first in the State to reach the markets, which insures a good demand at high prices. Pears are of some importance around Kennewick and Prosser, and cherries are grown to some extent, chiefly in the vicinity of Kennewick. Owing to the early season and the light, sandy soils at Kennewick, this section is well suited to the production of strawberries. Shipments begin the latter part of May and continue well into June. Grape growing is rapidly becoming an important industry at Kennewick, Prosser, and Richland. In 1915 about 7,000 cases, or between 11 and 12 carloads, of grape juice and about one-half as much apple juice were shipped from this point. The grape juice is of superior quality, and was awarded first prize at the San Francisco Exposition. The Concord and Worden are the varieties best suited to the making of grape juice, and during the last year a number of acres of these varieties have been planted. The growing of vegetables for market is increasing.

During the year of this survey 80 cars of sheep, 67 cars of hogs, and 1 car of cattle were shipped from Benton County. Dairying is practiced on a small scale in the vicinity of Prosser and Kenne-

wick, the milk being delivered from house to house in the towns or the cream to local creameries.

The growing of potatoes for seed is becoming an important industry in the vicinity of Prosser. During the present year (1916) one seed firm furnished 3,000,000 pounds of potatoes for planting in the Yakima Valley, and during the next season 10,000,000 pounds are expected to be supplied. The potatoes are grown under irrigation. The yields in Benton County have not fallen below 10 tons and have been as high as 24 tons, or 800 bushels, per acre. The acreage of rye is increasing in the Horse Heaven country, and corn is being extended over a considerable acreage in the irrigated sections near Prosser and Kennewick. Both crops are used for feeding hogs and work stock on the farms.

The farmers of Benton County recognize that the Ritzville loam, Ritzville very fine sand, and Sagemoor silt loam are well suited to the production of wheat, but that practically all the soils coarser than a very fine sand are not well adapted to crop production without the aid of irrigation. It has been demonstrated that the sandy soils under irrigation are well suited to peaches and that such soils in the vicinity of Hanford, White Bluffs, and Kennewick are the earliest in the county, especially suited to the production of strawberries and early vegetables. The Ephrata fine sandy loam, heavy phase, the Ephrata gravelly fine sandy loam, the Esquatzel silt loam, and the Pasco fine sandy loam, heavy phase, are considered the best soils for alfalfa, corn, apples, cherries, and pears, while the lighter textured soils of the Ephrata series are considered better for grapes.

The wheat crop is harvested with a header or with a combined harvester that cuts and thrashes the grain at one operation. In the former case the grain is stacked and thrashed later. The wheat is sacked, and usually hauled to the railroads as soon as possible after being thrashed. A large part of the crop is loaded directly on cars and shipped immediately, while the remainder is stored in local warehouses for later market.

Although there are still a few fruit growers who ship their product individually, by far the greater part of the fruit grown in the county is sold through a fruit growers' association. It is subject to rigid inspection, which insures a high standard of quality and uniformity of packing. No provision is made for utilizing cull fruit, and large quantities of apples which should be useful for canning or drying are wasted. The business of marketing in distant cities is in the hands of experts, and the speculative feature which in the past so often proved disastrous to the industry has largely been overcome.

There are a number of fruit diseases and insect pests, the most common diseases of apples and pears being blight and core rot. The former is controlled by cutting away the affected parts and the latter by supplying good drainage. Powdery mildew is a common disease of apples, peaches, and grapes, and is counteracted by spraying with free sulphur. Among the most common insect pests are the scale, codling moth, and aphis. The scale is controlled by spraying with oil emulsion or with a lime-sulphur preparation, usually in the spring before the buds open. The codling moth is controlled by arsenate of lead sprays, applied according to instructions from the horticultural office as to the proper time. The aphis is combated by a spray composed of lime and nicotine applied either with or without the arsenate of lead, and at the time the insects appear.

Frosts cause very little damage to fruit in the Yakima Valley. Cherries and peaches are sometimes injured by late spring frosts, but as a rule the low spring temperatures cause nothing more than a desirable thinning of all kinds of fruit. Smudging or heating the orchards artificially is not practiced in Benton County.

During the fall months large numbers of sheep are driven from their summer range in the lower Cascades and pastured for a few weeks on the alfalfa in the valleys. During the open part of the winter they are grazed on the bunch-grass lands within the county, and when the snow gets too deep for grazing they are fed alfalfa. The hogs raised in the irrigated valleys are maintained for about seven months of the year chiefly on alfalfa pasture, while in the wheat-growing sections they are given the run of the grain fields. During the last few years a number of silos have been built throughout the irrigated sections, and part of the corn grown is made into ensilage and used in the dairy industry.

The farm buildings throughout the irrigated valleys are commodious and well built. The dwellings especially are substantial and many are of concrete. In the dry-farming sections the buildings are poor and in bad repair. Many of the fences consist of only two or three wires, and in many instances where the land is untenanted the fences are down. In all cases, however, the farm implements are modern and well adapted to the type of farming practiced. Gang plows, disk harrows, and large, improved cultivators and weeders especially adapted to summer-fallow work are found on practically every farm in the Horse Heaven region. These are usually drawn by four or six horses, although in some instances tractors are employed. The binders have largely been superseded by headers and combined harvesters. The work stock consists of horses and mules of medium to heavy weight, and an unusually

large supply is kept on most of the ranches. The dairy cattle are mainly well-bred Holsteins and Jerseys, and the hogs are of Duroc-Jersey and Berkshire breeds.

Practically all the wheat produced in Benton County is grown by summer fallowing. A few of the farmers plow their land in the fall, but the greater number begin plowing or disking in the early spring. During the summer the fields are gone over three or four times with a disk harrow or some form of combined weeder and cultivator especially designed for this purpose. Many fields receive no other preparation than shallow disking. This usually leaves the ground clean, though it is sometimes necessary to remove persistent weeds by hand. Seeding is done in the fall as soon as possible after the first good rain.

Practically all the corn produced in Benton County is grown under irrigation. The land is plowed in the spring to a depth of 8 to 10 inches and the seed is planted 6 to 8 inches deep. If the land is unusually dry it may be irrigated before planting, but this is not very common. As a rule the first cultivation is given when the corn is 6 to 8 inches high and the first irrigation when it is about 2 feet high or in the early part of June. Two irrigations are given as a rule, the last one at the time the ear is forming. Following each irrigation the soil is thoroughly worked to break the crust and check evaporation.

Many of the young orchards are given clean cultivation, being cultivated 12 to 14 times during the summer. While the trees are young, corn, potatoes, or some other intertilled crop is commonly grown between the rows. A strip 6 or 8 feet wide, however, is left along the trees, and this is thoroughly cultivated. After the fifth or sixth year many of the orchards are seeded to alfalfa, which is grown for hay and often used for grazing sheep in the fall. The trees are irrigated by the furrow system, but the time of watering and the quantity applied vary with the topography and character of the soil. In some cases three irrigations are considered sufficient, and the water is applied about the 1st of June, the middle of July, and the middle of August. On the more gravelly soils, however, where the surface is unfavorable to a proper distribution of the water, irrigation begins early in April and continues until late in September.

Large quantities of water are used in growing strawberries. Irrigation begins early in April and continues at frequent intervals up to the picking season, during which time the plants are watered every other day or daily. Following the picking season the plants are first mowed and then about one-half of them are removed with a turning plow. The beds are then heavily fertilized and thoroughly culti-

vated, both lengthwise and crosswise, with a spring-tooth or spike-tooth harrow. Following this, water is again turned onto the land and irrigation and cultivation continue as before harvest until late fall.

According to the census, commercial fertilizers were used on only 61 farms, or less than 5 per cent of the number in the county, in 1909. The total value of the fertilizers used was $1,837, or $30.11 per farm. Practically all the fertilizer is 15 to 20 per cent nitrate of soda, usually in the form of dry powder mixed with tankage, and is used on strawberries at the rate of 400 to 800 pounds per acre. The importance of barnyard manure is generally not appreciated, and the supply is not carefully conserved.

Except during the rush seasons, the supply of farm labor is adequate. Imported labor is usually employed to assist in harvesting wheat and, sometimes, in picking fruit. The census reports a total expenditure for labor in 1909 of $341,067, or an average of $584.02 for each of 584 farms reporting. When employed by the month laborers are generally paid $30 to $45, with board. Harvest hands receive $2 to $3 a day. Strawberries are generally picked by women and children, and women do much of the work of grading and packing the fruit. Four cents a box is paid for packing apples which have previously been graded, and about $2.50 a day for grading. For 1909 a total of 657 farms report an expenditure of $110,973, or an average of $168.91 per farm, for seed.

In the irrigated valleys the farms vary from 5 to 20 acres in size, with an average of about 15 acres. In the wheat-growing sections the farms are much larger, from 160 acres to as much as 8,000 acres being under single management. Of the undeveloped land the Northern Pacific Railway Co. still holds nearly 75,000 acres, a Minneapolis firm over 30,000 acres, and several residents within the county 5,000 to more than 20,000 acres each. The 1910 census reports 88.9 per cent of the farms operated by owners, 6.8 per cent by tenants, and 4.3 per cent by managers. At present it is believed a somewhat larger percentage of the farms is operated by tenants. Practically all the rented land is in the wheat-growing sections and is farmed on the share basis. The owner of the land receives one-fourth the crop delivered at the freight station, and furnishes the sacks for his share. The periods of rental range from 1 year to 5 years.

Undeveloped land in the sandy sections of the county ranges in value from $1.25 to $5 an acre. The wheat lands range from $10 to $25, with an average of about $15, an acre. In the irrigated valleys the prevailing price of land is between $200 and $350 an acre, with some areas as low as $125 and others as high as $500 an acre, depending on the improvements and nearness to towns.

## SOILS.

Benton County lies entirely within the Northwest Intermountain soil province, and is a part of a treeless, desert plateau region extending from the Okanogan Highlands on the north to the Blue Mountains in Oregon on the south and from the Cascades on the west to the Bitter Root and Coeur d'Alene Ranges in Idaho on the east.

The entire county is underlain by a succession of basaltic sheets of the Columbia River lava field, which cover a large part of southern Washington and eastern Oregon, and broad areas in Idaho, Nevada, and California. The rock is dark colored, usually crystalline, and is known as the Yakima basalt. It has an estimated thickness in this area of more than 2,500 feet. In the valleys and level areas the layers are nearly horizontal, but on the slopes the beds are folded and often steeply inclined. In places thin deposits of stratified material occur between the sheets. The rock is prominently exposed along the eroded stream courses and forms the canyonlike walls of the larger streams, as on the south side of the Yakima River, along the Columbia River near the northwestern corner of the county, and in the vicinity of Yellepit and Tomar. Local exposures of the underlying basalt are common in the valleys and on the ridges and terraces, the rock outcrops being interspersed with areas of shallow and stony soils, which are extensive in the aggregate.

Overlying the basalt in various parts of the county are sedimentary beds, which were laid down in horizontal layers in former lakes.[1] This material is known as the Ellensburg formation and consists for the most part of stratified, light-colored deposits of very fine sand, silt, and clay. In places the beds have been faulted and folded so that the layers are no longer horizontal. In such areas lens-shaped pockets of sand are common, and transverse vertical veins of sand and silt extend downward many feet into the deposits. Bowlders of granite and other rocks are common on the surface and throughout the underlying strata. The surface rocks are of glacial origin and are most numerous along the slopes of Cold Creek Valley. Their arrangement indicates the existence in this section of a lobe of the continental ice sheet whose melting waters scoured out the wide glacial valley and distributed great volumes of gravel and coarse sand over the broad terraces between this valley and the Columbia. In other sections the scattered surface rocks may have been carried down by drift ice from the region of crystalline rocks and deposited from floating ice in former lakes. Typical exposures of the stratified deposits may be seen at Benton City and Kiona. More extensive deposits occur in the White Bluffs of the Columbia River, opposite

[1] Geology and Water Resources of a Portion of South-Central Washington, by Gerald A. Waring, U. S. Geol. Survey.

Hanford and the town of White Bluffs. Here the material has a thickness of over 700 feet. The maximum depth of these deposits in Benton County has not been determined. The distribution of the material was at one time much greater than at present, as much of it has been washed away from the higher areas, while many of the valley deposits have become obscured by accumulation of wind-blown and water-laid materials. In general, it may be said that evidence of the Ellensburg formation is not seen in Benton County above an elevation of 1,300 feet.

Above this elevation most of the basalt is buried beneath a mantle of fine-grained, light-brown material of homogeneous character. This material has a high silt content, is remarkably uniform in texture, and is unstratified. It is considered of loessial or wind-borne origin.

On the basis of the origin of their material the soils of Benton County may be grouped into four general divisions: Soils derived from loessial or wind-borne material; soils derived from eolian or wind-blown material; soils derived from old valley-filling material, mainly lake laid; and soils derived from stream-laid material. The stream-laid soils may be subdivided into soils derived from (*a*) glacial outwash or river-terrace material, (*b*) river flood-plain material, and (*c*) alluvial-fan material.

In addition to the 26 soils classed with these four groups three classes of miscellaneous material, largely nonagricultural, are mapped. These are Scabland, Riverwash, and Dunesand. The various series comprise soils of similar color, origin, topography, drainage, etc., and are separated into soil types on the basis of texture.

The accompanying sketch map (fig. 2) indicates the extent and location of the four groups of soils and of Scabland.

The group derived from loessial or wind-borne material comprises the light-brown soils of the high plateaus. These consist of fine material which is believed to have been derived from an undetermined wide range of rocks and minerals and borne aloft by winds and air currents, slowly filtering down as dust deposits. Some of this material may be of volcanic origin. Wind-borne material also occurs, covering the valley-filling material at lower elevations. As a rule the loessial soil rests directly on the underlying basalt, the depth to this bedrock varying greatly in different parts of the county. In the eastern part of the Horse Heaven Plateau the loessial deposits range from 50 to more than 100 feet in depth. With increasing elevation to the north and west the material thins out to 1 to 5 feet. The present topography is undulating to rolling and has been determined by erosion. A large part of the deposits on the slopes of the Rattlesnake Hills is less than 3 feet deep. The soils of the loessial group are classed with the Ritzville series, which includes by far the

most extensive and important upland types in the county. Plate I, fig. 1, gives a general view showing the topography and vegetation of these soils on the Horse Heaven Plateau.


FIG. 2.—Sketch map showing distribution of soil materials, grouped according to origin.

The Ritzville series is characterized by light-brown to light grayish brown soils with slightly lighter colored subsoils, resting on gray, unstratified, silty deposits of homogeneous character. The dry,

bleached surfaces of cultivated fields are gray. Both soil and subsoil usually are calcareous. It is probable that much of the material is preglacial in origin. The soils contain no stones or gravel aside from fragments of the underlying basaltic rock. The Ritzville soils are extensively developed on the Horse Heaven Plateau and on the slopes of the Rattlesnake Hills. The loam is the most important upland soil in the county.

The eolian or wind-blown soils are confined mainly to two rather extensive areas, one in the northeastern corner of the county and the other in the southern part. They also occur on the islands in the Columbia River and in isolated bodies in the vicinity of Kennewick, Vista, and Prosser. They rarely occupy elevations of more than 900 feet. The surface is billowy or dunelike, the low, rounded ridges sometimes extending for miles in one direction. The soils seem to consist of sandy material blown by wind from the shores of the Columbia River, most of the material being moved along or close to the surface. They are classed with three series, the Quincy, Koehler, and the Winchester. Dunesand, a type of miscellaneous material, might also, from the standpoint of origin, be properly regarded as belonging to this group.

The Quincy series comprises light-brown or light grayish brown soils and subsoils, often appearing grayish in dry, bleached fields. The subsoil is generally similar to the surface material in texture and structure, but usually is of slightly lighter color. The soils of this series are without hardpan but are underlain by compact stratified silts, fine sands, and clays, probably of lake-laid origin, within a few feet of the surface. The surface material is readily blown where unprotected by vegetation, and the topography is undulating or hummocky, marked by frequent parallel wind-blown ridges. Particles of the underlying calcareous sediments frequently have been distributed through the soil and subsoil by burrowing animals, rendering the material distinctly calcareous.

The Koehler series consists of light-brown or light grayish brown soils and subsoils, similar to the Quincy soils, except for a firmly consolidated, calcareous hardpan which occurs at depths ranging from 18 inches to 6 feet or more. Fragments of light-colored hardpan material in many places have been brought to the surface and distributed through the soil and subsoil by burrowing animals.

The soils of the Winchester series have a characteristic "pepper and salt" color, caused by the admixture of black basaltic particles with light-colored quartz grains. The general shade is gray to dark gray. The coarser particles are sometimes concentrated on the surface, owing to the removal of the finer, lighter colored particles by winds, giving the surface a nearly black appearance. The subsoil is similar to the surface soil, and usually is underlain at a

depth of several feet by stratified, waterworn sands and gravels. The soils of this series are loose and open, and of low moisture-retaining capacity. They occupy dunes or ridges ranging from 3 to 30 feet in height and separated by narrow valleys.

Bordering the lower margin of the loessial soils are extensive areas of old valley-filling deposits. These consist of light-colored sands and silts laid down in horizontal layers, probably for the most part in previously existing lakes. The soils have a firm, compact structure. The surface is level to gently sloping, and drainage is good. They are classed in two series, the Burke and the Sagemoor.

The Sagemoor series comprises light-brown to grayish-brown soils with light grayish brown to gray subsoils resting on stratified deposits of gray, silty material many feet in depth. These soils in Benton County are confined to elevations below 1,300 feet. The material is deepest on the lower slopes, and generally thins out toward the higher elevations. Winds have contributed to some extent to the modification or formation of the surface material of the lighter types. Waterworn granite bowlders and a variety of other rocks, probably floated in by ice, occur on the surface in places, indicating a glacial influence in the origin of the material. The surface ranges from nearly level to gently sloping or rolling, and the drainage is good.

The Burke soils are identical with the Sagemoor, except that they are underlain by a white, calcareous hardpan. This usually occurs at a depth of 18 to 30 inches.

The soils derived from stream-laid materials have a wide distribution through the valleys and terraces. Of the soils of this group those derived from glacial outwash material are confined largely to the broad terraces in the northern and southern parts of the county. These lie 50 to 400 feet above the present level of the streams and a glacial origin is ascribed to them, though it is probable that not all the material was deposited by glacial streams and that many of the areas along the present rivers have been formed in precisely the same manner as were the older areas of river flood-plain material. The soils might be characterized as old river flood-plain material, occupying high terraces, in contradistinction to the recent flood-plain soils of the low terraces and present flood plain. The glacial outwash soils of the stream-laid group are classed with the Ephrata series.

The Ephrata series includes grayish-brown to light-brown soils and subsoils overlying a substratum of porous gravels or coarse, dark-colored basaltic sand. The subsoils and substratum are somewhat calcareous, and the underlying gravels are often coated with lime. The topography is smooth. The Ephrata gravelly fine sandy

loam and the heavy phase of the fine sandy loam are the most important soils in the agriculture of the county.

The river flood-plain soils of the stream-laid group are of comparatively small extent. They are confined to the lower terraces and first bottoms of the Columbia and Yakima Rivers, and to the narrow coulée of Cold Creek. Four series are represented, the Beverly, Pasco, Esquatzel, and Prosser. Riverwash is a miscellaneous type which might properly be considered as belonging to this group.

The Beverly series consists of light-brown soils, with light-brown subsoils, which usually contain gravel and are underlain by a shallow substratum of waterworn gravel and bowlders. The soils are of recent alluvial origin. Crystalline rocks predominate in the gravels, but these soils are derived from a variety of materials. In places the surface has been somewhat modified by winds. Only a few of the lower lying areas are subject to overflow. Surface drainage is well established and subdrainage frequently is excessive. These soils resemble the Ephrata soils except for their occurrence on present flood plains and the lower terraces.

The Pasco series as mapped in previous surveys is characterized by brown to dark grayish brown soils, with slightly lighter subsoils. In this county, however, these soils have a much more pronounced gray color under field conditions, the lighter-textured soil being gray to light gray in dry cultivated fields and the heavier soil dark grayish or nearly black. Both soil and subsoil frequently are micaceous. Waterworn gravel and cobbles are sometimes found in the deeper subsoil. These soils occupy the first bottoms along present streams. Some low-lying areas are subject to overflow, but otherwise drainage is well established. The series differs from the Beverly in its more grayish and darker color and in the absence of a shallow gravel substratum.

The Esquatzel series consists of light-brown to light yellowish brown soils and subsoils, with a substratum of gravel or coarse sand at a depth of 5 feet or more. The soil is moderately compact, and in areas that have been flooded or irrigated the soil has a slight tendency to crack when dry. This series is of mixed origin, but is derived mainly from the erosion of loessial and basaltic materials. It occupies the first bottoms of coulées or along old intermittent stream channels. There is a gentle slope in the direction of stream flow, and aside from occasional flooding after showers or thawing of snow in the hills the drainage is good. While these soils are chiefly alluvial, they have been modified in places by the addition of wind-blown material. The soils of this series are distinguished from the Beverly soils by the greater depth to gravel and from the Pasco series by their light-brown or yellowish-brown color.

The Prosser series includes light-brown to brown soils and subsoils overlying basaltic bedrock at a depth ranging from a few inches to 2 feet. Small outcrops of basalt are of occasional occurrence, and fragments of this material are sometimes found throughout both soil and subsoil. The series represents shallow water-laid material deposited over volcanic bedrock, and probably later modified by the addition of wind-blown or loessial material. Drainage is only moderately well established, and small areas in irrigated sections are affected by alkali. The series is distinguished from the Ephrata by its browner color, the shallower depth to bedrock, and the absence of the gravel substratum. In some respects the shallower areas of these soils resemble Scabland, but the average depth of the soil material is greater and a much greater proportion is tillable.

The alluvial-fan soils consist of material transported by streams that lose their waters in the sandy soils of the desert plains soon after debouching from canyons, depositing their load of débris over cone or fan shaped areas. The streams giving rise to these deposits usually drain only small areas. The alluvial-fan soils are classed with the Stacy series.

The soils of the Stacy series range from rather light to medium brown, frequently with a characteristic reddish or rusty-brown tint. The subsoils are generally similar to the surface soils in color, texture, and structure. The series consists of imperfectly assorted or stratified deposits derived mainly from basaltic rocks and occupying gently to rather steeply sloping alluvial fans. Drainage is good and the soils are generally free from alkali, but owing to the lack of irrigation development they are of little agricultural importance.

There is a widespread belief that the finer textured soils of Benton County consist chiefly of volcanic ash. To determine this point a number of samples of the type having the greatest resemblance to volcanic ash were examined in the laboratories of the Bureau of Soils. Isotropic material with low refractive index and conchoidal fracture was found in very small quantities in each of the seven samples examined. The general appearance of this material, as well as its inclusions, strongly indicates that it is volcanic glass, but the conclusion that all the soil or any considerable proportion of it is volcanic ash can not be drawn. The results of the analyses simply indicate that these soils do contain small quantities of volcanic ejectments.

The following table gives the name and the actual and relative extent of each soil type mapped in Benton County:

*Areas of different soils.*

| Soil. | Acres. | Per cent. | Soil. | Acres. | Per cent. |
|---|---|---|---|---|---|
| Ritzville loam | 388,688 | 30.9 | Pasco fine sandy loam | 6,400 | 1.0 |
| Sagemoor silt loam | 118,272 | 10.7 | Heavy phase | 3,840 | |
| Scabland | 93,952 | 8.5 | Prosser fine sandy loam | 9,728 | .9 |
| Winchester fine sand | 75,264 | 7.0 | Dunesand | 7,936 | .7 |
| Heavy phase | 2,048 | | Beverly very fine sand | 7,168 | .7 |
| Sagemoor fine sandy loam | 60,672 | 5.5 | Quincy very fine sand | 6,912 | .6 |
| Winchester sand | 51,968 | 4.7 | Riverwash | 6,912 | .6 |
| Quincy sand | 48,384 | 4.4 | Burke fine sandy loam | 6,656 | .6 |
| Ephrata sand | 43,008 | 4.4 | Sagemoor fine sand | 6,144 | .6 |
| Coarse phase | 4,864 | | Beverly fine sand | 4,608 | .4 |
| Ephrata fine sandy loam | 37,888 | 4.3 | Esquatzel silt loam | 4,352 | .4 |
| Heavy phase | 9,728 | | Esquatzel fine sandy loam | 3,072 | .3 |
| Ephrata sandy loam | 37,120 | 3.4 | Ephrata gravelly fine sandy loam | 2,560 | .2 |
| Ritzville very fine sand | 31,232 | 2.8 | Burke fine sand | 2,304 | .2 |
| Quincy fine sand | 24,832 | 2.3 | Ritzville fine sand | 1,280 | .1 |
| Stacy fine sandy loam | 17,664 | 2.1 | Pasco clay | 512 | .1 |
| Heavy phase | 5,888 | | | | |
| Koehler fine sand | 15,992 | 1.7 | Total | 1,100,800 | |
| Heavy phase | 3,072 | | | | |

RITZVILLE FINE SAND.

The Ritzville fine sand consists of about 12 inches of light-brown, micaceous fine sand, underlain to a depth of 3 feet or more by a similar subsoil, which rests on light grayish brown, silty deposits characteristic of the series. Both soil and subsoil are usually calcareous. They are loose and incoherent in structure. In a few localities, notably in secs. 15 and 16, T. 6 N., R. 29 E., the soil is a light-brown fine sandy loam resting either on grayish-brown silt loam or on basaltic bedrock at depths ranging from a few inches to 20 inches.

The Ritzville fine sand occurs only in a few small areas in the southern part of the Horse Heaven Plateau. The surface in general is smooth, with small wind-blown patches having a slightly billowy topography.

The type is not tilled. A native growth of bunch grass affords good early-summer grazing. The soil is low in organic matter and of poor moisture-holding capacity. It is not adapted to dry farming and under present conditions is best used for pasture.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Ritzville fine sand:

*Mechanical analyses of Ritzville fine sand.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551232 | Soil | 0.0 | 0.2 | 0.8 | 55.6 | 39.4 | 3.1 | 0.6 |
| 551233 | Subsoil | .0 | .3 | .8 | 42.6 | 48.0 | 7.5 | .9 |

RITZVILLE VERY FINE SAND.

The Ritzville very fine sand to an average depth of 12 inches is a light-brown very fine sand. The subsoil to a depth of 5 feet or more is a grayish-brown or brownish-gray compact silt loam or silty very fine sand. Both the soil and subsoil usually are well supplied with lime. In places the soil carries a rather high percentage of fine material and closely resembles the Ritzville loam. It includes patches of Ritzville fine sand which are too small to be shown satisfactorily on the map. As a rule the soil and subsoil are more than 5 feet deep, but, as in the case of the Ritzville loam, the depth is variable. North of Prosser the underlying basaltic bedrock is encountered within a foot of the surface. Such areas are indicated on the map by cross ruling.

The Ritzville very fine sand occurs principally in the southeastern part of the Horse Heaven Plateau. It occurs in rather large areas as an intermediate type between the Ritzville loam and the Sagemoor soils. A few narrow strips are found along the draws in this section, and a few bodies occur north of Prosser.

The surface typically is smooth, but some small bodies have a dunelike appearance, the mounds being 2 to 3 feet high and formed around clumps of vegetation or along roadways. With the exception of these areas and a few narrow strips of steep topography along draws, the surface could easily be prepared for irrigation should water for that purpose become available. Both the surface drainage and underdrainage are good, and there are no harmful accumulations of alkali.

The Ritzville very fine sand is one of the more important dry-farming soils of Benton County. From 25 to 40 per cent of it is now in cultivation, but a much larger proportion has been used for crops. Wheat is the principal crop, and a small acreage is devoted to rye. Some areas that were previously in crops now support a rank growth of wild mustard and Russian thistle. Where the native bunch grass is still undisturbed the type affords good grazing. Good crops are generally produced on this soil. Wheat yields 10 to 30 bushels per acre. The rye is usually cut for hay.

This soil is handled in the same manner as the Ritzville loam, except that greater care is required to prevent blowing. The better land of this type can be bought for $10 to $25 an acre.

The type is in need of the same improvement as the Ritzville loam. The best results with crops are obtained by disking stubble rather than plowing where there is a marked tendency toward drifting. The stubble if left standing reduces soil drifting and retains snow in the winter. From the experience of farmers in other States it would seem good practice to scatter straw over the newly plowed land. This would add organic matter and in time increase the moisture-holding capacity of the soil. Care should be observed, however, not to apply the straw too thick, as the trash material decays slowly under the dry climatic conditions prevailing and may temporarily cause increased damage through drought by making the soil too loose and porous. The Ritzville very fine sand has a subsoil favorable for the retention of moisture, while the surface soil easily works into a dust mulch which prevents the loss of moisture by evaporation. For this reason the type, where properly handled, is one of the surest dry-farming soils in Benton County. Considerable areas are topographically favorable for irrigation, and with water available the land should prove well suited to all the crops now grown in this region.

The results of mechanical analyses of samples of the soil and subsoil of the Ritzville very fine sand are given in the following table:

*Mechanical analyses of Ritzville very fine sand.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551223..... | Soil..... | 0.1 | 0.2 | 0.3 | 19.0 | 66.0 | 12.8 | 1.7 |
| 551224..... | Subsoil..... | .0 | .0 | .2 | 4.8 | 51.4 | 41.0 | 2.5 |

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$) : No. 551224, 3 per cent.

RITZVILLE LOAM.

The surface soil of the Ritzville loam is a light-brown loam of uniform silty texture, 12 to 15 inches deep. The soil is frequently high in silt and often approaches a silt loam in texture. The subsoil to a depth of 5 feet or more is a grayish-brown to brownish-gray, moderately compact silt loam, silty very fine sand, or loam of high silt content, becoming somewhat lighter colored with depth. Dry and dusty field surfaces have a grayish color, but both the soil and subsoil are decidedly brown when even slightly moist. The surface soil and subsoil are generally well supplied with lime and are often pronouncedly calcareous. The entire type is underlain by basaltic bed-

rock, which is encountered at depths ranging from only a few inches on ridges and slopes to 100 feet or more in extensive smoother areas. In general, the bedrock is deepest in the eastern part of the county and gradually approaches the surface toward the west. The areas of pronounced shallow soil, described below, are indicated upon the soil map by cross ruling. Gravel and bowlders do not occur in either the soil or subsoil, nor are they exposed by deep cuts in the underlying material. The surface of virgin areas is moderately compact, but the soil is friable and easily cultivated.

In a number of localities the soil has a relatively high content of very fine sand. This is especially noticeable along the southern margin of the type and in areas adjacent to sandy types, where much of the soil approaches the texture of a very fine sandy loam. The surfaces of such areas have been somewhat modified by winds, and small bodies of very fine sandy loam and very fine sand have resulted from the removal of the fine material. These bodies frequently occur as narrow strips along roadways and small weedy patches around abandoned farm buildings, but they are too small and indistinct to be shown separately on the map. Another variation from the typical soil occurs in the vicinity of the Bennett Ranch, just south of the crest of the Rattlesnake Hills, where the surface of cultivated fields when viewed from a distance appears decidedly darker than typical. This is apparently due to a somewhat heavier rainfall and higher content of organic matter.

The Ritzville loam is by far the most extensive soil type in Benton County. It is most typically developed on the Horse Heaven Plateau, extending east and west across the county in an almost continuous body 40 miles long and 8 to 15 miles wide. Another extensive area occurs in the western part of the county a few miles north of the Yakima River, where the type covers the greater part of the southward-facing slopes of the Rattlesnake Hills. A large body, more or less broken by various stony soils, is found on the north slope of these hills. Other bodies occur in the high hills near the northwestern corner of the county, east of Kiona, and on the north slopes of the Horse Heaven Hills.

The Ritzville loam has a varied topography. In the western part of the Horse Heaven Plateau the land slopes gently to the south and east. A number of narrow drainage ways 25 to 100 feet in depth extend southward across it to the Columbia River, giving the surface a somewhat broken appearance when examined in detail. A very large percentage of this extensive region lies favorably for irrigation. Farther east, in T. 7 N., Rs. 28 and 29 E., where the crest of the hills swings across the plateau in a southeasterly direction, the surface is that of a broad divide maturely dissected by erosion. The drainage ways range from 50 to 200 feet deep, and

the numerous intervening ridges have steep slopes. A large part of this section is being farmed, and modern machinery is in common use. North of the hills there is an extensive smooth area, while to the east and south the country is gently sloping. In these localities the surface of much of the land is favorable for irrigation. The area east of Kiona varies from nearly level to very steep. The areas on the south side of the Rattlesnake Hills are gently sloping, while those on the north side near the summit are steep. At the base of the hills on the north side the type slopes gently northward.

The elevation of that part of the type on the Horse Heaven Plateau ranges between 1,000 and 2,000 feet, and on the slopes of the Rattlesnake Hills between 1,000 and 3,000 feet, above the sea. A large part of the type therefore lies between 1,000 and 2,000 feet above running water. The sloping surface and numerous draws give good drainage.

The Ritzville loam is the most important upland soil in Benton County. A comparatively small part of it is now in cultivation, but before the exodus of the settlers from the Horse Heaven Plateau probably 80 per cent of the type in this part of the county was tilled. The native vegetation consists chiefly of sagebrush and a luxuriant growth of bunch grass. As a rule, the sagebrush is smaller and more scattered and the bunch grass thicker and more vigorous than on the other soils of the county. The original bunch grass remains over considerable areas, and such land is still highly prized for grazing. Large areas that were previously cultivated and have since been abandoned are given over to a rank growth of Russian thistle and wild mustard.

Wheat is the chief money crop and occupies perhaps 80 per cent of the cultivated acreage. Rye is grown both for grain and for hay, and occasionally a wheat field which shows little promise of producing a profitable yield of grain is cut green for hay. Oats are of minor importance, being grown to feed work stock. Potatoes and vegetables are grown in a few places for home use. Hogs are kept by some farmers for home use and for market.

Yields vary widely with the season and the cultural treatment. In favorable seasons and with good treatment the yield of wheat ranges from 20 to 30 bushels, with an average of about 15 bushels per acre. Individual fields sometimes yield as much as 35 bushels per acre, but in many cases only 3 to 8 bushels per acre is obtained. The oat crop frequently suffers from drought, and only the most promising fields are thrashed. Potatoes yield 50 to 150 bushels per acre. Summer fallowing is universally practiced on this type. This frequently begins by disking the stubble land in the fall. In some cases cattle or horses are turned on the stubble during the fall and winter months, and disking or plowing is begun as early as possible

in the spring. The soil is gone over with a disk or weeder at intervals of 4 to 6 weeks during the summer for the purpose of destroying weeds and conserving moisture. Wheat is sown in the fall as soon as possible after the first good rain. Harvesting is done either with a header or a combined harvester. Most of the grain is hauled immediately to the railroads for shipment.

Land in cultivation to wheat can be bought for $20 to $25 an acre. Undeveloped tracts suitable for farming sell for $6 to $15 an acre.

This soil is easily handled and is well suited to a system of farming in which summer fallowing is necessary. Its chief requirement is thorough cultivation to destroy weeds and to maintain a dust mulch on the surface to check evaporation. In order to prevent drifting, the surface should be left rough and the furrows run at right angles to the prevailing winds. Occasionally good yields are obtained with no other preparation than disking, but this tends to form a compact layer a few inches beneath the surface and thus reduces the water-storing capacity of the soil. Plowing from 6 to 10 inches deep in the fall is preferable. The plowing under of rye greatly improves the soil. In certain sections of Kansas good results have been obtained on a similar soil by scattering straw over the surface of wheat fields in the late fall. This prevents the wind from drifting the soil and removing the light falls of snow and in addition builds up the low organic-matter content.

The varieties of wheat giving best results are the Turkey Red, Red Russian, Fife, Blue Stem, and Club. A number of hybrids also are grown. An effective means of controlling rust and smut is to treat the seed grain with copper sulphate.

Under present farming conditions the Ritzville loam is best adapted to growing wheat. A great many more hogs could profitably be raised to utilize the grain that now goes to waste, and the raising of chickens and turkeys might be made very profitable. At present none of the type is under irrigation, but the irrigation of a vast tract on the Horse Heaven Plateau is projected. Under irrigation this land would be adapted to a wide range of crops.

In the shallow areas of the Ritzville loam shown on the soil map two conditions are indicated. These are: Areas in which basaltic bedrock is encountered within 3 feet of the surface and areas in which bedrock or hardpan is encountered at a depth of 3 to 5 feet.

In the first mentioned areas bedrock or broken fragments of basalt are encountered at an average depth of about 19 inches. In a number of localities the underlying rock comes within a few inches of the surface, while in other places it is 30 inches to 3 feet in depth. These areas are very similar to the Prosser fine sandy loam, but the soil is lighter colored and of loessial or wind-borne rather than alluvial origin. They are extensively developed north of Prosser

on the slopes of the Rattlesnake Hills, also on the north slope of the Horse Heaven Hills and along some of the draws on the Horse Heaven Plateau. There is good surface drainage, but the nearness to the underlying rock interferes with the storage of water, and the soil is droughty. About 15 per cent of the total area of these shallow bodies is under cultivation, the remainder being in sagebrush and bunch grass and used as range for cattle and horses. Wheat is practically the only crop grown. In favorable seasons the yield is about the same as on the typical Ritzville loam, but the average for a series of years is slightly lower. The land can be bought for $5 to $15 an acre.

In the areas where bedrock or hardpan occurs at depths of 3 to 5 feet, the rock usually consists of lime-coated fragments of basalt overlying bedrock or of a thin stratum of white calcareous hardpan resting on angular fragments of basalt. Small fragments of hardpan are frequently scattered over the surface; as a rule they have been brought up by burrowing animals. These areas are rather extensive on the Horse Heaven Plateau in the western part of the county. A few small areas occur on the south slope of the Rattlesnake Hills. The topography is smooth and drainage is good. If water were available the soil could easily be irrigated. About 75 per cent of this land is under cultivation, the remainder being in sagebrush and bunch grass. Wheat occupies practically all the cultivated acreage. The yields range from 5 to 25 bushels per acre, with an average of about 12 bushels. Land of this character can be bought for $10 to $25 an acre.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of the typical Ritzville loam:

*Mechanical analyses of Ritzville loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551213, 551230. | Soil | 0.1 | 0.2 | 0.4 | 10.3 | 34.7 | 39.6 | 14.7 |
| 551214, 551231. | Subsoil | .0 | .1 | .2 | 6.8 | 39.2 | 50.4 | 3.3 |

QUINCY SAND.

The soil of the Quincy sand is a grayish-brown or light-brown medium to rather fine textured sand, with an average depth of about 12 inches. The subsoil is a grayish-brown or light-brown sand or fine sand, generally of slightly finer texture and more compact structure than the surface soil, resting on a stratified deposit of gray, compact silty material at a depth of 3 to 5 feet or more. In places

the surface 2 or 3 inches consists largely of coarse sand, the fine material having been removed by the wind. The soil is loose and incoherent and low in organic matter.

The largest area of this type occurs in the southern part of the county. It occupies a strip about 2 miles wide and 12 miles long on the north slope of Paterson Ridge and in the low depression which separates this ridge from the Horse Heaven Plateau on the north. Narrow strips occur along the dunes in this vicinity, and several bodies lie just to the north of Canoe Ridge near the southwestern corner of the county. Several rather extensive areas occur along the dry channel of Cold Creek in townships 11 and 12 north, ranges 25 and 26 east. Another large area lies along the Oregon-Washington Railroad east of Benton City. Small bodies are encountered in the vicinity of Benton City, near the Grosscup Ranch, and along the Columbia River near Plymouth, Berrian, and Mottinger.

The surface of the larger areas is undulating or rolling, with low rounded dunes and ridges, usually extending in a northeast-southwest direction. The smaller bodies are confined chiefly to draws and have a comparatively smooth surface. In the vicinity of Cold Creek some of the dunes have a height of 20 to 30 feet, but most of them range from 3 to 6 feet.

The surface soil is well drained, and the compact substratum would tend to conserve moisture in case the land was irrigated. The constant shifting of the sand by the winds forms a natural mulch and retards evaporation, so that the deeper soil and subsoil usually are moist.

The Quincy sand is not cultivated. The native vegetation consists of sagebrush and a sparse growth of bunch grass and spear grass, which furnishes some grazing for cattle and horses.

No recent sales of this land are reported, and there is little demand for this type of soil. The greater part of the land has an assessed valuation of $1 to $1.25 an acre.

The Quincy sand is not adapted to dry farming, and at present the greater part of it has no water available for irrigation. Even if water was available the cost of leveling and of protecting the soil from blowing would be high.

### QUINCY FINE SAND.

The Quincy fine sand to a depth of 10 to 12 inches is a light-brown or light grayish brown fine sand containing a rather high percentage of mica. It is loose and incoherent, and its content of organic matter is low. The subsoil consists typically of light grayish brown, micaceous, open-structured fine sand overlying light-gray,

stratified silt loam at a depth of 3 to 5 feet or more. Locally the subsoil is somewhat heavier and may be a fine sandy loam.

The largest body of this type occurs at Vista. A more or less broken strip extends east and west between the areas of Sagemoor fine sandy loam and Quincy sand, just to the north of Paterson Ridge, in the southern part of the county. There are several narrow strips along the draws leading south from the Horse Heaven Plateau and along the draws a few miles northwest of Prosser. Small areas also occur in the vicinity of the Benson Ranch and strips one-eighth to one-fourth mile in width occur along Dead Canyon, the Glade, and other dry draws near the southwestern corner of the county. Small bodies are found along the Inland Empire Highway between Kiona and Grosscup and on the north bank of the Yakima River west of Prosser.

The topography of the larger areas is undulating to rolling. The surface has been blown into low, rounded dunes and parallel ridges varying from 3 to 10 or more feet in height. The surface sand is deepest on the dunes and frequently very shallow or absent in the intervening depressions. Since the type consists of wind-blown sands over old valley-filling material, bowlders of granite and a variety of other rocks are sometimes found on the surface where the underlying deposits are exposed. The presence of bowlders, however, is not typical. The smaller areas are confined chiefly to the floors and slopes of narrow V-shaped draws and have either a smooth or sloping topography. In many cases the draws are traversed by gravelly or stony channels, which wind from side to side and render the valleys unsuited to agriculture. Drainage is good and the soil shows no harmful accumulations of alkali, except in one small irrigated field west of Prosser.

Not more than 5 or 10 acres of this type is under cultivation, and this is confined to a field which has recently been brought under irrigation. An attempt is being made to establish alfalfa. In parts of the field the results have been poor, imperfect distribution of water resulting in the blowing of the dry soil away from the young plants before they become firmly set. The sparse native growth of bunch grass, spear grass, and sagebrush has some value for grazing.

The greater part of this type can be bought for $1.25 to $3 an acre, but a few areas near towns are held at $10 to $15 an acre.

This soil is unretentive of moisture and not adapted to dry farming. At present it is not probable that much of it can be profitably irrigated, but with an adequate supply of water for irrigation it should prove well suited to alfalfa, early truck crops, and certain varieties of fruits.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Quincy fine sand are given:

*Mechanical analyses of Quincy fine sand.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551244 | Soil | 0.0 | 0.1 | 0.3 | 69.1 | 28.2 | 1.1 | 1.2 |
| 551245 | Subsoil | .1 | .2 | .8 | 67.8 | 29.0 | .9 | 1.4 |

QUINCY VERY FINE SAND.

The Quincy very fine sand to an average depth of about 12 inches consists of light grayish brown very fine sand, which is rather loamy and frequently approaches a very fine sandy loam. The content of organic matter is low and the material is pervious and friable. The grayish color is most pronounced where the surface material is thin and there is some admixture of the lighter colored underlying material. The subsoil to about 36 inches is a gray to light brownish gray, compact very fine sandy loam, overlying compact, stratified deposits of gray silty material. In places the soil is drifted into low mounds, the depth varying with the extent of drifting, being deepest on the mounds and ridges. A few bowlders of granite and of a variety of other rocks are sometimes embedded in the underlying material, which approach the surface or may be exposed in the hollows between the mounds. These bowlders are not typical of the Quincy series and belong entirely to the underlying old lake-laid deposits.

The Quincy very fine sand is inextensive. The largest areas occur just northwest of the Benson Ranch and along the Glade about 8 miles north of the Columbia River, near the southwestern corner of the county. There is a small but important area at Kennewick. Several small bodies occur northwest of Prosser and along the draws leading south from the Horse Heaven Plateau.

The topography is typical of wind-blown soils, and consists of mounds and ridges 2 to 3 feet in height with narrow depressions of shallow soil intervening. The surface drainage is adequate, and the compact structure of the subsoil is favorable for the storing of moisture.

Probably not more than 20 acres of this type is under cultivation. A few small tracts formerly dry farmed to wheat and rye have been abandoned, and sagebrush and other desert plants are slowly regaining a foothold. The yields of grain rarely exceeded 8 to 10 bushels per acre and the crop frequently was a failure. A part of the small tract near Kennewick is under irrigation and produces satisfactory yields of fruits, melons, and vegetables. The type is handled in much the same way as the Winchester soils.

With the exception of the small body in the vicinity of Kennewick, which is valued at $100 or more an acre, the greater part of this type can be bought for $1.50 to $5 an acre. Even at this low price there is no demand.

With a good supply of water for irrigation the Quincy very fine sand should prove well suited to the production of alfalfa, fruit, and vegetables. The land would require considerable leveling and careful treatment to prevent blowing. The addition of organic matter by plowing under rye or alfalfa is beneficial.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Quincy very fine sand.

*Mechanical analyses of Quincy very fine sand.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551228..... | Soil..... | 0.0 | 0.4 | 0.9 | 26.0 | 53.0 | 17.9 | 1.7 |
| 551229..... | Subsoil..... | .0 | .2 | .2 | 8.3 | 51.6 | 36.2 | 3.5 |

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$) : No. 551229, 2.20 per cent.

KOEHLER FINE SAND.

The Koehler fine sand to a depth of 12 to 15 inches consists of a light-brown to light grayish brown fine sand, containing small fragments of white calcareous hardpan which have been brought up from below by burrowing animals. The soil is low in organic matter and of open, porous structure. A grayish color is frequently quite conspicuous, particularly in dry or bleached fields, but when moist the material is distinctly brown. The subsoil is a light grayish brown fine sand, slightly finer and more compact than the soil, resting on a hard, impervious layer of white calcareous material at depths ranging from 24 inches to 5 feet or more. The hardpan varies in thickness from a few inches to several feet and is underlain by fine, stratified deposits of lacustrine character. In places the hardpan lies only a few inches below the surface, such areas being conspicuous owing to the greater quantity of white fragments on the surface. In several areas in the southern part of the county small, waterworn gravel is abundant in the soil.

The Koehler fine sand occurs in a large number of small bodies, mainly throughout the sandy plains in the southern part of the county, where it is closely associated with other sandy types of windblown origin. A rather extensive body is found in the bend of the Yakima River south of the Horn, and small bodies occur in the vicinity of Vista and Grosscup and north of Prosser.

The general topography is smooth or gently rolling. In detail the surface consists of small wind-blown mounds and ridges 2 to 3 feet in height. The sandy soil quickly absorbs all the rainfall. There are no indications of alkali.

The type is not tilled. Farming on the part of the early homesteaders met with disappointing results, owing to the insufficient supply of moisture and the tendency of the soil to blow when cleared of its native vegetation. Wheat as a grain crop usually was unprofitable. Rye produced fair yields of hay and in favorable seasons 10 to 15 bushels of grain. The native vegetation consists of a scattered growth of sagebrush, rabbit brush, bunch grass, and a variety of plants common to sandy areas. The type is used as open range for stock.

No recent sales of this land have been made, but the greater part of it can be bought for $1.50 to $5 an acre.

The Koehler fine sand is too droughty for dry farming, and there seems little prospect of much of the type being placed under irrigation. As long as better land is available for crop production this soil can best be used for grazing.

*Koehler fine sand, heavy phase.*—The Koehler fine sand, heavy phase, to an average depth of about 12 inches, is a light-brown or light grayish brown micaceous fine sand containing comparatively little material either coarser or finer than a fine sand or very fine sand. It is low in organic matter and of loose structure, and contains numerous fragments of the underlying white calcareous hardpan. The gray color frequently is quite pronounced, particularly in dry, bleached fields, but when moist the soil is distinctly brown. Some of the included material is quite loamy, and the soil in places approaches in texture a fine sandy loam or very fine sandy loam. The subsoil varies from a light-brown or light grayish brown fine sand to compact silt loam. It rests on white, calcareous hardpan at a depth ranging from 24 inches to 3 feet or more. This hardpan varies in thickness from a few inches to several feet. Where it lies at considerable depth the subsoil below about 28 inches frequently is a light-colored, compact, very fine sandy loam. Below the layer of hardpan are several feet of gray, fine, stratified deposits of lacustrine character.

The Koehler fine sand, heavy phase, is inextensive. One small body occurs about 1 mile northwest of Paterson, others north of Canoe Ridge, in the southwestern corner of the county, and three small areas northwest of the Benson ranch. The surface is undulating and choppy, with low, wind-blown mounds and ridges. The soil quickly absorbs rainfall, and no drainage ways have been developed. There are no accumulations of alkali.

This phase is not in cultivation and it is relatively unimportant. The native vegetation is chiefly sagebrush, with a sparse growth of grasses of inferior value, cactus, and sand-loving weeds. At present there is no demand for this land, and it can be bought for $1.50 to $3 an acre.

The Koehler fine sand, heavy phase, is susceptible to drought and unsuited to dry farming. Under irrigation it probably would be adapted to all the common crops except deep-rooted crops such as alfalfa and fruit. The possibility of irrigation seems remote, and without water the land is best suited to grazing.

The results of mechanical analyses of samples of the soil and subsoil of the Koehler fine sand, heavy phase, are given in the following table:

*Mechanical analyses of Koehler fine sand, heavy phase.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551237 | Soil | 1.6 | 1.9 | 3.9 | 54.0 | 23.0 | 10.1 | 5.6 |
| 551238 | Subsoil | .0 | .4 | .7 | 11.2 | 23.4 | 58.6 | 5.7 |

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$) : No. 551238, 6.68 per cent.

WINCHESTER SAND.

The soil of the Winchester sand is a dark-gray to almost black, loose, medium to coarse sand, with an average depth of about 12 inches. The subsoil is a dark brownish gray to nearly black open-structured sand resting on loose, black coarser sand at 3 to 5 feet in depth. The surface is generally covered with a thin, incoherent mantle of dark-colored coarse sand, composed largely of small, rounded, and subangular particles of basalt. The finer material in the soil consists of about equal quantities of dark-colored particles of basalt and light-colored quartz grains, which give the material a characteristic "pepper and salt" appearance. The type is not very uniform in texture and small areas of Winchester coarse sand are included. In such areas some rounded basalt gravel occurs on the surface and in the first few inches of the soil. In places the porous substratum below the depth of 6 feet carries quantities of water-worn gravel and bowlders.

This type is most extensive in the northeastern part of the county. The largest body lies along the Columbia and Yakima Rivers, just north and west of Richland. This area is broken by irregular strips of other sandy types, particularly north of the Horn and Cold Creek. A number of bodies of typical Winchester sand occur between Hanford and White Bluffs, and a narrower east-west strip about 8 miles

long occurs south of Hanford. A few small areas occur in the southern part of the county near Coolidge and Plymouth.

The surface of the Winchester sand is undulating and consists of mounds and ridges with intervening narrow hollows and level strips. The ridges vary from a few feet to 30 feet or more in height and generally extend in a northeast-southwest direction. The type is well drained and is free from alkali.

With the exception of possibly 100 acres which have been put under irrigation in the vicinity of Hanford and White Bluffs the type is undeveloped, supporting only a growth of sagebrush and other desert shrubs. Apples, peaches, pears, and grapes are about the only crops grown. Where sufficient water is used in irrigation good yields of fruit are obtained, and the peaches grown are of good color and flavor. This soil is one of the earliest in the county, the fruit from the sandy district around Hanford and White Bluffs reaching the market a week or 10 days before that from other sections of the State. The type is low in organic matter and the loose surface is drifted by winds. This seriously interferes with the growth of young trees and makes it difficult to obtain a good stand of crops. In many cases the spring winds blow the seed out of the ground or cover the young plants to such an extent that reseeding is necessary. This type is too loose and porous for profitable dry farming, and the expense of leveling for irrigation is too great to warrant such improvement except in small tracts which can be developed in connection with other soils near towns.

Very little of this type is sold. Undeveloped tracts remote from railroads are assessed at $1 an acre.

The Winchester sand responds readily to good treatment. The addition of organic matter is essential for best results, and where barnyard manure is not available green crops of rye should be turned under. After a few seasons of this practice a stand of alfalfa can usually be obtained, and thereafter this crop should be plowed under at intervals of 2 or 3 years. To avoid blowing the land should be kept as completely covered as possible with vegetation. Late spring plowing is a good practice. Rye stubble should be disked and seeded without plowing, especially during the first few seasons of soil improvement, when the danger of blowing is greatest.

On account of the porous structure liberal irrigation is necessary for best results. When properly irrigated and protected from blowing the Winchester sand is adapted to the production of peaches and early truck crops. With the incorporation of sufficient organic matter the soil could be used under irrigation for potatoes and alfalfa, though the yields would be considerably lower than on heavier types of soil.

WINCHESTER FINE SAND.

The Winchester fine sand is a dark-gray to brownish-gray, loose fine sand to an average depth of about 12 inches. The subsoil is a dark brownish gray to grayish-brown, loose fine sand, resting on waterworn gravel at a depth of 3 feet or more. Gravel may occur on the surface and throughout the soil section. Both the soil and subsoil are low in organic matter, and porous and incoherent, though the subsoil is slightly more compact. The soil is micaceous, and the presence of black basaltic grains of quartz gives the type the "pepper and salt" appearance characteristic of the Winchester series. In places small areas of Winchester sand are included.

Large areas of Winchester fine sand occur on the desert plains in the vicinity of Hanford and White Bluffs and along the road leading south from Hanford. Other large areas occur north of Benson Ranch and in the vicinity of the Grosscup Ranch. Many small bodies are found along the Columbia River and in the Yakima Valley near Prosser.

The topography is characterized by wind-blown dunes and parallel ridges with narrow intervening troughs. The dunes range from 3 to 30 feet in height, and in the larger areas maintain a characteristic northeast-southwest direction for miles. The type is well drained and is free from alkali.

The Winchester fine sand is of little agricultural importance, as less than 1 per cent of it is under cultivation. The cultivated areas are chiefly in the vicinity of Hanford, White Bluffs, Kennewick, and Plymouth. The native vegetation is mainly sagebrush and greasewood, with a very sparse growth of bunch grass.

The principal crops are peaches, apples, pears, and grapes. A small acreage is in alfalfa and vegetables. With thorough cultivation and copious irrigation fair yields are obtained. The soil is handled in the same manner as the Winchester sand.

Undeveloped tracts of this land can be bought for $1.25 to $5 an acre. Irrigated orchards in the vicinity of towns are held at $125 to $150 or more an acre.

The same methods of improvement needed by the Winchester sand are applicable to this type. Especial care is necessary to prevent drifting. The type requires considerably more water for irrigation than do the heavier soils and, except in the most favorable locations, the results obtained under irrigation do not warrant the high expense of leveling and preparing the land.

*Winchester fine sand, heavy phase.*—The soil of the Winchester fine sand, heavy phase, is a light-brown to grayish-brown very fine sand, 12 to 15 inches deep. The subsoil is similar and usually extends to depths of several feet, where it rests on a substratum con-

taining waterworn gravel. The soil is low in organic matter and the loose surface material is easily shifted by winds.

This soil occurs only in a few small bodies near Hanford, Prosser, Kennewick, and Hover. The surface is marked by low wind-blown dunes and ridges, though it is somewhat smoother than that of the coarser soils of the series. The phase is well drained and free from alkali. It is of little agricultural importance. Less than 40 acres is under cultivation. Corn and alfalfa are grown under irrigation and give fair yields.

Unimproved land is held at $25 to $100 an acre, the higher prices prevailing near towns.

This soil is too light for dry farming, but under irrigation it is desirable for fruit, melons, and early truck crops. Like the other soils of the series, it is in need of more organic matter and requires careful handling to prevent drifting by the wind.

### SAGEMOOR FINE SAND.

The soil of the Sagemoor fine sand is a light-brown fine sand, 12 to 15 inches deep. It is low in organic matter and has a pervious, friable structure, but the surface is moderately firm and compact. The subsoil, to a depth of 36 inches or more, is a light-brown to light grayish brown fine sand resting on light-gray, calcareous, stratified deposits, which are probably of lacustrine origin. Both the soil and subsoil are often conspicuously calcareous and effervesce freely with acid. This is due largely to an admixture of small fragments of the underlying calcareous material brought to the surface by burrowing animals.

This soil is confined to small areas in the southern part of the Horse Heaven Plateau. The general topography is smooth, though in detail the surface is slightly undulating owing to modification by winds. Only the comparatively level surface and the apparent lake-laid origin differentiates this type from the closely associated sands of the Quincy series. Drainage is not well established, though the soil quickly absorbs rainfall.

At present this soil is not farmed. The native vegetation consists of a good growth of various kinds of bunch grass, sagebrush, rabbit brush, and a variety of sand-loving plants. The land is used for pasturing cattle and horses and can be bought for $3 to $5 an acre.

Irrigation is necessary for the development of this type, and at present water is not available. The land would require little leveling, and with irrigation would be adapted to a wide range of crops.

### SAGEMOOR FINE SANDY LOAM.

The soil of the Sagemoor fine sandy loam is a light grayish brown or light-brown fine sandy loam with an average depth of about 12

inches. Much of the included material seems to be of rather light texture, approaching a fine sand, and a few patches are included where the soil is a fine sand about 24 inches deep overlying a very fine sandy loam or silt loam. The content of organic matter is low. Except for a thin mantle of loose fine sand, the surface is firm and moderately compact. The subsoil, to a depth of 30 or 36 inches or more, is a gray, compact very fine sandy loam or silt loam, resting on stratified material of the same color and texture to many feet in depth. The soil and subsoil are calcareous and contain conspicuous particles of calcareous material from the underlying sediments. Small areas occur in which the soil material is thinner than typical and is underlain by basaltic rock.

The Sagemoor fine sandy loam occurs in widely scattered areas in various parts of the county. Several of the areas are closely associated with the Sagemoor fine sand and Quincy sand in the southern part of the county, chiefly in T. 6 N., Rs. 26 to 30 E. Other bodies occupy a definite position part way up the slopes of the old valley-filling material as an intermediate type between the Sagemoor silt loam on the upper side and areas of wind-blown soils below. The most prominent of these bodies occur along the south side of Horse Heaven Plateau in T. 6 N., Rs. 26 and 27 E., and along the lower part of the slope on the north side of the Rattlesnake Hills in T. 10 N., R. 27 E., and T. 11 N., R. 26 E. Other areas occur in T. 13 N., R. 25 E., north of Prosser, and a few miles north of Carley.

The general topography is smooth, with a gentle slope. Along the lower margin, where the type frequently merges into soils of the Quincy series, the surface is slightly billowy and the texture somewhat coarser, while along the upper margin of the areas the surface is firm and smooth and the texture approaches that of the Sagemoor silt loam. The surface drainage and underdrainage are good, and the surface of most of the type is favorable for irrigation. The soil is fairly well drained and is free from alkali.

Small areas of this soil were used for wheat production by the early settlers, but these have been abandoned and are growing up to weeds and sagebrush. The scant growth of bunch grass affords some pasturage.

The selling price of this land ranges from $3 to $10 an acre.

The Sagemoor fine sandy loam is not well adapted to dry farming, but under irrigation it would be well suited to the staple crops. Water for irrigation is not available at present.

### SAGEMOOR SILT LOAM.

The soil of the Sagemoor silt loam is a light-brown to light grayish brown, compact silt loam with an average depth of about 12 inches. The subsoil is a gray to light grayish brown, compact

silt loam extending to a depth of about 36 inches, where it rests on fine gray stratified deposits which are apparently of lacustrine origin. The deposits vary in thickness from a few feet on the higher elevations to considerably more than 100 feet where erosion has not worn them away. Along the higher margin of the areas the type is very similar to the Ritzville loam, and in places is not easily distinguished from it, but in general the distinguishing features are its firmer surface, the occurrence of rounded bowlders or cobbles of granite and other rocks, its finer texture, and its lighter colored substratum of stratified material. In the area north of Walnut Grove School the soil and subsoil material is thin and basaltic bedrock occurs at shallow depths. This shallow soil is indicated on the soil map by cross ruling.

The type also comprises a lighter colored variation. This consists of 1 foot or more of light-gray, floury, silt loam overlying light-gray silt loam which extends to depths of 3 feet or more. The substratum consists of stratified deposits of light-colored silt and very fine sand containing vertical veins or dikelike partitions of coarser material. The veins vary from one-half inch to 4 or 5 inches across and extend many feet into the underlying material. In places the land has been elevated since the deposition of the material and faulting has occurred, so that the veins are no longer vertical nor are the strata horizontal.

Large areas of the Sagemoor silt loam are found bordering the lower or southern side of Horse Heaven Plateau, east of Prosser, near Benton City and Kennewick, and along the lower side of the north slope of the Rattlesnake Hills. Areas occur also near the northwestern corner of the county. The type is encountered along the lower margin of the Ritzville soils, and is the highest lying soil derived from the old valley-filling material. It is not found in Benton County above an elevation of 1,300 feet. The greater part of this type lies between 700 and 1,000 feet above sea level.

The larger areas have the appearance of almost level flats, with a gentle fall in the direction of the valleys. A number of narrow, V-shaped draws from 25 to 100 feet in depth cross the type. These carry water in early spring or after heavy rains and supply good surface drainage. The smaller areas are undulating to gently rolling. About 85 per cent of the type has a surface favorable for irrigation.

Only a very small part of the Sagemoor silt loam is under cultivation. About 40 per cent of the type in the Horse Heaven region was broken by homesteaders and used for growing wheat and rye, but at present not more than 5 per cent of it in this section is under cultivation. A few fields are used for grain in the vicinity of Prosser and at Hodges Ranch, north of the Rattlesnake Hills. Small acreages are irrigated and devoted to fruit at Benton City and Kennewick.

At least 90 per cent of the type is covered with sagebrush and bunch grass and used only for grazing. (Pl. I, fig. 2.)

On the dry-land farms wheat is the principal money crop and the rye grown is used chiefly for hay. Probably 80 per cent of the dry-farmed area is devoted to wheat. On the irrigated lands the principal crops are apples and alfalfa, with some peaches and pears. The grain crops yield about the same as on the Ritzville loam, and irrigated crops about the same as on the Ephrata fine sandy loam, heavy phase.

Unimproved land of this type at some distance from railroads sells for $3 to $5 an acre. The better improved farm land in the Horse Heaven section sells for $15 to $25 an acre, while well-developed tracts under irrigation are held at $150 to $250 an acre.

Dry-farmed areas of the Sagemoor silt loam are adapted to the same range of crops as the Ritzville loam. On parts of the type lying north of the Rattlesnake Hills considerable work will be required to remove surface stones before the land can be cultivated. These areas are indicated on the map by stone symbols. In some places in the lighter colored areas, where the content of silt is especially high, the soil has a tendency to puddle in early spring following saturation from the melting snow. These silty patches are principally in the irrigated section near Benton City. Small quantities of alkali are present in this vicinity. Care in the use of irrigation water and in providing underdrainage is needed for the control of alkali, while the turning under of alfalfa or the application of barnyard manure improves the physical condition of the soil and makes it more productive and easier to handle. As is common with silty soils, the Sagemoor silt loam is easily eroded and great damage is sometimes caused by negligence in controlling spillways. (Pl. II, fig. 1.)

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Sagemoor silt loam:

*Mechanical analyses of Sagemoor silt loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551246 | Soil | 0.1 | 0.6 | 1.0 | 10.8 | 26.4 | 53.6 | 7.5 |
| 551247 | Subsoil | .6 | 2.0 | 1.2 | 7.2 | 23.4 | 59.7 | 5.8 |

BURKE FINE SAND.

The soil of the Burke fine sand consists of about 10 inches of light-brown fine sand frequently containing considerable very fine sand. The soil carries a small quantity of white calcareous fragments,

derived from the underlying substratum and distributed through the surface material by burrowing animals. These are frequently sufficient in quantity to render both the soil and subsoil distinctly calcareous, the material usually effervescing freely with acid. The soil has a low organic-matter content and is pervious and friable. The subsoil is a light-brown very fine sand resting on calcareous hardpan at 18 to 30 inches. The surface soil is firm, and the subsoil is moderately compact. In places the usual subsoil is displaced by a grayish-brown compact silt loam.

The Burke fine sand is mainly confined to a few small areas in T. 6 N., Rs. 27 and 28 E. The topography is smooth. The native vegetation consists of sagebrush, rabbit brush, and a scattered growth of bunch grass, dock, and other sand-loving plants. The type is not cultivated and can be bought for $1.50 to $3 an acre.

On account of the porous nature of the soil and the nearness to the underlying hardpan, the type is quickly affected by drought and is not suited to dry farming. It affords some spring and early summer grazing. With an abundant water supply this land would be adapted to such shallow-rooted crops as small grains, potatoes, and vegetables, but on account of the poor drainage injury from seepage and the accumulation of alkali might result if not prevented by artificial means.

The results of mechanical analyses of samples of the soil and subsoil of the Burke fine sand are given in the following table:

*Mechanical analyses of Burke fine sand.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551280 | Soil | 0.0 | 0.4 | 1.6 | 58.8 | 34.2 | 4.6 | 0.4 |
| 551281 | Subsoil | .0 | .3 | .3 | 6.1 | 26.6 | 63.7 | 3.1 |

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): 551281, 8.61 per cent.

BURKE FINE SANDY LOAM.

The soil of the Burke fine sandy loam consists of about 12 inches of light-brown to light grayish brown fine sandy loam, high in very fine sand and silt. The subsoil is a light-brown to light grayish brown very fine sandy loam or silt loam, slightly lighter colored than the soil and generally slightly heavier in texture or more compact. It rests on hardpan, or a calcareous formation resembling limestone, at depths of 18 to 28 inches. The soil is low in organic matter and is friable, but the surface is firm and both the soil and subsoil are rather compact. The thickness of the hardpan ranges from a few inches to several feet.

The Burke fine sandy loam is confined to a few small bodies in the southern and southeastern part of the Horse Heaven Plateau. The areas usually occur near the upper margin of the old valley-filling material, or just below areas of Ritzville soil. A small body is found 3 miles northwest of Benton City, and another about 5 miles northwest of Prosser.

The topography is nearly level to gently sloping. There are no surface drainage ways, and underdrainage is poor. Very little leveling would be required for irrigation, but at present water is not available.

This type has the same general appearance as the Sagemoor and Ritzville loams, but differs from them in texture and the presence of hardpan. In this region of scant rainfall the lack of surface drainage is an advantage rather than a detriment in dry farming. The presence of the hardpan prevents large quantities of water from being stored in the lower subsoil, while the compact structure of the surface material favors a rapid loss of water by evaporation.

The type is unimportant in this county; probably not more than 1 per cent is under cultivation. The remainder supports a good growth of bunch grass and a scattering of sagebrush, rabbit brush, and other desert plants. The land is valued as pasture for cattle and horses and is almost exclusively used for this purpose. A small acreage is in wheat. In favorable seasons the yield ranges from 6 to 15 bushels per acre, but lack of moisture frequently results in low yields, and the crop is often cut for hay. The land is handled in the same way as the Ritzville loam. It is held at $5 to $15 an acre.

In favorable seasons there is little difference in the producing capacity of the Burke fine sandy loam and hardpan-free soils of similar or even finer texture. However, owing to the droughtiness of the type in seasons of unfavorable rainfall, it is not so well adapted to dry farming as are soils that are free from hardpan. The type lies favorably for irrigation, and with the application of water it would be adapted to small grains and all other shallow-rooted crops commonly grown in the county.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of the Burke fine sandy loam:

*Mechanical analyses of Burke fine sandy loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551234, 551266. | Soil..... | 0.6 | 1.2 | 1.0 | 26.2 | 41.0 | 26.2 | 3.8 |
| 551235, 551267. | Subsoil..... | 4.2 | 3.8 | 2.0 | 19.7 | 40.3 | 26.2 | 3.9 |

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 551235, 9.29 per cent; No. 551267, 4.68 per cent.

EPHRATA GRAVELLY FINE SANDY LOAM.

The Ephrata gravelly fine sandy loam consists of 20 to 24 inches of light-brown to light grayish brown fine sandy loam, containing quartzitic gravel, and resting on a mass of waterworn gravel, cobbles, and bowlders embedded in light-gray silty material. The substratum generally is similar to the overlying material to a depth of 50 feet or more, but a layer of coarse sand sometimes occurs 10 to 15 feet below the surface. The stones in the soil and subsoil vary in diameter from one-half inch to a foot or more and are chiefly quartzitic. A few rounded bowlders of the same material 2 or 3 feet in diameter are found in places about 3 feet below the surface. The type differs from the gravelly areas of the Ephrata fine sandy loam in having a greater depth of soil and in the absence of the layer of coarse sand within the 6-foot section.

This type of soil is inextensive. It occurs on the West Highlands near Kennewick and in narrow strips along the Yakima River near Prosser and the Valley Heights School. In the vicinity of Kennewick the type occupies two level terraces separated by a short, steep slope. The smaller areas are level to gently sloping, and the entire type has good surface drainage and underdrainage. No trouble is experienced from the accumulation of alkali.

This is an important irrigated soil. Probably 80 per cent of it is under irrigation, and the remainder supports a growth of bunch grass and is used for pasture. The principal crops grown are apples, alfalfa, strawberries, grapes, pears, and peaches. The yields of tree fruits are about the same as on the Ephrata fine sandy loam, heavy phase. Alfalfa yields 5 to 7 tons per acre a season, and strawberries an average of 100 to 150 crates per acre. All of the above crops are grown commercially, although some of the alfalfa is fed on the farm.

The orchards are managed in about the same way as those on the Ephrata fine sandy loam, heavy phase. In growing strawberries the beds are mowed immediately after harvesting and are then gone over with a turning plow, about one-half the plants being removed. From 400 to 800 pounds per acre of fertilizer containing 15 to 20 per cent nitrate of soda, usually in the form of dry salts mixed with tankage, is then applied, and the land is thoroughly cultivated with a spring-tooth harrow. Following this, irrigation and cultivation are continued as before harvest until late fall.

Irrigated land of this type sells for $150 to $350 an acre.

The Ephrata gravelly fine sandy loam is easily cultivated and irrigated and is well drained and productive. Besides the principal crops now grown the type is adapted to corn, melons, potatoes, and a wide variety of truck. A few almond trees are just coming into bearing and give good results. The younger trees are susceptible to freezing, and some of them show more or less injury from the unusu-

ally severe winter of 1915–16. The injury was undoubtedly increased by late irrigation, as trees which were not watered late, but allowed to go into the dormant state before winter set in, were almost invariably uninjured.

This type is adapted to the same tree fruits as the Ephrata fine sandy loam, heavy phase, and requires the same treatment.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Ephrata gravelly fine sandy loam:

*Mechanical analyses of Ephrata gravelly fine sandy loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551270 | Soil | 1.0 | 2.4 | 9.4 | 53.8 | 17.2 | 12.1 | 3.9 |
| 551271 | Subsoil | 6.0 | 5.8 | 12.9 | 25.8 | 16.8 | 28.8 | 3.9 |

EPHRATA SAND.

The Ephrata sand to a depth of about 12 inches is a light-brown to light grayish brown sand of medium to rather fine texture. Small undifferentiated areas of Ephrata fine sand occur locally. The surface 2 or 3 inches is loose and incoherent, but below this depth the structure is moderately compact. The upper subsoil is generally similar to the soil, though it is sometimes a little lighter colored, more compact, and of slightly finer texture. The type is underlain at depths of 30 inches to 5 feet by a mass of waterworn gravel and cobbles embedded in coarse, black sand, which usually extends to a depth of several feet without important change.

Rounded, waterworn gravel is sometimes found on the surface and in places through the entire soil section. In a number of locations waterworn bowlders ranging from 6 inches to 3 feet in diameter occur in the soil and embedded in the subsoil and substratum. Areas in which coarse material is sufficiently abundant to influence cultivation are indicated on the soil map by stone or gravel symbols.

The Ephrata sand occurs on the old high terraces bordering the Columbia River. The largest areas are in the northern part of the county near Allard, Hanford, and White Bluffs, and in the southern part near Paterson, Coolidge, and Plymouth. Other important areas are found at Kennewick and about 3 miles west of Richland. Small bodies occur north of the Horn and elsewhere on the terraces along the Yakima River. The principal gravelly areas occur near Kennewick, Richland, and Coolidge, and the principal stony areas in the vicinity of Hanford and Allard.

The Ephrata sand lies 50 to 200 feet above the river, occupying a succession of terraces separated by rather steep slopes The terraces

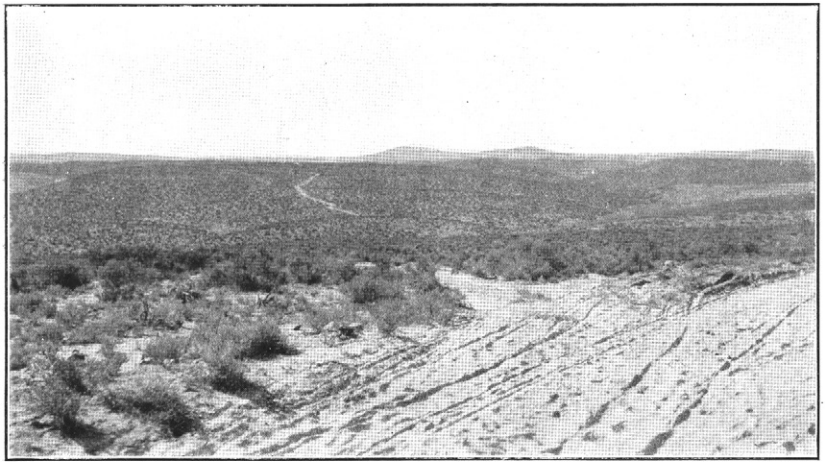

FIG. 1.—GENERAL VIEW IN THE HORSE HEAVEN PLATEAU, SHOWING TOPOGRAPHY AND NATIVE VEGETATION OF THE SOILS OF THE RITZVILLE SERIES.

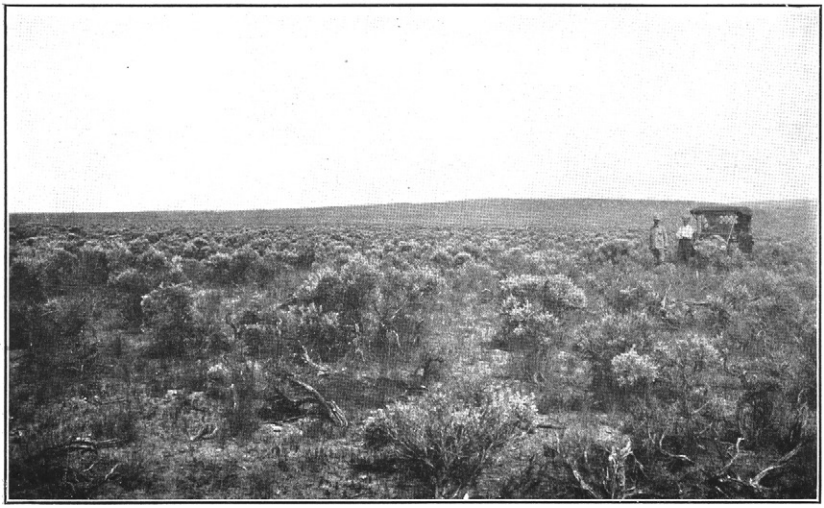

FIG. 2.—TOPOGRAPHY AND NATIVE VEGETATION OF SAGEMOOR SILT LOAM.

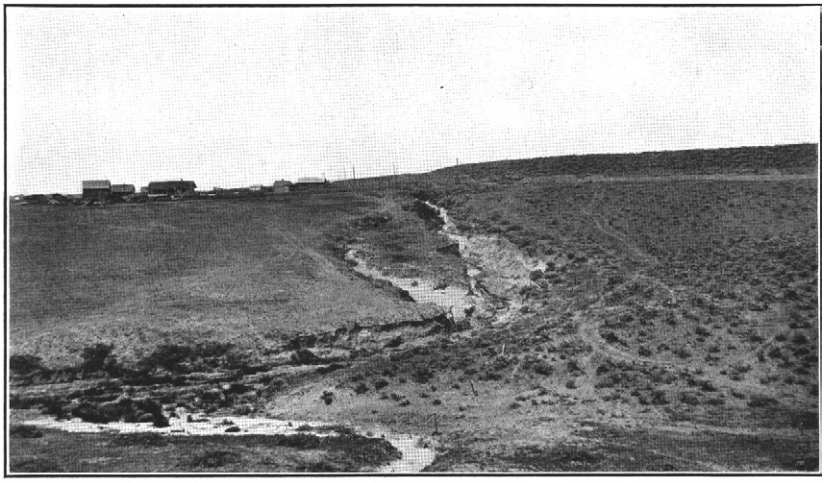

FIG. 1.—SPILLWAY ON SAGEMOOR SILT LOAM.

FIG. 2.—APPLE ORCHARD ON GRAVELLY AREA OF THE EPHRATA FINE SANDY LOAM, HEAVY PHASE.

are comparatively level, though there are a few low mounds and ridges formed by drifting of the sand. The greater part of the type requires little leveling for irrigation. It is well drained, and the gravelly deposit forming the deep subsoil and substratum insures good underdrainage.

Only a small acreage of this type in the vicinity of Hanford and Kennewick has been placed in cultivation. It is farmed only with irrigation. The greater part of the Ephrata sand is used for grazing. The native growth consists of sagebrush, dock, and an inferior stand of bunch grass, and the grazing value is low. The principal crops grown are apples and peaches. A small acreage is devoted to alfalfa and rye for hay. Potatoes, melons, and vegetables are grown in a few small fields, and where sufficient water is available for irrigation good yields are obtained.

The Ephrata sand is easily cultivated and responds readily to improvement. It is handled in practically the same way as the Winchester sand and fine sand. Unimproved land can be bought for $5 to $10 an acre, the higher values being due to improvements and nearness to towns.

This soil is in need of about the same improvement as the Winchester sand. Especial effort should be made to increase the amount of organic matter and to prevent drifting. On account of the porous structure of the underlying material, considerably more water is required for irrigation than on the heavier soils. When well irrigated the type is adapted to a wide range of crops, including fruits, alfalfa, rye, and early vegetables.

*Ephrata sand, coarse phase.*—The surface soil of the Ephrata sand, coarse phase, consists of 10 to 12 inches of sand about equally divided between light-colored quartzitic grains and black, subangular grains of basalt. The texture ranges from medium to coarse and the general color from dark grayish brown to nearly black. The subsoil is slightly more compact, but is otherwise similar to the surface soil to a depth of 5 feet or more, where it passes into coarse, dark-colored sand, containing waterworn gravel and bowlders.

This phase occurs in long, narrow terraces south of White Bluffs, north of Longview, and near the center of T. 12 N., R. 26 E. It occupies low, rounded swells, hollows and steep slopes, separating areas of other sandy types. It is well drained and free from alkali.

This soil is not under cultivation. The native sagebrush, weeds, and scant bunch grass afford poor grazing. At present there is no demand for this soil and none of it is being sold. It is valued in connection with adjoining sandy types, at $1 to $1.25 an acre.

The Ephrata sand, coarse phase, is in need of organic matter. It is too porous for profitable dry farming, and most of it is so far

above the present supply of water that irrigation is impracticable. With the application of water it would probably be adapted to the same crops as the Winchester sand and would require similar improvement.

### EPHRATA SANDY LOAM.

The Ephrata sandy loam to an average depth of about 12 inches consists of a light-brown sandy loam of medium to coarse texture. The subsoil is a grayish-brown sandy loam or fine sandy loam of moderately compact structure resting on coarse, dark-colored sand at a depth of 3 to 5 feet. Waterworn stones and gravel are often encountered in the subsoil and substratum, and gravel frequently occurs on the surface. The gravelly material is generally coated with lime. The subsoil is always compact, but the substratum is loose and porous.

Gravel symbols are used on the soil map to indicate gravelly areas in which the soil to about 24 inches in depth is a light-brown sandy loam carrying waterworn gravel, especially on the surface. The subsoil in such areas is a mass of coarse gravel and cobbles, with a deep substratum of coarse sand. The stones and gravel are principally of basaltic origin, though quartzitic material is also present at the surface in places.

The Ephrata sandy loam occurs in widely scattered areas, some of the largest of which are on the terraced flats in Ts. 12 and 13 N., Rs. 25, 26, and 27 E. Small bodies are scattered over the desert plains near and north of the Horn and in the southern part of the county in the vicinity of Berrian. Other small bodies are mapped on the outskirts of Kennewick, 1 to 3 miles north of Coolidge and Longview. Several small bodies occur just west and north of Hanford and north of White Bluffs.

The surface of the larger areas is terraced, and consists of broad, level flats separated by short, steep slopes. The smaller areas are level and frequently occupy slight depressions surrounded by windblown sands. Surface drainage is not always well established, but the open character of the subsoil and substratum insures good underdrainage.

This soil is of little agricultural importance. Cultivation is practically confined to a few small fields in the vicinity of Hanford, where apples and peaches are grown, with some alfalfa and vegetables between the trees. According to statements of farmers, the type yields about the same as the other sandy soils of the county. It is handled in the same manner as the Winchester soils, except that a little less water is required in irrigation. The native vegetation of bunch grass and sagebrush is slightly better than on the adjoining sandy types and affords a small amount of grazing. The greater

part of this type can be bought for $3 to $10 an acre, but the areas in the vicinity of Hanford and Kennewick, where water for irrigation is available, are held at $100 to $250 an acre.

The Ephrata sandy loam is not adapted to dry farming under the prevailing climatic conditions. With irrigation it is well suited to alfalfa, apples, potatoes, melons, and other truck crops. The soil is low in organic matter, like the other sandy types, and unprotected fields are subject to drifting. The type requires about the same treatment as the Winchester soils.

### EPHRATA FINE SANDY LOAM.

The Ephrata fine sandy loam to an average depth of 12 inches is a light-brown fine sandy loam, frequently containing a high percentage of very fine sand. The subsoil is a light grayish brown fine sandy loam or very fine sandy loam to an average depth of 5 feet, where it rests on a mass of waterworn gravel embedded in coarse, dark-colored sand. In places material of this character continues to a depth of more than 100 feet. Both the soil and subsoil are compact.

In some areas waterworn gravel from one-half inch to 3 inches in diameter is thickly strewn over the surface and is more or less abundant throughout both soil and subsoil. Such areas are indicated on the soil map by gravel symbols. On the high terrace east of Benton City the type as mapped consists of a light-brown very fine sandy loam about 18 inches deep, resting on a mass of lime-coated fragments consisting principally of basalt. At about 3 feet a thin hardpan layer is encountered. The deep substratum consists of light-gray silty or very fine sandy material.

Extensive areas of the Ephrata fine sandy loam occur on the broad terraces along the Columbia River in the northern part of the county, at Richland, and along the river between this town and Fruitvale School. A large body occurs east of Benton City, and several strips border the areas of Scabland near the Columbia River in the southern part of the county. Small areas are mapped north of Longview and northeast of Paterson.

The Ephrata fine sandy loam occupies a series of smooth terraces separated by short, steep slopes. The elevation ranges from 50 to 300 feet above the river, except in a few places where the type lies only about 20 feet above the streams. There is usually a good slope, and the porous structure of the subsoil insures adequate underdrainage. The topography of fully 90 per cent of the type is favorable for irrigation.

At present the greater part of the soil is not farmed. Much of it is covered with a good growth of bunch grass and is used for grazing.

A small irrigated acreage in the vicinity of Richland is devoted to apples, alfalfa, and grapes, and the yields are very satisfactory. The soil is handled in the same manner as the heavy phase of the type.

Irrigated bodies of this soil in the vicinity of Richland sell for $150 to $250 an acre. Undeveloped areas without facilities for irrigation can be had for $5 to $15 an acre.

The greater part of the Ephrata fine sandy loam has good shipping facilities, lies favorably for irrigation, and is productive and easily handled. Irrigation is necessary for the development of the type, and where properly watered it is well adapted to all the common crops grown under irrigation. For its improvement it requires the same treatment as its heavy phase.

*Ephrata fine sandy loam, heavy phase.*—The Ephrata fine sandy loam, heavy phase, to an average depth of 12 inches is a grayish-brown to light-brown fine sandy loam, containing somewhat more finer material than the typical soil and with a rather high content of very fine sand. The subsoil is a compact, grayish-brown fine sandy loam grading into a mass of waterworn gravel and cobbles at a depth of 18 inches to 3 feet. The substratum is a compact mass of waterworn gravel, cobbles, and bowlders firmly embedded in light-gray silt. In the vicinity of Prosser the gravelly substratum overlies basaltic bedrock at depths of 4 to 25 feet, while near Kennewick the basaltic rock is 50 to 100 feet or more below the surface and the soil is often free from gravel to a depth of 30 inches. In the vicinity of Prosser the waterworn gravel and bowlders frequently are found in profusion on the surface and through both soil and subsoil. Areas in which the coarse materials are especially abundant are indicated on the soil map by gravel or stone symbols. In some cases the stones are sufficiently numerous to prevent cultivation until removed from the field.

The Ephrata fine sandy loam, heavy phase, is confined principally to the Yakima Valley in the vicinity of Prosser, where it extends in a more or less broken strip about 1½ miles in width from the western boundary of the county to Gibbon. Four small but important bodies occur near Kennewick, and a narrow strip on the floor of the Cold Creek Valley. The surface is smooth. In the vicinity of Prosser the phase occupies a terrace 20 to 150 feet above the Yakima River, with a gradual slope away from the stream. Ordinarily, both surface drainage and underdrainage are sufficient, but there are a number of almost level areas where drainage is poor and alkali is present in harmful quantities. Bedrock usually is encountered in these areas at shallow depth. With the exception of one steep terrace slope, the

areas near Kennewick are level. They show no indications of alkali.

The heavy phase of the Ephrata fine sandy loam is one of the most important irrigated soils in Benton County. About 80 per cent of it is under irrigation; the remainder supports a good growth of bunch grass and is used for grazing. The largest undeveloped body lies at the base of the foothills near Kennewick.

The principal crops on this soil are apples and alfalfa, followed by peaches, pears, and cherries. Apples and alfalfa occupy about an equal acreage. Plate II, figure 2, shows a thrifty young apple orchard on a gravelly area of this soil. They are the principal money crops, although peaches, pears, and cherries are also important commercially. During the present season (1916) a considerable acreage of potatoes was grown under contract for sale as seed, and corn is beginning to occupy an important place as feed for hogs and work stock. Strawberries and grapes are becoming prominent as money crops.

The yield of fruit varies greatly with the age of the trees and the condition of the orchards. Well-cared-for orchards in the Yakima Valley give heavy yields, the best apple orchards 10 years old yielding as much as 800 boxes per acre. Pears at the same age often yield 1,000 boxes per acre; peaches, 1,000 boxes; and cherries, 10 tons. Many of the orchards are less than 10 years old and have not reached their most productive stage. The average yield of alfalfa is about 5 tons per acre, with a range from 4 to 7 tons. Potatoes yield 400 to 700 bushels per acre.

It is common practice to grow alfalfa between the fruit trees and harvest it three times a season. Several fields are devoted entirely to alfalfa. In growing this crop about 3 acre-feet of water is applied during the season. In a few instances orchards are given clean cultivation throughout the season. Frequently corn, potatoes, or garden crops are grown between the rows of trees. The farms on this soil are small and all of them are under irrigation.

The prevailing price of irrigated farms on the heavy phase of the Ephrata fine sandy loam is $200 to $300 an acre. Unimproved tracts can be bought for $50 to $100 an acre in the vicinity of Prosser and Kennewick, and for considerably less in the narrow strip in the Cold Creek Valley.

This soil is well adapted to alfalfa and fruit. Clean cultivation for a few years favors a rapid growth of the trees, but experience has shown that a long continuation of the practice after the trees have attained maturity is wasteful.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Ephrata fine sandy loam and of the heavy phase:

*Mechanical analyses of Ephrata fine sandy loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| Typical soil: | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551204 | Soil | 4.4 | 5.0 | 3.0 | 34.6 | 30.7 | 19.2 | 3.2 |
| 551205 | Subsoil | 11.9 | 6.8 | 3.9 | 37.1 | 26.0 | 13.7 | 0.9 |
| Heavy phase: | | | | | | | | |
| 551272 | Soil | 0.8 | 4.2 | 10.3 | 34.4 | 14.7 | 30.0 | 5.9 |
| 551273 | Subsoil | 2.6 | 3.0 | 15.0 | 27.6 | 17.6 | 31.2 | 3.2 |

BEVERLY FINE SAND.

The soil of the Beverly fine sand is a light-brown, loose fine sand of low organic-matter content, with an average depth of 12 inches. The subsoil to 36 inches or more is a light-brown fine sand of moderately compact structure. Both the soil and subsoil contain varying quantities of waterworn gravel, and the substratum usually consists of a mass of waterworn stones and gravel embedded in sand. The type includes areas having a quite pronounced grayish color, which is most strongly developed in dry, cultivated, or bleached fields. In these gray areas the subsoil is a gray, compact fine sand to a depth of about 36 inches, resting on a gray fine sandy loam which contains a high percentage of very fine sand or silt. This type includes also well-developed gravelly areas, which are indicated on the soil map by gravel symbols. Here the surface soil consists of about 12 inches of light-brown fine sand, containing from 25 to 75 per cent of waterworn gravel, underlain by material of the same color and texture to a depth of 3 feet or more. The entire soil section is loose and incoherent. The gravel, which is chiefly quartzitic, ranges from one-half inch to 3 inches or more in diameter and is always more abundant on the surface. The first few inches usually are coarser than the underlying soil, owing to the removal of the finer material by winds.

The Beverly fine sand is inextensive. It occurs in narrow strips along the Columbia River, on the islands in this stream, and in slightly depressed areas at the foot of the higher terraces. On the islands and along the shore the type frequently is slightly elevated above the adjoining soils. The few areas mapped occur near Kennewick, Coolidge, Berrian, and Plymouth; on Blalock and Mottinger Islands; and near the mouth of the Yakima River. The most prominent gravelly body is found in Whitcomb, with smaller ones near Longview and Coolidge and on Blalock Island.

The surface is smooth to gently undulating. The type ranges from a few feet to 50 feet above the Columbia River, and much of the soil, particularly on the island areas, is overflowed during periods of flood,

In general the drainage is good, and there is no indication of alkali accumulations.

The greater part of the type is covered with sagebrush and a scattering growth of a tall variety of coarse grass and other native plants. Most of the land used for farming is on the island at the mouth of the Yakima River, and in the vicinity of Kennewick. Alfalfa, the principal crop, is grown under irrigation and yields 3 to 6 tons per acre. A small acreage of native grasses is mowed for hay in this vicinity. Corn is grown to a small extent and yields 40 to 60 bushels per acre.

Irrigated land of this type sells for $100 to $150 an acre. Unimproved land can be bought for $3 to $50 an acre, depending on the location and facilities for irrigation.

This land is too droughty for dry farming. The greater part of it lies favorably for irrigation and with an abundant water supply would be adapted to berries, early truck, and other crops now grown under irrigation. In some of the lower areas, which receive the seepage from the higher-lying soils, there is a slight tendency toward the accumulation of alkali. These areas, which are usually small, are underlain at shallow depth by bedrock and require less water in irrigation than soils of better underdrainage. The more gravelly areas, owing to the porous nature of the soil, would require considerable water.

### BEVERLY VERY FINE SAND.

The soil of the Beverly very fine sand is a light-brown very fine sand of low organic-matter content. It has an average depth of 12 inches. The subsoil, to 36 inches or more in depth, is a compact, light grayish brown very fine sandy loam. Both the soil and subsoil contain varying quantities of waterworn gravel, and the substratum below about 36 inches usually is a thick deposit of waterworn gravel and cobbles. In some areas gravel and bowlders are very abundant on the surface, and these areas are indicated on the soil map by gravel and stone symbols.

This type is confined to the lower terraces along the Columbia and Yakima Rivers. The largest areas occur in the northern part of the county near White Bluffs, and on the flat near Whitcomb. Other areas are mapped along the Columbia River near Richmond Ferry, Richland, Kennewick, and Carley, and on Blalock Island. Very small bodies occur along the Yakima River at Prosser and between Kiona and the Grosscup Ranch.

The Beverly very fine sand has a comparatively level topography, with an elevation of 5 to 50 feet above the rivers. The entire type is irrigable, and the porous structure of the underlying material assures good underdrainage. Some of the lower areas are overflowed by exceptionally high water.

Owing to its small extent this type is not important, although part of it near Richland and Kennewick is under irrigation. A small acreage of alfalfa and some orchards near Richmond Ferry and a few small fields of alfalfa along the Yakima River are irrigated. Near Richland and Kennewick the chief crop is alfalfa. It yields an average of about 5 tons per acre. Some corn is grown, yielding 50 to 75 bushels per acre. This land is not farmed without irrigation. It is handled in the same manner as the Ephrata fine sandy loam and its heavy phase and requires the same treatment.

The Beverly very fine sand sells for $100 to $150 an acre under irrigation and for $15 to $25 an acre where undeveloped. A few of the stony and gravelly areas have a somewhat lower value.

Irrigation is necessary for the successful farming of this type. With an adequate water supply it is well adapted to all the crops commonly grown in the county.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Beverly very fine sand are given.

*Mechanical analyses of Beverly very fine sand.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551262 | Soil | 0.2 | 0.6 | 0.8 | 35.9 | 46.5 | 12.6 | 3.3 |
| 551263 | Subsoil | .1 | .4 | .6 | 24.7 | 40.4 | 28.6 | 5.1 |

PASCO FINE SANDY LOAM.

The soil of the Pasco fine sandy loam consists of about 12 inches of gray or brownish-gray to dark brownish gray fine sandy loam. The subsoil to about 36 inches is a gray, moderately compact fine sandy loam containing considerable fine sand and very fine sand. The substratum consists of gray, compact very fine sandy or silty material, sometimes overlying a mass of waterworn gravel at 6 feet or more in depth. The soil is only moderately compact and is easily cultivated.

The type is confined to small areas along the Columbia River and the lower part of the Yakima River. The most important areas are found at the Grosscup Ranch, between this point and the mouth of the Yakima River, and near Richland, Kennewick, Paterson, and

Kiona. Other bodies occur near Carley, Longview, Plymouth, Hanford, and White Bluffs, and on islands in the Columbia.

The type usually occurs as narrow strips along the river banks or as shallow depressions along the foot of terraces. The greater part of it lies only a few feet above the normal flow of the rivers, and many areas are subject to overflow. The surface usually is smooth, though there are a few low mounds adjoining areas of wind-blown sands. Both surface drainage and underdrainage are good, and there is little indication of alkali.

Probably 60 per cent of this type of soil, exclusive of the island areas, is under irrigation. The island areas and many of the bodies along the Columbia are covered with a rank growth of sagebrush. Near the mouth of the Yakima River the unbroken areas support a growth of water-loving grasses, which afford good grazing and are sometimes cut for hay.

The same crops are grown, and about the same yields are obtained, as on the heavy phase of the type. The soil is handled in the same manner and has about the same range in value.

The Pasco fine sandy loam has a wide crop adaptation and is considered one of the best soils in Benton County. In a few favorable locations having natural subirrigation in seasons when the rivers are high, thriving orchards are maintained without further watering. The greater part of the type, however, requires irrigation for its best development, and in most cases the elevation, topography, and drainage are favorable for such improvement.

*Pasco fine sandy loam, heavy phase.*—The Pasco fine sandy loam, heavy phase, to an average depth of 12 inches, is a light grayish brown or brownish-gray fine sandy loam of somewhat heavier texture than the typical Pasco fine sandy loam. It has a firm surface and compact structure. The subsoil is a light-gray, compact fine sandy loam. In places gravelly material is encountered at 6 feet or more. As mapped, the phase includes a few small areas of rather dark gray soil.

The phase is confined to narrow strips along the Yakima River from Grosscup Ranch to the Columbia River, and along the Columbia in the vicinity of Richland and Kennewick. A small body is mapped about 2 miles east of Whitcomb. The phase occupies the lowest parts of the valleys and either lies along the banks of the streams or occurs as slightly depressed areas at the foot of terrace slopes. The topography is smooth, and some of the areas are too nearly level for adequate surface drainage. In addition, its low position and the compact structure of the underlying material are not conducive to the downward movement of water and some of the lower lying irrigated bodies are poorly drained and contain injurious quantities of alkali. Near the mouth of the Yakima the phase lies

only a few feet above the normal level of the Columbia River and is subject to frequent overflows.

Although this soil is of small extent, it occupies a rather important place among the irrigated soils of Benton County. Approximately 50 per cent of it is under irrigation. A small part of the remainder near the mouth of the Yakima River supports a good growth of rather coarse grasses and is mowed for hay, while the rest is covered with a heavy growth of sagebrush and grass and is used for pasture.

The principal crops grown are alfalfa, apples, and corn. Alfalfa and apples occupy about an equal acreage, and the acreage devoted to corn while smaller is steadily increasing. There are some plantings of pears, an orchard of this kind being shown in Plate III, figure 1. Most of the alfalfa and corn is used on the farm for feeding work stock, cattle, and hogs. Alfalfa yields 5 to 7 tons per acre and corn 60 to 100 bushels per acre. This land is not farmed without irrigation. It is handled in about the same way as the heavy phase of the Ephrata fine sandy loam. On some of the areas a little less water is applied.

This soil under irrigation sells for $150 to $300 an acre, depending on the improvements and nearness to towns. Unimproved land is held at $50 to $125 an acre, and a few areas can be bought for less.

The phase is very productive, and is adapted to practically all the crops grown in Benton County. It is easily cultivated and irrigated. A number of areas are in need of better underdrainage to remove the excess of water and to check the accumulation of alkali. The soil is greatly improved by turning under alfalfa or applying barnyard manure. Owing to the low position of the land and its shallow water table, it is probable that most of it would produce fair yields of cultivated crops without irrigation, but irrigation is necessary for its most profitable development.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Pasco fine sandy loam and of its heavy phase:

*Mechanical analyses of Pasco fine sandy loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| Typical soil: | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551215 | Soil | 0.0 | 0.3 | 1.3 | 44.6 | 33.8 | 16.8 | 3.5 |
| 551216 | Subsoil | .0 | .2 | 1.8 | 53.4 | 25.2 | 16.1 | 3.3 |
| Heavy phase: | | | | | | | | |
| 551253 | Soil | .1 | .6 | .6 | 20.4 | 34.0 | 36.5 | 8.1 |
| 551254 | Subsoil | .0 | .3 | .4 | 22.0 | 29.6 | 37.4 | 10.5 |

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 551253, 1.43 per cent; No. 551254, 2.25 per cent.

PASCO CLAY.

The soil of the Pasco clay is a dark brownish gray or grayish-brown clay, sometimes of silty texture and having an average depth of 10 to 12 inches. The subsoil to a depth of many feet is a dark grayish brown or brownish-gray, compact silty clay, usually heavier or more compact and of lighter color than the surface soil. The surface soil is compact, and when wet is rather plastic and almost black in color.

This is one of the least extensive soils in Benton County. Only a few small bodies are mapped along the lower Yakima River in the vicinity of Richland and the Grosscup Ranch, with one small area on the Columbia River near Richmond Ferry. The type lies 10 to 20 feet above the normal flow of the rivers and occasionally is overflowed. The surface is smooth, but is marked by a few depressions or former stream channels. As a rule the surface drainage is good, but the impervious subsoil retards the downward movement of water, and the lower areas are slow in drying out after being flooded. All the bodies lie favorably for irrigation.

About 75 per cent of the type is dry farmed, and the remainder supports a good growth of grass. The principal crops are alfalfa, corn, potatoes, and wild hay. The yields vary from almost nothing to high, depending on whether or not the land is overflowed in early summer, and the cultivation given the crop. The land is valued at $25 to $125 an acre, the higher prices being due to favorable location and good improvements.

The Pasco clay is naturally a strong soil, but it requires considerable cultivation for good results. The soil is rather hard to work and is greatly improved by the addition of organic matter. For best results it requires irrigation, protection from overflow, and in some cases artificial drainage.

The results of a mechanical analysis of a sample of the soil of the Pasco clay are given in the following table:

*Mechanical analysis of Pasco clay.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551255 | Soil | 0.1 | 0.3 | 0.4 | 8.9 | 22.0 | 30.0 | 38.2 |

ESQUATZEL FINE SANDY LOAM.

The soil of the Esquatzel fine sandy loam is a light-brown fine sandy loam of compact structure, with an average depth of 12 inches. The subsoil to a depth of 6 feet or more is a light-brown to slightly

yellowish brown, compact fine sandy loam containing a rather large quantity of fine material. In places there is a recently formed crust of yellowish-brown, smooth silt loam on the surface, while in other areas, associated with soils of the Quincy series, the surface is covered with a thin mantle of various grades of sand. Coarse sand and gravel are not encountered in the soil or subsoil, but are sometimes present below the depth of 6 feet. In places the texture is not uniform throughout the soil section, the type consisting of alternating layers of fine sandy loam and silt without definite order of arrangement.

This type is confined chiefly to narrow strips in the dry valleys of Cold Creek and Dry Creek in T. 12 N., Rs. 24, 25, and 26 E. A small body is found at the western edge of the town of Prosser, and others occur along the Yakima River between Prosser and the western county line. The topography is nearly level, but both the surface drainage and underdrainage are good. There are no indications of alkali.

Owing to its small extent the type is unimportant. Only the small bodies near Prosser are under cultivation, the remainder supporting a vigorous growth of sagebrush. The chief crop is alfalfa, with smaller acreages of corn, vegetables, and fruit. Alfalfa yields 5 to 7 tons of hay per acre, and corn 50 to 75 bushels per acre. This soil is not farmed without irrigation.

The small irrigated bodies in the vicinity of Prosser are held at $250 to $350 an acre. Undeveloped and remote areas are held at $5 to $10 an acre.

The Esquatzel fine sandy loam is considered one of the best agricultural soils in the county. It is probable that dry farming could successfully be developed in the Cold Creek Basin. Occasionally the land is flooded by run-off from heavy freshets or from the melting of snow on the hills, and while the water remains on the ground for only a short period the beneficial results are lasting, as is indicated by the large growth of sagebrush. The soil appears to hold moisture well and where thoroughly cultivated is well suited to small grains, potatoes, berries, and vegetables. In general, however, maximum results can be obtained only with irrigation.

### ESQUATZEL SILT LOAM.

The soil of the Esquatzel silt loam is a light-brown to slightly yellowish brown smooth silt loam, with an average depth of about 12 inches. The subsoil is a light grayish brown to slightly yellowish brown smooth silt loam or loam of silty texture extending to a depth of 6 feet or more. In some parts of the type it rests on coarser material. In places the dry surface soil of irrigated or overflowed areas approaches a grayish-buff color, and has a slight tendency to check

and form a thin crust. However, the firm surface is easily pulverized, forming a good seed bed. The entire soil section is compact.

In the vicinity of Prosser the type contains a high percentage of fine sand, and there are a few small included areas of Esquatzel fine sandy loam. In other localities the texture throughout the soil section is not entirely uniform, thin lenses of fine sandy loam being encountered at various depths.

The Esquatzel silt loam is confined to comparatively narrow strips in the Yakima Valley and the dry valleys of Dry and Cold Creeks. The largest and most typical bodies are found in the latter valleys, in T. 12 N., Rs. 24, 25, and 26 E. The type covers practically all the Yakima Valley on the south side of the river from Prosser to the western county line.

The surface is nearly level, or slopes gently with the direction of the stream. The areas along Cold Creek and Dry Creek are traversed by numerous channels which carry water after heavy rains or following sudden thawing of snow on the hills. At such times parts of the type are covered with a foot or more of water for short periods, which serves the purpose of a copious irrigation and is decidedly beneficial. Both the soil and subsoil are well drained.

Although the Esquatzel silt loam is of comparatively small extent, it is one of the important irrigated soils of the county. Practically all the type along the Yakima River is under irrigation. About 60 acres of alfalfa on this type at the Benson Ranch is irrigated by a gravity system from springs near the base of the Rattlesnake Hills. The unirrigated land is not tilled. The native vegetation consists chiefly of a vigorous growth of sagebrush. The most important crops are alfalfa, apples, cherries, corn, and potatoes. The acreage in alfalfa is a little greater than that devoted to apples, and the acreage in corn is somewhat less. Plate III, figure 2, shows a young apple orchard on this type, with potatoes interplanted. Alfalfa and apples are the principal money crops, while most of the corn is fed to hogs and work stock on the farms. Dairying is carried on in a small way on a number of farms in the Yakima Valley, milk being delivered in Prosser or the cream collected for the local creamery. Alfalfa yields 5 to 7 tons of hay per acre, corn 60 to 100 bushels, potatoes 300 to 600 bushels, and fruit about the same as on the heavy phase of the Ephrata fine sandy loam. The farms on this type are small and are intensively farmed under irrigation. The soil is handled in the same manner as the Ephrata fine sandy loam, heavy phase, and can be improved in the same way.

The irrigated areas of the Esquatzel silt loam in the vicinity of Prosser sell for $200 to $350 an acre, and a few tracts are held at higher figures for residential purposes. Undeveloped land along Dry

and Cold Creeks for which water is not available is said to be valued at only $5 to $10 an acre.

The Esquatzel silt loam retains moisture well, is easily cultivated and irrigated, and is very productive. To overcome the slight tendency to form a surface crust the plowing under of alfalfa is effective. The type is well suited to alfalfa, fruit, corn, and a variety of truck crops.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Esquatzel silt loam are given:

*Mechanical analyses of Esquatzel silt loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551219 | Soil | 0.1 | 0.2 | 0.4 | 12.4 | 10.6 | 70.2 | 6.2 |
| 551220 | Subsoil | .1 | .4 | .8 | 18.4 | 29.2 | 42.1 | 9.1 |

PROSSER FINE SANDY LOAM.

The Prosser fine sandy loam is a brown to light-brown fine sandy loam of rather heavy texture resting on basaltic bedrock at any depth from a few inches to about 3 feet. The subsoil of the deeper areas is similar to the surface soil in color and texture, but usually is mixed with a quantity of broken fragments of the underlying rock. Basaltic bowlders and fragmentary material are thickly strewn over the surface of some of the areas, and in a few instances the type includes small patches of rock outcrop. The location of the stony areas is indicated on the soil map by stone symbols.

The Prosser fine sandy loam is comparatively inextensive. The largest body occurs on the north side of the Yakima Valley in the vicinity of Prosser. Narrow strips are found along the south bank of the Yakima River between Prosser and the western county line. Other areas occur northwest of Benton City, and strips are found on the south side of Paterson Ridge, on the north side of Canoe Ridge, and along Dead Canyon near the southwestern corner of the county.

The Prosser fine sandy loam occupies old river terraces and lies 20 to 250 feet above the present levels of the streams. It has a level to gently sloping topography, favorable to irrigation. Surface drainage is not always well established, and the nearness of the underlying rock to the surface prevents free underdrainage. In a few of the more poorly drained irrigated areas alkali is encountered. In some localities the type has the appearance of the shallow areas of the Ritzville loam but is distinguished from them by its terrace position and the occasional occurrence of fine waterworn quartzitic

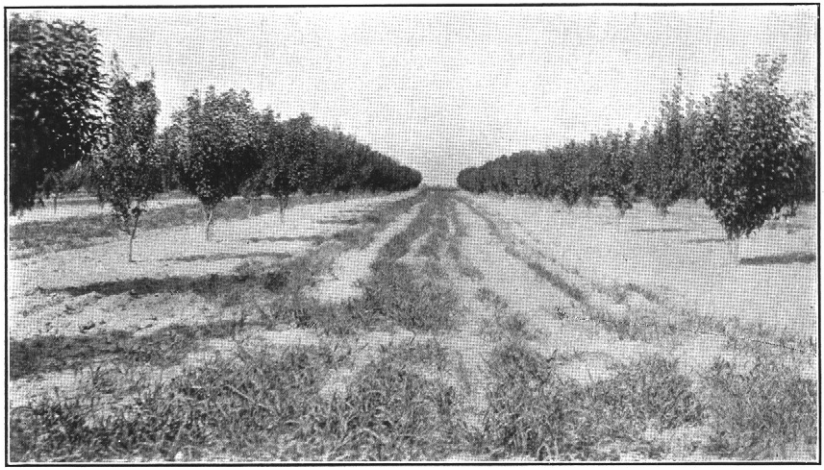

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FIG. 1.—PEAR ORCHARD ON PASCO FINE SANDY LOAM, HEAVY PHASE.

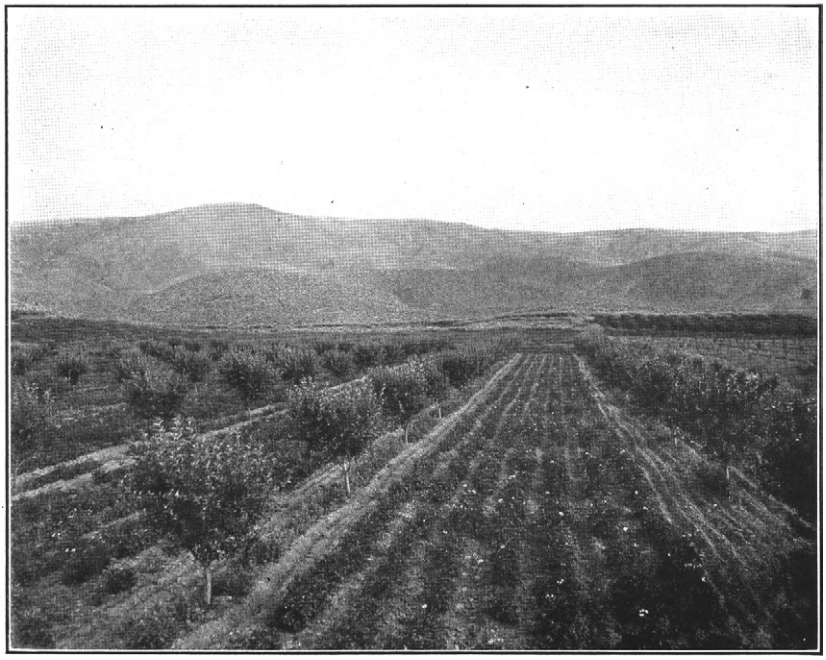

FIG. 2.—GROWING POTATOES IN YOUNG APPLE ORCHARD ON ESQUATZEL SILT LOAM.

Horse Heaven Hills in the distance.

gravel. However, in some localities more or less Ritzville material has been distributed over the surface by winds.

A small part of this type in the vicinity of Prosser is under irrigation, and the remainder supports a good growth of sagebrush and bunch grass and is used for pasture. Apples and alfalfa are the principal crops and occupy about an equal acreage. The improved fields are confined to the deeper areas of soil, and where alkali is not present in injurious quantities the yields are about the same as on the heavy phase of the Ephrata fine sandy loam. The type is handled in about the same manner as that phase.

Irrigated land of this type in the vicinity of Prosser sells for $125 to $200 an acre, while unimproved areas in the same vicinity can be bought for $10 to $50 an acre, depending on the nearness to town and the quantity of rock material present in the soil. Areas at some distance from markets are valued at $3 to $6 an acre.

The Prosser fine sandy loam is too shallow and droughty for dry farming. Although there are a few thrifty orchards on some of the deeper areas, the type in general does not seem adapted to fruit. It is best suited to potatoes, vegetables, and shallow-rooted crops. Some areas are in need of better underdrainage to prevent the accumulation of alkali.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Prosser fine sandy loam:

*Mechanical analyses of Prosser fine sandy loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551268 | Soil | 1.2 | 1.6 | 1.6 | 20.0 | 32.0 | 37.3 | 6.6 |
| 551269 | Subsoil | 1.1 | 1.5 | 1.0 | 13.4 | 31.2 | 44.8 | 7.2 |

STACY FINE SANDY LOAM.

The soil of the Stacy fine sandy loam consists of about 12 inches of brown fine sandy loam. The subsoil is a brown, compact fine sandy loam extending to a depth of 18 to 20 inches, where it rests on broken, subangular fragments of basalt. As a rule the fragments have a small quantity of interstitial material and grade into bedrock at comparatively shallow depth. Basaltic bowlders and angular fragments of basalt are numerous on the surface in some areas, and in places the type consists of a mass of bowlders and rock fragments with very little interstitial material. Such areas constitute a stony variation of the type which is indicated on the map by stone symbols.

The Stacy fine sandy loam is confined to the floors of narrow draws or to small fan-shaped areas where the draws emerge upon the lower

plains. It is most typically developed along the base of the north slope of the Rattlesnake Hills, but is somewhat more extensive in the draws leading southward from the Horse Heaven Plateau. In the latter locality and in the vicinity of Prosser the type contains windblown sand which gives it a lighter color and texture than is considered typical.

The topography in general is smooth, but the floors of the narrow valleys usually are cut by dry, winding channels of sand or stony material which makes tillage impracticable. The type is of little agricultural importance. It supports a growth of sagebrush, and some of the areas on the slopes of the Rattlesnake Hill have a good growth of bunch grass, which constitutes good pasturage. The land is held at $1.50 to $5 an acre. It is best adapted to grazing.

*Stacy fine sandy loam, heavy phase.*—The Stacy fine sandy loam, heavy phase, is a brown fine sandy loam, with an average depth of 12 inches. The subsoil is similar to the soil except that it contains many angular fragments of basalt. At an average depth of 30 inches the subsoil grades into basaltic fragments with very little interstitial soil material. Bedrock is encountered at 3 to 5 feet. The surface is firm, and both the soil and subsoil are compact. In places basaltic bowlders and fragments are scattered throughout the soil section. These areas are indicated on the map by stone symbols.

The Stacy fine sandy loam, heavy phase, occurs only in narrow strips along draws or in small fan-shaped areas where the draws emerge from the hills upon the lower plains. It is most typically developed along the base of the north slope of the Rattlesnake Hills. Areas also occur in the Yakima Valley near Prosser.

As a rule the draws are cut by winding, stony channels which make them unfit for cultivation. The dry stream beds usually disappear at the upper side of the fans, but their former courses can be traced across the type by slightly elevated ridges containing a high percentage of rock fragments. The surface drainage is good, and the underdrainage frequently is excessive, so that the phase in many cases is droughty.

Practically none of this soil is under cultivation. It supports a good growth of bunch grass and is used for pasture. The greater part of it can be bought for $3 to $5 an acre.

A large part of the phase is too shallow and droughty for dry farming, and no water is available at present for irrigation. The stony areas are not suitable for cultivation.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Stacy fine sandy loam and of the heavy phase:

*Mechanical analyses of Stacy fine sandy loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| Typical soil: | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 551242 | Soil | 4.4 | 7.8 | 4.6 | 24.6 | 32.0 | 22.2 | 4.3 |
| 551243 | Subsoil | 4.0 | 6.4 | 4.1 | 22.4 | 33.0 | 25.7 | 4.3 |
| Heavy phase: | | | | | | | | |
| 551221 | Soil | 1.6 | 2.6 | 1.3 | 12.2 | 38.2 | 39.2 | 4.8 |
| 551222 | Subsoil | 3.0 | 3.8 | 1.4 | 11.8 | 38.8 | 36.9 | 4.7 |

SCABLAND.

Scabland comprises intricately associated areas of shallow soil, rock outcrop, and slopes that are too steep or stony for cultivation. The soil material is a brown to light-brown fine sandy loam or very fine sandy loam and usually is very shallow, with frequent masses of the underlying basalt protruding above the surface. The areas of rock outcrop vary from only a few rods in diameter to tracts of several square miles. Many areas of shallow soil unbroken by rock outcrop occur, but are too small to be shown separately on the map. On the terraces these areas represent principally the Prosser fine sandy loam, while at higher elevations they consist chiefly of shallow areas of the Ritzville loam.

Scabland is rather extensive and is widely distributed through the county. The largest areas occur on the Rattlesnake Hills and on the north slopes of the Horse Heaven Hills. Other important bodies are found on the Yakima Range, along the Columbia River, on Gable Mountain in the northern part of the county, on Canoe Ridge from Paterson to the southwestern corner of the county, and along the Columbia from Plymouth to Hover. An area extends along the north side of the Yakima River from the Valley Heights School to Benton City.

Scabland includes all classes of topography from smooth or gently sloping to steep and precipitous. Cliffs 20 to 50 feet in height are of common occurrence along the Columbia River on the southern boundary of the county and along the Yakima River in the vicinity of Glen. Vertical walls of rock occur along many of the draws, while along the Columbia in the northwestern corner of the county the slopes have a fall of nearly 2,000 feet to the mile. The smoother areas occur along the north side of the Yakima River.

The areas of Scabland are too steep or stony for cultivation, but between the areas of rock outcrop the soil supports a good growth of bunch grass which furnishes considerable pasturage. This land sells for $1.50 to $5 an acre. It is best suited for grazing.

### RIVERWASH.

Riverwash consists of a deposit of sand, gravel, and bowlders along the channels of the rivers and on the overflowed islands in the Columbia River. The greater part of it lies only 1 or 2 feet above the normal flow of the rivers and is subject to frequent overflows. Except for a few willows and bushes along the Yakima River, it is barren of vegetation. This land has no agricultural value.

### DUNESAND.

Dunesand consists of gray or grayish-brown sand of fine to medium texture extending to depths of many feet without material change. In a few localities there are small patches in which the sand is rather coarse and dark grayish brown to nearly black. A few areas of Winchester sand, too small to be shown on the map, also are included. Dunesand differs from the Winchester soils in being barren of vegetation and in having a greater tendency to drift. It has a more dunelike topography. On the windward side of the dunes the surface is often relatively firm, but otherwise the sand is loose and incoherent.

The largest area of Dunesand is mapped along the Columbia River about 5 miles southeast of Hanford. A number of smaller bodies occur along the Columbia between Paterson and Plymouth and on Blalock Island. There are a few small bodies near the northwestern corner of T. 11 N., R. 27 E.

The type occupies dunes varying in height from 20 to more than 60 feet. Many of these are crescent shaped or consist of a number of small dunes joined together to form a long continuous ridge. On the windward side the dunes are smoothly rounded, while on the opposite side the descent is steep and abrupt. Between the dunes are long, narrow troughs or shallow basins from 1 to 40 acres or more in extent.

The greater part of the Dunesand consists of sandy material blown from the channel of the Columbia River. The continual drifting of the sand has prevented the growth of vegetation. According to statements of the older residents, the dunes are moving in a northeasterly direction at an average rate of about 30 feet a year.

At present the Dunesand has no importance agriculturally. It is not adapted to dry farming, and under present conditions irrigation is impracticable. The few small "potholes," which comprise less than 1 per cent of the total area, afford some grazing for cattle and horses.

### IRRIGATION.

Although irrigation has been carried on in parts of the Yakima Valley for more than 50 years the first development in Benton

County was in 1894, when the original Kennewick Canal was built. The water was diverted by gravity from the right bank of the Yakima River about 10 miles above its mouth, and the canal was about 30 miles in length. Owing to financial difficulties this canal was abandoned after about two years, but during the next few years irrigation was permanently established at various points in the county. In 1902 the Kennewick Canal was enlarged and extended at a cost of more than $200,000, and 12,000 acres were brought under irrigation, while 4,000 acres were actually irrigated in 1906.[1] At present (1916) 35,000 acres are irrigated in Benton County. There are four principal districts, the Richland-Kennewick District, the Prosser District, the Benton City District, and the Hanford-White Bluffs District.

The Richland-Kennewick District includes a narrow strip along the Columbia River from a point a few miles above Richland to Hover. The strip varies from 1 to 4 miles in width, and has a total length of about 30 miles. This district is the last to receive water from the Yakima River, and with the exception of the west highlands of Kennewick, which are watered by pumping from the canal, all the land is irrigated by gravity.

The Prosser District includes the 10 miles of the Yakima Valley extending from the western boundary of the county to Gibbon. It is about 4 miles wide at the western border of the county and narrows to a point at Gibbon. It comprises about 8,000 acres and is irrigated principally by gravity from the Government Sunnyside Canal. This canal has recently been extended to Benton City, though as yet it waters only a small acreage in this vicinity. There are, however, between 2,000 and 2,500 acres under irrigation at Benton City, the water being taken from the Yakima River and supplied by gravity from a canal heading 4 miles above the town.

The Hanford-White Bluffs District includes a strip 2 to 4 miles in width and about 15 miles in length, extending along the Columbia River from the foot of Coyote Rapids to 3 miles below Hanford. About 3,200 acres are under irrigation. The water is pumped into the canal by electric power developed at Priest Rapids and is furnished to the farmers at a stated price. The price has advanced to such a point that in some cases it is prohibitive. At present the maximum rate permitted to be charged is fixed at $4.80 for 32 inches of water and 10 cents for each additional inch. As the soils in this district are all sandy and porous, it is necessary for most of the farmers to use extra quantities of water for best results.

[1] For a complete discussion of irrigation in the Yakima Valley, see Bul. No. 188, Office of Experiment Stations, U. S. Dept. of Agr., Irrigation in the Yakima Valley, by S. O. Jayne.

There are a number of private pumping plants at various points along the Columbia River. The most important of these are at White Bluffs, where about 500 acres are irrigated; at Richmond Ferry, near the northwestern corner of the county; and at Plymouth, Longview, Paterson, and Carley. At the last-named place a small acreage is irrigated in Artesian Coulée with artesian water. Most of the pumping is done by gasoline engines, though water wheels are in use at Gibbon on the Yakima River and at Longview on the Columbia. Large expenditures have been made in attempts to pump water over the sandy and gravelly terraces at Whitcomb, Paterson, and Coolidge and at various other points along the Columbia River. At Paterson the lift of 200 feet or more is said to have been too great for the type of machinery used, and here, as elsewhere along the river, expensive machinery has been lying idle for a number of years. At the Benson Ranch about 65 acres are irrigated from a spring on the north side of Rattlesnake Hills. Several hundred acres are irrigated at the Grosscup Ranch by a gravity ditch from the Yakima River.

There are good opportunities for the extension of irrigation in Benton County. In no case is the entire acreage for which ditches are provided watered. There are 7,000 or 8,000 acres irrigable under the Hanford Canal, of which less than one-half is being watered. The enlargement of the canal will be necessary before the entire acreage can be irrigated. By pumping, or by the construction of a high-line canal, between 15,000 and 20,000 acres can be irrigated near Kennewick. Many thousand acres of sandy soils along the south side of the county are irrigable by pumping from the Columbia River. The river maintains a strong flow at all times of the year, and for all practical purposes the supply is inexhaustible. The supply of the Yakima River is limited, and during the past two seasons practically the entire flow has been diverted. Under the prevailing methods a great deal of water is wasted by overirrigation and by seepage from canals. As most of the irrigated lands in Benton County are either sandy or have gravelly subsoils, a larger quantity of water is required than would be needed if the soils were heavier, but many irrigators use more water than is required by the crops, resulting in the formation of swamps and alkali wastes in lower areas. Before there can be a very extensive increase in the irrigated acreage in the Yakima Valley it will be necessary to construct reservoirs to save the water which now goes to waste between the irrigating seasons and to practice more economy in supplying water to the land.

For a number of years there has been a movement on foot to irrigate an extensive acreage on the Horse Heaven Plateau by means of water brought from the foothills of the Cascade Range. A number

of preliminary surveys have been made, and an irrigation district has recently been formed. If completed, this project will be one of the largest of its kind ever undertaken. At present its feasibility has not been definitely determined. The expense would undoubtedly be high, but there would be a great increase in the value of this extensive tract. Both the soil and topography are well adapted to irrigation.

### DRAINAGE AND ALKALI.

Under existing conditions of low rainfall practically all the unirrigated land in Benton County is sufficiently well drained for farming and shows no harmful accumulations of alkali. The only exceptions are the few small potholes in the larger areas of sand dunes and a narrow strip in Glade Coulée. As other natural conditions render these areas unfit for farming, the question of drainage and alkali in the unirrigated lands is not important. In the irrigated areas, however, this question is of first importance, though until very recently it seems to have been entirely neglected.

In general, wherever irrigation is practiced in the West good drainage is an absolute necessity. In most cases the irrigated lands of Benton County have a favorable slope, or the soil is deep, sandy, or underlain with gravel, and there are no indications of alkali, but in most sections which have been extensively irrigated for several years with no provision made for drainage there are many low areas which have become saturated with the seepage water from higher irrigated lands and are now worthless marshes or alkali wastes. Had proper drainage been provided at the beginning of irrigation, at comparatively small expense, practically none of these areas would have been damaged, while now the cost of their reclamation would be very high and in some cases almost prohibitive. The affected areas are gradually enlarging, and the soil each year is becoming more strongly impregnated with salts. Very frequently the source of damage is seepage water from leaky canals, many of the worst affected areas lying along the lower sides of the ditches. The damage, however, is not confined to the vicinity of the canals; alkali areas are becoming common in many of the lower fields having irrigated lands above them. In fact, these fields are first to suffer and are in greatest need of drainage.

Alkali accumulations in Benton County are due in every instance to poor drainage. In the vicinity of Prosser the affected areas have a shallow soil with bedrock at shallow depth, or are partly encircled by ledges of basalt, which act as barriers to drainage. In the latter case blasting is necessary. In this vicinity only a few areas are so strongly impregnated with alkali as to be unsuited to agriculture,

though a number of fields, devoted to alfalfa and fruit, are becoming badly affected.

All the lower part of Artesian Coulée is poorly drained and small patches scattered through it are practically worthless, owing to the accumulation of alkali. Narrow, poorly drained strips containing harmful quantities of alkali occur at the foot of the terraces below Kennewick and in the vicinity of Richland. The largest poorly drained areas are found along the lower part of the Yakima or between this river and the Columbia. During the irrigating season, when there is considerable seepage from the canals and higher irrigated lands, and during periods of overflow from the rivers much of this land is under water, or if not actually flooded is more or less saturated and in a marshy condition for several months. It supports a good growth of water-loving grasses where not too thickly covered with small trees and shrubs.

It is a general belief that most of the soil proposed to be irrigated on the Horse Heaven Plateau is 100 feet or more in depth and that the naturally favorable slope and numerous draws will provide all necessary drainage. By reference to the soil map it will be seen that considerable areas along the upper side of the plateau are not only less than 100 feet deep, but are underlain by basaltic rock at depths of 2 to 5 feet, and that many areas along the lower side are underlain by hardpan at depths of 18 inches to 3 feet. If the seepage water from the higher irrigated areas is allowed to collect and evaporate in the lower areas underlain by hardpan, there is danger that the soils will eventually become affected by alkali.

The following table gives the results of an analysis of an alkali crust formed in the Ephrata fine sandy loam, heavy phase, in the vicinity of Prosser:

*Analysis of alkali crust in Ephrata fine sandy loam, heavy phase.*

[Parts per 100,000 of alkali crust.]

| Ion: | | Conventional combination: | |
|---|---|---|---|
| Ca | 280 | $CaSO_4$ | 952 |
| Mg | 80 | $MgSO_4$ | 397 |
| Na | 5,008 | $K_2SO_4$ | Trace. |
| K | Trace. | $Na_2SO_4$ | 13,217 |
| $SO_4$ | 9,920 | NaCl | 924 |
| Cl | 560 | $NaHCo_3$ | 689 |
| $HCo_3$ | 500 | $Na_2Co_3$ | 389 |
| $Co_3$ | 220 | | |
| | 16,568 | | 16,568 |

## SUMMARY.

Benton County lies along the southern boundary of Washington, and has an area of 1,720 square miles, or 1,100,800 acres. It is bounded on the north, east, and south by the Columbia River and is crossed from west to east near the center by the Yakima River. The

principal topographic divisions are the Rattlesnake Hills and Yakima Range, which are outlying spurs of the Cascade Mountains, the Horse Heaven Hills, the Horse Heaven Plateau, and the Columbia and Yakima River Valleys. The first two divisions lie 2,000 to 3,500 feet above sea level. Their north slopes are steep, but the south slopes are long and favorable for cultivation. The Horse Heaven Hills rise abruptly 1,000 to 1,400 feet along the south side of the Yakima Valley. The river valleys consist chiefly of terraces 50 to 400 feet above the rivers and 240 to 800 feet above sea level.

The population of the county is given in the 1910 census as 7,937. About 95 per cent lives in the Columbia and Yakima Valleys. The principal towns are Prosser and Kennewick. Transportation facilities are good, railroads extending from east to west across the northern, southern, and central parts of the county. Good roads are being built throughout the valleys. Fruit is shipped to the Pacific-coast cities, Chicago, New York, South America, Australia, and Alaska.

The climate of Benton County is arid, the mean annual precipitation at Kennewick being reported as 6.34 inches. The snowfall varies from a few inches in the valleys to 2 feet or more on the Rattlesnake Hills. The mean annual temperature at Kennewick is about 54° F., and the normal growing season is reported as 170 days.

The agriculture of Benton County consists of the production of wheat and fruit for sale, the growing of hay and vegetables for sale and for home use, hog raising, dairying, and the winter grazing and feeding of sheep. The principal crops are wheat, alfalfa, apples, peaches, pears, cherries, strawberries, and grapes. In 1915 more than 600,000 boxes of fruit and nearly 20,000 boxes of vegetables were shipped from Benton County.

The farm buildings throughout the irrigated valleys are commodious and well built. In the dry-farmed sections they are generally poor and in bad repair. The work stock consists of a good supply of horses and mules of medium to heavy weight, and the farming implements are modern and well adapted to the type of farming practiced.

All the wheat produced is grown by summer fallowing, and all of the fruit, alfalfa, and vegetables by irrigation. Commercial fertilizers are used only for strawberries.

In the irrigated valleys the farms vary from 5 to 20 acres in size. In the wheat-growing sections they range from 160 acres to as much as 8,000 acres under single management. The 1910 census reports the average size of farms as 209.9 acres. Lands adapted to wheat growing sell for $10 to $25 an acre. Irrigated lands generally sell for $200 to $350 an acre, but in some cases bring as low as $125 an acre and in others as much as $500 an acre.

Benton County lies entirely within the Northwest Intermountain soil region and forms a part of the Columbia River Plains. The

region is practically treeless, and the native vegetation consists of sagebrush and bunch grass.

The entire county is underlain by a succession of basaltic sheets of the Columbia lava field. The rock is prominently exposed in canyonlike walls along stream courses, and local outcrops are common in various parts of the county. The rock in general is deeply buried and has entered little into the formation of the soils.

The soils of the Horse Heaven Plateau and the Rattlesnake Hills are of loessial origin and belong to the Ritzville series. Adjoining the Ritzville soils at a lower elevation are old valley-filling materials which give rise to the Sagemoor and Burke soils. The latter are underlain by hardpan. In the northeastern, eastern, and southern parts of the county are large areas of wind-blown soils which give rise to Dunesand and the Winchester, Quincy, and Koehler series. The Koehler soils are underlain by hardpan. In the Columbia River Plains and throughout the Yakima Valley are extensive terraces of glacial outwash material, giving rise to the Ephrata series. The river flood plain material, which is inextensive, is classed with the Beverly, Pasco, Esquatzel, and Prosser series. The Stacy series comprises alluvial-fan soils derived from basaltic material.

The Ritzville loam, the most extensive type in the county, is a good wheat soil. The very fine sands and fine sandy loams of the Kennewick, Ephrata, and Beverly series are well suited to fruit, vegetables, and corn under irrigation. The more sandy soils of the county when irrigated are adapted to peaches, strawberries, and early truck crops, but are too droughty for dry farming.

There are about 35,000 acres under irrigation in Benton County. In the Prosser, Benton City, and Richland-Kennewick districts the water is supplied by gravity ditches from the Yakima River. For the lands near Hanford and White Bluffs and along the south side of the county the water is pumped from the Columbia River.

Alkali is not troublesome except in a few poorly drained areas, but if extensive areas are placed under irrigation it will be necessary to make provision for drainage, to prevent alkali accumulation.

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[PUBLIC RESOLUTION.—No. 9.]

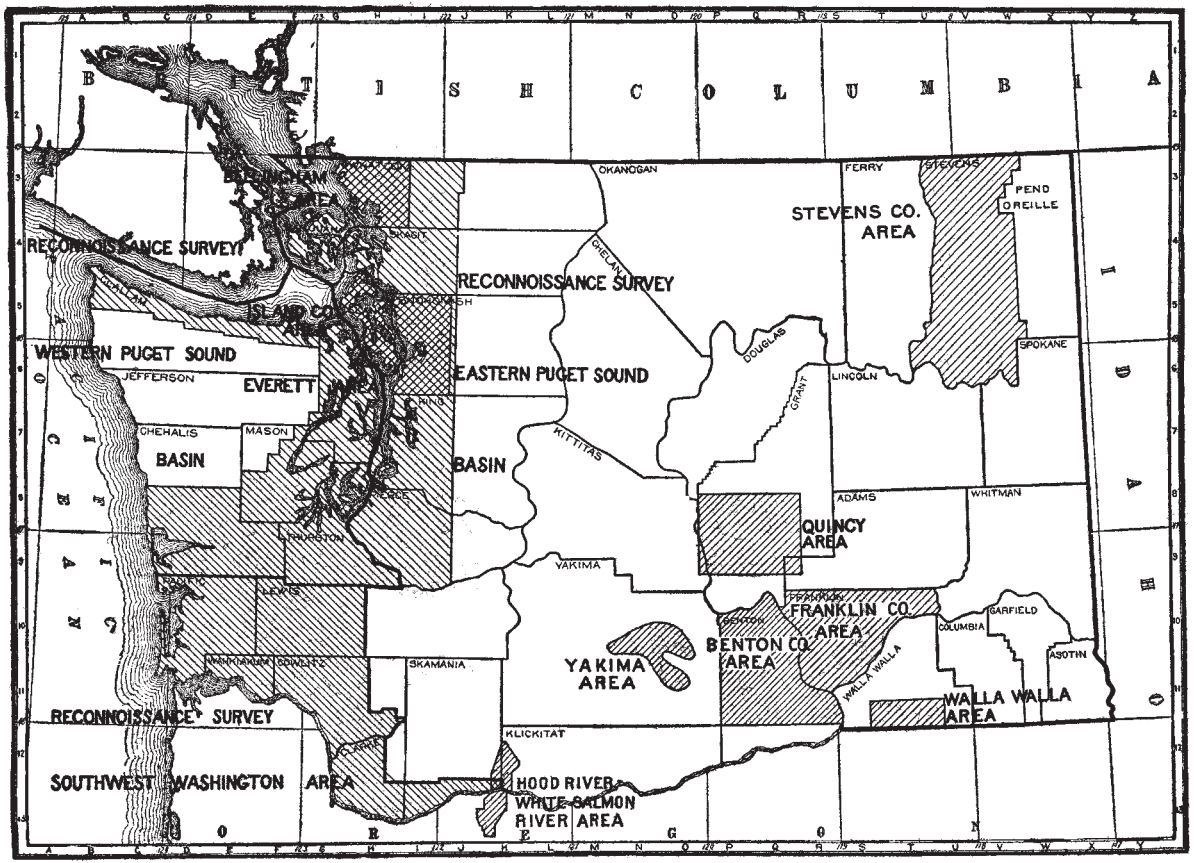
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

*Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]




Areas surveyed in Washington.

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