# SOIL SURVEY

SERIES 1954, No. 7
ISSUED MAY 1959

# *Portales Area*
# NEW MEXICO

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
NEW MEXICO AGRICULTURAL EXPERIMENT STATION

# HOW TO USE THE SOIL SURVEY REPORT

THIS SURVEY of the Portales area will help you plan the kind of farming that will protect your soils and provide good yields. It describes the soils; shows their location on a map; and tells what they will do under different kinds of management.

### Find your farm on the map

In using this survey, you start with the soil map, which consists of the sheets bound in the back of this report. These sheets, if laid together, make a large photographic map of the area as it looks from an airplane. You can see fields, roads, creeks, and many other landmarks on this map. The aerial photograph on the cover shows Portales, the county seat in Roosevelt County, and the surrounding area.

To find your farm on the large map, you use the index to map sheets. This is a small map of the area on which numbered rectangles have been drawn to show where each sheet of the large map is located.

When you have found the map sheet for your farm, you will notice that boundaries of the soils have been outlined in red and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map.

Suppose you have found on your farm an area marked with the symbol Pc. You learn the name of the soil this symbol represents by looking at the map legend. The symbol Pc identifies Portales loam, 0 to 1 percent slopes.

### Learn about the soils on your farm

Portales loam, 0 to 1 percent slopes, and all the other soils are described in the section Soil Series and Mapping Units. Soil scientists walked over the land and mapped the soils. They dug holes and examined surface soils and subsoils; measured slopes with a hand level; noted differences in growth of crops, brush, or grasses; and, in fact, recorded all the things about the soils that they believed might affect their suitability for irrigated farming.

The scientists talked with people who use the soils, studied experimental data, and placed each soil in a land capability group according to its relative fitness for crops, grazing, or other use.

If you want to know in general about soil management in this area, turn to the section Use and Management of Soils. The yields to be expected from the irrigated crops common to the area are shown in table 4. Because the soils in this area are dry and sandy, they need to be irrigated if crops are to be grown and the surface is to be kept from blowing. By turning to the subsections Control of Wind Erosion, and Soil Moisture and Irrigation, one can get a better understanding of the practices used in the area.

If you want to know how the soils are formed and classified, turn to the sections Geology, and Classification and Morphology of Soils. A detailed profile description of a representative soil of each series is given in this section. In the section General Patterns (soil associations) broad areas of soils are described for those who want general knowledge about the soils.

### Make a farm plan

For the soils on your farm, compare your yields and farm practices with those given in this report. Look at your fields for signs of runoff and erosion or of too much or too little irrigation. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or any other farm in the county.

If you find that you need help in farm planning, consult the local representative of the Soil Conservation Service or the county agricultural agent in Roosevelt County. Members of the staff of your State agricultural experiment station and others familiar with farming in your county will also be glad to help you. Supervisors of the Roosevelt Soil Conservation District will arrange for you to get technical help on a farm conservation plan.

The fieldwork for this survey was completed in 1954. Unless otherwise specifically noted, all statements refer to conditions at the time of the survey.

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# Contents



Series 1954, No. 7 Issued May, 1959

# SOIL SURVEY OF PORTALES AREA, NEW MEXICO

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## *General Description of the Area*

The Portales area occupies a shallow water basin in Roosevelt County. It extends diagonally in a southeastern-northwestern direction for 33 miles (fig. 1). It ranges from 6 miles to less than 1 mile in width. Portales, the county seat, is centrally located in the area.

During the latter part of the 19th century, large cattle ranges were established in eastern New Mexico and Texas. The building of a railroad through Roosevelt County encouraged settlement, and Portales became a cattle-shipping town.

In recent years irrigation farming has increased greatly because it has become feasible to sink wells to the natural supply of water in an underground storage basin. The economy of the Portales area is now based on agriculture. Cotton, peanuts, grain sorghum, sweetpotatoes, and alfalfa are the major crops. Alfalfa and sorghum are fed primarily to dairy cattle. Much of the area is subject to wind erosion, and many acres have been seeded to pasture grasses to prevent blowing of the surface soil.

To provide a basis for the best agricultural uses of the land, a cooperative soil survey was made by the United States Department of Agriculture and the New Mexico Agricultural Experiment Station.

### Location and Extent

Roosevelt County, in which the Portales area is located, is on the western edge of the southern High Plains in the east-central part of New Mexico. The county line, running north and south for about 50 miles, separates Roosevelt County from the State of Texas. The area surveyed covers 80,310 acres, of which 49,019 acres is irrigated.

The city of Portales has an elevation of 4,004 feet. According to the 1950 census, it had a population of 8,112 persons. It is in the northeast-central part of the county on United States Highway No. 70. Several State highways, as well as the Atchison, Topeka, and Santa Fe Railway, go through Portales.

### Climate

The climate of the area is semiarid. It is characterized by fairly cool winters, warm summers, light rainfall, abundant sunshine, and low relative humidity. The average relative humidity is 68 percent in the forenoon and 35 percent in the afternoon. On the average the sun shines 74 percent of the possible hours of sunlight annually. Figures on the normal monthly, seasonal, and annual temperature and precipitation are given in table 1. They were compiled from records at the United States Weather Bureau station at Portales.

Although the average rainfall over a 32-year period is about 18 inches, records show that precipitation is less than that amount for 60 percent of the time. During

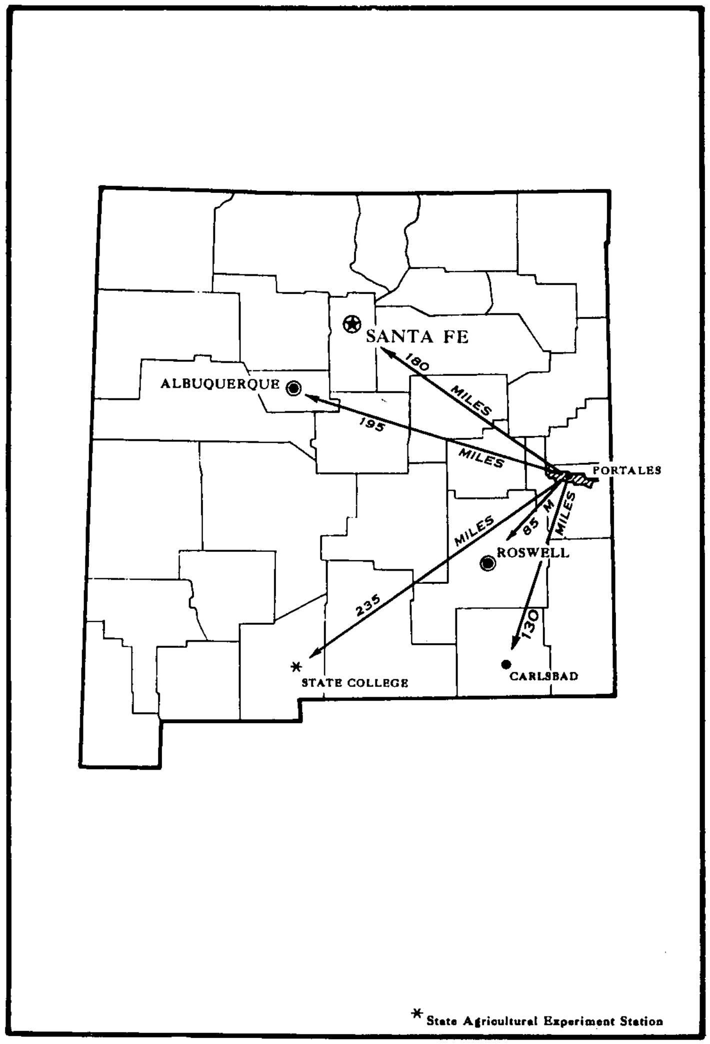


*Figure 1.*—Location of Portales area in New Mexico.

TABLE 1.—*Temperature and precipitation at Portales, New Mexico*

[Elevation, 4,004 feet]

| Month | Temperature[1] | | | Precipitation[2] | | | |
|---|---|---|---|---|---|---|---|
| | Average | Absolute maximum | Absolute minimum | Average | Driest year (1917) | Wettest year (1941) | Average snowfall |
| | ° F. | ° F. | ° F. | Inches | Inches | Inches | Inches |
| December | 37. 7 | 77 | −9 | 0. 65 | (3) | 0. 49 | 2. 7 |
| January | 36. 4 | 80 | −18 | . 38 | . 54 | . 31 | 2. 2 |
| February | 41. 2 | 83 | −28 | . 39 | . 08 | . 09 | 1. 8 |
| Winter | 38. 4 | 83 | −28 | 1. 42 | . 62 | . 89 | 6. 7 |
| March | 47. 6 | 92 | −4 | . 73 | . 02 | 3. 01 | 1. 4 |
| April | 56. 7 | 98 | 11 | 1. 14 | . 21 | 1. 60 | . 4 |
| May | 65. 5 | 102 | 25 | 2. 53 | 1. 19 | 12. 05 | . 1 |
| Spring | 56. 6 | 102 | −4 | 4. 40 | 1. 42 | 16. 66 | 1. 9 |
| June | 74. 1 | 109 | 33 | 2. 54 | (3) | 7. 45 | (3) |
| July | 77. 1 | 107 | 50 | 2. 84 | 1. 19 | 3. 62 | (3) |
| August | 75. 9 | 105 | 40 | 2. 66 | 3. 77 | 2. 29 | (3) |
| Summer | 75. 7 | 109 | 33 | 8. 04 | 4. 96 | 13. 36 | (3) |
| September | 69. 0 | 104 | 31 | 2. 29 | . 38 | 7. 66 | 0 |
| October | 58. 6 | 94 | 15 | 1. 37 | (3) | 5. 20 | . 2 |
| November | 45. 9 | 90 | 0 | . 55 | . 02 | . 33 | 1. 1 |
| Fall | 57. 8 | 104 | 0 | 4. 21 | . 40 | 13. 19 | 1. 3 |
| Year | 57. 1 | 109 | −28 | 18. 07 | 7. 40 | 44. 10 | 9. 9 |

[1] Average temperature based on a 32-year record, through 1955; highest and lowest temperatures based on a 40-year record, through 1952.

[2] Average precipitation based on a 36-year record, through 1955; wettest and driest years based on a 45-year record, in the period 1905–1955; snowfall based on a 41-year record, through 1952.

[3] Trace.

normal years, 15 inches of rain falls during the growing season of April through October. During the particularly dry years of 1951 through 1954, much of the precipitation came in one or two storms of high intensity but of short duration. They contributed about 20 percent of the effective moisture.

Crops are damaged by severe rainstorms, as well as by hail. The hailstorms are in small localized areas, however. They have no predictable pattern and come during May through August.

Winds of high velocity and droughts are other major climatic hazards to the agriculture of the area. The dry season parallels the windy season that reaches its peak during March and April.

Wind velocities of 25 to 60 miles per hour are called dusters. These duststorms originate locally with afternoon and evening thunderstorms and are usually of short duration.

Duststorms that originate outside the area are more intense and of longer duration. Their development is usually associated with low pressure troughs along the east side of the Rocky Mountains. Turbulent winds of 25 miles per hour or more move eastward into an area of low atmospheric pressure and carry great quantities of soil. Since the season of greatest wind velocity coincides with the dry season and comes at a time when the fields have the least protective cover, these duststorms are particularly damaging.

## Physiography, Relief, and Drainage

The Portales area, on the western edge of the southern High Plains, is at an elevation of 4,000 to 4,200 feet. The southern High Plains form a vast plateau extending north and west of Texas (*2*)[1] that slopes gently to the southeast. As a result of the geologic wearing down of the Rocky Mountains, the Ogalalla formation developed. It is the main source of underground water. Sand, silt, clay, gravel, and caps of limestone (caliche) characterize the Ogalalla formation. Figure 2 shows the relative position of the main soils in the Portales Valley. For a detailed discussion of the geological formations underlying this area, see the section Geology.

In general the area is a broad, gently sloping plain. Sediments were deposited on this plain by an ancient low-gradient shifting stream that flowed eastward and southeastward from the Rocky Mountain Uplift. The sediments have been reworked and redeposited by wind. These soil-building processes have developed a mixed alluvial-eolian type of soil.

Subdued ridges, caliche outcrops, and sand dunes occur in places. The caliche is associated with all of the soils within the irrigated area. It may be dispersed uniformly throughout the profile or may be an accumulated lime zone within the profile. Where it occurs as a zone it is a factor in measuring soil depth. The caliche ranges from soft chalklike to rocklike material.

Shallow undrained basins, called playas, contain water after heavy rains or during wet years. The intermittent streams or draws flow toward these lakes during rainy seasons. Tierra Blanca Lake in the western part of the Portales area is the largest of these dry lakes.

Because the area is generally level, the porous crumbly soils absorb most of the rainfall. Their capacity to store water and to supply moisture to plants is good, but little rainfall occurs. Most farmers, therefore, must depend on irrigation water.

## Source of Water

The water for irrigation in the Portales Valley is entirely from an underground storage basin. The basin and its contributing area occupy about 850 square miles. Recharge is entirely from rainfall over this surface (*7*). The recharge to the underground storage basin from precipitation is estimated to be about 0.5 inch annually, or about 22,700 acre-feet. At present, water is probably being discharged through pumpage much faster than it is being restored. The conservation of water through improved irrigation methods, therefore, has become essential. This problem is recognized by both local and State officials, and laws have been passed governing the use of underground water in the Portales Valley.

*Laws governing the use of underground water.*—The Portales Valley was declared an underground water

[1] Italic numbers in parentheses refer to Literature Cited, p. 27.

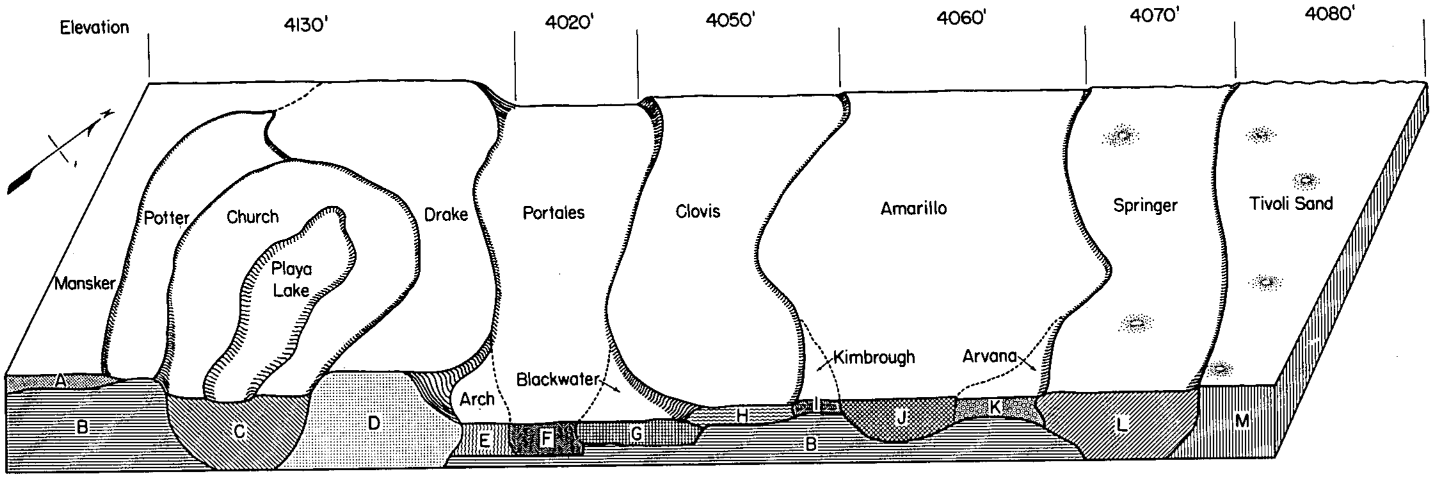


*Figure 2.*—Relative position and underlying material of main soils of Portales Valley: *A, B,* Mansker (shallow) and Potter (very shallow), underlain by rocky caliche and High Plains marl. *C,* Church, underlain by strongly calcareous lake sediments. *D,* Drake, underlain by strongly calcareous sediments from lakebeds. *E, F,* Arch and Portales, underlain by strongly calcareous valley fill of mixed wind- and water-deposited materials. *G,* Blackwater, underlain by valley fill and, in turn, by hard caliche at moderate depths. *H,* Clovis, underlain by mixed water- and wind-deposited sediments from the High Plains upland. *I, J, K,* Kimbrough, Amarillo, and Arvana, underlain by mixed water- and wind-deposited materials from the High Plains upland; Kimbrough soils underlain by hard caliche at shallow depth, and Arvana soils by hard caliche at moderate depth. *L, M,* Springer (deep) and Tivoli (very deep), underlain by wind-deposited sands.

basin on May 1, 1950. This declaration by the State engineer fixed the boundaries of the basin. All wells therein were recognized as having vested rights. The drilling of new wells, or the irrigation of new areas from existing wells, requires a legal permit.[2]

## Agricultural History

Late in the 1800's and early in the 1900's Portales was a typical cattle town. Portales Springs, 6 miles east of town, was a stopping place for thirsty cattle. As late as May 1905, an estimated 11,000 head of cattle were shipped from Portales to eastern markets.

In 1907 homesteaders came into the area. They "broke out their forty" (acres), as required by law. The High Plains grassland gradually was converted to tilled crops. Agricultural development and dryland farming date from this time.

A news story in 1903 states that a farmer in Roosevelt County "using a gas engine pumped 5,000 gallons an hour (80 gallons per minute) at a cost of 4 cents an hour." This account may not have induced farmers to sink wells locally, but the establishment of artesian wells in the Roswell area at about that time stimulated interest in water development at Portales. A territorial act had been passed enabling communities to let obligation bonds up to $6,000. If approved by the community, the territorial legislature would assist in developing the water supply. Portales tried to take advantage of this act, but the vote failed to carry the necessary two-thirds majority.

This failure did not discourage local businessmen in their search for artesian water. They solicited money to put down two wells. This venture also failed, but it led to the conclusion that the known underground storage basin might be a better source of water than the artesian flow. In 1909 an irrigation company was organized. A power plant was constructed for pumping water on about 10,000 acres of land. The plan was feasible, but the financial burden was too heavy. After 2 years this enterprise was also abandoned.

In 1911 farmers began connecting their gasoline power units to irrigation pumps. Since 1929 the number of operating wells has increased steadily. In 1944 a field inventory recorded 516 wells in operation in Portales Valley. By 1954 the number of wells had more than doubled.

## General Patterns (soil associations)

A small-scale map in the back of this report shows soil areas (associations) within the area surveyed. The map has been generalized from the detailed maps and shows only dominant soils, not the details needed to plan use of soils on farms.

This section describes briefly each of the general areas and the principal soil series within each. The six soil associations are as follows:

### Red Sandy Land; Amarillo-Springer

Amarillo soils are reddish-brown deep loams or sandy loams that do not contain a layer of accumulated lime within 3 feet of the surface. Springer soils are more sandy and more red than the Amarillo. Both are nearly level or gently sloping. The association contains small areas of the Clovis and Arvana soils that are moderately deep over a lime layer and small areas of the very sandy, hummocky Tivoli soil.

This association occupies about 12,000 acres along the northern part of the area. Nearly half the land is irrigated for crops, chiefly grain sorghum, broomcorn, sweetpotatoes, and alfalfa. At the time of the survey the number of wells was 1 for each 100 to 150 acres of land.

[2] A copy of the MANUAL OF RULES AND REGULATIONS FOR USE OF UNDERGROUND WATERS IN DECLARED BASINS OF NEW MEXICO can be obtained by writing to the State Engineer, Santa Fe, N. Mex.

### Mixed Sandy Land; Clovis-Arvana

Clovis soils are reddish brown and contain soft lime (caliche) at 20 to 36 inches. Arvana soils are less red than the Clovis and are underlain by rocklike caliche. The soils are nearly level to gently sloping. The association contains a small proportion of Amarillo, Mansker, Kimbrough, and Blackwater soils.

This association occupies about 35,000 acres in a fairly wide transitional belt running southeast and northwest. It separates the deep soils of the Amarillo-Springer association from the Valley Fill soils. Farming in this association is diversified and is governed by variations in soil depth and texture. Crops commonly grown are cotton, peanuts, vegetables, sweetpotatoes, alfalfa, and sorghum. About half of all the wells in the irrigated area are located within the Clovis-Arvana soil association.

### Valley Fill Soils; Portales-Arch

Portales and Arch soils are forming in sedimentary deposits of strongly calcareous lime. They are characterized by an accumulated lime zone, or soft caliche, at depths ranging from 10 to 36 inches. This lime occurs at an average depth of 24 inches in the Portales soils and at an average depth of 14 inches in the Arch soils.

The Portales soils are brown to light reddish brown and moderately deep. Lime has been leached from the topsoil and upper subsoil to an average depth of 12 inches. The subsoil is a loam that forms moderately stable clods. The Arch soils are light brown and shallow. They are strongly calcareous to the surface. Stable clods will not form from their subsoil.

Minor areas of Mansker, Clovis, Kimbrough, and Blackwater soils occur within this association.

The Portales-Arch association, occupying more than 20,500 acres, is the second largest in the irrigated area. It is located along the indistinct channel of the old Brazos River. More than 17,000 acres is irrigated, with 1 well supplying water to an average of 40 acres. Cash crops are generally grown.

### Portales Springs Chalky Soils; Drake-Church

This association consists almost entirely of shallow, strongly calcareous soils. The Drake soils are weakly developed and occupy the slopes on the leeward sides of playas or enclosed depressions. They are characterized by hummocks deposited by wind and are locally known as chalk hills. The light grayish-brown Church soils occur on slopes of 0 to 1 percent in a lower position than the Drake soils. Included in this association are areas of Arch, Mansker, and Portales soils.

The Drake-Church association occupies more than 4,200 acres along the better defined channel of the ancient Brazos River. It extends in a southeasterly direction. The highly erodible soils in this association are not suited to farming. They support a good cover of saltgrasses.

### Poker Flat Chalky Soils; Arch-Drake

The shallow and strongly calcareous soils in this association have been eroded by wind. They occur on an extension of the old Brazos riverbed.

The Arch soils in this association are like the Arch soils in the Portales-Arch association except that the fine sandy loams and loamy fine sands are more common. The Drake soils are like those in the Drake-Church association. Some Portales and Mansker soils are included.

Only 2,416 acres are in this association, which is locally known as Poker Flat. When farmed, the soils in the Arch-Drake association should be kept in close-growing crops to prevent wind erosion.

### Playa Lake Chalky Soils; Drake-Mansker

The soils in this association are calcareous throughout their profiles. They are typical of the High Plains topography that is distinguished by playas. Included in this association are small areas of Church, Arch, and Potter soils.

The Drake soils in this association are like those in the Drake-Church and Arch-Drake associations. The Mansker soils are light gray to pale brown and have developed from sediments that are strongly calcareous. They are influenced by wind-sorted deposits. Weak to moderately stable clods form in the sandy loam to loam subsoil.

The Drake-Mansker soil association occupies 3,780 acres around Tierra Blanca Lake. Most of the soils occur on slopes too steep to irrigate and are too shallow or too salty to farm.

## *Soil Series and Mapping Units*

The soils of the Portales area are described in the following pages. Their location and distribution are shown on the maps at the back of this report, and their acreage and proportionate extent are given in table 2. Six monoliths of the principal soils in the surveyed area are shown in figure 3. A detailed profile description of a representative soil of each series is given in the section Classification and Morphology of Soils.

### Amarillo Series

The Amarillo series consists of deep soils with reddish-brown, noncalcareous, sandy clay loam to loam subsoils. The subsoil structure is moderate medium to coarse prismatic; it becomes weaker and indistinct in the lower subsoil. Below 36 inches the massive sandy clay loam to fine sandy loam layers are violently calcareous. Areas of slightly indurated to indurated caliche occur in many places at about 3½ feet.

Air and water move readily through the moderately permeable subsoil. Deep-rooted crops penetrate to about 4 feet. The Amarillo series is the most extensive within the area surveyed.

**Amarillo loam, 0 to 1 percent slopes** (Ae) (capability unit IIe-1).—This soil is not so red as the sandier members of the Amarillo series, and its surface layer is more granular and has better tilth.

The surface soil compacts readily if it is tilled or grazed when it is wet. The average intake of irrigation water is about 1 inch per hour if a compact tillage pan is present. If the soil is not compact, intake rates of 1½ inches per hour may be expected. The average refill irrigation (the amount of moisture required to replace that which has been extracted from the soil by a rapidly growing crop) is about 5 inches for deep-rooted crops. Irrigations of 7 inches may be needed before

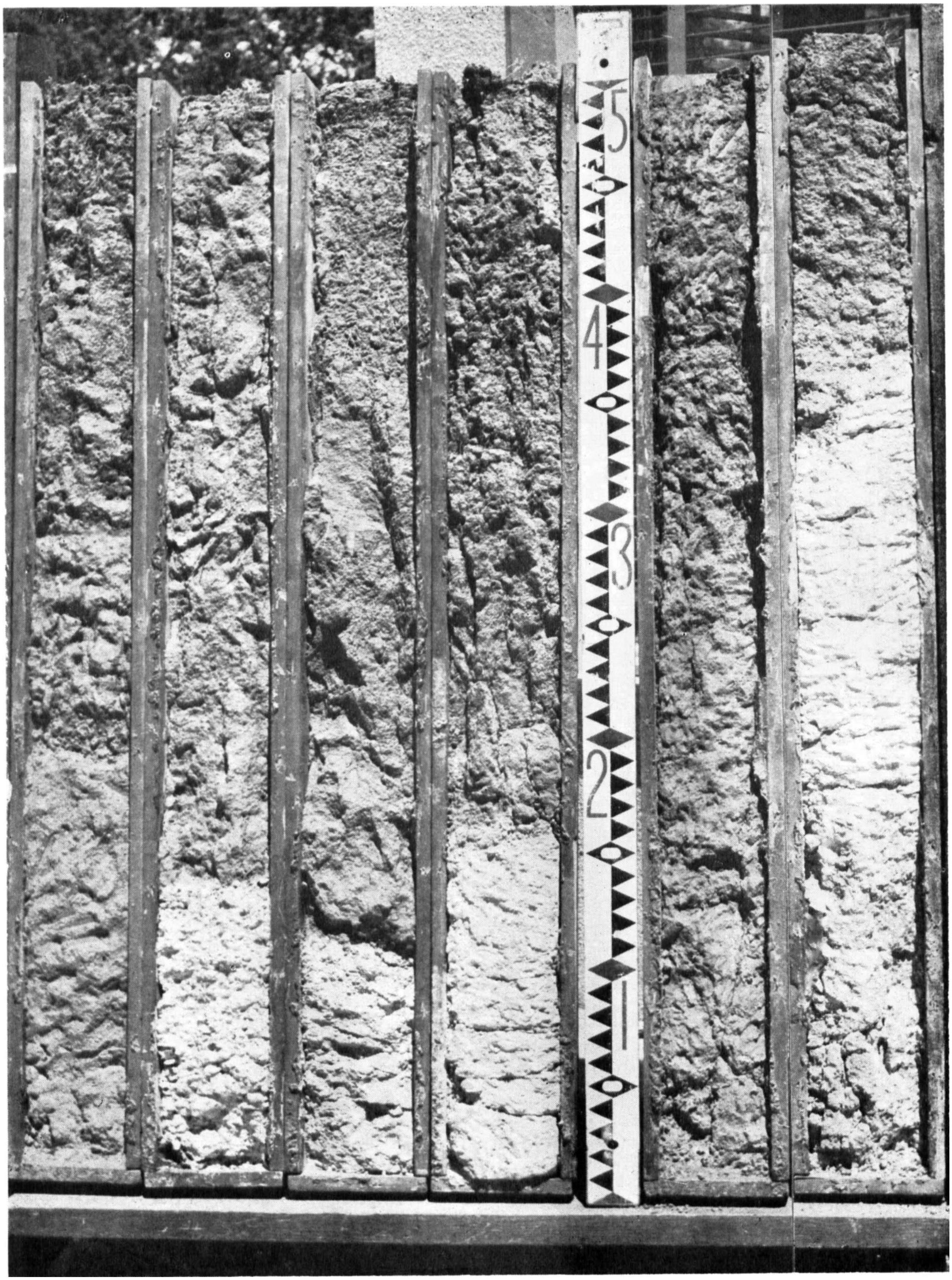


*Figure 3.*—Soil monoliths (left to right) of principal soils  n the irrigated area: Amarillo fine sandy loam, Springer loamy fine sand, Amarillo loamy fine sand, Clovis fine sandy loam, Amarillo loam, and Kimbrough loam.

TABLE 2.—*Approximate acreage and proportionate extent of the soils*

| Soils | Acres | Percent |
|---|---|---|
| Amarillo loam, 0 to 1 percent slopes | 717 | 1.0 |
| Amarillo fine sandy loam, 0 to 1 percent slopes | 5,769 | 7.2 |
| Amarillo fine sandy loam, 0 to 1 percent slopes, wind eroded | 104 | .1 |
| Amarillo fine sandy loam, 1 to 3 percent slopes | 306 | .4 |
| Amarillo fine sandy loam, 1 to 3 percent slopes, wind eroded | 317 | .4 |
| Amarillo loamy fine sand, 0 to 3 percent slopes | 5,768 | 7.2 |
| Amarillo loamy fine sand, 0 to 3 percent slopes, wind eroded | 1,223 | 1.5 |
| Arch loam, 0 to 1 percent slopes | 4,370 | 5.4 |
| Arch fine sandy loam, 0 to 1 percent slopes | 1,772 | 2.2 |
| Arch fine sandy loam, 0 to 1 percent slopes, wind eroded | 644 | 1.0 |
| Arch loamy fine sand, 0 to 1 percent slopes, wind eroded | 275 | .3 |
| Arvana loam, 0 to 1 percent slopes | 1,355 | 1.7 |
| Arvana fine sandy loam, 0 to 1 percent slopes | 3,585 | 4.5 |
| Arvana fine sandy loam, 0 to 1 percent slopes, wind eroded | 262 | .3 |
| Arvana loamy fine sand, 0 to 1 percent slopes | 1,114 | 1.4 |
| Arvana loamy fine sand, 0 to 1 percent slopes, wind eroded | 1,329 | 1.6 |
| Blackwater loam, 0 to 1 percent slopes | 1,393 | 1.7 |
| Blackwater loam, marl substratum variant, 0 to 1 percent slopes | 428 | .5 |
| Church loam, 0 to 1 percent slopes | 337 | .4 |
| Church loam, 0 to 1 percent slopes, wind eroded | 122 | .1 |
| Church clay loam, 0 to 1 percent slopes | 1,811 | 2.2 |
| Clovis fine sandy loam, 0 to 1 percent slopes | 6,386 | 8.0 |
| Clovis fine sandy loam, 0 to 1 percent slopes, wind eroded | 345 | .4 |
| Clovis fine sandy loam, 1 to 3 percent slopes | 535 | .7 |
| Clovis loam, 0 to 1 percent slopes | 3,666 | 4.6 |
| Clovis loamy fine sand, 0 to 3 percent slopes | 1,030 | 1.3 |
| Clovis loamy fine sand, 0 to 3 percent slopes, wind eroded | 1,627 | 2.0 |
| Drake fine sandy loam, 1 to 5 percent slopes | 2,099 | 2.6 |
| Drake fine sandy loam, 1 to 5 percent slopes, wind eroded | 197 | .2 |
| Drake loam, 1 to 5 percent slopes | 1,447 | 2.0 |
| Kimbrough fine sandy loam, thick solum variant, 0 to 1 percent slopes | 904 | 1.1 |
| Kimbrough loam, thick solum variant, 0 to 1 percent slopes | 1,131 | 1.4 |
| Kimbrough loamy fine sand, thick solum variant, 0 to 1 percent slopes | 416 | .5 |
| Kimbrough loamy fine sand, thick solum variant, 0 to 1 percent slopes, wind eroded | 428 | .5 |
| Mansker fine sandy loam, 0 to 1 percent slopes | 1,881 | 2.3 |
| Mansker fine sandy loam, 0 to 1 percent slopes, wind eroded | 623 | 1.0 |
| Mansker fine sandy loam, 1 to 3 percent slopes | 687 | 1.0 |
| Mansker loam, 0 to 1 percent slopes | 2,537 | 3.1 |
| Mansker loam, 1 to 3 percent slopes | 573 | .7 |
| Mansker loamy fine sand, 0 to 3 percent slopes | 416 | .5 |
| Mansker loamy fine sand, 0 to 3 percent slopes, wind eroded | 544 | .7 |
| Portales loam, 0 to 1 percent slopes | 9,216 | 11.6 |
| Portales fine sandy loam, 0 to 1 percent slopes | 3,510 | 4.0 |
| Portales fine sandy loam, 0 to 1 percent slopes, wind eroded | 349 | .4 |
| Portales loamy fine sand, 0 to 1 percent slopes | 193 | .2 |
| Portales loamy fine sand, 0 to 1 percent slopes, wind eroded | 330 | .4 |
| Portales silt loam, 0 to 1 percent slopes | 217 | .3 |
| Potter fine sandy loam, 0 to 5 percent slopes | 404 | .5 |
| Potter loam, 0 to 1 percent slopes | 508 | .6 |
| Potter loamy fine sand, 0 to 3 percent slopes | 287 | .3 |
| Springer loamy fine sand, 0 to 5 percent slopes | 1,825 | 2.3 |
| Springer loamy fine sand, 0 to 5 percent slopes, wind eroded | 608 | .7 |
| Sand dunes<br>Tivoli fine sand | 482 | .6 |
| Roads, farmsteads, etc | 1,908 | 2.4 |
| Total | 80,310 | 100.0 |

planting time to refill 3½ feet of dry soil. The loss of water in ditches is 2 gallons per minute per 100 feet of ditch.

This is one of the most productive soils in the county. It ranks first in cotton yields and second in peanuts. All locally adapted crops can be grown successfully on it.

**Amarillo fine sandy loam, 0 to 1 percent slopes** (Aa) (capability unit IIIs–1).—This soil does not have such good tilth as Amarillo loam, 0 to 1 percent slopes. Furthermore, it has a weaker and less granular structure. Tillage pans, or traffic pans, are formed easily in both soils.

The average intake of irrigation water ranges from 2 to 3 inches per hour when the soil is firm to less than 1 inch if a compact tillage pan is present. The average refill irrigations for mature deep-rooted crops are 4 to 5 inches. Preplanting irrigations of 6 to 7 inches may be required to fill 4 to 5 feet of dry soil. Measured ditch loss is 7 gallons per minute per 100 feet of ditch.

Winds readily blow the silt and clay from the fine sandy loam surface of this soil. Wind erosion can be reduced by planting close-growing crops or by leaving 10 to 14 inches of sorghum stubble on the surface during the dry season. Timely irrigation and listing across the direction of the prevailing wind are other measures for controlling wind erosion.

This soil is suitable for all crops locally grown. The average yields for cotton and peanuts are about midway among the 19 soils used for these crops.

**Amarillo fine sandy loam, 0 to 1 percent slopes, wind eroded** (Ab) (capability unit IVe–1).—This soil is like Amarillo fine sandy loam, 0 to 1 percent slopes, except that its surface is more windblown and the supply of organic matter is lower. The fields are so hummocky that it is difficult to irrigate them. Such areas should be leveled and planted to close-growing crops, as alfalfa and pasture grasses.

**Amarillo fine sandy loam, 1 to 3 percent slopes** (Ac) (capability unit IIIs–1).—This deep soil differs little from Amarillo fine sandy loam, 0 to 1 percent slopes, except that it has stronger slopes and is characteristically more red.

If this soil is bench-leveled and irrigated, use and management are similar to those of Amarillo fine sandy loam, 0 to 1 percent slopes. Some areas not bench-leveled may be furrow-irrigated if nonerosive flows are used. Areas that cannot be leveled or irrigated can be dry-farmed, left in grass, or replanted to grass and thus used as range.

**Amarillo fine sandy loam, 1 to 3 percent slopes, wind eroded** (Ad) (capability unit IVe–1).—Sand accumulates in hummocks on this soil. It is somewhat redder than Amarillo fine sandy loam, 0 to 1 percent slopes, wind eroded phase, but the irrigated areas of the two soils can be treated and managed in the same way. It is necessary to relevel this soil in order to irrigate. Close-growing crops such as alfalfa and pasture grasses are the most suitable.

**Amarillo loamy fine sand, 0 to 3 percent slopes** (Ag) (capability unit IVe–1).—This soil has a rougher surface and poorer tilth than the loams or fine sandy loams of the Amarillo series. There are subdued dunes in some places. The soil is less cloddy and slightly more reddish than other members of the Amarillo series.

The loamy fine sand surface soil is subject to wind erosion if it is row cropped or left without cover during the blowing season. During this period sorghum stubble 10 to 14 inches high should be left on the surface and should not be grazed.

When this soil is firm, it has an intake rate of more than 2 inches of water per hour. The average refill irrigation for mature deep-rooted crops is 4 inches. Ditch losses are high. Large nonerosive flows of water are needed to irrigate quickly and efficiently.

The soil is extremely low in available nitrogen and phosphorus. It is not suited to cotton and peanuts, because these crops do not leave enough residue to control blowing. It is better for alfalfa, grain sorghum, and sweetpotatoes, but yields are low under average practices.

**Amarillo loamy fine sand, 0 to 3 percent slopes, wind eroded** (Ah) (capability unit VIe–2).—This soil is rougher and more windblown than Amarillo loamy fine sand, 0 to 3 percent slopes. The dunes are more prominent. The surface soil has a very loose, sandy, single-grain structure.

The fields have blown so extensively that efforts to reclaim them for irrigation do not appear to be feasible, nor are any efforts toward reclamation. Since this soil is not productive and is highly subject to blowing, it is best to seed it to grass.

The small hummocks should be leveled and the field deep broken and planted to sorghum or sudangrass. Grass should be planted the following spring in the stubble. These areas should not be grazed until the grass is well established.

## Arch Series

Soils of the Arch series are shallow and do not show much development from the wind-sorted alluvial sediments. At depths between 10 and 20 inches the subsoil is a chalky fine sandy loam or loam that has very little structure. Most of the roots are in the light-brown surface soil above this layer.

Water and air enter Arch soils easily. Because of the shallowness of these soils, refill irrigations of 3 to 4 inches are the most efficient. Crops should be irrigated more often than on the deeper soils.

Because the profile of Arch soils is calcareous throughout, the natural resistance to wind erosion is low. These chalky soils lack the ability to form aggregates strong enough to form a cloddy surface. Emergency tillage is therefore not effective. The farmer must rely on a good plant cover to control wind erosion on Arch soils.

**Arch loam, 0 to 1 percent slopes** (An) (capability unit IVs–3).—This soil is somewhat darker brown than the sandier soils of the Arch series. It also has a thin semi-indurated caliche layer in places. The surface 6 to 8 inches has a weak granular structure in some areas.

The average refill irrigation is 2 to 3 inches for crops with mature root systems. Intake rates average 1½ inches per hour. Tillage pans are not common, but thin semi-indurated caliche pans occur in places. These pans slow the movement of moisture in the subsoil. Deep chiseling to crush these layers may result in increased crop yields.

Because this soil blows easily, cotton and peanuts are not suited to it. Alfalfa, sorghum, small grains, and irrigated pasture are suitable. So long as suitable crops are grown, wind erosion should not be serious.

**Arch fine sandy loam, 0 to 1 percent slopes** (Ak) (capability unit IVs–3).—This soil is light brown and has a weak granular to single grain structure in the topmost 8 inches.

Water and air penetrate readily. The water intake averages 2½ inches per hour. Tillage pans are not common, but some areas may have thin impervious caliche layers like those underlying Arch loam, 0 to 1 percent slopes.

Wind erosion is a potential risk on this soil. Only such crops as alfalfa, sudangrass, and irrigated pasture should be grown. Grain sorghum may be planted occasionally if it is not grazed, but peanuts and cotton should not be grown.

**Arch fine sandy loam, 0 to 1 percent slopes, wind eroded** (Am) (capability unit VIe–3).—This soil contains many blowout spots where severe wind erosion has exposed the chalky subsoil. The surface soil has no structure and is grayer than that of Arch fine sandy loam, 0 to 1 percent slopes.

This soil is best suited to grass. Most of the areas will need to be reseeded.

**Arch loamy fine sand, 0 to 1 percent slopes, wind eroded** (Ao) (capability unit VIe–3).—In numerous blowout spots severe wind erosion has exposed the white chalky substratum. There are many sand hummocks 12 to 36 inches high and a few larger dunes. The surface soil has a single-grain structure.

The hummocks and undulating fields that have been blown severely should be seeded to grass. A protective cover of plants or crop residue should be left on the surface at all times.

The hummocky, undulating, eroded fields are best suited to grass. A protective cover of crop residue is needed in order to establish perennial grasses.

## Arvana Series

Soils of the Arvana series are brown to reddish brown and noncalcareous. They have a dense rocklike layer of hard caliche 20 to 36 inches below the surface.

Arvana soils have moderate very coarse (2 to 4 inches) subangular blocky structure in the subsoil. The aggregates are friable when moist, slightly plastic when wet, and hard when dry.

Tilth is good. Air and water penetrate at a moderate rate if there is no tillage pan.

When cuts are necessary to level the surface, they should not exceed one-fourth the depth at which the underlying hard caliche occurs. If an underground pipe is to be installed, this caliche layer usually limits the maximum depth at which the pipe can be buried.

**Arvana loam, 0 to 1 percent slopes** (As) (capability unit IIs–1).—This soil has a dark-brown surface soil with excellent tilth and a strong granular structure in the upper 6 or 8 inches. The content of organic matter is above the average for soils in the area.

The rate of water intake averages 1 to 1½ inches per hour if the soil is not compact. Where there is a tillage pan, this rate is reduced to less than 1 inch per hour. This soil will hold about 4 inches of readily available moisture. It is quite resistant to wind erosion. If the cover is not adequate to control erosion, rough tillage is effective in an emergency. Under irrigation, erosion does not exceed 1 ton per acre.

This soil is suited to all crops locally grown. It is very good for peanuts and cotton.

**Arvana fine sandy loam, 0 to 1 percent slopes** (Ap) (capability unit IIIs–2).—This soil is brown to reddish brown; it has good tilth and a moderate granular structure in the surface layer. Its content of organic matter is somewhat less than that in Arvana loam, 0 to 1 percent slopes.

This soil will hold about half an inch less of readily available moisture than Arvana loam, 0 to 1 percent slopes, because its surface soil is more sandy. The intake rate is about 2 inches per hour.

This soil is moderately susceptible to wind erosion. Blowing can be reduced by planting close-growing crops or by leaving 10 to 14 inches of sorghum stubble on the surface during windy spring months. Timely irrigation and listing crosswise to the prevailing wind are other measures to help control wind erosion.

A small acreage of Arvana fine sandy loam, 1 to 3 percent slopes, is included with this soil. Most of these areas are not suitable for bench leveling, because of the shallow depth to caliche.

Arvana fine sandy loam, 0 to 1 percent slopes, is suited to all crops locally grown. In peanut and cotton production it ranks midway among the 19 soils used for these crops.

**Arvana fine sandy loam, 0 to 1 percent slopes, wind eroded** (Ar) (capability unit VIe–2).—This soil has numerous 12- to 24-inch hummocks and some caliche outcrops. Because the reddish-brown subsoil has been exposed by erosion, this soil is redder than uneroded areas of Arvana fine sandy loam.

This soil has been severely eroded (loss of more than 5 tons per acre) and should be seeded to grass. Reclaiming it for irrigation is not feasible.

**Arvana loamy fine sand, 0 to 1 percent slopes** (At) (capability unit IVe–2).—This soil is redder than the Arvana loams, contains less organic matter, and does not have the granular surface soil. Nevertheless, the surface soil is deeper, or 10 to 12 inches thick. The soil has a subdued dunelike appearance when in native grass.

The average intake rate of this soil is about 2 inches per hour. The capacity to hold readily available moisture is low, or from 2½ to 3½ inches.

If crops not suited to this soil are grown, the hazard of wind erosion will be severe. About half of the original acreage of this soil is now Arvana loamy fine sand, 0 to 1 percent slopes, wind eroded. This emphasizes the risk of wind erosion. Soil losses are moderate (1 to 2 tons per acre) even under careful management.

Cotton, peanuts, and sweetpotatoes are not suitable, because the surface soil is sandy. The crops that can be grown are sorghum, alfalfa, and pasture.

**Arvana loamy fine sand, 0 to 1 percent slopes, wind eroded** (Au) (capability unit VIe–2).—This soil is more hummocky than Arvana fine sandy loam, 0 to 1 percent slopes, wind eroded, but the color and structure of the two soils are the same. The depth to the underlying reddish-brown subsoil ranges from 10 to 12 inches. This wind-eroded soil should be seeded to grass.

## Blackwater Series

The soils in the Blackwater series are dark brown. They are noncalcareous to within a few inches of the hard caliche, which underlies a clay loam subsoil of strong medium blocky structure. The rocklike caliche occurs at depths of 16 to 18 inches.

The aggregates in the subsoil are 1- to 2-inch angular blocks. They are very hard when dry, firm when moist, and very plastic when wet. Because of the tight subsoil, the movement of air and water is slow and root penetration is restricted.

The soils of the Blackwater series are characterized by their narrow streamlike patterns.

**Blackwater loam, 0 to 1 percent slopes** (Ba) (capability unit IVs–1).—The average intake rates for this soil are 1 inch per hour or less, because it has a compact, blocky, heavy clay loam subsoil. The capacity to hold readily available moisture is low, or 2½ to 3 inches, since the soil is 16 to 18 inches deep to hard caliche. Wind erosion is not significant.

This soil often occurs as narrow bands across fields of soils that have higher intake rates and a higher readily available moisture capacity. The irrigation layout in such fields is designed to water the more permeable adjacent soils. The crops on Blackwater loam, therefore, are likely to show stress and reduced growth, because the soil does not get enough water and has very low capacity for holding readily available moisture. Cuts for leveling Blackwater loam should not be deeper than one-fourth the normal depth to the underlying caliche.

Yields of sorghum and cotton are about average on this soil. Yields of alfalfa and sweetpotatoes are low, and these crops are not well suited.

**Blackwater loam, marl substratum variant, 0 to 1 percent slopes** (Bb) (capability unit IIs–2).—This soil does not have the hard caliche substratum characteristic of the Blackwater soils. Instead, at depths of 28 to 36 inches there is light-gray marly clay loam. The subsoil is similar to that of Blackwater loam, 0 to 1 percent slopes, and is slowly permeable to air and water. Wind erosion is not serious.

The capacity of this soil to hold readily available moisture ranges from 4 to 5 inches. The average intake rates are 1 inch per hour, or less.

Most of this soil is farmed. The crops most suitable are sorghum and cotton. Sweetpotatoes and alfalfa do not yield so well as on soils that have a more permeable subsoil.

## Church Series

Soils of the Church series are grayish brown and strongly calcareous. They occupy first terraces around enclosed basins. Many of them are high in soluble salts, which are extremely difficult to leach through the clay subsoil.

The subsoil in the Church series is a clay to silty clay loam that has moderate aggregation. The structure is medium (¾ to 1 inch) subangular blocky. The material below the subsoil is massive and violently calcareous.

When the native grass sod is destroyed by tillage,the surface soil soon loses its granular structure and becomes powdery. Then the soils blow readily and water penetrates very slowly into the subsoil.

**Church loam, 0 to 1 percent slopes** (Cb) (capability unit VIs-1).—This soil is grayish brown and has a moderate granular structure. Where a dense stand of tobosa occurs, the surface is smooth and level. If this protective cover is overgrazed, shallow blowouts develop.

This soil occurs principally as first terraces within small playas. It is not suitable for cultivation. It is best suited to salt-tolerant native grasses such as tobosa.

**Church loam, 0 to 1 percent slopes, wind eroded** (Cc) (capability unit VIIe-2).—This soil has no protective cover. The salt-encrusted surface is undulating. Many grayish-brown, small, silty dunes are present.

This soil has been severely eroded. All of the surface soil is gone, and the subsoil has become impervious to air and water.

This soil is not suited to cultivation. It should be fenced to exclude grazing until cover is well established.

**Church clay loam, 0 to 1 percent slopes** (Ca) (capability unit VIs-1).—Except for texture, this soil differs little from Church loam, 0 to 1 percent slopes. It is the most extensive soil within the Church series and occurs principally along the Portales Springs drainage area.

On this saline soil, native salt-tolerant grasses such as tobosa will grow best.

## Clovis Series

Soils of the Clovis series are moderately deep. They have a zone of accumulated lime at an average depth of 32 inches that limits root penetration. Clovis soils are much like those of the Amarillo series in color, structure, and texture of the subsoil. Prisms 1 to 3 inches in size become weaker with depth. The lower subsoil is massive. A few to many, medium to large caliche fragments occur below a depth of 32 inches.

The subsoil of the Clovis soils is moderately permeable to air and water. Only a few roots go into the zone of accumulated lime.

**Clovis fine sandy loam, 0 to 1 percent slopes** (Cd) (capability unit IIIs-2).—This reddish-brown soil has good tilth and a weak fine granular surface soil. It is much like Amarillo fine sandy loam, 0 to 1 percent slopes, except that the soft caliche zone in this soil is not so deep. Also, like Amarillo fine sandy loam, 0 to 1 percent slopes, its rate of moisture intake is 2 to 3 inches per hour, but a compact layer will reduce this rate by more than half. The average refill irrigation is 3 inches for crops with mature root systems.

The measured loss of water from percolation in ditches is 7 gallons per minute per 100 feet of ditch. The installation of an underground pipeline will prevent this loss.

Wind erosion can be severe on this soil if the plant cover is not sufficient. Emergency tillage to create a cloddy surface is effective in controlling wind erosion. All crops common to the area can be grown on this soil.

**Clovis fine sandy loam, 0 to 1 percent slopes, wind eroded** (Ce) (capability unit VIe-2).—This soil is more reddish than the uneroded Clovis fine sandy loam because its red subsoil has been exposed by erosion. The surface soil has poor granular structure and tilth. Some accumulations of sand 12 to 24 inches high also occur on the eroded areas.

Areas of this soil are too severely eroded to be used for crops. A cover crop usually should be planted before trying to establish perennial grasses.

**Clovis fine sandy loam, 1 to 3 percent slopes** (Cg) (capability unit IIIs-2).—This soil can be bench-leveled and irrigated, but cuts should not be made deeper than one-fourth of the depth to accumulated lime. Some areas not bench-leveled may be furrow-irrigated if nonerosive flows are used.

**Clovis loam, 0 to 1 percent slopes** (Ch) (capability unit IIs-1).—This soil has slightly more organic matter in the surface layer than the sandier soils of the Clovis series; consequently, the red color is subdued and the surface soil is browner. This soil is similar to Amarillo loam, 0 to 1 percent slopes, in tilth and in soil-moisture relationship.

Clovis loam, 0 to 1 percent slopes, can hold between 4 and 5 inches of moisture that is readily available to crops that have mature root systems.

This soil is naturally resistant to wind erosion. If cover is not maintained, adequate emergency tillage can be used to create a rough, cloddy surface to help control erosion.

All crops that are grown locally can be grown on this soil.

**Clovis loamy fine sand, 0 to 3 percent slopes** (Ck) (capability unit IVe-2).—This soil is distinctly more reddish brown than the heavier soils of the Clovis series. There is no granular structure in the surface soil, and tilth is poor. The thickness of the loamy fine sand overlying the subsoil averages 10 inches. The surface soil blows readily.

Losses from wind erosion of more than 5 tons per acre have been measured in wind-tunnel studies on this soil. Row crops such as cotton and peanuts do not leave enough residue to control blowing. It is best to leave sorghum stubble 12 to 14 inches high.

When firm, this soil can absorb water faster than 2 inches per hour. The readily available moisture capacity is 2½ to 4 inches for crops with mature root systems. Ditch losses usually are more than 7 gallons per minute per 100 feet of ditch. Underground pipelines will prevent this loss.

Alfalfa, irrigated pasture, sorghum, and sweetpotatoes are suitable crops. Although good yields of broomcorn and grain sorghum have been produced, the yields of cotton and peanuts have been low. The last two crops are not suited, because they do not leave enough residue to control blowing.

**Clovis loamy fine sand, 0 to 3 percent slopes, wind eroded** (Cm) (capability unit VIe-2).—The extent of this eroded soil indicates the risk of blowing whenever Clovis loamy fine sand, 0 to 3 percent slopes, is cultivated. Eroded areas may be plowed to a depth of 16 to 18 inches to bring up the cloddy subsoil. This will allow establishment of a protective cover of sorghum stubble in which to seed grass.

## Drake Series

The landmarks locally called chalk hills are characteristic of the Drake series of soils. These soils blow readily. They are the weakly developed, strongly calcareous soils that occupy the eastern and northeastern slopes of enclosed depressions or playas.

**Drake fine sandy loam, 1 to 5 percent slopes** (Da) (capability unit VIe–3).—This very pale brown soil has a high content of lime. The lime is scattered throughout the profile, and the soil is chalky.

This soil is best used for grass. A few slopes having gradients of 1 to 2 percent are farmed with some success if the more lime-tolerant crops, such as alfalfa or cotton, are planted.

**Drake fine sandy loam, 1 to 5 percent slopes, wind eroded** (Db) (capability unit VIe–3).—This inextensive soil has many medium to large shifting dunes. These eroded places should be fenced to prevent further trampling by livestock, and then seeded to grass.

**Drake loam, 1 to 5 percent slopes** (Dc) (capability unit IVe–3).—This soil differs little from Drake fine sandy loam, 1 to 5 percent slopes, except that much of it occurs on slopes of 1 to 3 percent. Under native grass it contains a little more organic matter than Drake fine sandy loam under similar cover.

This soil is best used for grass. Small areas are planted to alfalfa and cotton, although the yields are low. Tillage increases the hazard of wind erosion, since stable aggregates are not formed.

## Kimbrough Series

Soils of the Kimbrough series are dark brown to reddish brown, noncalcareous, and shallow. The heavy loam or clay loam subsoil is of moderate structure and contains subangular blocky aggregates of medium size. The subsoil overlies a layer of hard caliche at depths of less than 10 to about 20 inches.

**Kimbrough fine sandy loam, thick solum variant, 0 to 1 percent slopes** (Ka) (capability unit IVs–3).—This soil resembles Arvana fine sandy loam, 0 to 1 percent slopes, in color and structure. The fine sandy loam surface soil is about 6 inches deep.

The average intake of irrigation water is 2½ inches per hour if the soil is firm. If the soil is compact, the intake may be less than 1 inch per hour. The readily available moisture capacity is very low, or from 1½ to 2½ inches.

At least 12 inches of sorghum stubble should be kept on the soil late in winter and early in spring to protect the soil from blowing. If it is left unprotected, chiseling or listing should be used as an emergency measure to control blowing.

Suitable crops are alfalfa, sorghum, and irrigated pasture. Yield data have not been recorded for this soil, but it would be expected to have yields slightly less than those of Kimbrough loam, thick solum variant, 0 to 1 percent slopes.

**Kimbrough loam, thick solum variant, 0 to 1 percent slopes** (Kb) (capability unit IIIs–3).—This soil is somewhat darker than the sandier Kimbrough soils. It has slightly better tilth and a stronger granular structure in the surface layer.

A water intake of 1 to 1½ inches per hour may be expected where the soil is firm. If a compact tillage pan is present, an intake may be less than 1 inch per hour. A 2½- to 3-inch irrigation will normally meet the refill requirements of deep-rooted crops on this shallow soil. For greatest yields of crops, however, this soil needs more frequent irrigations than moderately deep to deep soils.

Wind erosion is not severe on this soil. If blowing starts, emergency tillage to bring up clods is effective.

This soil is suited to cotton, peanuts, sorghum, truck crops, alfalfa, and irrigated pasture.

**Kimbrough loamy fine sand, thick solum variant, 0 to 1 percent slopes** (Kc) (capability unit VIe–3).—This reddish-brown soil has weak granular structure in the surface soil. Under native grass the topography has a subdued dunelike appearance. This soil is too sandy and droughty to farm safely. It is best used as rangeland.

**Kimbrough loamy fine sand, thick solum variant, 0 to 1 percent slopes, wind eroded** (Kd) (capability unit VIe–3).—This soil has the reddish-brown color of the noneroded Kimbrough loamy fine sand, but it has no granular structure in the surface soil. Areas containing dunes of moderate size are interspersed with blowouts or rock outcrops.

This soil blows easily and is more extensive than the similar noneroded soil. The areas should be fenced to exclude livestock so that native grasses can be established.

## Mansker Series

Soils of the Mansker series are well drained, strongly calcareous, and moderately deep. Under native vegetation the surface soil has weak medium granular structure. The subsoil, a moderately heavy loam to clay loam, has weak to moderate coarse prismatic structure that breaks to weak medium granules. At moderate depths, 20 to 26 inches, a very strongly calcareous zone of marl occurs. With increasing depth, there are many loose, cobble-sized caliche rocks.

It is difficult for machinery to compact Mansker soils because they contain so much lime and gravel. Therefore, tillage pans are not formed as they are in the finer textured noncalcareous soils of the area, and the movement of air and water through the soils is not retarded. The Mansker soils do not form stable clods when tilled, and they are highly subject to wind erosion.

**Mansker fine sandy loam, 0 to 1 percent slopes** (Ma) (capability unit IVe–2).—This soil is strongly calcareous to the surface. It has much caliche gravel throughout the profile. Tilth is poor, and the surface soil is of weak granular structure.

The readily available moisture capacity of the soil is between 3 and 4 inches for crops with mature root systems. The average intake rate is about 2 inches per hour.

Lime-induced chlorosis is serious on this soil. It can be reduced somewhat by adding barnyard manure to the annual applications of nitrogen and phosphorus. Plowing under a green-manure crop is also a good soil-building practice.

Rough tillage and deep plowing do not effectively control erosion on this soil, because the high content of lime throughout the profile prevents the formation of clods.

Mansker fine sandy loam, 0 to 1 percent slopes, is suited to limited farming. Suitable crops are sorghum, alfalfa, irrigated pasture, and small grains. Yields of cotton and peanuts are below average.

**Mansker fine sandy loam, 0 to 1 percent slopes, wind eroded** (Mb) (capability unit VIe-2).—This soil is like the uneroded Mansker fine sandy loam, 0 to 1 percent slopes, in color and structure but includes many small, active dunes. Some small areas show a rough, dunelike, windblown topography. The dunes are 24 to 36 inches high.

This eroded soil is indicative of the hazards of blowing common to all Mansker soils, particularly the sandy types. It should be seeded and then fenced to exclude livestock until the area is stabilized.

**Mansker fine sandy loam, 1 to 3 percent slopes** (Mc) (capability unit IVe-2).—This soil is suitable for cultivation only if it is leveled to conform to the grade of the irrigated soils adjoining it. It is more sloping than Mansker fine sandy loam, 0 to 1 percent slopes, but is otherwise similar. Cuts made in leveling should not exceed 1 foot. Manure helps restore the productivity of cut areas. It is best to leave extensive areas in grass.

**Mansker loam, 0 to 1 percent slopes** (Md) (capability unit IVs-2).—This soil is similar to the other soils in the Mansker series, but it has a darker color, somewhat better tilth, and some granular structure in the surface soil.

A moisture intake rate of about 2 inches per hour can be expected. This intake is slightly higher than for the noncalcareous loams in the area.

Although the surface soil is a loam, wind erosion is a hazard. A protective cover is essential. This is the most extensive of the Mansker soils surveyed. Suitable crops are sorghum, alfalfa, irrigated pasture, and small grains. Yields are slightly below average.

**Mansker loam, 1 to 3 percent slopes** (Me) (capability unit IVs-2).—This soil differs from Mansker loam, 0 to 1 percent slopes, only in its lighter color, poorer tilth, and greater slope. It occurs near the breaks of slopes in close association with soils of the Clovis and Potter series.

If this soil is farmed under irrigation, flows in the furrows should be nonerosive. Small areas that occur with other soils can be leveled to the suitable irrigation grade. Cuts made in leveling should not be deeper than 1 foot. In most places the stronger slopes are best suited to grass.

**Mansker loamy fine sand, 0 to 3 percent slopes** (Mg) (capability unit VIe-2).—This pale-brown soil has a very loose, strongly calcareous surface soil that blows readily. The surface soil ranges from 8 to 12 inches in thickness; it is 2 to 6 inches thicker than the surface layer of other soils in the Mansker series. This soil is otherwise similar to the other soils in the series. This soil is best used for grass.

**Mansker loamy fine sand, 0 to 3 percent slopes, wind eroded** (Mh) (capability unit VIe-2).—This soil is similar to Mansker fine sandy loam, 0 to 1 percent slopes, wind eroded, except that the wind accumulations are larger and more typically dunelike. Most of the dunes are more than 36 inches high.

This eroded soil occupies more acreage than the noneroded Mansker loamy fine sand, 0 to 3 percent slopes. The eroded areas should be fenced to keep the livestock from trampling until the soil is stabilized. Grass should be seeded, and a protective cover ought to be kept on the ground at all times.

## Portales Series

The surface soil of the Portales soils is noncalcareous or only slightly calcareous. The subsoil is a loam. The upper part of the subsoil has a weak coarse prismatic structure, whereas the lower part has a weak to moderate coarse subangular blocky structure.

Portales soils are moderately deep, and the lime zone is prominent at 20 to 36 inches. The lime is composed of soft, chalklike, medium to fine lacustrine sediments similar to underlying Blackwater loam, marl substratum variant, 0 to 1 percent slopes, and those in the substratum of the associated soils of the Arch series.

Normally, air and water move readily through the subsoil of the Portales soils. In some places, however, there are inclusions of thin lenses of semi-indurated caliche.

**Portales loam, 0 to 1 percent slopes** (Pc) (capability unit IIs-1).—This brown soil has a strong granular structure and excellent tilth. The relief is smooth and level.

Where the soil is firm, the intake of moisture averages between 1½ and 2 inches per hour. If the soil is compact, the intake rate will be reduced to 1 inch or less per hour. For good yields of well-established crops, a refill irrigation of 4 inches is normally adequate.

Wind erosion normally can be controlled on this soil by maintaining a good plant cover. Sorghum stubble should be left 10 to 14 inches high. If residues from row crops are not enough to control blowing, rough tillage is effective in an emergency.

This soil is one of the best of the soils studied as a producer of cotton and peanuts. It is suitable for all the crops that are grown in the area.

**Portales fine sandy loam, 0 to 1 percent slopes** (Pa) (capability unit IIIs-2).—This reddish-brown soil has good tilth and a moderate granular structure.

The water intake rates will average 2½ inches per hour under favorable conditions. Compaction of the soil by tillage implements will reduce this rate to 1 inch or less. A 3-inch refill irrigation is enough to get good yields of well-established crops. To prevent overirrigation on this sandy soil, somewhat larger irrigation heads may be desirable than on the soils that have slower intake rates.

If the surface cover on this soil is not enough during the blow season, emergency tillage 8 to 10 inches deep will create a cloddy surface and reduce wind erosion.

Portales fine sandy loam, 0 to 1 percent slopes, is suited to all locally grown crops. Good yields of sweetpotatoes, alfalfa, and sorghum are obtained. Yields of peanuts and cotton often are low.

**Portales fine sandy loam, 0 to 1 percent slopes, wind eroded** (Pb) (capability unit VIe-2).—This soil differs from Portales fine sandy loam, 0 to 1 percent slopes, in having hummocky areas and blowout spots where the soft caliche layer is exposed. Undulating areas, with sand accumulations about 2 feet high, and more severely eroded, hummocky blowout areas are about equal in extent. This soil is best used for grass.

**Portales loamy fine sand, 0 to 1 percent slopes** (Pd) (capability unit IVe-2).—This soil is susceptible to wind erosion because of poor tilth and little if any granular structure. The thickness of the surface soil averages 10 inches, which is 2 to 4 inches thicker than the surface soil of other members of the Portales series. The topography is undulating.

The average intake rate of this soil normally is more than 2 inches per hour. The readily available moisture capacity ranges from 2½ to 3½ inches for crops that have mature root systems.

Yields of alfalfa, sorghum, and sweetpotatoes are low. Cotton and peanuts do not produce enough residue to control blowing and, therefore, are not suitable. Poor stands of these crops are often obtained as a result of blowing.

**Portales loamy fine sand, 0 to 1 percent slopes, wind eroded** (Pe) (capability unit VIe-2).—This soil differs from Portales fine sand, 0 to 1 percent slopes, in having many medium to large blowout spots scattered over the surface. In the bottom of these blowout areas, the light-gray substratum is exposed. The dunes on this soil may reach 6 feet or more in height.

This soil is more extensive than the noneroded Portales loamy fine sand, 0 to 1 percent slopes. This eroded soil can be used best as range, and in most areas it needs to be reseeded. Grazing should be controlled so that an effective cover remains on the surface at all times.

**Portales silt loam, 0 to 1 percent slopes** (Pg) (capability unit IIs-3).—This soil occupies depressions within areas of Portales loam, 0 to 1 percent slopes. Refill irrigations are about the same for the two soils, but water and air move more slowly through the subsoil of this silt loam. Intake rates on this silt loam are also slower, often less than 1 inch per hour. The silt loam surface soil, however, contains more organic matter and has a stronger fine granular structure than the Portales loam.

Yields on this silt loam, under present management, are slightly lower than those on Portales loam, 0 to 1 percent slopes. Yields are often reduced by ponding.

## Potter Series

The soils of the Potter series are brown to grayish brown and are very shallow. They have a hard caliche layer within 10 inches of the surface and are too shallow to be farmed successfully.

**Potter fine sandy loam, 0 to 5 percent slopes** (Ph) (capability unit VIs-2).—This yellowish-brown soil has very poor tilth and a weak granular surface layer. Caliche rock, distributed uniformly over the surface, makes tillage difficult. This soil is best used for grass.

**Potter loam, 0 to 1 percent slopes** (Pk) (capability unit VIs-2).—This soil has a moderately to strongly granular surface soil. It is pale brown but is slightly darker at depths of 4 to 6 inches. The content of organic matter is noticeably higher in this soil than in the sandier soils of the Potter series. The numerous, loose, rocklike caliche fragments scattered over the surface make this soil very difficult to till.

This soil is not suitable for farming. Small plots that occur within irrigated areas of arable land are tilled.

**Potter loamy fine sand, 0 to 3 percent slopes** (Pm) (capability unit VIs-2).—This light reddish-brown soil has very poor tilth and no granular structure in the surface layer. In other respects it is like Potter fine sandy loam, 0 to 5 percent slopes.

Potter loamy fine sand, 0 to 3 percent slopes, is not only too shallow to farm successfully but is also too sandy. It should be kept under permanent grass cover.

## Sand Dunes

Sand dunes contain little organic matter and support little or no vegetation.

**Sand dunes** (Sd) (capability unit VIIe-3) consists of windblown drifts or active dunes, usually along fence rows. These dunes are prominent, but they are long and narrow, and their acreage is small.

Little or no cover is present on the dunes. Farmers often encourage the dunes to blow so that the underlying subsoil of Amarillo, Clovis, or Springer soils will be exposed. When this is done, adjoining soils may be damaged by the blowing sand.

## Springer Series

In the Springer series are the deep, reddish-brown, noncalcareous soils of the area. Aeration and water penetration are rapid in the subsoil, but the moisture-holding capacity is low—about 1 inch of available water per foot of soil. Commonly, the structure of the sandy subsoil is massive, but in places it has very weak, very coarse prismatic structure.

The clay content in the Springer subsoil is about a third less than that in the Amarillo. Consequently, Springer soils have a low resistance to wind erosion. Farmed areas are severely damaged by wind.

**Springer loamy fine sand, 0 to 5 percent slopes** (Sa) (capability unit VIe-1).—This soil has little or no structure in the surface soil, which averages 12 inches in depth. This soil is slightly to moderately undulating.

This soil is best used as range. The best way to establish grass is to plant a cover crop and seed grass in the residue.

**Springer loamy fine sand, 0 to 5 percent slopes, wind eroded** (Sb) (capability unit VIIe-1).—This soil has numerous large dunes and deep blowout spots. In other respects it is similar to Springer loamy fine sand, 0 to 5 percent slopes.

Farming has been tried unsuccessfully on Springer loamy fine sand, 0 to 5 percent slopes, wind eroded. The soil is now severely eroded and should not be reclaimed for irrigation. This soil is best used as range.

## Tivoli Series

The Tivoli series is made up of light yellowish-brown or light grayish-brown loose sandy soils that are locally called sandhills. The soils have no soil horizons, but there is a few inches of organic staining near the surface. The sandhills occur almost entirely on the extreme northern boundary of the Portales area. The sandhills are valuable catchment areas for rainfall that is subsequently recharged into the shallow storage basin.

**Tivoli fine sand** (Ta) (capability unit VIIe-1).—This soil occupies undulating to rolling dunelike areas. It includes some small areas of active dunes. Some dunes that have been fenced to exclude livestock show signs of natural reseeding. None of this soil is suitable for farming, and it is best used for range.

## *Use and Management of Soils*

Some suggestions for use and management of groups of similar soils are given in this section. These groups are called capability units. The suitability of representative soils for the principal crops is given in tabular form, as well as the estimated yields of the principal soils under prevailing management and improved management. Control of wind erosion and irrigation practices are also discussed.

## Capability Groups

Capability grouping is a system of classification used to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the needs, limitations, and risks of damage to the soils, and also their response to management. There are three levels above the soil mapping unit in the grouping—the capability unit, subclass, and class.

The capability unit, sometimes called a management group, is the lowest level of grouping. A capability unit is made up of soils similar in the kind of management they need, in risk of damage, and in general suitability for use.

The next broader grouping, the subclass, is used to indicate the dominant kind of limitation. The letter symbol "e" indicates that the main limiting factor is risk of erosion if the plant cover is not maintained; "w" means excess water that retards plant growth or interferes with cultivation; and "s" shows that the soils are shallow, droughty, or usually low in fertility.

The broadest grouping, the land class, is identified by Roman numerals. All the soils in one class have limitations and management problems of about the same degree, but of different kinds, as shown by the subclass. All the land classes except class I may have one or more subclasses.

In classes I, II, and III are soils that are suitable for annual or periodic cultivation for annual or short-lived crops. Class I soils are those that have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. They can be cultivated with almost no risk of erosion and will remain productive if managed with normal care. There are no class I soils in the Portales area.

Class II soils can be cultivated regularly, but they do not have so wide a range of suitability as class I soils, or they need more protection. Some class II soils need moderate care to prevent erosion; others may be slightly droughty or somewhat limited in depth.

Class III soils can be cropped regularly, but they have a narrower range of use. They need even more careful management than class II soils.

In class IV are soils that should be cultivated only occasionally or only under very careful management.

In classes V, VI, and VII are soils that, as a rule, should not be cultivated for annual or short-lived crops but can be used for pasture or range, as woodland, or for wildlife. Class V soils (none in this area) are nearly level to gently sloping but are droughty, wet, low in fertility, or otherwise unsuitable for cultivation. Class VI soils are not suitable for crops, because they are steep or droughty or otherwise limited, but they produce fair yields of forage. Class VII soils provide only poor to fair yields of forage.

In class VIII (none in this area) are soils that have practically no agricultural use. Some of them have value as watersheds, wildlife habitats, or scenery.

The capability classes, subclasses, and units in the Portales area are shown in the following list. The soils in each capability unit are also shown.

CAPABILITY CLASSES, SUBCLASSES, AND UNITS

Class II.—Soils that have moderate limitations if cultivated.

Subclass IIe: Soils limited chiefly by risk of erosion.

IIe-1: Deep soil (42 inches average depth to lime zone) that has loam surface soil and permeable sandy clay loam or loam subsoil. Dominant limitation is susceptibility to wind erosion when left without protective cover or plant residues.

Amarillo loam, 0 to 1 percent slopes.

Subclass IIs: Soils limited chiefly by moisture capacity.

IIs-1: Moderately deep soils that have loam surface soil and permeable sandy clay loam or loam subsoil. Dominant limitation is moderate depth over caliche.

Arvana loam, 0 to 1 percent slopes.
Clovis loam, 0 to 1 percent slopes.
Portales loam, 0 to 1 percent slopes.

IIs-2: Moderately deep soil (32 inches average depth to soft lime zone) that has loam surface soil and tight, very slowly permeable subsoil. Dominant limitation is tight subsoil.

Blackwater loam, marl substratum variant, 0 to 1 percent slopes.

IIs-3: Moderately deep soil (28 inches average depth to soft lime zone) that has silt loam surface soil and slowly permeable subsoil. Dominant limitation is slow intake rate and position in concave areas.

Portales silt loam, 0 to 1 percent slopes.

Class III.—Soils that can be cultivated regularly but have severe limitations and require careful management.

Subclass IIIs: Soils limited chiefly by texture and moisture capacity.

IIIs-1: Deep soils (42 inches average depth to lime zone) that have a fine sandy loam surface soil and permeable subsoil. Dominant limitation is moderately sandy surface soil.

Amarillo fine sandy loam, 0 to 1 percent slopes.
Amarillo fine sandy loam, 1 to 3 percent slopes.

IIIs-2: Moderately deep, noncalcareous soils that have a fine sandy loam surface soil and permeable loam subsoil. Dominant limitation is moderate depth to lime zone and moderately sandy surface soil.

Arvana fine sandy loam, 0 to 1 percent slopes.
Clovis fine sandy loam, 0 to 1 percent slopes.
Clovis fine sandy loam, 1 to 3 percent slopes.
Portales fine sandy loam, 0 to 1 percent slopes.

IIIs-3: Shallow, nearly level soil that has a loam surface soil and a zone of hard caliche at an average depth of 14 inches. Dominant limitation is shallow depth.

Kimbrough loam, thick solum variant, 0 to 1 percent slopes.

Class IV.—Soils fairly well suited to limited or to careful cultivation under careful management.

Subclass IVe: Soils limited chiefly by risk of erosion.

IVe-1: Deep, nearly level or gently sloping, wind-eroded fine sandy loams, and loamy fine sand. Dominant limitations are susceptibility to erosion and damage already caused by erosion.

Amarillo fine sandy loam, 0 to 1 percent slopes, wind eroded.
Amarillo fine sandy loam, 1 to 3 percent slopes, wind eroded.
Amarillo loamy fine sand, 0 to 3 percent slopes.

IVe-2: Moderately deep, nearly level or gently sloping loamy fine sands and fine sandy loams. Dominant limitation is susceptibility to wind erosion.

Arvana loamy fine sand, 0 to 1 percent slopes.
Clovis loamy fine sand, 0 to 3 percent slopes.
Portales loamy fine sand, 0 to 1 percent slopes.
Mansker fine sandy loam, 0 to 1 percent slopes.
Mansker fine sandy loam, 1 to 3 percent slopes.

IVe-3: Gently sloping, calcareous loam of the chalk hills. Dominant limitation is limy profile and unstable structure.

Drake loam, 1 to 5 percent slopes.

Subclass IVs: Soils limited chiefly by depth or moisture capacity.

IVs-1: Shallow, nearly level, noncalcareous loamy soil with tight subsoil; hard caliche at average depth of 17 inches. Dominant limitation is tight, slowly permeable subsoil.

Blackwater loam, 0 to 1 percent slopes.

IVs-2: Moderately deep, calcareous soils with loam surface soil. Dominant limitations are calcareous profile and the slope.

Mansker loam, 0 to 1 percent slopes.
Mansker loam, 1 to 3 percent slopes.

IVs-3: Soils shallow to lime zone (14 inches); noncalcareous fine sandy loam surface soil and clay loam or sandy clay loam subsoil overlying hard caliche; or shallow, noncalcareous fine sandy loam surface soil overlying caliche. Dominant limitation is shallow depth to caliche.

Arch fine sandy loam, 0 to 1 percent slopes.
Arch loam, 0 to 1 percent slopes.
Kimbrough fine sandy loam, thick solum variant, 0 to 1 percent slopes.

Class VI.—Soils not suitable for cultivation and moderately limited if used for grazing.

Subclass VIs: Soils limited chiefly by salinity or shallow depth.

VIs-1: Saline loam or clay loam soils on edges of depressions. Dominant limitation is salinity and tight subsoil.

Church clay loam, 0 to 1 percent slopes.
Church loam, 0 to 1 percent slopes.

VIs-2: Very shallow soils (hard caliche at depth of less than 10 inches) on nearly level to strong slopes. Dominant limitation is extremely shallow solum over rock.

Potter fine sandy loam, 0 to 5 percent slopes.
Potter loamy fine sand, 0 to 3 percent slopes.
Potter loam, 0 to 1 percent slopes.

Subclass VIe: Soils limited chiefly by risk of erosion.

VIe-1: Deep, nearly level to gently sloping sandy soil. Dominant limitation is sandiness of entire profile.

Springer loamy fine sand, 0 to 5 percent slopes.

VIe-2: Wind-eroded, deep and moderately deep loamy fine sands and fine sandy loams. Dominant limitations are susceptibility to wind erosion and the wind erosion that has already occurred.

Amarillo loamy fine sand, 0 to 3 percent slopes, wind eroded.
Arvana fine sandy loam, 0 to 1 percent slopes, wind eroded.
Arvana loamy fine sand, 0 to 1 percent slopes, wind eroded.
Clovis fine sandy loam, 0 to 1 percent slopes, wind eroded.
Clovis loamy fine sand, 0 to 3 percent slopes, wind eroded.
Mansker loamy fine sand, 0 to 3 percent slopes.
Mansker loamy fine sand, 0 to 3 percent slopes, wind eroded.
Mansker fine sandy loam, 0 to 1 percent slopes, wind eroded.
Portales fine sandy loam, 0 to 1 percent slopes, wind eroded.
Portales loamy fine sand, 0 to 1 percent slopes, wind eroded.

VIe-3: Soils dominantly calcareous and wind eroded. Main limitation is damage already caused by wind erosion.

Arch fine sandy loam, 0 to 1 percent slopes, wind eroded.
Arch loamy fine sand, 0 to 1 percent slopes, wind eroded.
Drake fine sandy loam, 1 to 5 percent slopes.
Drake fine sandy loam, 1 to 5 percent slopes, wind eroded.
Kimbrough loamy fine sand, thick solum variant, 0 to 1 percent slopes.
Kimbrough loamy fine sand, thick solum variant, 0 to 1 percent slopes, wind eroded.

Class VII.—Soils not suitable for cultivation and severely limited if used for grazing.

Subclass VIIe: Soils limited chiefly by risk of erosion.

VIIe-1: Severely eroded loamy fine sands and sandhills. Dominant limitations are the many sand dunes and blowouts.

Springer loamy fine sand, 0 to 5 percent slopes, wind eroded.
Tivoli fine sand.

VIIe-2: Severely eroded, calcareous soils not easily reclaimed. Dominant limitation is eroded, not easily reclaimed areas in which there are blowouts and windblown accumulations.

Church loam, 0 to 1 percent slopes, wind eroded.

VIIe-3: Actively blowing eroded areas of fine sand and loamy fine sand, mainly Amarillo, Clovis, and Springer soil materials.

Sand dunes.

## Suitability of Soils for Crops

The soils in capability classes II and III are listed according to their suitability for crops in table 3. These are the soils that can be cultivated regularly if care is taken to control soil blowing. All the soils listed are good or excellent for cotton, truck crops, and irrigated pasture. Some are only fair for peanuts, sweetpotatoes, and alfalfa.

## Estimated Yields

Yields that can be expected on the principal soils under prevailing management and improved management are given in table 4. Yields of cotton and peanuts under prevailing management were obtained from records of agricultural programs; those of cotton were checked with records kept by the cotton gins. Yields of other crops were obtained from reports of experiments and from experience reported by farmers. Yields under improved management are those obtained by farmers who irrigate carefully, manage soil and crop residues to control blowing, and plant good varieties (fig. 4).

An analysis of long-time climatic data shows that heat units during the growing season are not enough for good yields of cotton. According to one method of calculation, cotton requires at least 6,000 heat units for good yields. At Portales, the heat units amount to 6,000 in slightly fewer than half the growing seasons for which records have been studied.

*Figure 4.*—**Field showing effects of irrigation and good soil management.**

TABLE 3.—*Suitability of representative soils for principal crops*

| Land class and soil | Capability unit | Cotton | Peanuts | Sorghum | Sweet-potatoes | Alfalfa | Truck crops | Irrigated pasture |
|---|---|---|---|---|---|---|---|---|
| Class II: | | | | | | | | |
| Amarillo loam, 0 to 1 percent slopes. | IIe-1 | Excellent | Excellent | Excellent | Good | Excellent | Excellent | Excellent. |
| Arvana loam, 0 to 1 percent slopes. | IIs-1 | Excellent | Excellent | Excellent | Good | Excellent | Excellent | Excellent. |
| Clovis loam, 0 to 1 percent slopes. | IIs-1 | Excellent | Excellent | Excellent | Good | Excellent | Excellent | Excellent. |
| Portales loam, 0 to 1 percent slopes. | IIs-1 | Excellent | Excellent | Excellent | Good | Excellent | Excellent | Excellent. |
| Class III: | | | | | | | | |
| Amarillo fine sandy loam, 0 to 1 percent slopes. | IIIs-1 | Good | Good | Excellent | Excellent | Excellent | Excellent | Excellent. |
| Arvana fine sandy loam, 0 to 1 percent slopes. | IIIs-2 | Good | Good | Good | Excellent | Excellent | Excellent | Excellent. |
| Clovis fine sandy loam, 0 to 1 percent slopes. | IIIs-2 | Good | Good | Good | Excellent | Excellent | Excellent | Excellent. |
| Portales fine sandy loam, 0 to 1 percent slopes. | IIIs-2 | Good | Good | Good | Excellent | Excellent | Excellent | Excellent. |
| Kimbrough loam, thick solum variant, 0 to 1 percent slopes. | IIIs-3 | Good | Fair | Good | Fair | Good | Good | Good. |
| Class IV: | | | | | | | | |
| Amarillo loamy fine sand, 0 to 3 percent slopes. | IVe-1 | Not suited [1] | Not suited [1] | Good | Good | Good | Fair | Good. |
| Arvana loamy fine sand, 0 to 1 percent slopes. | IVe-2 | Not suited [1] | Not suited [1] | Good | Good | Good | Fair | Good |
| Clovis loamy fine sand, 0 to 3 percent slopes. | IVe-2 | Not suited [1] | Not suited [1] | Good | Good | Good | Fair | Good. |
| Mansker fine sandy loam, 0 to 1 percent slopes. | IVe-2 | Not suited [1] | Not suited [1] | Good | Fair | Good | Fair | Good. |
| Portales loamy fine sand, 0 to 1 percent slopes. | IVe-2 | Not suited [1] | Not suited [1] | Fair | Fair | Good | Fair | Good. |
| Blackwater loam, 0 to 1 percent slopes. | IVs-1 | Good | Not suited [2] | Good | Not suited [2] | Fair | Good | Fair. |
| Mansker loam, 0 to 1 percent slopes. | IVs-2 | Not suited [1] | Not suited [1] | Good | Fair | Good | Good | Good. |
| Arch loam, 0 to 1 percent slopes. | IVs-3 | Not suited [1] | Not suited [1] | Good | Fair | Good | Fair | Good. |
| Arch fine sandy loam, 0 to 1 percent slopes. | IVs-3 | Not suited [1] | Not suited [1] | Good | Fair | Good | Fair | Good. |

[1] Not suited because of wind erosion.

[2] Not suited because of tight subsoil.

TABLE 4.—*Average acre yields of principal crops to be expected over a period of years on 19 selected soils*

[Yields in columns A are those to be expected under prevailing management; those in columns B are to be expected under improved management. Absence of yield data indicates that the crop is not grown, or that sufficient data were not available to make reliable estimates]

| Soil type | Cotton [1] (lint) | | Peanuts [2] | | Grain sorghum | | Sweetpotatoes | | Alfalfa | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B |
| | *Lb.* | *Lb.* | *Lb.* | *Lb.* | *Lb.* | *Lb.* | *Bu.* | *Bu.* | *Tons* | *Tons* |
| Amarillo loam, 0 to 1 percent slopes | 500 | 900 | 1,750 | 2,400 | 5,000 | 7,500 | | 950 | 5.0 | 8.0 |
| Amarillo fine sandy loam, 0 to 1 percent slopes | 400 | 700 | 1,600 | 2,400 | 4,000 | 5,000 | 940 | 950 | 4.5 | 8.0 |
| Amarillo loamy fine sand, 0 to 3 percent slopes | 250 | 400 | 1,050 | 1,800 | 3,000 | 3,500 | | 400 | 3.5 | 6.0 |
| Arch loam, 0 to 1 percent slopes | 400 | 700 | 1,200 | 1,800 | 3,500 | 4,000 | | 300 | 3.5 | 6.0 |
| Arch fine sandy loam, 0 to 1 percent slopes | 400 | 600 | 1,000 | 1,100 | 3,000 | 3,500 | | 250 | 3.5 | 6.0 |
| Arvana loam, 0 to 1 percent slopes | 450 | 800 | 1,750 | 2,200 | 5,000 | 7,500 | | 750 | 5.0 | 7.0 |
| Arvana fine sandy loam, 0 to 1 percent slopes | 400 | 600 | 1,300 | 2,000 | 4,000 | 5,000 | 700 | 750 | 4.5 | 7.0 |
| Arvana loamy fine sand, 0 to 1 percent slopes | | 400 | | | 3,000 | 3,500 | | 400 | 3.5 | 5.0 |
| Blackwater loam, 0 to 1 percent slopes | 400 | 700 | 1,650 | 2,200 | 4,000 | 5,000 | | 400 | 2.5 | 5.0 |
| Clovis loam, 0 to 1 percent slopes | 470 | 800 | 1,600 | 2,200 | 5,000 | 7,500 | 530 | 700 | 5.0 | 7.0 |
| Clovis fine sandy loam, 0 to 1 percent slopes | 400 | 600 | 1,600 | 2,200 | 4,000 | 5,000 | 700 | 750 | 4.5 | 7.0 |
| Clovis loamy fine sand, 0 to 3 percent slopes | 250 | 400 | 600 | 1,000 | 3,000 | 3,500 | | 400 | 3.5 | 5. [illegible] |
| Kimbrough loam, thick solum variant, 0 to 1 percent slopes | 400 | 600 | 1,350 | 2,000 | 4,000 | 5,000 | | 600 | 4.5 | 5. [illegible] |
| Mansker loam, 0 to 1 percent slopes | 340 | 600 | 1,400 | 2,000 | 4,000 | 5,000 | | 250 | 3.5 | 6. [illegible] |
| Mansker fine sandy loam, 0 to 1 percent slopes | 300 | 500 | 1,000 | 1,100 | 3,500 | 4,000 | | 250 | 3.5 | 6.0 |
| Mansker loamy fine sand, 0 to 3 percent slopes | 250 | 300 | | | 2,500 | 3,000 | | | 3.0 | 5.0 |
| Portales loam, 0 to 1 percent slopes | 450 | 800 | 1,500 | 2,200 | 5,000 | 7,500 | 660 | 700 | 5.0 | 7.0 |
| Portales fine sandy loam, 0 to 1 percent slopes | 330 | 600 | 1,300 | 2,000 | 4,000 | 5,000 | 750 | 750 | 4.0 | 7.0 |
| Portales loamy fine sand, 0 to 1 percent slopes | 155 | 300 | 550 | 1,000 | 3,000 | 3,500 | 300 | 400 | 3.0 | 5.0 |

[1] Average yields of cotton are based on a 4-year record.

[2] Average yields of peanuts are based on a 5-year record.

## Control of Wind Erosion

The hazard from blowing varies greatly according to cloddiness, roughness of the surface, and amounts of residue on the surface. Soils containing 70 percent or more of particles and clods larger than 0.84 millimeters (about 1/32 of an inch in diameter) can be considered resistant to wind erosion.

The formation of clods is related to the texture of the soil. The amount of clay in the soil is important. The largest number of clods are formed by soils that contain roughly 20 to 30 percent clay. Soils of this kind are the loams of the Amarillo, Arvana, Blackwater, Clovis, and Portales series.

The most erodible soils are the loamy sands, which have a clay content of less than 10 percent. Wind-tunnel studies in the Portales area have shown that, on the average, 33 times as much soil is blown off test plots of loamy sands as off test plots of loams. Likewise, four times as much soil is blown off the fine sandy loams than the loams.

Lime in the soil appears to make clods break down more readily to an erodible size. Soils that have limy surface soils, the Arch, Drake, and Mansker, for example, are highly susceptible to blowing. Even the limy soils that have a loam texture are susceptible. Consequently, peanuts, cotton, and similar crops that leave little residue are not suitable for the limy soils because of the hazard of wind erosion.

On sandy soils with a sandy clay loam subsoil—the Amarillo, Clovis, and Arvana, for example—cloddiness can be increased by deep breaking; that is, plowing to depths of 12 to 20 inches. The loamy subsoil is thus mixed with the sandy surface soil, the clay content of the surface layer is increased, and more cloddiness results.

Roughness of the surface is important on all soils subject to blowing, because higher wind velocities are required to start erosion on a rough surface. The roughness achieved will depend on the size and shape of the clods, the presence of ridges, and the height and density of the plant cover.

Plant residues help control soil blowing by breaking the force of the wind. At a height of 1 inch, a nearly bare surface breaks the force of the wind very little. In contrast, a thick, ungrazed leafy sorghum stubble may almost completely break the force of the wind. Closely spaced strong stubble 10 to 14 inches high normally prevents blowing.

Even the most erosion resistant soils of the Portales area—those of the Amarillo, Clovis, Arvana, Portales, and Blackwater series—will blow if they are left unprotected. Then, the sorting action of the wind removes

*Figure 5.*—**Grain sorghum stubble left after harvest protects the soil from blowing.**

much of the clay and organic matter and leaves the surface more erodible than before. A cover crop, stubble, or a crop residue should be left on the soil during winter and spring to prevent blowing (fig. 5). If the soil must be left without cover, irrigation and tillage will help prevent blowing by establishing a rough cloddy surface.

Alfalfa or irrigated pasture should be a part of any cropping system used on these loamy soils if they are to be kept productive. Cash crops should not be grown for more than 3 years in succession; they should be followed by alfalfa or irrigated pasture (fig. 6) or a winter grain mixed with sweetclover or vetch to be plowed under as a green-manure crop. A minimum application of 10 tons per acre of barnyard manure is a good replacement for any green-manure crop. Commercial fertilizers high in nitrogen and phosphorus are also suggested for maintaining the productivity of these soils.

*Figure 6.*—**Irrigated pasture under effective crop-residue management.**

The soils that have moderately sandy surface layers and heavier subsoils are less resistant to wind erosion than the loamy soils. The fine sandy loams that make up capability units IIIs–1 and IIIs–2 are in this group. They need extra care to keep a protective cover or stubble on them during winter and spring.

These soils are particularly well suited to alfalfa, grain sorghum, and sweetpotatoes. If sweetpotatoes follow alfalfa in the rotation, a rough low-grade potato usually results. Inasmuch as cotton and peanuts (fig. 7) afford little protective cover, these crops should not be grown in successive years, nor should one follow the other in the crop rotation. Whenever possible, small grains, irrigated pasture, and truck crops should be worked into the rotation. If the protection is not adequate to reduce wind erosion, the soil can be watered before emergency tillage to get the most effective results from the tillage.

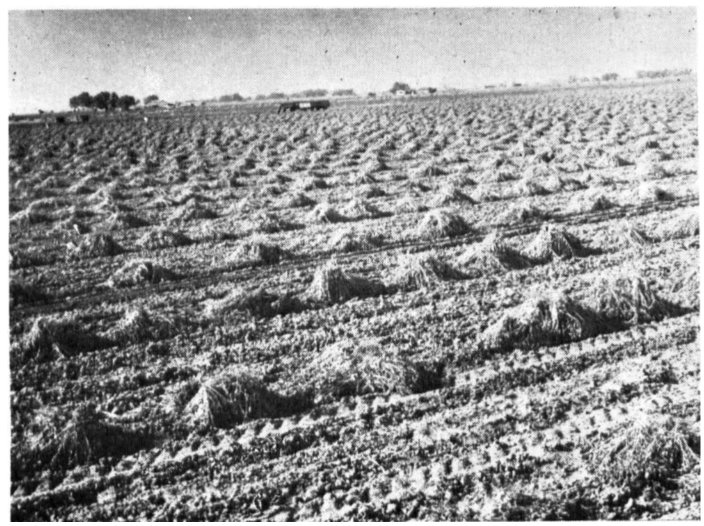

*Figure 7.*—**A harvested peanut field provides little crop residue.**

The sandy soils that have moderately heavy subsoils can be cultivated, but they need special care and management to control blowing. Wind erosion is always a potential hazard on them. Cover or dense stubble is necessary to protect the soils during winter and spring.

If the cash crop has left the soil bare and unprotected, a rough cloddy surface can be created by deep listing to reduce the damage from wind erosion. The best conservation measure for sandy soils is to grow only those crops that are suitable—alfalfa, irrigated pasture, grain sorghum, broomcorn, and sweetpotatoes.

Wind damage can be minimized by avoiding the grazing of stubble fields and by maintaining the level of organic matter through applications of barnyard manure every 2 to 4 years.

## Soil Moisture and Irrigation

If you do a good job of irrigating, your crop will have enough but not too much water at any time during the growing season. To find out the efficiency of irrigation, we measure the percentage of water supplied at the source (pump) that reaches the roots of a nearly mature, rapidly growing crop. Efficiencies as low as 43 percent and as high as 75 percent have been measured in the Portales Valley.

The primary cause of low irrigation efficiency is loss of water beyond the root zone. This may amount to as much as 40 percent. The loss is caused by applying too much water. Excess water is applied because the operator (1) fails to determine the amount of water needed to refill the root zone; (2) fails to calculate the time required to apply the water needed; (3) fails to measure the water being pumped. Regarding failure to measure water, it is worth considering that a flow of 450 gallons per minute is equivalent to covering one-third of an acre 3 inches deep in 1 hour. Likewise, a flow of 900 gallons per minute will cover the same area 6 inches deep in the same time.

Water also may be lost beyond the root zone by poor layout of irrigation systems in relation to the size of flow available. If the flow is small, the size of the border large, and the intake rate is high, it will take too long to get the border covered. As a result, soil close to the ditch will be overirrigated. So, the length and width of the border should be adjusted to the size of the stream available, to the intake rate, and to the refill requirements of the soil.

Another important cause of low irrigation efficiency on farms is ditch loss, especially on the sandy soils. These losses are more important if the wells are weak. If 1,000 feet of sandy ditch loses 70 gallons of water per minute, that is 20 percent of the flow from a well yielding 350 gallons per minute; or 10 percent of the flow from a well yielding 700 gallons per minute.

If a well is weak and ditch loss is high, the reduced size of the stream may cause failure to cover the irrigated area in a reasonable length of time. Losses from ditches can be reduced by lining them. Preferable to this is use of underground pipe, which will control both ditch loss and evaporation.

Loss of water by evaporation from ditches and while ponded on the soil is minor. It usually varies from ¼ to ½ inch.

An irrigator can work best if he knows the *readily available moisture* of his soil and the amount of water needed to refill the root zone to *field capacity*. At field capacity, clay loams or loams hold about 2 inches of readily available moisture per foot, sandy loams and loamy sands hold about 1 inch, and fine sands hold about 0.7 inch.

Readily available moisture is the moisture that the plant can get and maintain rapid growth. Field capacity is the amount of moisture in a soil 2 or 3 days after a good irrigation or a heavy rain. At field capacity, the soil contains all the water it can hold against the force of gravity. Water has drained out of the larger pores, but with respect to practical water-holding capacity, the root zone is 100 percent filled with water.

It is best to irrigate a crop just before the readily available moisture is used up. In table 5 the total readily available moisture is expressed in inches for most of the soil types in the county. It is the inches of water needed to bring the soil to field capacity when a rapidly growing crop such as alfalfa needs irrigation. The figures given do not include ditch loss, or loss from evaporation, which commonly amounts to ½ to 1 inch.

Most farmers will want to irrigate 2 to 3 days before the last half inch of readily available moisture is used. So the values given in the table can be discounted by half an inch in figuring the refill irrigation. These readily available moisture values were derived from irrigation trials in the Portales area and from those reported by Diebold (*3*) in New Mexico and neighboring States.

TABLE 5.—*Thickness of soil zone and available moisture capacity of representative soil types*

| Soil type | Approximate thickness of root zone | Readily available moisture capacity |
|---|---|---|
| | *Inches* | *Inches* |
| Amarillo loam | 36–60 | 5–6 |
| Amarillo fine sandy loam | 36–60 | 4–5 |
| Amarillo loamy fine sand | 36–60 | 4–4½ |
| Arch loam | 10–20 | 2–3 |
| Arch fine sandy loam | 10–20 | 2–2½ |
| Arvana loam | 20–36 | 3½–4½ |
| Arvana fine sandy loam | 20–36 | 2½–4 |
| Arvana loamy fine sand | 20–36 | 2–3½ |
| Blackwater loam | 16–18 | 2½–3 |
| Blackwater loam (marl substratum variant) | 28–36 | 4–5 |
| Clovis loam | 20–36 | 4–5 |
| Clovis fine sandy loam | 20–36 | 3–4 |
| Clovis loamy fine sand | 20–36 | 2½–4 |
| Drake loam | 20–36 | 4–5 |
| Kimbrough loam, thick solum variant | 10–20 | 2½–3 |
| Kimbrough fine sandy loam, thick solum variant | 10–20 | 1½–2½ |
| Mansker loam | 20–26 | 3–4 |
| Portales loam | 20–36 | 4–5 |
| Portales silt loam | 20–36 | 4–5 |
| Portales fine sandy loam | 20–36 | 3–4 |
| Portales loamy fine sand | 20–36 | 2½–4 |

### *When to irrigate*

The best way to keep plants growing rapidly is to irrigate when the level of readily available moisture in the top 6 to 12 inches is between one-fourth and one-half of field capacity. Irrigation trials have shown that 40 percent of the moisture needed by crops is extracted from the upper quarter of the root system; 30 percent by the second quarter; 20 percent by the third quarter; and 10 percent by the fourth quarter. Since the root system absorbs the greatest amount of moisture from the upper part of the soil, a sample taken from the top 6 to 12 inches will show the content of available moisture. By applying the ball test (*4*) as shown in table 6, you can determine if irrigation is needed and how much water to apply. These are the steps to follow in estimating the amount of moisture in the soil:

First, take a sample of the upper part of the root zone and firmly squeeze some of the soil in the hand. If no ball forms, the soil is *dry*, or the moisture content is less than one-fourth of field capacity. At this stage, irrigation has been delayed too long because the moisture is now at the wilting point.

If the soil forms a ball, it contains at least one-fourth of the readily available moisture it would have had at field capacity. Toss the moist ball 1 foot into the air, and catch it as you would catch a baseball. If the ball breaks within five tosses or less, it is *fragile*, or the amount of water stored in the soil is between one-fourth and one-half of field capacity. This is the best time to irrigate.

If the ball remains intact after it has been tossed five times, it is *durable*, and irrigation can be delayed for a few days.

TABLE 6.—*Estimating soil moisture by feel (ball test)*

| Readily available moisture present in soil | Clues | Water needed to refill root zone | | |
|---|---|---|---|---|
| | | Medium- to fine-textured soils | Sandy loams | Loamy sands |
| | | *Inches per foot* | *Inches per foot* | *Inches per foot* |
| 0 to ¼ | Soil too dry to form a ball | 1. 5–2. 0 | 0. 9–1. 2 | 0. 7–1. 0 |
| ¼ to ½ | Soil forms a ball after being tossed 1 foot into the air and caught as a baseball; if the ball breaks within five tosses or less, it is fragile, and indicates it is time to irrigate. | 1. 0–1. 5 | (1) | (1) |
| ½ to ¾ | If the ball remains intact after five tosses, it is durable | 0. 5–1. 0 | (1) | (1) |
| ¾ to field capacity | Soil is sticky; at least 1/10 inch sticks to thumb after soil is squeezed firmly. | 0–0. 5 | 0–0. 3 | 0–0. 2 |
| Field capacity | Film of moisture can be seen for a few seconds on clean (nonoily) fingers. | 0 | 0 | 0 |

[1] No clues for ¼ to ¾ readily available moisture.

If, after you have squeezed the soil firmly, some sticks to your hand, the readily available moisture is between 75 and 100 percent of field capacity. A sticky soil needs little or no additional moisture.

### *How much water to apply*

If the ball test shows that your soil needs irrigation, you will want to know the amount of water to apply. Sample each quarter of the root zone with an auger, or take increments of soil at 1-foot depths and make the ball test. Then, in table 6, read the approximate number of inches of water needed to refill each foot of the root zone. Next, refer to table 5, which gives the depth of the root zone for soil types, as well as the inches of water needed to fill the root zone. For instance, if you have Arvana loam on your farm, and the ball test shows that the soil is dry, you will have to add about 2 inches of water to each foot of the root zone to bring the soil moisture up to field capacity—about 4 inches of water in a 2-foot root zone.

### *Overnight storage tanks*

By enlarging a natural depression or by digging a pit and using the excavated soil as a retaining wall, a tank or basin can be built that will provide additional irrigation water. The water is pumped in from the adjacent well at night and is released as needed for crops or cattle during the day.

Several factors should be considered before such a storage tank is installed, however, and the advantages weighed against the disadvantages. The cost of building the earthwork and the installation of pipes should be compared with the expected returns. The site should be inspected to see if the soil is suitable and if, when completed, the tank will require special treatment to make it hold.

The principal advantage is the saving of labor during irrigation. An overnight storage tank provides opportunity for better irrigation. It can be used in emergency if power fails or in case of fire. In addition, it can be used for swimming and fishing.

The chief disadvantage is that the tank site is taken out of cultivation. An overnight storage tank provides a breeding place for mosquitoes, and weeds become unsightly along its banks.

The design of the tank is also important. Its size should be determined by the capacity of the well serving it. The top width of the banks should be 8 to 10 feet, with an inside slope of 3 to 1 and an outside slope of 2 to 1. The width of the base is determined by the width at the top and the degree of the inside and outside slopes. A safety outlet or switch should be installed to prevent any overflow of water.

## *Geology*

To understand how the water for irrigation developed in an underground storage basin, one should know something about the geologic history of the area. The Ogalalla formation, the water-bearing stratum, is the principal source of water in the Portales area. It was formed from material deposited more than a million years ago during the early Pliocene age (*6*). The Ogalalla formation is underlain by clays and shales known as the Triassic Red Beds, which were deposited more than 100 million years ago.

The deposition of the Ogalalla formation resulted from the rise of the Rocky Mountains. As the mountains were worn down by erosion, the streams began to deposit sand, gravel, and silt near their sources. These deposits formed alluvial fans of coarse gravelly material along the foot slopes of the mountains; the finer materials were moved and spread farther to the east. The Ogalalla formation developed from these deposits of outwash material; the deposits were built up gradually to about the present level of the High Plains. Fresh water saturated the Ogalalla formation at times during its deposition. It came either from precipitation or from the eastern edge of the Rocky Mountains. Water could have accumulated on the Ogalalla formation for perhaps a little more than a million years.

Since the ice age, tributaries of the Pecos River, eroding headward to the north, and tributaries of the Canadian River, eroding headward to the west, have met and have eroded through the Ogalalla formation into the underlying redbeds. At present the Ogalalla formation is at a higher elevation on the High Plains than the surface on all sides. No water enters it from the Rocky Mountains. The only recharge of any consequence for the ground water reservoir is from rain or snow that falls on the High Plains area (*6*).

In addition to the Canadian and Pecos Rivers, the ancient Brazos River influenced the geology of the Portales Valley. In ages past its headwaters were generally northwest of San Miguel County, N. Mex., near Truchas Peak. It flowed generally southeastward to a point northeast of Lubbock, Tex. At that point its channel is known today as the Double Mountain Fork of the Brazos River. The headward cutting of the Pecos River bisected the Brazos River 2 miles south of Fort Sumner in De Baca County, N. Mex. From the time the tributaries of the Canadian and Pecos Rivers merged, the flow of water into the Brazos dwindled, became intermittent, and finally ceased. The remnant of this dry channel is now known as the Portales Valley. It is underlain at various depths by the characteristic soft, white to light-gray caliche.

During the early Pliocene or late Pleistocene age when streams were active, and before the capture of the Brazos River by the Pecos, the rapidly flowing Brazos laid down a high terrace of sand and gravel mixed with the redbed clays. Such a formation is exposed in a gravel pit northwest of Portales.

The stream activity coincided with the beginning of a climatic sequence of alternate wet and dry cycles. Following the initial wet cycle and the capture of the Brazos River by the Pecos, the intermittent dry cycles caused increased deposition of eolian sands upon the region. These deposits were saturated with water high in minerals, principally calcium, during the alternate wet periods. Following each saturation and during the next dry cycle, caliche (calcium carbonate) was precipitated as a cap over the windblown material.

It is believed that the protective vegetation was destroyed during each dry period and that wind activity increased. In places where the caliche was less mature, the winds scooped out depressions that are now the characteristic playas. The deposition and solution of minerals, followed by drought and chemical precipitation of the minerals, took place at least three and perhaps five times during the Pleistocene age. Evidence of this activity can be seen in the eolian chalky material on the east slopes of the numerous playas, particularly in soils of the Drake series. With each cycle the lakes were enlarged and new materials were deposited. Terraces were formed that are now evident in soils of the Church series.

## *Classification and Morphology of Soils*

Soils are placed in narrow classes for the organization and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparisons of large areas such as continents. In the comprehensive system of soil classification followed in the United States (*1*), the soils are placed in six categories, one above the other. Beginning at the top, the six categories are order, suborder, great soil group, family, series, and type.

In the highest category, the soils of the whole country are grouped into three orders, whereas thousands of soil types are recognized in the lowest category. The suborder and family categories have never been fully developed and thus have been little used. Attention has been given largely to the classification of soils into soil types and series within counties or comparable areas and to the subsequent grouping of series into great soil groups and orders. Soil series, type, and phase are defined in the Glossary in the back of this report. Subdivisions of soil types into phases provide finer distinctions significant to soil use and management.

Classes in the highest category of the classification scheme are the zonal, intrazonal, and azonal orders (*8*). The zonal order comprises soils with evident, genetically related horizons that reflect the predominant influence of climate and living organisms in their formation. In the intrazonal order are soils with evident, genetically related horizons that reflect the dominant influence of a local factor of topography, parent materials, or time over the effects of climate and living organisms. In the azonal order are soils that lack distinct, genetically related horizons, commonly because of youth, resistant parent material, or steep topography.

In table 7 the soil series are classified by higher categories and their important characteristics are given. Following the table is a discussion of the morphology of the soil series and a description of a typical soil profile for each series. The soils are discussed according to order and great soil group.

## Zonal Order

The zonal soils in the Portales area are members of the Reddish Chestnut great soil group, which includes the Amarillo, Arvana, Clovis, Kimbrough, and Springer series. All of these soils, with the exception of those of the Springer series, have reached the medial stage of development. They show moderate medium to coarse prismatic structure in the textural B horizon. Mid and short grasses—little bluestem, side-oats grama, blue grama, and buffalograss—are the typical vegetation on these soils.

The Springer series has a weak structural B horizon and a weak very coarse prismatic structure in situ. The characteristic vegetation on Springer soils is predominantly tall and mid grasses, sandsage, and shinnery oak.

Typical soils of the area in the Reddish Chestnut group are those of the Amarillo series. They have a prominent $A_1$ horizon and a textural B horizon that has moderate to medium prismatic structure. The native cover is mid and short grasses.

### *Reddish Chestnut group*

**Amarillo series.**—This series comprises the normal, strongly oxidized, medial Reddish Chestnut soils of the southern High Plains. They have developed on unconsolidated alluvial and eolian, moderately sandy, calcareous sediments of late Tertiary outwash. The associated soils are principally the Springer, which have a sandier textural B horizon; the Pullman (not extensive enough in this area to be delineated separately on the map), which are less red and have a more strongly developed B horizon; and the Mansker, which are calcareous at a shallower depth and are less well developed.

TABLE 7.—*Soil series arranged by higher categories and some important characteristics of each series*

ZONAL ORDER

| Great soil group and series | Horizon characteristics: Texture of B horizon or subsoil | Depth to $C_{ca}$ or caliche | Dry consistence of $C_{ca}$ or caliche | Parent material | Relief and physiographic position |
|---|---|---|---|---|---|
| | | *Inches* | | | |
| Reddish Chestnut: | | | | | |
| Amarillo | Sandy clay loam | 36 to 60 | Friable to semi-indurated. | Tertiary outwash | Gently sloping High Plains upland. |
| Arvana | Loam to sandy loam | 16 to 36 | Indurated | Tertiary outwash | Gently sloping High Plains upland. |
| Clovis | Sandy clay loam | 16 to 36 | Friable to semi-indurated. | Tertiary outwash | Gently sloping High Plains upland. |
| Kimbrough | Clay loam | 10 to 20 | Indurated | Caliche | Smooth to level High Plains upland. |
| Springer | Loamy sand to sandy loam. | 40 to 60 | Weak | Reworked Tertiary outwash. | Gently sloping to undulating High Plains upland. |

INTRAZONAL ORDER

| Great soil group and series | Texture of B horizon or subsoil | Depth to $C_{ca}$ or caliche | Dry consistence of $C_{ca}$ or caliche | Parent material | Relief and physiographic position |
|---|---|---|---|---|---|
| Planosol: | | | | | |
| Blackwater | Silty clay loam to clay loam. | 15 to 20 | Friable or indurated | Sediments deposited by water. | Level or slightly depressed areas on High Plains. |
| Calcisol: | | | | | |
| Arch | Sandy clay loam or loam. | 6 to 10 | Friable | Calcareous alluvium | Smooth depressed areas on High Plains. |
| Church | Silty clay loam | 20 to 30 | Friable | Sediments deposited by water. | Level playa terraces. |
| Mansker | Loam | 18 to 30 | Friable or indurated | Tertiary outwash | Gently sloping to sloping High Plains upland. |
| Portales | Loam to sandy loam | 40 to 60 | Friable | Lacustrine and alluvial sediments. | Smooth depressed areas on High Plains. |

AZONAL ORDER

| Great soil group and series | Texture of B horizon or subsoil | Depth to $C_{ca}$ or caliche | Dry consistence of $C_{ca}$ or caliche | Parent material | Relief and physiographic position |
|---|---|---|---|---|---|
| Regosol: | | | | | |
| Drake | Loam | 15 to 20 | Not distinct | Calcareous sediments reworked by wind. | Leeward slopes of playas. |
| Tivoli | Fine sand | (1) | (2) | Sands deposited by winds | Rolling sandhills of High Plains. |
| Lithosol: | | | | | |
| Potter | Loam | 8 to 12 | Usually indurated | Caliche | Sloping High Plains upland. |

[1] No caliche in Tivoli soil.

[2] Caliche normally absent.

Profile of Amarillo loamy fine sand, 0 to 1 percent slopes; location, SE¼NE¼ sec. 24, T. 1 S., R. 34 E.:

$A_p$ 0 to 10 inches
Reddish-brown (5YR 5/4, dry; 5YR 4/4, moist)[3] loamy fine sand; single-grain or very weak medium granular structure; soft when dry, friable when moist, nonsticky to very slightly sticky when wet; noncalcareous; boundary abrupt at 10 inches.

$B_2$ 10 to 32 inches
Reddish-brown (5YR 4/3, moist) sandy clay loam that changes one chroma (5YR 4/4) when crushed; contains moderate medium to coarse prisms that have distinct colloidal varnish on the cleavage planes; firm when moist, slightly sticky when wet; noncalcareous; boundary gradual at 32 inches.

$B_3$ 32 to 44 inches
Yellowish-red (5YR 5/6, moist) noncalcareous sandy clay loam; weak coarse to very coarse prisms; when broken, structure is weak medium granular; firm when moist, nonsticky to slightly sticky when wet; boundary abrupt at 44 inches.

$C_{ca}$ 44 inches+
Light reddish-brown (5YR 6/4, moist) structureless, very fine sandy clay loam; violently calcareous; contains both slightly indurated and indurated medium to very coarse caliche.

[3] Symbols in parentheses are Munsell color notations.

*Range in characteristics:* The greatest variation in the Amarillo series is in texture of the subsoil. It ranges from loam to sandy clay. Below the strongly calcareous marl zone, the soil in many places is sandier in texture and less calcareous. The depth to the lime zone ranges from 36 to 60 inches. Indurated caliche in the substratum ranges from little or none to numerous and abundant, medium to large, rocklike fragments.

*Topography:* Occupies a vast graded plain, nearly level to gently undulating, with a modal gradient of ½ to 2 percent.

*Drainage:* Moderate to rapid surface intake; permeability of subsoil, moderate.

**Arvana series.**—The Arvana soils are among the brown and reddish-brown medial Reddish Chestnut soils of moderate depth. They developed over Tertiary outwash. A layer of very hard, stonelike caliche distinguishes this series from the Clovis and Amarillo series. The depth to the caliche layer averages 24 inches. The soils are leached within 2 to 4 inches of the caliche rock, and this boundary is abrupt. Loams, fine sandy loams, and loamy fine sands are the types of Arvana soils within the area surveyed.

Profile of Arvana fine sandy loam, 0 to 1 percent slopes; location, SW¼NW¼ sec. 17, T. 1 S., R. 34 E.:

$A_p$ 0 to 10 inches
Dark-brown (7.5YR 4/4, dry; 7.5YR 3/4, moist) fine sandy loam, single-grain structure; some horizontal cleavage planes have developed because of tillage; friable when moist, soft when dry, slightly sticky when wet; noncalcareous; boundary clear.

$B_2$ 10 to 15 inches
Dark reddish-brown (5YR 3/4, moist) sandy clay loam; medium, coarse subangular blocky structure; friable when moist, slightly plastic when wet; noncalcareous; boundary clear.

$B_3$ 15 to 26 inches
Dark-brown (7.5YR 4/2, moist) clay loam; weak medium blocky structure; firm when moist, sticky when wet; noncalcareous; boundary to hard caliche is abrupt.

$D_2$ 26 inches+
Rocklike caliche.

*Range in characteristics:* The color ranges from reddish brown to dark brown. The depth to caliche ranges from 16 to 36 inches. The subsoil may show less structural development and be somewhat sandier than the surface soil. Colloidal staining of the aggregates corresponds to the degree of structural development. The more development shown, the greater the colloidal varnish on the aggregates.

*Topography:* Occurs on the more nearly level slopes; less than 2 percent of the soil has an average slope of 1 percent.

*Drainage:* Runoff, moderate to slow; permeability, moderate.

*Vegetation:* Grama and buffalograss; bluestem on the sandier soils.

**Clovis series.**—The Clovis series is composed of the moderately deep, medial Reddish Chestnut soils that occur on the High Plains in association with soils of the Amarillo, Springer, and Mansker series. Usually the Clovis series occupies the transitional zone between the higher lying Amarillo series and the soils formed in valley fills. The soils of the Clovis series have thinner solums than the Amarillo soils and a somewhat less strongly developed B horizon.

Profile of Clovis fine sandy loam, 0 to 1 percent slopes; location, SW¼NW¼ sec. 16, T. 1 S., R. 34 E.:

$A_p$ 0 to 10 inches
Reddish-brown (5YR 4/4, moist) nonsticky, weak fine granular fine sandy loam.

$B_2$ 10 to 13 inches
Reddish-brown (5YR 4/3, dry; 5YR 4/2, moist) sandy clay loam; weak medium to coarse prismatic structure; sticky to slightly sticky; slightly to strongly calcareous.

$B_3$ 13 to 36 inches
Reddish-brown (5YR 5/3, dry; 5YR 5/3, moist) sandy clay loam; weak coarse prismatic structure; slightly sticky; strongly calcareous; faint mottling (10YR 7/2, moist).

36 inches+
Light reddish-brown (5YR 6/4) slightly sticky to sticky fine sandy clay loam; structureless; violently calcareous; light-gray (10YR 7/2) mottles are common and distinct, contains medium-sized lime concretions (indurated).

*Range in characteristics:* The depth to the zone of lime accumulation ranges from 16 to 36 inches. The subsoil texture varies from light clay loam to clay loam. The A and B horizons are brown to reddish brown.

*Topography:* Occurs on nearly level to gentle slopes; gradients may be as strong as 3 percent, but the average slope is less than 1 percent.

*Drainage:* Good; runoff, slight to moderate; permeability, moderate.

*Vegetation:* Dominantly grama; some bluestem and buffalograss.

**Kimbrough series (thick solum variant)**.—The Kimbrough series is composed of shallow (10 to 20 inches), leached, moderate to strongly developed soils that overlie a hard limestonelike caliche cap of variable thickness. The soils are well drained and nearly level. They are associated with soils of the Potter and Amarillo series. The Kimbrough soils are usually darker than Potter soils. They are more strongly developed, and the horizons above the indurated caliche are leached of lime. The soils of the Kimbrough series are less reddish than those of the Amarillo series and are not so deep.

Profile of Kimbrough loam, thick solum variant, 0 to 1 percent slopes; location, NE¼NW¼ sec. 29, T. 1 S., R. 34 E.:

$A_p$ 0 to 1 inch
Dark-brown (10YR 3/4, moist) loam; noncalcareous; strong coarse to medium granular structure; slightly sticky, friable; boundary clear.

$B_{12}$ 1 to 4 inches
Dark-brown (10YR 3/3, moist) noncalcareous, light clay loam; moderate medium subangular blocky structure; slightly sticky, friable; boundary clear.

$B_{22}$ 4 to 14 inches
Dark-brown (10YR 3/3, moist) noncalcareous, heavy clay loam; strong coarse prismatic and moderate strong subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; boundary abrupt.

$D_r$ 14 inches+
Hard limestonelike caliche of undetermined thickness.

*Range in characteristics:* The color of the surface soil ranges from reddish brown to dark brown. The structure of the B horizon may not be so strong as that shown in the typical profile. The depth to hard caliche ranges from 10 to 20 inches.

*Topography:* Level High Plains area.

**Springer series.**—The minimal Reddish Chestnut soils of the Springer series are somewhat excessively drained and strongly oxidized. They have developed from coarse and moderately coarse reworked Tertiary outwash. Springer soils are associated with Amarillo soils but differ from them in having a less strongly developed B horizon and a coarser texture throughout the profile.

Profile of Springer loamy fine sand, 0 to 5 percent slopes; location, SW¼NW¼ sec. 27, T. 1 S., R. 35 E.:

$A_{11}$ 0 to 2 inches
Yellowish-red (5YR 5/6, dry; 5YR 4/8, moist) loose single-grain, loamy fine sand that stains the fingers slightly when moist; boundary clear.

$A_{12}$ 2 to 5 inches
Reddish-brown (5YR 4/4, moist) loose, single-grain, noncalcareous, clean fine sand; boundary clear.

$B_1$ 5 to 19 inches
Yellowish-red (5YR 5/6, moist) single-grain, noncalcareous fine sand; very weak very coarse prisms in place; boundary gradual.

$B_2$ 19 to 26 inches
Yellowish-red (5YR 5/6, moist) loamy sand; weak coarse prismatic structure; slightly hard when dry; noncalcareous; boundary clear.

C 26 to 60 inches+
Reddish yellow (5YR 6/8, moist) single-grain fine sand; noncalcareous.

*Range in characteristics:* The series usually has stronger structural characteristics than the typical profile described. Some areas are calcareous below 40 inches. Some Springer soils are less red than here described.
*Topography:* Gentle undulating High Plains, often of subdued dune topography.
*Drainage:* Intake rate is rapid; permeability of subsoil, rapid.

## Intrazonal Order

In the Portales area, the Planosol and Calcisol great soil groups are in the intrazonal order.

The Blackwater series is a member of the Planosol group. It has maximal horizonation and a strong textural B horizon. The $A_1$ and $C_{ca}$ horizons are prominent. The soils of this series developed over fine alluvial sediments that probably were laid down by slowly moving and receding brackish streams or sloughs. Short grasses are the native cover.

Soils of the Arch, Church, Portales, and Mansker series are members of the Calcisol group (*5*).

The Church soils have minimal horizonation. The soils are on very slowly permeable alluvial and lacustrine deposits that occur on low terraces along intermittent playas or dry stream channels. They developed from fine-textured sediments that have been modified since deposition by poor aeration and highly calcareous vadose waters. Salt-tolerant grasses are the dominant cover.

Soils of the Arch and Portales series developed on strongly calcareous mixed alluvial and lacustrine sediments. The Portales series has a weak textural B horizon in the medial stage of development, whereas the Arch series has the characteristics of a minimal Calcisol. The Arch soils have a weak $A_1$ horizon, no distinct B horizon, and, like the Portales series, a prominent $C_{ca}$ horizon, but at a shallower depth. The native cover on Portales and Arch soils is mid grasses and short grasses. Soils of the Mansker series developed on medium to coarse calcareous sandy outwash of Tertiary origin. They have a prominent $A_1$ horizon but no distinct B horizon. The Mansker series has minimal development. The native cover consists of mid and short grasses.

### *Planosol group*

**Blackwater series.**—The Blackwater soils occur in a fairly narrow, banded, streamlike pattern. They are associated with Kimbrough and Arvana soils but differ from these soils in having a strongly developed subsoil. The boundary between the Blackwater soils and the associated soils is noticeably sharp; the normal transitional zone is lacking.

Profile of Blackwater loam, 0 to 1 percent slopes; location, SW¼SE¼ sec. 20, T. 1 S., R. 34 E.:

$A_p$ 0 to 5 inches
Dark-brown (10YR 4/3, dry; 10YR 3/3, moist) loam; weak medium granular structure; layer is soft when dry, friable when moist, and slightly sticky when wet; noncalcareous; lower boundary abrupt.

$B_{21}$ 5 to 11 inches
Clay loam; dark brown (10YR 4/3) when crushed and dry; 10YR 3/3 to 4/4 when crushed and moist; strong medium blocky structure; very hard when dry, very firm when moist, very plastic when wet; noncalcareous; boundary clear at 11 inches.

$B_{22}$ 11 to 18 inches
Dark grayish-brown (10YR 4/2, moist) clay loam; moderate medium blocky structure; hard, firm, and plastic; noncalcareous to slightly calcareous; boundary abrupt at 18 inches, where rocklike caliche occurs; some mottlings of segregated gypsum in this layer.

$D_2$ 18 inches+
Hard layer of caliche of undetermined thickness.

*Range in characteristics:* The principal variation is associated with the depth to the geologic material and the characteristic mottling in the $B_1$ horizon. In some places this mottling is calcium carbonate, and in others it is gypsum and has the yellowish brown of High Plains marl.
*Topography:* Level or slightly depressed areas.
*Drainage:* Rapid runoff; slow permeability.
*Vegetation:* Short grasses.

**Blackwater series (marl substratum variant).**—The Blackwater variant is quite similar to the soils of the Blackwater series in having a strong structural B horizon. The boundary between this soil and the associated Portales and Arch series is sharp; the normal transitional zone between soil boundaries is lacking. This soil occurs in a narrow streamlike pattern through the valley. The lime zone at depths of 24 to 36 inches is similar to that within the Portales and Arch series. From 20 to 40 percent of it is calcium carbonate. The boundary of the leached zone above the accumulated lime layer is clear.

Profile of Blackwater loam, marl substratum variant, 0 to 1 percent slopes; location, NE¼SE¼ sec. 15, T. 1 S., R. 33 E.:

$A_p$ 0 to 2 inches
Brown loam; weak very fine granular structure; very friable when moist; noncalcareous; lower boundary abrupt.

$B_{21}$ 2 to 18 inches
Dark-brown silty clay; moderate subangular to angular blocky structure; noncalcareous; moderately friable when moist, slightly plastic when wet; lower boundary gradual.

$B_{22}$ 18 to 36 inches
Dark grayish-brown clay loam; distinct mottling (10YR 6/1); moderate medium granular structure; sticky when wet; slightly calcareous.

$C_{ca}$ 36 inches+
Light-gray clay loam; prominent mottling (10YR 6/4); weak fine granular structure; sticky when wet; violently calcareous.

*Range in characteristics:* The depth to lime accumulation ranges from 16 to 36 inches.
*Topography:* Narrow streamlike pattern; lacks the transition zone of a normal soil boundary.

### *Calcisol group*

**Arch series.**—These soils are the pale-brown and grayish-brown minimal Calcisols of the southern High Plains. The substrata are chalky earths of old alluvium or mixed outwash that appear to have been modified by deposition of calcium carbonate from ground water.

The series more closely related to the Arch series are the Portales, the Church, and the Drake. The Portales is deeper and darker; the Church has more clayey subsoils; and the Drake has few modified eolian sediments.

Arch loam, fine sandy loam, and loamy fine sand have been mapped. The loamy fine sand occurs to a very limited extent within the boundaries of the survey.

Profile of Arch loam, 0 to 1 percent slopes:

$A_p$ 0 to 4 inches
Light-brown (10YR 5/3, dry; 10YR 3/3, moist) loam; weak medium granular structure; soft when dry, friable when moist, slightly sticky when wet; slightly calcareous; lower boundary clear.

$B_{ca}$ 4 to 8 inches
Light-brown (10YR 5/3, dry; 10YR 3/3, moist) loam; weak medium granular structure; soft when dry, friable when moist, slightly sticky when wet; a few lime concretions; slightly to strongly calcareous; lower boundary clear.

$C_{ca}$ 8 inches+
Light brownish-gray (10YR 6/2, moist) sandy clay loam; weak medium granular structure; soft when dry, friable when moist, slightly sticky to sticky when wet; strongly calcareous.

*Range in characteristics:* The B horizon may be absent. The color of surface soil ranges from light gray to light grayish brown. Pockets of indurated caliche occur at depths of 10 to 16 inches in places. The soils may be strongly calcareous at the surface.

*Topography:* Level areas and in shallow broad valleys or on benches around intermittent lakes on the High Plains.

*Drainage:* Runoff is moderate to slow; permeability is moderate.

*Vegetation:* Moderately dense cover of short grasses.

**Church series.**—Much of the soil of the Church series occupies the typical low-lying saltgrass position along the geologic feature known as Portales Springs. It is also mapped in the first-terrace position around large playas. It is believed that Church soils developed in place from strongly calcareous materials under hydromorphic conditions.

The Church series is associated with the Arch and Drake series. It differs from the Arch soils in being finer textured and darker gray, and in having a stronger structural development. The Drake soils are lighter in color than the Church soils and occupy the eastern and northeastern slopes.

Profile of Church clay loam, 0 to 1 percent slopes; location, West quarter corner of sec. 15, T. 2 S., R. 35 E.:

$A_1$ 0 to 2 inches
Light brownish-gray (2.5Y 6/2; 2.5Y 4/2) strongly calcareous clay loam; moderate medium granular structure; weakly friable to firm; slightly to moderately saline; contains numerous grass roots; lower boundary distinct.

$A_2$ 2 to 7 inches
Light brownish-gray (2.5Y 6/2; 2.5Y 4/2) clay loam; strong granular structure; hard when dry, firm when moist, sticky when wet; strongly calcareous; moderately saline; lower boundary gradual.

$B_{3ca}$ 7 to 25 inches
Light-gray (2.5Y 7/2; 2.5Y 5/2) silty clay loam; weak medium granular structure; friable when moist, sticky when wet, slightly hard when dry; extremely calcareous; strongly saline; lower boundary gradual.

$C_{ca}$ 25 to 48 inches
Light grayish-brown (2.5YR 6/2; 2.5YR 5/2) silty clay; hard when dry, friable when moist, slightly plastic when wet; very fine medium crumb structure; extremely calcareous.

*Range in characteristics:* From little structural development to almost strong blocky structure, and from a very fine sandy loam to a silty clay loam. Pockets of gypsum occur in the lower subsoil in some places.

*Topography:* Low-lying flats of Portales Springs and first terraces of playas.

*Drainage:* No surface drainage; very slow internal drainage.

*Vegetation:* Saltgrasses; not suitable for cultivation.

**Mansker series.**—The soils of the Mansker series are minimal Calcisols that developed on medium-textured limy Tertiary outwash. They have a prominent $A_1$ horizon, no distinct $B_2$ horizon, and a prominent $C_{ca}$ horizon. The soils commonly occupy the gentle slopes of draws and depressions. Occasionally, they are on the more nearly level slopes in association with soils of the Clovis and Amarillo series. The Mansker soils differ from the Clovis and Amarillo in being calcareous throughout the profile and less well developed.

Profile of Mansker loam, 0 to 1 percent slopes:

$A_p$ 0 to 3 inches
Brown (10YR 5/3; 10YR 4/3) strongly calcareous weak medium granular loam; slightly hard when dry, friable when moist, and slightly sticky when wet; lower boundary gradual.

$B_{ca}$ 3 to 23 inches
Dark-brown (10YR 4/3, moist) strongly calcareous loam; moderate coarse prismatic structure that breaks further to medium weak granules; hard when dry, friable when moist, and slightly sticky when wet; boundary diffuse at 23 inches.

$C_{ca}$ 23 inches+
Dry, loose, gravelly marl; cannot be penetrated with the Retzer-type auger; violently calcareous.

*Range in Characteristics:* In some areas the degree of structure is not as strong as in the typical profile.

*Topography:* Gentle slopes of draws and depressions.

*Vegetation:* Grama grasses, occasionally buffalograss.

**Portales series.**—The Portales series is made up of brown and grayish-brown (10YR 5/3, dry; 10YR 3/2, moist) medial Calcisols. They developed within very calcareous moderately fine textured lacustrine and alluvial sediments. The Portales soils occupy the somewhat indistinct geologic relic of the ancient Brazos riverbed in association with the Arch soils. The Portales soils are deeper and somewhat darker than the Arch, however, and have stronger development in the B horizon.

Profile of Portales loam, 0 to 1 percent slopes; location, NW¼NW¼ sec. 28, T. 2 S., R. 36 E.:

A 0 to 2 inches
Brown (10YR 5/3) noncalcareous loam; weak medium granular structure; soft when dry, nonsticky when wet, friable when moist; lower boundary clear.

$B_{21}$ 2 to 10 inches
Dark-brown (10YR 4/3, dry) noncalcareous loam; weak coarse prismatic structure; slightly hard when dry, nonsticky when wet, friable when moist.

$B_{22}$ 10 to 28 inches
Light brownish-gray (10YR 6/2) slightly calcareous loam; moderate, coarse, subangular blocky structure; slightly sticky when wet, slightly hard when dry, friable when moist; boundary clear at 28 inches.

$B_{3c2}$ 28 to 46 inches
Light brownish-gray (10YR 6/2, dry) very fine sandy loam; strongly calcareous; weak fine granular structure; many, prominent, white mottles (10YR 8/2); boundary clear at 46 inches.

$C_{ca}$ 46 to 56 inches
Light-gray to white (10YR 8/2, dry) violently calcareous silty clay loam; weak coarse granular structure; hard when dry, friable when moist, slightly sticky when wet; boundary clear at 56 inches.

C 56 to 66 inches
Light-gray to white (10YR 8/2, dry) violently calcareous clay loam; hard when dry, friable when moist, slightly sticky when wet.

$C_u$ 66 to 76 inches
Light yellowish-brown strongly calcareous High Plains marl; sandy loam texture; a few coarse gritty sand grains in the matrix, and also a few imbedded fragments of indurated caliche; nonsticky; structureless; boundary abrupt at 76 inches.

$D_{ca}$ 76 inches+
Light-gray silty clay; violently calcareous; very hard when dry; some fine imbedded gravel.

*Range in characteristics:* The soils are slightly calcareous at the surface in places. The zone of accumulated lime occurs at depths of 16 to 30 inches. The degree of development ranges from slight to moderate, but the subsoil rarely has strong development.

*Drainage:* Moderate.

## Azonal Order

Within the High Plains area surveyed, the Regosol and Lithosol great soil groups are members of the azonal order. The Drake and Tivoli soils are Regosols, and the Potter are Lithosols.

The Drake series consists of friable, strongly calcareous soils. They have a weak $A_1$ horizon and no distinct B and $C_{ca}$ horizons. Mid and short grasses are the native cover.

Soils of the Tivoli series are recently deposited eolian sands. They have no true development and only a very weak $A_1$ horizon. The topography is rolling, and the areas called sandhills are representative of these soils.

Members of the Potter series are well-drained soils developing on strongly calcareous, indurated, or semi-indurated beds of caliche. They have a weak $A_1$ horizon and a prominent $C_{ca}$ horizon at a very shallow depth.

### *Regosol group*

**Drake series.**—These are typical of the calcareous soils of the southern High Plains. They occupy the steeper slopes of the Drake-Church soil association and the slopes to the leeward of playas. Tierra Blanca Lake, one of the largest of the playas in the High Plains area, is west of Portales. The landmark known as Chalk Hill is composed of Drake soils. The Drake soils are light-gray or pale-brown Regosols having no distinct zone of accumulated lime.

Profile of Drake fine sandy loam, 1 to 5 percent slopes; location, NE corner sec. 14, T. 2 S., R. 35 E.:

A 0 to 9 inches
Very pale brown (10YR 7/3; 10YR 5/3) strongly calcareous single-grain fine sandy loam; soft when dry, very friable when moist, nonsticky when wet; lower boundary gradual.

C 9 to 19 inches
Very pale brown (10YR 8/3; 10YR 7/3) single-grain, strongly calcareous loam; same consistence as layer described above; lower boundary gradual.

$C_{ca}$ 19 to 60 inches
Violently calcareous very pale brown clay loam without structural development; slightly hard when dry, firm when moist, and slightly sticky when wet.

*Range in characteristics:* Typical characteristic is the lack of variation within the profile.

*Topography:* Slopes on the leeward sides of playas (east and northeasterly slopes).

*Drainage:* Runoff is rapid; permeability is moderate.

**Tivoli series.**—Soils of the Tivoli series consist of the loose, sandy, undeveloped wind-reworked quartz material of Tertiary age. They have a looser, incoherent profile and a more rolling dunelike topography than the associated Springer soils.

Profile of Tivoli fine sand; location, NE¼NE¼ sec. 1, T. 1 S., R. 33 E.:

0 to 18 inches
Light yellowish-brown (10YR 6/4, dry; 10YR 5/4, moist) sand; single-grain structure; stains fingers slightly when moist; gradual lower boundary.

18 inches +
Brownish-yellow (10YR 6/6, moist) loose incoherent fine sand; noncalcareous; sand grains are clean.

*Range in characteristics:* Color in some places is less red than in the typical profile described above; also less red in the underlying geologic material. Some blowouts expose sand resting on chalky sedimentary lime; others show the yellowish marl of the High Plains.

*Drainage:* Runoff is very slight; permeability of subsoil is very rapid.

### *Lithosol group*

**Potter series.**—Soils of the Potter series are shallow (less than 10 inches deep). They have developed over semi-indurated or indurated caliche. Potter soils are associated with Mansker soils, which are darker and are usually deeper to the zone of lime accumulation.

Profile of Potter loam, 0 to 1 percent slopes; location, NW¼NW¼ sec. 29, T. 1 S., R. 34 E.:

$A_p$ 0 to 2½ inches
Yellowish-brown (10YR 5/6) slightly calcareous light loam; weak medium granular structure; nonsticky when wet, very friable when moist, soft when dry; clear lower boundary.

$A_3$ 2½ to 7½ inches
Yellowish-brown (10YR 5/4) slightly calcareous loam; very weak very coarse prismatic and weak medium subangular blocky structure; soft when dry, very friable when moist, nonsticky when wet; clear lower boundary.

$C_{1ca}$ 7½ to 10 inches
Pale-brown calcareous loam; weak fine granular structure; abrupt lower boundary.

$C_{ca}$ 10 inches
Loose large caliche rocks to undetermined depths, imbedded in violently calcareous matrix of light yellowish-brown sandy loam.

*Range in characteristics:* Usually less development and fewer horizons than in profile of Potter soil described.

*Topography:* Potter soils most often occur on slopes of 3 to 5 percent. Like the soil described, some areas of Potter soils occur on slopes of less than 1 percent.

*Drainage:* Moderate to rapid.

## Laboratory Determinations

Mechanical and chemical analyses of samples of the principal soils in the Portales area are given in table 8.

TABLE 8.—*Analytical data on some soils in the Portales area*

| Soil type | Depth | pH | | Total soluble salts | Organic matter | $CaCO_3$ (Lime) | Available phosphate ($PO_4$) | Nitrogen as nitrate ($NO_3$) | Available potassium (K) | Size class and diameter of particles | | | | Dispersion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Saturated paste | 1:5 soil-water suspension | | | | | | | Sand (2.0–0.05 millimeters) | Silt (0.05–0.002 millimeters) | Clay (less than 0.002 millimeters) | Clay (less than 0.005 millimeters) | |
| | *Inches* | | | *Percent* | *Percent* | *Percent* | *p. p. m.* | *p. p. m.* | *p. p. m.* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| Amarillo loam | 0–6 | 7.8 | 8.0 | 0.05 | 0.87 | 0 | ------ | ------ | ------ | 56.9 | 24.2 | 18.9 | ------ | ------ |
| | 6–14 | 7.3 | 7.7 | .05 | .73 | 0 | ------ | ------ | ------ | 50.5 | 22.3 | 27.2 | ------ | ------ |
| | 14–21 | 7.4 | 8.0 | .05 | .57 | .6 | ------ | ------ | ------ | 36.7 | 27.6 | 35.7 | ------ | ------ |
| | 21–37 | 7.8 | 8.2 | .02 | .26 | 3.8 | ------ | ------ | ------ | 46.0 | 24.2 | 29.8 | ------ | ------ |
| | 37–42 | 7.8 | 8.3 | .07 | .30 | 1.4 | ------ | ------ | ------ | 51.5 | 22.0 | 26.5 | ------ | ------ |
| | 42–60 | 8.1 | 8.7 | .02 | ------ | 57.8 | ------ | ------ | ------ | 51.0 | 23.8 | 25.2 | ------ | ------ |
| | 60–72 | 7.9 | 8.3 | .13 | ------ | 4.5 | ------ | ------ | ------ | 51.6 | 24.6 | 23.8 | ------ | ------ |
| Amarillo fine sandy loam. | 0–6 | 7.6 | ------ | .10 | .80 | ------ | 32.4 | 1.4 | 50 | 79.8 | 10.6 | 9.6 | 10.2 | 22.0 |
| | 6–12 | 7.5 | ------ | .18 | .52 | ------ | 4.7 | (Trace) | 57 | 82.1 | 8.9 | 9.0 | 9.6 | 22.5 |
| | 12–24 | 7.2 | ------ | .14 | ------ | ------ | ------ | ------ | ------ | 70.9 | 4.8 | 24.3 | 25.3 | ------ |
| | 24–60 | 7.6 | ------ | .13 | ------ | ------ | ------ | ------ | ------ | 77.9 | 5.5 | 16.6 | 16.6 | ------ |
| Amarillo loamy fine sand. | 0–8 | ------ | ------ | ------ | 1.20 | .6 | 2.5 | ------ | ------ | 84.0 | 6.0 | 10.0 | 13.0 | ------ |
| Arch fine sandy loam | 0–12 | 7.8 | 8.2 | .07 | .9 | .1 | 13.5 | 4.0 | ------ | 68.0 | 19.0 | 13.0 | 15.0 | 16.5 |
| | 12–24 | 7.9 | 8.6 | .12 | .4 | 20.4 | 5.0 | 2.5 | 50 | 57.0 | 18.0 | 25.0 | 34.0 | 10.3 |
| | 24–48 | 8.5 | 9.4 | .13 | ------ | 2.5 | ------ | ------ | ------ | 71.0 | 13.0 | 16.0 | 26.0 | ------ |
| Arch loam | 0–12 | 8.1 | 8.5 | .11 | 1.2 | 10.2 | ------ | ------ | ------ | 56.0 | 22.0 | 22.0 | 25.0 | 9.4 |
| | 12–36 | 8.1 | 8.5 | .09 | ------ | 20.7 | ------ | ------ | ------ | 55.0 | 19.0 | 26.0 | 30.0 | 7.9 |
| | 36–48 | 8.1 | 8.6 | .08 | ------ | ------ | ------ | ------ | ------ | 55.0 | 16.0 | 29.0 | 35.0 | 9.9 |
| Arch loamy fine sand | 0–6 | ------ | ------ | ------ | 1.0 | ------ | ------ | ------ | ------ | 86.0 | 5.0 | 9.0 | 9.0 | ------ |
| Arvana loam | 0–10 | 7.7 | ------ | .12 | 1.2 | 1.0 | 4.2 | 10.8 | ------ | 59.4 | 22.9 | 7.7 | 20.8 | 9.2 |
| | 10–24 | 7.8 | ------ | .13 | .91 | .49 | 1.2 | 4.8 | ------ | 46.6 | 26.4 | 27.0 | 35.5 | 5.6 |
| | 24–36 | 7.9 | ------ | .14 | 1.15 | 5.36 | 4.5 | 5.4 | ------ | 37.9 | 43.1 | 19.0 | 30.1 | 8.7 |
| Arvana fine sandy loam. | 0–12 | ------ | ------ | ------ | .9 | 1.6 | ------ | ------ | ------ | 74.0 | 10.0 | 16.0 | 20.0 | ------ |
| | 12–24 | ------ | ------ | ------ | .4 | 6.5 | ------ | ------ | ------ | 72.0 | 10.0 | 18.0 | 20.0 | ------ |
| | 24–36 | ------ | ------ | ------ | .3 | 11.5 | ------ | ------ | ------ | 74.0 | 8.0 | 18.0 | 20.0 | ------ |
| Arvana loamy fine sand. | 0–8 | 7.7 | 8.0 | .02 | 1.0 | 0 | ------ | ------ | ------ | 86.0 | 4.0 | 10.0 | 10.0 | ------ |
| | 8–30 | 7.6 | 7.9 | .07 | ------ | (Trace) | ------ | ------ | ------ | 73.0 | 6.0 | 21.0 | 21.0 | ------ |
| Blackwater loam | 0–5 | 7.8 | 8.2 | .11 | .75 | .5 | ------ | ------ | ------ | 50.6 | 24.9 | 24.5 | ------ | ------ |
| | 5–9 | 7.8 | 8.4 | .13 | .87 | .4 | ------ | ------ | ------ | 32.5 | 27.0 | 40.5 | ------ | ------ |
| | 9–17 | 7.7 | 8.4 | .14 | .63 | .5 | ------ | ------ | ------ | 33.9 | 21.6 | 44.5 | ------ | ------ |
| | 17–22 | 7.7 | 8.3 | .15 | .52 | 4.3 | ------ | ------ | ------ | 36.3 | 21.6 | 42.1 | ------ | ------ |
| Church clay loam | 0–6 | 8.2 | 8.2 | .38 | 7.2 | 10.2 | 11.0 | 7.0 | 1,000 | 39.0 | 39.0 | 13.0 | 22.0 | ------ |
| | 6–18 | 8.4 | 8.5 | 1.15 | 2.7 | 16.2 | 2.4 | 5.2 | 650 | 32.0 | 44.0 | 20.0 | 24.0 | ------ |
| Church loam | 0–6 | 8.0 | 8.2 | .14 | 2.7 | 8.9 | 3.8 | 2.0 | 900 | 50.0 | 27.0 | 17.0 | 17.0 | ------ |
| | 6–18 | 8.0 | 8.1 | .36 | 1.1 | 25.0 | 3.6 | 10.5 | 1,000 | 39.0 | 24.0 | 29.0 | 37.0 | ------ |
| | 18–36 | 8.3 | 8.4 | 1.15 | ------ | 27.6 | ------ | ------ | ------ | 32.0 | 16.0 | 38.0 | 52.0 | ------ |
| | 36–60 | 8.2 | 8.5 | .98 | ------ | ------ | ------ | ------ | ------ | 42.0 | 8.0 | 38.0 | 50.0 | ------ |
| Portales silt loam | 0–8 | 7.9 | 8.2 | .13 | ------ | .3 | ------ | ------ | ------ | 32.0 | 43.0 | 25.0 | 39.0 | ------ |
| Portales loam | 0–2 | 7.7 | 8.1 | .02 | 3.11 | 1.4 | ------ | ------ | ------ | 46.5 | 31.8 | 21.7 | ------ | ------ |
| | 2–10 | 7.8 | 8.3 | .02 | 1.73 | 1.5 | ------ | ------ | ------ | 57.9 | 20.3 | 21.8 | ------ | ------ |
| | 10–28 | 8.0 | 8.7 | .05 | 1.10 | 4.0 | ------ | ------ | ------ | 58.4 | 17.9 | 23.7 | ------ | ------ |
| | 28–46 | 8.4 | 9.1 | .02 | .96 | 21.3 | ------ | ------ | ------ | 59.4 | 10.9 | 29.7 | ------ | ------ |
| | 46–56 | 8.5 | 9.2 | .02 | .83 | 41.5 | ------ | ------ | ------ | 44.3 | 8.1 | 47.6 | ------ | ------ |
| | 56–66 | 8.4 | 9.3 | .05 | .69 | 11.3 | ------ | ------ | ------ | 66.1 | 7.5 | 26.4 | ------ | ------ |
| | 66–76 | 8.3 | 9.2 | .02 | .69 | 15.1 | ------ | ------ | ------ | 65.2 | 8.5 | 26.3 | ------ | ------ |
| | 76+ | 8.5 | 9.2 | .07 | .76 | 27.1 | ------ | ------ | ------ | 43.9 | 19.2 | 36.9 | ------ | ------ |
| Portales fine sandy loam. | 0–6 | 8.1 | ------ | .10 | 1.10 | .95 | ------ | ------ | ------ | 63.5 | 22.7 | 13.8 | 16.6 | 26.7 |
| | 6–12 | 7.7 | ------ | .15 | .89 | .02 | ------ | ------ | ------ | 59.4 | 18.8 | 21.8 | 24.3 | 11.0 |
| | 12–24 | 8.0 | ------ | .14 | ------ | 2.10 | ------ | ------ | ------ | 56.2 | 17.2 | 26.6 | 29.4 | 10.9 |
| | 24–36 | 8.0 | ------ | .14 | ------ | 16.37 | ------ | ------ | ------ | 53.6 | 15.4 | 31.0 | 33.9 | 11.8 |
| Portales loamy fine sand. | 0–36 | 7.3 | 7.6 | .05 | 1.2 | 1.0 | 11.9 | 5.0 | ------ | 82.0 | 8.0 | 10.0 | 12.0 | 22.3 |
| | 36+ | 7.5 | 8.3 | .02 | ------ | 17.8 | ------ | ------ | ------ | 68.0 | 11.0 | 21.0 | 24.0 | ------ |
| Springer loamy fine sand. | 0–10 | 7.5 | 7.5 | .09 | .09 | .1 | 5.5 | 5.5 | ------ | 96.0 | 1.0 | 3.0 | 4.0 | ------ |
| | 10–24 | 7.4 | 8.2 | .05 | .60 | .8 | .5 | 1.5 | ------ | 91.0 | 6.0 | 3.0 | 4.0 | ------ |

## *Literature Cited*

(1) Baldwin, M., Kellogg, C. E., and Thorp, J.
1938. SOIL CLASSIFICATION. U. S. Dept. Agr. Ybk. 1938: 979–1001.

(2) Barnes, J. R., and others.
1949. GEOLOGY AND GROUND WATER IN THE IRRIGATED REGION OF THE SOUTHERN HIGH PLAINS IN TEXAS Tex. Bd. of Water Engin. Prog. Rpt. 7: 51 pp., illus. [Reprinted 1953.]

(3) Diebold, C. H.
1952. IRRIGATION TRIALS IN THE SOUTHWEST REGION. U. S. Dept. Agr. Soil Conserv. Serv. Region. Bul. 113, Soil Ser. 14: 36 pp., illus.

(4) ———
1953. SIMPLE SOIL TEST THAT TELLS WHEN TO IRRIGATE. What's New in Crops and Soils 5 (6): 14–15, illus.

(5) Harper, W. G.
1957. MORPHOLOGY AND GENESIS OF CALCISOLS. Soil Sci. Soc. Amer. Proc. 21: 420–424, illus.

(6) Hayes, W. C.
1953. THE HOW AND WHY OF OGALALLA SANDS. Southwest. Crop and Stock 7 (7): 12, 94, illus.

(7) Theis, C. V.
1932. REPORT ON THE GROUND WATER IN CURRY AND ROOSEVELT COUNTIES, NEW MEXICO. N. Mex. State Engin. Bien. Rpt. 10: 99–161, illus.

(8) Thorp, James, and Smith, Guy D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.

## *Glossary*

**Aggregate** (of soil). Many fine soil particles held in a single mass or cluster, such as a clod, block, or prism.

**Alkali soil.** A soil containing harmful quantities of exchangeable sodium in amounts that interfere with growth of crop plants, either with or without appreciable quantities of soluble salts.

**Alkaline soil.** Any soil that is alkaline in reaction; pH above 7.0.

**Alluvial soils.** Soils developing from transported and relatively recently deposited material (alluvium) with little or no modification of the original materials by soil-forming processes.

**Azonal soil.** Any group of soils having little or no profile development.

**Calcareous soil.** A soil that is so alkaline in reaction, because of the presence of calcium carbonate, that it will effervesce (fizz) when treated with dilute hydrochloric acid.

**Calcisol.** A soil that occurs on highly calcareous parent material in arid and semiarid regions. In these soils accumulated calcium carbonate has formed a prominent horizon. Calcisols differ from zonal soils in not having an accumulation of silicate clay minerals in the B horizon.

**Caliche.** More or less strongly cemented deposits of calcium carbonate in many soils of arid and semiarid regions. When near the surface or exposed to erosion, the material hardens.

**Capability class.** A rating of soils in relation to their intensity for use and the complexity of conservation practices that must be applied to maintain their productivity under such use.

**Chisel.** A tillage implement that has one or more soil-penetrating points that can be drawn through the soil to loosen or shatter the subsoil to a depth of 12 to 18 inches.

**Clay.** Mineral soil particles less than 0.002 mm. in diameter.

**Colloid, soil.** Material, both organic and inorganic, of clay particle size, with high surface area per unit of mass.

**Colluvium** (colluvial deposits). Mixed deposits of rock fragments and coarse soil materials near the base of steep slopes. The deposits have accumulated through soil creep, slides, and local wash.

**Consistence, soil.** The combination of properties of soil material that determines its resistance to crushing and its ability to be molded or changed in shape. Consistence depends mainly on the forces of attraction between soil particles. Terms used to describe consistence are—

*rm* When moist, crushes under moderate pressure, but resistance is distinctly noticeable. Firm soils are likely to be difficult to till.

*Friable.* When moist, easily crushed by hand and coheres when pressed together. Friable soils are easily tilled.

*Hard.* When dry, moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.

*Indurated.* Very strongly cemented; brittle; does not soften under prolonged wetting.

*Loose.* Noncoherent when moist or dry; loose soils are generally coarse textured and are easily tilled.

*Plastic.* Readily deformed without rupture; pliable but cohesive; can be readily molded.

*Soft.* Weakly coherent and fragile; when dry, breaks to powder or individual grains under slight pressure.

*Sticky.* Adhesive when wet, but cohesive when dry; tends to adhere to other material and objects.

**Contour tillage.** Furrows plowed at right angles to the direction of the slope, at the same level throughout, and at regular intervals.

**Cretaceous.** A period of geologic time that occurred between 60 and 130 million years ago. Also, geologic materials deposited during the Cretaceous period.

**Deep plowing.** A tillage practice, generally used as a protective measure against wind erosion, whereby the finer textured subsoil materials are turned up and mixed with the sandy surface soils.

**Dry farming.** Generally, producing crops that require some tillage, without irrigation, in subhumid to semiarid areas. The system usually involves periods of fallow between crops during which water from precipitation is absorbed and retained. The fallow period is usually 1 or 2 years for each year of cropping.

**Eluviation.** The movement of soil material from one soil horizon to another. Soil horizons that have lost material through eluviation are said to be eluvial; those that have received material are illuvial.

**Eolian soils.** Soils formed from materials deposited by winds.

**Erosion.** The wearing away or removal of soil material by wind or water.

**Field capacity.** The moisture content of soil 2 or 3 days after a heavy rain or irrigation. At this time nearly all the free water has drained into the underlying material or soil. Field capacity is often expressed in inches per foot.

**Genesis, soil.** Mode of origin of the soil, referring particularly to the processes responsible for the development of the solum from the unconsolidated parent material.

**Great soil group.** Any one of several broad groups of soils with fundamental characteristics in common.

**Horizon, soil.** A layer of soil, approximately parallel to the land surface, with distinct characteristics produced by the soil-forming processes.

**Humus.** The well-decomposed, more or less stable part of the organic matter in mineral soils.

**Intrazonal soil.** Any one of the great soil groups having more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or of parent material over the normal influences of climate and vegetation.

**Land, arable.** Land which in its present state is capable of producing crops that can be tilled.

**Leaching, soil.** The removal of materials in solution by the passage of water through the soils.

**Lithosol.** A soil having little or no evidence of soil development and consisting mainly of a partly weathered mass of rock fragments or of nearly barren rock.

**Loess.** Geologic deposit of relatively uniform, fine material, mostly silt, presumably transported by wind.

**Marl.** An earthy deposit mainly of calcium carbonate mixed with clay and other impurities. It is formed chiefly at the margins of fresh water lakes.

**Morphology, soil.** The constitution of the soil including the texture, structure, consistence, color, and other physical, chemical, and biological properties of the various soil horizons that make up the soil profile.

**Mottled.** Soil horizons irregularly marked with spots of color; mottling is usually associated with poor drainage.

**Normal soil.** A soil having a profile nearly in equilibrium with its environment; developed under good but not excessive drainage from parent material of mixed mineral, physical, and chemical composition. In its characteristics it expresses the full effects of the forces of climate and living matter.

**Parent material.** The unconsolidated mass of rock material (or peat) from which the profile develops.

**Phase, soil.** The subdivision of a soil type or of some other classification unit having variations in characteristics not significant to the classification of the soil in its natural landscape but significant to the use and management of the soil. Examples of the variations recognized by phases of soil types include differences in slope, stoniness, and thickness because of accelerated erosion.

**Planosol.** An intrazonal group of soils with eluviated surface horizons underlain by claypans or fragipans, developed on nearly level or gently sloping uplands in humid or subhumid climates.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

**Readily available moisture.** The amount of moisture in the soil that plants can obtain from the soil while maintaining rapid growth.

**Reddish Chestnut soils.** A zonal group of soils with dark-brown, tinted pinkish or reddish, surface soils up to 2 feet thick over heavier reddish-brown soil, over grayish or pinkish lime accumulation; developed under warm-temperate semiarid climate and mixed grasses, and some shrubs.

**Refill irrigation.** The amount of moisture required to replace that which has been extracted from the soil by a mature, rapidly growing root system.

**Regosol.** An azonal group of soils without definite genetic horizons and developing from deep unconsolidated or soft rocky deposits.

**Relief.** Elevations or inequalities of the land surface, considered collectively.

**Residual material.** Unconsolidated and partly weathered parent material for soils assumed to have developed from the same kind of rock as that on which it lies. The term "residual" is sometimes incorrectly applied to soils, but it can be applied correctly only to the material from which soils are formed.

**Root zone.** The part of the soil that is invaded by plant roots.

**Runoff.** The surface flow of water from an area, or the total volume of surface flow during a specified time.

**Saline soil.** A soil containing enough soluble salts to impair its productivity for plants but not containing an excess of exchangeable sodium.

**Sand.** Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Usually sand grains consist chiefly of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more of sand and not more than 10 percent of clay.

**Series, soil.** A group of soils that have horizons similar in their differentiating characteristics and arrangement in the soil profile, except for the texture of the surface soil, and are formed from a particular type of parent material. The soil series is an important category in detailed soil classification. Individual series are given proper names from place names near their first recorded occurrence. Thus, names like Amarillo, Church, Portales, and Potter are names of soils that appear on soil maps, and each connotes a unique combination of many soil characteristics.

**Silt.** Small grains of mineral soil ranging from 0.05 to 0.002 millimeters in diameter.

**Soil.** The natural medium for the growth of land plants on the surface of the earth; composed of organic and mineral materials.

**Solonchak soils.** An intrazonal group of soils with high concentrations of soluble salts in relation to those in other soils; usually light colored, without characteristic structural form; developed under salt-loving plants; occur mostly in a subhumid or semiarid climate. In soil classification, the term applies to a broad group of soils and is only approximately equivalent to the common term "saline soil."

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons. Usually the characteristics of the material in those horizons are quite unlike those of the underlying parent material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles.

**Subsoil.** Technically, the B horizon; roughly, that part of the profile below plow depth.

**Substratum.** Any layer lying beneath the solum, or true soil.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness.

**Texture, soil.** The relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically, texture refers to the proportions of sand, silt, and clay.

**Tilth, soil.** The physical condition of a soil in respect to its fitness for the growth of a specified plant or sequence of plants.

**Type, soil.** A subgroup or category under the soil series based on the texture of the surface soil. A soil type is a group of soils having horizons similar in differentiating characteristics and arrangement in the soil profile and developed from a particular type of parent material.

**Weathering.** The physical and chemical disintegration and decomposition of rocks and minerals.

**Wilting point** (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which plants (specifically sunflower plants) wilt and fail to recover their turgidity when placed in a dark humid atmosphere. The percentage of water at the wilting point approximates the minimum moisture content of soils under plants in the field at depths below the effects of surface evaporation.

**Zonal soil.** Any one of the great soil groups having well-developed soil characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation.

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