SOIL SURVEY OF THE BAKERSFIELD AREA, CALIFORNIA.

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LOCATION AND BOUNDARIES OF THE AREA.

The Bakersfield area, with which this report deals, lies in the extreme southern or upper portion of the San Joaquin Valley.

Although small in extent, consisting of only about 200 square miles, the area surveyed includes nearly all the irrigated lands about the

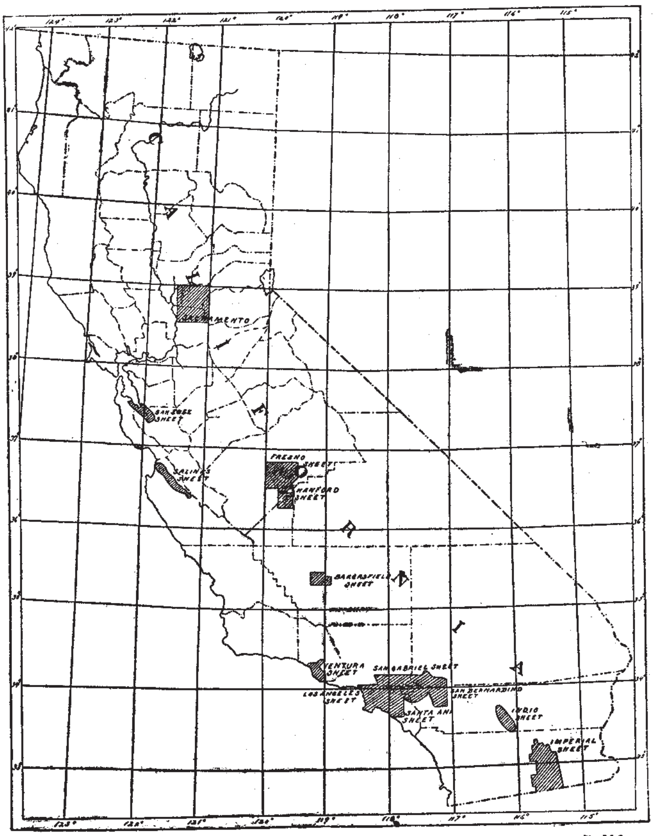

FIG. 44.—Sketch map showing location of the Bakersfield area, California.

city of Bakersfield, and is representative of the lands of the San Joaquin Valley of this section of the State.

[a] The authors were assisted in the field work of this survey by Messrs. W. W. Mackie and A. T. Strahorn.

With the exception of a few square miles of nonagricultural land in the northeastern corner, the survey covers a rectangular area of six townships. Of this area the southern and central portions are most important from an agricultural standpoint. In addition to the farming lands, the area includes a relatively large extent of unirrigated lands, grazing lands, and alkali lands of nominal value.

To the north of the area mapped extends a great stretch of tillable land, capable of being rendered very valuable under irrigation. At one time a large area of this land was under cultivation, but it has now reverted nearly to its original desert condition, owing to the use of the limited water supply upon the more thickly settled districts of the Kern River Delta. To the west and south lie vast bodies of grazing lands, with here and there a small irrigated tract. These lands, while valuable to the beef-producing industry, are for the most part nonirrigable under the present conditions of water supply, and merge into the dry bed of Kern Lake and the swamp and desert lands of the valley trough. To the eastward of the area surveyed stretches a nearly barren desert. This desert land extends to the base of the mountains, and, with the exception of small, favorably situated tracts dry farmed to wheat, is in its present condition of little or no agricultural value.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The early history of this region, like that of many other now important agricultural districts of the Southwest, is that of the desert—dry, barren, and desolate. To the south lay Kern and Buena Vista lakes, into which emptied the waters of the Kern River. From these lakes the overflow found its way through Buena Vista Slough and Swamp into Lake Tulare, some distance to the northward, said to have been at one time the largest body of fresh water west of the Rocky Mountains.

The first settlement of this part of California was made by the Mission fathers and by authority of Spanish land grants. Gradually the lands came to be recognized as of value for grazing purposes by the few settlers, chiefly of the Spanish or Mexican races. An abundance of game, consisting chiefly of antelope, elk, and wild fowl, ranged the plains or thronged the tule lands of the lakes and swamps. Droves of hogs and bands of horses, escaped from domestication, ran wild over the valley. As in many other sections of the State, grazing led slowly to the introduction of cereals and alfalfa as staple crops. This was made possible, however, only with the introduction of irrigation.

As early as 1864 the construction of artificial channels and the diversion of water from the Kern River for purposes of irrigation took place. These early efforts were only partially successful. Temporary headworks were swept away, water-ways were filled with débris, and old natural stream channels obliterated by the sudden and violent spring freshets. For several years diversion ditches were but small and temporary affairs, and the methods of irrigation were crude and primitive. Later on companies were formed for the construction and maintenance of more extensive and enduring systems. The construction of the Kern Island Canal—the earliest of the main canals of the present system covering the delta lands—took place during the period from 1870 to 1874. This canal is entitled to a priority of 300 second-feet over all others, has a carrying capacity of 500 second-feet, and with its branches cost about $200,000. The construction of additional systems covering other sections of the area followed, and the primitive means of applying water by "wild" flooding gave way to more exact and economical methods, while with these improvements a rapid rise in land values occurred and interest in the growing of alfalfa and other general farm crops increased.

For a time successful irrigation led the oversanguine to hope for much more than could be obtained from a limited water supply. Canal construction seemingly ran riot, and many thousands of dollars were invested in expensive systems under the Galloway and Beardsly canals and covering a large area of valley lands lying northwest of Bakersfield. Then a succession of dry seasons, coupled with the extension of irrigation upon the delta lands and the appropriation of almost the entire available water supply by those systems holding prior rights, led to failure and the abandonment of large tracts.

With the use of Kern River water for irrigation purposes, less and less found its way into Kern and Buena Vista lakes, while lands subject to occasional inundation were successfully diked, and thus many thousand acres were reclaimed for grazing and agricultural purposes. By the construction of an extensive system of levees the flood waters which occasionally found their way to the valley trough were confined in Buena Vista Lake, which now serves the purpose of a reservoir, with a capacity reckoned at 150,000 acre-feet. The outlet is by way of Buena Vista Slough and an artificial channel of the Kern Valley Water Company into Tulare Lake.

With the recent business activity and increase in population due to the development of mineral-oil interests, local markets offer increased inducements for the products of agriculture.

CLIMATE.

The weather records of the Bakersfield area are somewhat incomplete. The average annual rainfall, however, is about 5 inches, nearly all of which occurs during the rainy season. From November to

April is considered the rainy period, although the fall rains are often delayed until well into the winter, and the total annual precipitation is subject to considerable variation. The rain usually comes in gentle or steady showers, thunderstorms and cloudbursts being very rare, except in the mountains.

A table giving temperature and precipitation for the Bakersfield area follows.

Normal monthly and annual temperature and precipitation.

Month.	Bakersfield.		Month.	Bakersfield.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° F.	*Inches.*		*° F.*	*Inches.*
January	48.1	1.11	August	84.7	0.01
February	52.4	.51	September	75.8	.13
March	57.9	.93	October	66.0	.47
April	64.7	.22	November	55.9	.38
May	72.9	.18	December	48.2	.80
June	81.9	.05	Year	66.4	4.81
July	88.6	.02			

During the winter and early spring months the days frequently become quite warm, though sometimes followed by frosty nights. This unfortunate condition attending an otherwise subtropical climate renders the growing of citrus and other delicate fruits impossible, or at best a matter of great risk. During the dry summer months the temperature reaches a maximum exceeded in but few localities within the boundaries of the United States. The extreme degree of heat attained during the day is, however, greatly modified by the low relative humidity, and the heat is much less oppressive than the readings would indicate. Although temperatures ranging from 110° to 120° F. are experienced, sunstroke is almost unknown. The nights are generally cool and pleasant.

The low relative humidity is also important in its relation to evaporation. With the associated conditions of cloudless skies and high temperatures evaporation takes place very rapidly. The necessity of keeping soil surfaces shaded by a dense covering of crops, or covered by a loose mulch maintained by frequent cultivation, is a matter of more than ordinary importance in this area.

During the winter and spring months sudden dust storms and brisk winds frequently occur. During the summer period the prevailing winds are from the northeast and are light and steady in character.

The proportion of cloudy days is very small. During the dry season clouds are rarely seen. Fogs occur during the winter months, but are not always a prominent climatic feature.

Although malarial diseases sometimes prevail, owing, it is believed, largely to poor drainage conditions in portions of the area, the climate as a whole is healthful, and such as, with the aid of irrigation, to hasten a vigorous vegetable growth.

PHYSIOGRAPHY AND GEOLOGY.

One of the most striking features of California is the great central valley. Formed by the conjunction of the Sacramento and San Joaquin valleys, it extends in a northwesterly and southeasterly direction through the north-central portion of the State for a distance of some 400 miles. It is with the upper part of the southern or San Joaquin Valley that we are concerned.

In physiographic as in climatic features the San Joaquin Valley is remarkably uniform. Its eastern wall is formed by the Sierra Nevada Mountains, a range of unusually high peaks, snowy crests, precipitous slopes, deep canyons, heavy precipitation, dense forests, and important perennial streams. To the northeast of the area surveyed the mountain slopes become less precipitous and the altitude lower, merging into the ridges of the Tejon and San Emidio mountains and forming the semicircle inclosing the southern extremity of the valley. Although the summits are subject to considerable precipitation during the rainy season no streams of importance find their way to the valley.

Upon the west the Coast Range rises from the valley in a succession of rolling hills and ridges, usually reaching an altitude of from 2,000 to 4,000 feet. These are dissected by narrow canyons—the courses of intermittent streams that during the rainy season disappear upon the slopes below. No perennial streams having their sources in these ridges reach the valley trough. The Coast Range hills—rarely and only for short intervals covered with snow—hot, dry, and, save in the vicinity of stream courses, barren, are thus in striking contrast to the heavily forested, humid summits of the Sierras.

Formed by the melting snows and heavy rains of the mountains, torrents rush down the inclines and through the canyons, gathering as they go the soil and rock débris. When the slopes of less degree are reached the water spreads outward, and the velocity and transporting power of the stream is lessened, while the water sinks into the desert soil. The load of the débris is thus spread outward in gently sloping fanlike forms. This process many times repeated has resulted in the gradual coalescing of the numerous canyon fans, finally producing the valley plain with nearly smooth, uniform surface sloping slightly from the base of the mountains toward the valley trough.

Owing to the heavier precipitation and greater run-off, the débris removed from the Sierras greatly exceeds that carried away by the insignificant streams of the Coast Range, resulting in the formation of a much more extensive valley plain upon the east side, and the pushing to the westward of the valley trough or axial drainage depression. More recent distribution of the alluvial material by the larger perennial streams of the Sierras has in places resulted in the formation of extensive delta deposits overlying the valley plain.

Within the limits of the area surveyed the physiography is simple and without great topographic variety. To the north and east of Bakersfield gradually sloping mesa lands merge into rolling hills and gravelly bluffs cut by the channel of the Kern River. With increasing elevation these extend to the base of the mountains. South of a line drawn directly east from Bakersfield but little foothill or mesa land interposes between the valley plain and the mountain ranges.

At a point about 10 miles east of Bakersfield the Kern River, rising in the high Sierras, after following a southerly course for about 120 miles and presenting splendid natural resources for the development of water power, breaks through the lower ridges in a deep, narrow canyon. It then takes a westerly course between the gravelly bluffs of the mesa lands to a point near Bakersfield. Here the stream becomes wider and more shallow and threads its way through the delta lands to the lake basins lying to the southwest. Owing to the occurrence of warm rains and melting snows in the mountains, the stream is subject to sudden and violent floods during the spring and early summer. At such times the débris-carrying power of the river is greatly augmented. This has led to the obliteration of old channels and the formation of new, and left many sloughs, streaks, ridges, and spits of sandy land.

The delta land known locally as Kern Island extends, with a generally smooth, even surface and uniform slope—6 to 7 feet to the mile—southward and westward to the valley trough marked by Kern and Buena Vista lakes and the swamp lands connecting them with Tulare Lake to the north.

A considerable growth of cottonwood, willow, and sycamore frequently covers the lands bordering stream channels. Upon the soils to the north and east of the delta trees and shrubs are wanting, except for an occasional growth of saltbush and other characteristic bushes usually found on desert or alkali lands. A dense growth of a low-growing form of the prickly pear cactus covers the loose sands along the southeastern margin of the area, while grasses, including salt grass, foxtail, and erodium, cover considerable areas of the valley plains and delta lands utilized for grazing purposes.

The rocks of the Sierra Nevada Mountains, from which the soils of the Bakersfield area are derived, are chiefly granites. Associated with the granites and granitic rock of this range occur large areas of ancient metamorphic and secondary slates, amphibolites, sandstones, basalts, etc. It is probable, however, that the soils of the area are derived very largely from the disintegration of granitic rocks.

The rocks of the Coast Range are often subject to even greater variation in character and complexity of structure than those of the Sierras. The resulting soils are, however, found only upon the plains and delta lands of the western side of the valley trough and do not enter into the formation of the soils of the Bakersfield area.

The soils of the valley are very deep, without rock outcrops, gravel, or bowlders, and were probably laid down in the deep waters of an inland sea or arm of the Pacific once covering the valley.

Within the Bakersfield area recent colluvial material or mountain waste and the alluvial material of the Kern River Delta have formed a more or less superficial stratum overlying the original valley sediments. The thickness of this layer is greatest upon the mesa lands near the northeastern margin of the area. This material here consists of stratified deposits of coarse and fine sands, well-worn bowlders, and gravel, silts, and loams. A stratum of reddish-yellow coarse sandy adobe generally overlies these deposits. Owing to changes in level these materials, of which the greater part was originally laid down by the waters of the Kern River, have since been cut and terraced by the same stream.

Moderately fine waterworn gravel frequently covers the slopes of the mesas and hills.

Certain soil areas are marked by the occurrence of alkali carbonate hardpans, which are treated in a following chapter.

The soils of the delta grade from coarse and fine sands to heavy clay loams and silts. They are generally rich in micaceous material, and the heavy, poorly drained soils are frequently impregnated with the soluble alkali salts.

In the vicinity of the mesa lands north of the Kern River petroleum oils occur in great abundance and have given rise to a great oil-producing industry.

SOILS.

The soil types in the area surveyed may be roughly divided into two classes, according to their origin, viz, alluvial, or sedimentary, soils and colluvial soils. The alluvial soils are found in the Kern River delta, and consist of the Fresno fine sandy loam, Fresno fine sand, Oxnard silt loam, Riverwash, and a part of the Fresno sand. These types owe their origin chiefly to sedimentation from the Kern River.

The colluvial class is made up of the Maricopa sandy adobe, Placentia sandy loam, Maricopa loam, and the remaining part of the Fresno sand. The Maricopa loam also probably owes its origin partly to sedimentation from the Kern River.

No residual soils were found in the area. All the soils were correlated with types previously established.

The following table gives the extent of each of the types, while the accompanying soil map shows their distribution over the area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Fresno sand	43,264	34.6	Maricopa sandy adobe	5,120	4.1
Fresno fine sand	33,920	27.2	Placentia sandy loam	4,928	3.9
Fresno fine sandy loam	23,744	19.0	Oxnard silt loam	1,664	1.3
Riverwash	6,464	5.2	Total	124,928	
Maricopa loam	5,824	4.7			

RIVERWASH.

The Riverwash consists of a few inches of fine sand, of the same texture as the Fresno fine sand, underlain to a depth of 6 feet by a loose, incoherent, generally coarse, micaceous sand. The surface coating of fine sand is absent from the dry stream beds.

The type is found chiefly along the Kern River, is level, and at the time of the survey was well drained and free from alkali.

It is sedimentary in origin, the fine sand coating having been deposited on the lands immediately adjoining the river during temporary overflows of that stream.

With the exception of small areas of this type in the extreme eastern part of the area, the Riverwash is not under cultivation, being used for grazing only.

FRESNO SAND.

Two phases of the Fresno sand are found in the area surveyed, but the distinction between them seems insufficient to warrant a separation into two types. These phases are a compact soil and one that is loose or only slightly coherent. The latter, or loose phase, consists of 6 feet of coarse, micaceous, yellowish sand containing appreciable quantities of clay, but not enough to make it sticky when wet. The compact phase generally consists of 6 feet of coarse, reddish, compact sand, often containing considerable clay, and less micaceous than the loose phase. It compacts well in roads, though easily tilled, and is sometimes underlain at 2 or 3 feet by about a foot of light sandy adobe, which is in turn underlain by loose sand. This phase of the Fresno sand grades into the Placentia sandy loam.

The largest areas of this type are located in the northern part of the area, but small strips are found scattered through its entire extent. It occurs on level plains, gentle slopes, and local, slightly elevated ridges; also at times in small, narrow, slightly depressed areas which represent former stream channels.

The soil is well drained, occupying, as it usually does, the higher elevations. It seldom contains injurious amounts of alkali, and when soluble salts are present they are usually concentrated in the surface foot.

In origin the type is both colluvial and alluvial, the former in the case of the compact phase in the northern part of the area, which is derived chiefly from wash from the foothills to the north; the latter in the case of the loose phase deposited by the Kern River. The two phases, however, grade so gradually into each other that both processes of formation are often responsible for quite large areas of the type.

The principal crops grown are alfalfa, fruit, and raisin grapes. The soil is adapted to any crop suited to the climatic conditions of the area.

The following table, giving mechanical analyses of typical samples of the soil and subsoil, shows the texture of this type:

Mechanical analyses of Fresno sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10510	NW. cor. sec. 30, T. 29 S., R. 27 E.	Coarse sand, 0 to 72 inches	18.6	17.7	9.7	23.9	20.0	6.9	3.3
10508	N. of W. cen. sec. 8, T. 29 S., R. 27 E.	Compact sand, 0 to 12 inches.	9.2	17.9	12.5	24.1	20.8	9.5	6.0
10509	Subsoil of 10508	Compact sand, 12 to 72 inches.	13.3	20.3	12.6	18.7	14.6	12.7	7.6

FRESNO FINE SAND.

The Fresno fine sand is a yellowish micaceous fine sand, containing little coarse sand or grit. Its depth varies from 3 to 6 feet, though perhaps more often it extends to a depth of 6 feet without change. When of less depth, it is underlain to 6 feet with sand, more rarely with fine sandy loam, and rarely with loam. A small area of less than a square mile in the extreme northwestern corner of the area is underlain by heavy adobe or clay loam at a depth of 2 to 3 feet.

The Fresno fine sand is quite generally distributed throughout the area, except in the northwestern township, where only small, isolated areas occur. It occupies level delta plains and narrow, slightly elevated ridges, and owing to its position is generally quite well drained, though some areas in the southwestern township do not have good natural drainage.

The soil is generally of sedimentary origin, being composed of material originally derived from the disintegration of granitic rocks carried down and deposited by the Kern River.

Alkali is quite generally found in soil of this type where not cultivated or irrigated, the maximum amount being usually in the surface foot, with but little in the subsoil.

The principal crops grown are truck, fruit, alfalfa, and raisin grapes, to all of which the type is excellently adapted.

The following table, giving mechanical analyses of typical samples of the soil and subsoil, shows the texture of the Fresno fine sand:

Mechanical analyses of Fresno fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10512	1/4 N. of cen. sec. 11, T. 30 S., R. 26 E.	Fine sand, 0 to 24 inches	0.3	5.0	9.8	47.9	28.0	5.5	3.4
10514	1/16 N. of cen. sec. 18, T. 29 S., R. 26 E.	Fine sand, 0 to 24 inches	1.0	5.2	5.9	48.3	29.7	6.4	3.5
10515	Subsoil of 10514	Fine sand, 24 to 36 inches	1.0	4.6	5.0	48.6	29.5	7.3	3.3
10513	Subsoil of 10512	Fine sand, 24 to 48 inches	.7	5.0	9.3	50.3	25.4	5.5	3.4

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam consists of yellowish or dark-drab micaceous fine sandy loam, quite uniform in texture, and extending to a depth of from 3 to 6 feet. As mapped in the area surveyed, the depth varies irregularly on account of its mode of formation. When not extending to a depth of 6 feet the lower 2 or 3 feet may be sand, fine sand, sandy loam, or rarely, loam. Usually this underlying material is of the same origin as the soil and is in general of much the same character, differing only in texture.

The type is quite generally distributed in the central and southern parts of the area, but very little of it is found in the northern part, though a similar sandy loam material was occasionally encountered there underlying the sandy adobe.

The Fresno fine sandy loam occurs in the level delta plains and in the lower or slightly depressed draws and basins. Generally the drainage is good, though many isolated areas have poor natural drainage, with subsoil water within 4 or 5 feet of the surface.

This type of soil has been formed almost entirely from sediments deposited by the Kern River and originally derived from the disintegration products of granitic rocks in Kern Canyon. Much of the type, where not cultivated or irrigated, contains both white and black alkali, with the maximum amount usually in the surface foot.

The Fresno fine sandy loam is cultivated chiefly to alfalfa, fruit, truck, and raisin grapes and is adapted to any crop suited to the climatic conditions of the area.

The following mechanical analyses show the texture of this type of soil:

Mechanical analyses of Fresno fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10517	½ mile W. of cen. sec. 6, T. 30 S., R. 28 E.	Fine sandy loam, 0 to 12 inches.	1.5	6.4	4.5	12.5	29.9	32.0	13.1
10519	SE. cor. sec. 2, T. 30 S., R. 27 E.	Silt loam, 0 to 12 inches	.5	1.2	1.0	5.1	11.8	61.1	19.3
10518	Subsoil of 10517	Fine sandy loam, 12 to 72 inches.	2.2	4.1	3.3	16.1	26.0	39.9	8.3
10520	Subsoil of 10519	Fine sandy loam, 12 to 72 inches.	1.2	3.4	6.3	25.7	28.5	25.6	9.0

PLACENTIA SANDY LOAM.

The Placentia sandy loam consists of from 12 to 18 inches of compact coarse sandy loam, containing considerable fine sand and fine gravel, underlain to a depth of 3 or 4 feet with heavy, coarse, red sandy loam, quite compact and hard, containing considerable clay and approaching sandy adobe in texture. This is underlain to 6 feet with a lighter phase of the same material, but without the adobe property. The type is intermediary between the compact phase of the Fresno sand and the Maricopa sandy adobe.

This type of soil is located in the northern and northeastern parts of the area. The areas in the latter region have a gentle slope from the foothills forming the boundary on the north, while the other areas are practically level. The soil is naturally well drained and usually free from harmful accumulations of alkali, though the subsoil sometimes contains appreciable quantities.

This type is principally colluvial, having been formed chiefly from wash from the foothills lying to the north.

Only small areas of the type are at present under cultivation, and they are planted chiefly to alfalfa. Small orchards and one or two small orange groves have been set out and are doing well. Under irrigation the type is adapted principally to alfalfa and fruit.

The following table gives the results of a mechanical analysis of this soil:

Mechanical analysis of Placentia sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10528	W. cen. sec. 27, T. 29 S., R. 28 E.	Coarse sandy loam, 0 to 12 inches.	10.6	13.2	6.7	19.1	20.6	18.9	10.7

MARICOPA LOAM.

The Maricopa loam consists of from 18 to 24 inches of sticky, pink or reddish very fine loam, underlain to 3 or 3½ feet by loam of similar appearance containing layers of lime carbonate hardpan, with indications of soluble alkaline carbonates. This is underlain to 6 feet by a sticky, whitish-gray fine loam of ashy texture and appearance and of puttylike consistency, usually containing less clay than the upper soil. The small areas of loam mapped in the southwestern township as a rule do not contain hardpan, and the soil is also quite heavily impregnated with organic matter, which is not the case with the larger, typical areas of the type.

The most typical areas are located in the northeastern part of the area, are rather low-lying and level, and are not naturally well drained.

The Maricopa loam is of both alluvial and colluvial origin, having been formed partly from wash from the canyon of Caliente Creek and the foothills forming the northeastern boundary of the area surveyed, and partly from sediments deposited by the Kern River. The small areas of loam in the southwestern township of the area are entirely alluvial in origin, having been formed by deposition of the finer particles carried by the Kern River.

Most of the type contains considerable alkali, both white and black, in soil and subsoil, which condition will be discussed in a succeeding chapter.

Only small local areas of the Maricopa loam have been brought under cultivation, owing chiefly to excess of alkali and to lack of irrigation facilities. The small areas, when reclaimed, give fairly good yields of alfalfa. A few thrifty olive trees are also found on this type. It is not an ideal soil, however, for fruit trees and deep-rooted crops, owing to the quite generally distributed lime hardpan.

The following mechanical analyses show the texture of this soil:

Mechanical analyses of Maricopa loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10521	S. cen. sec. 34, T. 29 S., R. 28 E.	Heavy loam, 0 to 12 inches.	0.3	3.0	3.2	10.1	22.6	35.1	25.4
10522	Subsoil of 10521	Heavy loam, 24 to 48 inches.	4.9	7.4	4.7	10.3	14.7	33.3	24.6

OXNARD SILT LOAM.

The Oxnard silt loam consists of a very fine, smooth, chocolate-brown silt loam of uniform texture and generally 6 feet or more in depth. It contains considerable very fine micaceous material, and the subsoil is sometimes streaked or underlain by micaceous fine sand or fine sandy loam. In a dry condition it is loose and powdery, and may readily be taken for a soil of fine sandy character. When wet, however, it becomes very sticky and exhibits the peculiar smooth properties of the true silt loams.

This soil type occurs only in the extreme southeastern portion of the area, occupying a rather flat and low tract, cut by sloughs and remnants of former stream channels bordering the soils of the valley plain lying east of the Bakersfield area. The surface is level and covered in places with a heavy growth of the alkali-loving bushy samphire, also known locally as "greasewood" (*Allenrolfea occidentalis*). On the eastern portion of the main soil body this shrubby growth gives way to the saltwort (*Dondia* sp.).

The typical loose and open structure of this soil gives it excellent natural drainage, often in marked contrast to adjoining bodies of the Maricopa loam. It may, however, under unwise or lax methods of irrigation become puddled and more dense and heavy. Although drainage is favored by the soil texture and structure the physiographic position of the land is such that artificial drainage is difficult. However, some of the old slough channels extending through this type might be rendered of some value in removing limited quantities of excess seepage or irrigation waters. The formation of a reclamation district, with the right to condemn and acquire lands lying in the natural drainage basin to the south, must necessarily precede drainage on an extensive scale.

The Oxnard silt loam originates from the very fine sediments laid down at some former period by the slack waters of older channels of the Kern River.

With little exception the soil is heavily impregnated with the soluble alkali salts, a large part being sodium chloride or common salt. A heavy crust or loose alkali mulch generally appears upon the soil surface, but the lime carbonate hardpan of the Maricopa loam and injurious quantities of the destructive black alkali or sodium carbonate of adjoining soil types are, so far as observed, entirely lacking. Owing to the presence of white alkali on the surface, to the present limited water supply, and to the lack of artificial drainage, this soil type is entirely uncultivated and must be classed as desert land. With the securing of better drainage, even by occasional open drains, and a more abundant water supply, this land, although heavily charged with alkali salts, should be capable of complete and rapid reclamation. It should become very productive and well adapted to the growing of alfalfa, corn, grains, and other crops.

The following table of mechanical analyses shows the texture of typical samples of this soil:

Mechanical analyses of Oxnard silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10526	¼ mile E. of cen. sec. 27, T. 30 S., R. 28 E.	Brown silty loam, 0 to 12 inches.	0.4	0.9	0.6	6.3	21.3	42.6	27.8
10527	Subsoil of 10526	Brown silty loam, 12 to 72 inches.	.5	.8	.8	9.2	18.2	48.0	22.5

MARICOPA SANDY ADOBE.

The Maricopa sandy adobe consists of a few inches to about 1 foot of coarse sand or sandy loam, underlain to 4 or 5 feet by coarse sandy adobe, red in color and very compact, and containing a high percentage of both clay and coarse sand or fine gravel. In many local spots the adobe reaches the surface and extends to 6 feet without much variation in texture or compactness. These small areas can always be recognized by the hard, reddish, shiny, smooth, or slightly cracked surface, bare of vegetation.

The compactness of the subsoil is apparently due partly to the physical arrangement of the coarse, subangular sand and the clay particles, and partly to the cementing action of iron oxides and hydrates. No carbonates were found in the sample examined.

This type of soil occurs entirely in the northern and northeastern parts of the area surveyed. It occupies level, slightly sloping, and slightly depressed areas, and is not typical of any special physiographic features, being found at the highest elevations in the area, in the lowest portions of that section of the area where found, and on the intervening slopes.

In the present condition and state of cultivation and irrigation the areas of this soil are well drained. Excessive irrigation on the higher lying, surrounding areas would undoubtedly cause accumulation of subsoil water in the depressed areas. The danger from this source, however, is not immediate.

The Maricopa sandy adobe is colluvial in origin, and is derived from wash from the range of low hills just north of the soil areas, these hills being largely composed of similar soil. The type is also of later formation, apparently, than the delta soils—the fine sandy loams and fine sands—as shown by the fact that the latter were often found underlying the adobe.

The Maricopa sandy adobe is, generally speaking, free from harmful accumulations of alkali, though the small local spots reaching the surface and extending to a depth of 6 feet or more often contain considerable quantities. As these areas are small and scattered, there will probably be but little trouble from this cause. The alkali found consists entirely of chlorides and sulphates.

Only small areas of this type have yet been cultivated, and these only to alfalfa. This crop does very well with irrigation, the adobe softening under the influence of the water and enabling the roots to penetrate quite readily the heavier subsoil. The sand or sandy loam underlying the adobe also gives a favorable deeper subsoil for this deep-rooted crop. Fruit trees would also undoubtedly do well on this type with irrigation.

The following table gives mechanical analyses of the fine earth portion of this soil:

Mechanical analyses of Maricopa sandy adobe.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10524	¼ S. and ¼ W. of NW. cor. sec. 10, T. 29 S., R. 27 E.	Coarse sandy loam, 0 to 12 inches.	4.5	6.2	4.1	14.9	24.8	28.0	17.4
10525	Subsoil of 10524	Yellow sandy loam, 12 to 72 inches.	8.2	10.4	5.7	14.0	20.3	21.9	19.5

HARDPAN.

Hardpan was found in one or two places in the extreme northern part of the area, in the Fresno sand, but its occurrence is not at all general so far as the area surveyed extends. It is reported that considerable hardpan exists north of the area beneath this type of soil.

In only one soil type—the Maricopa loam—is hardpan found to occur generally, and in this type, with very few exceptions, all borings revealed its presence. The hardpan stratum was usually found at from 18 to 36 inches below the surface, and consisted of insoluble carbonates—calcium and probably magnesium—together with soluble alkaline carbonates. It is usually only 3 to 6 inches in thickness, sometimes less, and is composed of layers separated from each other by thin bands of fine earth or by air spaces. In only one or two borings was it found to be too hard to penetrate with the auger. Generally just above and just below the compactly cemented material thin strata of softer material 1 or 2 inches in thickness were found, being either partially disintegrated hardpan or, more probably, hardpan in process of formation.

As has been observed in other hardpan areas, the cemented material occurs at the place of change from a heavy soil to a lighter subsoil, and usually in the lighter rather than in the heavier soil.

In the Maricopa loam there are usually present considerable quantities of soluble salts, and as the soil occupies a rather low position in relation to the surrounding country it is always moist, the subsoil being usually quite wet. Free water sometimes occurs at a depth of 6 feet. The soluble salts in the surface foot of soil, consisting of sulphates, chlorides, and carbonates, are occasionally carried down below the surface by the heavier rains—a movement made easier and more rapid by the moist condition of the soil. This salt solution, which is quite concentrated, will also carry in solution comparatively large quantities of calcium and magnesium—hydrogen carbonates—these salts having been formed by the aid of carbon dioxide in the soil atmosphere. These bicarbonates being carried down through the heavy surface soil would, on reaching the lighter subsoil, come in contact with larger soil grains, a decreased soil surface, and more free air spaces, and with the decreased partial pressure of carbon dioxide would partially break down, precipitating the normal difficultly soluble carbonates of calcium and magnesium on the soil grains. Continued repetition of this process would eventually form a solid layer of hardpan, which would always by this method form in the lighter soil just below the heavier surface soil.

The subsoil of this type being always very moist or wet, with occasionally free water at a depth of 6 feet, there is undoubtedly an upward movement of salt-carrying water due to capillarity. This solution after having passed through the lighter subsoil would, on reaching the heavier texture soil, come in contact with a much greater soil surface, which would give rise to absorption or deposition on the soil grains. In this case the cementing action would take place in the first layers of the heavier soil just above the lighter subsoil. Both processes of formation are undoubtedly responsible for the hardpan of this area.

As this soil type is cultivated only to a very small extent, no serious trouble has yet been experienced with the hardpan. There is reason to believe, however, that under irrigation, unless practiced to excess, the hardpan conditions would not be greatly ameliorated. Excessive irrigation, on the other hand, would raise the water table to the danger point, and accumulation of alkali might result. Shallow-rooted crops would be better for this soil should it ever become extensively used, and its cultivation should be coupled with artificial underground drainage for permanently good results. Irrigation and underdrainage would gradually but surely remove the hardpan.

WATER SUPPLY FOR IRRIGATION.

The water for irrigation in the Bakersfield area is drawn from two sources, viz, Kern River water and underground water. Of the two sources of supply that of the Kern River is the more important.

This stream, rising as two separate forks in the highest peaks of the Sierra Nevada Range, drains an area of about 2,350 square miles. According to Water Supply and Irrigation Papers, No. 46, United States Geological Survey, the mean annual rainfall of the Kern River drainage basin is about 23 inches. The stream is very rapid, falling about 8,000 feet before entering the valley. The channel is cut through granite, and there is very little loss from seepage or underflow. Below the junction of the South Fork—40 miles above the point where the river emerges from the mountains—such losses begin to occur, while below the canyon, where the stream enters the mesa lands and valley plain, the channel becomes wider, shallower, and of a sandy character, and here the loss rapidly increases until at a point near Bakersfield, owing to the removal of water for irrigation purposes and losses by underflow, the channel generally becomes dry.

Prior to the recent series of dry years and to the extension of irrigation practice upon the delta lands, the waters of the Kern River found their way to the beds of Kern and Buena Vista lakes, and thence northwestward to Lake Tulare, as stated in a preceding chapter. At present, however, aside from losses, the entire flow of the river, except during floods, is utilized for purposes of irrigation. During spring freshets and brief flood periods the excess waters are now conducted into Buena Vista Lake, which has been made available as a reservoir by the construction of a levee along its eastern shore. the storage water being used for the irrigation of lands under the Kern Valley Water Company's canals to the northwest. Evaporation losses here are very great, and owing to this and to the uncertainty of supply this system has met with only partial success.

In flow the Kern River is subject to great seasonal and annual variation. According to reports of the United States Geological Survey above cited, the mean annual discharge at the gaging station near the mouth of the canyon for the period 1895–1899 was 864 second-feet. The low stage occurs during the fall and early winter, at which time a flow of less than 200 second-feet at the gaging station is sometimes reached. The high stage occurs during the spring and early summer, during which a flow exceeding 5,000 second-feet has been recorded.

The location of the main canal systems covering the area may be ascertained by referring to the soil map. Of these the East Side Canal and those covering the delta lands extending southward from the river channel are most important.

As before stated, the construction of irrigating systems has greatly exceeded the available water supply. The large and expensive system of canals and laterals covering the lands of the northern portion of the area is rendered useless during the greater part of the year for want of water. The area watered by the East Side Canal is small and narrow. Lying between this irrigated strip and the land covered by the branches of the Kern Island Canal is a large body of desert and alkali land capable of reclamation under conditions of a more abundant water supply, supplemented by artificial drainage. Vast bodies of unirrigated grazing lands occur in the western and southwestern parts of the area, while upon Kern Island itself, the most extensively cultivated portion of the area, there is in the aggregate a large area of unirrigated land.

No great extension of irrigation within the Bakersfield area can take place under present conditions, since even with the inauguration of greater economy in the use of water and a more careful leveling and preparation of the land which might be practicable, the available water supply is already too limited for the systems so far constructed.

In the case of wells supplying water for irrigation within the limits of the area surveyed, with but few exceptions pumping is necessary. In the valley trough and in the southwestern part of the area artesian or flowing wells are occasionally encountered. The flow of such wells is inconsiderable, however, and is used mainly for the watering of stock on grazing lands, being negligible as a source of water for irrigation.

As an auxiliary supply for tracts unfavorably situated with regard to canal systems, pumping systems are becoming of increasing importance. About 35 electrically driven pumping plants are located within the area. These are operated by power generated in the Kern River Canyon, and are used for the most part in irrigating alfalfa lands of the central and eastern parts of the area, although a certain amount of water is supplied by this means for the irrigation of vineyard and fruit lands on the north side of the river.

The average depth of these wells is about 100 feet, a plant generally comprising four wells sunk in a pit and worked by a single centrifugal pump with direct-connected motor. A reservoir is often profitably used in connection with the system. Some of the larger plants are supplying 2,000 gallons per minute, are operated at a very high percentage of efficiency, and require but little attention. The majority of these plants are owned and operated by the Kern County Land Company in connection with its canal systems, water being supplied to patrons at the rate of 75 cents per acre-foot. In the case of plants operated by smaller individual landowners the cost is somewhat increased.

Upon the mesa lands northeast of Bakersfield an abundant supply of underground water seems to exist, usually at depths of less than 100 feet. With the increasing value of land and water the profitable extension of these systems seems probable. For the smaller plants in use only a portion of the time gasoline engines, using a distillate produced at the local refineries, are said to be more economical than electric motors.

The water obtained from the artesian wells is of very good quality, and that from Kern River is excellent for irrigation purposes, the proportion of soluble alkali salts held in solution being low.

UNDERGROUND AND SEEPAGE WATERS.

It was at first intended to make a map of the Bakersfield area showing the depth to standing water, but upon further investigation such a map was decided to be unnecessary and of doubtful value, owing to the limited water supply and the rather limited areas under cultivation.

Underground water at 6 feet or less was general in only one soil type, viz, the Maricopa loam, and water was not always found so near the surface even in that type. In the remainder of the area a few borings in isolated, low areas found standing water within 3 to 6 feet, but through the area in general it was below 6 feet, and was undoubtedly below 10 feet in the greater part of the area surveyed. A heavy surface coating of alkali, which in many areas almost invariably indicates underground water at 6 feet or less, here seldom showed more than moist conditions at that depth. This is due to the high capillarity of the soils of this area, which also explains why in such a hot and dry summer climate more frequent irrigations are not necessary.

An examination of the subsoil water of the area showed that in general it is not badly charged with alkali salts. Wells examined throughout the area, ranging in depth from 10 to 100 feet, were found to contain from 15 to 180 parts of soluble salt per 100,000 parts of water. The higher figure was from one well near Rosedale, and came from the worst subsoil water found. The lower salt contents were from deep wells at pumping stations used for irrigation purposes. The flowing wells of the area were also found to be of good quality. Some sloughs and seepage waters were found to contain from 200 to 300 parts of salts, but very little importance need be attached to the results, as the occurrences are very local.

The principal salt constituent in the subsoil water is hydrogen carbonate, and the quantity present varies from 6 to 60 parts per 100,000. Chlorides varied from 2 to 40 parts, and in one instance 2 parts of normal carbonates were found. In some places heavy precipitates of sulphates were had.

It will be seen that the underground water is not bad, and with the good quality of irrigation water in the area the alkali conditions should be easily controlled.

ALKALI.

The alkali map represents the average percentage of total soluble salts in the soil to a depth of 6 feet, the determinations being made at soil saturation by means of the electrolytic bridge, each foot-section determined separately. As soluble alkaline carbonates, or black alkali, are found in some parts of the area, a black alkali map was also constructed, showing the percentage of this salt in the surface foot. These determinations were made volumetrically in the field on the same samples used in the determination of the total soluble salts. In the black alkali determinations the ratio of dry soil to water used was approximately 10 grams to 250 c. c. These same solutions were used for the quantitative determinations of chlorides and hydrogen carbonates and for qualitative tests for sulphates.

Harmful accumulations of alkali are confined chiefly to the southern half and northwestern corner of the area. Only small local areas of alkali exist in the remainder of the area surveyed.

The general absence of harmful accumulations of alkali in the northern part of the area is due to the lighter soil and greater elevation. The alkali is thus confined chiefly to the heavier soil types, including the Fresno fine sand, the Fresno fine sandy loam, the Maricopa loam, and the Oxnard silt loam. The Fresno sand is practically free from alkali, and but small amounts exist in the Maricopa sandy adobe and the Placentia sandy loam.

By a consideration of the origin of the soils, the vertical distribution of the alkali in the soil, and the climatic conditions of the area, it is apparent that the alkali owes its origin principally to the small amounts of soluble salts in the sediments brought down by the river, which gradually have accumulated at or near the surface by evaporation of subsoil water brought to the surface by capillarity. There are no residual soils in the area surveyed, and all the soils in which large amounts of alkali occur are of alluvial origin. There is no evidence of very deep-seated accumulations of alkali, at least not in the portion of the valley under discussion. Since the maximum salt content was almost invariably found in the surface foot, with very little in the subsoil, it is also evident that the small amounts of soluble salts necessarily found in any soil have concentrated at the surface by the upward movement of the subsoil water carrying the salts in solution.

In making soil investigations in unsettled areas where there were naturally no alkali accumulations in either soil or subsoil, and where only nominal amounts were found by careful examination, it is very common to find in a few years—sometimes only three or four—a very heavy surface accumulation of alkali, sufficient to prohibit the growth of any agricultural plant, such accumulation having been caused entirely by a rise of the water table through irrigation. A small amount of alkali salts—far too little to have any toxic effect on cultivated crops—with uniform vertical distribution in the soil soon gives a heavy surface incrustation under such conditions. This condition is more quickly reached and further aggravated in case the soil has a high capillarity, as is the case with all of the alkali-containing soils in the area surveyed.

The scanty rainfall in the area—about five inches—is not sufficient to wash away any of the surface alkali. The hot summer weather and warm weather during the rest of the season also favor rapid accumulation of surface alkali.

A large number of titrations, covering the whole alkali area, were made in order to ascertain the character of the soluble salts. As will be seen by the black alkali map, very little of this salt was found in the northern half of the area, even where heavy surface accumulations existed. In these places the salts were apparently evenly divided between the chlorides and sulphates. Not having a quantitative field method for sulphates, the relation could be only approximately determined.

In the southern half of the area much alkaline carbonate was found, as well as the "white" alkali. No definite relation existed between the total amount of soluble salt in the surface foot and the amount of soluble alkaline carbonates. In many instances, where as much as from 2 to 7 per cent of the former was found, less than 0.05 per cent of the latter existed. Again, in other places the same amount of salts in the surface foot would yield 0.3 per cent to 1 per cent of alkaline carbonates. High percentages of black alkali, however, were generally associated with much surface salt.

A somewhat curious relation existed between the sulphates and soluble carbonates. While in some instances no black alkali, or only small amounts occurred where much sulphate was found, on the other hand high percentages of alkaline carbonate were more generally found together with large amounts of sulphates. On tabulation of a large number of titrations made and averages computed, it was found that in the cases where heavy or very heavy precipitates of sulphates were obtained the average percentage of soluble alkaline carbonates was seven times as high as where only traces of sulphates or none at all existed.

No definite relation was found between the total amount of soluble salts in the surface foot of soil and the sulphates in the same section, the latter not increasing with the former. On the other hand, the amounts of chlorides were much more constant, and in a general way showed increased amounts, with increasing surface accumulations.

With few exceptions, the bicarbonates were present only in small amounts, and showed no relation in quantity to either the total soluble salts in the surface foot or to any of their constituents, except that, as is nearly always the case, the ratio of bicarbonates to carbonates was greater in the presence of small amounts of the latter than in the presence of large amounts of carbonates. But even then the relation was not very conspicuous.

The vertical distribution of the amounts of soluble salts was very irregular. With very few minor exceptions the maximum salt content occurred in the surface foot, with very rapidly decreasing amounts in the subsoil. Owing to this, it was found that mapping only the average percentage of alkali in the first 6 feet of soil did not give a true conception of the alkali conditions. Therefore a legend of different hatchings was employed on the total alkali map, showing the amount in the surface foot. In many instances quite a heavy surface accumulation of salts would give less than 0.20 per cent for the average of 6 feet. The grade 0.60 to 1 per cent nearly always, and that of 0.40 to 0.60 per cent very often, showed surface accumulations of alkali.

In the Maricopa loam areas, as mentioned in the description of that type, soluble alkaline carbonates were found associated with the lime hardpan in the subsoil. Titrations and other examinations often showed as much black alkali in this subsoil as in the surface foot.

The alkali conditions in the area have in many instances been improved by cultivation and irrigation, but in many other cases conditions have been aggravated.

The method of irrigation practiced in the area—chiefly by contour checks—successfully washes the surface alkali into the subsoil, and this is rendered easier by the fact that the texture of the subsoil is as light or lighter than that of the soil. Some fields in the worst alkali districts in the area—in the southeastern township—have been successfully reclaimed in this way. Borings made in the edges of these alfalfa fields showed less than 0.10 per cent of total salts as an average in the first 6 feet, while a few feet outside the fences the average for the same depth ranged from 1 to 3 per cent.

Owing, however, to the small amount of this work done throughout the area in general, no serious or extensive damage has yet taken place, though in many local places the effect of overirrigation is plainly visible. These local areas could of course be much improved by underdrainage, but owing to the character of the topography it would not be feasible to undertake drainage on a small scale.

The absence of any good natural drainage channels for the area in general makes the question of underdrainage a difficult and expensive problem. The topography of this part of the valley is such that a very general system would have to be installed, much on the same principle as an irrigation system. It would be out of the question to put through such an undertaking at the present time for several reasons. The state of cultivation and character of crops produced would not justify the expense. Considerably less than half the area surveyed is cultivated, some of it not being under any system of irrigation, and much yet unsupplied with irrigation water. Probably less than one-third of the area was irrigated at the time the survey was made, though a few years earlier, when water was more plentiful, a much larger area was irrigated and successfully cultivated.

The scarcity of water for irrigation will in itself make unnecessary any extensive underdrainage in the near future, unless a very much more elaborate system of pumping is introduced, and even then, as this method of irrigation would encourage a very economical use of water, the necessity for underdrainage would be more or less retarded. When the state of cultivation made possible by a larger water supply shall require the use of all the land in the area, underground drainage will be imperative in order to reclaim and keep the land in cultivable condition.

AGRICULTURAL METHODS.

A common method of bringing new land into permanent use is to plant it to corn or grain for from one to three years, thus getting the soil into good physical condition, and, where it exists in injurious quantities, washing the surface alkali into the subsoil. The necessary permanent checks and ditches are thus built, and then the land is usually planted to alfalfa, or sometimes to tree fruits or grapes.

The usual method of irrigation in the area is by contour checks, that method having generally replaced the more wasteful one of "wild" flooding. Considerable initial expense is often incurred in perfecting a good permanent system, in order to increase the duty of water. These check banks are usually from 1 to 3 feet high, and inclose, according to the topography of the field, from one-third or one-half an acre to 2 or 3 acres. In a few instances checks inclosing 10 or 15 acres were seen, but such large areas are not economical, as a rule, and are unsatisfactory, owing to the greater tendency to accumulate subsoil water. The check banks, being permanent, are usually rolled and partially smoothed, so that farm machinery may be drawn across them.

If the fields are large a number of series of checks will be arranged, as a rule, each check opening into some other check of the same series. If the field is small one series will be enough. This arrangement, however, varies with the character of the land, the topography, texture of the soil, and the amount of water available. With a large head of water more checks can be filled without change than with a small flow.

Orchards are usually irrigated by furrows, but occasionally by checks. Grain receives the same treatment in irrigation as alfalfa, the check method being used exclusively.

Alfalfa yields three and sometimes four crops, though usually the field is more valuable for grazing after the third crop is removed than it is for cutting. It is a common practice for cattle and sheep owners to rent fields of all descriptions for grazing in the fall, paying a stipulated price per acre for the privilege.

Alfalfa receives from one to three irrigations a season, more water being necessary in the northern and sandy areas than in the central and southern parts of the area surveyed. In many instances, however, this is not enough, and more frequent applications would be more remunerative. In the southern and central portions of the area, where the subsoil water is nearer the surface, two irrigations are usually sufficient for the entire season.

No attention is paid to rotation of crops when grain is grown, cereal succeeding cereal as long as it is desired to raise those crops. In fact, very little agricultural skill is shown in the area, so far as general farming is concerned, with the possible exception of the irrigation practices. The area is not yet densely enough settled to call for any but the most general farming methods. The only intensive cultivation practiced in the area is carried on by the Chinese on their small tracts of land devoted to truck growing.

AGRICULTURAL CONDITIONS.

The agricultural conditions in the area surveyed differ somewhat from those generally found in agricultural communities. Instead of the area being dotted with convenient-sized farms, each with its comfortable house and outbuildings, well-cultivated land, and carefully kept surroundings, one finds large areas of land owned or controlled by companies or wealthy individuals. According to maps made in 1896, one company alone then owned over 50,000 acres in the area surveyed and much larger tracts adjoining the area. Another company not owning very large tracts in the area surveyed owns probably hundreds of square miles south, west, and north of the area. Hence, instead of a dense farm population one finds here and there a few buildings, or perhaps only one small house for the accommodation of the person or persons looking after the property of another. Scattered here and there over the area are a few well-kept and well-cultivated farms owned by more prosperous farmers, who can devote their time and energy to their own interests.

The holders of wide tracts of land have overseers or managers, who carry on large operations by means of labor hired for the work. In other instances a certain amount of land is rented to tenants for a specified number of years. The labor hired is drawn chiefly from the floating foreign population, consisting largely of Chinese, Japanese, Portuguese, and Italians, the first two races being especially steady and reliable.

The principal crops grown are alfalfa and other forage crops. Alfalfa does well on most of the soil types and is a paying crop, selling at the time of this survey for from $12 to $14 a ton. Barley, hay, and clover also receive some attention, but are distinctly second to alfalfa in importance. Part of the forage crops is fed to sheep and cattle at home, and some is shipped to outside markets. Large numbers of cattle and sheep, with some hogs, are raised in the area and in the valley generally, and during the winter the first two classes of animals are pastured in large herds in the fenced fields or tended by herders in the open virgin areas. During spring and summer the surrounding hills and mountains generally afford a good feeding ground. The winters being very mild, no shelter is necessary for sheep, cattle, or hogs. The range cattle are generally conspicuous for their long horns and vicious character. The better breeds of cattle are not numerous in the area, though an occasional small herd of good dairy cattle was noticed.

Fruit was formerly of some importance, but of late years not many orchards have been set out. This is due to the uncertainty of the spring season. The mild winters bring out the fruit buds early in the spring, before the danger of night frosts is over, and as a consequence the buds are often nipped and the prospective crops destroyed. The woody portion of the fruit trees grows rapidly, as practically all the plant energy can be devoted to this development. In seasons when the fruit escapes frosts the trees are usually not pruned back sufficiently, with the result that they overbear. A number of instances were met where the farmers were cutting out their orchards and planting forage crops instead.

Small grain receives some attention, but chiefly for the purpose of preparing the land for alfalfa or some other forage crop. Corn is grown to some extent for the same purpose.

Raisin grapes are a relatively important product of the area, and the vineyards are usually well kept. This crop is produced chiefly on the Fresno sand.

Six or seven years ago the area was much more extensively cultivated than at present, especially in the northern part, and for many miles north of the northern boundary. In late years the water supply has greatly diminished, and many square miles of alfalfa and orchards that formerly were doing well were, at the time of the survey, entirely dead and the cultivation of the land temporarily abandoned. The spring of 1904 was more hopeful than many preceding seasons in the matter of rainfall. It is quite likely that another cycle of rainy seasons is approaching.

A few small orange groves in the area were doing well, but the best orange district is south of the area surveyed, along the foothills at the southern end of the valley. Figs are raised, but only as an incidental crop, the trees being planted, as a rule, only along the sides and fences of the fields.

Most of the nonalkaline soils are pretty well adapted, under irrigation, to any crop suited to the climate, so that very little attention need be paid to adaptation of soils to crops.

The area would no doubt be much more important agriculturally than it is at present if the land holdings in general were smaller. This would furnish homes for quite a large population and result in more intensive cultivation.

Transportation facilities are excellent, two important railroads, the Southern Pacific and a line of the Santa Fe system, traversing the area and valley, and giving an outlet in all directions for the products grown.

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