

SOIL SURVEY OF

# Palo Verde Area, California



**United States Department of Agriculture**  
**Soil Conservation Service**  
In cooperation with  
**University of California**  
**Agricultural Experiment Station**

Issued September 1974

Major fieldwork for this soil survey was done in the period 1962-68. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in the publication refer to conditions in the Area in 1968. This survey was made cooperatively by the Soil Conservation Service and the University of California Agricultural Experiment Station. It is part of the technical assistance furnished to the Palo Verde Resource Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

## HOW TO USE THIS SOIL SURVEY

**T**HIS SOIL SURVEY contains information that can be applied in managing farms; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

### Locating Soils

All the soils of Palo Verde Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

### Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the Area in alphabetic order by map symbol and gives the capability classification and the Storie index rating of each. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation

of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and those who work with farmers* can learn about use and management of the soils from the descriptions of the soils and of the capability units and from the discussion of management practices and estimated yields.

*Engineers and builders* can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

*Community planners and others* can find information that affects the choice of sites for dwellings, industrial buildings, and recreation areas in the engineering tables.

*Scientists and others* can read about how the soils formed and how they are classified in the section "Formation, Morphology, and Classification of the Soils."

*Newcomers in the Palo Verde Area* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the sections "General Nature of the Area," "Irrigation and Development of Farming," and "The Climate of Palo Verde Area."

**Cover: Lettuce beds on Holtville silty clay.**

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# SOIL SURVEY OF PALO VERDE AREA, CALIFORNIA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

**P**ALO VERDE AREA is made up of the extreme southeastern part of Riverside County and the north-eastern part of Imperial County (fig. 1). The survey area is 154,500 acres in extent. It has a population of 16,000. Blythe, the principal town, has a population of 8,480.

High-value row crops are grown extensively in Palo Verde Area. Large acreages are used to grow cantaloup, watermelon, lettuce, onions, tomatoes, and winter squash for shipment to areas where such produce is out of season. Lesser areas are used for asparagus, cabbage, corn, carrots, garlic, summer squash, and other kinds of melons. Cotton and alfalfa are other important crops. All crops have to be grown under irrigation.

## *How This Survey Was Made*

Soil scientists made this survey to learn what kinds of soil are in Palo Verde Area, where they are located, and how they can be used. The soil scientists went into the Area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the kinds of crops and native plants, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

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

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Holtville silty clay is one of the two phases within the Holtville series.

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

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in plan-

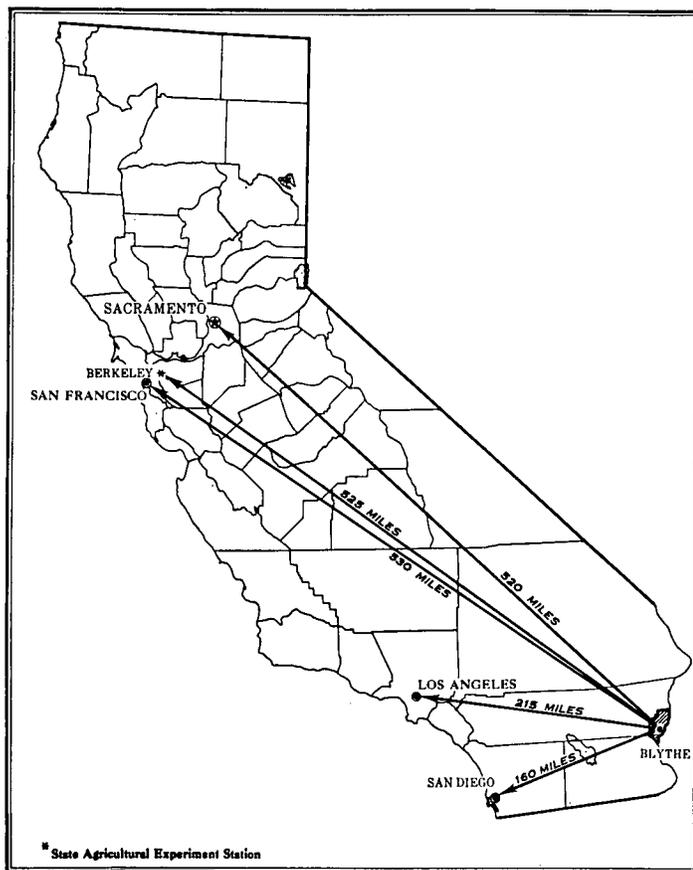


Figure 1.—Location of Palo Verde Area in California.

ning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Badland is a land type in this survey area.

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

Soil scientists observe how soils behave when used as a growing place for plants and as materials for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential use.

After data have been collected and tested for the key; or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

## General Soil Map

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

A map showing soil associations is useful to people who want a general idea of the soils in an Area, who want to compare different parts of an Area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for

planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The five soil associations in Palo Verde Area are each described in the following pages. The textures named in the legend of each association are those of the surface layer of the dominant soils. In association 1, for example, the Rositas and Gilman soils have a surface layer of fine sand, fine sandy loam, and silty clay loam.

## 1. Rositas-Gilman Association

*Nearly level, somewhat excessively drained and well-drained fine sands, fine sandy loams, and silty clay loams, in Palo Verde Valley*

The soils of this association formed in sandy alluvium deposited by the Colorado River. The slope is less than 1 percent or has been graded to less than 1 percent. These soils are very deep. They are moderately to strongly alkaline and calcareous throughout. The content of organic matter is very low. The supplies of nitrogen and phosphorus are deficient for maximum plant growth. The water table is normally at a depth of more than 6 feet.

This association occupies about 20 percent of the Area. About 40 percent of the acreage consists of Rositas soils, and about 40 percent consists of Gilman soils. The remaining 20 percent is minor soils.

Rositas soils are somewhat excessively drained. They have a surface layer of pinkish-gray fine sand or silty clay loam. Between depths of about 10 inches and more than 40 inches, the average texture is fine sand. Rositas soils are nonsaline or slightly saline.

Gilman soils are well drained. They have a surface layer of brown or light-brown fine sandy loam or silty clay loam. Between depths of about 13 inches and more than 40 inches, the texture is fine sand to fine sandy loam. Gilman soils are nonsaline.

Minor soils of this association are the Indio, Meloland, and Ripley and very small, scattered areas of the Cibola, Holtville, and Imperial.

Practically all areas of this association are cultivated. All suitable irrigated crops are grown.

## 2. Rositas-Aco-Carrizo Association

*Nearly level to moderately sloping, excessively drained to well-drained fine sands, gravelly sands, sandy loams, gravelly loamy sands, and loamy fine sands, on higher terraces of Colorado River*

The soils of this association formed in sandy or gravelly alluvium on Palo Verde Mesa. Elevation ranges from 300 to 700 feet. Slopes are generally less than 2 percent but range to 9 percent in some areas. These soils are very deep and are calcareous and moderately alkaline throughout. The content of organic matter is very low and decreases with depth. Supplies of nitrogen and phosphorus are deficient for maximum plant growth. The water table is at a depth of 150 feet or more.

This association occupies about 25 percent of the Area. About 35 percent of the acreage is Rositas soils, 30 percent

is Aco soils, and 25 percent is Carrizo soils. The remaining 10 percent is miscellaneous land types and some minor soils.

Rositas soils on the Mesa have a surface layer of pinkish-gray fine sand or gravelly loamy sand. When mixed the average texture below a depth of 10 inches to more than 40 inches is fine sand. Rositas soils are somewhat excessively drained.

Aco soils have a surface layer of pinkish-gray sandy loam or gravelly loamy sand. At a depth of 3 inches to 46 inches is sandy loam. These soils are well drained. They are slightly hard when dry but are friable or very friable when moist. Aco soils contain accumulations of lime concretions and soft lime masses.

Carrizo soils consist of barely stabilized recent alluvium that merges into fresh alluvium in places. No definite line of separation is apparent. These soils have a surface layer of very pale brown stratified gravelly sand, gravel, cobblestones, or sand. The lower layers are dark grayish-brown very cobbly sandy loam and brown very cobbly sand. These layers are more than 75 percent gravel and cobblestones. Carrizo soils are excessively drained.

Minor miscellaneous land types of this association are Dune land and Badland. Among the minor soils are the Chuckawalla and Orita and the shallower Carrizo soils that are underlain by unconforming finer textured material.

Approximately 4,500 acres of this association are cultivated. Citrus, alfalfa, small grains, and sorghums are the principal crops. Except for some urban use, the balance of the association is desert.

### 3. Cibola-Ripley-Indio Association

*Nearly level, well-drained fine sandy loams, very fine sandy loams, or silty clay loams, in Palo Verde Valley*

The soils of this association formed in stratified alluvium derived from mixed sources and deposited by the Colorado River. The slope is less than 1 percent. These soils are nonsaline to moderately saline, calcareous, and moderately alkaline throughout. The supplies of nitrogen and phosphorus are deficient for maximum plant growth. The content of organic matter is very low in the surface layer and decreases with depth. The water table is normally at a depth of more than 6 feet. Surface runoff is not a concern in management.

This association occupies about 20 percent of the Area. About 25 percent of the acreage is Cibola soils, 25 percent is Ripley soils, 20 percent is Indio soils, and 15 percent is Glenbar soils. The remaining 15 percent is minor soils.

Cibola soils have a surface layer of fine sandy loam or silty clay loam. At a depth of 10 to 20 inches or even as deep as 35 inches the average texture is silty clay loam. Then there is abrupt change to sand or loamy sand that extends to a depth of many feet. Cibola soils are generally slightly to moderately saline.

Ripley soils have a surface layer of very fine sandy loam to silty clay loam. At a depth of 10 to 40 inches is very fine sandy loam to silt loam. Below a depth of 20 to 40 inches is mainly fine sand. Ripley soils are generally slightly saline.

Indio soils range from loamy very fine sand to silt loam at a depth of 10 to 40 inches or more, but normal texture is either very fine sandy loam or silt loam. The coarser textures are in strata less than 5 inches thick. Indio soils are generally slightly saline.

Minor soils of this association are the Gilman, Holtville, Imperial, and Rositas.

A wide variety of climatically adapted crops is grown on this association.

### 4. Imperial-Holtville-Meloland Association

*Nearly level, well-drained and moderately well drained fine sandy loams, silty clay loams, and silty clays, in Palo Verde Valley*

The soils of this association formed in stratified fine-textured alluvium deposited by the Colorado River. These soils are very deep, and the slope is less than 1 percent. They are calcareous and moderately to strongly alkaline throughout. The content of organic matter is very low in the surface layer and decreases with depth. Supplies of nitrogen and phosphorus are deficient for maximum plant growth. The water table is commonly at a depth of more than 6 feet, but a perched water table occurs temporarily in the Meloland soils.

This association occupies 30 percent of the Area. About 35 percent of the acreage is Imperial soils, 30 percent is Holtville soils, and 20 percent is Meloland soils. The remaining 15 percent is minor soils.

Imperial soils generally have a surface layer of silty clay, but in places the surface layer is fine sandy loam. Below a depth of 10 inches, and even as deep as 15 feet, the dominant texture is silty clay. Layers of fine sand generally occur, however, at depths of less than 7 feet. The hazard of salinity is generally moderate. Imperial soils are moderately well drained.

Holtville soils have a surface layer of silty clay or silty clay loam. In some areas 10 inches of fine sandy loam overlies the silty clay. Below a depth of 20 to 35 inches is loamy fine sand or fine sand. These soils are generally slightly saline. Holtville soils are well drained.

Meloland soils have a surface layer of fine sandy loam or silty clay loam. At a depth of 10 to 35 inches is fine sandy loam to sandy loam. The next layer ranges from heavy clay loam to clay that extends to a depth of 10 feet or more. Meloland soils are moderately saline. They are well drained, but temporarily perched water tables form in places in areas that are frequently irrigated during periods of hot weather.

Minor soils of this association are the Cibola, Gilman, Glenbar, and Rositas.

Most areas are cultivated. Barley and cotton are the principal crops.

### 5. Orita-Chuckawalla Association

*Nearly level, well-drained fine sands, gravelly loamy sands, gravelly fine sandy loams, and very gravelly silt loams, on upper terrace of Palo Verde Mesa*

The soils of this association formed in older alluvium deposited by the Colorado River. These soils are very deep and are calcareous throughout. The water table is

at a depth of 150 feet or more. The slopes are 0 to 2 percent.

This association occupies about 3 percent of the Area. About 60 percent of the acreage is Orita soils, and about 30 percent is Chuckawalla soils. The remaining 10 percent is minor soils and miscellaneous land types.

Orita soils have a surface layer of gravel pavement, and the gravel is darkened by coatings of iron and manganese oxide. Underlying this layer is light-brown gravelly fine sandy loam, fine sand, or gravelly loamy sand. The next layer is brown fine sandy loam. The subsoil is reddish-yellow and light reddish-brown gravelly clay loam. These soils are slightly saline.

Chuckawalla soils have a gravel surface layer that is darkened by desert varnish. The next layer of pale-brown very gravelly silt loam is underlain by a subsoil of light-brown, light reddish-brown, and reddish-yellow gravelly silty clay loam and very gravelly clay loam. The substratum is light-brown very cobbly and gravelly fine sandy loam.

Minor soils of this association are the Aco, Carrizo, and Rositas. Minor miscellaneous land types are Badland and Dune land.

Orita soils provide limited range for sheep. Where irrigation systems have been developed, these soils are used for row crops and vegetables. Chuckawalla soils are not cultivated. At times they provide gravel for construction.

## Descriptions of the Soils

In this section the soil series and mapping units of Palo Verde Area are described. To get full information about any given mapping unit, it is necessary to read the description of the series as well as that of the mapping unit.

Each series description includes descriptions of soil properties and environmental factors that are common to all the soils of the series and also a short description of a profile representative of the series.

Following each series description is a description of the mapping unit that has the representative profile, including a technical description of that profile detailed enough to be used by persons who need to make thorough and precise studies of the soils. Differences between this mapping unit and the others in the series are pointed out in the descriptions of individual units, unless they are apparent from the soil names, as, for example, are differences in texture.

All colors mentioned are those of the dry soil, unless otherwise stated.

As explained in the section "How This Survey Was Made," not every mapping unit is part of a soil series. Badland, for example, is not in a soil series, but it is described in this section, in alphabetic order, along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description is the capability unit in which the mapping unit has been placed. The page for the description of each mapping units and each capability unit is given in

the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (6).<sup>1</sup>

## Aco Series

The Aco series consists of well-drained soils on terraces. The slope is less than 1 percent. The range in elevation is 300 to 700 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the length of the growing season is 290 to 310 days. The vegetation is chiefly brush but includes a few annual grasses and forbs. Aco soils are used for citrus and vegetable crops.

In a representative profile the surface layer is about 3 inches of pinkish-gray sandy loam. Below it is a 15-inch layer of light-brown coarse sandy loam, then a 28-inch layer of light-brown sandy loam, both containing concretions of lime. At a depth of about 46 inches is

<sup>1</sup> Italic numbers in parentheses refer to Literature Cited, p. 35.

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

Soil	Acreage	Percent
Aco gravelly loamy sand.....	5, 470	4. 0
Aco sandy loam.....	8, 095	5. 0
Badland.....	3, 290	2. 0
Carrizo gravelly sand.....	9, 835	6. 0
Chuckawalla very gravelly silt loam.....	4, 600	3. 0
Cibola fine sandy loam.....	1, 650	1. 0
Cibola silty clay loam.....	6, 350	4. 0
Dune land.....	485	. 3
Gilman fine sandy loam.....	12, 195	8. 0
Gilman silty clay loam.....	4, 070	3. 0
Glenbar silty clay loam.....	5, 815	4. 0
Holtville fine sandy loam.....	610	. 4
Holtville silty clay.....	14, 580	9. 0
Imperial fine sandy loam.....	710	. 5
Imperial silty clay.....	15, 600	10. 0
Indio very fine sandy loam.....	4, 050	3. 0
Indio silty clay loam.....	1, 410	. 9
Meloland fine sandy loam.....	7, 675	5. 0
Meloland silty clay loam.....	3, 175	2. 0
Orita fine sand.....	2, 150	1. 0
Orita gravelly loamy sand.....	1, 415	. 9
Orita gravelly fine sandy loam.....	4, 835	3. 0
Ripley very fine sandy loam.....	3, 835	3. 0
Ripley silty clay loam.....	3, 730	2. 0
Rock land.....	465	. 3
Rositas fine sand, 0 to 2 percent slopes.....	14, 650	9. 0
Rositas fine sand, 2 to 9 percent slopes.....	4, 140	3. 0
Rositas fine sand, wet, 0 to 2 percent slopes.....	460	. 3
Rositas gravelly loamy sand, 0 to 2 percent slopes.....	2, 655	2. 0
Rositas silty clay loam, 0 to 2 percent slopes.....	6, 080	4. 0
Rositas silty clay loam, wet, 0 to 2 percent slopes.....	420	. 3
Water, gravel pits, etc.....		. 1
Total.....	154, 500	100. 0

very pale brown fine sand that extends to a depth of 60 inches or more.

**Aco sandy loam (Af).**—This soil is on terraces. The slope is less than 1 percent.

Representative profile, located about 1,180 feet south and 335 feet west of the monument in the northeast corner of NE $\frac{1}{4}$  sec. 2, T. 6 S., R. 22 E.:

- A1—0 to 3 inches, pinkish-gray (7.5YR 7/2) sandy loam; brown (7.5YR 5/4) moist; strong, thin to very thick, platy structure; slightly hard, very friable, non-sticky and nonplastic; surface pavement of very coarse sand and gravel (in places pebbles have a weak desert varnish, and some are imbedded half an inch into the soil); very few fine roots; many, very fine, discontinuous, vesicular pores; few colloidal coatings on sand grains; slightly effervescent; moderately alkaline; clear, wavy boundary.
- C1ca—3 to 18 inches, light-brown (7.5YR 6/4) coarse sandy loam; strong brown (7.5YR 5/6) moist; massive; slightly hard; very friable, nonsticky and nonplastic; very few very fine medium roots; few, very fine, open, vesicular pores in upper part of horizon and common, very fine, tubular pores throughout; few colloidal coatings and stains on mineral grains; violently effervescent; about 7 percent (by volume) medium to large, irregular lime concretions; moderately alkaline; diffuse, irregular boundary.
- C2ca—18 to 46 inches, light-brown (7.5YR 6/4) sandy loam; brown (7.5YR 5/4) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; no observable roots; common very fine pores; few coleoidal coatings and stains on mineral grains; violently effervescent; about 9 percent (by volume) medium to large, irregular lime concretions; moderately alkaline; gradual, wavy boundary.
- IIC—46 to 60 inches, very pale brown (10YR 7/4) fine sand; light yellowish brown (10YR 6/4) moist; single grain; loose (moist or dry), nonsticky and nonplastic; violently effervescent; lime on bottoms of some coarse fragments near top of horizon; moderately alkaline.

The gravelly surface pavement tends to disappear if the soil is cultivated.

The A horizon ranges from loamy fine sand to fine sandy loam in texture but is most commonly loamy fine sand. The upper part of the C horizon is slightly hard or hard when dry and friable and very friable when moist. Accumulation of lime concretions begins at a depth of less than 10 inches. The depth to the IIC horizon ranges from 40 to 50 inches.

Included with this soil in mapping were small areas of Aco gravelly loamy sand and of Rositas fine sand. Also included were areas in which the depth to fine sand is less than 40 inches.

This Aco soil is deficient in nitrogen and phosphorus but rich in other plant nutrients. Available water capacity is between 5.5 and 7.0 inches. This soil is nonsaline or only slightly saline. Permeability is moderately rapid. Runoff is slow. The hazards of wind erosion and water erosion are slight in tilled areas.

If this Aco soil is irrigated, it can be used for deep-rooted and cool-season crops. Citrus, alfalfa, and melons are the main cultivated crops. Capability unit IIS-4.

**Aco gravelly loamy sand (Ac).**—Except for the texture of the surface layer, the profile of this soil is like that of Aco sandy loam. Gravel covers 10 to 30 percent of the surface. Included in mapping were areas of Aco sandy loam and of Rositas gravelly loamy sand.

Available water capacity is 5 to 6 inches. Runoff is slow. The hazards of water erosion and wind erosion are slight.

If this Aco soil is irrigated, it can be used for deep-rooted and cool-season crops. Citrus, alfalfa, and melons are the main cultivated crops. Because of the coarse texture of the surface layer, establishing seedlings is somewhat difficult, particularly in hot weather. Capability unit IIS-4.

## Badland

Badland (BcG) has a slope range of 9 to 75 percent. Some less steep areas that are not suitable for farming because of size and location were included with this land type in mapping.

Vegetation is sparse or lacking, except for short periods after rains. Runoff after local storms is rapid, and the hazard of erosion is high.

Some areas of this land type command pleasant views and consequently are desirable as homesites. Capability unit VIIIe-1.

## Carrizo Series

The Carrizo series consists of excessively drained soils that contain coarse fragments, predominantly gravel. The soils are in arroyos. The slopes are less than 2 percent. The range in elevation is 300 to 450 feet. The annual rainfall averages less than 4 inches; but Carrizo soils receive runoff from adjacent Aco, Orita, and Chuckawalla soils and from soils of higher areas. Brief periods of flooding are common. The average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. The vegetation is chiefly small desert trees and brush and an understory of galleta grass and forbs. Areas are used for limited desert range for sheep and cattle. Gravel pits are present in places.

In a representative profile about 1 inch of gravel pavement is at the surface. Below this is a 36-inch layer of very pale brown, stratified sand, gravel, and cobblestones. Next is a 10-inch layer of dark grayish-brown, mottled very cobbly sandy loam. Below this is brown very cobbly sand that extends to a depth of 60 inches or more.

**Carrizo gravelly sand (Ce).**—This soil is in arroyos. The slope is less than 2 percent.

Representative profile in a dry wash, located about 600 feet north of State Highway 95 in sec. 26, T. 5 S., R. 23 E.:

- C1—0 to 1 inch, granitic gravel pavement (no desert varnish); winnowed.
- C2—1 to 37 inches, very pale brown (10YR 7/3) stratified gravel, cobblestones, and sand; single grain; loose (dry or moist), nonsticky and nonplastic; slight lime deposit on some cobblestones below a depth of 20 inches; moderately alkaline; abrupt, broken boundary.
- IIC3—37 to 47 inches, dark grayish-brown (10YR 4/3) very cobbly sandy loam (75 percent coarse fragments): very dark brown (10YR 2/2) moist; common yellow (10YR 7/8) mottles; colors probably inherited from manganese and iron in the mineral grains; single grain; loose (dry or moist), slightly sticky and nonplastic; lime deposits at random on some cobblestones; moderately alkaline; abrupt, smooth boundary.
- IIC4—47 to 60 inches, brown (10YR 5/3) very cobbly sand (75 percent fragments 2 millimeters in diameter or larger); brown to dark brown (10YR 4/3) moist; streaks of iron oxide and manganese dioxide.

The C1 horizon is commonly gravelly sand but in places ranges to loamy sand in texture. The content of lime is variable, but some lime is present throughout.

Included with this soil in mapping were areas in which the profile is more compact than that of the representative profile and is slightly cemented with lime. Also included were small areas of Chuckawalla and Rositas soils and small areas of Badland. Small escarpments have slopes of more than 2 percent, and in spots under mesquite trees the surface layer is darkened.

This soil is deficient in nitrogen, phosphorus, and possibly potassium. Available water capacity is between 2.5 to 3.5 inches. Runoff is very slow, and the hazard of erosion is slight. Salinity is generally slight. Permeability is rapid.

This soil provides limited desert range for sheep and cattle. Some areas are used for gravel pits. Capability unit IVs-4. (Areas that are not irrigated are treated as Class VIII.)

### Chuckawalla Series

The Chuckawalla series consists of well-drained, very gravelly soils on old alluvial fans. The slope is less than 1 percent. The range in elevation is 450 feet to 1,000 feet. The annual rainfall averages less than 4 inches, the average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. The soils are not cultivated, and they are barren except for annual grasses and forbs after rains and native shrubs in arroyos. Gravel pits are present in a few areas. The runoff of storm water from these soils has an important effect on areas of soils below.

In a representative profile the surface layer is covered by a close-fitted surface pavement of gravel coated with dark-brown to black desert varnish on top and tinted red or orange on the bottom. The surface layer is about 1¾ inches of bleached, pale-brown very gravelly silt loam. Below it is a 14½-inch layer of light-brown, light reddish-brown, and reddish-yellow gravelly silty clay loam and very gravelly clay loam. At a depth of about 16 inches is light-brown very cobbly and gravelly fine sandy loam that extends to a depth of more than 60 inches.

**Chuckawalla very gravelly silt loam** (Ch).—This soil is on old alluvial fans. The slope is less than 1 percent. The soil is barren except for native shrubs in dry washes and annual grasses and forbs after rains.

Representative profile 525 feet south and 300 feet east of west quarter corner of sec. 24, T. 5 S., R. 23 E.:

A2—0 to 1¾ inches, pale-brown (10YR 6/3) very gravelly silt loam; brown (10YR 5/3) moist; surface pavement of closely fitted subangular and rounded gravel, strong desert varnish; weak, thick, platy structure; soft, very friable, slightly sticky and slightly plastic; no roots; many, very fine and medium, vesicular pores; slightly effervescent on sides and bottoms; moderately alkaline; abrupt, wavy boundary.

B1t—1¾ to 2½ inches, light-brown (7.5YR 6/4) gravelly silty clay loam (about 15 percent gravel); brown (7.5YR 4/4) moist; weak, very thick, platy structure that parts to weak, fine, medium subangular blocky; slightly hard, friable, sticky and plastic; many, very fine and medium, vesicular pores; few

thin clay films in pores; strongly effervescent; strongly alkaline; clear, smooth boundary.

B21t—2½ to 4 inches, light reddish-brown (5YR 6/4) gravelly silty clay loam (about 15 percent gravel); reddish brown (5YR 4/4) moist; weak, medium, angular blocky and weak, fine, prismatic structure; slightly hard, friable, sticky and plastic; common, very fine and medium, vesicular pores; moderately thick clay films in pores; violently effervescent; strongly alkaline; clear, smooth boundary.

B22tea—4 to 7 inches, light reddish-brown (5YR 6/4) gravelly silty clay loam (about 25 percent gravel); yellowish red (5YR 5/6) moist; weak, fine, subangular blocky structure that parts to granular; soft, very friable, sticky and plastic; many, very fine, interstitial pores; colloidal staining on mineral grains; violently effervescent; few lime-coated sand grains and rounded lime pellets; moderately alkaline; clear, wavy boundary.

IIB23t—7 to 16 inches, reddish-yellow (7.5YR 6/6) very gravelly clay loam (about 70 percent gravel); strong brown (7.5YR 5/6) moist; massive; soft, very friable, sticky, and plastic; many, very fine, interstitial pores; colloidal staining on mineral grains; strongly effervescent on bottoms of pebbles; less lime than in B22tea horizon; strongly alkaline; clear, smooth boundary.

IICca—16 to 60 inches, light-brown (7.5YR 6/4) very cobbly and gravelly fine sandy loam (about 90 percent gravel and cobbles); brown (7.5YR 5/4) moist; cobbles and gravel have thick lime coating on bottoms and sides; weakly cemented.

The gravel content ranges from 15 to 25 percent in the upper part of the B horizon and from about 50 to 70 percent in the bottom part. Gypsum crystals or gypsum pendants are on the bottoms of pebbles in the very gravelly part of the profile.

Included with this soil in mapping were small areas of Carrizo soil, Badland, and Rock land and many braided washes that are generally dry.

Permeability is moderate in the upper part of the profile and rapid in the lower part. Runoff is rapid. Available water capacity is 2.7 to 3.5 inches. The hazard of erosion is slight, but salinity is high.

This Chuckawalla soil is not cultivated, but is an important part of the watershed. Gravel is mined in some areas. Capability unit VIIIs-1.

### Cibola Series

The Cibola series consists of well-drained soils that formed in alluvium on the floor of the Palo Verde Valley. The slope is less than 1 percent. The range in elevation is 225 to 300 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. Cibola soils are intensively cultivated. They are used for irrigated field and vegetable crops.

In a representative profile the upper 30 inches is pinkish-gray silty clay loam. Below a depth of 30 inches and extending to a depth of 60 inches, the substratum is pinkish-gray silt clay loam and fine sand.

**Cibola silty clay loam** (Cs).—This soil has slopes of less than 1 percent.

Representative profile in an irrigated cotton field, located 1,200 feet south of 18th Avenue and 1,200 feet south and 200 feet east of north quarter corner of sec. 13, T. 7 S., R. 22 E.:

- Ap**—0 to 10 inches, pinkish-gray (7.5YR 6/2) silty clay loam; brown (7.5YR 4/3) moist; few, medium, very dark gray (N 3/0) spots associated with and near decayed organic matter; massive; hard, very firm, sticky and very plastic; common, very fine, tubular pores; violently effervescent where carbonates are disseminated; moderately alkaline; clear, wavy boundary.
- C1**—10 to 16 inches, pinkish-gray (7.5YR 6/2) silty clay loam; brown (7.5YR 4/2) moist; massive; hard, very firm, sticky and very plastic; common, very fine, tubular pores; violently effervescent where carbonates are disseminated; moderately alkaline; clear, smooth boundary.
- C2**—16 to 24 inches, pinkish-gray (7.5YR 6/2) silty clay loam that contains slightly less clay and is slightly paler than Ap and C1 horizons; brown (7.5YR 4/2) moist; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; massive; hard, very firm, sticky and very plastic; many, very fine and fine, tubular pores; very few thin clay films in pores; violently effervescent where lime is disseminated; moderately alkaline, clear, wavy boundary.
- C3**—24 to 30 inches, pinkish-gray (7.5YR 7/2) silty clay loam that contains slightly less clay than Ap and C1 horizons; brown (7.5YR 5/2) moist; few, fine, distinct, strong-brown (7.5YR 5/6) mottles, fewer mottles than in C2 horizon; massive; hard, friable, sticky and very plastic; many, very fine and fine, tubular pores; very few thin clay films in pores; violently effervescent where lime is disseminated; moderately alkaline; abrupt, smooth boundary.
- IIC4**—30 to 60 inches, pinkish-gray (7.5YR 7/3) fine sand with translucent and black mineral grains, same color rubbed; light brown (7.5YR 6/4) moist; single grain; loose (dry or moist), nonsticky and nonplastic; many, very fine and fine, interstitial pores; strongly effervescent where lime is disseminated; moderately alkaline; clear, smooth boundary.

The Ap horizon ranges from silty clay loam to silty clay in texture. Between depths of 10 and 20 or 35 inches is silty clay loam that is underlain by fine sand or loamy fine sand. The depth to the IIC4 horizon ranges from 20 to 35 inches. The soils are calcareous throughout.

Included with this soil in mapping were small areas of Holtville silty clay and Ripley silty clay loam. Also included were some areas where the surface texture has been modified by deep tillage.

In cultivated areas this soil needs applications of nitrogen and phosphorus according to soil tests. Available water capacity is about 7 to 9 inches. Permeability is slow in the upper part of the profile and rapid in the lower part. Salinity is generally slight to moderate. Runoff is very slight, if any, and the hazard of erosion is nonexistent.

This Cibola soil is used for irrigated row and field crops. Capability unit IIS-6.

**Cibola fine sandy loam (Co).**—This nearly level soil is on the floor of the Palo Verde Valley. Except for texture and color of the surface layer, the profile of this soil is like that of Cibola silty clay loam. The surface layer is about 10 inches of brown or light-brown fine sandy loam. Included in mapping were small areas of Holtville fine sandy loam and Ripley very fine sandy loam.

In cultivated areas the soil needs applications of nitrogen and phosphorus according to soil tests. Available water capacity is 6 to 8 inches. Salinity generally is slight to moderate. Runoff is very slight, if any, and the hazard of erosion is nonexistent.

This Cibola soil is used for a variety of irrigated row crops and field crops. Capability unit IIS-6.

## Dune Land

Dune land (DuD) consists of hills of fine sand that have a slope range of 9 to 20 percent. The dunes have only recently been stabilized or are being drifted by wind. Low dunes that have been leveled for irrigation, or dunes that have the potential of being leveled for this purpose, are mapped with soils of the Aco, Orita, and Rositas series. In places small areas of Carrizo or Rositas soils were included with Dune land in mapping.

Dune land has no practical value for farming. About one year of every 15 it provides sheep range for a short period. Some areas have recreational value, but controls are needed to prevent encroachment of Dune land on farmland. Capability unit VIIIe-1.

## Gilman Series

The Gilman series consists of well-drained soils that formed in alluvium on the valley floor. The slope is less than 1 percent. The range in elevation is 225 to 300 feet. The average annual rainfall is less than 4 inches, the average air temperature is about 72° F., and the frost-free season is 290 to 310 days. The Gilman soils are used for all locally adapted irrigated crops. A few small areas are used for citrus.

In a representative profile the surface layer is about 3½ inches of brown fine sandy loam. It is underlain by light-brown, pink, and very pale brown stratified loamy sands and sands that average loamy fine sand and extend to a depth of more than 60 inches.

**Gilman fine sandy loam (Gb).**—This soil is on the valley floor. Slope is less than 1 percent.

Representative profile, located in Imperial County, ¼ mile east of Palo Verde, in partly cleared field of native shrubs about 700 feet west and 100 feet south of the northwest corner of sec. 2, T. 9 S., R. 21 E.:

- Ap**—0 to 3½ inches, brown (10YR 5/3) fine sandy loam; dark yellowish brown (10YR 3/4) moist; massive; weak, fine, granular structure; soft, very friable, slightly sticky and plastic; many very fine roots; slightly effervescent; moderately alkaline; clear, wavy boundary.
- C1**—3½ to 13 inches, light-brown (7.5YR 6/4) loamy very fine sand, brown to dark brown (7.5YR 4/4) moist; massive; soft, very friable, nonsticky and nonplastic; common fine, medium, and coarse roots; strongly effervescent; strongly alkaline; fine reticulate masses of gypsum; distinct, smooth boundary.
- C2**—13 to 20 inches, pink (7.5YR 7/4) loamy very fine sand; brown to dark brown (7.5YR 4/4) moist; massive; soft, very friable, nonsticky and slightly plastic; common fine, medium, and coarse roots; very fine tubular pores; strongly effervescent; strongly alkaline; fine reticulate masses of gypsum; abrupt, smooth boundary.
- C3**—20 to 28 inches, pink (7.5YR 7/4) very fine sand; brown (7.5YR 5/4) moist; massive; soft, very friable, nonsticky and nonplastic; few very fine, fine, and medium roots; strongly effervescent; strongly alkaline; abrupt, smooth boundary.
- C4**—28 to 33 inches, pink (7.5YR 7/4) loamy fine sand; brown (7.5 YR 5/4) moist; massive; soft, very friable, nonsticky and nonplastic; few fine and medium roots; strongly effervescent; moderately alkaline; abrupt, smooth boundary.
- IIC1**—33 to 60 inches, very pale brown (10YR 7/3) fine sand; brown to dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky and nonplastic; few

fine and medium roots; slightly effervescent; moderately alkaline.

The Ap horizon is generally thicker than that shown in the representative profile and generally has been disturbed by cultivation to at least a depth of 10 inches. Reaction in the irrigated soil normally does not exceed pH 8.4 and is mostly about pH 8.2. The A horizon is fine sandy loam, very fine sandy loam, or loamy fine sand. The underlying layers are stratified and range from fine sand to loamy very fine sand and sometimes have ¼-inch strata of silty clay loam or silty clay.

Included with this soil in mapping were small areas of Gilman silty clay loam, Meloland fine sandy loam, Ripley very fine sandy loam, and Rositas fine sand.

This Gilman soil is suited to cotton, small grains, sorghums, alfalfa, melons, onions, and other winter crops. Crops respond to applications of nitrogen and phosphorus according to soil tests. This soil is nonsaline. Available water capacity is 5 to 6 inches. Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Runoff is slow or does not occur in irrigated fields. The hazard of erosion is none to slight. Capability unit IIs-4.

**Gilman silty clay loam (Gc).**—This soil is on the floor of the Palo Verde Valley. Slope is less than 1 percent. Except for the texture of the surface layer, the profile is like that of Gilman fine sandy loam. It has a light brownish-gray to brown surface layer that is generally silty clay loam but in places ranges to silty clay. The surface layer is about 12 inches thick. Included in mapping were small areas of Meloland silty clay loam and Ripley silty clay loam.

Crops respond to applications of nitrogen and phosphorus according to soil tests. Runoff is slow or not present in irrigated fields. The hazard of erosion is none to slight. Available water capacity is 6 to 7 inches.

Irrigated cotton, small grain, sorghum, alfalfa, melons, onions, tomatoes, and other winter vegetables are grown on this soil. Capability unit IIs-4.

## Glenbar Series

The Glenbar series consists of well-drained soils that formed in alluvium deposited on the floor of the Palo Verde Valley by the Colorado River. The slope is less than 1 percent. The range in elevation is 225 to 300 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the average frost-free season is 290 to 310 days. All these soils are irrigated. They are used for all-local, climatically adapted row and field crops.

In a representative profile the surface layer is about 10 inches of pinkish-gray silty clay loam. The next layer is 8 inches of brown silty clay loam. This layer is underlain by 21 inches of pinkish-gray sandy clay loam. The next layers are pinkish-gray stratified materials ranging from loamy fine sand to sandy clay loam that extend to a depth of more than 60 inches.

**Glenbar silty clay loam (Ge).**—This soil is on the floor of the Palo Verde Valley. Slope is less than 1 percent.

Representative profile, located about ¼ mile south of 16th Avenue and ¼ mile east of Neighbor's Blvd., southwest corner of NE¼NW¼ sec. 11, T. 7 S., R. 22 E.:

Ap—0 to 10 inches, pinkish-gray (7.5YR 6/2) silty clay loam; brown to dark brown (7.5YR 4/2) moist;

weak, thin, platy structure; hard, friable, sticky and plastic; common fine and very fine roots; many, very fine, interstitial and few, fine, vesicular pores; violently effervescent; moderately alkaline; gradual, wavy boundary.

C1—10 to 18 inches, brown (7.5YR 5/2) silty clay loam; brown to dark brown (7.5YR 4/2) moist; weak, thin, platy and weak, fine, subangular blocky structure; hard, friable, sticky and plastic; many, very fine, interstitial and many, very fine and fine, tubular pores; violently effervescent; moderately alkaline; abrupt, smooth boundary.

C2—18 to 31 inches, pinkish-gray (7.5YR 7/2) sandy clay loam; brown (7.5YR 5/2) moist; massive; hard, friable, sticky and slightly plastic; many, very fine and fine, tubular pores; violently effervescent; moderately alkaline; diffuse, irregular boundary.

C3—31 to 39 inches, pinkish-gray (7.5YR 6/2) sandy clay loam; brown (7.5YR 4/2) moist; massive; hard, friable, sticky and slightly plastic; many, very fine and fine, tubular pores; violently effervescent; moderately alkaline; reticulate threads of salt; clear, smooth boundary.

C4—39 to 44 inches, pinkish-gray (7.5YR 7/2) stratified very fine and fine sandy loam that averages very fine sandy loam; dark brown (7.5YR 4/4) moist; massive; hard, friable, slightly sticky and slightly plastic; many, very fine and fine, tubular pores; violently effervescent; moderately alkaline; clear, smooth boundary.

C5—44 to 54 inches, pinkish-gray (7.5YR 7/2) stratified fine sandy loam and sandy clay loam that averages sandy clay loam when mixed; brown (7.5YR 5/4) moist; massive; hard, very friable, sticky and slightly plastic; many, very fine and fine, tubular pores; violently effervescent; moderately alkaline; abrupt, smooth boundary.

C6—54 to 62 inches, pinkish-gray (7.5YR 7/2) stratified fine sandy loam and loamy fine sand; few, fine, distinct, reddish-yellow (7.5YR 6/6), threadlike mottles; massive parts to single grain and to weak, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; many, very fine and fine, tubular pores; violently effervescent; moderately alkaline.

The A horizon is generally silty clay loam and ranges from silty clay loam to sandy clay and clay. In places strata less than 5 inches thick, and of material that is coarser textured than the surrounding material, are between depths of 10 and 40 inches. Below a depth of 40 inches, the C horizon ranges from fine sand to silty clay loam.

Included with this soil in mapping were small areas of Cibola silty clay loam, Imperial silty clay, and Indio silty clay loam. Also included, in places, are areas where the material in the surface layer is coarser textured than that of this soil.

Crops respond to applications of nitrogen and phosphorus fertilizer according to soil tests. This soil is slightly saline. Available water capacity is 9 to 11 inches. Permeability is slow, and runoff is slow or not present in fields that have irrigation borders. Erosion is not a hazard.

This Glenbar soil is used for irrigated field and vegetable crops. Capability unit IIs-6.

## Holtville Series

The Holtville series consists of well-drained soils that formed in alluvium deposited on the floor of the Palo Verde Valley by the Colorado River. The slope is less than 1 percent. The range of elevation is 225 to 300 feet. The annual rainfall is less than 4 inches, the aver-

age air temperature is about 72° F., and the frost-free season is 290 to 310 days. The Holtville soils are used for irrigated cotton, barley, alfalfa, melons, and winter vegetables.

In a representative profile the surface layer is grayish-brown silty clay about 10 inches thick. The upper part of the substratum is light brownish-gray silty clay about 6 inches thick. It is underlain by about 10 inches of pale-brown clay loam. The lower part is light-brown loamy fine sand and extends to a depth of more than 60 inches.

**Holtville silty clay (Hc).**—This soil is nearly level. It is on the floor of Palo Verde Valley.

Representative profile, located about ¼ mile west of the southeast corner of sec. 18, T. 6 S., R. 22 E.:

- Ap—0 to 10 inches, grayish-brown (10YR 5/2) silty clay; dark brown (10YR 4/3) moist; weak, coarse, blocky structure; very hard, firm, very sticky and very plastic; strongly effervescent; moderately alkaline; abrupt, smooth boundary.
- C1—10 to 16 inches, light-brownish gray (10YR 6/2) silty clay; dark grayish brown (10YR 4/2) moist; massive; very hard, firm, very sticky and very plastic; strongly effervescent; moderately alkaline; gradual, smooth boundary.
- C2—16 to 26 inches, pale-brown (10YR 6/3) silty clay loam; dark brown (10YR 4/3) moist; massive; very hard, firm, very sticky and very plastic; strongly effervescent; moderately alkaline; abrupt, smooth boundary.
- IIC3—26 to 60 inches, light-brown (7.5YR 6/4) loamy fine sand; brown (7.5YR 5/4) moist; massive; soft, very friable, nonsticky and nonplastic; strongly effervescent; moderately alkaline.

The A horizon is generally silty clay but in places ranges to silty clay loam or clay. The C horizon below 10 inches and down to the coarse horizons is generally silty clay but in places ranges to sandy clay loam, silty clay loam, or clay. Loamy fine sand or fine sand is at a depth of 20 to 35 inches. The soils are calcareous throughout the profile.

Included with this soil in mapping were small areas of Rositas silty clay loam and Cibola silty clay loam.

Crops need nitrogen and phosphorus fertilizer according to soil tests. Available water capacity is 7.5 to 9.5 inches. Permeability is slow in the upper part of the profile and rapid in the lower part. Runoff is very slow or does not occur. The hazard of erosion is none to slight, and the hazard of salinity is generally slight.

This Holtville soil is used for irrigated cotton, alfalfa, melons, and winter vegetables. Surface crusting and cracking can be a problem with seedling plants. Capability unit IIs-5.

**Holtville fine sandy loam (Hb).**—This nearly level soil is in the Palo Verde Valley. Except for the texture and color of the surface layer, the profile of this soil is like that of Holtville silty clay. The surface layer is brown or light-brown fine sandy loam.

Included with this soil in mapping were small areas of Cibola fine sandy loam and Ripley very fine sandy loam. Also included were small areas of soils having a surface layer of fine sand or loamy fine sand.

Crops need nitrogen and phosphorus. Runoff is very slow. The hazard of erosion is none or slight. Available water capacity is 7 to 8.5 inches. Salinity is slight.

This soil is used for irrigated cotton, alfalfa, barley, melons, and winter vegetables. Capability unit IIs-6.

## Imperial Series

The Imperial series consists of moderately well drained soils that formed in alluvium deposited in the Palo Verde Valley by the Colorado River. The slope is less than 1 percent. The range in elevation is 225 to 300 feet. The annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. Vegetation in uncultivated areas is chiefly saltbush and saltcedar. Cotton, barley, sorghums, and limited amounts of alfalfa and melons are grown in cultivated areas.

In a representative profile, the soil material is brown, pinkish-gray, and reddish-brown silty clay throughout. The surface layer is about 10 inches thick. The substratum extends to a depth of 60 inches or more. Below a depth of 27 inches, the substratum is mottled. If the soil is dry, it is blocky and has cracks that extend to a depth of 20 inches or more.

**Imperial silty clay (Ic)**—This nearly level soil is on the floor of the Palo Verde Valley.

Representative profile, located about 100 feet east of Arrowhead Boulevard and ¼ mile north of 18th Avenue, northwest corner of SW¼ sec. 12, T. 7 S., R. 22 E.:

- Ap—0 to 10 inches, brown (7.5YR 5/2) silty clay; dark brown (7.5YR 4/2) moist; weak, thin and medium, platy structure; hard, very firm, sticky and plastic; few fine roots; few, fine, tubular pores; violently effervescent; moderately alkaline; few fine pockets of salt; abrupt, smooth boundary.
- C1—10 to 24 inches, pinkish-gray (7.5YR 7/2) coarse silty clay with very fine strata of silt and very fine sand; brown (7.5YR 5/2) moist; massive or weak sub-angular blocky structure; hard, firm, sticky and plastic; few fine roots; few, fine, tubular pores; violently effervescent; moderately alkaline; clear, smooth boundary.
- C2—24 to 27 inches, pinkish-gray (7.5YR 6/2) silty clay; dark brown (7.5YR 4/2) moist; massive; hard, very firm, sticky and plastic; violently effervescent; lime in threads and seams; strongly alkaline; clear, smooth boundary.
- C3—27 to 36 inches, pinkish-gray (7.5YR 6/2) and reddish-brown (5YR 5/3) silty clay; brown to dark brown (7.5YR 4/2) and reddish brown (5YR 4/3) moist; few, fine, distinct, reddish-yellow (7.5YR 6/6) mottles; massive; hard, very firm, sticky and plastic; few, fine, tubular pores; violently effervescent; lime in threads and seams; moderately alkaline; clear, smooth boundary.
- C4—36 to 39 inches, pinkish-gray (7.5YR 6/2) silty clay; brown (7.5YR 5/2) moist; common, fine, distinct, reddish-yellow (7.5YR 6/6) mottles; massive; hard, very firm, sticky and plastic; violently effervescent; salt efflorescence forms as moist soil dries; moderately alkaline; gradual, smooth boundary.
- C5—39 to 60 inches, pinkish-gray (7.5YR 6/2) silty clay; brown (7.5YR 5/2) moist; massive; hard, very firm, sticky and plastic; few, fine, tubular pores; violently effervescent; strongly alkaline; salt efflorescence forms as moist soil dries.

A light olive-gray to green algae surface is common if this soil is irrigated.

The C horizon between depths of 10 and 40 inches is generally silty clay but in places ranges to heavy silty clay loam or clay. In irrigated areas threads or soft masses of lime, gypsum, or other soluble salts are common below a depth of about 20 inches. Loose fine sand is at a depth of 3.5 to 15 feet.

Included with this soil in mapping were some small areas of Glenbar silty clay loam and Holtville silty clay.

In cultivated areas applications of nitrogen and phosphorus fertilizer are needed according to soil tests. Available water capacity is 10 to 14 inches. Permeability is very slow, and irrigation generally does not replace moisture to a depth of more than 2 to 3 feet, which limits depth to plant roots. Scalding of crops and surface crusting are common concerns in management. Runoff and erosion are not hazards. Generally, salinity is moderate after reclamation.

This Imperial soil is used mainly for cotton, barley, and sorghum. Limited areas are used for alfalfa and melons. Capability unit IIIs-5.

**Imperial fine sandy loam** (Ib).—This nearly level soil is in the Palo Verde Valley. Except for the texture and depth of the surface layer, the profile of this soil is like that of Imperial silty clay. The surface layer is generally fine sandy loam about 6 to 7 inches thick. The surface layer commonly results from leveling sand dunes and drainage-ditch banks or hauling in sand to mix with the surface layer.

In cultivated areas applications of nitrogen and phosphorus fertilizer are needed according to soil tests. Available water capacity is 9 to 14 inches. Permeability is very slow; and, therefore, irrigation generally does not replace moisture to a depth of more than 2 to 3 feet, which limits depth of plant roots. The management concern of surface crusting is less than on Imperial silty clay, where good seedling emergence is prevented. Also, some improvement in prolonged ponding of irrigation water is present. Runoff and erosion are not hazards. Salinity is moderate after reclamation.

This Imperial soil is used for cotton, barley, sorghum, and, to a lesser extent, for alfalfa and melons. Capability unit IIIs-5.

## Indio Series

The Indio series consists of small areas of well-drained soils in Palo Verde Valley. They formed in alluvium deposited by the Colorado River. The slope is less than 1 percent. The range in elevation is 225 to 300 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the average frost-free season is 290 to 310 days. All Indio soils are irrigated. They are used for growing cotton, alfalfa, small grains, melons, onions, and lettuce.

In a representative profile the surface layer is about 10 inches of pinkish-gray very fine sandy loam. The upper part of the substratum is about 40 inches of pinkish-gray silt loam and pink very fine sandy loam. It is underlain by pink very fine sand that extends to a depth of more than 60 inches.

**Indio very fine sandy loam** (Id).—This soil is on the floor of the Palo Verde Valley. Slope is less than 1 percent.

Representative profile, located in a cultivated field, about 8 miles southwest of Blythe, California, about 250 feet north of the southeast corner of sec. 32, T. 7 S., R. 22 E.:

Ap—0 to 10 inches, pinkish-gray (7.5YR 6/2) very fine sandy loam; dark brown (7.5YR 4/2) moist; massive; hard, firm, sticky and slightly plastic; common fine roots; common, fine and very fine, tubular pores; strongly effervescent; moderately alkaline; clear, smooth boundary.

C1—10 to 19 inches, pinkish-gray (7.5YR 7/2) silt loam, dark brown (7.5YR 4/4) moist; very few, medium, pink (7.5YR 7/4), soft masses of lime; massive; hard, friable, slightly sticky and slightly plastic; common very fine roots; many, very fine, tubular pores; strongly effervescent with disseminated and segregated lime; moderately alkaline; clear, smooth boundary.

C2—19 to 25 inches, pink (7.5YR 7/4) very fine sandy loam; brown (7.5YR 5/4) moist; massive; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many, very fine, interstitial pores; strongly effervescent; moderately alkaline; clear, smooth boundary.

C3—25 to 40 inches, pink (7.5YR 7/4) very fine sandy loam; light brown (7.5YR 6/4) moist; massive; soft, very friable, nonsticky and nonplastic; many, very fine, interstitial pores; strongly effervescent; moderately alkaline; clear, smooth boundary.

C4—40 to 60 inches, pink (7.5YR 7/4) very fine sand; light brown (7.5YR 6/4) moist; massive; soft, very friable, nonsticky and nonplastic; many, very fine, interstitial pores; slightly effervescent; moderately alkaline.

The A horizon is very fine sandy loam or silt loam. The upper part of the C horizon, between depths of 10 and 40 inches, is commonly very fine sandy loam but ranges from loamy very fine sand to silt loam. The C4 horizon is very fine sand, loamy fine sand, or fine sandy loam.

Included with this soil in mapping were small areas of Cibola fine sandy loam, Gilman fine sandy loam, and Ripley very fine sandy loam. Also included were small areas where silty clay loam is below a depth of 40 inches.

In cultivated areas applications of nitrogen and phosphorus fertilizer are needed according to soil tests. Available water capacity is 7.5 to 9.0 inches. Permeability is moderate. Runoff and erosion are not hazards. Salinity is slight if this soil is irrigated with Colorado River water.

This Indio soil is used for alfalfa, cotton, small grains, melons, onions, and lettuce. Capability unit IIs-6.

**Indio silty clay loam** (Ie).—This nearly level soil is on the floor of the Palo Verde Valley. Except for the texture and color of the surface layer, the profile of this soil is like that of Indio very fine sandy loam. It has a pinkish-gray to light-brown silty clay loam surface layer.

Included with this soil in mapping were small areas of Cibola silty clay loam, Gilman silty clay loam, and Ripley silty clay loam.

Crops need nitrogen and phosphorus fertilizer as indicated by soil tests. Permeability is moderate. Available water capacity is 7.5 to 9.0 inches. Runoff and erosion are not hazards. Salinity is slight.

This Indio soil is used for alfalfa, cotton, small grains, melons, onions, and lettuce. Capability unit IIs-6.

## Meloland Series

The Meloland soils are generally well drained, but perched water tables are present in irrigated areas. These soils formed in alluvium deposited in the Palo Verde Valley by the Colorado River. The slope is less than 1 percent. The range in elevation is 225 to 300 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. All areas of these soils are cultivated. The main crops are alfalfa, cotton, lettuce, and barley.

In a representative profile the surface layer is about 24 inches of pinkish-gray fine sandy loam. At a depth of

about 24 inches, the soil abruptly changes to light-brown heavy clay loam. This layer is underlain, at a depth of about 48 inches, by light-brown fine sand that extends to a depth of more than 60 inches.

**Meloland fine sandy loam (Mc).**—This soil is nearly level. It is on the floor of the Palo Verde Valley.

Representative profile, located near the intersection of 25th Avenue and Keim Blvd., near the west quarter corner of sec. 33, T. 7 S., R. 22 E.:

C1—0 to 24 inches, pinkish-gray (7.5YR 6/3) fine sandy loam; brown (7.5YR 5/3) moist; massive or very weak, medium, blocky structure; soft, very friable, nonsticky and nonplastic; strongly effervescent; moderately alkaline; clear, smooth boundary.

IIC2—24 to 48 inches, light-brown (7.5YR 6/4) heavy clay loam; dark brown (7.5YR 4/3) moist; massive; very hard, firm, very sticky and very plastic; strongly effervescent; moderately alkaline; clear, smooth boundary.

IIC3—48 to 60 inches, light-brown (7.5YR 6/4) fine sand; brown (7.5YR 5/3) moist; massive; soft, very friable, nonsticky and nonplastic; strongly effervescent; moderately alkaline.

Where present, the A horizon ranges from loamy fine sand to fine sandy loam. The IIC2 horizon ranges from heavy clay loam to clay. In some places, it continues to a depth of 10 feet or more or is underlain by sand at a depth of more than 40 inches.

Included with this soil in mapping were small areas of Gilman fine sandy loam, Gilman silty clay loam, and Rositas fine sand. Also included were areas of soils that have a 10- to 40-inch surface layer of loam to silt loam.

Because the water table is perched in irrigated areas, roots of some plants are limited to a depth of 24 to 36 inches. In cultivated areas applications of nitrogen and phosphorus fertilizer are needed according to soil tests. Available water capacity is 8.5 to 11.0 inches, based on a drained profile. Permeability is moderately rapid in the upper part of the profile and slow in the lower part. Runoff is slow or does not occur in irrigated fields. Erosion is not a hazard. Salinity is generally moderate.

This Meloland soil is used for irrigated cotton, alfalfa, lettuce, and barley. Capability unit IIIw-3.

**Meloland silty clay loam (Me).**—This nearly level soil is on the floor of the Palo Verde Valley. Except for the thickness, color, and texture of the surface layer, the profile of this soil is like that of Meloland fine sandy loam. The surface layer is about 12 inches of light brownish-gray to brown silty clay loam.

Included with this soil in mapping were small areas of Gilman silty clay loam and Rositas silty clay loam. Also included were some places where the surface layer is silt loam or silty clay and small areas of loam or silt loam overlying the heavy clay loam substratum at a depth of 10 to 40 inches.

Because of a perched water table resulting from irrigation of this Meloland soil, roots of some plants are limited to a depth of 24 to 36 inches. In cultivated areas applications of nitrogen and phosphorus fertilizer are needed according to soil tests. Permeability is slow. Runoff is very slow or does not occur in fields that have irrigation borders. No erosion hazard exists. Salinity is moderate.

This Meloland soil is used for irrigated cotton, alfalfa, lettuce, and barley. Capability unit IIIw-3.

## Orita Series

The Orita series consists of well-drained gravelly soils that formed in alluvium deposited by the Colorado River. The slope is less than 1 percent. These soils are on the upper terrace of Palo Verde Mesa on old alluvial fans and flood plains. The range in elevation is 375 to 500 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is 72° F., and the frost-free season is 290 to 310 days. Vegetation is sparse and is principally creosote bush, but annuals occur in wetter years. The Orita soils are used mainly for sheep range. Recently they have been used to grow various kinds of vegetables, however, and this type of use is expected to expand as suitable water sources are developed.

In a representative profile about one-half inch of gravel pavement is at the surface. This gravel is darkened by iron and manganese oxide coatings. The next layer is about 9½ inches of light-brown gravelly fine sandy loam and gravelly sand. Underlying this layer is brown fine sandy loam that extends to a depth of 22 inches. This layer, in turn, is underlain by a buried subsoil of reddish-yellow and light reddish-brown, compacted gravelly clay loam about 46 inches thick. The next layer is light-brown or pink gravelly fine sandy loam that extends to a depth of 80 inches.

**Orita gravelly fine sandy loam (Or).**—The soil is on terraces (old alluvial fans and flood plains). The slope is less than 1 percent.

Representative profile, located about 7 miles west and 5 miles north of Blythe; about 55 feet west and 5 feet north of brass-capped monument at southeast corner of sec. 36, T. 6 S., R. 21 E.:

C1—0 to ½ inch, continuous fine gravel pavement of local granitics and some schists and quartz; some pebbles weakly varnished by iron and manganese oxides, others coated with lime; gravel remained after fines were removed by wind; abrupt, smooth boundary.

C2—½ inch to 4 inches, light-brown (7.5YR 6/4) gravelly fine sandy loam (about 15 percent gravel); dark brown (7.5YR 4/4) moist; moderate, thick, platy structure that parts to single grain and to weak, fine, granular structure; soft, very friable, nonsticky and nonplastic; few very fine roots; many, very fine, vesicular pores; slightly effervescent with lime disseminated; moderately alkaline; clear, smooth boundary.

C3—4 to 10 inches, light-brown (7.5YR 6/4) gravelly sand (about 25 percent gravel); brown (7.5YR 5/4) moist; moderate, thick, platy structure that parts to single grain; soft, slightly hard, nonstick and nonplastic; few fine and very fine roots; many, very fine, tubular and interstitial pores; slightly effervescent with lime disseminated; moderately alkaline; abrupt, smooth boundary.

IIA1b—10 to 22 inches, brown (7.5YR 5/4) fine sandy loam; dark brown (7.5YR 4/4) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; few fine roots to depth of 18 inches; many very fine tubular pores; strongly effervescent with fine lime mycelia; moderately alkaline; gradual, smooth boundary.

IIB21tb—22 to 42 inches, reddish-yellow (5YR 6/6) gravelly clay loam (about 15 percent gravel); yellowish red (5YR 4/6) moist; massive; hard, friable, sticky and plastic; many, very fine and fine, tubular pores; few pores with thin film clay linings; strongly and violently effervescent with fine and medium soft masses of lime; moderately alkaline; gradual, irregular boundary.

**IIB22tcab**—42 to 60 inches, light reddish-brown (5YR 6/4) gravelly clay loam (20 percent gravel); reddish brown (5YR 4/4) moist; massive; hard, friable, sticky and plastic; many, very fine and fine, tubular pores; clay in bridges between mineral grains and common colloidal stains on mineral grains; strongly and violently effervescent with lime segregated into medium and large soft masses and concretions; moderately alkaline; gradual, irregular boundary.

**IIB23tcab**—60 to 68 inches, reddish-yellow (5YR 7/6) gravelly clay loam (about 25 percent gravel); yellowish red (5YR 4/6) moist; massive; slightly hard, very friable, sticky and slightly plastic; many, very fine and fine, tubular pores; clay bridges and colloidal coatings on mineral grains; strongly and violently effervescent with lime in fine concretions and soft masses; moderately alkaline; clear, smooth boundary.

**IIC**—68 to 80 inches, light-brown or pink (7.5YR 6/4 or 7/4) gravelly fine sandy loam (40 percent gravel); brown (7.5YR 5/4) moist; massive parting to single grain; soft, very friable, nonsticky and nonplastic; many, fine and very fine, interstitial pores; few colloidal coatings on mineral grains; strongly effervescent in matrix, violently effervescent on gravel; moderately alkaline.

The gravel surface pavement and the upper part of the C horizon occur generally but are not present in some places. The IIA1 horizon is brown, light brown, yellowish brown or reddish yellow. It ranges from gravelly loamy fine sand to gravelly fine sandy loam. The IIBtb horizon is slightly redder than the IIA1 horizon and is gravelly sandy clay loam or gravelly clay loam in texture. In places the IIBtb horizon color and texture are modified by lime. Most lime nodules are in the lower part of the IIBt horizon. The IIC horizon ranges from soft gravelly fine sandy loam to loose gravelly sand.

Included with this soil in mapping were small areas of Aco gravelly loamy sand, Carrizo gravelly sand, and Orita gravelly loamy sand.

Crops on this soil respond to applications of nitrogen and phosphorus according to soil tests. Available water capacity is 7.5 to 8.5 inches. Permeability is moderately slow, runoff is medium, and salinity is slight. The erosion hazard is slight.

In some places this Orita soil is used as pasture for sheep or goats for short periods. If irrigated, it is suitable for vegetables, melons, and small grain. All irrigation water developed for use on this soil has had high boron content. Capability unit IIs-6.

**Orita fine sand (Oc)**.—This nearly level soil is on terraces, old alluvial fans, and flood plains. Except for the texture, color, and thickness of the surface layer, the profile of this soil is like that of Orita gravelly fine sandy loam. The surface layer is pinkish-gray to pink fine sand and is about 12 inches thick. The low hummocky relief of the surface results from rodent activity and wind modification, but it can be easily leveled to 1 percent slopes or less.

Included with this soil in mapping were small areas of Carrizo gravelly sand, Orita gravelly fine sandy loam, and Rositas fine sand, 0 to 2 percent slopes.

Crops on this soil respond to applications of nitrogen and phosphorus according to soil tests. The hazard of wind erosion is slight. Runoff is slow, and available water capacity is 6.5 to 7.5 inches. Salinity is slight.

In some places this Orita soil is used as range for sheep for limited periods. None of this soil is cultivated, but the soil has farming potential. Capability unit IIs-4.

**Orita gravelly loamy sand (Og)**.—This soil is on terraces in old alluvial fans and flood plains. It is nearly

level. Except for the texture, color, and thickness of the surface layer, the profile of this soil is like that of Orita gravelly fine sandy loam. The surface layer is reddish-gray or light-brown gravelly loamy sand overwash and is 6 to 8 inches thick.

Included with this soil in mapping were small areas of Carrizo gravelly sand and Orita gravelly fine sandy loam.

The hazard of wind erosion is slight. Runoff is slow, and available water capacity is 6.5 to 7.5 inches. Salinity is slight.

A few areas of this Orita soil are used as range for sheep. This soil is suitable for crops if irrigated, but none of it is in cultivation at this time because of the lack of water for irrigation. Capability unit IIs-4.

## Ripley Series

The Ripley series consists of well-drained soils that formed in alluvium deposited on the floor of the Palo Verde Valley by the Colorado River. The slope is less than 1 percent. These soils formed on the Colorado River flood plain. The water table is at a depth of 6.5 feet in a typical area. The range in elevation is 225 to 300 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. In uncultivated areas vegetation consists of saltcedar, arrowweed, and mesquite. Various irrigated field and truck crops are grown in cultivated areas.

In a representative profile the surface layer is light brownish-gray silty clay loam about 12 inches thick. The next lower layers are pinkish-gray coarse silt loam and very fine sandy loam about 20 inches thick. At a depth of about 32 inches, the material abruptly changes to light-brown fine sand. The fine sand extends to a depth of more than 60 inches.

**Ripley silty clay loam (Rc)**.—This soil formed on the Colorado River flood plain. The slope is less than 1 percent.

Representative profile, located about 1 mile northeast of Blythe, 700 feet west of Intake Boulevard and the east quarter corner of sec. 21, T. 6 S., R. 22 E.:

**Ap**—0 to 12 inches, light brownish-gray (10YR 6/2) silty clay loam; dark grayish brown (10YR 4/2) moist; weak, medium, platy structure; hard, very firm, sticky and plastic; many fine roots; common, fine, simple pores; violently effervescent; moderately alkaline; clear, smooth boundary.

**C1**—12 to 20 inches, pinkish-gray (7.5YR 6/2) coarse silt loam; brown (7.5YR 4/2) moist; massive; hard, friable, slightly sticky and slightly plastic; many fine roots; common, fine and medium, tubular and interstitial pores; violently effervescent; moderately alkaline; gradual, irregular boundary.

**C2**—20 to 32 inches, pinkish-gray (7.5YR 6/2) very fine sandy loam; brown (7.5YR 4/2) moist; occasional, fine, distinct, reddish-yellow (7.5YR 6/8) mottles; massive; slightly hard, very friable, nonsticky and slightly plastic; many fine roots; common, fine, tubular pores and many, very fine and fine, vesicular pores; violently effervescent; moderately alkaline, abrupt, smooth boundary.

**IIC3**—32 to 60 inches, light-brown (7.5YR 6/4) fine sand; brown (7.5YR 5/4) moist; single grain; loose (dry or moist), nonsticky and nonplastic; few fine and very fine roots to depth of about 48 inches; strongly effervescent; moderately alkaline.

The A horizon is generally silty clay loam but ranges to sandy clay and silty clay. Contrasting coarse texture is at a depth of 20 to 40 inches. It is generally fine sand but ranges to very fine sand or loamy fine sand. In places fine sand extends to a depth of 9 feet or more.

Included with this soil in mapping were small areas of Cibola silty clay loam and Rositas silty clay loam. Some areas of Ripley very fine sandy loam were also included.

Crops on this soil respond to applications of nitrogen and phosphorus according to soil tests. Available water capacity is 6.0 to 8.0 inches. Permeability is moderate in the upper part of the profile and rapid in the lower part. Runoff is slow or does not occur in fields that have irrigation borders. The hazard of erosion is none to slight. The water table is generally below a depth of 6 feet. Salinity is slight.

All local, climatically suitable crops are grown on this Ripley soil. Capability unit IIs-6.

**Ripley very fine sandy loam (Rb).**—This soil formed on the Colorado River flood plain. The slope is less than 1 percent. Except for the texture, color, and thickness of the surface layer, the profile of this soil is like that of Ripley silty clay loam. The surface layer is pinkish-gray very fine sandy loam or, in places, fine sandy loam and is about 10 inches thick. Included in mapping were small areas of Cibola fine sandy loam and Ripley silty clay loam.

Crops on this soil respond to applications of phosphorus and nitrogen according to soil tests. The hazard of erosion is none to slight. Runoff is very slow or does not occur. Available water capacity is 6.0 to 8.0 inches. Salinity is slight.

All local, climatically suitable crops are grown on this Ripley soil. If tilled extensively, this soil becomes powdery. Capability unit IIs-6.

## Rock Land

The land type Rock land (RdG) is 25 to 90 percent rock outcrops. The rest is mainly very shallow soil. Areas of Badland were included in mapping.

Rock land is commonly barren. After rains, lower lying soils are affected by large quantities of runoff water and debris from Rock land. Capability unit VIIs-1.

## Rositas Series

The Rositas series consists of somewhat excessively drained soils that formed in alluvium deposited in the Palo Verde Valley and on the Palo Verde Mesa by the Colorado River. Slopes are 0 to 9 percent. The range in elevation is 225 to 500 feet. The average annual rainfall is less than 4 inches, the average annual air temperature is about 72° F., and the frost-free season is 290 to 310 days. Vegetation consists of galleta grass, forbs, and desert shrubs on the Palo Verde Mesa. Closer to the Colorado River, vegetation consists of arrowweed, salt-cedar, and mesquite. Alfalfa is grown in cultivated areas. Also grown, during cooler seasons, are crops that have less demanding water requirements.

In a representative profile the upper 3 inches is pinkish-gray loamy fine sand. The next layer is pinkish-gray fine sand that extends to a depth of 72 inches or more.

**Rositas fine sand, 0 to 2 percent slopes (RoA).**—This soil is in the Palo Verde Valley and on the Palo Verde Mesa.

Representative profile, near intersection of 25th Avenue and Keim Blvd., about 100 feet north and 200 feet west of east quarter corner of sec. 32, T. 7 S., R. 22 E.:

C1—0 to 3 inches, pinkish-gray (7.5YR 7/3) loamy fine sand; brown (7.5YR 5/3) moist; weak, medium, platy structure; soft, very friable, nonsticky and nonplastic; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

C2—3 to 72 inches, pinkish-gray (7.5YR 6/3) fine sand; dark brown (7.5YR 4/3) moist; brownish mottles at a depth of 42 to 48 inches; single grain; loose (dry or moist), nonsticky and nonplastic; strongly effervescent; moderately alkaline.

Some profiles are stratified coarse sands or thin lenses of silt loam or silty clay loam that are generally not more than one-fourth inch thick. In recently cultivated areas the thin loamy sand surface layer is incorporated with the next lower layer, and the average resulting material is fine sand. Areas that have been irrigated many years have more silt in the surface layer because of silt in irrigation water. Some profiles on the Palo Verde Mesa contain segregated lime from the surface down and have slightly higher pH values.

Included with this soil in mapping were small areas of Gilman and Indio soils in the valley and small areas of Aco and Carrizo soils on the Palo Verde Mesa.

Crops on this soil respond to applications of nitrogen and phosphorus according to soil tests, and in some places crops on older irrigated areas respond to potassium. Available water capacity is 3.5 to 4.5 inches. Permeability is rapid, and runoff is either very slow or does not occur. The hazard of wind erosion is slight to moderate. Salinity is none or slight.

This Rositas soil is used for irrigated alfalfa, citrus, winter field crops, and winter vegetables. Nematodes occur in this soil. Capability unit IIIs-4.

**Rositas fine sand, 2 to 9 percent slopes (RoB).**—This soil is adjacent to the lower terrace of the Palo Verde Mesa at elevations near 300 feet and on top of the Mesa at elevations of about 350 to 400 feet. The profile of this soil is like that of Rositas fine sand, 0 to 2 percent slopes, but the surface layer is fine sand to loamy fine sand.

Included with this soil in mapping were small areas that have a gravelly surface pavement. Also included were some areas that have low dunes and some where slopes are complex.

Crops on this soil require applications of nitrogen and phosphorus according to soil tests. The hazard of erosion is slight and the hazard of salinity is none to slight. Available water capacity is 4 to 5 inches and runoff is slow.

Because of lack of irrigation water, most acreage of this Rositas soil has not been cultivated. Capability unit IIIs-4.

**Rositas fine sand, wet, 0 to 2 percent slopes (RrA).**—Except for the underlying layer of heavy clay loam to clay at a depth of more than 40 inches, the profile of this soil is like that of Rositas fine sand, 0 to 2 percent slopes. This soil is in the Palo Verde Valley, where it occupies less than 500 acres. Included in mapping were small areas of Meloland soils and other Rositas soils that have 0 to 2 percent slopes.

Crops on this soil respond to nitrogen and phosphorus. The hazard of wind erosion is slight to moderate. Run-

off is slow or not present, and permeability is rapid in the upper part of the profile and slow in the lower part. When this soil is irrigated, a perched water table forms above the clay substratum and the soil is difficult to drain because of the position of the clay layers. Salinity is moderate.

This Rositas soil is used for irrigated barley, alfalfa, and sorghum. Capability unit IIIw-3.

**Rositas gravelly loamy sand, 0 to 2 percent slopes (RsA).**—This soil is nearly barren and occurs near wind-swept breaks. The elevation is 400 to 500 feet on the Palo Verde Mesa. Except for the texture and thickness of the surface layer, the profile of this soil is like that of Rositas fine sand, 0 to 2 percent slopes. This soil has a gravelly loamy sand surface layer about 10 inches thick. Wind has removed the fine sand. In some areas this soil has lime nodules scattered throughout the profile.

Included with this Rositas soil in mapping were small areas of Aco soils and soils that have slightly steeper slopes.

Maximum crop production requires applications of nitrogen and phosphorus according to soil tests. The hazard of erosion is slight, and runoff is slow. Available water capacity is 3.0 to 4.0 inches. This soil is nonsaline to slightly saline.

Some areas of this Rositas soil have been leveled recently and planted to citrus. Capability unit IVs-4.

**Rositas silty clay loam, 0 to 2 percent slopes (RtA).**—This soil is in the Palo Verde Valley. Except for the texture and thickness of the surface layer, the profile of this soil is like that of Rositas fine sand, 0 to 2 percent slopes. The surface layer ranges from heavy clay loam to clay and is commonly silty clay loam that is about 10 inches thick. Included in mapping were small areas of Holtville soils and other Rositas soils that have 0 to 2 percent slopes.

Crops on this soil need applications of nitrogen and phosphorus according to soil tests. The hazard of erosion is none to slight. Available water capacity is 4 to 5 inches. Runoff is slight to medium in cultivated areas. This soil is nonsaline to slightly saline.

This soil is used for alfalfa, cotton, melons, corn, and winter vegetables. Capability unit IIIs-4.

**Rositas silty clay loam, wet, 0 to 2 percent slopes (RuA).**—This soil is on less than 500 acres in the Palo Verde Valley. The profile of this soil, between a depth of 10 to 40 inches, is like that of Rositas fine sand, 0 to 2 percent slopes. The surface layer ranges from fine sandy clay loam to clay but most commonly is silty clay loam. The soil below a depth of 40 inches ranges from heavy clay loam to clay. Included in mapping were small areas of Meloland soils and other Rositas soils that have 0 to 2 percent slopes.

Crops grown on this soil respond well to applications of nitrogen and phosphorus according to soil tests. Permeability is rapid in the upper part of the profile and slow in the lower part. The hazard of erosion is none to slight, and salinity is generally moderate. Runoff is slow or does not occur. Water intake rates are moderately slow to moderate. The soils develop a perched water table at a depth of 40 inches when irrigated and are difficult to drain.

This soil is used for crops that are moderately salt tolerant to highly salt tolerant. Capability unit IIIw-3.

## Use and Management of the Soils

In this section the system of capability grouping used by the Soil Conservation Service is explained; the capability units in this survey area are discussed; then the management of the important crops of the Area is discussed, and estimated yields of these crops under high-level management are given. Finally, the Storie index is explained.

### Capability Grouping

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

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

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

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

- Class I soils have few limitations that restrict their use. (None in Palo Verde Area.)
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, that require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, that require very careful management, or both.
- Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. (None in Palo Verde Area.)
- Class VI soils have severe limitations that make them generally unsuited to cultivation and that limit their use largely to pasture or range, woodland, or wildlife habitat. (None in Palo Verde Area.)
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat. (None in Palo Verde Area.)
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and

that restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

**CAPABILITY SUBCLASSES** are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIs. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is saline, droughty, or stony; and *c*, used in only some parts of the United States and not in Palo Verde Area, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

**CAPABILITY UNITS** are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIs-5 or IIIw-5.

In California, each unit number in classes I through IV indicates a particular kind of problem or limitation, as follows:

0. A coarse sandy or very gravelly substratum, which limits root penetration and retention of moisture.
1. A potential or actual hazard of soil blowing or water erosion.
2. Poor drainage or a flood hazard.
3. Slow or very slow permeability in the subsoil or substratum.
4. Coarse texture or excessive gravel.
5. Fine or very fine texture.
6. Salts or alkali sufficient to constitute a continuing hazard.
7. Stones, cobblestones, or rock outcrops sufficient to interfere with tillage.
8. Hardpan or unweathered hard bedrock within the root zone.
9. Low inherent fertility, associated with strong acidity, with a too low or too high calcium-magnesium ratio, or with excess calcium, boron, or molybdenum.

In this survey, a nonconnotative Arabic numeral 1 is used for classes V through VIII.

The system of numbering units is statewide, and not all the units that have been established in the State are represented in Palo Verde Area. Consequently, units may not be numbered consecutively within each subclass.

Basic assumptions applied in grouping the soils of the Area into capability units are given in the following paragraphs.

The climate generally favors intensive year-long cropping systems, and some temperature-inversion belts occur and are utilized for frost-sensitive crops. It is assumed that the Palo Verde Mesa is generally less subject to damaging frosts, and it is further assumed that frost protection for most crops is provided wherever they are grown. The relative frost hazard is therefore not considered in the capability classification.

It is also assumed that rainfall is not sufficient for crop production without irrigation. All soils that are unsuitable for irrigation because of stoniness, steep slope, etc., are therefore placed in class VIII. Soils suitable for irrigation but not now irrigated are classed on the same basis as soils under irrigation.

The common crops, for purposes of evaluating soil, include alfalfa, cotton, cereal grains, sorghums, winter-grown vegetables, pasture, and citrus fruits.

Irrigation water is assumed to be available or potentially available to all irrigable soils within the survey Area, either by diversion from the Colorado River or from wells. It is recognized that this water has high salinity hazards and for some crops has excesses of toxic ions, all of which require special management practices and systematic leaching.

Drainage to reduce the salinity hazard is required on all soils of the valley. The installation, operation, and maintenance of drainage facilities is considered a continuing need that is recognized in classification.

Wind erosion is not likely to impair significantly the productivity of soils under irrigation after crops are established. While some damage to emerging crops may be caused by loose soil blowing over the surface, the hazard is not considered serious enough to affect capability classification.

Overflow from the Colorado River is assumed to be effectively controlled. Storm water runoff is not considered to impose a permanent limitation on use and management of irrigated soils, although in some instances there is a need for fairly large flood-control projects to alleviate hazards of localized high intensity rains.

Management of farmland is assumed to be of a level high enough to sustain the productive capacity of the soils.

In the following pages, the capability units in Palo Verde Area are described, and suggestions for the use and management of the soils are given.

#### CAPABILITY UNIT IIs-4

The well-drained soils in this unit formed in recent alluvium. They are more than 5 feet deep and have a slope of no more than 2 percent and generally less than 1 percent.

Permeability to roots and water is moderately slow to moderately rapid. The available water capacity generally is between 5.0 and 7.5 inches in the 5-foot profile; but some of the soils have, at a depth of 3 feet or more, a coarse-textured, rapidly permeable layer that does not retain moisture. All the soils are moderately alkaline and calcareous. Small quantities of salts are present in some places, but the salts can be leached out readily.

Limited available water capacity is the principal limitation of these soils. Soil blowing is a hazard in some

localities, especially during leveling or tillage. Sometimes crops in the seedling stage are injured by abrasion.

Any of the crops suited to the Area can be grown. Alfalfa, vegetables, grain, and pasture are among those suitable.

Frequent applications of irrigation water are needed to keep crops supplied with moisture and to leach out salts with minimum losses of water and of plant nutrients. Nitrogen and phosphorus are needed, and occasionally crops respond to iron and zinc. Cropping systems generally include alfalfa and winter-grown vegetables. Crop residues are managed carefully. Nurse crops of grain help to reduce the hazard of wind-sand abrasion.

#### CAPABILITY UNIT II<sub>s</sub>-5

The one soil in this unit, Holtville silty clay, formed in recent alluvium. This soil is well drained, is more than 5 feet deep, and is nearly level.

Permeability is slow in the upper part of the profile and rapid in the lower part. Available water capacity is 7.5 to 9.0 inches in the 5-foot profile. This soil is calcareous and moderately alkaline. Small quantities of salts are present in the soil in some places, but irrigation and leaching removes the salts.

This soil, and especially the fine-textured surface layer, has few significant limitations or hazards that restrict the selection of crops and method of cultivation. Structural deterioration of the soil occurs sometimes if this soil is grazed, or if tillage or heavy equipment is used when it is wet.

Alfalfa, carrots, lettuce, grain, and pasture are the common crops suited to this soil. Applications of irrigation water are needed to leach out salts. Nitrogen and phosphorus are required. Crop residues are managed carefully, and chiseling or deep plowing is common if required to reduce compaction.

#### CAPABILITY UNIT II<sub>s</sub>-6

The well-drained soils in this unit formed in recent alluvium. They have slopes that range to 2 percent but are commonly less than 0.1 percent. The surface layer ranges from fine sandy loam to silty clay loam and is gravelly in places.

Permeability is slow to moderate, but some of the soils have a sand layer that is rapidly permeable. Available water capacity is 6 to 11 inches in the 5-foot profile. All of the soils are calcareous and moderately alkaline. The soils in this unit are slightly to moderately saline. Growth of salt-sensitive crops is restricted unless measures to reduce the saline content are taken.

Cropping systems commonly include all crops grown in the Area. Frequent applications of irrigation water and careful management of crop residues are needed to keep crops supplied with moisture and to leach out salts uniformly with minimum losses of water and plant nutrients. Nitrogen and phosphorus are needed.

#### CAPABILITY UNIT III<sub>w</sub>-3

The somewhat excessively drained to somewhat poorly drained soils in this unit formed in recent alluvium. The surface layer is fine sand to silty clay loam. It is underlain by a slowly permeable layer that impairs drainage and leaching. These soils are more than 5 feet deep and have a slope of less than 1 percent.

Permeability is slow to very slow. Available water capacity is 3.5 to 14.0 inches in the 5-foot profile. All the soils are calcareous and moderately alkaline. Considerable quantities of salt are present in places.

A limitation of these soils is a perched water table in some places during periods of frequent irrigation. Applications of irrigation water have significantly altered drainage.

Alfalfa, carrots, lettuce, grain, and pasture are suitable crops. These soils are not suitable for crops that are sensitive to salt.

Careful applications of irrigation water are needed to avoid a high water table and to leach out salt with minimum loss of plant nutrients. Existing cropping systems include moderately salt-tolerant plants, such as grass, alfalfa, barley, sorghums, and vegetables. During initial reclamation bermudagrass or barley is common. Other crops are used as salt is reduced.

#### CAPABILITY UNIT III<sub>s</sub>-4

The somewhat excessively drained soils in this unit formed in recent alluvium. They have a slope of less than 9 percent. In many places they are more or less stratified and in some places are thin strata or lenses of finer texture in a matrix of coarse material. The surface layer is fine sand or silty clay loam.

Permeability is rapid. The available water capacity for the 5-foot profile is 3.5 to 5.0 inches. All soils are calcareous and moderately alkaline.

Low available water capacity is the principal limitation of these soils. Soil blowing is a hazard in some areas, especially during leveling or tillage. Although the quantity of soil moved by blowing is generally small, crops in the seedling stage are injured by abrasion.

These soils are suited to drought-tolerant, deep-rooted, or cool-season crops, such as alfalfa, winter vegetables, citrus, and grapes.

Frequent applications of irrigation water are needed to keep crops supplied with moisture and to leach out salts with minimum losses of water and plant nutrients. The steeper soils need more elaborate irrigation systems. Nitrogen and phosphorus need to be applied according to soil tests. Occasionally crops respond to iron or zinc. Cropping systems generally include alfalfa and winter-grown vegetables. Cover crops are required in barren idle areas.

#### CAPABILITY UNIT III<sub>s</sub>-5

The soils in this unit have a texture of mainly silty clay and are well drained and nearly level. In places a thin surface layer of fine sandy loam is present because of the leveling of sand dunes and ditchbanks, or because sand that was hauled into the area has mixed into the surface layer.

Permeability is very slow. Available water capacity is 10 to 14 inches in the 5-foot root zone. It is difficult, however, to get irrigation water to this depth without inundating crops.

The hazard of salinity is moderate. No hazard of erosion exists.

Cropping systems are limited to crops that are highly salt tolerant, such as grass, barley, and cotton. Bermudagrass is commonly used during reclamation, and then

other crops are used as the amount of salt in the upper part of the profile is reduced by leaching.

Crops respond to applications of nitrogen and phosphorus according to soil tests. Careful crop-residue management, rough tillage, and irrigation water management with tailwater recovery systems are also important on the soils of this unit. If the soils in this unit are tilled when too wet, the surface seals; if they are tilled when too dry, large, extremely hard clods form. All tillage operations, therefore, must be performed when the soils have the proper moisture content.

#### CAPABILITY UNIT IVs-4

The soils in this unit are excessively drained and somewhat excessively drained. They formed in recent alluvium. Slopes are less than 2 percent. The surface layer is gravelly loamy sand or gravelly sand.

Permeability is rapid. Available water capacity is 2.5 to 4.0 inches in the 5-foot profile. All soils are calcareous and moderately alkaline.

The very low available water capacity is the principal limitation of these soils. In some localities soil blowing is a hazard, especially during leveling or extensive tillage operations. The quantity of soil moved by wind is commonly quite small, but abrasion is injurious to crops in some areas during the seedling stage.

Principal crops that are suitable for these soils are grapes, citrus, and winter vegetables. The soils are used mostly for orchards.

Irrigation water needs to be applied very carefully. Frequent light applications are needed to leach out salts and to keep crops supplied with moisture without excessive leaching of plant nutrients. Cover crops or windbreaks (or both) are required for plant protection. Nitrogen and phosphorus need to be applied according to soil tests, and some orchards require iron or zinc.

#### CAPABILITY UNIT VIIIe-1

This unit is made up of sloping to very steep land types. These areas are subject to slight to severe erosion or soil blowing.

Vegetation is needed to limit further erosion and to minimize damage to adjacent tillable soils.

#### CAPABILITY UNIT VIIIs-1

This unit is made up of one soil, Chuckawalla very gravelly silt loam, and one land type, Rock land. This Chuckawalla soil has a very gravelly or very cobbly substratum at very shallow depths. This soil is well drained. Rock land is commonly less than 10 inches deep and is underlain by fractured or impervious rock. About 25 to 90 percent of this land type is outcroppings of rock.

Permeability is moderate in the upper part of the profile and rapid in the lower part. Runoff is rapid, and available water capacity is 2.75 to 3.5 inches for the 5-foot profile of Chuckawalla very gravelly silt loam. Runoff is rapid on Rock land.

Gravel and low moisture retention are the limitations that make it impractical to use this Chuckawalla soil for growing commercial crops. The hazard of erosion on this soil is slight. Erosion is generally accelerated on Rock land, however, and lower lying soils need protection from sediment.

Chuckawalla very gravelly silt loam is used as watershed and as a source of gravel.

## Management Practices and Estimated Yields

More than 30 kinds of crops are grown commercially in Palo Verde Area, and many other kinds could be. This subsection describes the management practices under which farmers in the Area grow eight of the important crops and gives, in table 2, estimates of average yields of these eight crops under the management described. The description of management and the estimates of yields are based on observations made by the soil scientist who surveyed the Area, on information furnished by farmers, and on suggestions made by crop specialists of the Soil Conservation Service, the California Agricultural Experiment Station, and the Agricultural Extension Service. Federal and county census records and crop data also were reviewed and considered. More information was available for some soils than for others. If little or no information was available for a particular soil, or if the specified crop is not grown on the soil, yield estimates were made by comparisons with similar soils.

It can be anticipated that the management practices described will eventually become outdated as a result of the development of new equipment, new techniques, and new crop varieties.

*Alfalfa (Medicago sativa)* is grown and harvested throughout the year in the survey area. The acreage in alfalfa varies, ranging from one-fourth to one-half of the total irrigated acreage in the valley. Alfalfa is a prominent part of nearly all cropping systems and is grown for profit as well as soil improvement.

Six or seven cuttings of hay a year are made. Some alfalfa is green-chopped and fed to beef cattle. Baled alfalfa is sold to dairy areas near Los Angeles and San Diego. Some alfalfa is dehydrated and pelleted. Alfalfa supplies winter pasture for sheep, which are trucked in from other states.

Alfalfa varieties grown in the Area include Sonora, Moapa, Mesa, Sirsa, Valiverde, and African. Important local characteristics of the crop are resistance to spotted alfalfa aphid, root-knot nematode, downy mildew, leaf spot, and bacterial wilt.

Alfalfa is grown on all cultivated soils in the Area. Large yields are produced most easily on Cibola, Holtville, Indio, and Ripley soils. Soils with low available water capacity, such as Aco, Gilman, and Rositas, produce well with irrigation management. Salinity impairs yields.

Alfalfa is generally followed after 2 to 5 years by vegetables, cereal grains, or sorghums. Reseeded alfalfa is often less successful because of residual alfalfa diseases and pests that are detrimental to new seedlings. Root crops commonly do not immediately follow alfalfa, because the remaining alfalfa roots interfere with tillage. Alfalfa grown in sequence with crops grown in furrows helps to eliminate salt that builds up in the peaks of the furrows. Alfalfa roots help to aerate fine-textured soils and to improve soil tilth.

Twenty to 30 pounds of alfalfa seed per acre is planted in 4-inch to 6-inch rows, using an alfalfa drill or a grass seeder attached to a grain drill. Seed is planted across

TABLE 2.—Estimated average acre yields of some major crops under high-level management

[All crops are irrigated. The sign < stands for "less than" and the sign > for "more than." S=suited; M=marginal, because of climate or soil factors; and NS=not suited. Only arable soils are listed]

Soil	Alfalfa	Barley	Cotton	Cantaloup	Watermelon	Spring lettuce	Fall lettuce	Citrus
	Tons	Tons	Bales	Crates	Tons	Cartons	Cartons	
Aco gravelly loamy sand.....	4. 0-6. 0	<2. 0	<2. 0	>225	7. 0-10. 0	450-500	<350	S
Aco sandy loam.....	4. 0-6. 0	<2. 0	<2. 0	>225	7. 0-10. 0	450-500	<350	S
Carrizo gravelly sand.....	<4. 0	<2. 0	<2. 0	>225	<7. 0	450-500	<350	S
Cibola fine sandy loam.....	6. 0-7. 5	2. 0-3. 0	>3. 0	>225	7. 0-10. 0	450-500	350-400	M
Cibola silty clay loam.....	7. 5-10. 0	2. 0-3. 0	2. 0-3. 0	>225	>10. 0	>500	>400	M
Gilman fine sandy loam.....	6. 0-7. 5	2. 0	>3. 0	>225	7. 0-10. 0	450-500	350-400	M
Gilman silty clay loam.....	6. 0-7. 5	2. 0-3. 0	2. 0-3. 0	>225	7. 0-10. 0	>500	>400	M
Glenbar silty clay loam.....	6. 0-7. 5	2. 0-3. 0	2. 0-3. 0	>225	>10. 0	>500	>400	M
Holtville fine sandy loam.....	6. 0-7. 5	2. 0-3. 0	>3. 0	>225	7. 0-10. 0	450-500	350-400	M
Holtville silty clay.....	6. 0-7. 5	2. 0-3. 0	2. 0-3. 0	>225	>10. 0	>500	>400	M
Imperial fine sandy loam.....	4. 0-6. 0	<2. 0-3. 0	>2. 0-3. 0	>225	7. 0-10. 0	450-500	350-400	NS
Imperial silty clay.....	<4. 0	<2. 0	2. 0-3. 0	>225	7. 0-10. 0	450-500	350-400	NS
Indio very fine sandy loam.....	6. 0-7. 5	2. 0-3. 0	>3. 0	>225	7. 0-10. 0	>500	350-400	M
Indio silty clay loam.....	7. 5-10. 0	2. 0-3. 0	2. 0-3. 0	>225	>10. 0	>500	>400	M
Meloland fine sandy loam.....	4. 0-6. 0	2. 0	3. 0	<225	<7. 0	450-500	350-400	NS
Meloland silty clay loam.....	4. 0-6. 0	2. 0-3. 0	2. 0-3. 0	<225	7. 0-10. 0	450-500	350-400	NS
Orita fine sand.....	4. 0-6. 0	2. 0-3. 0	2. 0-3. 0	>225	7. 0-10. 0	450-500	<350	S
Orita gravelly loamy sand.....	4. 0-6. 0	2. 0-3. 0	2. 0-3. 0	>225	7. 0-10. 0	450-500	350	S
Orita gravelly fine sandy loam.....	6. 0-7. 5	2. 0-3. 0	>3. 0	>225	7. 0-10. 0	450-500	350-400	S
Ripley very fine sandy loam.....	6. 0-7. 5	2. 0-3. 0	2. 0-3. 0	>225	>10. 0	>500	>400	M
Ripley silty clay loam.....	7. 5-10. 0	2. 0-3. 0	2. 0-3. 0	>225	>10. 0	>500	>400	M
Rositas fine sand, 0 to 2 percent slopes.....	4. 0-6. 0	<2. 0	2. 0	<225	7. 0-10. 0	450-500	<350	M
Rositas fine sand, 2 to 9 percent slopes.....	4. 0-6. 0	<2. 0	2. 0	>225	7. 0-10. 0	450-500	<350	M
Rositas fine sand, wet, 0 to 2 percent slopes.....	4. 0-6. 0	<2. 0	2. 0	<225	<7. 0	450-500	<350	M
Rositas gravelly loamy sand, 0 to 2 percent slopes.....	4. 0-6. 0	<2. 0	2. 0	<225	7. 0-10. 0	450-500	<350	M
Rositas silty clay loam, 0 to 2 percent slopes.....	6. 0-7. 5	2. 0-3. 0	2. 0-3. 0	>225	7. 0-10. 0	>500	>400	M
Rositas silty clay loam, wet, 0 to 2 percent slopes.....	4. 0-6. 0	2. 0-3. 0	2. 0-3. 0	<225	>10. 0	450-500	350-400	M

field borders to utilize more soil, reduce the area of weed growth, and help in the stabilization of the borders.

Most successful seedlings are made during the cooler seasons, either around February 1 or after October 1. It is easier to maintain favorable moisture conditions for alfalfa seedlings in early February planting, and there is less of a weed problem in early February than in fall. Fall planting produces about twice as much hay the following summer as spring planting, so fall planting is preferable if preplant herbicides or other means of annual weed control are used.

In the Aco, Gilman, Rositas, and other soils that have a coarse-textured, loose surface layer, seedlings are subject to damage by wind abrasion. On these soils, a nurse crop of cereal grain is seeded with alfalfa. These grain seedlings are light—about 20 pounds of seed per acre. Alfalfa that is grown on Rositas soils that have slopes of more than 1 percent is irrigated by sprinklers. Alfalfa on other soils is irrigated by borders. Two or more irrigations are required between summer cuttings.

Soil that is bordered is first land planed or releveled if needed. The leveled soil is plowed or subsoiled, disked, and floated, or land planed. Soil that has a coarser surface layer may be disked and bordered. Tillage after seeding is not needed, except for spot treatment of grass.

Alfalfa seed is commonly planted in dry soil, and then the soil is irrigated. Irrigation water firms the soil over the seed. Seeding seasons are commonly dry and windy, and frequent irrigation is needed until plant roots ob-

tain some depth. The Imperial soils take water slowly, and irrigating alfalfa on these soils in summer without "scalding" the plants is difficult. It helps to leach these soils during the winter months and have the soil wet to field capacity to a depth of 6 feet before hot weather starts. Tailwater disposal ditches are used if there is an outlet. Two or more irrigations with reduced quantities of water are applied between summer cuttings. Alfalfa on Cibola, Indio, Meloland, and Ripley soils requires one irrigation between cuttings, except when weather is exceptionally hot and dry; then two irrigations are needed in some areas.

Alfalfa planted with a nurse crop or on recently leached soil requires nitrogen, up to 20 to 30 pounds per acre. All soils require phosphorus. To obtain maximum yields, 45 pounds of phosphorus is applied before planting, followed by 35 pounds per year. The annual applications are phosphoric acid added to irrigation water.

Rodent pests of alfalfa are gophers, ground squirrels, and rabbits. Gophers are most damaging to alfalfa and irrigation systems. Rabbits are particularly damaging to soil adjacent to uncultivated brushland.

Sometimes on sprinkler-irrigated Rositas soils, ants are damaging because they clear large areas of plant growth around their nests. Control requires treatment of individual nests.

Barley (*Hordeum vulgare*), oats (*Avena sativa*), and wheat (*Triticum aestivum*) are all grown in the Area. Around 1900, these crops commonly were grown with

alfalfa for winter pasture. Acreage for grain crops became extensive after it was shown that yields could be increased by fertilization.

Barley is the reclamation crop used most commonly to help bring uncultivated soils, which are nearly all saline, into cultivation. Its current greatest importance is as a grain crop and as a cover crop in new citrus plantings. Nearly all of the grain produced is used locally for feeding cattle. Two barley varieties that are suited to the area are California Mariout and Arivat. Arivat is planted earlier than California Mariout for a longer pasture season, but the latter generally produces more grain.

Oats are grown to a much lesser extent than barley, but they are preferred for pasture in some places because they continue to grow somewhat longer in the spring. Kanota oats, a variety with high resistance to yellow dwarf disease, is commonly used for grain or hay.

White Fed is a wheat variety preferred for early planting, but Ramona 50 will normally produce more grain if planted later. The new Mexican varieties have revived interest in this crop, and grain yields have been obtained that are nearly equal to that of barley.

Greatest cereal grain yields are obtained on soil with moderate to high available water capacity, such as the Cibola and Indio soils. Crops on Aco and Rositas soils provide good ground cover and wind protection, but seedheads are small and grain production is limited. Lodging is a common problem on fine-textured Holtville or Imperial soils and on Meloland soils, which often have excess moisture in the upper part of the profile. Salinity impairs grain yields, but barley can tolerate more salts than most other domestic plants. Oats and wheat are moderately salt tolerant.

Cereal crops are used in cropping systems to maintain productive soils. Periodic excess irrigation of these crops removes some of the salts that accumulate in the tops of furrows when crops are furrow irrigated. The many and relatively deep roots help to improve water and air permeability following vegetable crops that are shallower rooted. Cereal crops aid in the restoration of soil structure (through rooting systems, return of crop residue to the soil, and tillage) if they follow crops that are more extensively cultivated. These crops provide excellent cover for Aco and Rositas soils and other soils with surfaces that are coarser textured and subject to wind erosion.

On newly cultivated soils and on some other highly saline soils, barley is sometimes the only crop grown for several years in succession. Yields generally increase each season that salinity is reduced. If crops are rotated, cereal crops are followed by row crops such as cotton, squash, lettuce, tomatoes, or melons. Commonly, a time lag occurs after harvest of the cereal crops, and during this period fields are leveled, irrigation ditches are repaired, and other tillage operations are performed in preparation for the following crop. If the cereal grain is to be replanted immediately, 25 pounds of nitrogen per ton of straw left in the soil is applied to hasten decomposition and avoid nitrogen tieup for the succeeding crop.

Barley, oats, and wheat seed are treated with fungicides to help to protect against smut, stripe, seed rot, and

seedling blight. Insecticides are applied to seed as dust to help to control wireworm, bollworms, and other pests.

Seed is planted with a grain drill at spacings of 6, 7, or 8 inches. Barley is seeded at a rate of 60 to 100 pounds per acre, oats at 75 to 90 pounds per acre, and wheat at 60 to 80 pounds per acre. The lighter rates are used on droughty Aco, Gilman, and Rositas soils or in areas where less frequent irrigation is planned, such as areas where the crop is used only for cover. Sometimes seed is broadcast by air into a wet field, and heavier seeding rates are needed.

Barley that is used for pasture is planted between September 20 and November 15, but barley used for grain is not planted until January 15. Oats are planted between November 1 and January 1, and wheat is planted between November 15 and January 15. The earlier planting dates for oats and wheat are desirable if the crops are used for pasture, but if the crops are not used for pasture the planting is delayed until December 1st or later to eliminate any hazard of heading out before the last spring frost.

Fields for winter grain are either subsoiled or plowed, then disked and floated or land planed to form a seedbed. Shallow cultivation or disking is needed for cover crop planting in orchards on Aco and Rositas soils.

The crops are seeded into dry soil and then irrigated to firm the soil over the seed and provide moisture. Growth shades the surface by the next irrigation.

Irrigation is most frequent during February, March, and April. During the peak period in March, frequency of irrigation varies from about 6-day intervals on the Aco, Gilman, and Rositas soils and to about 19-day intervals on Glenbar, Holtville, Imperial, and Indio soils. Irrigation is timed to allow adequate drying of the surface layer of the soil before it is used for pasture.

The amount of nitrogen required varies between 60 and 120 pounds per acre. After vegetable crops, the lower rates apply on all except Aco, Gilman, and Rositas soils. Barley grown for reclamation of saline soil or a cover crop in orchards is also fertilized at the lower rates. Whenever cool weather follows planting, 30 pounds of actual nitrogen, and in places some phosphorus, is used to stimulate plant growth during a period when plant nutrients are less readily available. The sources of nitrogen are sulfate of ammonia, ammonium nitrate, urea, and agricultural ammonia gas.

Sufficient phosphorus is available in the soil for crops in a cropping system. On newly leveled soil that is cut deeply, however, or on leached soil or soil used for cereal crops several years in a row, up to 35 pounds of phosphorus per acre is required.

*Cotton* (*Gossypium hirsutum* and *G. barbadense*) grows well in the survey area. Varieties include Acala 4-42 and Acala 44, which produce high-quality yarns, and Deltapine Smooth Leaf, a very high-yielding variety with slightly less fiber length and strength. Pima S-4 (*G. barbadense*), a staple Egyptian variety that is extra long, is less extensive.

Most of the soils in the survey area can be used for cotton, but greater yields are usually obtained on soils that have high to moderate available water capacity, such as the Cibola or Indio soils. Soils that have low available water capacity, such as the Aco or Rositas, consistently

produce smaller yields. Salinity can also reduce yields, but cotton is generally less affected by salinity than other crops. For this reason, cotton is often the crop selected for the moderately saline Imperial and Meloland soils. Yields on all soils are affected by cultivation, fertilization, irrigation, and other management practices.

Cotton is grown in sequence with all field crops and vegetable crops grown in the Area. When a crop is grown in furrows continuously, salts accumulate in the tops of the furrows. In Imperial, Glenbar, Holtville, Meloland, and wet phases of Rositas soils, removal of this salt is difficult at times. Cotton requires considerable tillage for weed control, and if cotton is grown continuously this tillage leads to deterioration of soil tilth, especially on fine-textured surface layers. For satisfactory maintenance, the soil must be planted with close-growing crops that require less tillage. Assistance in combating disease and insect pests is obtained with a planned system of crop rotation. Cotton following cotton is more susceptible to Texas root rot, *Rhizoctonia*, leaf crumple virus, and insects. Corn, small grains, grass, and sorghums can help to reduce Texas root rot in contaminated soil. *Rhizoctonia*, the most frequent cause of damping off in cotton seedlings, and cutworms are more of a problem if cotton is followed by alfalfa. Stinkbugs and lygus bugs commonly migrate from adjacent alfalfa into cotton to cause considerable damage. Control of root-knot nematodes is an important consideration in determining the sequence of cotton and other crops.

Cotton seed is generally delinted mechanically or with acid and then treated to protect the plant against angular leaf spot, anthracnose, sore shin, seed rots, seedling blights, seed-corn maggot, and other insect pests. A number of chemicals are effective against seed-borne and soil-borne pathogens.

Cotton is seeded to a depth of 1.5 to 2.0 inches at the rate of 15 to 25 pounds per acre in 38-inch to 42-inch rows. This planting rate obtains good stands and allows for some loss resulting from crusting and cracking of soils that have a fine-textured surface layer, from disease, from pests, or from weather. It also permits thinning to the spacing that is desired. Final plant spacings in the row vary from 4 to 12 inches. Variations have only slight effect on yields.

The most favorable time for planting is early in spring, after the soil temperature has reached 60° F. Legal planting and "plow up" dates have been established to assist in controlling pink bollworm. Nearly all cotton is planted as soon after April 15th as possible, and the "plow-up" date is generally around December 15th.

Preplant operations may include shredding and disking followed by deep flatbreaking. Imperial, Holtville, and Meloland soils are often chiseled to break up the fine-textured or compacted subsurface layer in order to obtain better rooting and moisture penetration. Land planing and disking commonly follow flatbreaking. The soil is bedded in February or early in March. An alternative method often used is to border the field, plant the cotton flat, and then furrow out after emergence and just prior to the first irrigation. Bedding is more favorable if there is a hazard of salinity or surface crusting.

After cotton is planted, cultivation is used for weed control and for rebuilding cotton beds after hoeing. Much

cultivation is eliminated by using chemicals to control weeds. "Pre-emergence" weed-control chemicals have reduced the amount of hoeing that is needed, and other chemicals are used for spot treatment of grasses and annuals after emergence.

Irrigation begins prior to seeding. The Imperial, Holtville, and Glenbar soils generally are irrigated in February. This allows time for the surface to dry and be warm at planting time. This irrigation provides some leaching of salts and saturates the soil to about a depth of 6 feet. Other soils receive similar irrigation late in February or early in March.

If the surface layer is moist when the seed is drilled, irrigation is often delayed until the first squares appear on the cotton. Delaying irrigation avoids cooling the soil. If the soil cools, it inhibits growth and promotes seedling diseases. Delay in irrigation also discourages weed growth; but if irrigation is delayed too long, it harms young plants. The first irrigation is earlier on the Aco, Rositas, and Gilman soils, and on saline soils. Also, if weather conditions are unusually warm or windy, earlier irrigation may be needed. Soil that has a loose, coarse surface layer is subject to wind erosion hazard and injury to cotton seedlings by abrasion if these soils are allowed to become too dry. Soil that has a fine-textured layer or that has poor tilth requires light irrigations to keep the surface layer moist until the seedlings emerge. The frequency of irrigation during peak water use in July and August varies from about 5 days on the coarser Aco and Rositas soils to about 14 days on Glenbar, Imperial, and Indio soils. The timing of irrigation influences maximum yields.

Ample nitrogen is required for high yields of cotton. If the yield is more than 3 bales per acre, up to 325 pounds of nitrogen is required. The method of application and source of nitrogen will depend largely upon the price. In the Cibola, Holtville, Imperial, Indio, Meloland, and Ripley soils, one third of the nitrogen is applied before or at planting time. If ammonia fertilizer is used, it is injected well away from the seed to prevent injury to seedlings. The remaining two thirds of the nitrogen fertilizer is applied to these soils just prior to or in the early stage of square formation. The Aco, Gilman, and Rositas soils require more frequent and smaller applications of fertilizer to prevent excessive loss through leaching. Application of fertilizer on these soils is continued through the early open-boll stage of growth. To help to insure sufficient nitrogen fertilization and to avoid overfertilization, petiole analysis is made periodically during June and July.

Cotton response to phosphorus is inconsistent. On soil that has been without phosphorus for long periods or where a deficiency is suspected, 35 pounds per acre is advisable.

Insects and nematodes injurious to cotton must be adequately controlled. Frequent inspections of fields and specific pest-control programs are provided by insecticide companies and the University of California Agricultural Extension Service.

*Cantaloup* (*Cucumis reticulatis*) is the muskmelon grown to the greatest extent. PMRC 45 (Powdery mildew-resistant cantaloup No. 45) is the variety most commonly grown. Newer cantaloup varieties are the Camp

and Jacumba, which are reported to be resistant to the hazards of powdery mildew and moderately resistant to downy mildew and to have some tolerance to crown blight. They are also more tolerant to watermelon mosaic virus and other viruses than PMRC 45.

Muskmelons are grown successfully on all the irrigable soil in the Area. Crops mature earlier on the warmer Aco, Cibola, Gilman, Indio, Orita, Ripley, and Rositas soils; but greatest yields are most commonly obtained on the finer textured Glenbar and Holtville soils. The less well-drained Imperial and Meloland soils and the wet phases of Rositas soils are generally less productive and are more apt to have root rot fungi. The coarser textured Aco, Gilman, and Rositas soils are more susceptible to serious root-knot infestations.

In order to control diseases caused by soil-borne organisms and to keep the soils productive, muskmelons are rotated with alfalfa, corn, cereal grains, cabbage, lettuce, milo, and onions. Best melon yields are often obtained after alfalfa, even though cutworms make replanting necessary in some places. To reduce the hazard of powdery mildew, downy mildew, and watermelon mosaic virus, cantaloup is planted in soil that has not been used for melon, watermelon, pumpkins, or squash for more than three years. Melon crops are not grown in a cropping system with cotton or tomatoes for short periods unless preplant nematode fumigants are used. The hazards of root-knot nematode and verticillium wilt are minimized if cereal crops are included in the cropping system.

Quality seed must be used in planting. Seed from the Central Valley of California is free of many seed-borne diseases common in other melon-growing areas. Treatment with selected chemicals removes the causes of root rot, gummy stem blight, and seedling diseases.

Melons are planted on raised beds 2 feet high and 6 to 7 feet from center to center. If melons are planted before February 15, they are protected by caps, and groups of 8 to 10 seeds are planted at spacings of 18 to 24 inches. About 2 pounds of seed per acre are used if the spacing is 24 inches, and about 3 pounds per acre if it is 18 inches. Plantings after February 15 are not covered, and plants are spaced 9 to 12 inches apart in rows. This latter spacing requires 3 to 5 pounds of seed per acre. The wider spaced plantings are usually made by hand and the closer plantings with a drill. Drill plantings have the advantage of distributing seed evenly and at uniform depth.

The melons are planted on the south side of the beds. Cantaloups are planted from December 1 to March 1, honeydews between December 20 and March 20, casabas between February 20 and March 20, and Persian melons between April 1 and April 15. Seeds are planted at a depth of  $\frac{1}{2}$  to 1 inch. Soil temperature must be above 59° F. at the time of planting for satisfactory germination. Sometimes black-petroleum mulch is sprayed over the seed row, in a band 4 to 6 inches wide, to make the soil absorb more solar heat. This is particularly effective on the colder Holtville, Imperial, and Meloland soils.

To prepare for melons, the soil is plowed when moisture is low enough not to puddle or to cause the soil to be compact. On the other hand the soil must be moist

enough to be friable. The soil is disked after plowing to break up clods and then floated or land planed. Occasionally one or all of these procedures is repeated before the planting beds are formed. The raised beds are formed in an east-west direction and then mulched and shaped.

As soon as seedlings emerge, cultivation is needed to control weeds; but cultivation can be largely eliminated by herbicide applications. The protective caps of covered plants are temporarily removed after the plants have formed one or two true leaves, and weeds are removed between hills. The tops and north sides of the beds are then cultivated and new irrigation furrows are formed. Hoeing commonly is done twice to thin and space plants and to remove weeds that are inaccessible. Thinning leaves two well-spaced plants per hill in wide-spaced planting and a single plant in closely spaced planting.

The first irrigation is done in conjunction with seedbed preparation. After final shaping of the beds, a second irrigation is applied for leaching and to bring the soil up to maximum available water capacity to a depth of 5 or 6 feet. Soil that has a coarse-textured surface layer or a very dry surface layer is irrigated immediately after planting to wet the beds a little above the planting line. Generally, fields are not irrigated again until after blossoms appear. Earlier irrigation is needed in some places in unusually dry seasons, especially on the Aco, Gilman, and Rositas soils.

As the size of plants increases, irrigation frequency is also increased. Irrigation intervals for melons during their period of peak use and most vigorous plant growth will vary from 6 days on Aco, Gilman, and Rositas soils to 12 days on Glenbar, Indio, and Imperial soils.

Applications of organic matter to the soil in the form of manure help to increase the quantity and improve the quality of fruit. Where manure is not available, alfalfa, Sesbania, stubble, or other crop residues are plowed under.

Commonly, 11-48-0 or 16-20-0 fertilizer is applied in bands at planting time. Sixty to 120 pounds of nitrogen and 50 pounds of phosphorus per acre are used to mature the crop. All of the phosphorus and about one-third of the nitrogen is applied at planting time, and the rest is applied when runners begin to form on the vines. The easily leached Aco, Gilman, and Rositas soils at times require additional nitrogen, which is added to the irrigation water. Periodic analysis of petiole samples from mature leaves insures the correct amount of nitrogen.

Some methods of insect and disease control by crop rotation, seed treatment, and the planting of disease-resistant varieties have already been described. In addition, use of fungicides and spot control with insecticides is necessary in some places.

*Watermelon* (*Citrullus vulgaris*) is well suited to the survey area. The varieties that are most commonly planted are Peacock, improved, and Klondike, black-seeded.

Planting begins December 15. In a raised bed, 6 or 7 seeds are planted 1 inch deep at 3-foot intervals. A pound and a half to 2 pounds of seed per acre are used. Plantings made after March 1 are drilled in a continuous row. The type of plant protector used for cantaloup that is planted early is also used for watermelon.

Soil requirements, cropping systems, field preparation, cultivation, irrigation, fertilization, and general management are similar to those described for cantaloup.

Generally, watermelons are irrigated more frequently than cantaloups. When fruits of watermelon are large enough, they are lifted out of furrows to the tops before irrigation water is turned into the furrow. Some growers prune their vines so as to leave 4 to 6 melons per vine. This is done when the fruit is 3 to 4 inches long to obtain uniform shape and large size. About the middle of June, fruit is covered with barley straw to avoid sunburn.

*Lettuce (Lactuca sativa)* is planted from September through November. The harvest of fall lettuce begins in the middle of November and continues until early in April.

Lettuce growers prefer soil that has only one type of surface layer throughout so they can ensure against irregular germination and head development. A surface layer of loamy sand or fine sand produces good yields of spring lettuce but is often avoided because sand gets into the lettuce. The earliest planting in September is made while the weather is still very hot and drying; and soil that has high available water capacity in the surface layer, such as Holtville silty clay, is preferred. In cooler weather, soil that has a silty clay loam surface layer is preferred. Lettuce normally bolts earlier on the coarser Aco, Gilman, and Rositas soils than on finer textured soils.

Lettuce is moderately salt tolerant, but yields are higher on soil with low salt content.

Because lettuce is a furrow-irrigated crop, salt accumulates in the tops of the lettuce beds. Leaching is accomplished by rotating with crops that are grown on flat borders. Because lettuce is shallow rooted, it is used in systems that include deep-rooted crops to help keep soils open to greater depth.

Lettuce is grown in sequence with alfalfa, grass, and small grains to help restore soil structure and content of organic matter. Grass should be planted after lettuce in areas of severely compacted soils, such as those where lettuce is harvested after rain.

Alfalfa, onions, maize, grasses, and cereal grains are not subject to most of the same diseases and insects that affect lettuce and are commonly included in the cropping system with lettuce. At times, cutworms are more troublesome after alfalfa has been grown.

For September plantings, 3 to 3½ pounds of lettuce seed is planted per acre. When soil temperatures are cooler, half this amount of seed is sufficient. In hot weather the action of irrigation water settles the soil enough to cover seed. In cool weather seed is planted ¼ to ½ inch deep.

To prepare a seedbed, the soil is plowed, disked, and floated or land planed. One or more of the above is repeated as necessary to free the soil of clods and crop residues.

The lister beds are formed 20 inches apart and in a north-south direction so that each side of the plant will get sunshine. Each bed is 20 inches wide across the top. Seed is sown along each edge of the bed, forming two rows 14 to 16 inches apart. In one operation the beds are shaped, smoothed, and planted.

After two or three leaves develop, a heavy roller that spans three beds is pulled along the tops to smooth the spaces between seed rows and firm soil for easier thinning. The seedlings are thinned to 12 to 16 inches.

Weeds are controlled by herbicides or cultivation or a combination of the two.

Lettuce is irrigated by open furrows between beds. To reduce soil temperatures in September plantings, irrigation starts immediately after planting, and the soil surface is not allowed to dry until after a stand has emerged. Some lettuce is germinated with portable sprinklers that leach salts from the tops of the seedbeds and away from the roots of the young lettuce plants. Fall-planted crops sometimes need irrigation prior to thinning to soften the soil crust. Immediately after thinning, the crop is irrigated to firm and moisten the soil around the remaining plants. A constant and liberal supply of moisture is maintained throughout the growing period.

Frequent irrigation is needed to keep lettuce firm when it starts to mature. During this period irrigation will vary from an interval of 3 days on Rositas fine sand to 11 days on Holtville silty clay.

Nitrogen applications for lettuce vary from 45 to 120 pounds per acre. One-third of the nitrogen is added to the soil before planting, along with 60 to 80 pounds of phosphorus. Nitrogen is then added as anhydrous ammonia in the irrigation water about every 20 days until heading starts and then every 14 days until heads mature. Prompt disking of old lettuce fields after fall harvest helps to prevent spread of disease to spring crops. Sometimes it is necessary to protect lettuce from woolly-worm invasions by enclosing the fields with a 6-inch wide band of aluminum foil. Some insect pests of lettuce are aphids, root-knot nematodes, cutworms, various caterpillars, cabbage loopers, corn earworms, leafhoppers, and sometimes field crickets. Details for use of insecticides for the control of lettuce insects are published by the University of California.

*Grapefruit (Citrus parisi)*, *lemons (C. limonia)*, *oranges (C. sinensis)*, *tangerines (C. nobilis)*, and *tangelos (C. paradisi)* are at present grown on only limited acreage in the survey area; but it appears that prolific production of high-quality fruit is possible. The Palo Verde Mesa is the location of most new citrus plantings because new land was available there and the frost hazard is relatively slight. The Palo Verde Valley is considered marginal for citrus crops because of a more serious hazard of winter frosts, but production of citrus on the warmer Gilman and Rositas soils in the valley may be feasible if protection against frost damage is provided.

Varieties of grapefruit planted include Marsh, a vigorous, high-yielding variety, and Red Blush, which is similar to Marsh but pink. The fruit ripens in December.

Lemons have been planted more extensively than the other citrus crops. Pryor, Eureka, and Lisbon are common varieties. Only one crop a year is produced on the Yuma Mesa and in Coachella Valley. The fruit matures late in fall and early in winter.

Oranges, tangerines, and tangelos have been planted less extensively than grapefruit or lemons. Many varieties of oranges have been tried. Dancy tangerines have done well on Rositas, Carrizo, and Gilman soils. Either

Dancy tangerines or Temple oranges are needed for pollination of Orlando tangelos.

The Palo Verde Mesa is irrigated primarily with well water that has a high content of boron, lithium, and salt. The most common soils are Aco and Rositas, which have a fairly low available water capacity. Macrophylla rootstock is considered to be most tolerant of these conditions.

Soil used as orchards is leveled. If soils that have a fine-textured surface layer or soils of the Glenbar, Holtville, or Indio series are used for citrus, they are leveled enough to get sufficient moisture intake and to leach salts.

After leveling, a close-growing cover crop, such as alfalfa or barley, is planted. Disease-free, balled nursery trees that are one or two years old are then planted in the cover crop. Most trees are planted between March 1 and the end of June. New tree plantings on Aco, Carrizo, and Rositas soils are completed by the end of May. The buds are set at least 6 inches above ground, and the area of soil around the ball of each tree is carefully tamped.

Grapefruit trees are spaced 25 feet apart in rows that are 25 feet apart, and orange trees are spaced 24 feet apart in rows that are 24 feet apart. Lemon trees, on the other hand, are planted at intervals of 22 feet in rows that are 22 feet apart, and tangerine and tangelo trees are planted at intervals of 20 feet in rows that are 20 feet apart. In places orchards are double planted and thinned out when the trees begin to become crowded because this method provides earlier high yields. New tree trunks are wrapped with newspaper or commercial wrap to protect the trunks from the hot sun and reduce the hazard of frost.

The first irrigation immediately follows tree planting to soak the balls and pack the soil. Subsequently, the Aco, Carrizo, Gilman, and Rositas soils are irrigated at 2- or 3-day intervals for the first month and then at wider intervals as new roots form. Late plantings on Carrizo soils need frequent irrigations throughout the first summer.

Citrus requires moisture in the root zone at all times. Irrigation of citrus in the Area must be frequent and ample enough to keep salts diluted. Also, winter irrigations are necessary to assist in leaching of salt.

Too frequent irrigations create favorable conditions for root rot and fungus, and they increase water, fertilizer, and labor costs. The time to irrigate is determined by systematic and regular field checks using a soil auger and tensiometers. During the peak water use, frequency varies from approximately 3-day intervals on Carrizo soils to about 14-day intervals on Holtville soils.

One or two days after an irrigation, the groves are checked to ensure that water has penetrated to the full depth of the tree roots. Cibola, Glenbar, Holtville, and Ripley soils are checked with a 3/8-inch iron probe that determines the depth of water penetration during irrigation.

Sometimes, only every other furrow is irrigated in the first irrigation and the alternate furrows are irrigated in the second one. This practice of alternating irrigation has advantages under certain conditions. Soils that have a fine-textured surface layer or Holtville or Glenbar soils take water faster if alternate furrows between trees are allowed to dry enough for increased cracking and yet are able to supply sufficient water to prevent wilting. Root

rot can be controlled by allowing longer drying periods on alternate furrows. In the Aco and Orita soils, lime-induced chlorosis is reduced.

Because of the need for frequent leaching to keep salts diluted, frequent light applications of fertilizer are used to minimize leaching of nutrients. During the first and second years after planting, a new tree is fertilized three or four times each year with 1 ounce of actual nitrogen. The nitrogen is never applied when the weather is hot, and it is always followed by irrigation. Nitrogen is gradually increased as the tree matures until about 1 1/2 pounds is used each year for a bearing tree. If nitrate nitrogen is used, several smaller applications are used. If less soluble nitrogen is used, most of it is generally applied in February, just before spring growth. Fertilizers containing either sodium or chlorides are avoided.

When symptoms of iron deficiency develop, iron chelate is applied at the rate of 1/2 to 1 pound per tree. The trees are sprayed with zinc oxide, if zinc is needed.

Weeds are controlled with oil sprays and shallow disking (3). Manures containing weed seeds are avoided. Cover crops help to reduce weeds and help to control wind erosion. They also reduce the glare of the sun on young trees and help to reduce the effect of soil compaction caused by traffic.

Generally, little or no frost protection is provided for citrus on the mesa; but at times precautionary measures are needed when the trees begin to produce. Some frost damage occurs to young trees each year, but recovery has generally been quite rapid. When trees are frost damaged, frequency of irrigation is reduced, and the trees are not pruned until full recovery.

Rodents sometimes damage or kill trees, and control by trapping and poisoning is necessary.

During the first year trunk protectors are lifted, and the trees are inspected frequently so that attacks by ants or termites can be controlled with chlordane. Insecticides are used for thrips, mites, and cottony cushion scale when needed. Soil is fumigated for nematodes whenever a replacement tree is planted.

## Storie Index Rating <sup>2</sup>

The Storie index expresses numerically the relative degree of suitability, or value, of a soil for general intensive farming. The rating is based on soil characteristics only. It does not take into account other factors, such as availability of water for irrigation, climate, and distance from markets, which might determine the desirability of growing specific crops in a given locality. For these reasons the index in itself cannot be considered an index for land valuation.

Four general factors are considered in establishing the index rating of a soil: the characteristics of the soil profile, including depth; the texture of the surface layer; slope; and limiting factors, such as poor drainage, salts and alkali, and erosion. Each factor is considered separately and then all four are then considered together to arrive at the index. The Storie index for each soil in Palo Verde Area is given in the Guide to Mapping Units.

<sup>2</sup> By DR. FRANK F. HARRADINE, professor of soil morphology, University of California at Davis.

Soils are placed in grades according to their suitability for farm use as shown by their Storie index ratings. The six grades and their range in index ratings are:

	<i>Index rating</i>
Grade 1.....	80 to 100
Grade 2.....	60 to 79
Grade 3.....	40 to 59
Grade 4.....	20 to 39
Grade 5.....	10 to 19
Grade 6.....	Less than 10

Soils of Grade 1 have few or no limitations that restrict their use for crops. Soils of Grade 2 are suitable for most crops, but they have minor limitations that narrow the choice of crops and have few special management needs. Grade 3 soils are suited to a few crops or to special crops and require special management. Grade 4 soils are severely limited for crops. If used for crops, they require careful management. Grade 5 soils are not suited to cultivated

crops but can be used for pasture and range. Grade 6 consists of soils and land types that generally are not suited to farming.

### Engineering Uses of the Soils <sup>3</sup>

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built.

Among the properties and qualities important in engineering are permeability, density, shrink-swell potential, available water capacity, soil drainage, grain-size distribution, plasticity, salinity, and reaction (pH). Depth to

<sup>3</sup> PAUL K. KOLUVEK, agricultural engineer, Soil Conservation Service, assisted in the preparation of this section.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA texture	Unified	AASHO
Aco: Ac, Af.....	Ft. (1)	In. 0-46	Sandy loam (gravelly loamy sand surface in places).	SM	A-1, A-2
		46-60	Fine sand.....	SM	A-2
Badland: BaG. Characteristics too variable for valid estimates.					
Carrizo: Ce.....	(1 <sup>3</sup> )	0-37 37-60	Gravelly sand..... Very cobbly sandy loam and sand.....	SW-SM GP-GM	A-1 A-1
Chuckawalla: Ch.....	(1)	0-16 16-60	Very gravelly silty clay loam and very gravelly clay loam. Very cobbly and gravelly fine sandy loam	GC GP-GM	A-1 A-1
Cibola: Co, Cs.....	(1)	0-30 30-60	Silty clay loam (fine sandy loam in places) Fine sand.....	CL or ML SP-SM	A-6, A-7 A-2, A-3
Dune land: DuD.....	(1)	0-60	Fine sand.....	SP-SM	A-2, A-3
Gilman: Gb, Gc.....	(1)	0-33 33-60	Loamy very fine sand (silty clay loam in places). Fine sand.....	ML or SM SP-SM	A-4 A-2, A-3
Glenbar: Ge.....	(1)	0-18 18-62	Silty clay loam..... Stratified very fine sandy loam, sandy clay loam, and fine sandy loam.	CL ML or CL	A-6, A-7 A-4, A-6
Holtville: Hb, Hc.....	(1)	0-26 26-60	Silty clay and silty clay loam (fine sandy loam in places). Loamy fine sand.....	CH or CL SM	A-7 A-2
Imperial: Ib, Ic.....	(1)	0-60	Silty clay (fine sandy loam in places).....	MH or CH	A-7
Indio: Id, Ie.....	(1)	0-40 40-60	Very fine sandy loam and silt loam (silty clay loam in places). Very fine sand.....	ML SP-SM	A-4 A-2, A-3

See footnotes at end of table.

water table or to sand and gravel is also important. Special emphasis has been placed on these properties as related to agriculture and particularly those that affect irrigation and drainage and related structures.

The information in this section of the soil survey can be useful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they

are built for the purpose of predicting the performance of structures on the same or similar kinds of soil in other locations.

6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

7. Develop preliminary estimates pertinent for construction in a particular area.

Most of the information in this section is presented in tables 3 and 4, which show, respectively, estimates of several of the soil properties significant in engineering and interpretations of these properties in relation to specified engineering uses.

This information, together with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in table 4 and also can be used to make other useful maps.

*significant in engineering*

Particle-size distribution					Atterberg values		Permeability	Available water capacity	Reaction (1.5 dilution)	Salinity	Shrink-swell
Percentage larger than 3 inches	Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index					
	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)							
0	65-90	55-90	45-65	15-35	<sup>2</sup> NP	<sup>2</sup> NP	<i>In./hr.</i> 0.0-6.30	<i>In./in. of soil</i> 0.11-0.13	<i>pH value</i> 7.9-8.4	<i>Mmhos/cm. at 25° C.</i> 0.0-8.0	Low.
0	95-100	95-100	85-95	10-20	NP	NP	0.3-20.0	0.05-0.07	7.9-8.4	0.0-8.0	Low.
10-20	60-70	45-55	25-35	5-10	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	4.0-8.0	Low.
20-30	50-60	40-50	30-40	0-10	NP	NP	6.3-20.0	0.04-0.06	7.9-8.4	4.0-8.0	Low.
0-10	40-60	20-40	15-25	10-20	30-40	15-30	0.63-2.00	0.10-0.12	7.9-9.0	15.0-30.0	Low.
20-30	35-45	15-25	10-20	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	15.0-30.0	Low.
0	100	100	100	85-95	30-50	10-20	0.06-0.20	0.19-0.23	7.9-8.4	4.0-15.0	Moderate.
0	100	100	60-85	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	4.0-15.0	Low.
0	100	100	60-85	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	0.0-8.0	Low.
0	100	100	85-95	45-55	NP	NP	0.63-2.00	0.12-0.14	7.9-9.0	0.0-4.0	Low.
0	100	100	65-80	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	0.0-4.0	Low.
0	100	100	100	90-100	30-50	15-25	0.06-0.20	0.19-0.21	7.9-8.4	0.0-8.0	Moderate.
0	100	100	90-100	75-90	20-30	5-15	0.06-0.20	0.14-0.17	7.9-8.4	4.0-8.0	Moderate.
0	100	100	100	90-100	40-60	25-35	0.06-0.20	0.20-0.22	7.9-8.4	4.0-8.0	High.
0	100	100	85-95	25-35	NP	NP	6.3-20.0	0.11-0.13	7.9-8.4	0.0-8.0	Low.
0	100	100	100	90-100	50-60	20-35	<0.06	0.17-0.23	7.9-9.0	8.0-15.0	High.
0	100	100	100	50-60	0-15	NP-5	0.63-2.00	0.15-0.17	7.9-8.4	4.0-8.0	Low.
0	100	100	80-90	5-15	NP	NP	20.0-6.30	0.06-0.08	7.9-8.4	4.0-8.0	Low.

TABLE 3.—Estimated soil properties

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA texture	Unified	AASHO
Meloland: Md, Me-----	Fl. 2-3	In. 0-24	Fine sandy loam (silty clay loam in places).	ML	A-4
		24-48	Heavy clay loam-----	CL	A-6, A-7
		48-60	Fine sand-----	SP-SM	A-2, A-3
Orita: Oc, Og, Or-----	(1)	0-10	Gravelly loamy sand (fine sand or gravelly loamy sand in places).	SM	A-1, A-2
		10-22	Fine sandy loam-----	SM	A-4
		22-68	Gravelly clay loam-----	CL	A-6, A-7
		68-80	Gravelly fine sandy loam-----	GM	A-1, A-2
Ripley: Rb, Rc-----	(1)	0-12	Silty clay loam (very fine sandy loam in places).	CL or ML	A-6, A-7
		12-32	Silt loam and very fine sandy loam-----	SM or ML	A-4
		32-60	Fine sand-----	SP-SM	A-2, A-3
Rock land: RdG. Characteristics too variable for valid estimates.					
Rositas: RoA, RoB, RsA, RtA-----	(1)	0-72	Fine sand (gravelly loamy sand and silty clay loam in places).	SP-SM	A-2, A-3
RrA, RuA-----	3-5	0-10	Silty clay loam (fine sand in places)-----	CL	A-6, A-7
		10-40	Fine sand-----	SP-SM	A-2, A-3
		40-72	Silty clay-----	CH	A-7

<sup>1</sup> No water table within depth of examination.

<sup>2</sup> Nonplastic.

<sup>3</sup> Subject to flooding.

significant in engineering—Continued

Per-centage larger than 3 inches	Particle-size distribution				Atterberg values		Permeability	Available water capacity	Reaction (1.5 dilution)	Salinity	Shrink swell
	Percentage smaller than 3 inches passing sieve—				Liquid limit	Plas-ticity index					
	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)							
0	100	100	100	60-70	NP	NP	<i>In./hr.</i> 2.00-6.30	<i>In./in. of soil</i> 0.16-0.18	<i>pH value</i> 7.9-8.4	<i>Mmhos/cm. at 25° C.</i> 8.0-15.0	Low.
0	100	100	100	80-90	35-45	15-30	0.06-0.20	0.19-0.21	7.9-8.4	8.0-15.0	High.
0	100	100	95-100	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	0.0-8.0	Low.
0	75-85	65-75	45-55	20-25	NP	NP	2.0-6.30	0.04-0.06	7.9-8.4	4.0-8.0	Low.
0	90-100	80-90	70-80	35-45	15-25	NP-10	0.63-2.00	0.13-0.15	7.9-8.4	4.0-8.0	Low.
0	75-85	65-85	60-80	50-65	35-45	15-35	0.2-0.63	0.15-0.17	7.9-8.4	4.0-8.0	Moderate.
0	50-60	40-50	30-40	15-30	NP	NP	0.63-2.00	0.11-0.13	7.9-8.4	4.0-8.0	Low.
0	100	100	100	90-100	30-50	15-35	0.2-0.63	0.17-0.21	7.9-8.4	4.0-8.0	Moderate.
0	100	100	95-100	45-55	0-20	NP-5	0.63-2.00	0.15-0.17	7.9-8.4	4.0-8.0	Low.
0	100	100	65-80	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	4.0-8.0	Low.
0	95-100	70-95	65-80	5-15	NP	NP	6.3-20.0	0.05-0.08	7.9-8.4	0.0-8.0	Low.
0	100	100	100	90-100	30-50	15-25	0.2-0.63	0.19-0.21	7.9-8.4	0.0-8.0	Moderate.
0	100	100	65-80	5-15	NP	NP	6.3-20.0	0.05-0.07	7.9-8.4	4.0-15.0	Low.
0	100	100	100	90-100	50-60	25-35	0.06-0.20	0.15-0.17	7.9-8.4	4.0-15.0	High.

TABLE 4.—*Interpretations*

Soil series and map symbols	Suitability as source of road fill	Hydro- logic group	Soil features affecting—	
			Water retention	
			Embankments	
Aco: Ac, Af.....	Good.....	B	Medium shear strength; medium compacted permeability; medium to high piping hazard.	
Badland: BaG. Characteristics too variable for valid interpretations.				
Carrizo: Ce.....	Good.....	A	High shear strength; high compacted permeability; low to medium piping hazard.	
Chuckawalla: Ch.....	Good.....	B	High shear strength; high compacted permeability; low piping hazard.	
Cibola: Co, Cs.....	Poor to depth of 30 inches (A-6 or A-7); good below.	B	Medium shear strength; medium to low compacted permeability; medium to high piping hazard.	
Dune land: DuD.....	Good.....	A	Medium shear strength; high compacted permeability; medium to high piping hazard.	
Gilman: Gb, Gc.....	Fair to depth of 33 inches (A-4); good below.	B	Medium shear strength; medium to low compacted permeability; medium to high piping hazard.	
Glenbar: Ge.....	Fair to poor (mostly A-4 or A-6).....	B	Medium to low shear strength, compacted permeability, and piping hazard.	
Holtville: Hb, Hc.....	Poor to depth of 26 inches (A-7); good below that depth.	C	Medium to low shear strength; medium to low compacted permeability; high piping hazard.	
Imperial: Ib, Ic.....	Poor (A-7).....	D	Low shear strength; high compacted permeability; low piping hazard.	
Indio: Id, Ie.....	Fair to depth of 37 inches (A-4); good below that depth.	B	Medium to low shear strength and compacted permeability; high piping hazard.	
Meloland: Md, Me.....	Fair to depth of 24 inches (A-4); poor at depth of 24 to 48 inches (A-7); good below that depth.	C	Medium to low shear strength and compacted permeability; high piping hazard.	
Orita: Oc, Og, Or.....	Good to fair to depth of 22 inches (A-2 or A-4); poor below that depth (A-6 or A-7).	B	Medium to low shear strength; low compacted permeability; low to medium piping hazard.	
Ripley: Rb, Rc.....	Poor to fair to depth of 32 inches (A-4, A-6, or A-7); good below that depth.	B	Medium to low shear strength and compacted permeability; high piping hazard.	
Rockland: RdG. Characteristics too variable for valid interpretation.				
Rositas: RoA, RoB, RsA, RtA.....	Good.....	A	Medium shear strength; high compacted permeability; medium to high piping hazard.	
RrA, RuA.....	Good to depth of 40 inches; poor below that depth (A-7).	B	Medium to low shear strength and compacted permeability; high piping hazard.	

## of engineering properties

Soil features affecting—Continued			Soil limitations for septic tank filter field
Water retention—Continued	Agricultural drainage	Irrigation	
Reservoir area			
Moderately rapid permeability above a depth of 46 inches, rapid permeability below.	Moderately rapid permeability above a depth of 46 inches, rapid permeability below.	Moderate available water capacity; rapid intake rate; slight salinity in places.	Slight: possible ground water contamination.
Rapid permeability-----	Flood hazard-----	Low available water capacity; rapid intake rate; slight salinity; flood hazard.	Severe: flood hazard; possible ground water contamination.
Moderate permeability in solum, rapid permeability in substratum.	Moderate permeability in solum, rapid permeability in substratum.	Not irrigated-----	Slight.
Slow permeability above a depth of 30 inches, rapid permeability below.	Slow permeability above a depth of 30 inches, rapid permeability below.	Moderate to high available water capacity; moderately slow intake rate; slight to moderate salinity.	Slight if leach lines are placed in most permeable horizon; possible ground water contamination.
Rapid permeability-----	Rapid permeability-----	Not irrigated-----	Slight to severe: 0 to 15 percent slopes; possible ground water contamination.
Moderate permeability above a depth of 33 inches, rapid permeability below.	Moderate permeability above a depth of 33 inches, rapid permeability below.	Moderate available water capacity; slow intake rate.	Slight: possible ground water contamination.
Slow permeability-----	Slow permeability-----	High available water capacity; moderately slow intake rate; slight salinity.	Severe: slow permeability.
Slow permeability above a depth of 26 inches, rapid permeability below.	Slow permeability above a depth of 26 inches, rapid permeability below.	High available water capacity; slow intake rate; slight salinity.	Slight, if leach lines are placed in most permeable horizon; possible ground water contamination.
Very slow permeability-----	Very slow permeability; surface drainage difficult.	High available water capacity; very slow intake rate; moderate salinity.	Severe: very slow permeability.
Moderate permeability above a depth of 40 inches, rapid permeability below.	Moderate permeability above a depth of 40 inches, rapid permeability below.	High available water capacity; moderately slow intake rate; slight salinity.	Moderate: moderate permeability; slight, if leach lines are below depth of 40 inches.
Slow permeability above a depth of 48 inches, rapid permeability below.	Slow permeability above a depth of 48 inches, rapid permeability below; water table at depth of 2 to 3 feet.	High available water capacity; moderately slow intake rate; moderate salinity.	Severe: slow permeability; water table at depth of 2 to 3 feet.
Moderately slow permeability--	Moderately slow permeability--	Moderate available water capacity; rapid intake rate; slight salinity.	Severe: moderately slow permeability.
Moderate permeability above a depth of 32 inches, rapid permeability below.	Moderate permeability above a depth of 32 inches, rapid permeability below.	High available water capacity; moderately slow intake rate; slight salinity.	Slight, if leach lines are placed in most permeable horizon.
Rapid permeability-----	Rapid permeability-----	Low available water capacity; mostly rapid intake rate; nonsaline to slight salinity.	Slight: possible ground water contamination.
Rapid permeability above a depth of 40 inches, slow permeability below; water table at depth of 3 to 5 feet.	Rapid permeability above a depth of 40 inches, slow permeability below.	Low to moderate available water capacity; moderately slow to rapid intake rate; slight to moderate salinity.	Severe: slow permeability; water table at depth of 3 to 5 feet.

This information does not, however, eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those generally shown in the tables. Also, inspection of sites, especially small ones, is needed because many areas of a given soil contain small areas of other soils that may have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in the soil survey have different meanings in soil science than in engineering. The Glossary defines many of these terms as they are commonly used in soil science.

### **Engineering classification systems**

The two systems most commonly used in classifying soils for engineering purposes are the Unified system, which is used by Soil Conservation Service engineers, the Department of Defense, and others, and the system developed by the American Association of State Highway Officials (AASHO) and generally used by highway engineers.

In the Unified system (7) soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, ML-CL.

In the AASHO system (1), each soil is placed in one of seven basic groups, ranging from A-1 through A-7, on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest mineral soils for subgrade.

The estimated engineering classification of each soil of the survey area according to each of these two systems is given in table 3.

### **Estimated soil properties significant in engineering**

Table 3 lists the soils in the survey area and gives estimates of some of the properties and qualities significant in engineering. The estimates are based on field classification and descriptions; on physical and chemical tests from comparable soils in adjacent areas, especially the Imperial Valley; and on experience in working with the individual soil in the survey area.

The depth from the surface shown in table 3 generally is the depth given for horizons of the profiles described in the section "Descriptions of the Soils."

The percentages that pass the various-sized sieves are according to weight. Fragments more than 3 inches in diameter are shown separately.

The liquid limit and plasticity index indicate the effect of water on the consistence of the soil material. As the moisture content of a fine-grained soil increases from a very dry state, the material changes from a semisolid to a plastic state. As the moisture content is further in-

creased, the material changes from a plastic to a liquid state. The plasticity limit is the moisture content at which the material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. These limits of consistency are called Atterberg limits after a Swedish soil scientist who devised these two tests. The plasticity index is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Permeability, as used in table 3, relates only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral movement. Because of stratification and lack of soil structure, the permeability values given may be lower than values for soils of similar texture in other areas. The values used in this survey are based on standards established for the National Cooperative Soil Survey. They differ from those used by local designers of drainage systems, which are based on field tests in the Imperial Valley and laboratory data obtained in that area.

The available water capacity, expressed in inches per inch of soil depth, is that amount of capillary water in the soil available for plant growth after all free water has drained away. The listed values for available water capacity are based on moisture-extraction curves, also called "moisture-characteristic" curves. Because of microstratification or thixotropic properties in some of the soils, the listed values do not necessarily follow values of available water capacity for soils of similar texture in other areas.

Reaction is the degree of acidity or alkalinity of a soil, recorded as pH. The pH value and relative terms used to describe soil reaction are explained in the Glossary.

Salinity of a soil is based on the electrical conductivity of a saturated soil extract as expressed in millimhos per centimeter at 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as a construction material, and its corrosiveness to other materials.

The shrink-swell potential indicates the change in volume resulting from the shrinkage of the soil when it dries and from the swelling when it takes up moisture. It is estimated on the basis of the amount and type of clay in the soil layers. In general soils with a coefficient of linear extensibility (COLE) of 0.03 or less have a low shrink-swell potential, and soils with a COLE of more than 0.06 have a high shrink-swell potential.

All soils in the Area have a very high limitation rating for corrosivity of uncoated steel.

### **Interpretations of engineering properties**

Table 4 contains information regarding the use of the soils in construction of roads, ponds, and sewage disposal systems and the soil features that affect agricultural drainage and irrigation. Detrimental or undesirable features are emphasized, but very desirable features also may be listed. The ratings and other interpretations in this table are based on estimated engineering properties of the soils given in table 3, on available test data, and on field experience.

Ratings of suitability as sources of sand and gravel are not given in table 4. The main sources of sand and gravel are Carrizo and Chuckawalla soils. It is from these soils that aggregates are obtained for concrete. Areas from which gravel and sand are being or have been taken are shown by the conventional map symbol GP (gravel pits) on the soil maps. Cibola, Holtville, Ripley, and Rositas soils and Dune land are other sources; but the sand is not suitable for concrete. These sources of sand and gravel may have varying thicknesses of overburden.

The suitability of the soil material for road fill (sub-grade) depends on the texture and plasticity of soil material, its compaction characteristics, the hazards of erosion, and the presence of rock within the normal depth of the road excavation.

Hydrologic soil groups are used for estimating direct runoff. The soils are classified on the basis of estimates of the intake of water during the latter part of a storm of long duration, after the soil profile is wet and has an opportunity to swell and without the protective effect of any vegetation. In the A group of this system are soils that have the most rapid infiltration and the lowest runoff potential, and in D group are soils that have the slowest infiltration and the highest runoff potential. Soils in groups B and C have infiltration rates and runoff potentials that are intermediate to those of groups A and D.

In rating materials for embankments for water-retention structures, features of both the subsoil and substratum of the soils are considered. These features are shear strength, compacted permeability, and piping hazard. A thorough onsite investigation is necessary.

Reservoir areas are affected mainly by seepage loss of water and such soil features listed as permeability, depth to water table, and slope. A thorough investigation of the particular site is necessary.

The soil features considered for agricultural drainage are those that affect the installation and performance of surface and subsurface drainage practices. These include permeability, depth to water table, and hazard of flooding. Generally, subsurface drainage for other than farm use is being accomplished by open drains. There is need for some tile drainage where the water table is high. Lack of suitable outlets is the most serious limitation affecting tile drainage in cultivated areas, but outlets are not considered in the interpretations shown in table 4.

Most of the soils within the survey area are under irrigation. Soil features that affect irrigation design are available water capacity, intake rate, permeability, salinity, topography, and strata having significant textural differences.

The septic-tank filter field is part of the septic-tank absorption system for onsite sewage disposal. It is a subsurface tile system laid in such a way that effluent from the septic tank is distributed with reasonable uniformity into the natural soil. The soil properties and qualities most important in rating the soils for the proper operation of such a system are permeability, depth to water table (seasonal or permanent), flooding hazard, slope, and depth to bedrock or other impervious materials.

In general soils have slight limitations for septic-tank filter fields if permeability is more rapid than 1.0 inch per hour, the depth to the seasonal high water table is

more than 6 feet, the slope is less than 5 percent, the depth to impervious material is more than 6 feet, and there is no flood hazard. The limitation is severe if permeability is slower than 0.63 inches per hour, the slope is more than 9 percent, the seasonal high water table is at a depth of less than 4 feet, impervious material is at a depth of less than 4 feet, or flooding is frequent. A thorough investigation of the site is needed because of significant differences in permeability among soil strata.

## ***Formation, Morphology, and Classification of the Soils***

This section contains descriptions of the major factors of soil formation as they occur in Palo Verde Area, a summary of significant morphological characteristics of the soils of the Area, an explanation of the current system of classifying soils by categories broader than the series, and a table showing the classification of the soils of the Area according to the current system.

### **Factors of Soil Formation**

The nature of the soil at any given place depends upon the composition of the parent material, the climate under which the parent material accumulated and existed, the kinds of organisms that lived in and on the soil, the relief, or lay of the land, and the length of time the parent material has been in place and subject to soil-forming processes.

#### ***Parent material***

Parent material is the unconsolidated mass of material from which soils form. It largely determines the chemical and mineralogical composition of soils.

In Palo Verde Area all soils formed in sediment deposited by the Colorado River. This sediment was a mixture of materials from the upper watershed of the Colorado River. Much of the material, particularly that from which the Cibola, Holtville, and other soils of the valley floor formed, was probably deposited, eroded, reworked by the river, and redeposited several times before reaching Palo Verde Area. The parent material contained a substantial quantity of powdered minerals, so the soils that formed are rich in mineral nutrients. The soils of the valley floor are still being modified and enriched to a limited extent by irrigation with water from the Colorado River, which carries approximately 8 tons of suspended sediment per acre foot.

#### ***Relief***

Relief, or the shape of the landscape, influences formation of soils through its effect on drainage, erosion, plant cover, and temperature of the soil (2).

In the vicinity of the Palo Verde Area, the Colorado River is bordered by mountain ranges, which include from north to south the Maria, McCoy, Mule, and Palo Verde. Depending on the distance of these mountains from the river, the width of the valley of the Colorado on the California side ranges from about 4 to 15 miles. McCoy Wash is the largest tributary and is about 19 miles long. Water flows through it only after storms.

The survey area is mainly two distinct terraces separated by a prominent escarpment that is 75 to 125 feet high. The higher terrace represents a level at which the river formerly flowed. The lower terrace, called Palo Verde Valley, is the more recent and is similar to all landscapes formed by rivers. Nearest the present or most recent riverbeds are natural levees formed of sandy sediment from which evolved the Mecca and Rositas soils. Behind these natural levees are backwater areas in which were deposited the less permeable silts and clays from which the Holtville and Imperial soils were formed. Between these is sediment that was deposited in bands of various widths. Glenbar, Indio, Meloland, and Ripley soils formed in this sediment. These diversions are not sharply defined and have been influenced by the numerous conditions that affect transportation and sedimentation of mud, such as currents and the physical and chemical properties of both the mud and water.

Most areas mapped as Badland are remnants of deposits of alluvium that have been severely eroded and possibly affected by uplifting. Associated with Badland are Chuckawalla soils, which formed in somewhat more protected areas where the highest terraces grade into local alluvial fans. Orita soils also are on the highest terraces, but in somewhat lower positions than Chuckawalla soils.

In the steep mountainous areas mapped as Rock land, relief has prevented the formation of soil profiles.

### **Climate**

The climate of this Area is characterized by hot summers, mild winters, and very little rainfall. Presumably, it is similar to the climate under which the soils formed. Climatic data for the Area are given in the section, "The Climate of Palo Verde Area."

A hot, dry climate restricts the rate of soil formation. The process of soil formation in alluvium begins when the free salts are leached from the soil by water percolating through the solum. Illuviation then occurs, and it is followed by the downward movement of humus, iron, manganese, and clay. The lack of rainfall delays this leaching process and restricts the development of distinct horizons on all except the older Chuckawalla and Orita soils. The very hot summer temperatures also oxidize and destroy organic matter. The content of organic matter of all soils in the Area is very low. This is not a detriment except in the Holtville and Imperial soils. A higher content of organic matter in these soils would undoubtedly improve the structure and increase the rate of water intake.

### **Living organisms**

Plants, animals, insects, bacteria, and fungi affect formation of soils by causing gains in content of organic matter and nitrogen in the soil, gains or losses in plant nutrients, and changes in structure and porosity.

In Palo Verde Area biological effects began after the stratified alluvial deposits were sufficiently drained to support plants and animals. Some areas of the Aco, Chuckawalla, Orita, and Rositas soils have been mixed extensively by rodent activity. Through the combined activities of living organisms the river deposits become more mixed, obtain a more open structure, and develop a

heterogeneous pore system that is conducive to still further and stronger biological activity.

### **Time**

A long time is required for formation of soil horizons. Commonly, the presence of horizons is a function of the length of time that parent materials have been in place and have been drained. If the factors of soil formation have been in effect long enough to form well-defined genetically related horizons and a soil is in equilibrium with its environment, the soil is considered mature. The only examples of mature soils in the Area are Chuckawalla and Orita soils. However, if, like Rositas and most other soils in the Area, there is little or no horizon differentiation and the processes of formation are still active, the soil is considered an immature or young soil.

### **Morphology of the Soils**

The majority of the soils within the survey area have a surface layer that is designated as the Ap, or plow layer. This layer differs from the original deposited alluvium only because of mechanical disturbance which alters structure and textural stratification.

Enough organic matter has accumulated in the surface layer of Aco and Orita soils and in a few small areas of Carrizo soils to form an A1 horizon. This horizon is slightly darkened or has mineral particles that are organically coated. These A1 horizons are shown in the description of these soils. In Orita soils this horizon is generally covered by a few inches of overwash derived from adjacent higher areas.

Chuckawalla soils have a very thin and pale surface horizon with an apparent loss of clay and iron. The movement of clay has resulted in an increased percentage of silt in the horizon. The symbol A2 is used to denote these changes.

The B horizons in the Chuckawalla and Orita soils are soil horizons that have increased silicate clay and iron content. Colors of these horizons are redder than either overlying or underlying horizons, which indicates increased iron concentration. Consistence, texture, and stronger structure indicate clay increase, which is noted by using a small letter t as in Bt.

The C horizons of all soils in the Area consist of unconsolidated, mixed, calcareous alluvium. This material is presumed to be only slightly or not at all affected by processes of soil formation. All the C horizons are alike in that they are light colored, low in content of organic matter, generally rich in lime, and of mixed mineral composition. They are irregularly stratified and extremely variable in texture and consistency, generally ranging from sand to clay, and they are loose to hard.

The C horizons of Chuckawalla, Carrizo, and Orita soils contain gravel. The surface layers of Rositas gravelly loamy sand and Orita soils have increased gravel concentration because of the removal of finer mineral particles by wind.

The Aco and Chuckawalla soils have accumulations of carbonates in the C horizon, which is designated as "Cca."

## Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Soil classification enables us to assemble knowledge about a specific soil, to see the relationship of one soil to another and to the whole environment, and to form principles that help us to understand the behavior of soils and their response to manipulation. First through classification and then through use of soil maps, we can apply our knowledge of soils to specific areas.

Thus, in classification soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, in developing rural areas, in engineering work, and in many other ways. Soils are placed in broad categories to facilitate study and comparison in large areas, such as countries and continents.

The current system of classifying soils (5) was adopted for general use by the National Cooperative Soil Survey in 1965. Persons interested in the development of the system should refer to available literature (4). The system has six categories. Beginning with the most inclusive, the categories are the order, the suborder, the great group, the subgroup, the family, and the series. The categories are defined briefly in the following paragraphs, and the classification of the soils of Palo Verde Area according to this system is shown in table 5.

*Order.*—Ten soil orders are recognized in the current system: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. The exceptions, Entisols, Vertisols, and Histosols, occur in many different climates. Two of the soil orders are represented in Palo Verde Area, Entisols and Aridisols.

Entisols are young mineral soils that do not have genetically related horizons. Aco, Cibola, Gilman, Glenbar, Holtville, Imperial, Indio, Meloland, Ripley, and Rositas soils are Entisols.

Aridisols are primarily soils that are generally dry when not frozen or irrigated and have definitely started to form genetically related horizons. Chuckawalla and Orita soils are Aridisols.

*Suborder.*—Each order is divided into suborders, primarily on the basis of soil characteristics that produce classes having the greatest genetic similarity. The suborders have a narrower climate range than the orders. The criteria for suborders chiefly reflect the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

*Great group.*—Each suborder is divided into great groups according to the presence or absence of genetic horizons and the arrangement of these horizons.

*Subgroup.*—Each great group is divided into subgroups. One of these subgroups (typic) represents the central segment of the great group, and the others, called intergrades, contain soils that have most of the properties of one great group but also one or more properties of another great group, suborder, or order.

*Family.*—Families are established within each subgroup, primarily on the basis of properties important to the growth of plants, but also relevant to the behavior of soils used in other ways. Among the properties considered

in this Area are texture, mineralogy, reaction, and soil temperature.

*Series.*—The series consists of a group of soils that formed from a particular kind of parent material and has genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the soil profile. Among the characteristics are color, texture, structure, consistence, reaction, and mineralogical and chemical composition.

## General Nature of the Area

Palo Verde Area is made up of river bottoms and terraces and smaller acreages of mountains and badlands. The Area is 29 miles long and has a maximum width of about 15 miles. The Colorado River forms the east boundary, and more or less continuous mountain masses delineate the other boundaries.

The upper terraces are barren of vegetation except for the bottoms of drainage channels that are generally dry. The drainage channels support a sparse cover of small desert trees, shrubs, grasses, and other plants that have a short life. These upper terraces grade downward onto the Palo Verde Mesa which is separated from the Palo Verde Valley by an abrupt bluff 75 to 125 feet high. Native mesa vegetation consists of widely spaced desert shrubs and grasses. In some wetter years, sufficient ephemerals provide sheep range for a limited time.

Before irrigation the Palo Verde Valley was a thicket of mesquite, cottonwood, and phreatophytes.

Earliest economic activity in the Area was gold and silver mining in the mountains near the river and the operation of steamboats on the Colorado River from 1852 to 1877 to haul out these ores and bring in supplies.

Year-round favorable climate, abundant open space, and many miles of water in canals, open drains, and the Colorado River provide varied recreational opportunities.

One popular and growing recreation is the use of 4-wheel-drive vehicles for sand dune or hill climbing and for exploration of the desert and nearby rough mountainous areas. In the desert surrounding the Area are deposits of quartz crystals, geodes, agate, and other semi-precious stones.

The Colorado River provides areas for water skiing, fishing, boating, and camping. Recreational improvements on the river include a managed sport fish development program, a marina, several county and private boat ramps and parks, a projected river parks development program, and a river pollution-control program. The river and waters in irrigation canals and in drainage systems provide the angler with striped bass, white bass, largemouth bass, catfish, crappie, and bluegill. Carp are caught with bow and arrow in drainage ditches, and gigging for bullfrogs is popular in season. Swimming is also available in quiet areas of the river.

The Palo Verde Valley offers dove hunting late in fall and early in winter. Other game are quail, pheasant, duck, geese, rabbit, deer, and varmints.

Transportation for the Area is provided by a major airline, private aircraft, a spur line of a major railroad, and three interstate trucking companies. The airport has runways for large jet aircraft. Several packing plants sort, grade, pack, and ice farm products for marketing.

TABLE 5.—*Soil series classified according to the current system*

Series	Family	Subgroup	Order
Aco.....	Coarse-loamy, mixed (calcareous), hyperthermic.....	Typic Torriorthents.....	Entisols.
Carrizo.....	Sandy-skeletal, mixed, hyperthermic.....	Typic Torriorthents.....	Entisols.
Chuckawalla.....	Loamy-skeletal, mixed, hyperthermic.....	Typic Haplargids.....	Aridisols.
Cibola.....	Fine-silty over sandy or sandy-skeletal, mixed (calcareous), hyperthermic.	Typic Torrifluvents.....	Entisols.
Gilman.....	Coarse-loamy, mixed (calcareous), hyperthermic.....	Typic Torrifluvents.....	Entisols.
Glenbar.....	Fine-silty, mixed (calcareous), hyperthermic.....	Typic Torrifluvents.....	Entisols.
Holtville.....	Clayey over loamy, montmorillonitic (calcareous), hyperthermic.	Typic Torrifluvents.....	Entisols.
Imperial.....	Fine, montmorillonitic (calcareous), hyperthermic.....	Vertic Torriorthents.....	Entisols.
Indio.....	Coarse-silty, mixed (calcareous), hyperthermic.....	Typic Torriorthents.....	Entisols.
Meloland.....	Coarse-loamy over clayey, mixed (calcareous), hyperthermic.....	Typic Torrifluvents.....	Entisols.
Orita.....	Fine-loamy, mixed, hyperthermic.....	Typic Haplargids.....	Aridisols.
Ripley.....	Coarse-silty over sandy or sandy-skeletal, mixed (calcareous), hyperthermic.	Typic Torrifluvents.....	Entisols.
Rositas.....	Mixed, hyperthermic.....	Typic Torripsamments.....	Entisols.

U.S. Highway 60 crosses the Area from the northwest to the southeast. U.S. Highway 95, which begins near Blythe, leaves the Area in a northerly direction. State Highway 78 begins about 4 miles west of Blythe and runs south into Imperial County.

### Irrigation and Development of Farming

The first use of water from the Colorado River for irrigation was made by Thomas H. Blythe, who acquired 40,000 acres of land east of Defrain Boulevard in Range 22 East, Township 6, 7, and 8 South San Bernardino benchmark. Blythe used Colorado River water for irrigation of pasture and in 1877 filed and recorded at San Diego, California, a request for 3,800 second-feet of Colorado River water to be used for "agricultural, mining, manufacturing, domestic, and commercial uses."

The valley lands were used chiefly for cattle feeding until the Blythe estate was purchased by the newly organized Palo Verde Mutual Water Company in 1908. Then, in 1910, government lands were opened for settlement under the homestead and desert acts, and rapid development of farmland in the valley began.

Probably the most severe problem for the early farmers resulted from the annual fluctuations of the river. The flow varied from about 3,000 to about 200,000 second-feet in a single year, which prevented dependable irrigation-water diversion installations and caused much erosion of river banks and often disastrous flooding. The Palo Verde Levee District was organized in 1917 in an attempt to alleviate these problems.

The most devastating of these overflows occurred in 1922 when the river broke through a levee and flooded 35,000 acres south of Blythe, destroying miles of canals and many irrigation structures. Finally, with the completion of Hoover (Boulder) Dam in 1935, river controls that marked the turning point in the valley's prosperity were attained.

The first settlers of the valley saw the rise in the water tables brought about by irrigation, and they soon recognized the necessity of improved drainage to maintain irrigated cropland. In 1921 a bond issue of \$850,000 was approved to form a drainage district and to begin construction of open drains. Progress in construction of open drains for ground-water control gradually advanced,

until in 1960 there were more than 150 miles of drainage channels that took ground water out of the valley and returned it downstream to the river.

Despite the drainage channels, rising water tables were still threatening. Increased irrigated acreage and more intensive use of the land compounded the problem. Furthermore, river-control structures had reduced the ability of the river to keep its channel scoured, and bed-load sediment raised the river to a level that prevented adequate depth for drainage outlets.

In 1964 the United States Bureau of Reclamation started work on a long-planned project to rechannel, straighten sections of the channel, and lower the Colorado River. This work, still in progress, made lowering of drainage outlets possible. The Palo Verde Irrigation District had already started (in 1960) an accelerated program for drainage improvement in anticipation of being able to obtain lower drainage outlets. This program of deepening, enlarging, and otherwise improving existing drainage channels and constructing new channels where needed is still in progress.

Also during this period, farmers in the valley made conscientious and concentrated efforts toward irrigation improvements. From 1960 through 1968 virtually all irrigated land in the valley was leveled to precise and uniform gradients, and about one-fourth of all field irrigation ditches were lined with concrete for improved irrigation water management.

Through these combined efforts of government agencies and land users, high water tables are no longer a serious threat to farming in the valley. Continued maintenance of open drains and high irrigation efficiency, however, is still a requisite on all Palo Verde Valley lands.

Thomas Blythe diverted irrigation water from the river through a dug canal in the northeast corner of the valley. During flood flows he was able to divert water through this canal and have it carried a mile south to be stored in Olive Lake slough. This stored water was used to provide irrigation to lower lying lands during periods when the river was low.

In 1908, after the Palo Verde Mutual Water Company was formed, the first intake structure was built near the present site of the Palo Verde Diversion Dam. Also, at

that time, the principal canals were located much as they are today.

After the construction of Hoover (Boulder) Dam, silts settled behind the dam, and clear water flowed below this point. The greater cutting action of the clear water caused the river bed to become gradually lower and made it more difficult to dependably divert sufficient water for irrigation of the valley.

In 1945 a rock weir was installed below the intake to raise the level of the river. It was soon apparent, however, that the weir was not stable, and the annual maintenance was expensive. In January 1952 the rock weir washed out and had to be replaced. In addition, two pumps with a capacity of 90 second feet and three with a capacity of 50 second feet were installed to assure some water in case of more failures. It was apparent that something more stable was needed for water diversion before the dredging that was needed at the lower end of the valley for drainage improvements could be started.

In September 1954 the Palo Verde Dam construction was authorized. The Palo Verde Irrigation District began modification of a part of the canal system which was needed because the dam was constructed on a lower elevation than the weir which it replaced. With the modern diversion facilities provided by the dam and the 300 miles of canals, water distribution in the valley is now dependable.

All of this early farmland development was in Palo Verde Valley. Development of Palo Verde Mesa was delayed for many years because of the high costs of development and operation. In 1959 only 635 acres on the mesa were cultivated, all on the lower terrace. Only after big corporations became involved did the momentum increase in development of mesa lands. At this writing, about 7,000 acres on the mesa have been prepared for irrigation. Most of this development has occurred within the past two years, and more acreage is currently being developed for farmland. Most of this new land is being irrigated from wells, but some river water is being pumped up to the mesa.

## The Climate of Palo Verde Area <sup>4</sup>

The climate of this area follows a characteristic desert pattern. Hot, dry summers and moderate to cool winters with limited precipitation are the rule. An average of 4,000 hours of sunshine occur each year, amounting to more than 90 percent of the possible hours of sunshine for the year. In the summer months the sun shines on the valley about 95 percent of the possible hours.

The low latitude, clear skies, and relatively dry air result in wide temperature ranges, both from day to night and from winter to summer. The diurnal range averages from 30° to 35° F., and the difference from summer to winter is around 40° F. Although the average maximum in July is more than 108° F., the minimum in January is only 37° F., 71° F. cooler. There are 185 days per year with maximum readings of 90° F. or higher and 12 days per year with minimums of 32° F. or colder. The growing season is long, however, with 290 days between the average spring and average fall freeze dates of 32°

F. temperature readings and 345 days between 28° F. readings.

Precipitation is generally light. The average annual precipitation of less than 4 inches falls in a few showers during the year. Blythe averages only 6 days per year with 0.1 inch or more of precipitation. Heavy showers may occur at any time during the year, although the typical pattern is one of extended periods without precipitation. Records indicate that once in 10 years a 30-minute rainfall of 0.75 inch, a 1-hour amount of 1.0 inch, and a 24-hour amount of 2.0 inches occur.

Relative humidity is moderate to low throughout the year. Readings around 45 percent are characteristic of the early morning hours in all seasons, and afternoon readings range from around 25 percent in the winter to 15 percent late in spring and early in summer. Air occasionally drifts northward from Baja, California or from the Gulf of Mexico. The higher humidity readings on these occasions signal the possibility of thundershowers forming over the desert areas.

Wind is moderate over the flat reaches of the desert. An average speed of 8 mph has been observed at Blythe, with only occasional strong winds reported. Almost half of the observations show wind from the south or west, and about a quarter of the wind blows from the northwest or north. It has been estimated that an average exposure in the Blythe area experiences 75 mph winds about once in 50 years.

Evapotranspiration at Blythe, according to the Thornthwaite method of calculation, totals about 48 inches per year, with 46 inches occurring during the 32° F. growing season. Precipitation is so light, however, that the actual evapotranspiration on a dry-farmed basis is limited to around 3.5 inches per year or 2.2 inches during the growing season.

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## Glossary

AC soil. A soil that has an A and a C horizon but no B horizon. Commonly such soils are immature, as those developing from alluvium or those on steep, rocky slopes.

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- Aggregate, soil.** Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.
- Alkali soil.** Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.
- Alluvial fan.** A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly.
- Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.
- Available water capacity** (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.
- Badlands.** Areas of rough, irregular land where most of the surface is occupied by ridges, gullies, and deep channels. Land hard to traverse.
- Brush.** Stands of shrubs and short, scrubby trees that do not reach marketable size.
- Buried soil.** A developed soil, once exposed but now overlain by more recently formed soil.
- Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.
- Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.
- Clay film.** A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.
- Coarse-textured soil.** Soil of the sand or loamy sand textural class.
- Cobblestone.** A rounded or partly rounded fragment of rock, 3 to 10 inches in diameter.
- Concretions.** Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.
- Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—
- Loose.*—Noncoherent when dry or moist; does not hold together in a mass.
- Friable.*—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.
- Firm.*—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.
- Plastic.*—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.
- Sticky.*—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.
- Hard.*—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.
- Soft.*—When dry, breaks into powder or individual grains under very slight pressure.
- Cemented.*—Hard and brittle; little affected by moistening.
- Cover crop.** A close-growing crop, grown primarily to improve the soil and to protect it between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.
- Desert varnish.** Brown or black surface stain or crust of manganese or iron oxide, usually with a glistening luster.
- Drainage class** (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.
- Excessively drained* soils are commonly very porous and rapidly permeable and have a low water-holding capacity.
- Somewhat excessively drained* soils are also very permeable and are free from mottling throughout their profile.
- Well-drained* soils are nearly free from mottling and are commonly of intermediate texture.
- Moderately well drained* soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.
- Somewhat poorly drained* soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.
- Poorly drained* soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.
- Very poorly drained* soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.
- Dry wash.** An arroyo.
- Dune.** A mound or ridge of loose sand piled up by the wind.
- Evapotranspiration.** The combined loss of water from a given area, and during a specified time, by evaporation from the soil surface and by transpiration of the plants.
- Erosion.** The wearing away of the land surface by wind (sandblast), running water, and other geological agents.
- Fertility, soil.** The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.
- Fine-textured soil.** Soil of the sandy clay, silty clay, or clay textural class.
- First bottom.** The normal flood plain of a stream, subject to frequent or occasional flooding.
- Flood plain.** Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.
- Gravel.** Rounded or angular rock fragments, not prominently flattened, up to 3 inches in diameter.
- Hardpan.** A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.
- Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:
- O horizon.*—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.
- A horizon.*—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).
- B horizon.*—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.
- C horizon.*—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.
- R layer.*—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.
- Illuviation.** The accumulation of soil material in a soil horizon through the deposition of suspended material and organic matter removed from horizons above. Since part of the fine clay in the B horizon (or subsoil) of many soils has moved into the B horizon from the A horizon above, the B horizon is called an illuvial horizon.
- Irrigation.** Application of water to soils to assist in production of crops. Methods of irrigation are—
- Border.*—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

- Basin.**—Water is applied rapidly to relatively level plots surrounded by levees or dikes.
- Controlled flooding.**—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.
- Corrugation.**—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops, or in orchards, to confine the flow of water to one direction.
- Furrow.**—Water is applied in small ditches made by cultivation implements used for tree and row crops.
- Sprinkler.**—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.
- Subirrigation.**—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.
- Wild flooding.**—Irrigation water, released at high points, flows onto the field without controlled distribution.
- Land leveling.** The reshaping of the ground surface to make for a more uniform application of irrigation water.
- Leaching.** The removal of soluble materials from soils or other material by percolating water.
- Medium-textured soil.** Soil of the very fine sandy loam, loam, silt loam, or silt textural class.
- Moderately coarse textured soil.** Soil of the sandy loam or fine sandy loam textural class.
- Moderately fine textured soil.** Soil of the clay loam, sandy clay loam, or silty clay loam textural class.
- Morphology, soil.** The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.
- Mottling, soil.** Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common, and many*; size—*fine, medium, and coarse*; and contrast—*faint, distinct, and prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.
- Nurse crop.** A crop that is grown with another crop, usually a small grain sown with alfalfa, clover, or some other forage crop for the purpose of protecting the forage crop until it is well established.
- Nutrient, plant.** Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil, and carbon, hydrogen, and oxygen obtained largely from the air and water, are plant nutrients.
- Ped.** An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.
- Permeability.** The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid*.
- pH value.** A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.
- Plow layer.** The soil ordinarily moved in tillage; equivalent to surface soil.
- Porosity, soil.** The degree to which the soil mass is permeated with pores or cavities.
- Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.
- Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; and alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		pH
Extremely acid....	Below 4.5	Mildly alkaline.....	7.4 to 7.8
Very strongly acid..	4.5 to 5.0	Moderately alkaline..	7.9 to 8.4
Strongly acid.....	5.1 to 5.5	Strongly alkaline....	8.5 to 9.0
Medium acid.....	5.6 to 6.0	Very strongly alka-	
Slightly acid.....	6.1 to 6.5	line .....	9.1 and
Neutral .....	6.6 to 7.3		higher

**Relief.** The elevations or inequalities of a land surface, considered collectively.

**Saline soil.** A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

**Sand.** Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeter. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Silt.** Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

**Soil.** A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

**Soil separates.** Mineral particles, less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

**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 soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Stratified.** Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geological material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

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

**Subsoiling.** Tillage of a soil below normal depth ordinarily to shatter a hardpan or claypan.

**Substratum.** Technically, the part of the soil below the solum.

**Surface layer.** A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

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

**Texture, soil.** The relative proportions of sand, silt, and clay particle in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

**Water table.** The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the description of the series to which the unit belongs. Other information is given in tables, as follows:

- Acreage and extent of soils, table 1, page 4.
- Estimated yields of major crops, table 2, page 18.
- Estimated engineering properties, table 3, page 24.
- Engineering interpretations, table 4, page 28.

Map symbol	Mapping unit	De-scribed on page	Capability unit		Storie index
			Symbol	Page	
Ac	Aco gravelly loamy sand-----	5	IIs-4	15	34
Af	Aco sandy loam-----	5	IIs-4	15	71
BaG	Badland-----	5	VIIIe-1	17	<10
Ce	Carrizo gravelly sand-----	5	IVs-4	17	21
Ch	Chuckawalla very gravelly silt loam-----	6	VIIIs-1	17	32
Co	Cibola fine sandy loam-----	7	IIs-6	16	75
Cs	Cibola silty clay loam-----	6	IIs-6	16	68
DuD	Dune land-----	7	VIIIe-1	17	<10
Gb	Gilman fine sandy loam-----	7	IIs-4	15	95
Gc	Gilman silty clay loam-----	8	IIs-4	15	86
Ge	Glenbar silty clay loam-----	8	IIs-6	16	65
Hb	Holtville fine sandy loam-----	9	IIs-6	16	75
Hc	Holtville silty clay-----	9	IIs-5	16	53
Ib	Imperial fine sandy loam-----	10	IIIs-5	16	59
Ic	Imperial silty clay-----	9	IIIs-5	16	41
Id	Indio very fine sandy loam-----	10	IIs-6	16	100
Ie	Indio silty clay loam-----	10	IIs-6	16	90
Md	Meloland fine sandy loam-----	11	IIIw-3	16	59
Me	Meloland silty clay loam-----	11	IIIw-3	16	53
Oc	Orita fine sand-----	12	IIs-4	15	49
Og	Orita gravelly loamy sand-----	12	IIs-4	15	30
Or	Orita gravelly fine sandy loam-----	11	IIs-6	16	56
Rb	Ripley very fine sandy loam-----	13	IIs-6	16	77
Rc	Ripley silty clay loam-----	12	IIs-6	16	69
RdG	Rock land-----	13	VIIIs-1	17	< 5
RoA	Rositas fine sand, 0 to 2 percent slopes-----	13	IIIs-4	16	42
RoB	Rositas fine sand, 2 to 9 percent slopes-----	13	IIIs-4	16	38
RrA	Rositas fine sand, wet, 0 to 2 percent slopes-----	13	IIIw-3	16	39
RsA	Rositas gravelly loamy sand, 0 to 2 percent slopes-----	14	IVs-4	17	21
RtA	Rositas silty clay loam, 0 to 2 percent slopes-----	14	IIIs-4	16	72
RuA	Rositas silty clay loam, wet, 0 to 2 percent slopes-----	14	IIIw-3	16	54

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