

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL  
EXPERIMENT STATION, THOMAS F. HUNT, DIRECTOR;  
CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

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SOIL SURVEY OF THE LOS ANGELES AREA,  
CALIFORNIA.

BY

J. W. NELSON, IN CHARGE, AND C. J. ZINN, OF THE UNIVERSITY  
OF CALIFORNIA, AND A. T. STRAHORN, E. B. WATSON, AND  
J. E. DUNN, OF THE U. S. DEPARTMENT OF AGRICULTURE.

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MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

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



WASHINGTON:  
GOVERNMENT PRINTING OFFICE.

1919

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## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS,

*Washington, D. C., October 23, 1918.*

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of the Los Angeles area, California, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1916, as authorized by law.

This work was done in cooperation with the University of California Agricultural Experiment Station.

Respectfully,

MILTON WHITNEY,

*Chief of Bureau.*

Hon. D. F. HOUSTON,

*Secretary of Agriculture.*

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## MAP.

Soil map, Los Angeles area sheet, California.

# SOIL SURVEY OF THE LOS ANGELES AREA, CALIFORNIA.

By J. W. NELSON, In Charge, and C. J. ZINN, of the University of California, A. T. STRAHORN, E. B. WATSON, and J. E. DUNN, of the U. S. Department of Agriculture.—Area Inspected by MACY H. LAPHAM.

## DESCRIPTION OF THE AREA.

The Los Angeles area, comprising part of southern Los Angeles County, is situated in southern California. The Santa Monica Mountains and the San Rafael and Puente Hills lie along its northern boundary and the Pacific Ocean borders it on the south and west. The eastern boundary is an arbitrary line extending north through Alamitos Bay to a point about  $2\frac{1}{2}$  miles east of Clearwater, thence running about 6 miles northeast, and thence north to the crest of the Puente Hills. From this point it follows the general crest of the Puente Hills in a northwesterly direction, thence continues as a north and south line about midway between the cities of Los Angeles and Pasadena. Bordering on the east, northeast, and north are the areas covered by the soil surveys of the Anaheim, Pasadena, and San Fernando Valley areas, respectively,<sup>1</sup> and the present survey includes much of the territory embraced in the earlier soil survey of the Los Angeles area.<sup>2</sup>



FIG. 1.—Sketch map showing location of the Los Angeles area, California.

The area is roughly a square. It covers about 563 square miles, or 360,320 acres.

The base maps used in the field work consist of topographic sheets of the United States Geological Survey, with portions of a local county map, which were revised in the field to make necessary additions and changes in culture.

Topographically the area consists of the fringe of low hills lying along the northern and eastern boundaries, constituting the low foothills of the ranges mentioned above, and a low plain sloping gently

<sup>1</sup> See Soil Surveys of the Anaheim and Pasadena areas, Field Operations of the Bureau of Soils, 1916; also Soil Survey of the San Fernando Valley area, Field Operations, 1915.

<sup>2</sup> See Soil Survey of Los Angeles Area, Cal., Field Operations, Bureau of Soils, 1903.

southward to the sea. In the eastern part of the area this plain is uninterrupted by either significant elevations or depressions. The western part, however, is broken by a belt of mesalike elevations several miles wide extending in a general southeasterly direction from Playa del Rey to Long Beach. These uplands range in elevation from 100 to 500 feet above sea level and are continuous except at Cerritos, where the Los Angeles River has eroded a valley about  $1\frac{1}{2}$  miles wide through them. The San Pedro Hills, with an elevation of nearly 1,500 feet, are situated in the southwestern extremity of the area. These, with a belt of sand-dune ridges extending from Malaga Cove to Playa del Rey and the mountainous and hilly areas along the northern boundary, form, with the broad sloping plain, the physiographic features of the area.

The natural drainage of the region is effected by the Los Angeles and San Gabriel Rivers with their tributaries. All the tributaries are intermittent, while the two main streams are subject to very great changes of volume, becoming practically intermittent in stretches of very sandy channel during the dry season.

The slope of the great plain making up nearly the entire area is sufficient to give good drainage, except in the region around Nigger Slough and in several tidal marshes along the coast.

The streams in the eastern half have reached base level and are now building rapidly. They are very shallow and sluggish and frequently shift their channels. They cause considerable devastation during flood periods, as they deposit large quantities of sand and silt.

The area surveyed was sparsely settled prior to the building of the Southern Pacific Railroad across it in 1874. This and the Atchison, Topeka & Santa Fe Railroad, completed to Los Angeles in 1885, gave a great impetus to immigration. The population has increased rapidly since. The inhabitants are mainly Americans from all parts of the United States, with some Europeans. Of the other nationalities represented, Mexicans rank first in numbers. The Mexicans are employed mainly as laborers. Japanese are second in number, and largely control the trucking industry. There are about the same number of negroes as Japanese and a smaller number of Chinese.

There are about 30 or more thriving cities and towns in the Los Angeles area. The center of population is in the northern part. About one-third of the total population is rural.

Los Angeles, with 319,198 people in 1910, is the county seat of Los Angeles County. It is situated in the northern part of the area surveyed, and the city boundaries extend over 20 miles south to San Pedro Bay. Much of the area included within the city limits is devoted to general farming and truck growing at present, but is being subdivided and used for building purposes or more intensive

cultivation quite rapidly. Cities and towns are well distributed over the area, and are usually important agricultural or manufacturing centers. Among the inland cities and towns are Hollywood, Glendale, Tropic, Whittier, Downey, Compton, Inglewood, Gardena, Palms, Culver City, Watts, Huntington Park, Sawtelle, and Montebello. Among the important cities and towns along the ocean beach are Long Beach, Wilmington, San Pedro, Redondo, Hermosa, Venice, and Santa Monica. The foothills and valley slopes along the Santa Monica Mountains west of Los Angeles contain very attractive building sites, because of the desirable climate and opportunity for the cultivation of flowers and subtropical plants.

The area is well supplied with transportation facilities. The main lines and many branch lines of the Southern Pacific; Atchison, Topeka & Santa Fe; and Los Angeles & Salt Lake Railroads traverse the region. Eight branch lines, with local spurs, in addition to numerous lines of the Pacific Electric Railroad, radiate throughout the area and serve as feeders for the main lines running east and north. The area possesses a fine system of surfaced roads, radiating from Los Angeles and connecting with all parts of the area and with outside points. These main highways and numerous well-constructed crossroads are nearly always in excellent condition, and serve a heavy traffic throughout the year. Practically every part of the area is provided with good schools, electricity for power and lighting purposes, rural mail delivery service, and the telephone.

The city, State, and Federal Governments are actively engaged in the construction of a deep-water harbor at San Pedro, now included within the Los Angeles city limits, and a large breakwater, with piers and warehouses, has been constructed to meet the increasing demands of commerce.

Several important oil fields within the area yield a large production of oil and furnish much of the asphalt for road construction and other purposes.

Los Angeles and other local markets consume most of the berries and dairy and poultry products produced, but large quantities of citrus fruits, walnuts, and truck crops are shipped to eastern and northern markets.

City and suburban development is gradually encroaching upon general-farming districts, and this condition, with other important factors, has greatly increased land values over much of the area.

#### CLIMATE.

The favorable climate of this region is responsible to a large extent for the remarkable development that has taken place. The year is divided into two seasons, a wet and a dry, corresponding to winter

and summer, respectively. The rainy period usually extends from about November to May, with most of the precipitation occurring during the three winter months. The precipitation varies considerably from year to year, and it is usually greatest along the foothills in the northern part of the area. Occasionally there are periods of heavy rainfall which cause considerable damage. On the steep, mountainous slopes, with slight soil and vegetative covering, much of the rainfall is lost as run-off, leaving such areas very dry and barren during the summer months. Snow, hail, and thunderstorms are very rare. The summers are dry and during several months each year little or no rain falls, making irrigation necessary for the successful maturing of most of the crops grown.

The following tables, covering a period of years, give temperature and rainfall data for Los Angeles, Santa Monica, Whittier, and Santa Ana, the last-named place lying a short distance southeast of the Los Angeles area.

*Normal monthly, seasonal, and annual temperature and precipitation at Los Angeles.*

[Elevation 293 feet. Length of record 34 years.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	° F.	° F.	° F.	Inches.	Inches.	Inches.
December.....	55.3	89	30	2.93	0.12	15.80
January.....	53.1	87	30	3.00	1.26	.25
February.....	54.1	88	28	2.83	.51	.92
Winter.....	54.2	89	28	8.76	1.89	16.97
March.....	55.6	99	31	3.10	.98	6.48
April.....	57.6	100	36	1.00	.03	.27
May.....	60.5	103	40	.45	1.75	.62
Spring.....	57.9	103	31	4.55	2.76	7.37
June.....	64.5	105	46	.07	T.	.00
July.....	67.4	109	49	.01	.07	.00
August.....	68.6	106	49	.03	T.	.28
Summer.....	66.8	109	46	.11	.07	.28
September.....	66.5	108	44	.13	.02	.33
October.....	62.3	102	40	.72	.09	6.96
November.....	58.4	96	34	1.31	T.	1.35
Fall.....	62.4	108	34	2.16	.11	8.64
Year.....	60.3	109	28	15.58	4.83	33.76

*Extreme monthly temperature and mean monthly, seasonal, and annual precipitation at Santa Monica.*

Month.	Temperature.		Precipitation.		
	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1909).
	° F.	° F.	Inches.	Inches.	Inches.
December.....	79	32	2.52	0.28	6.70
January.....	86	26	3.28	1.70	8.24
February.....	83	36	2.61	T.	3.94
Winter.....	86	26	8.41	1.98	18.88
March.....	92	37	2.94	2.09	2.56
April.....	95	39	.63	.22	0
May.....	86	39	.34	0	0
Spring.....	95	37	3.91	2.31	2.56
June.....	81	45	0	0	T.
July.....	80	47	0	T.	0
August.....	91	48	.04	0	.40
Summer.....	91	45	.04	T.	.40
September.....	104	44	.14	T.	0
October.....	93	38	.72	.83	.44
November.....	90	36	1.63	.49	1.88
Fall.....	104	36	2.49	1.32	2.32
Year.....	104	26	14.85	5.61	24.16

*Normal monthly and annual temperature and precipitation at Whittier and Santa Ana.*

Month.	Whittier.		Santa Ana.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January.....	56.7	2.54	54.3	2.31
February.....	58.5	2.13	57.2	2.46
March.....	61.1	2.07	59.3	2.49
April.....	65.4	.24	64.2	.32
May.....	68.6	.66	68.8	.37
June.....	73.2	.06	72.2	.05
July.....	77.4	.00	75.0	.00
August.....	76.9	.08	75.4	.06
September.....	74.3	.02	73.3	.07
October.....	67.7	.89	68.4	.74
November.....	63.5	1.22	61.8	.74
December.....	57.9	1.56	57.5	2.45
Year.....	66.8	12.07	65.6	12.06

Temperatures are more uniform in the Los Angeles area than in adjacent districts to the east and north, owing mainly to the moderating influence of the ocean. According to records covering a period of 34 years at Los Angeles, the mean annual temperature at that place is 60.3° F., with an absolute maximum of 109° and an absolute minimum of 28°. Temperatures usually are higher toward the eastern part of the area, and they are noticeably influenced by topography, wind movement, and exposure. The steeper foothills, alluvial-fan slopes, and situations where canyons emerge from the mountains have the most uniform and moderate temperature, while the lower, more level, and slightly depressed portions of the valley floor are subject to much more frequent and severe freezes, except near the ocean or where no land barriers occur along the ocean to intercept the free movement of moderating winds. Vegetables are grown during the winter months in all parts of the area, but citrus fruits and the more tender crops are grown commercially only on slopes and protected areas. Tomato vines bear fruit for two or more years on the best protected slopes, and sunflowers bloom every month in the year in all parts of the area.

The earliest killing frost in the fall recorded at Los Angeles occurred December 23, and the latest in the spring, January 27. This station is quite typical of the area as a whole, but it does not accurately represent the most frost-free district or those subject to the most severe freezes.

Wind movement is principally from the south and southwest. Winds rarely reach a high velocity, generally occurring as gentle to moderate breezes which increase in velocity eastward. These ocean breezes have a pronounced moderating influence both in winter and summer, and serve to make the climate uniform.

Some fog occurs at intervals during the winter, spring, and summer months. This also helps to regulate temperatures, and makes possible the growing of certain dry-farmed crops which require such climatic features for their best development. Fogs are most common at night, and usually break before midday. The humidity of the atmosphere is relatively high. It is highest along the ocean, and diminishes gradually inland.

#### AGRICULTURE.

Soon after the founding of Los Angeles in 1781 the first large land grants, such as the San Pedro, Los Metos, and San Rafael, were made by the Mexican Government, and these were followed by other grants of like nature. Stock raising soon became the chief industry and remained such for nearly half a century. The earliest Spanish settlers occupied land along the main streams which could be easily irrigated,

and grapes, peaches, figs, olives, apricots, pears, quinces, and some oranges were among the earliest crops. Agriculture made a slow growth previously to 1850, being mainly confined to the activities of the Mission Fathers and their converts. After 1850 a much more rapid development was made, and in 1876, according to the records of the county surveyor, there were about 64,500 acres under cultivation in Los Angeles County. Of this area, nearly 5,000 acres were in vineyards, about 400 acres in oranges, between 50 and 100 acres in limes and lemons, about 100 acres in walnuts, 50 acres in figs, a slightly smaller acreage in olives, and considerable areas in other deciduous fruits. Stock raising also developed rapidly during this period, and the number of sheep reached about one-half million in 1875, an increase of nearly 100 per cent over the previous decade. The only agricultural statistics available are for the entire county, but they quite accurately represent conditions covered by this survey, as the area surveyed occupies the greater part of the agricultural land of the county and has been the center of development.

Following the entry of the Southern Pacific and the Atchison, Topeka & Santa Fe Railroads into Los Angeles in 1874 and 1885, respectively, rapid settlement and agricultural development took place. According to the census, the average size of farms in Los Angeles County decreased from 337 acres to 95.7 acres in the 30-year period preceding 1910, and the number of farms increased from 1,941 to 7,919 in the same period. Property values increased 255 per cent during this period. The percentage of farms operated by tenants increased only from 23 per cent in 1880 to 24.9 per cent in 1910. The total population increased from 33,381 in 1880 to 504,131 in 1910, nearly 412,000 in this latter year being urban. Farm expenses also increased quite rapidly in the period mentioned, and the value of fertilizer used advanced from \$2,500 to \$669,152. In 1910 the value of all farm products amounted to more than \$17,000,000.

The extensive development of irrigation from underground water, the great increase in population, and the favorable climate and soils have combined to make possible the production of a wide range of crops, the most important of which can best be discussed in classes.

#### TRUCK CROPS.

There are nearly 15,000 acres devoted to truck crops in the Los Angeles area and in value of products trucking probably ranks first among the agricultural industries. The earliest truck crops are produced along the lower slopes of the east, south, and west sides of the San Pedro Hills, in the Inglewood district, and on the southwestern slope of Signal Hill near Long Beach. Other more extensive trucking areas are situated south, southwest, and southeast of Los Angeles, in the region of Gardena, east of Redondo, and west of Montebello. The

industry is almost entirely controlled by Japanese, who pay cash rent for the land, in the irrigated districts from \$20 to \$45 an acre per year, depending upon the location, quality of soil, and water supply. The dry-farmed trucking soils rent for \$5 to \$20 an acre per year.

Truck is produced on a wide range of soils, varying in texture from sand to clay adobe. The greater part is planted on three types of soil, the Oakley fine sand, Hanford fine sandy loam, and Ramona loam. Other types used to some extent are the Diablo clay adobe, Altamont clay adobe, Montezuma clay adobe, Chino silty clay loam and silt loam, and Hanford clay loam. The very favorable climate and water supply, the extensive areas of friable recent-alluvial soils, the favorable physical properties of the Ramona loam, and the high organic matter and lime content of the Montezuma clay adobe combine to make the region unusually well suited to the growing of truck crops. The large area of Altamont clay adobe used for trucking around the base of the San Pedro Hills produces good yields without irrigation, owing mainly to the favorable exposure and the high humidity of the atmosphere. The yields are not as large as those in irrigated districts, however, and on soils where water for irrigation is available two or more crops are possible each year.

Some commercial fertilizer and barnyard manure are used, but the prevailing short-term leasing system does not tend to encourage practices designed to build up the soil, and the tenants claim that they can not afford to purchase fertilizers that are not entirely available within two seasons. The cost of producing truck crops varies widely. It is much greater in the irrigated districts than in the dry-farmed districts, but the returns are proportionately greater.

*Lettuce.*—Lettuce probably ranks first in importance among the truck crops. About 1,200 carloads are shipped east and north each year. Two crops, one in summer and one in winter, are produced each year, each crop yielding between 300 and 500 crates per acre. During the short period between the crops, radishes, spinach, or some other quickly growing crop is often planted. The Summer, or Iceberg, lettuce, planted in April and harvested during July, August, and September, is consumed by the local market, while two winter varieties, the New York Wonderful and the Green are the principal ones shipped to outside markets. The greater part of the winter lettuce goes to the eastern market, where it is sold as Los Angeles lettuce and is very popular, bringing high prices. The lettuce of the Wonderful variety is shipped in October and November and also in April and May, while the Green variety is marketed from December to March 15, the later crop being more desirable and standing shipment better. The sections around Inglewood and Simons are the largest winter-lettuce districts, and the quality of the product ranks high.

*Tomatoes.*—Tomatoes are probably second in importance among the truck crops. About 500 or 600 carloads are sent to eastern and northern markets between September and December. The bulk of the crop is marketed in the fresh condition. Tomatoes are irrigated four or five times, at a cost of about \$10 an acre, and average from 500 to 700 30-pound boxes per acre. The price varies from 10 to 75 cents a box. During the summer it averages about 15 cents a box.

Of the early varieties grown Sparks Earliana is the most popular. It is planted from the hothouse, in the San Pedro region, as early as January, and matures about June 1, producing well until August 15. Most of the product is used locally. The Stone variety comes on the market between August 1 and Christmas. It is the most popular tomato and ships well.

*Cauliflower.*—From 700 to 800 cars of cauliflower are shipped to eastern markets each year, very little of this going beyond Chicago. Cauliflower averages from 600 to 700 dozen per acre. The early kind is planted in July and put on the market between September and Christmas, and the midseason crop, which represents about four-fifths of the total, is planted in September and reaches the market between December and March. The cost of production is about the same as for lettuce. Prices range from 20 to 60 cents a dozen.

*Cabbage.*—The quantity of cabbage shipped from southern California depends largely upon the condition of the crop in Texas and the cold-storage cabbage of the East. In a favorable year about 1,000 cars may be shipped east and north between October and June. Flat Dutch cabbage yields between 15 and 25 tons per acre. It is usually planted in August or September, and is harvested in the winter, yielding well until March. It is sold in considerable quantities to canneries. Early Winningstadt is generally considered the most popular and the best flavored variety. Yields of 6 to 15 tons per acre are obtained, and the product is practically all used in the fresh state. The price varies greatly.

*Cucumbers.*—About 40 acres on the southwestern slope of Signal Hill near Long Beach are devoted to the growing of cucumbers in forcing beds. The crop matures very early and brings exceptionally high prices. The plants are grown in cloth-covered beds and are irrigated one day each week with sprinklers. The crop is fertilized with manure and chemical fertilizers. Beds containing 2,500 square feet yield 7 to 30 shipping boxes at each picking. The cost of production is very high, and returns very largely depend on the ravages of pests and the competition of other producing regions. The first cucumbers are picked from April 10 to May 4. The Arlington and Klondike varieties are preferred. Cucumbers grown in this manner are in great demand in both local and eastern markets. The product must generally be disposed of before the large outside acreage comes

into bearing. Field-grown cucumbers are produced in large numbers and are disposed of locally and on outside markets. The crop is quite certain, and the acreage in cucumbers could well be considerably extended if means were provided for handling the increased production.

*Melons.*—There is only a small acreage in melons in the area. The experience of Japanese farmers indicates that this region is not well adapted to their culture. Early cantaloupes from Imperial Valley are considered to have a better flavor and texture and to contain more sugar than those produced locally, and experience seems to indicate that the cassaba, which is also a very popular melon in other portions of the State, deteriorates in quality when grown locally.

*Green corn.*—Green or table corn is planted more extensively each year, and Los Angeles furnishes a ready market for most of the production. There are about 3,000 acres in corn in the area, about 90 per cent being planted on Oakley fine sand in the region east of Redondo, while other types, such as the Ramona fine sandy loam and loam, Hanford fine sandy loam, the fine sandy phase of Tujunga sand, and the Altamont clay loam and clay adobe are used to some extent.

*Potatoes.*—Potatoes are grown to a limited extent, the crop being confined to the early-maturing varieties. These yield quite well. The crop is produced mainly on the Oakley fine sand and Hanford fine sandy loam (Pl. I, fig. 1), with scattered plantings on the Ramona loam, Tujunga sand, and several other types. Potatoes frequently are followed by some other crop the same season where ample water for irrigation is available.

*Strawberries.*—Strawberry growing is almost entirely confined to the Gardena district. There are about 2,000 acres devoted to strawberry culture in this locality. More than half this acreage is on the Montezuma clay adobe. Several other soils of light to medium texture are also used, such as the Ramona fine sandy loam and loam, and the Oakley fine sand, but the yields on the sand are usually light. The dark-colored adobe soils are usually preferred, as they produce good yields of large tart berries which sell readily. The cost of irrigation depends largely upon the nature of the soil, but averages from \$10 to \$15 an acre. Very little fertilizer is used by berry growers, and practically no attention is given to the maintenance of soil fertility, largely because of the prevailing short-term leases. No suitable local strains have been developed for propagating purposes and most of the plants are brought from Michigan, Arkansas, Illinois, and other eastern States. The first year they yield from 400 to 700 crates per acre and the second year from 200 to 500 crates, after which they usually become unprofitable and are plowed up. The producer receives 50 to 80 cents a crate. Large shipments are

made to the northern part of the State each year and most of the remainder is consumed locally. There are two periods of ripening, one from about April 1 to May 10 and the other between May 25 and June 15. A small part of the crop continues to mature until about the last of December. About 75 per cent of the commercial strawberries grown are of the Klondike and the remainder mostly of the Brandywine variety.

*Bramble berries.*—A considerable acreage is devoted to blackberries, Logan blackberries, and raspberries. Most of the crop is used for home consumption, and the yields, cost of production, and prices received are approximately the same as for strawberries.

*Miscellaneous vegetables.*—Large shipments of miscellaneous vegetables, chiefly carrots, turnips, beets, beans, and peas, are sent east and north each year. More than 30 carloads of string beans are shipped to San Francisco each year.

#### WALNUTS.

English walnuts have been grown in this area for the last 45 years, and some of the oldest trees are still bearing. The largest plantings are in the Whittier district, mainly on the lower slopes just below the citrus belt. The area contains about 6,000 acres in walnut groves. Walnuts are produced principally on soils of medium texture, more than 50 per cent being grown on the Hanford fine sandy loam, and about 40 per cent on the Yolo loam and clay loam. Minor plantings have been made on the Ramona clay loam and a few other types. The deep, friable, well-drained, medium-textured soils appear to be best adapted to this crop.

The irrigation necessary in walnut culture depends upon the soil, exposure, distribution of rain, atmospheric humidity, winds, and temperature. On the bottom lands, with light-textured soils, little or no irrigation is given, while the less favorable soils sometimes require three or four applications of water each year. Water is applied about April 1, the last of May, the last of July, and the middle of August. Three or four acre-inches are applied at each irrigation. Cover crops are grown to some extent, and where water is plentiful they give satisfactory results.

Walnuts average about 850 pounds per acre the tenth year. Yields range from 200 to 2,500 pounds. The nuts are harvested from October 1 to December 1, and more than 50 per cent are shipped to points east of the Mississippi River.

The Placentia Perfection constitutes about 75 per cent of the new plantings. This variety pays expenses about the sixth year, while seedlings require eight or nine years. The Placentia Perfection is more susceptible to frost than the Eureka, but it can be grown below

the safety line for orange culture. At present the Santa Barbara soft-shell variety represents over 90 per cent of the crop produced.

Walnut trees were formerly planted 40 to 45 feet apart, but recently 60 feet has been found to give better results. Other varieties of walnuts and peaches are grown as fillers, and hoed-crops are frequently interplanted until bearing begins, when the filler trees are removed and the annual crops abandoned, clean culture henceforth being the rule. Blight is the worst disease attacking the walnut, and very little progress has been made in checking it to date. The aphid also does some damage in unfavorable weather.

California produces about 47 per cent of all the English walnuts consumed in the United States, Los Angeles County producing over 5,000 tons a year. Imported walnuts are generally considered inferior to the California product in appearance, size, and quality. A large proportion of the foreign product does not average more than 65 per cent good edible nuts, while the better brands from California are guaranteed to be 90 per cent good.<sup>1</sup>

#### SUGAR BEETS.

About 15,000 acres were devoted to sugar beets in the Los Angeles area in 1916. Beets are planted extensively in the districts about 4 miles northeast of Long Beach, 7 miles northwest of Long Beach, southeast and northeast of Compton, and northeast of Watts. Many other plantings of minor importance are scattered over the area. The river flood-plain soils are in greatest demand for the crop. The Hanford fine sandy loam is the most extensively used soil for this crop, followed by the Chino silt loam. Many other soils, ranging from fine sandy loam to clay adobe in texture, are used to a small extent. Sugar beets are the principal crop in the alkali-affected portions of the area. They appear to do well in the presence of moderate concentration of salts, provided the soil is in good tilth and weather conditions are favorable during the period of germination and early growth of the plants.

About 80 per cent of the area in beets is irrigated. An application of water about the middle of May and another the last of June are considered sufficient. Yields average about 8½ tons per acre. In some cases as much as 20 tons per acre have been obtained. The average sugar content is about 19 per cent. Excellent results have been obtained with beets on the medium-heavy soils which have been drained and reclaimed from alkali. Light soils usually give a lower yield but a higher sugar content.

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<sup>1</sup> Valuable information on walnut culture will be found in Bul. No. 231, "Walnut Culture in California," issued by the Cal. State Agr. Expt. Sta. at Berkeley; also Bul. No. 254, "The Persian Walnut Industry in the U. S.," issued by the U. S. Dept. of Agriculture.

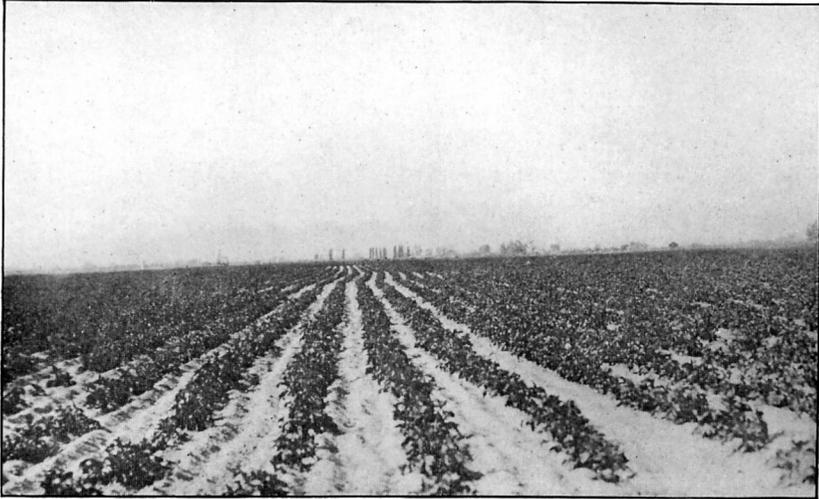


FIG. 1.—POTATOES IN SOILS OF THE HANFORD SERIES NEAR COMPTON.



FIG. 2.—ORANGE AND LEMON ORCHARDS ON ALLUVIAL FANS OF THE YOLO SERIES, NEAR WHITTIER.



The beets are thinned four or five weeks after planting, at a cost of about \$4 per acre, which with the hoeing, cultivation, and irrigation necessary makes the cost of production from \$30 to \$40 an acre. During the last two years the price paid for the crop has been \$4.50 a ton for beets containing 15 per cent sugar and 30 cents a ton additional for each unit increase in percentage. There is an ample number of factories for handling the beets grown. Nearly all are located several miles east of the area surveyed, in Orange County.

Beets are planted from the latter part of December until late in May, the time depending on the rainfall and condition of the land. In some years when the spring is foggy and cold, cutworms do considerable damage, sometimes necessitating one or two replantings. Very little rotation of crops has been practiced in sugar-beet districts in the past. In some instances beets have been grown in the same field continuously for 15 years. Recently beans, alfalfa, corn, potatoes, and other crops have been introduced into a system of rotation with good results. The best beet land is held at about \$500 an acre, a valuation based on its capacity for the production of other crops and upon other considerations rather than on its value for beet growing. Artificial drainage is quite commonly necessary on the soils devoted to beets. The cost of draining these beet lands varies from \$25 to \$50 an acre.

#### ORANGES.

There are over 4,000 acres of oranges in the area, principally on the foothills around Whittier. (Pl. I, fig. 2.) The soils used vary considerably in texture, ranging from the Hanford fine sandy loam to the Yolo loam and clay loam and the Ramona clay loam. Considerable plantings have been made on the upper flood plains of the Rio Hondo and the San Gabriel River, but situations with a moderate slope, thorough drainage, and relative freedom from frost are necessary for the greatest success. The irrigation required depends upon the soil, subsoil, temperature, winds, and the distribution and amount of rainfall. Five to eight irrigations are usually given each year, the furrow method is used, and the soil moistened to a depth of several feet. A miner's inch of water as used usually covers from 3 to 7 acres.

The best results are obtained where large quantities of organic matter, in the form of stable manure or green cover crops, are added to the soil. Large amounts of commercial fertilizers are used also. They are applied at different times of the year, and their most economic and efficient use for the different soils has not yet been ascertained. All kinds of mixtures are used, and the results with the same combinations vary greatly in different places. Orchards are plowed

once a year, and clean culture, to work up an effective surface mulch 4 to 6 inches deep, is usually practiced.

Yields depend on the care given the orchard, the age of the trees, the soils, fertilizers used, location, and water. Trees begin to bear about the fourth year and reach their maximum production between the 12th and 18th years. Records of the Citrus Protective League show an average yield per acre for a five-year period of 157.6 packed boxes. This is for a large acreage and is far below the average results where conditions are very favorable. The maintenance cost per acre ranges from \$50 to \$150 a year for bearing trees. Smudging, or heating, to prevent frost is practiced in many orchards, but this is very expensive and greatly increases the cost of production. The Navel and Valencia are the chief varieties of oranges grown. The former is harvested from December to May, inclusive, and the latter from May to August, inclusive.

#### LEMONS.

Lemon plantings are confined to the district around Whittier (Pl. I, fig. 2), and to a few small areas in the Hollywood and Glendale districts. They total about 2,000 acres. Lemons are generally grown in the same situations as oranges but, being more susceptible to frost, they are not planted so far out on the valley floor. The soils most commonly used are the medium to light textured types of the Hanford and Yolo series. Lesser plantings have been made on the Ramona loam and clay loam, the Altamont clay, and other soils.

Lemons usually demand more care than oranges, but the trees are generally thrifty and are heavy bearers. Orchard heating is necessary in most localities because of the long season of the crop, and pruning is done once a year. In other cultural requirements the crop is similar to oranges. The Eureka and Lisbon varieties are most largely grown. From 75 to 90 trees are planted to the acre. Statistics compiled by the Citrus Protective League show a maintenance cost up to the end of the fifth year of \$30 to \$100 an acre per year. After this period the cost is slightly more than for oranges. On account of the many and variable factors influencing the yield the returns vary considerably, but profits are generally greater than in the case of oranges, and land adapted to lemon culture brings a higher market price than that for any other fruit. Lemon growing is an industry of high specialization, and injury to an orchard by disease, insect pests, or through neglect results in heavy losses.

#### MISCELLANEOUS FRUITS.

Small plantings of grapes, peaches, pears, figs, plums, prunes, apricots, pomeloes, and apples have been made throughout the area. The fruit is either consumed fresh or dried. Grapes do moderately

well but are produced less extensively than in former years. The vineyards are usually set out on light-textured soils and receive little or no irrigation. Apples are planted principally on the low, moist, river flood-plain soils and are mainly of the summer varieties. The region is not well adapted to apple culture, and the apples grown are of rather poor quality. Near-by regions outside the area are better adapted to most of the deciduous fruits, and most of the supply for local consumption is shipped in.

#### GRAIN AND GRAIN HAY.

Although the area is thickly settled and intensively cropped there are about 84,000 acres in grain and grain hay. Barley is the principal crop, and most of it is cut before maturity and cured for hay. The hay and grain crops are grown on a wide range of soils, being seeded on almost every piece of land not producing some other crop. They are grown without fertilization or irrigation. In years of heavy and favorably distributed rainfall more of the crop is left to mature for grain, while in dry years most of it is cut for hay. Yields of hay vary greatly but average from 1 to 1½ tons per acre, while barley averages about 10 sacks per acre. Both hay and grain are consumed in the area, and do not supply local demands. Most of the seeding is done in December, January, and February. The lack of rotation or summer fallowing accounts in part for the low yields. Grain and grain hay are grown until the the soil is used for some other purpose, or because of lack of irrigation water for more intensive crops, and they usually are not considered profitable crops in themselves under present land values.

#### ALFALFA.

Alfalfa is increasing in importance each year. About 6,000 acres are devoted to this crop at present. It is grown in small areas wherever irrigation is possible, but principally on the recent-alluvial soils south, southeast, and southwest of Los Angeles. It is well adapted to a wide range of soils, but where grown on sand with light porous subsoils, on heavy old-alluvial deposits with compact, poorly aerated subsoils, or wherever alkali is present, or the water table is within 4 feet of the surface, the yields are irregular and the stands short lived. Five to seven cuttings are obtained each year, and yields of ¾ to 1½ tons per acre are obtained at each cutting. The first crop is produced without irrigation, but one application of water is usually given each succeeding crop. Nearly all the water used for irrigation is pumped from underground sources. The alfalfa produced is fed within the area.

## BEANS.

The production of beans has increased rapidly in recent years, and at the present time about 15,000 acres are devoted to this crop. The largest plantings are on a strip of land a few miles east of Playa del Rey, extending south to the San Pedro Hills. Other large plantings occur east of Santa Monica, north of Long Beach, and in the San Pedro Hills. Beans are planted on a wide range of soils, but the bulk of the crop is grown on the fine sandy loam, loam, and clay loam of the Ramona series, the Diablo clay adobe, the Dublin clay adobe, the Montezuma clay adobe, the Oakley fine sand, and the Yolo loam. Lima beans are grown most extensively, but black-eye beans are also successfully produced. Both varieties receive little or no irrigation. Very little fertilizer is used, and continuous cropping for many years on the heavier types does not appear to decrease yields. Alternate cropping with grain is the practice on the Oakley fine sand and the lightest textured portions of the Ramona fine sandy loam, and yields of 5 to 8 sacks per acre are obtained under such conditions. Yields on the heavier textured types are larger, ranging from 10 to 20 sacks of 80 pounds each per acre. Most of the beans produced are sold in eastern markets. The price received is ordinarily 4 to 5 cents a pound. Beans are planted between April 1 and May 15, depending upon weather conditions, and are harvested about four months later. As yet there has not been any heavy loss from diseases. Wireworms are the most serious insect pest.

## FLOWER SEEDS.

The area is particularly well adapted to the production of nearly all kinds of seeds. At the time of this survey there were 358 acres devoted to the growing of sweet-pea seed. This was on one soil type, the Montezuma clay adobe. In years where late spring rains occur no irrigation is needed; in other years one application of water between April 1 and May 15 is sufficient. Seeding is done in December and flowering begins about the last of May and continues for a month. In years when the aphid is not a serious factor, yields of seed from the Grandiflora variety average 1,200 pounds per acre. The New Spencer, a locally developed variety, does not yield heavily, averaging 200 pounds per acre. Over 50 per cent of the seed produced is sent to Europe, England receiving the greater part. The remainder is sold to wholesale seed dealers in all parts of the United States. A considerable acreage is planted to asters and zinnias for seed production.

## CUT FLOWERS.

The city of Los Angeles and its many suburban towns offer a good market for cut flowers. Carnations and violets are raised in large

quantities. Carnations are on the market during the greater part of the year, while other flowers are marketed in season. The greater part of the flowers are raised by Japanese, who lease the land. Carnations are grown in small beds, which are irrigated about once a week. During the holiday season carnations sell for about \$2 a hundred. At the time of heaviest blooming the price ranges from 5 cents to 10 cents a dozen. An average price of 25 cents a hundred is said to be needed to insure a profit. Violets are produced mainly in open fields. They are sold in bunches containing about 50 flowers and bring from 25 cents to \$1.25 per dozen bunches. Marigolds, sweet peas, roses of all varieties, California poppies, and several other varieties of flowers are produced in large quantities to reach the market in season.

#### DAIRYING.

Dairying has increased rapidly in recent years, but its development has scarcely kept pace with the increased consumption of milk, butter, and cheese due to the rapid increase in population. There are many large, well-stocked dairies in the area. They find a ready sale for their products in the local markets. Most of the milk produced is sold to the city trade as fresh milk or cream, while most of the butter and cheese consumed in the area are obtained from outside sources. On the dairy farms each cow is fed about 50 pounds of green alfalfa per day besides other feeds such as oat hay, beet pulp, and cottonseed meal. There are over 6,000 acres of alfalfa in the area, but the alfalfa produced does not supply the demand for cow feed. Dairying is not confined to any particular soil type or location, but is carried on wherever soil, water, feed, and shipping facilities are favorable.

#### POULTRY.

The large population of the Los Angeles area insures a ready market for all the eggs produced. The local production is not nearly equal to the consumption, but it is gradually increasing. Gardena is the largest center of production. Other important centers are located at various advantageous points throughout the area. About half the eggs produced are supplied by farmers who do not make a specialty of poultry raising. Fowls of the White Leghorn breed represent about 90 per cent of the egg-producing stock and of the Rhode Island Red breed most of the remainder. Very little attention is given to the raising of meat-producing chickens, and the two breeds mentioned above are used as meat fowls. Very few turkeys or ducks are raised in the area.

## SOILS.

The Los Angeles area is situated in the coast region of southern California. It occupies part of a structural valley and coastal plain lying south of the Santa Monica Mountains and the San Rafael and Puente Hills. This valley has received extensive alluvial deposits from the San Gabriel and San Bernardino Mountains to the north and east, respectively, with minor quantities from the Santa Monica Mountains and from the Puente, San Rafael, and San Pedro Hills occurring partly or wholly within the area surveyed. The deposits are many hundreds of feet deep in most places, and during their accumulation changes in elevation of the region have had an important bearing upon the position of the material laid down. The material is very young geologically, and erosion has only partially furrowed and altered the more elevated and marginal portions. Most of the streams are rapidly building up that portion of the area they traverse with fresh accumulations of light-textured material. The sediments have been spread broadly by the larger streams, and most of the region surveyed has the appearance of an extensive, nearly level waterlaid plain, with elevated mesalike or hilly remnants of older, unconsolidated deposits occurring at intervals over the surface and around the valley margin. The minor streams have deposited their sediment in a series of moderately to steeply sloping, coalescing alluvial fans, which are building outward from the hilly and mountainous elevations where the streams emerge, and with other recent deposits are slowly covering the older unconsolidated deposits. Most of the soil material has been moved a greater distance than that in the San Fernando, Pasadena, and Riverside areas, and it has undergone more complete assorting and contains a much greater proportion of fine-textured material.

Following the classification used in other soil surveys in the State, the soils of the Los Angeles area may be classed into five groups, as follows: Residual soils, old valley-filling and coastal-plain soils, recent alluvial-fan and flood-plain soils, wind-laid soils, and miscellaneous material. The last group includes Rough broken land, Tidal marsh, Coastal beach and Dunesand, and Riverwash.

The recent-alluvial soils are most extensive, covering more than half the total area mapped. The old valley-filling soils are next in extent, with the residual and wind-laid soils following, in the order named. Of the miscellaneous material, the Rough broken land is most extensive. The other three types together form only a few square miles.

The groups named are characterized by essential differences in character of soil and subsoil material, topographic position, age, chemical properties, and mode of formation. They are subdivided

into groups called soil series, each of which includes soils having certain common characteristics, such as color, character of subsoil, origin, and other features, distinguishing it from other series in the same province. The types, or members of the series, are separated on the basis of texture, or the relative amount of sand, silt, and clay present.

#### RESIDUAL SOILS.

The residual soils have been formed by the weathering in place of consolidated rocks, and usually occur in hilly and mountainous positions. They are typically well drained. These soils vary greatly in depth, but the parent rock is usually encountered at less than 6 feet. The residual soils are frequently associated with Rough broken land. They contain varying amounts of rock outcrop, and are eroded or deeply furrowed in most places. The underlying rocks vary greatly in composition, origin, and topographic position. They are sedimentary, igneous, or metamorphic in character. Those of sedimentary origin are principally calcareous shales and sandstones, with lesser amounts of conglomerate. They give rise to the soils of the San Pedro and Puente Hills and supply most of the soil material on the hills from Los Angeles eastward to the entrance of the Rio Hondo into the area. Smaller developments of these rocks also occur at intervals westward from Los Angeles to the ocean. Two fairly extensive series of soils, the Altamont and the Diablo, have been derived from sedimentary rocks in the Los Angeles area.

The soils of the Altamont series are residual from associated or interbedded shales, sandstones, and similar sedimentary rocks. They range in color from light to dark brown, and include some slightly reddish brown phases. The subsoils are usually lighter in color, ranging from light brown or yellowish brown to reddish brown. Bedrock generally occurs at depths of less than 6 feet. The subsoils are often heavier in texture and more compact than the surface soils, but these features are not so marked in the heavier textured types. Lime is apparent in the lower subsoil in places. The Altamont soils occupy slopes and rolling, hilly, or mountainous areas. (Pl. II, fig. 1). They are most shallow and eroded on the steepest slopes, where small areas of rock outcrop may occur. The soils are well drained, but when tilled they are retentive of moisture. The Altamont series differs from the Diablo series in color and in its lower content of lime and organic matter. The soils in their virgin state support little tree or brush growth.

The Diablo series is residual from shales, sandstones, impure limestones, and similar rocks, being usually identified with more calcareous formations than is the Altamont series. The soils are typically dark gray to black, but have a dark brownish gray color

in places. They are usually high in organic matter. In most areas the subsoil is lighter in color, being of various shades of gray or brown, but the dark surface color continues to bedrock in places. Ordinarily the subsoil is heavier and more compact than the surface soil, especially in the lighter textured types. Bedrock is encountered at depths of less than 6 feet. It is nearest the surface on the steepest slopes. Noticeable concentrations of lime are present in the lower subsoil. With good tillage, the Diablo soils are very retentive of moisture. They occupy slopes and rolling or hilly areas, and in their virgin state support few trees or bushes.

Granitic and schistose-igneous rocks are less extensive than sedimentary formations, but they are quite prominently developed in the hills north and northeast of Los Angeles and westward in the Santa Monica Mountains to the Pacific Ocean. They break down quite uniformly but erode rapidly, giving the areas in which they occur such a rough, dissected surface that only a very small proportion can be considered agricultural land. In the areas smooth enough to be mapped the soils are classed in the Holland series.

The Holland soils are typically brown in color, but range to grayish brown and reddish brown in places. They are micaceous and friable, with light-brown, reddish-brown, or yellowish-brown subsoils. The subsoil is, in many places, similar to the surface soil in texture and structure, but may be heavier, more compact, and less permeable. Partially weathered or firm bedrock usually is encountered at a depth of less than 6 feet. The soil appears to be low in organic matter. It is not difficult to till except where steep and hilly. The topography is rolling, hilly, or mountainous, but the surface is generally smooth. Run-off is excessive on the steeper, shallower, and more broken areas.

#### OLD VALLEY-FILLING AND COASTAL-PLAIN SOILS.

Soils derived from old valley-filling or coastal-plain deposits are extensively developed in the Los Angeles area. They consist of elevated, unconsolidated, water-laid deposits which have undergone marked changes in soil and subsoil features since they were laid down, and in many places their geological origin is not clear. They vary widely in color and mineral composition. Their heavy, compact subsoils and substrata are among the most important features which serve to distinguish them from soils of the other provinces. Some of the series in this group are marked by calcareous subsoils, others by gravelly substrata, and some by the presence of an indurated hardpan. They vary greatly in topography, but usually occupy sloping, rolling, hilly, or terraced positions representing older valley or coastal-plain surfaces that have been elevated or partially removed by erosion since the soils were deposited. They are found below the

residual soils and above the recent-alluvial soils and differ from the latter in that they are undergoing active erosion or are slowly being covered by more recent deposits. Their less well-aerated and permeable subsoils often make them less desirable for tree fruits. The soils of this group along the ocean are characterized by their terraced position and frequently by an escarpment of 20 to 100 feet or more along the water front; they appear to have been materially influenced by conditions of marine deposition at an early stage of their development. The terraces occur singly or as series one above the other, with indistinct outlines, possibly the result of erosion.

Four soil series, the Ramona, Pleasanton, Madera, and Montezuma, are recognized in this soil province, with minor included developments of the San Joaquin and Antioch series, which are considered too small in extent to map separately.

The Ramona series is derived from old unconsolidated water-laid deposits which have been considerably altered since deposition by weathering, leaching, and erosion. The parent material is derived mainly and typically from granitic rocks, but small amounts of material from other sources are present in the Los Angeles area. The soils are brown in color, with slightly reddish-brown and grayish-brown variations. They frequently contain a small amount of mica and are underlain at a depth of 10 to 24 inches by heavier and much more compact, brown, reddish-brown, light-brown, or red subsoils. Locally, and in the gravelly types, a distinct subsoil is not present, but a compact structure is a general feature of the underlying material to a depth of many feet. The surface in most places is uneven, being slightly rolling or gently to moderately sloping. Many deeply entrenched drainage ways occur in the higher situations, and a smooth, uniform surface prevails in places on the lower valleyward extensions. Locally there may be a tendency toward a "hog-wallow" surface. Drainage is good except in depressions and flat areas with heavy subsoils.

The Pleasanton series consists of weathered and otherwise altered old unconsolidated water-laid deposits derived from a variety of rocks in which sedimentary formations are prominent. In this area, however, dark-colored schists are apparently responsible for much of the material forming this series, as is indicated by the included gravel fragments. The soils are brown or grayish brown in the lighter textured types and brown to dark brown in the heavier members. A slightly reddish variation is developed in places. The subsoils usually are light shades of brown. They are compact and heavier textured than the surface soil. The subsoil rests upon a gravelly substratum composed of rounded or flattened quartzose or schistose gravel with finer textured interstitial materials. Varying

amounts of gravel are present in the soil and subsoil in places. The series occupies fragmentary remnants of old alluvial deposits, usually occupying a position between areas of residual and recent-alluvial soils. The topography is undulating, rolling, or hilly, but the surface is smooth except where erosion has been unusually active. (Pl. II, fig. 1 and fig. 2.) The Pleasanton soils are well drained, but become wet and miry during the rainy season, owing to their heavy subsoils. They differ from the related Ramona soils in origin, color, and substratum features.

The Madera series consists of weathered and variously modified old unconsolidated water-laid deposits derived from a wide range of rocks. The soils are typically brown in color, the lighter textured members often being light brown or grayish brown and the heavier members reddish brown or dark brown. The subsoils also are brown, reddish brown, or red, and are heavier textured and more compact than the surface soil. At depths of less than 6 feet they rest upon a brown, reddish-brown, red, or mottled brown and gray, iron-cemented hardpan, containing seams or crusts of calcareous material. The substratum below the hardpan is permeable except locally, where it consists of soft sandstone over which the soil-forming material has been deposited. The Madera soils are rather low in organic matter. They do not contain concentrations of lime except occasionally in the lower subsoil and hardpan. The soils usually have a somewhat "hog-wallow" surface. They occupy old alluvial fans and valley slopes, and occur less frequently as interrupted or isolated remnants of old, elevated, water-laid deposits. A reddish-brown loam occurring in three bodies in Eagle Rock Valley and on the west side of Verdugo Canyon is included with the Madera series as mapped. If more extensive it would have been mapped with the San Joaquin series.

The soils of the Montezuma series are derived from old water-laid deposits considerably altered by weathering and erosion since their deposition. They are derived from a wide range of rocks, in which those of sedimentary origin are most conspicuous. The surface soils are typically dark gray to black in color, but often assume a dark brownish gray cast in the field. The subsoil to a depth of 6 feet is grayish brown, yellowish brown, or gray. It contains lime concentrations which vary greatly in abundance and depth in different places. It usually is heavier textured and more compact than the surface soil, but is permeable to roots and water. The soils are high in organic matter, and with good tillage are retentive of moisture. The topography is gently sloping, undulating, or rolling, with a smooth to slightly uneven surface and few gullies. Drainage usually is good, and there is some run-off on the steeper areas. The series differs from the dark-colored series of recent-alluvial origin in having better de-

veloped drainage and in the presence of lime concentration in the subsoil, which is also more compact in structure. It differs from the Diablo series of residual origin in that the latter is derived from consolidated material. Few trees and little brush occur on the Montezuma soils in the virgin state.

#### RECENT-ALLUVIAL SOILS.

The soils of recent-alluvial origin are still in process of accumulation. They cover more than half of the total area surveyed, and include the lightest colored and lightest textured soils. They have a smooth, uniform surface and permeable subsoils, in contrast to the higher and more uneven surfaced old valley-filling soils with their heavy, compact, and poorly aerated subsoils.

The recent-alluvial soils occupy a broad alluvial plain southeast and south of Los Angeles, and occur also on a series of rather small, moderately to steeply sloping alluvial fans along the base of the hills and mountains in the northern portion of the area and around portions of the San Pedro Hills in its southern part. Other minor developments extend southwest of Los Angeles to the ocean at Venice and form part of the valley floor in the region of Gardena. The soils have a wide range in color and mineral composition and are derived from a variety of rocks, chief among which in this area are granites, schists, shales, and sandstones.

These are the most intensively developed soils of the area, and they have a higher average value than any other group. Underground water for irrigation is readily available by pumping over most of their extent where they occur on the valley floor or along stream bottoms, but owing to the position and elevation of the more steeply sloping alluvial fans these areas have only a very scant water supply, which must be increased from outside sources if fruit and truck crops are to be grown under the most intensive management. A high water table exists in much of the lower plains portion, and injurious amounts of alkali have accumulated locally.

Five soil series are recognized in this province. The soils derived from deposits coming from granites and similar rocks are included in the Hanford, Tujunga, and Chino series, and those formed of materials washed from sedimentary rocks in the Yolo and Dublin series.

The Hanford series consists of recent-alluvial deposits derived predominantly from areas of granitic and schistose rock. The soils are typically brown, with variations of grayish brown and buff, the lighter shades predominating. The soils are micaceous, and usually friable. The material may extend to 6 feet or more without change in subsoil, or may be underlain by interbedded or alternating strata

of varied character. The subsoil may be similar to the surface soil in color, but it is usually a lighter shade of brown. The soils are moderate to low in organic matter. They occur on alluvial fans, on low recently-built stream terraces, and in stream deltas and bottoms. The fans along the valley margins are gently to moderately sloping, and the other lower positions on the valley plain have the relatively flat gradient of the adjacent or parent streams. Drainage is good except locally in stream bottoms, where overflows or a high water table affect the conditions. These soils are differentiated from the Tujunga mainly on a basis of color.

The Tujunga series comprises recent water-laid material, which is mainly derived from granitic rocks, and is still in process of accumulation. The soils are gray in color, with a brownish cast in many places, and are micaceous. The organic content is low, but the soils are friable and easily tilled. The subsoils generally resemble the surface soils in color and texture, but may contain strata of different textures. Areas situated on alluvial fans usually are more uniform in cross section than those in the lower lying stream bottoms, and are also better drained. The Tujunga soils occupy sloping alluvial fans and river bottoms, and have a smooth surface, except locally, where stream erosion or deposition has been active. The soils resemble those of the Hanford series, except in color.

The Chino soils consist of recent alluvial deposits, derived principally from granitic and schistose igneous rocks, which show an accumulation of lime in the subsoil. The surface soils are dark gray to black in color, with variations of dark brownish gray and occasionally very dark grayish brown. They are micaceous, friable, high in organic matter, and easily tilled. The subsoil below 18 inches is dark gray, gray, or grayish brown. It is micaceous and contains calcareous concentrations. In texture it is similar to or slightly heavier than the surface soil, with a tendency toward mottling and stratification. The substratum resembles the subsoil except that it may be somewhat mottled in color and contain less lime. The Chino soils have a smooth surface. They occupy nearly level or flat to slightly depressed positions in stream bottoms or minor basinlike areas. Drainage is restricted, and a high water table with local accumulations of alkali frequently occurs.

The Yolo soils consist of recent-alluvial deposits typically washed from upland regions of sedimentary rocks, though in this area the deposits are more complex in origin. The surface soils are brown in color, with variations of grayish brown, light brown, or dark brown. The subsoil is lighter colored than the soil, ranging from yellowish brown or light brown to grayish brown. They are either similar to the surface soil in texture or may consist of strata of different textures. The Yolo soils are friable and contain moderate supplies of

organic matter. They occupy alluvial fans, stream bottoms, or recent low terraces of gentle slope and have either smooth or slightly uneven surfaces, the latter due to local erosion or deposition. Drainage usually is good. The areas on the valley plains support few or no trees or bushes, but such growth is common along stream bottoms.

The soils of the Dublin series consist of recent-alluvial deposits which typically are derived from upland areas occupied by sedimentary rocks, but in this survey included material from older unconsolidated deposits is conspicuous. The soils are dark gray to black, with a slightly brownish cast in places. The subsoils are lighter in color than the soils, ranging from gray to grayish brown or brown. They are similar to the surface soils in texture or may consist of sediments of varying texture. The soils are high in organic matter. They are well drained except in the lower and flatter areas, where water frequently collects in the winter months. The soils are differentiated from the related Yolo series on a basis of color and organic-matter content. In their native state few trees or bushes occur on these soils except in stream bottoms.

#### WIND-LAID SOILS.

The soils of wind-laid origin are quite extensively developed in the region from Playa del Rey to the San Pedro Hills and southeastward nearly to Wilmington. They have a ridged, undulating, or hilly topography and in this area have been formed almost entirely by material drifted inland from the sandy ocean beaches. The soils are quite uniform, but usually become somewhat finer in texture with increased distance from the ocean. Drainage is good to excessive. The soils are classed in the Oakley series.

The soils of the Oakley series are brown, with variations to grayish brown and light brown or buff. The soil and subsoil do not differ essentially in texture within the depth of 6 feet, but the lower part of the section is frequently lighter brown in color. The soils in most places contain considerable fine material, giving them a somewhat loamy feel. They are low in organic-matter content, but are quite retentive of moisture. The material is easily tilled. It drifts considerably in exposed places. The surface is undulating or rolling to hilly, and in places dunelike. Drainage is good, and the rainfall is nearly all absorbed. Some grass and small scrubby brush constitute the native vegetation.

#### MISCELLANEOUS MATERIAL.

The group classed as Miscellaneous material includes variable soils which under existing conditions are mainly nonagricultural. Four types are mapped, viz, Rough broken land, Riverwash, Coastal beach

and Dunesand, and Tidal marsh. The material in each of these divisions varies greatly.

*Areas of different soils.*

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Ramona loam.....	63,360	17.6	Coastal beach and Dunesand....	4,864	1.4
Hanford fine sandy loam.....	57,216	15.9	Altamont clay adobe.....	4,224	1.2
Rough broken land.....	36,992	10.3	Ramona sandy loam.....	4,224	1.2
Oakley fine sand.....	19,264	5.3	Yolo clay loam.....	3,840	1.1
Yolo loam.....	18,624	5.2	Tujunga sand.....	2,688	.7
Chino silt loam.....	16,832	4.7	Dublin clay adobe.....	2,624	.7
Light phase.....	256		Riverwash.....	2,624	.7
Ramona fine sandy loam.....	15,360	4.3	Holland sandy loam.....	1,728	.6
Montezuma clay adobe.....	15,040	4.2	Coarse phase.....	256	
Ramona clay loam.....	13,056	3.6	Dublin clay.....	1,664	.5
Altamont clay loam.....	11,520	3.2	Tidal marsh.....	1,536	.4
Pleasanton loam.....	11,200	3.1	Hanford clay loam.....	1,216	.3
Diablo clay adobe.....	9,536	2.6	Yolo sandy loam.....	384	.3
Tujunga fine sand.....	7,040	1.9	Heavy phase.....	704	
Hanford sandy loam.....	3,904	1.9	Madera fine sandy loam.....	1,024	.3
Coarse phase.....	3,072		Altamont clay.....	512	.1
Hanford loam.....	6,720	1.9	Tujunga fine sandy loam.....	384	.1
Chino clay loam.....	5,824	1.6	Holland loam.....	384	.1
Altamont loam.....	5,632	1.6			
Hanford sand.....	4,992	1.4	<b>Total.....</b>	<b>360,320</b>	<b>.....</b>

DESCRIPTION OF SOIL TYPES.

ALTAMONT LOAM.

The Altamont loam to a depth of 8 to 12 inches consists of a light-brown to dark-brown loam, usually free from gravel but sometimes carrying small quantities of shale fragments. In places the color ranges to slightly reddish brown, but such areas are usually too small and irregular in occurrence to warrant separate mapping. The soil is somewhat variable in texture, being lighter in the steeper and more elevated situations and heavier on the lower and more gentle slopes. Some of the included material is of rather light fine sandy loam texture. The color is somewhat darker and the organic-matter content higher as the texture becomes heavier. The subsoil consists of a brown or reddish-brown loam, heavy loam, or clay loam, becoming lighter in color and coarser in texture with depth, until bedrock is encountered. The heavier textured portions of the subsoil are compact and hard when dry and frequently crack upon exposure. The subsoil is permeable to roots and water, however, and aids in the retention of moisture under normal conditions. At a depth of 1 to 5 feet the subsoil gradually merges into the partially weathered underlying shales and sandstones from which the type has been de-

rived. Small concentrations of lime often occur in the subsoil, as well as partially disintegrated shale. This in places influences the surface color, but to a much less extent than in similar types of the Diablo series of like origin. The soil has a small to moderate content of organic matter, and is tilled without difficulty where the surface is not too irregular.

The most important bodies of Altamont loam occur in the northern part of the area, on a number of small rolling hills similar to those occupied by the Altamont clay loam. Most of the hills are one to two hundred feet higher than the surrounding plains and have a smooth, rounded surface, giving good surface and subsurface drainage. The presence of soft sandstone interbedded in the underlying shales is the cause of the lighter textured variations of the type.

This soil is of small extent, and its agricultural use is decreasing, owing to its desirability for home sites. Grain is the principal crop grown. Good yields are obtained where the soil is not too shallow. Some truck crops are successfully grown on the deeper areas without irrigation. Land values are high in most places, being based on the use of the land for building sites rather than upon returns from crops.

#### ALTAMONT CLAY LOAM.

The Altamont clay loam to a depth of 12 to 18 inches is a brown, light-brown, or dark-brown clay loam, and the subsoil a light-brown or reddish-brown loam, clay loam, or clay, its texture depending upon the amount of sandstone bedded in the underlying shales. At variable depths the subsoil rests upon the parent rocks, which are greatly distorted and upturned. The shale is soft, and few rock outcrops or rock fragments exist in the soil or subsoil. Seams and small concentrations of lime occur in the subsoil locally, but their influence has not been sufficient materially to affect the color of the soil. The type is deeper on gentle slopes and in ravines of low gradient. In the steeper situations and on hilltops it is often shallow and droughty. The soil is friable. It contains a moderate amount of organic matter, and is retentive of moisture where 4 feet or more deep. There is a slight tendency toward an adobe structure where the soil is deep and where the type grades into soils of the closely related Diablo series.

Several small to fair-sized bodies of Altamont clay loam adobe are included with the Altamont clay loam as mapped. One of these is situated about 1 mile north of Evergreen Cemetery, one about  $1\frac{1}{4}$  miles west of Silver Lake Reservoir, and several in the vicinity of Echo Park. All the tillable soil in the hills north of Whittier mapped with the Altamont clay loam is of this adobe variation. All the areas except those in the Whittier region are in the city of Los Angeles and are used for home sites. In color and character of soil,

subsoil, and bedrock this variation is similar to the typical Altamont clay loam. The soil cracks considerably when dry and uncultivated, but forms a friable, moist seed bed when tilled. It is capable of giving good yields without irrigation in years of normal rainfall. It absorbs moisture more readily than the clay loam, largely on account of its structure. North of Whittier it is used in the production of lemons, with some avocados and truck crops, in addition to the crops grown on the typical Altamont clay loam. Water for irrigation, which is necessary in growing fruits, has been supplied at a great cost.

The Altamont clay loam forms a number of small areas in the northern part of the area surveyed. It occupies hilly land, seldom too steep or broken for tillage. The hills are rounded and have a smooth, uniform surface of sufficient slope to give good drainage. The upturned shales consist of thin layers of varying hardness which weather irregularly but permit of fairly deep root penetration.

Owing to the small extent of the type, the scarcity of water for irrigation, and occupation of the areas for home sites, this soil is of little agricultural importance. Dry-farmed grain and grain hay are the principal crops grown, of which good yields are obtained in years of normal rainfall. The soil is tilled without difficulty when in the proper moisture condition. Areas favorably located and retentive of moisture are devoted to truck crops without irrigation, good yields being obtained. Land values are high, being based upon the use of the land for building purposes.

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

*Mechanical analyses of Altamont clay loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574103.....	Soil.....	0.0	0.1	0.2	6.0	22.2	43.5	27.9
574104.....	Subsoil.....	.4	.8	1.2	15.2	20.0	44.8	17.5

ALTAMONT CLAY.

The Altamont clay consists of a brown or dark-brown, heavy clay with minor inclusions of dark grayish brown material closely resembling the related darker colored soils of the Diablo series. The soil in places has a tendency to crack and assume an adobe structure when dry. It is usually free from gravel, but occasionally contains small quantities of coarse sand. When dry it is hard and compact, and when moist it is plastic and sticky. The soil contains a moderate quantity of organic matter, the proportion increasing with the depth of soil. At 12 to 24 inches the material grades into a clay loam or

clay subsoil of light-brown, yellowish-brown, brown, or grayish-brown color. The subsoil contains varying amounts of lime, which is frequently concentrated giving the material a mottled gray and brown appearance. At any depth from 24 to 60 inches the subsoil gradually passes into a soft shale with included strata of sandstone. The lower subsoil and the upper part of the shale are usually of lighter texture than the upper subsoil, owing largely to its partially disintegrated condition. The shale weathers uniformly, and there are no rock outcrops. The soil mass is deeper on gentle slopes, where the bedrock lies in places more than 6 feet below the surface, while on the steeper slopes rock is sometimes encountered at depths of less than 1 foot. The soil absorbs moisture less freely than the types of well-developed adobe structure, and part of the rainfall is lost as run-off. The Altamont clay is of small extent. It occurs northeast of Boyle Heights, as an extension of a larger development in the Pasadena area. It has an uneven, rolling, or hilly topography and is cut by a number of ravines serving as drainage ways during wet weather. In detail the surface usually is smooth. Most of the type lies at an elevation of 100 feet or more above the valley floor and rests upon highly tilted shales. The drainage is good.

The Altamont clay is of minor agricultural importance. It is used mainly for the growing of dry-farmed grain and grain hay, which give small to moderate yields. The soil is tilled with difficulty unless handled under proper moisture conditions, but then forms a fair seed bed, capable of maturing certain crops in the more favorable situations without irrigation.

Where not devoted to crops it is used as pasture land. The type in most places is desirable for home sites on account of its elevation. It lies near the city of Los Angeles and is supplied with good roads and shipping points. Land values usually are much higher than crop returns warrant. The type requires irrigation for most of the highly specialized crops, but the lift necessary in pumping makes this very costly.

#### ALTAMONT CLAY ADOBE.

The Altamont clay adobe consists of a brown to dark-brown, heavy, plastic clay, 10 to 18 inches deep of pronounced adobe structure. The subsoil, which is lighter than the surface soil, ranges from light brown to reddish brown in color and from loam to clay in texture. The parent shale is encountered at an average depth of 3 feet, though on the more gentle slopes and ridges it may lie below 6 feet. In places the subsoil is quite compact, and here and there seams of limy material occur. Locally small angular fragments of chert and shale are mixed with the soil and subsoil, but the stone content is not

sufficient to interfere with tillage, except in areas of very shallow soil or where the rocks outcrop.

The type in general is quite uniform, but near areas of Diablo clay adobe it becomes darker in color and contains more lime and organic matter. The soil is sticky when wet and must not be plowed in this condition or when dry, as it either puddles badly or forms a very cloddy surface.

Several large areas of the Altamont clay adobe lie on the slopes and eastern crest of the San Pedro Hills. The surface is uneven and hilly, and in part too steep for tillage. Much of the type occurs on marine terraces, and in such places varying amounts of alluvial wash have been contributed from the intervening slopes, giving rise to considerable variation. Erosion is now taking place over much of the type, but the surface is smooth except where traversed by ravines. The land is well drained. This soil absorbs water slowly, but the numerous surface cracks and the usually gentle character of the rainfall enable the subsoil to become quite well saturated during the rainy season.

Most of the Altamont clay adobe is under cultivation. It is used principally for the production of grain and lima beans. Some of the deeper areas are used successfully for growing truck crops. Alfalfa and tree fruits are not grown on account of the lack of water for irrigation. Truck crops, which mature before the soil dries out, can be grown without irrigation. Good yields of peas, beans, tomatoes, and sweet corn are obtained. The soil is well adapted to dry-farmed grain. The steeper land supports a good growth of grass and is used for pasture.

This soil is owned in large tracts, and most of it is rather unfavorably located with reference to shipping points. Owing to these factors and to the water supply, which restrict the range of crops, the type is sparsely settled.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Altamont clay adobe:

*Mechanical analyses of Altamont clay adobe.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574107.....	Soil.....	0.1	0.4	0.4	3.9	13.3	42.8	38.9
574108.....	Subsoil.....	.0	.8	1.4	15.0	17.2	46.8	18.7

DIABLO CLAY ADOBE.

The Diablo clay adobe to a depth of 10 to 36 inches consists of a dark-gray to black, heavy clay showing a pronounced adobe structure. The cracks in this soil when dry are numerous and deep, often extend-

ing several feet below the surface. The soil is sticky when wet and baked and hard when dry. The subsoil is a light-brown to dark-brown clay containing mottlings, seams, or nodules of calcareous material and resting upon partially weathered shale at variable depths below 1 foot. The area on the summit of the San Pedro Hills is the most uniform, and the soil and subsoil in places exceed 6 feet in depth.

Locally the shale is hard, and in such places the soil may contain small quantities of grit and larger fragments of the rock. In many places the soil has a noticeably brownish cast, which is most pronounced near types of the Altamont series. Some variation in texture and structure occurs, but this usually is confined to marginal areas, slight elevations, or where the parent rock contains alternating seams of sandstone and shale. The soil is high in organic matter.

The Diablo clay adobe is an important type in the Los Angeles area. It is prominently developed in the San Pedro Hills and in a few small bodies northeast and northwest of Los Angeles. It is associated with the Altamont soils and occurs in residual areas where there is considerable lime in the parent rock.

In the region northeast and northwest of Los Angeles the type has a gently to moderately rolling or hilly topography, but in the San Pedro Hills it occurs on a series of old elevated marine terraces and mountainous elevations with moderate to steep slopes. The surface is smooth except for occasional gullies and ravines. Much of the shale giving rise to this soil in the San Pedro Hills is highly siliceous and resistant to weathering. Locally the rock outcrops, making the surface stony in places.

The position of the type gives it good drainage, and in periods of heavy rainfall considerable moisture is lost by run-off. The numerous surface cracks enable the type to absorb most of the rainfall until the soil becomes saturated, while similar types lacking the adobe structure absorb moisture so slowly that their subsoils at a depth of 4 or 5 feet are frequently quite dry even after abundant rainfall.

This soil is hard to till unless handled under the proper moisture conditions, when it pulverizes well and forms a well-granulated mellow seed bed. Untilled fields crack and become very dry, but with good cultivation the type retains moisture remarkably well and matures good crops under dry farming.

The Diablo clay adobe is used principally for growing grain and lima beans, good yields being obtained. Beans, peas, corn, tomatoes, squash, and potatoes are produced on the areas of more favorable situation on the lower terraces of the San Pedro Hills, and give very good yields without irrigation. The soil is kept well cultivated to form an effective surface mulch, which reduces evaporation to a minimum. The type is all under cultivation except in a few places where the slope is too steep. More than 75 per cent of the type is in one

holding, the land being farmed by tenants who usually pay cash rent. The type is not very well supplied with roads or shipping points, but low rent and high productiveness enable farmers to compete with those on soils more favorably situated. With irrigation the range of crops could be increased, and two or more crops could be grown on the same land each year.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Diablo clay adobe:

*Mechanical analyses of Diablo clay adobe.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574109.....	Soil.....	0.2	0.5	0.7	5.4	7.8	43.3	41.9
574110.....	Subsoil.....	1.6	2.2	1.2	6.0	9.1	35.4	44.4

The following samples contained more than one-half of 1 per cent calcium carbonate (CaCO<sub>3</sub>): No. 574109, 5.72 per cent, and No. 574110, 13.61 per cent.

#### HOLLAND SANDY LOAM.

The Holland sandy loam to a depth of 10 to 18 inches consists of a brown or grayish-brown, gritty, friable, micaceous sandy loam, relatively low in organic matter and in places somewhat compact. The subsoil is a brown, light-brown, or slightly reddish brown, rather compact, gritty, heavy sandy loam, or clay loam, merging at an average depth of 18 to 36 inches into partially weathered granite, which consists of coarse, gritty, material penetrable in many places by roots and water to a depth of several feet. Occasionally bedrock is encountered at depths of less than 1 foot, and in other places it lies below 6 feet. It weathers quite uniformly, and little or no rock outcrop occurs, though the material becomes more gritty as the depth increases. In places the surface soil closely approaches a loam or fine sandy loam in texture, and in some areas the subsoil is hard and compact when dry and absorbs moisture very slowly. The deeper areas with permeable subsoils retain moisture best; where the soil is shallow, it is inclined to be droughty.

As mapped, the type includes some areas of slightly reddish brown color which if more extensive would be mapped as soil of the Sierra series.

The Holland sandy loam is not very extensive. It occurs in several areas in and around the Eagle Rock Valley and in smaller areas in the foothills north and northeast of Glendale and Hollywood. It has a rolling, hilly, or mountainous surface, more or less dissected by ravines. The soil is well drained and free from alkali.

The type has a low agricultural value, but it is situated near cities and offers many desirable locations for suburban homes. It is being

used for this purpose quite rapidly. Only a small part is tilled. Grain and grain hay are the principal crops grown, with low to moderate yields. The soil is easily cultivated. The untilled areas support a scant growth of brush, scrubby oak, and grass, and are used for pasture. Good highways pass through the type in places and much of it has been subdivided.

*Holland sandy loam, coarse phase.*—The surface soil of Holland sandy loam, coarse phase, consists of a brown or grayish-brown, coarse, gritty, micaceous sandy loam. The subsoil and parent rock resemble those of the typical Holland sandy loam except that there is more coarse material in the subsoil. The phase varies considerably in texture, and in places may be a gritty loam or gritty fine sandy loam. There are also included small patches of slightly reddish brown soil representing types of the related Sierra series. The phase is compact in places. It is low in organic matter, but easily tilled, and absorbs moisture readily except on the steep slopes.

This phase is inextensive. It occurs in several small areas along the side of Verdugo Canyon, along the east side of Griffith Park, and from Beverly Hills eastward to Los Angeles. It has a hilly, sloping, or mountainous topography, and in places the soil is removed by erosion almost as rapidly as it forms. The phase has good to excessive drainage and most of the rainfall is lost as run-off.

This soil is of little agricultural value. Grain and grain hay are the principal crops grown, and yields are small. Grapes and a few other crops are produced to some extent. Water for irrigation is costly and difficult to obtain. The untilled land supports a scant growth of brush, scrubby oak, and grass, and is used for grazing. All the phase is reached by good roads, and there are numerous near-by shipping points.

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

*Mechanical analyses of Holland sandy loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574113.....	Soil.....	8.6	17.4	7.8	22.4	13.0	22.6	8.0
574114.....	Subsoil.....	3.6	10.2	6.0	19.2	12.7	26.2	22.0

HOLLAND LOAM.

The Holland loam is a brown, micaceous, friable loam having an average depth of 10 to 18 inches. In some places the soil continues practically without change in color and texture to the underlying bedrock, while in others there is a light-brown subsoil, which may be

either lighter or heavier in texture than the surface soil. At depths varying greatly but generally less than 6 feet, the subsoil, which is usually gritty, rests upon partially weathered granite or schist, from which the soil is derived. Both soil and subsoil in places contain small amounts of rock fragments, which are seldom sufficient to interfere with tillage. The type usually is low in organic matter, but is easily tilled except on the steeper and more uneven surfaces, where plowing is difficult. Little of this type of soil is found in the survey. It occurs in several small areas extending into the area from a point north and northeast of Glendale. In most places it has a smooth, uniform surface, but it occupies rolling or hilly to mountainous country, much of which is above the existing water supply for irrigation. The type is well drained. Much of the rainfall on the steeper areas is lost as run-off. The soil is droughty where shallow, but retentive of moisture where deep and not too compact.

Grain and grain hay, the principal crops, give moderate yields. No attempt has been made to grow intensive crops. It is not as well located as the Altamont clay loam and does not command nearly so high a price.

#### RAMONA SANDY LOAM.

The soil of the Ramona sandy loam is brown, grayish brown, or, rarely, dark brown in color, with a tendency to become slightly reddish brown in places when wet. It is generally friable, but becomes quite compact when dry, owing to its low organic-matter content. Where the soil is not far removed from the parent material it sometimes contains small quantities of mica, but this constituent is lacking over much of the area in the region south of Inglewood. At depths ranging from 12 to 24 inches the soil passes into a brown, reddish-brown, or red, compact sandy loam, loam, clay loam, or, rarely, sand, compact and in some places approaching a hardpan. The subsoil may continue uniform to a depth of 6 feet or more, but ordinarily at variable depths below 4 feet it grades into material closely resembling the surface soil except in color. The substratum below this resembles the lower subsoil in texture and color. It frequently shows some stratification. In places the soil and subsoil contain small quantities of gravel or coarse, gritty material. This becomes less abundant farther out in the valleys. The soil and subsoil do not absorb water readily following periods of drought, but when they are once wet moisture passes downward without great difficulty and tends to soften the subsoil materially. Neither soil nor subsoil is as permeable to roots and water as are those of the recent-alluvial types, and gullies tend to form on sloping areas during heavy rains. The soil and subsoil materials have been altered considerably by weathering since deposition, and their lithological identity has almost disappeared in most places. Locally, and

in close proximity to recent-alluvial types, the surface material has been somewhat reworked and small quantities of fresh alluvial material deposited as an overwash, giving the type a more friable structure.

The Ramona sandy loam is most prominently developed in the vicinity of Inglewood and Redondo. Its total extent is small, but the type is quite important agriculturally. It has a smooth surface and occupies sloping to moderately rolling areas on old alluvial fans or terraces. Drainage is good in most places, and somewhat excessive on the steeper slopes.

This soil is retentive of moisture when well handled. It responds readily to applications of organic matter and to good tillage. Grain, grain hay, lima beans, corn, and some fruit and walnuts are the principal crops. All the type is under cultivation, but it is not irrigated except locally. The soil is easily tilled. Yields are only moderate, but are much increased where water is applied. The type is well supplied with good roads and shipping points. It is usually held in large tracts.

#### RAMONA FINE SANDY LOAM.

The Ramona fine sandy loam to a depth of 12 to 24 inches is brown, light-brown, or grayish-brown, smooth-textured fine sandy loam. Some included areas, which are too small to map, have a distinct reddish-brown color, closely resembling the soils of the related Placentia series. The subsoil is generally heavier than the soil, ranging from a brown to reddish-brown, compact fine sandy loam or loam to a heavy clay loam, and either continues uniform to 6 feet or more or rests upon a less compact substratum of slightly lighter texture, showing in many places slight stratification. In places the subsoil is more compact than usual and is known as hardpan. Even in such places, however, it softens materially in wet weather and becomes permeable. A small quantity of fine gravel or gritty material is sometimes present in the soil and subsoil. This condition exists only where there are sudden changes in topography, and the quantity of coarse material in no way interferes with cultivation. Included with the type as mapped there are areas of reddish-brown soil resembling Placentia soils. These are too small to map.

The Ramona fine sandy loam occurs in large areas around Long Beach, east and southwest of Lomita and east of Torrance, west of Nigger Slough. Part of the town of Wilmington is built in a large area extending north and southwest.

The type occupies a definite terrace position at Long Beach and at some other places, and also occurs as gently sloping to undulating or rolling areas. The surface is smooth and uniform except for a few gullies in the steeper situations. Drainage is everywhere thorough and on the steeper slopes excessive.

Part of this type has been improved as city property. The remainder is cultivated. Dry-farmed grain, grain hay, lima beans, and sweet corn are important crops. Moderate yields are obtained. Some grapes, deciduous fruits, and alfalfa are grown. Large plantings of truck crops also have been made. These last-named crops, except grapes, are grown mainly under irrigation, and good yields are obtained. Very little fertilizer is used. The small quantity of manure available is applied to the land.

Owing to its friable structure, this soil is easily cultivated except in occasional areas of heavier texture. Its organic-matter content is low, and it responds readily to applications of stable manure or green manure.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Ramona fine sandy loam:

*Mechanical analyses of Ramona fine sandy loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574119.....	Soil.....	0.1	0.5	1.3	50.6	19.1	21.7	6.5
574120.....	Subsoil.....	.1	.4	1.2	49.0	19.4	20.5	11.4

RAMONA LOAM.

The surface soil of the Ramona loam consists of 12 to 24 inches of a brown, grayish-brown, or dark-brown, light-textured loam, containing small proportions of mica and gritty material. The subsoil is a reddish-brown, brown, or red, compact clay loam or clay, containing variable quantities of gritty material and mica, especially in the northern part of the area surveyed. The subsoil may extend to 6 feet or more, but usually at about 4 feet it gives way to a brown or grayish-brown substratum of loam or clay loam, which either continues uniform to great depths or is succeeded by stratified beds of silt, sand, gravel, or clay. The subsoil is semicemented in places, closely approaching a hardpan. In such places it absorbs water slowly, especially after protracted dry periods, but when once wet it softens considerably and retains moisture quite well, though neither so permeable nor so retentive of moisture as the subsoil of the recent-alluvial types of the Hanford and Yolo series. The soil and subsoil usually are less oxidized than those of the related Placentia series, and there generally is less difference between soil and subsoil. Small quantities of small to medium gravel, mainly of granitic origin, are scattered through the soil and subsoil in places in the northern third of the area. Gravel may also occur in irregular strata or lenses in the subsoil or substratum near drainage ways or

sudden breaks in topography, but it is seldom sufficiently abundant to interfere with tillage, water movement, or root development.

Some modification by wind and water action has taken place in a few areas, resulting in variable texture. The higher, more irregular, and steeper areas usually have a somewhat lighter texture than typical, in places approaching a heavy fine sandy loam or sandy loam. In the nearly level, slightly depressed, and marginal situations the soil may be a heavy loam containing patches of clay loam having a high content of organic matter.

A number of variations occur in this type, several of which if sufficiently extensive would be mapped as soils of other series. Along the foothills east and west of Los Angeles more or less reworking has recently taken place, resulting in the deposition of fresh alluvial material over the surface by spreading streams. These fresh deposits are irregular in extent and variable in texture. The material deposited ranges from a thin surface covering to a layer nearly 1 foot in depth. One or two small bodies of quite pronounced reddish-brown loam west of Los Angeles and several east of the city along the foothills are included with the Ramona loam as mapped. They represent Placentia soils, mapped in the Riverside and other surveys. The soil and subsoil are redder and more highly oxidized than those of the Ramona loam. The soil in most places has a different crop adaptation from the latter type. It is shallower and shows a more definite demarcation between soil and subsoil.

A silty variation of the Ramona loam occurs in several large bodies southeast of Inglewood. The soil is slightly deeper than that of the typical Ramona loam and works into a more friable seed bed. Some small areas in this body are high in fine sand or sand, giving this silty variation a somewhat variable texture. A calcareous, light-textured loam variation occurs about  $1\frac{1}{2}$  miles east of Palms and just south of the Southern Pacific Railroad. The subsoil here is light brown or grayish brown. It is not so compact as that of the typical Ramona loam and contains many lime nodules. The area covered by this variation is less than one-half square mile in extent. If this soil were more extensive it would be classified with the Antioch series encountered in the soil survey of the Riverside area and elsewhere in the State. Other areas with concentrations of lime in the subsoil were encountered in a few places. They usually lie next to areas of sedimentary rocks or near breaks in topography. Except for color, texture, and lime content of the subsoil, this variation closely resembles the typical Ramona loam.

The Ramona loam is one of the most extensive and important agricultural types in the Los Angeles area. It occurs in the region east and west of Los Angeles, south of Whittier, between Inglewood and Long Beach, north and northwest of Wilmington, in minor areas

northeast of Los Angeles, and elsewhere in areas of old valley-filling soils. It occupies old alluvial fans, foot slopes, marine terraces, and elevated mesalike areas. It has a gently sloping or undulating to rolling and dissected surface. Eighty per cent or more of the type has a smooth and uniform surface, except for minor drainageways, which have rounded sides and bottoms. The type generally lies at higher elevations than associated recent-alluvial soils, and is either undergoing erosion or is being covered by more recent deposits. Its origin can be quite definitely established in the northern part of the area, where it is closely associated with the parent granitic and schistose-igneous rocks, but farther south it has undergone such marked internal changes by weathering that its identity is not so evident. The slope and the internal structure of the type favor good drainage in most places, though some of the more gently sloping land north of Burnett and around Nigger Slough receives seepage from higher areas and contains varying amounts of alkali. The rather slow absorption of water, due to the compactness of soil and subsoil, causes considerable loss by run-off during periods of heavy rainfall. This can be remedied to a great extent by proper tillage, the addition of organic matter, and the growing of deep-rooted crops.

The Ramona loam is practically all under cultivation. Most of the farmed land, including the more uneven areas, is used for dry-farmed crops, such as grain, grain hay, and lima beans. Yields are moderate to good, depending largely upon the system of cropping and the care given the soil. Water for irrigation has been supplied for the type in the region about Los Angeles, Whittier, Inglewood, and Gardena, and in a few other places. In the first two localities mentioned citrus fruits, alfalfa, and flowers are very successfully produced. Around Inglewood and Gardena truck crops predominate, with alfalfa and deciduous fruits of minor importance. Little or no commercial fertilizer is used, except for citrus fruits and certain truck crops. No systematic crop rotations are followed, but crops are generally changed where intensive farming is carried on.

The type is well supplied with roads and shipping points; all parts are easily accessible, except the hilly area north of Inglewood. Yields are much increased, and the soil made more retentive of moisture by the addition of organic matter, but this is practiced by only a few farmers. The best results with both citrus and deciduous fruits are obtained where the subsoil is not compact and is 24 inches or more below the surface. The land is not valued as highly as the recent alluvial soils of the same localities.

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

*Mechanical analyses of Ramona loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574121.....	Soil.....	2.8	6.4	3.9	15.4	17.7	40.0	13.8
574122.....	Subsoil.....	3.4	9.4	5.2	17.0	14.9	28.4	21.6

## RAMONA CLAY LOAM.

The Ramona clay loam to a depth of 8 to 24 inches consists of a brown, dark-brown, or grayish-brown, light-textured clay loam. Small quantities of mica, gravel, and gritty material are of common occurrence in that part of the type lying in the northern third of the area, but are practically lacking farther south, where a somewhat smoother and more uniform texture prevails. The soil is, however, variable in texture, being lighter in the higher and more uneven areas and heavier in the more gently sloping or nearly level situations. The color also varies with the texture, being lighter where the texture is lighter and the drainage best developed, and darker where the soil is heavy and more moist. It absorbs water slowly when dry, but when once wet is permeable and quite retentive.

The subsoil is a heavy, compact clay loam or clay, of brown or reddish-brown color. It contains small concentrations of lime in places, and here another type of soil would be shown, if such areas were not too irregular in occurrence to warrant mapping. The subsoil in some small, scattered areas also is quite firmly cemented, closely approaching a hardpan. The subsoil rests at 4 to 6 feet upon a variably textured substratum of loam or clay loam, which either continues uniform to a depth of 10 feet or more, or consists of alternating strata of sand, silt, clay, and gravel. The substratum usually is lighter colored and more permeable than the subsoil, but it is generally quite compact. In some places along the foothills and where slight reworking has occurred there is a little gravel in the soil and subsoil, but the quantity is too small to affect tillage or crop growth. The type as a whole is higher in organic matter than the Ramona loam, but there usually is not sufficient organic matter to prevent puddling and the formation of clods if the soil is handled when wet or is irrigated by flooding.

The Ramona clay loam is an extensive soil. It occurs principally north of Burnett, Culver City, and Gardena; north of Bixby Slough, northwest and southeast of Whittier, northeast of Inglewood, and east of Venice. Several bodies are encountered in and about the city of Los Angeles, and a few others of minor importance are scattered widely over the area surveyed.

The type occurs mainly on old alluvial fans, foot slopes, and marine terraces, and in elevated mesalike positions. Many small ravines and

intermittent streamways, with rounded, smooth banks, traverse most areas of the type, but the slopes are not too steep for tillage, and little or no leveling is necessary for irrigation. The elevated position and slope give good drainage in most places, but locally, as in the region northeast of Burnett, there are some seepage areas. Accumulations of alkali in injurious amounts occur in such places. The dense subsoil retards the absorption of moisture, and much of the rainfall is lost in the run-off.

The Ramona clay loam is quite important agriculturally. Most of it is dry farmed to grain, grain hay, and lima beans, of which moderate to good yields are obtained. In the region near Whittier citrus fruits and walnuts are the principal crops, and where the subsoil and drainage are favorable good results are obtained. Elsewhere, with water available for irrigation, deciduous fruits, alfalfa, berries, and truck crops are the more important products. Some dairying is successfully carried on where alfalfa and other forage and hay crops do well. In growing the fruits and, to some extent, the truck crops fertilizers are used. Deep and thorough cultivation with the application of manure and the growing of cover crops has proved very effective in improving the physical condition of the soil and in increasing the yields and quality of fruit. Crops are changed from year to year, but no systematic rotations are followed. All parts of the type are reached by good roads and are conveniently located with reference to shipping points.

This soil should be plowed deeply. Where the subsoil is dense and refractory, blasting would be of benefit in setting out fruit trees. The soil is refractory when dry, and difficult to till unless handled when in the proper moisture condition. It absorbs water slowly when dry, but when once wet it is permeable. It is quite retentive of moisture.

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

*Mechanical analyses of Ramona clay loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574123.....	Soil.....	0.6	1.6	1.2	5.5	19.6	44.8	26.5
574124.....	Subsoil.....	2.0	3.8	1.8	8.6	19.5	42.0	22.1

PLEASANTON LOAM.

The surface soil of the Pleasanton loam consists of a light-brown to dark-brown rather compact, medium-textured loam to silty loam, 12 to 36 inches deep, containing in most places small quantities of

gravel and gritty material, the quantity being greater as the Santa Monica Mountains are approached.

The subsoil consists of a light-textured, brown, light-brown, or reddish-brown silty clay loam or clay not quite so dense and impervious as the subsoil of the Ramona loam. At a depth ranging from 18 to 72 inches it rests upon a gravelly substratum which may be several feet thick or may continue as alternating layers of small to medium gravel, silt, or clay to a depth of many feet (Pl. III, fig. 1). The interstitial filling in the gravelly layers consists of compact silt, sand, or clay. The gravelly substratum layers are seldom continuous but appear in most cases as numerous disconnected lenses. Gravelly strata may not occur within 6 feet of the surface.

The more gravelly areas of the type are indicated on the soil map by gravel symbols. They are somewhat more difficult to till than the typical soil. The gravel is mainly dark-colored schist and has a slaty structure in nearly all instances.

The type closely resembles the loam of the Ramona series except for its gravelly substratum. As mapped, it includes some small, irregular bodies of reddish-brown loam, which, if of sufficient extent, would be mapped as the Corning loam.

The Pleasanton loam is confined to the northwestern part of the area, principally north and northeast of Santa Monica. It is quite extensive. It occupies gently to moderately sloping or rolling country, and generally at much higher elevations than the associated recent-alluvial types of the Yolo series. Its surface is considerably dissected in many places by deep drainage ways, but elsewhere it is smooth and uniform. In places the topography and cross section closely resemble those of an old marine terrace, but in general the material consists of old alluvial deposits transported only a short distance from the Santa Monica Mountains. The type has good drainage, and much water is lost as run-off during rainy periods, owing to the slope and the compactness of soil and subsoil. The soil is retentive of moisture if properly handled.

Practically all the type is under cultivation. It is mainly dry farmed with grain, grain hay, and lima beans as the important crops, which give moderate yields. The crop range is limited by the scarcity of water for irrigation. In a few places where water has been made available lemons and a few other intensive crops are being planted. The topography and climatic features make the type very desirable for home sites, and its agricultural use is becoming more restricted each year on this account. The type is well located with reference to cities and roads.

The type requires irrigation to insure certain returns from fruits and other intensive crops. Deep tillage, thorough subsoiling, and

the application of organic matter and commercial fertilizer are necessary for the best results with tree fruits.

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

*Mechanical analyses of Pleasanton loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574129.....	Soil.....	0.6	1.8	1.5	7.4	18.8	51.7	18.0
574130.....	Subsoil.....	.6	2.4	1.8	8.4	14.8	50.4	21.6

MADERA FINE SANDY LOAM.

To a depth of 8 to 18 inches the Madera fine sandy loam consists of a brown, light-brown, or grayish-brown, friable fine sandy loam, low in organic matter. In many places it closely approaches a sandy loam or a loam in texture, and becomes slightly reddish brown when wet. The material packs sufficiently during heavy rains to cause much of the rainfall to escape as run-off. The subsoil consists of a compact, gritty clay loam or clay, brown or reddish brown in color, extending from a depth of about 18 inches to 30 inches. It is dense, poorly aerated, and not very permeable to roots and water. It rests upon a brown or reddish-brown, indurated, impervious hardpan, which may extend to a depth of 6 feet or more, or may give way at a depth of 36 inches to a substratum of loam or clay loam, usually coarser and lighter in color than the subsoil. (Pl. III, fig. 2.) The substratum has a loose, open structure, but seldom receives moisture because of the overlying impenetrable hardpan.

Neither soil nor subsoil shows stratification, but the substratum in many places consists of alternating beds of silt, sand, clay, or fine gravel. Small concentrations of lime sometimes occur in the lower subsoil, and may also occur in seams or thin crusts through the hardpan. The hardpan usually is near enough to the surface to impair the agricultural value of the type. It serves as an effective check to the downward movement of water, often making the land boggy in wet weather.

The Madera fine sandy loam is of minor importance agriculturally. It occurs in two small, clearly defined areas about 2 miles southeast of Palms. It occupies the top of an elevated mesa, from which deeply eroded ravines radiate in all directions. The type consists of the remnant of an old alluvial deposit now undergoing destructive erosion. It is well elevated above the surrounding country, and has sufficient slope for good drainage. It lies much above the available

water supply for irrigation and its shallow hardpan permits of the storage of little moisture, causing it to become droughty in summer. Blasting the hardpan where it lies near the surface has given good results in growing deep-rooted crops.

Nearly all the type is under cultivation, being devoted to the growing of grain and grain hay or to pasturage. In favorable years the yields are moderate to good, but they are low in years of light rainfall. The type is not very accessible at present.

As mapped, the Madera fine sandy loam includes a reddish-brown variation. This consists of a rather compact, reddish-brown to red fine sandy loam or loam, closely resembling the typical Madera fine sandy loam in all features except color. If this soil were more extensive it would be mapped as the San Joaquin fine sandy loam. It occurs in three small bodies in the northeastern part of Eagle Rock Valley and in one body along the west side of Verdugo Canyon north of Glendale. The material has been transported a much shorter distance than that of the typical Madera fine sandy loam. In some places small amounts of gravel or coarse gritty material are present in soil, subsoil, and substratum. This variation occurs on ridges projecting from the mountain sides. In crop range and other features it closely resembles the typical soil.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the typical Madera fine sandy loam:

*Mechanical analyses of Madera fine sandy loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574125.....	Soil.....	1.0	9.7	10.8	24.8	14.2	27.4	12.2
574126.....	Subsoil.....	.6	8.6	10.1	18.2	8.7	24.5	29.2

MONTEZUMA CLAY ADOBE.

The Montezuma clay adobe consists of a dark-gray to black, in places brownish, heavy, compact clay containing small quantities of gritty material of adobe structure. Some gravel occurs in the soil and subsoil in the northern part of the area and in those bodies on the eastern and southern slopes of the San Pedro Hills, but not in sufficient quantities to affect cultivation. At a depth of 18 to 36 inches the soil passes into a light-brown to dark-brown, heavy calcareous clay loam or clay subsoil, which continues uniform to a depth of 6 feet or more. The subsoil is calcareous, the lime being distributed uniformly through the soil mass or concentrated in spots, giving a mottled appearance. In places the content is sufficient to give the mate-

rial a gray color when dry. The substratum is usually similar to the subsoil, but in some places consists of strata of differing textures. The soil is high in organic matter. Two small areas, one about three-fourths mile west, and one about  $1\frac{1}{4}$  miles northwest of Silver Lake Reservoir, are in reality clay loam adobe in texture, and would be so mapped if their extent warranted separation.

The Montezuma clay adobe is a very important agricultural soil, ranking among the most productive types in the area. It occupies a large total area, mainly south and east of Inglewood and Redondo, with smaller areas east of Venice, along the east and north sides of the San Pedro Hills, southeast of Whittier, and west of Compton and Los Angeles.

Much of the type west of Gardena is gently sloping, with a smooth, uniform surface closely resembling that of the Dublin soils. Elsewhere it is gently sloping, undulating, or rolling, usually with a smooth surface traversed by drainage ways with rounded banks. The type occurs on old dissected terraces, on footslopes, or on old alluvial fans and above the recent alluvial soils. Drainage is good except in nearly level areas, where water sometimes stands for short periods in wet weather. Both soil and subsoil naturally absorb water slowly, although the numerous cracks increase the absorption greatly. During the winter the land is miry and almost impassable, owing largely to the heavy texture of the soil and the slowness with which water percolates through it.

The type is practically all under cultivation. Dry-farmed grain and grain hay are the principal crops. Lima beans and a few truck crops are successfully produced without irrigation and are grown to some extent. The yields vary according to the season, however, and much better results are obtained where irrigation is practiced, especially with the intensive crops. With irrigation, truck crops, bush and vine fruits, and alfalfa do very well. Strawberries are a very important crop on this soil. They produce large vines with very tart berries. The land devoted to berry culture frequently is plowed, partially smoothed, and then planted while still cloddy and rough. Furrow irrigation is practiced, and the clods are raked into the water, where they break down and pulverize readily. This is said to reduce the cost of preparing the seed bed. Raspberries, loganberries, and blackberries give large yields of good quality. Irrigation by flooding is injurious on this type, owing to the tendency of the soil to puddle. The soil works into the most friable and favorable seed bed if plowed in the fall and left to be acted upon by the winter rains, but it is difficult to plow at that time of the year, and plowing is usually done in the spring. Some commercial fertilizer is used for certain intensive crops. Commercial fertilizer varies greatly in effectiveness, but the addition of organic matter nearly always increases the

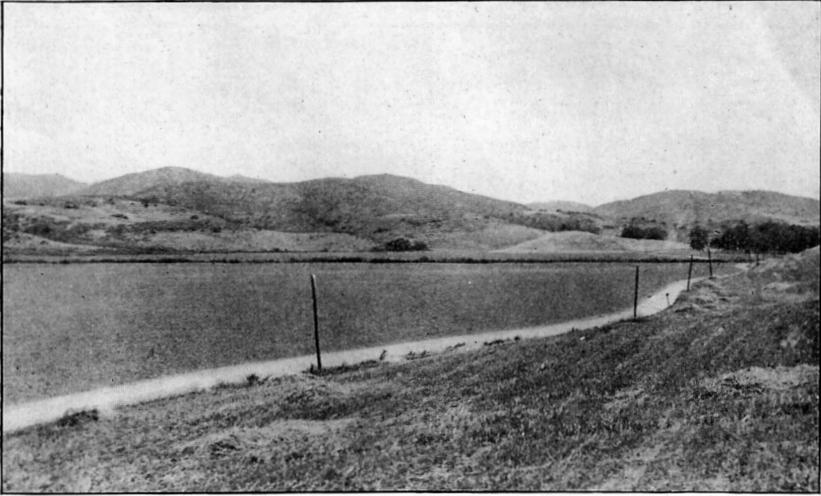


FIG. 1.—VIEW NEAR SAWTELLE, LOOKING TOWARD SANTA MONICA MOUNTAINS. Recent-alluvial fan occupied by soils of the Yolo series on the left, edge of terrace occupied by Pleasanton loam on right, with soils of the Altamont series covering the hills in the distance.

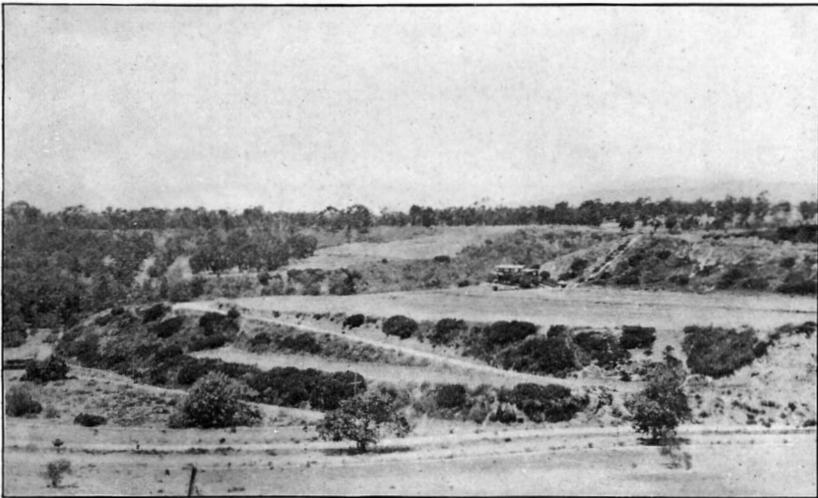


FIG. 2.—VIEW NEAR SANTA MONICA, SHOWING TERRACES OCCUPIED BY PLEASANTON LOAM ERODED AND ENTRENCHED BY RECENT-ALLUVIAL STREAM VALLEYS.



FIG. 1.—EXPOSURE SHOWING GRAVELLY SUBSTRATUM IN PLEASANTON LOAM.



FIG. 2.—MADERA FINE SANDY LOAM, SHOWING HARDPAN OUTCROPPING ALONG ERODED EDGE OF TERRACE.

yields. The type is within easy reach of shipping points and is well supplied with roads. The type in most places sells for several hundred dollars an acre, but land values vary greatly, depending upon the location and state of development.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Montezuma clay adobe:

*Mechanical analyses of Montezuma clay adobe.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574127.....	Soil.....	0.2	0.8	1.0	5.0	15.4	44.4	33.4
574128.....	Subsoil.....	.8	2.0	1.1	4.8	14.3	42.4	34.8

The following samples contained more than one-half of 1 per cent calcium carbonate (CaCO<sub>3</sub>): No. 574127, 0.54 per cent, and No. 574128, 8.65 per cent.

HANFORD SAND.

The Hanford sand consists of a brown, buff, or grayish-brown, friable, micaceous, medium-textured to rather fine sand, in most places resting at about 12 inches on a subsoil of brown or grayish-brown strata of fine sand, silt, or gravel. In some places the soils extend without change to 6 feet or more. Small patches or streaks of fine sand or loose gravelly material occur here and there, giving the soil a variable texture.

Three small bodies of Hanford fine sand are included with the Hanford sand as mapped, because of their slight extent. One is situated about one-half mile east of Huntington Park, one about the same distance east of Watts, and one about one-half mile south of Ascot Park. The total area of these bodies is about one-half square mile. The soil closely resembles the Hanford sand except in texture. It is a little more desirable agriculturally, as it is more retentive of moisture and drifts less. A long, narrow strip of Hanford coarse sand, less than one-half square mile in extent, is also included with the Hanford sand. It lies about one-third mile west of Verdugo Road, in the eastern part of Glendale. This soil is the product of an intermittent stream which deposited the material during flood periods before its drainage was diverted to other channels. This soil is very coarse and gritty and moisture drains away rapidly, causing it to be droughty and poorly adapted to farming, except where it is underlain by a heavier subsoil or can be liberally irrigated. In addition to these areas of fine sand and coarse sand, there are several included areas of Hanford gravelly sand, with a total extent less than 1 square mile. These areas, one of which lies along the Los Angeles River north of Silver Lake Reservoir, and several others along the lower course of the Arroyo Seco, are shown

on the map by gravel symbols. The soil contains sufficient gravel to interfere with tillage and to cause droughtiness. It is low in organic matter and less coherent than the sand, and requires more water for irrigation.

The Hanford sand is an inextensive type of little agricultural importance. It is confined to a number of small bodies in the region traversed by the Rio Hondo and by the San Gabriel and Los Angeles Rivers from their entrance into the area southward to Compton. It occupies part of the valley floor along the streams, and has a uniform, smooth surface. The type is well drained and inclined to be slightly droughty where the subsoil is exceptionally light in texture.

The surface is easily prepared for irrigation. A high water table exists in places, but alkali has not yet appeared in harmful amounts. The soil is low in organic matter, but absorbs and retains moisture well, owing mainly to its loaminess and the relatively large proportions of fine sand and silt often present in the subsoil. It is easily tilled, though it has a tendency to drift in exposed situations.

All the type is under cultivation except some of the small areas near the larger streams which are subject to overflow. The untilled areas support a scattered growth of willow and vines, and are used mainly for pasture. A wide range of crops is grown on the type, but the returns are not quite equal to those obtained on the heavier types of the Hanford series. Peaches, walnuts, beets, alfalfa, and garden vegetables are the main crops. Some citrus fruits are produced east of Montebello. Most of the type is too low lying and too light textured for the safe production of citrus fruits, but with good care and fertilization fair returns are obtained. Alfalfa is short lived. Nearly all crops require irrigation for success. Some early potatoes are produced, and sweet corn does well.

Part of the type is situated conveniently with respect to roads and shipping points, but that part lying close to the streams is less accessible.

The incorporation of more organic matter and careful selection of crops to be grown are necessary for the best returns from this type.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the Hanford sand:

*Mechanical analyses of Hanford sand.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574131.....	Soil.....	0.1	6.6	18.4	55.0	11.9	5.9	2.1
574132.....	Subsoil.....	.0	8.9	22.5	55.5	6.2	4.9	1.8

## HANFORD SANDY LOAM.

The Hanford sandy loam consists of a brown or grayish-brown, friable, micaceous sandy loam, in places containing small quantities of gravel and gritty material, and generally continuing uniform in texture to 6 feet. In some places, however, the soil is only 12 or 15 inches deep, below which lies a subsoil composed of different strata ranging from fine sandy loam to sand or silt loam in texture, and lighter in color than the surface soil. Where uniform to 6 feet in depth it is more retentive of moisture than where the underlying material consists of loose, stratified deposits. The organic-matter content varies considerably but is low over most of the type.

In areas subject to overflow and reworking by streams the soil shows considerable variation, usually being coarser in texture and lighter colored, with small patches of sand or coarse gravelly material. Near soils of the Chino series the texture tends to become heavier and the color darker.

Two small areas of the Hanford gravelly sandy loam have been included with the sandy loam. These are indicated on the map by gravel symbols. The soil differs little from the typical Hanford sandy loam except in its moderate to large content of rounded, waterworn granitic gravel.

The Hanford sandy loam is most extensively developed in the vicinity of Glendale, where it is used principally as sites for suburban houses. Smaller areas lie in the northern part of Eagle Rock Valley, northeast of Clearwater, southeast of Boyle Heights, at the junction of Arroyo Seco and the Los Angeles River, and northwest of Ascot Park. The type occupies sloping alluvial fans and stream bottoms, in most places little or no leveling being required to fit the land for irrigation. The type is well drained but subject to overflows, which occasionally do some damage. The lower and flatter areas, such as some of those southeast of Los Angeles, have a moderately high water table, the supply of water in such places usually being sufficient for irrigation by pumping.

The included gravelly sandy loam areas occur just northwest of Glendale and near the upper part of Verdugo Canyon. Both occupy gently sloping recent-alluvial fans and stream bottoms. The open, loose structure of the subsoil and substratum permits of a rapid downward movement of water, and drainage ranges from good to excessive. Overflows occasionally do considerable damage to crops.

About one-third of the Hanford sandy loam is used for residence purposes, the remainder being cultivated. The lower and flatter areas on the valley floor are used mainly for the production of truck crops, alfalfa, deciduous fruits, grain, and grain hay. Under irrigation these give good yields. The higher and more sloping areas

are devoted to citrus fruits, in addition to the crops named above. Some commercial fertilizer is used for citrus fruits and certain truck crops, but in growing other crops little is used. Some crops are produced successfully without irrigation where the soil and subsoil are uniform, though the yields under irrigation are greatly increased. A greater variety of crops can be grown with irrigation than without.

*Hanford sandy loam, coarse phase.*—The coarse phase of the Hanford sandy loam, which is indicated upon the soil map by cross lines in the Hanford sandy loam color, consists of a brown or grayish-brown micaceous coarse sandy loam, often containing numerous small particles of granitic rock. Rounded gravel and fine material are also present in small quantities. Over much of its area the soil is uniform to a depth of 6 feet or more, but in a few places a subsoil of semistratified brown or slightly reddish-brown sandy loam or fine sandy loam occurs below 18 inches.

The soil and subsoil are open and absorb moisture rapidly, but they do not retain it well except in the comparatively few areas where the underlying material is somewhat heavier and more compact than the surface soil. The material is low in organic matter. Tillage is easy except in areas of unfavorable surface conditions.

The coarse phase is somewhat more extensive than the typical Hanford sandy loam. It occurs in a number of bodies north and northeast of Glendale, in the Eagle Rock Valley, and west and northeast of Hollywood, along Coldwater Canyon, and in the vicinity of Sherman. It comprises most of the tillable land in Verdugo Canyon. Most of the phase occupies more steeply sloping alluvial fans than does the typical sandy loam, but the surface for the most part is smooth and uniform and easily cultivated and irrigated.

All this soil is under cultivation. Water for irrigation is costly and must be obtained in nearly all instances from sources outside the area. The soil responds to good agricultural methods. It is well adapted to a wide range of deciduous and citrus fruits and other intensive crops where sufficient water is available and organic manures are applied. It is used successfully in growing carnations. The soil gives greatly increased yields with applications of organic matter and is capable of maturing two or more crops in one year if well handled. Numerous good highways lead to all parts of this phase.

#### HANFORD FINE SANDY LOAM.

The soil of the Hanford fine sandy loam consists of a brown or grayish-brown, relatively light-textured, micaceous fine sandy loam, open and friable in structure, and containing only a moderate proportion of organic matter. The subsoil, generally encountered at 12 or 15 inches, consists of variably stratified deposits of sand, silt, and

gravel. The texture of this type is subject to great variation near streamways and toward the northern part of the area of its occurrence. In such places small patches or very narrow strips of sand, fine gravel, fine sand, or silt loam may be included, the texture having a marked influence upon crop growth and moisture-retaining properties. In some places the material continues uniform to 6 feet in depth. The subsoil also is most uniform in areas farthest from the streams. Gravelly substrata frequently occur, often marking the beds of abandoned stream channels, as is the case in the region between Exposition Park and the Los Angeles River, where the uplands and lowlands meet, and for several miles along the Rio Hondo and the Los Angeles and San Gabriel Rivers after they enter the area.

In the region of Bellflower, from Compton north nearly to Huntington Park, west and southwest of Exposition Park, and at a few other places the soil frequently is darker in color and higher in organic matter than typical. It gradually merges into the soils of the Chino series, from which in places it is with difficulty distinguished. The subsoil here is slightly heavier and more silty than typical, is somewhat mottled in places, and occasionally contains a few small lime nodules. The water table is usually within 6 or 8 feet of the surface.

A very light grayish brown variation occurs along the three main rivers and at a few other places where floods have been active. It closely approaches the gray color of the Tujunga series of soils, into which it gradually merges. The soil is low in organic matter and is more irregular in texture, structure, and moisture-retaining properties than the typical Hanford fine sandy loam. It frequently is overflowed and locally affected by drifting, but in other respects is typical.

The Hanford fine sandy loam is the second most extensive and one of the more important soils in the area surveyed. It occurs mainly in the eastern two-thirds of the area, and is most largely developed over the plains region southeast of Los Angeles. Other important areas lie along the Los Angeles and San Gabriel Rivers and the Rio Hondo northward to their entrance into the area, with small bodies along some of the minor creeks emerging from granitic hills. Several of the areas forming level to gently sloping flood plains of the rivers are very large. The surface in most places is uniform. Part of the type is subject to overflow and reworking, and in the region west and northwest of Long Beach fresh surface deposits of similar material, sometimes a foot or more in depth, are deposited over considerable areas in a single flood. A part of the material is removed from other parts of the type by swollen streams and a part is brought

from the mountains and other areas to the north and northeast of the area surveyed. Overflowed areas usually have a slightly furrowed and irregular surface, and require leveling before crops are planted. Nearly all of the type occurs in rather low positions and generally has a relatively shallow water table lying 4 to 10 feet below the surface. Most of the type north of Huntington Park is well drained and free from alkali, but a large proportion of the type south of this point contains alkali in harmful amounts. Some of the lower land has been successfully drained and reclaimed, making possible the growing of a wide range of crops.

Near streams the type frequently supports a scant to heavy growth of willow, brush, and vines. Elsewhere the native vegetation consists of grasses. Salt grass and other alkali-resistant plants characterize areas affected by alkali. A considerable part of the type is occupied by the city of Los Angeles and smaller towns. The remainder, except small strips along some of the rivers and small tracts containing high concentrations of alkali, is under cultivation. Much of the type is devoted to truck crops which give very good results. Under intensive methods two or more crops are produced in one year. Extensive plantings of sugar beets are made each year, and the crop gives good yields where the best practices are followed. Sugar beets are quite resistant to alkali, but they do best where very little or none is present. Alfalfa is grown on a considerable acreage and does well, but the crop is short lived where drainage is deficient or the subsoil light and porous. Potatoes, cabbage, cauliflower, sweet corn, tomatoes, and melons are successfully grown. Peaches rank first among the deciduous fruits. A considerable acreage is devoted to walnuts and oranges, with moderate to good success. The perennial crops are deep rooted where drainage is good and require less irrigation than where grown on the higher, old valley-filling soils with heavy subsoils. Good results are obtained without irrigation with many of the crops grown, but the yields of fruits, nuts, alfalfa, sugar beets, and certain truck crops usually are increased where water is applied. Some commercial fertilizer is used for citrus fruits, walnuts, and certain truck crops, but the incorporation of organic matter, either stable manure or green manure, gives the most satisfactory results. Crop yields vary greatly, depending upon the time of planting, the preparation of the seed bed, the drainage, uniformity of soil, and whether or not irrigation is practiced. The hardy vegetables mature every month of the year.

Nearly all parts of the type are traversed by excellent roads, and it is well supplied with shipping points. This is one of the most highly developed soils in the area. In most places it is thickly settled. Land of this type rents for \$20 to \$45 an acre per year.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Hanford fine sandy loam :

*Mechanical analyses of Hanford fine sandy loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574135.....	Soil.....	0.0	0.1	0.1	17.7	41.6	34.9	5.6
574136.....	Subsoil.....	.0	.2	.2	20.6	36.8	36.2	6.1

HANFORD LOAM.

The Hanford loam, to a depth varying from 12 to 72 inches or more, consists of a brown or grayish-brown, friable, light-textured, micaceous loam, usually free from gravel. The subsoil is lighter brown than the surface soil, but locally, where more weathering has taken place, it is slightly reddish brown. Some coarse, gritty material occurs in the surface soil near the foothills. Small patches and low strips of sandy loam and gravelly soil occur in places throughout the type. These lie in the courses of minor streamways or are the result of floods.

The soil in the flattest and lowest lying situations is sometimes dark brown and includes small areas closely resembling types of the Foster and Chino series. On foot slopes or alluvial fans the soil is uniform to a depth of 6 feet, but over the flatter alluvial fans and flood plains the material below 12 inches frequently consists of stratified beds of sand, silt, or gravel.

Near areas of the Chino soils the subsoil frequently becomes dark brown or dark grayish brown. Over part of the area north of Exposition Park the subsoil below 4 or 5 feet consists of rather loose gravel and stones mixed with sand. Such material extends to a depth of 8 feet or more, and apparently the area is the bed of an abandoned streamway having its outlet to the southwest.

The Hanford loam is generally low in organic matter. The soil and subsoil are open, and the type absorbs and retains moisture well except where the subsoil and substratum are loose and porous. Tillage is not difficult at any time, and there are no obstructions to deep root development except in low spots where a high water table occurs.

The type has an extent of several square miles. It is confined to the eastern and northern parts of the area. Several small bodies are encountered in Eagle Rock Valley, one at Watts, and one east of Bouton Lake. Important areas occur in and near Hollywood, Franklin Canyon, north of Exposition Park, northwest and northeast of Glendale, and south and west of Sherman. Those west and north-

east of Los Angeles occupy moderately to gently sloping alluvial fans, while the areas occurring on the plains south and southeast of Los Angeles have a nearly level to very gently sloping surface. Drainage is good over nearly all the type, but some of the lower-lying portions have a high water table. Where this condition exists some alkali has accumulated. The surface is uniform, and the land easily prepared for irrigation, except where intermittent streams have furrowed it slightly.

All this soil is farmed. The areas with good slope, situated along the foothills, are devoted to citrus fruits, alfalfa, potatoes, truck crops, sugar beets, and deciduous fruits. Where water is available for irrigation good yields are obtained. The lower lying valley land is used for all the crops mentioned above except citrus fruits. Grain and grain hay are grown to some extent, mainly to round out crop rotations. Commercial fertilizer is used for citrus fruits and certain truck crops, but stable manure is preferred where available. The liberal use of organic matter, good tillage, systematic crop rotations, and careful selection of crops are necessary for the fullest returns from this type.

The Hanford loam is well situated with reference to roads and shipping points.

#### HANFORD CLAY LOAM.

The Hanford clay loam consists of a brown or grayish-brown, light-textured, micaceous clay loam, seldom carrying gravel or coarse gritty material. In the body south of Hollywood the texture has been influenced locally by intermittent streams spreading small quantities of fresh grayish material of variable texture along their courses. The soil here is quite uniform in cross section to a depth of 6 feet, except where it grades into a brown or slightly reddish brown, heavy clay loam or clay subsoil of rather close structure at 24 to 36 inches below the surface. This latter condition is not typical, however; it represents a stage of weathering comparable with that of the Ramona soils. The body east of Nigger Slough is also quite variable, owing to its low-lying position and periodically overflowed condition. The soil in this locality is somewhat higher in organic matter than that south of Hollywood. It includes a few small patches of dark-colored soils closely resembling those of the Chino series.

In the lower and flatter areas the type is either uniform to a depth of 6 feet or consists of alternating strata of silt, sand, or clay, with occasional calcareous nodules in the heavier textured strata. The type is not difficult to till when properly moist. Its structure is favorable for the absorption and retention of moisture and for deep root penetration.

The Hanford clay loam occurs in two bodies, one just south of Hollywood and one extending a short distance eastward from Nigger Slough. The former lies on a moderately sloping alluvial fan and is well drained and free from alkali. The latter occupies a nearly level flood-plain area, and is subject to overflow and standing water. Drainage here is stagnated, and much of the land contains enough alkali to injure crops.

All the type, except some areas where drainage and overflow conditions are most unfavorable, is under cultivation. The well-drained land is used for the production of potatoes, grain, grain hay, alfalfa, and sugar beets. Most crops give good yields without irrigation. Alfalfa requires irrigation for full crops, however, and some water is necessary for the best results with sugar beets.

#### TUJUNGA SAND.

The Tujunga sand consists of a gray, brownish-gray, or very light grayish brown fine to medium-textured, loose, micaceous sand. On footslopes and alluvial fans the soil is uniform in texture to a depth of 6 feet, but the material below 12 inches generally is somewhat browner than the surface soil. Along stream bottoms the soil is more variable in texture, including many narrow strips of fine sand, sandy loam, or gravelly soil, and the subsoil in such places consists of variably textured strata of fine sand, silt, or gravel. The subsoil below 12 inches is slightly more compact than the surface soil, which drifts considerably. In some places the soil contains considerable fine sand and silt, making it loamy. It is low in organic matter, but its large content of fine material enables it to absorb and retain moisture well. It is easily tilled, but becomes compact for short periods after rains or irrigation.

The type is of small extent and minor agricultural importance. The largest area lies southeast of Los Angeles, and smaller areas southwest and east of Montebello and west of Glendale. The surface is smooth and uniform. The type occupies abandoned stream channels or forms narrow strips paralleling streamways. In places light surface irregularities, caused by flood or wind action, occur. The material has been derived mainly from granitic rocks, and is added to yearly by deposition from flood waters, the deposits in places covering the surface to a depth of 1 foot or more during a single period of flood.

The type is partly under tillage. Some of the land along the Rio Hondo and southeast of Los Angeles occupying flood-swept positions or coarse, leachy stream bottoms, is covered with brush and willow. Some grain hay is grown, but potatoes, corn, and truck are the leading crops. Grain hay gives light yields, but the yields of other

crops are fair, depending largely upon the proportion of fine material in soil and subsoil and upon the irrigation given. The soil is greatly improved and crop yields are increased where manure or green crops are plowed under. Peaches do quite well in the more favorable situations and come into bearing early.

Good roads are near all parts of the type, but some of the roads leading to the main highways are sandy, making hauling heavy and difficult. The lack of flood protection gives the type a much lower selling value than that of similar soils better located.

#### TUJUNGA FINE SAND.

The Tujunga fine sand consists of a gray, brownish-gray, or light grayish brown, incoherent, micaceous, loamy fine sand which ranges in depth from a few inches to 6 feet or more. The soil varies considerably in texture, owing to reworking by periodic overflows, and includes narrow strips of sand, fine sandy loam, or silt loam, usually free from gravel or other coarse material. The subsoil resembles the surface soil in texture and color or it may be slightly browner, and may consist of alternating, variable light-textured strata. When wet the surface material is compact but upon drying it becomes loose, drifting in exposed positions. The type is low lying and subject to periodic overflows, which frequently alter the surface texture materially by the addition of fresh deposits or the removal of the upper layer. The soil is low in organic matter. It is easily tilled and retentive of moisture.

The Tujunga fine sand is confined to low areas along the Los Angeles River, the Rio Hondo, and the San Gabriel River. It usually borders the river banks and grades into soils of the Hanford series lying back from the streams.

The surface is smooth, and there is only a slight slope. The type has a high water table. Water passes downward rapidly and owing to frequent flooding little alkali is present. The water table falls as the season advances and irrigation is sometimes necessary for late-maturing crops.

In its native state part of the type supports a moderate growth of willow and vines and is used largely for pasture. A part is devoted to the growing of sugar beets, potatoes, and truck crops. Planting usually is deferred until April or May, because of the wet condition of the soil. Some leveling and the removal of debris is necessary after each flood period. The soil warms up quickly and crops mature rapidly. In some cases two or more crops can be grown in one year. The type is, however, relatively unimportant.

Increase in the content of organic matter and protection from overflow are necessary to insure the best returns from this soil.

## TUJUNGA FINE SANDY LOAM.

The Tujunga fine sandy loam, to a depth varying from 1 to 6 feet, consists of a gray, brownish-gray, or very light grayish brown, friable, micaceous fine sandy loam. The type is uniform in texture, but along stream bottoms the material below the depth of 12 inches may consist of layers of sand, fine sand, silt, or fine gravel.

Small strips of sand, fine sand, or gravelly sand sometimes occur at irregular intervals over the surface. This light-textured material has a tendency to drift, but in general the soil is compact after rains or irrigation. It is low in organic matter, and is easily tilled at all seasons of the year. The type is retentive of moisture where the subsoil is not too porous.

The Tujunga fine sandy loam occurs in several narrow strips along the Los Angeles River to its junction with the Arroyo Seco. It has a gently sloping to nearly level surface which usually is smooth and easily prepared for irrigation. In some of the lower areas the water table is high, but the type as a whole is very well drained and free from alkali. In places it is subject to overflow, fresh material of varying texture being added at each flood.

Although of small extent, this type is important. It is well suited to a wide range of intensive crops, and nearly all of it is under cultivation. Truck crops, peaches, grapes, and apricots are the principal crops, and good yields are obtained. Most of the type lies too low for success with citrus fruits. It is well situated with reference to roads and shipping points. Much of it lies within the city limits of Los Angeles.

## CHINO SILT LOAM.

The Chino silt loam, to a depth varying from 1 to 6 feet, consists of a dark brownish gray to nearly black, friable, micaceous silt loam, seldom carrying any coarse material. The texture is variable in places, owing to the action of stream currents, and the type includes small patches or strips of fine sandy loam in the higher situations and small bodies of silty clay loam or clay loam in the lower and flatter positions. The color is also quite variable. A distinct dark-brown or dark grayish brown cast appears in many places, and the type includes some material closely approaching the brown soils of the Hanford series.

The lighter textured areas are lighter in color and lower in content of organic matter. In places the presence of alkali gives the soil a slaty color and a compact structure. The soil rarely continues uniform in texture to 6 feet in depth. Generally below 12 or 18 inches the subsoil consists of brown or grayish-brown strata of silt, clay, and fine sand. The lighter textured parts of the subsoil usually

are brown, and the heavy portions are nearly always dark colored and contain varying quantities of small calcareous nodules or concretions. The subsoil is somewhat lighter in color and coarser in texture in the higher and better-drained situations. It frequently is mottled with gray and brown where drainage is poor. The type contains a moderate to large amount of organic matter. Its silt content prevents cracking to a large extent and makes possible the formation of a friable seed bed. The soil absorbs and holds moisture well. It is easily tilled and both soil and subsoil are readily penetrated by roots where the water table does not interfere.

The Chino silt loam is an extensive and important agricultural type. It occurs along Compton Creek from Wilmington north nearly to Huntington Park, and on the uniform alluvial plains south and southeast of Los Angeles. Small areas are encountered northeast of Long Beach, south of Montebello, along the Los Angeles River northeast of Los Angeles, west of Exposition Park, south of Culver City, southwest of Whittier, east of Hyde Park, and northwest of Downey. The type occupies a very gently sloping to nearly level surface which is smooth and easily prepared for irrigation. The low-lying position of much of the type and the sluggish movement of streams passing through it give rise to a permanent water table at depths usually less than 6 feet in the lower parts of the type. The higher lying portions are much better drained. During wet weather the water table rises to the surface in places and constant evaporation over large areas has caused the accumulation of injurious amounts of alkali. Some of the low-lying bodies tend to puddle and bake quite badly and are not suited to crop production unless drained and reclaimed from alkali. Considerable drainage has already been done over part of the type, resulting in marked improvement in alkali and water-table conditions. The soil in such case is well suited to the production of a wide range of profitable crops.

Practically all the type, except a few small bodies containing an excess of alkali salts, is cultivated. The principal crops grown are sugar beets, alfalfa, walnuts, potatoes, corn, berries, grain, grain hay, and deciduous fruits and truck crops. Lima beans are grown to some extent. Many crops yield well in favorable years without irrigation, but the returns are increased where water is applied. Grain and grain hay are grown in rotations and usually yield well. In alkali-affected areas with an unusually high water table crops are irregular, and there are many stunted, discolored plants and bare spots. Low, poorly drained places are avoided for tree fruits. The presence of alkali checks the growth of most legumes. Some commercial fertilizer is used for certain truck crops and berries, but manure is preferred where obtainable. Good highways and railroads give all parts

of the type excellent outlets. Water for irrigation is readily available by pumping and the type is in great demand for intensive crops where drainage conditions are favorable. Land prices are high, the type renting for \$15 to \$45 an acre per year in areas where the most intensive crops are grown.

*Chino silt loam, light phase.*—The Chino silt loam, light phase, is mapped in four areas, aggregating about one-half square mile in extent, lying southwest of Clearwater, southeast of Compton, and two east of Watts. The soil consists of a dark grayish brown to black, friable, micaceous fine sandy loam, and rests on a subsoil usually somewhat lighter in texture. This phase is better drained than the Chino silt loam, but in other respects it closely resembles the typical soil. It is high in humus, is easily tilled, is retentive of moisture when well handled, and is well located. The phase is all under cultivation except some small areas which are badly affected with alkali. It is used for the same crops as the typical soil.

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

*Mechanical analyses of Chino silt loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574139.....	Soil.....	0.1	0.4	0.4	10.2	23.6	52.2	13.1
574140.....	Subsoil.....	.2	.4	.3	7.0	23.2	47.0	22.0

The following samples contained more than one-half of 1 per cent calcium carbonate ( $\text{CaCO}_3$ ): No. 574139, 1.45 per cent; No. 574140, 2.84 per cent.

#### CHINO CLAY LOAM.

The soil of the Chino clay loam consists of 12 to 18 inches of dark-gray to black, in places brownish, rather friable, micaceous clay loam, relatively high in silt. The subsoil is of brown or dark grayish brown, stratified layers of clay, silt, or fine sand, the heavier textured layers carrying varying numbers of small calcareous nodules. In some places the subsoil is lacking, the soil continuing to 6 feet or more without change. Poor drainage has developed mottled gray, brown, and yellow subsoil colors in many places, and the material is saturated at depths ranging from 3 to 6 feet. Both soil and subsoil are generally free from gravel or coarse, gritty material, and where well drained and free from alkali are readily penetrated by roots.

The type is high in organic matter and usually forms a desirable seed bed when tilled at the right degree of moisture, unless it has been puddled by standing water and alkali, as is sometimes the case in low spots.

In the flat region about 3 miles east of Palms the type is unusually high in organic matter and includes a few small, shallow areas of material closely resembling muck or peat. The proportion of organic matter here is gradually diminishing as a result of oxidation and burning and the admixture of mineral matter by tillage. The type as mapped also includes some low, flat patches of puddled clay in the more level situations, as well as some small patches or strips of silt loam or silty clay loam along intermittent streamways and overflow areas.

The Chino clay loam is well developed west and southwest of Los Angeles. Smaller areas lie south of Eagle Rock Valley, west of Compton, north of Long Beach, and southwest of Culver City. The type has a smooth and uniform surface except locally, where it is crossed by the channels of small intermittent streams. It lies slightly lower than the Chino silt loam and usually is not quite so well drained. Injurious amounts of alkali have accumulated over portions of the type, and this in conjunction with the high water table has greatly impaired its agricultural value in such places. Some drainage has been done, with excellent results.

All of the type, except small poorly drained tracts with a high alkali content, is highly improved and under cultivation. Truck and sugar beets are the leading crops, followed by corn, potatoes, alfalfa, tomatoes, lima beans, berries, grain, and grain hay. Crops give good yields where the soil is well drained and free from alkali, but irrigation is required for the best results with practically all crops except lima beans, grain, and grain hay. Water for irrigation is available by pumping from shallow wells and the pumping of large quantities generally benefits the land by lowering the water table.

The soil requires more careful handling than the Chino silt loam to prevent puddling and formation of clods. For best results the type needs to be drained, freed from alkali, and given thorough tillage. It is readily accessible over good roads, and is well located with reference to shipping points. Land values are high, areas best adapted to intensive crops renting for \$20 to \$40 an acre per year.

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

*Mechanical analyses of Chino clay loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574145.....	Soil.....	0.4	2.9	2.6	14.6	15.0	42.5	21.9
574146.....	Subsoil.....	5.1	5.6	2.9	10.8	18.7	39.3	17.6

The following samples contained more than one-half of 1 per cent calcium carbonate (CaCO<sub>3</sub>): No. 574145, 3.56 per cent; No. 574146, 1.13 per cent.

## YOLO SANDY LOAM.

The Yolo sandy loam consists of a brown or grayish-brown, non-micaceous though friable sandy loam, containing a small proportion of gravel or other coarse material in places. In areas situated on alluvial fans the soil extends to 6 feet or more without change, but along streams a subsoil is encountered at 12 inches. This consists of imperfectly stratified layers of sand, silt, or gravel. The soil is lightest in texture and contains the greatest amount of gravel along streamways, where overflows sometimes occur. Such areas are also lighter colored and lower in organic matter, and less retentive of moisture. Areas containing a large proportion of gravel are indicated on the map by symbols. If more extensive, these would be mapped as a gravelly type of the series.

Small patches or narrow strips of sand or gravelly sand sometimes occur in stream bottoms. The soil here is somewhat more difficult to till than elsewhere. As mapped, the type includes a very light textured variation lying along the base of the San Pedro Hills on the north side. Much of the soil in these small bodies is coarse and in places consists of a rather loose sand.

The Yolo sandy loam is easily tilled and absorbs moisture well. In general it requires little leveling for irrigation. The type is lower in organic matter than the Yolo loam and, except in the area north of Gardena, is inferior in crop production. Where the soil is uniform to 6 feet in depth the type is retentive of moisture and well adapted to deep-rooted crops, but where the subsoil is porous water leaches away rapidly and crop yields are irregular and uncertain.

The Yolo sandy loam is of little agricultural importance, because inextensive. It occurs in a number of small areas widely distributed over the western half of the survey, principally north of Gardena and southeast of Palms. Other small areas are situated northwest of Sawtelle, southeast of Redondo, northwest of San Pedro, and southwest of Lomita. The type occupies stream bottoms, alluvial fans, or footslopes. It usually has a smooth surface, with sufficient slope to give good drainage and insure freedom from alkali.

This soil is all under cultivation except where it occurs in strips along stream courses or on small alluvial fans which are porous and droughty and of little value for crops unless liberally irrigated. Some trees and bushes grow along streamways at the base of the Santa Monica Mountains, such areas being used for pasture. Grain and grain hay are the principal crops grown, and yields are light and uncertain. The better areas, where water is available for irrigation, are devoted to deciduous fruits and truck crops, with good success. The type is accessible. It is lower in agricultural value than the Yolo loam.

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

*Mechanical analyses of Yolo sandy loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574149.....	Soil.....	4.8	15.4	11.0	31.8	16.8	14.6	5.9
574150.....	Subsoil.....	2.7	13.4	9.9	29.9	15.2	15.7	13.3

*Yolo sandy loam, heavy phase.*—Areas of the Yolo fine sandy loam are shown on the map as a heavy phase of the Yolo sandy loam. If these areas had been more extensive they would have been given a separate color. The soil consists of a brown or grayish-brown friable fine sandy loam. The phase occurs in 4 bodies, one southeast of Redondo, one north of Gardena, and two south of Inglewood. In topography, drainage, and crop range it is similar to the typical Yolo sandy loam, but usually gives larger yields both with and without irrigation.

#### YOLO LOAM.

The Yolo loam consists of a brown or grayish-brown, nonmicaceous loam containing in many places some small to medium gravel. The material is generally uniform to 6 feet in depth, but at any depth between 12 and 36 inches it may become either slightly heavier or lighter in texture, or may be composed of strata of silt, sandy loam, or clay loam containing gravel or coarse, gritty material. The subsoil is generally somewhat lighter in color than the surface soil, often being light brown, yellowish brown, or slightly reddish brown. Pockets or layers of loose gravel occur in the subsoil near the foothills and where the slopes are relatively steep. The substratum resembles the subsoil, and is permeable to roots and water to a depth of many feet.

On the more gentle slopes the type is relatively high in silt. It contains some small areas of textures distinctly heavier or lighter than loam.

The gravel content increases considerably nearer the mountains, and is sufficiently abundant to interfere with tillage in some places. These areas are shown on the map by symbol. Light gravelly and sandy streaks occur along stream bottoms, usually where the type is subject to overflow. The soil here is inclined to be porous and droughty, but where gravel is abundant on the upper portions of old alluvial fans it causes the soil to become compact and to absorb

moisture rather slowly. Elsewhere the gravel content is too small to interfere with tillage or crop growth, or to affect the moisture conditions.

Small bodies of dark-brown or reddish-brown soil are included in the type. The former are the result of poor drainage and the accumulation of organic matter, and the latter of greater age and usually heavier subsoils.

The Yolo loam is friable and easily tilled. The soil has a moderate content of organic matter and both soil and subsoil absorb and retain moisture well in most places, so that the type is well adapted to deep-rooted crops.

The Yolo loam is quite an extensive soil, though it occurs mainly in small areas. These lie along streamways or on minor alluvial fans. The largest areas occur near Sawtelle, Inglewood, and Gardena, southeast of Los Angeles, and in the region about Whittier. Many smaller bodies are encountered along the foothills from Santa Monica eastward across the area surveyed, and also around the north and east sides of the San Pedro Hills.

The Yolo loam occupies gentle slopes, stream bottoms, and alluvial fans. The surface is smooth, except for occasional stream channels. Small streams from higher areas sometimes spread over the surface in places, resulting in great variation in texture, color, and surface features. Drainage is well established and the soil is seldom affected with seepage or alkali.

The Yolo loam is an important agricultural type for both dry-farmed and irrigated crops. Practically all of it is under cultivation. Good yields of grain, grain hay, lima beans, grapes, walnuts, and certain truck crops are obtained without irrigation, and returns are more certain than on the more elevated old valley-filling soils. Yields of highly specialized crops are greatly increased, however, and the crop range made much wider where irrigation is practiced. Truck crops, berries, and deciduous tree fruits are successfully grown on the type under irrigation in the region of Inglewood and Gardena and citrus fruits and walnuts in the region about Whittier. Alfalfa is grown in a small way and gives very good returns where water is applied. No regular rotations are practiced, but a change of cropping is followed by most farmers. Fertilizer is used freely for citrus fruits and certain truck crops. The soil is much improved where manure is added or green crops are plowed under.

The Yolo loam is very well located in regard to roads and transportation facilities. Water for irrigation is costly and difficult to obtain for much of the type west and southwest of Los Angeles.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the Yolo loam:

*Mechanical analyses of Yolo loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574151.....	Soil.....	3.3	6.4	3.8	16.8	17.4	39.8	12.5
574152.....	Subsoil.....	4.8	8.0	4.6	18.0	16.4	34.9	13.2

YOLO CLAY LOAM.

The Yolo clay loam to a depth ranging from 1 to 6 feet consists of a brown, grayish-brown, or dark-brown, nonmicaceous clay loam, usually friable and free from gravel or coarse material. The subsoil in alluvial fans and footslope areas differs little from the soil, but in stream bottoms and in some other places it may consist below 12 inches of strata of materials of different textures. It usually is lighter brown than the surface soil, and in places is slightly compact, as in the region about Whittier, Venice, and Palms. The substratum resembles the subsoil, but is not quite so compact. The entire soil column is readily penetrated by roots and water. Flooding has a tendency to pack and puddle the soil, greatly impairing its physical condition. The soil in some places has an adobe structure. In some areas intermittent streams have spread small amounts of silt or fine sand over the surface.

On the more gentle slopes some areas are not thoroughly drained and here the color is darker, the type gradually merging into soils of the Dublin series. In some of the more elevated situations the soil has weathered considerably and has developed a subsoil slightly heavier and more compact than typical. As mapped the type includes occasional patches of reddish-brown soil which if more extensive would be mapped as soils of the Placentia series. The soil here is more highly oxidized, and the subsoil is heavier and more compact than typical.

The Yolo clay loam is well supplied with organic matter and is retentive of moisture when properly handled. The higher and lighter textured areas are easily tilled, but the more compact and heavier-textured areas clod when plowed and require much subsequent work to form a desirable seed bed.

The Yolo clay loam is an extensive and important soil. Important areas are mapped around Whittier, East Lake Park, and Palms, west of Lomita, southwest of Montebello, and east of Venice, with smaller areas northeast of Los Angeles and northwest of Point Fermin.

The type occupies gently sloping alluvial fans, footslopes, and stream bottoms. The surface usually is smooth, though undulating or dissected by minor streamways in places. Little or no leveling is necessary to prepare the land for irrigation, and water enters the soil readily, unless it is puddled or compacted as a result of improper tillage or continued surface flooding. Some fresh material is added locally by the streams from time to time. These new deposits are somewhat lighter in texture and color than the older deposits and in places contain some fine gravel. Good slope and favorable subsoil structure favor drainage, and only in the small area southwest of Montebello and in one or two others of nearly level or slightly depressed surface is drainage deficient.

In the region about Whittier the type is successfully used for the production of citrus fruits and walnuts. Elsewhere, deciduous fruits, lima beans, alfalfa, truck crops, berries, grain, and grain hay are the principal crops. Grain, grain hay, and lima beans are produced without irrigation, but water is required for satisfactory returns from other crops. With proper tillage and care the soil gives good yields, but its tendency to puddle and pack under poor cultural methods seriously affects yields and makes returns uncertain. The type is practically all under cultivation. It is well supplied with roads and shipping points.

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

*Mechanical analyses of Yolo clay loam.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574153.....	Soil.....	1.4	5.6	4.4	22.4	12.0	35.4	19.0
574154.....	Subsoil.....	1.6	6.4	4.7	22.9	11.8	32.2	20.4

DUBLIN CLAY.

The surface soil of the Dublin clay consists of a dark-gray to black, rather friable, nonmicaceous clay, seldom carrying gravel or other gritty material. It has a dark-brownish cast in places when dry. The soil tends to crack and assume an adobe structure in some small flat or slightly depressed areas. At varying depths below 12 inches the soil grades into a brown, dark-brown, or grayish-brown subsoil. On the alluvial fans and footslopes the subsoil is quite similar to the surface soil in texture and structure, but in stream bottoms it may consist of different textured strata similar to those existing in the Yolo clay loam. The subsoil is sometimes calcareous and small con-

centrations of lime occur in places near areas of older soils. The soil is high in organic matter. It becomes very friable and mealy if handled when in proper condition as regards moisture. If tilled when wet or where irrigated continuously by flooding, however, it tends to bake and become hard, and crops fail to make their best growth.

The Dublin clay is extensive and of little importance. Three small bodies lie east of Venice, one south of Lomita, and one east and two northeast of Palms. The area south of Lomita lies on a slope and has good drainage. The other areas are rather low and level and have rather poor surface and subdrainage.

The Dublin clay is all under cultivation, mainly to grain, grain hay, and lima beans. These crops give good yields where the soil is well handled. Some truck crops, berries, and deciduous fruits are successfully grown with irrigation in favorable situations.

#### DUBLIN CLAY ADOBE.

The Dublin clay adobe consists of a dark-gray to black, heavy clay of adobe structure. In stream bottoms the subsoil below 12 inches consists of strata of silt, sand, or clay, but on slopes and alluvial fans it is usually uniform to a depth of 6 feet or more, and in many places resembles the surface soil except in color and organic-matter content. The color is light brown to dark brown, sometimes mottled where the drainage is deficient. In places the subsoil contains small concentrations of lime, the material here closely resembling that of the Montezuma series.

Some minor variations exist in this soil. The color, for instance, may be dark grayish brown and the texture slightly lighter than clay. In sloping areas the soil is more friable and less compact than in the more nearly level situations or slight depressions. The soil is free from gravel, but sometimes contains small amounts of coarse gritty sand.

The organic-matter content of the surface 2 feet is high, but owing to the heavy texture the soil is difficult to till. It tends to form a rough, cloddy surface if plowed when dry and becomes compact and puddled when wet. If the plowed land is allowed to weather over winter it forms a favorable, well-granulated seed bed which is very retentive of moisture, but under improper cultural methods or where irrigated by surface flooding its physical condition is greatly impaired.

The Dublin clay adobe is of little importance. One small body is mapped south of Whittier, one west and one east of East Lake Park, one northwest of Point Fermin, and one of medium size south and west of Lomita. These occupy footslopes, gently sloping alluvial fans, or nearly level to slightly depressed stream bottoms,

and have a smooth surface easily prepared for cultivation and irrigation. The low-lying area west of Lomita has somewhat stagnated drainage and is covered with standing water in periods of wet weather. The other areas are fairly well drained except during wet weather.

The type is practically all under cultivation. Grain, grain hay, and lima beans are the principal crops. These yield well where good stands are obtained. The irrigated land produces fair yields of truck crops. The type is not well adapted to citrus fruits, but some success has been attained in the growing of berries and deciduous fruits.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Dublin clay adobe:

*Mechanical analyses of Dublin clay adobe.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574157.....	Soil.....	0.2	0.8	0.9	7.2	18.8	40.4	31.8
574158.....	Subsoil.....	.1	.3	.4	7.4	19.4	40.6	31.8

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO<sub>3</sub>): No. 574158, 0.56 per cent.

OAKLEY FINE SAND.

The Oakley fine sand consists of a brown, light-brown, or grayish-brown fine sand, in most places 6 feet or more in depth. Locally the subsoil below 4 feet may be a compact, reddish-brown sand or sandy loam, closely approaching a hardpan in places. There is a range in texture from sand, on the one hand, to a sandy loam, on the other, the latter condition occurring especially on the lower slopes and near heavier textured soils, but such departures from the typical description are unimportant. The type is low in organic matter.

The Oakley fine sand is confined to areas near the coast. It occurs principally in the region from Playa del Ray southward to the San Pedro Hills. It is associated with the Ramona sandy loam and Coastal beach and Dunesand and resembles the former type except in subsoil and substratum. The type has an undulating to rolling or hilly topography, with a smooth surface modified more or less by wind. The ridges and intervening depressions usually parallel the coast, on which the prevailing winds impinge for the most part at right angles.

The rainfall is all absorbed, the open structure of the soil giving good drainage and aeration. The soil drifts in exposed situations.

The Oakley fine sand is quite important, but it does not rank with the heavier textured types of the area. Where the land is held in

large tracts it is used for grain, hay, lima beans, and corn, which give low to moderate yields. Beans and grain are grown in alternate years, as beans do not do well if grown continuously. Beans yield an average of 5 or 6 sacks per acre. Where the type is held in small tracts trucking and the growing of flowers, principally carnations, are important industries. With proper care moderate to good returns are obtained in the better areas. Crops are grown without irrigation, as water is costly and irrigation difficult on such loose soils.

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

*Mechanical analyses of Oakley fine sand.*

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
574159.....	Soil.....	0.1	5.2	5.8	77.0	7.2	2.4	2.6
574160.....	Subsoil.....	.0	1.0	2.4	80.0	5.5	8.7	2.3

ROUGH BROKEN LAND.

Rough broken land comprises areas unfit for use under the prevailing form of agriculture, on account of their topography. The soil is relatively free from rock outcrop and is covered with grass or a dense growth of brush. The land may consist of steep escarpment faces or hillsides with occasional steep-sided gullies. Rough broken land, which is rather extensive, occurs mainly along the northern boundary of the area though, also, to a smaller extent on the slopes of the San Pedro Hills. In the Santa Monica Mountains the soil material is shallow over the bedrock, and, in areas of granite, resembles soils of the Holland series, and in regions of sedimentary rocks the soils of the Altamont and Diablo series. Drainage usually is excessive. The east and north slopes and deep ravines retain moisture longest, on account of the protection from the hot afternoon sunshine, and in such places the vegetation is most abundant. Rough broken land is used principally as pasture land.

RIVERWASH.

Riverwash consists principally of gray sand, being free from gravel in this area, except along the upper course of the Los Angeles River and in the Arroyo Seco, where varying amounts are present. The soil varies greatly in texture, even within short distances, often ranging from coarse sand to silt. It is practically nonagricultural, owing to its flood-swept position—the bottoms of

intermittent streams. In the sandy areas the material usually is incoherent to a depth of several feet, although sand and silt may be interstratified. After the recession of flood waters in early summer winds frequently remove considerable sand to adjoining areas. Annual contributions of sediment by floods tend to fill and choke the stream beds, and after a building process continues for a few years the streams are forced out of their existing courses and form new channels through lower lands, where the cycle is repeated. Vines and willows gradually encroach upon the stream beds as they become clogged. This further checks stream currents, and such areas gradually become covered with a surface layer of fine sandy loam or silt which when cleared and protected from overflow forms good soil.

Riverwash is mapped along the Los Angeles and San Gabriel Rivers and the Rio Hondo. Some small areas are used to grow certain truck crops during summer, and fairly good yields are obtained where the soil contains enough fine material.

#### TIDAL MARSH.

Tidal marsh, as mapped in this survey, includes a wide variety of sediments laid down near tide level, and more or less subject to inundation by salt or brackish water. The soil ranges in color from gray or brown to black, and in texture from sand near the ocean shore to heavy, plastic clay farther inland. There is no essential difference in texture between soil and subsoil, but the latter is mottled with red or yellow in places, is somewhat stratified locally, and in some places contains small calcareous nodules in the heavier subsoil layers.

Tidal marsh is confined to a low, flat area southeast of Venice, one east of Wilmington, and another east of Long Beach. There is little variation in the surface except for a number of winding sloughways and small lagoons. The area southeast of Venice is separated from the ocean by a rim of sand dunes traversed by narrow passageways through which the tides flow and ebb and which serve as outlets for flood waters from inland areas. The permanent water table usually is a few inches below the surface, and salts, principally sodium chloride, are present in large amounts in both soil and subsoil. Drainage and reclamation usually are accomplished by means of levees, open canals, tide gates, and pumping.

Tidal marsh is naturally nonagricultural. In its native state it usually supports a heavy growth of pickle weed. This land has been successfully reclaimed in other sections of the State, and all the type in this area can probably be brought under tillage.

## COASTAL BEACH AND DUNESAND.

Coastal beach and Dunesand comprise areas of loose, incoherent sand occurring along the ocean front from Santa Monica to Redondo, from San Pedro to Long Beach, and in the region of Alamitos Beach. The gently sloping water front forms the beach portion and the contiguous undulating to roughly rolling, landward rim, the dune part. The beach sand occurs as a very narrow belt, rarely one-fourth mile wide, and partly subjected to inundations at times of high tides and severe storms. The dunes are wind-blown products of the beach sand. In some places the strip of Dunesand is about one-fourth mile wide. The material is a brown to gray sand containing considerable fine material. Where it occurs above inundation and is protected from drifting it is retentive of moisture and capable of growing a wide range of truck crops. Few dunes occur where high bluffs front on the ocean. They are largely confined to unprotected areas of low back country most exposed to winds. Only a small portion of this land is farmed.

Several rather small areas mapped with the Coastal beach and Dunesand consist of material which has been dredged from harbors and inland channels and which if more extensive would be mapped as Madeland. It consists principally of gray or light grayish brown sand and shells with a small admixture of silt and clay, and occurs as it was left after dredging operations, except for some leveling and reworking by wind. The principal areas of this material occur along the ocean front from San Pedro to Long Beach with smaller areas in the southeastern corner of the survey. The material in general has been placed in low marshy areas to elevate them above high-tide level. The soil varies in depth from 1 to 6 feet or more. It usually is well drained and the land is used for building sites. It has little agricultural value, but some small areas are devoted to trucking.

## IRRIGATION.

Owing to the low rainfall, especially in the spring and summer, irrigation is necessary in the Los Angeles area for the greatest returns with most crops. This is especially true in the case of fruits; where a succession of crops is grown in the same field each year; on shallow soils; on soils deficient in organic matter; and in areas of excessive drainage or unfavorable exposure.

Settlers on the lowlands began irrigation at an early date, and all the readily available surface water was soon diverted from the streams. This supply has since been supplemented by large volumes of underground water made available by pumping and by artesian wells. The San Gabriel River and the Rio Hondo, with a few creeks in the mountains bordering the area, supply practically all the water

obtained by a simple diversion. The volume from these sources is about 200 second-feet in an average year. Much larger supplies are obtained by pumping. Artesian wells furnish relatively small amounts, and in some years require pumping during the driest part of the summer. All the water is of good quality for irrigation except some of that obtained from deep wells or from saline, swampy areas. The total amount of water available depends upon the rainfall over the area surveyed and in the watershed of the streams entering it from the north. Underground water is abundant in the recent sedimentary deposits south and southeast of Los Angeles, and large volumes are obtained with an average lift of 40 to 60 feet. The cost of water increases rapidly as the lift becomes greater, and the higher the lift the narrower becomes the range of profitable crops. The limit of available underground water apparently has not yet been reached, and, in addition, a surplus from the city supply of Los Angeles is available for irrigation within the city limits.<sup>1</sup>

About one-half the pumped water is supplied by companies which distribute it to the users. The remainder is obtained by individual owners.

The cost of water varies greatly, depending upon the lift, the supply available, the distance of consumers from the source of the supply, the type of engine and pump used, and the source of power. Gravity water is the cheapest, the cost averaging about \$6 an acre per annum. The cost is much greater for pumped water, in the irrigation of citrus fruits averaging \$10 to \$15 an acre per year.

Water is distributed to consumers through pipes or cement-lined ditches in order to prevent loss by seepage and evaporation. The furrow system prevails in the irrigation of fruits and truck crops, and flooding in checks or by movable pipe lines is the usual practice in alfalfa growing. Other methods are used to some extent. The efficiency of the different methods depends much on the type of soil. Flooding the surface generally is considered injurious to soil structure on loams or heavier textured types, a cloddy surface usually resulting.

The duty of water varies greatly, depending upon the available supply and upon whether the water is obtained at a flat rate or at a unit cost per acre. The flat-rate charge usually results in wastefulness and, at times, injury to the soil. The duty is also less where the supply is plentiful and most easily available. In addition to the rainfall about 2 acre-feet per annum is applied for citrus fruits over

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<sup>1</sup> For more detailed information regarding water resources of the area, see Water-Supply Paper No. 139, U. S. Geological Survey, on "Development of Underground Waters in the Western Coastal-Plain Region of Southern California," by W. C. Mendenhall; Water-Supply Paper No. 138, U. S. Geological Survey, on "Development of Underground Waters in Central Coastal-Plain Region of Southern California," by W. C. Mendenhall; and Report of the Conservation Commission of California, 1912.

the more uniform and gently sloping areas. For alfalfa a total of about  $2\frac{1}{2}$  acre-feet is used each year, distributed through about five irrigations. Practically no use is made of the sewage waters from Los Angeles at the present time. With the rapid growth in population and the increased consumption of water, a large volume of water and a great amount of fertility are lost annually.

#### ALKALI.

At the time the earlier soil survey of the Los Angeles area was made<sup>1</sup> a map was prepared showing not only the locations of alkali soils but also the average amounts of alkali salts in the soil to a depth of 6 feet. In the present survey a separate alkali map has not been prepared, the alkali conditions being indicated upon the soil map.

In this, as in the former survey, the distribution of alkali as shown upon the map was determined by numerous field tests by the electrolytic-bridge method. Average percentages of total salts present to a depth of 6 feet were determined. Areas indicated by the symbol [S] either contain alkali in small amounts uniformly distributed through the soil column in local concentrations too small to injure any crops except the most sensitive legumes and tree fruits, or consist of alternating barren spots of high salt concentration and alkali-free areas so mixed that differentiation is not feasible. Areas indicated by the symbol [A] contain enough alkali either greatly to reduce the producing power of the soil or to render it entirely worthless for the production of crops until reclaimed.

The largest area of alkali-affected land extends from a point near Culver City southeastward to the boundary of the survey at Bellflower and southward to the coast near Long Beach and Wilmington. A smaller area occupies lowland between Santa Monica and Playa del Ray and extends eastward for 3 or 4 miles. Two small isolated areas of alkali land lie on the plain west and southwest of Montebello. These areas are not shown on the map. In and adjacent to the Tidal marsh along the coast the regular overflow and evaporation of ocean water has resulted in the accumulation in places of enough alkali salts to prevent the growth of even the most alkali-resistant vegetation. Away from the coast alkali accumulations are mainly due to poor drainage, a high water table, or seepage from higher lying areas. In some places the unchecked flow of artesian wells has resulted in the accumulation of alkali over areas of considerable extent.

Most of the alkali-affected areas occur in the recent-alluvial soils, those of the Hanford, Chino, and Tujunga series, situated within

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<sup>1</sup> See Soil Survey of the Los Angeles Area, California. Field Operations of the Bureau of Soils, 1903.

the alluvial plains of the Los Angeles River, the Rio Hondo, and the San Gabriel River. Small amounts of alkali occur in the vicinity of Bouton Lake in an area of older soils of the Ramona series, as well as in an area of Montezuma soils west of Culver City and Inglewood. The occurrences in the latter areas are not outlined on the map. West and northwest of Nigger Slough, in an area of old valley-filling deposits, the surface soil is entirely free from excessive alkali, and none occurs in the subsoil to a depth of 5 feet, but below this, extending to 10 or 12 feet below the surface, alkali is commonly present in concentrations as high as one-half of 1 per cent. Below this the soil is again free from alkali.

In areas where there is a sandy subsoil and a high water table practically all of the alkali occurs in the surface 12 inches. The greatest concentrations of alkali commonly are associated with soils heavier than loam in texture, and in such cases the salts are generally distributed uniformly throughout the soil material to a depth of 6 feet. In other localities with medium to light-textured surface soils and heavy subsoils, the concentration of salts is often greater in the subsoil. In the Tidal marsh, except where the soil is leached by recent floods, alkali occurs quite uniformly throughout the soil column, regardless of the texture.

The following table gives the results of a chemical analysis of a composite sample of alkali crusts obtained from inland areas in the region south and southeast of Los Angeles:

Constituents of alkali crusts.	Parts per 100,000.
Carbonates, as $\text{CO}_2$ .....	0
Bicarbonates, as $\text{HCO}_3$ .....	470
Chlorides, as $\text{Cl}$ .....	2, 220
Sulphates, as $\text{SO}_4$ .....	16, 120
Calcium, as $\text{Ca}$ .....	455
Magnesium, as $\text{Mg}$ .....	461
Potash, as $\text{K}$ .....	121
Sodium, as $\text{Na}$ .....	7, 883
Total salts.....	27, 730

The composition of the alkali varies with the location, sodium chloride predominating in and near Tidal marsh and sodium sulphate in other localities. Sodium carbonate, or black alkali, is conspicuous in patches south and southeast of Los Angeles. It is mainly confined to the surface foot of soil, and its presence usually is indicated by a brown or black discoloration of the surface. It is more injurious than sodium sulphate, and has a marked tendency to puddle the soil and thus impair its physical condition.

Aside from the Tidal marsh lands, an area of several hundred acres adjacent to Clearwater on the south comprises practically all the land that is untilled because of the presence of alkali. Most of

the cultivated lands affected with alkali are used for sugar beets, barley, and alfalfa, and numerous trucking centers have developed where the alkali content of the soil is not too high for such crops.

Field tests at the present time show the area affected by alkali to be as large as, or larger than, that at the time of the former survey, but in most places there are now, except in the Tidal marsh lands, smaller amounts than in 1903. This is due partly to the long-continued cultivation and irrigation of alkali-affected districts and partly to the installation of open ditches and tile drains in localities where both unfavorable alkali and ground-water conditions previously existed. No figures are obtainable as to the acreage which has been drained, but it is large and much good has resulted both in lowering the water table and in removing in solution much of the alkali salts present.

Areas only slightly affected tend to improve under irrigation, provided the water table is kept at proper depth. Alkali-affected areas not irrigated, drained, or tilled usually continue to grow worse unless the unfavorable conditions causing the formation of alkali are removed. Suburban development is covering considerable areas of alkali land. Alkali areas capable of producing profitable yields of beets, grain, and certain other crops without irrigation will probably continue in cultivation without much effort to reduce the alkali condition. The light-textured alluvial types, well located and suitable for irrigation, can be profitably reclaimed for intensive crops, but the alkali should be thoroughly removed and the water table lowered to a depth of 6 feet or more before fruit trees are planted.

The Tidal marsh lands have little or no agricultural value until reclaimed. Similar areas elsewhere in the State have been reclaimed at a reasonable cost by the installation of drains and by flooding and pumping drainage waters over inclosing levees.

#### SUMMARY.

The Los Angeles area is situated in Los Angeles County, in southern California, and covers an area of about 563 square miles, or 360,320 acres. The eastern half of the area consists of an extensive, nearly level alluvial plain in which the larger streams have reached base level and are now rapidly building up their flood plains, extensive deposits of sediments being laid down in places each year. The western half includes a series of elevations, of which the San Pedro Hills are the most conspicuous. The northern boundary is flanked by the eastern extension of the Santa Monica Mountains and the San Rafael and Puente Hills. The Los Angeles and San Gabriel Rivers and the Rio Hondo are the principal streams of the area, but even these are intermittent. The water table is high over much of the southeastern half of the area, but otherwise it is well drained.

The area is thickly settled. Los Angeles is the chief city. Several commercial and attractive residential cities and towns are situated along the ocean front to the west and south. An excellent system of highways and electric railway lines reaches nearly every part. The Southern Pacific; Atchison, Topeka & Santa Fe; and the San Pedro, Los Angeles & Salt Lake Railroads enter Los Angeles and have a number of branch lines radiating to various parts of the area. The city limits of Los Angeles now extend to the ocean at San Pedro, at which place an extensive harbor is being developed.

The climate is mild in winter and pleasant in summer. Frosts are not severe and seldom damage any except the most tender plants. The annual rainfall at Los Angeles averages 15.58 inches, nearly all of which occurs from November to May, inclusive. The atmospheric humidity is higher than in the more inland districts, and cool breezes from the ocean keep the temperatures comparatively uniform. Hail storms and destructive thunderstorms are very rare. Some damage is caused by floods over the lower lying portions of the area.

The agriculture of the Los Angeles area is highly developed, and many valuable crops, such as oranges, lemons, walnuts, sugar beets, lima beans, deciduous fruits, and truck crops, are grown. Alfalfa, grain, grain hay, and other general farm crops are also extensively grown. Irrigation is necessary for the best returns. Almost all crops are irrigated. Grain, hay, beans, and some other crops are usually grown where irrigation has not been developed. Good yields are generally obtained. Very little fertilizer is used except for citrus fruits. Dairying is quite extensively developed, but the dairy products are not sufficient to supply the local demands. Trucking is the principal agricultural industry. It is conducted almost entirely by Japanese. City and suburban subdivisions are quite rapidly encroaching upon the desirable farm lands, and the area of farm land is diminishing each year. Land values are high and are seldom based upon crop returns.

Many different soils occur in the Los Angeles area. The soils differ widely in origin, color, physical properties, drainage, alkali content, fertilizer requirements, and crop adaptation. They are classified into four groups. Thirteen series are recognized. The differentiation between the series is based on origin, mode of formation, age, color, and other physical and chemical properties constituting important soil differences. Granite, schist, sandstone, and shale rocks have contributed most of the soil material, and alluvial agencies are mainly responsible for its present position. The soils are productive and have a range in texture favorable to high specialization in cropping. They are practically all under cultivation.

Most of the crops grown are irrigated. Irrigation results in greatly increased yields, and frequently makes it possible to grow two or

more crops in one year. Some water is obtained from the streams by simple diversion, but underground sources are drawn upon to a much greater extent. Large supplies of water of good quality are obtained at relatively shallow depths. Water is generally distributed by flooding, by movable pipe lines, or by furrows. Flooding works well on light-textured soils, but is harmful on the heavy types. The duty of water varies with the supply and cost, but water generally is economically used.

In the southeastern third of the area the water table is prevailingly high, and injurious amounts of alkali have accumulated over considerable areas. Alkali occurs both in continuous areas of small extent and in patches, as well as in amounts too small to affect plant growth. Sodium sulphate prevails over inland areas and sodium chloride or common salt in the marshes along the coast. Black alkali has developed in some small accumulations. Considerable areas have been drained and much of the alkali removed by leaching, with consequent greatly increased yields and a wider range of crops.



[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved March 14, 1904.

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



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