U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE STOCKTON AREA, CALIFORNIA.

BY

MACY H. LAPHAM AND W. W. MACKIE.

[Advance Sheets—Field Operations of the Bureau of Soils, 1905.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., May 24, 1906.

SIR: During the season of 1905 a soil survey was made of an area around Stockton, Cal. Requests for this work showed a variety of special interests which would be served. The following request, transmitted by the Hon. J. C. Needham and indorsed by him, sets forth the conditions in the region:

> The peat soils, the adobe soils, and other characteristic soils around Stockton have never been studied in a scientific manner. The great Tokay belt of California is supposed to lie just north of Stockton. The limits of this area have never been determined. Vineyardists are experimenting every year, setting out Tokays and losing their investments from lack of knowledge of soil and climatic conditions, the very conditions that a soil survey would establish. I know of no one thing that would do more to build up this part of California than a soil survey. Not only would it help our own people, but it would attract to central California many people because of the facts that would be established.

The making of this survey was also advocated by Senator George C. Perkins, and in compliance with these requests a survey of the Stockton area was made. The work in this area should form a basis for the further extension of the survey of the soils of this region, and it would seem advisable to continue the survey to cover the greater part of the Tokay grape region.

I transmit herewith the map and report on the Stockton area, California, for publication as advance sheets of the Field Operations of the Bureau of Soils for 1905, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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Soil map, Stockton sheet, California.

SOIL SURVEY OF THE STOCKTON AREA, CALIFORNIA.

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LOCATION AND BOUNDARIES OF THE AREA.

The Stockton area lies in the northern or lower part of the San Joaquin Valley, entirely within the county of San Joaquin, and near the geographical center of the State of California. It is nearly rectangular in shape and has an extent of 333,248 acres, or about 521

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

square miles. The city of Stockton is situated near the center of the area.

The base map used in the soil survey was made by the party in the field as the work progressed, no accurate published map being available.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

In the history of the discovery and early exploration of California the Jesuit priests and missionaries with their followers played important and romantic rôles. The scene of their struggles and sacrifices was, however, mainly confined to the coastal region. While the San Joaquin River owes its discovery in 1783 to the Jesuit missionary, Father Crispi, the exploration and the settlement of the district covered by this report fell to Americans and French Canadians at a later date.

The first of these to visit the San Joaquin Valley were hunters and trappers, some of them in the service of the historic Hudson Bay Company. At that time wild game, consisting of bear, deer, elk, and antelope, wild horses (escaped from the early Spanish adventurers and mission padres during their pilgrimages along the coast), and many smaller fur-bearing animals were abundant. These nomadic trappers explored the network of streams and held undisputed sway over the valley for a period of about twenty years prior to 1844.

In 1843 a tract of land embracing over 48,000 acres, near the center of the area surveyed, and including the site of the present city of Stockton, was obtained from the Mexican Government, under the title of the Campo de los Franceses grant, by Capt. C. M. Weber, of San Jose.

This was followed by the arrival of a few early settlers and the founding of a few small colonies, the earliest farming being carried on along the Calaveras River. Early but temporary settlements were also made by the Mormons at French Camp and upon the banks of Mormon Slough. The city of Stockton was founded by Captain Weber in 1847.

With the rush of gold seekers to California immediately after the discovery of this metal in 1848, Stockton became one of the objective points and an important outfitting station for the mines. The population, although of a somewhat unstable character, rapidly increased, representing nearly all States and nationalities of the world. The most of these came by sailing vessels by way of the Horn, and found their way to the San Joaquin River.

Early efforts in agriculture were for the most part confined to stock raising. With the sudden increase in population, prices of farm products greatly advanced. Vegetables, hay, grain, and other staple crops were in demand. Some of those who came in quest of gold found their wealth only when, as a last resort, they turned their attention toward producing supplies for the mines. The growing of wheat in large tracts, however, became the main agricultural industry. Later barley came into favor, and the production of these two grains is still of leading importance. The use of farm machinery

consistent with the farming of extensive tracts became an early outgrowth of this practice. Sailing vessels were partly supplanted by steam river packets. Then came the railroads, and Stockton became an important manufacturing center and grain and hay shipping point.

With more recent immigration the population has taken on an even more cosmopolitan character, and this has resulted in improved agricultural practices. Reduction of profits in grain ranching, owing to declining yields, the occurrence of dry years, and to unfavorable prices, has opened the way for the introduction of irrigation and a system of diversified farming, including especially the growing of vines, fruits, alfalfa, and the production of stock and dairy products.

Within the last few years the reclamation and utilization of the rich peat lands of the western part of the area have proceeded rapidly, with the consequent improvement in shipping facilities by water and the addition of the special crops of this section to the staple agricultural products of the earlier developed parts to the east.

CLIMATE.

The climate of the Stockton area is characteristic of the lower San Joaquin and Sacramento valleys. It is marked by the occurrence of two seasons, a wet and a dry, contrasting considerably in temperature, and widely in precipitation, humidity, wind movement, and the relative number of clear days.

The normal annual temperature at Stockton is about 60° F. Normal monthly temperatures vary from a maximum of about 72.5° F. for the months of July and August to about 46.5° F. for the month of January. In the summer months high temperatures are frequently reached during the day, but the nights are usually cool and pleasant. During the winter or rainy season periods of clear weather, often accompanied by frost, are of frequent occurrence. Killing frosts may occur as early as November and continue into the month of April, but are usually confined to the winter months and rarely are so severe as to interfere with farming operations.

The average annual precipitation amounts to about 15.5 inches, taking place almost entirely during the period from November to April, inclusive. The rains commonly occur as gentle, steady showers, or in rainy periods continuing from one to three days, interspersed with periods of clear or foggy weather. The occurrence of snow, violent storms, and thunderstorms is very rare.

A condition of low relative humidity, accompanied by cloudless skies, generally occurs during the summer season, but is less marked than in the upper and drier portions of the San Joaquin Valley. It, however, greatly lessens the sensible temperature of the hot summer days. Throughout the winter season the atmosphere is frequently laden with moisture during intervals between cloudy and rainy

periods, and dense fogs are of frequent occurrence. During the night and early morning the fogs are generally dense, but they frequently disappear or lift during the day, sometimes continuing, however, as "high fog" for unbroken periods of several days, and even occasionally for weeks at a time. These winter fogs form a prominent local climatic feature of the great interior valley of California, and although obscuring the sun for long intervals, are unaccompanied by rain, are distinguished from ordinary cloud, and are considered in the official records as fair weather.

During the winter the winds are variable and light in character. During the summer season wind movement is dominated by the sea breezes, entering the valley by way of the Straits of Karquines, of moderate briskness, and greatly tempering the heat of the interior.

The climate is, as a whole, healthful and well adapted to the production of general farm and truck crops. A large proportion of the winter rains is retained by the soils to be used in plant production, while during the harvest season but little or no hindrance is experienced in farming operations because of unfavorable weather. The growing of the more tender fruits is rendered somewhat hazardous, owing to the occurrence of late warm winter periods sometimes followed by frosts, but hardier fruits and ordinary farm crops are unharmed by frost, while the hardier vegetables and truck crops, such as onions, cabbages, etc., are produced the year round.

The normal monthly and annual temperature and precipitation, as compiled from official data of the Weather Bureau, reported for the stations at Stockton, Lodi, and Tracy, the latter two located just outside the northern and the southern boundaries of the area, respectively, are shown in the following table:

Normal monthly and annual temperature and precipitation.

Month.	Stockton.		Tracy.		Lodi.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*In.*	° *F.*	*In.*	° *F.*	*In.*
January	46.5	2.99	46.9	1.64	46.2	3.71
February	50.0	2.18	50.5	1.16	50.1	2.26
March	54.5	2.28	54.8	1.53	54.7	3.02
April	58.9	1.29	60.9	.95	58.3	1.27
May	64.1	.67	69.1	.55	63.4	1.36
June	69.9	.09	75.9	.18	69.1	.19
July	72.6	.02	79.9	.01	73.7	.00
August	72.5	.01	77.5	.01	73.0	.05
September	69.0	.14	72.0	.19	69.7	.46
October	61.7	.62	63.5	.60	62.3	1.42
November	53.9	1.76	54.2	1.15	53.6	2.49
December	47.1	3.36	49.6	2.16	47.3	3.56
Year	60.1	15.41	62.9	10.13	60.1	19.79

PHYSIOGRAPHY AND GEOLOGY.

In general, the area surveyed is without marked topographic variety, the most noteworthy feature consisting of the advanced drainage system. The elevation ranges from that only slightly above sea level and below mean high-tide level upon the western or river-delta part of the area to slightly more than 100 feet above sea level at the northeastern extremity. The slopes are in general scarcely noticeable and the area is devoid of rock outcrop, bluff, or terrace lines. Tree growth usually occurs only in the vicinity of the streams as groves, or as scattered individuals upon the lower valley plain. Drainage is effected by the San Joaquin River, with its tributaries, the Calaveras River and Mormon Slough, passing across the eastern and central parts of the area, while a multitude of meandering branches of the main river, with blind and open tidal sloughs, traverse the western half.

Along the northern part of the eastern half of the sheet, and lying just east from the towns of Linden and Peters, the western edges of the lower foothills of the Sierra Nevada Mountains project into the valley plain and are included within the boundaries of the area. These first prominent foothill slopes consist of treeless plains of quite marked incline or of the lower, rounded, or gently undulating hills and ridges, covering only 1 or 2 square miles, and forming the only prominent features of this character in the entire area.

About one-half of the area surveyed consists of the valley plain proper, at one time covered by the waters of an ancient Pleistocene lake or bay. The central part is traversed in a general southwesterly direction by the Calaveras River and Mormon Slough, the waters from both of which enter the San Joaquin a little below Stockton. Mormon Slough, sometimes called Mormon Channel, is itself a branch of the Calaveras River, which it leaves a short distance outside the northwestern extremity of the area, and now carries nearly all the water which at one time found its way through the Calaveras proper. Formerly but an imperfect channel carrying water only during flood periods, it owes its origin as the main channel to artificial cuts made for the purpose of irrigation, which, increased by the erosive action of flood waters, rendered the flow perennial and captured the entire flow of the Calaveras at the point of diversion, except during flood periods. The bed of the lower course of Mormon Slough is filled to the depth of many feet by detritus derived from waste of the mountains, which is frequently carried by winter and spring floods into the still waters of Stockton Channel, forming bars and impeding navigation or entirely blocking the harbor until removed. A movement is now on foot to connect the lower courses of Mormon Slough and the Calaveras River, thus

deflecting the bulk of the flood water into the Calaveras and depositing the stream-borne detritus in the San Joaquin River, where current and tide may assist in removing it.

Both the Calaveras River and Mormon Slough, except near their mouths, are narrow and deep. Flood waters of these two streams, aided by those from numerous minor intermittent streams, have in many places deposited extensive bodies of recent alluvial material over the valley floor. Lying to the south and eastward from Lathrop the outlying extremities of extensive deposits of fine and coarse sands of nearly level or gently undulating surface, locally known as the "sand plains," are encountered.

The San Joaquin River delta, a part of which is included in the western half of the Stockton area, consists of a vast tract of level swamp or "tule" lands, lying below the high-tide level of the adjacent streams. Numerous interlacing streams and sloughs divide the lands into tracts or "islands." This natural division is augmented by canals and cuts constructed in the progress of reclamation and navigation interests. Two prominent branches of the San Joaquin River, viz, Old River and Middle River, which, with the San Joaquin proper and many smaller sloughs, are navigable to river boats throughout the greater parts of their courses within the area surveyed, traverse the delta lands of the Stockton area. The soil consists of a light, loose Peat formed of river sediments mingled with accumulations of organic matter, the remains of partially decomposed masses of roots, stems, and fibers of aquatic plants. This soil, when drained and protected from tide and flood waters by artificial means, proves extremely productive. These finer river silts and sediments are continually deposited by flood waters upon the lands when not protected by levees, which with the growth and decomposition of vegetable matter effects a gradual extension of the delta toward the sea.

The materials entering into the various soils of the lower foothills, valley plain, and river delta are derived from the granitic, volcanic, and other altered rocks of the Sierra Nevada Mountains.

SOILS.

The soils of the Stockton area are mainly of alluvial or lacustrine origin, being deposited by subsidence from the waters of modern or ancient streams, lakes, or inland seas, or formed by the growth and partial decomposition of masses of aquatic vegetation mixed with stream or tide borne sediments. Naturally the degraded particles of a variety of rocks enter into the composition of these complex deposits. Only along the northeastern margin of the area surveyed do deposits of less complexity occur, as colluvial wash material distributed by heavy rains and streams and derived directly from the residual materials of the adjacent foothills.

The boundaries marking the various soil types are frequently indistinct, related types passing into each other by imperceptible degrees. In the accompanying maps such areas are necessarily separated by lines somewhat arbitrarily drawn. Nearly all the soils are remarkably productive and give large yields wherever proper cultural methods are followed.

The extent of the several types is given in the following table:

Areas of different soils.

Soils.	Acres.	Per cent.	Soils.	Acres.	Per cent.
Peat	107,584	32.3	Fresno fine sand	8,128	2.4
Stockton clay loam adobe	53,312	15.9	Fresno sandy loam	5,952	1.8
Sacramento clay loam	41,088	12.4	San Joaquin sandy loam	5,824	1.7
Stockton clay adobe	40,832	12.3	San Joaquin loam	5,440	1.6
Stockton loam	26,176	7.9	Stockton loam adobe	2,560	.8
Stockton silt loam	16,512	4.9	Total	333,248	
Fresno fine sandy loam	10,304	3.1			
Fresno sand	9,536	2.9			

SAN JOAQUIN LOAM.

The surface of the San Joaquin loam consists of a bright to dark red plastic loam of fine, somewhat silty texture and firm, compact structure, with a depth ranging from a few inches to 3 or more feet. It frequently carries gravel throughout the soil section, though not uniformly distributed. When in proper moisture condition it breaks upon cultivation into a loose loam, but becomes very sticky when wet, with a tendency to puddle and bake upon exposure. In the lower part of the section the soil suddenly becomes heavier, taking on the properties of a heavy adobe. This material extends for only a few inches, passing into an impervious hardpan of red color, and generally of fine texture and firm, dense structure. This hardpan stratum will be discussed further in a succeeding part of this report.

The San Joaquin loam, while covering extensive tracts of the foothills of the Sierra Nevada Mountains, occurs in the area surveyed only in a few relatively small and unimportant bodies, lying along and adjacent to its northeastern boundary. It forms the rolling uplands of the lower or first foothill slopes, and extends to the margins of the nearly level valley plain. These slopes and rolling hills are treeless and devoid of rock outcrop or similar features, save for the occasional appearance of the underlying hardpan.

Natural drainage is favored by the elevated position and well-defined slopes of these soil bodies. While the surface run-off is thus generally free, percolation is greatly retarded and in many cases prevented by the underlying hardpan, so that the surface waters frequently collect and remain in local drainage depressions until dispelled by evaporation. The soil, following wet seasons, is conse-

quently marked by wet and boggy spots and is often cultivated with difficulty. On the other hand, it frequently becomes compact, hard, and impracticable of cultivation before the advent of the winter rains. These conditions greatly limit the variety of crops grown and the period of successful cultivation of these lands.

The San Joaquin loam is derived from valley sediments of early Pleistocene age and from the weathered product of the complex rocks, generally of metamorphosed or altered character, of the Sierra Nevada foothills, the latter material being gradually transferred and spread about the valley margins through washing by torrential rains and streams. Some of these soil bodies are obviously modified by an admixture of recent alluvium. The soil and subsoil are free from alkali salts in injurious amounts.

In other parts of California soils of essentially the same characteristics as the San Joaquin loam have been successfully devoted to fruit culture, but owing to the shallowness in this area the type is suited only to the production of shallow-rooted crops. Grazing and dry farming to grain are the principal interests, the land being summer fallowed every other year. Owing to long-continued grain culture and to inadequacy of moisture supply occasioned by the occurrence of hardpan near the surface, light yields are obtained except in the most favorable seasons.

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

Mechanical analyses of San Joaquin loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13072	Soil	1.0	6.6	6.0	16.7	15.3	35.5	18.8
13073	Subsoil	1.5	6.7	5.8	16.3	16.7	33.0	19.9

STOCKTON SILT LOAM.

The Stockton silt loam is subject to considerable variation in depth of soil and in the character of the subsoil, small, widely distributed bodies of fine silty loam occurring merely as superficial deposits over many of the other soils of the area. Typically, however, the Stockton silt loam is an extensive, important, and easily distinguished soil type, consisting of a fine, friable silty loam of light-brown color, extending to the depth of 6 feet or more, and becoming somewhat lighter in color and texture in the lower section of the profile. Although loose and friable when in proper condition, it becomes sticky when wet and may be rendered very compact. No gravel or other coarse material appears in this soil, except in the immediate vicinity of present or abandoned stream channels.

The Stockton silt loam covers a considerable area in the northeastern part of the survey, where it is found in one continuous body of irregular outline, most typically developed in the vicinity of the Calaveras River. Other small, less typical bodies occur along some of the other streams of the valley plain. The surface is nearly level and without variety, save for an occasional grove of valley oak or of willows bordering the streams, which in the northeastern part of the area flow in deep channels with vertical banks. The soil passes gradually into the Stockton loam and somewhat more abruptly into the other adjacent types. It is generally well drained, percolation taking place readily, but with proper cultivation is capable of retaining a large supply of moisture.

Material derived from a great variety of rocks probably enters into the composition of the Stockton silt loam. Much of the fine silty micaceous material, however, is believed to have its origin in the slates, amphibolites, and other altered rocks of the Sierra Nevada Mountains, transported to the valley and distributed by flood waters of the streams in recent times.

A hardpan of calcareous nature is sometimes exposed in stream channels cutting this type, but occurs at such depths as hardly to influence the growth of fruit trees or ordinary crops. The soil is also free of alkali salts in injurious quantities.

The Stockton silt loam is one of the most productive soils of the area and is well adapted to the growing of vegetables, grains, alfalfa, root crops, and hardy fruits. Hay and grain, consisting of wheat, barley, and oats, are grown, giving good yields without irrigation, under proper cultural conditions. Almonds, cherries, and peaches also yield well. Bramble fruits, grapes for table and winery purposes, and vegetables are grown to a comparatively small extent, but with considerable success.

The following table gives the results of mechanical analyses of the Stockton silt loam:

Mechanical analyses of Stockton silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
12077	Soil	0.2	0.9	0.7	5.4	15.6	52.8	21.4
12078	Subsoil	.0	.0	.5	5.4	19.6	53.1	20.8

FRESNO SANDY LOAM.

The Fresno sandy loam varies somewhat in texture and in the character of the subsoil, but typically the surface soil consists of about 3 feet of gray to light-brown sandy loam of medium to rather fine texture, frequently carrying considerable fine angular gravel or coarse

sand particles. While usually loose and friable, the soil is sticky when wet and frequently becomes compact. At the depth of 3 feet this soil grades into a fine silty loam or silty clay loam. This subsoil also frequently carries some coarse material, is of a light-yellow or brown color, compact structure, and smooth and somewhat ashy texture, sometimes becoming sandy in the extreme lower part of the profile. The subsoil frequently carries concretions and is underlain at a depth of about 5 feet by hardpan, impenetrable to the soil auger or ordinary plant roots.

The Fresno sandy loam occurs mainly in a single body covering an area of some 8 square miles lying in the southeastern part of the area. A number of small and unimportant bodies also occur in the vicinity and southeast of Lathrop and French Camp. The surface is level or only very slightly rolling and is generally treeless. Some of the smaller bodies occur in slight depressions, while much of the larger area is low, flat, and somewhat poorly drained. This condition is augmented in places by the occurrence of hardpan. Considerable improvement may be effected in the case of the depressions and minor sinks by artificial drainage.

The Fresno sandy loam has been formed by the deposition of materials derived from the Sierra Nevada Mountains, and distributed over the valley plain by former streams. Considerable granitic material can be identified in the soil. Small quantities of alkali salts frequently occur, and particularly in the underlying hardpan, which not infrequently becomes the seat of, and in fact probably owes its origin somewhat to, the especially injurious alkali carbonates. While the quantity of these salts is generally not excessive, in a few cases it is sufficient to prove injurious to vegetation.

With irrigation alfalfa, fruits, and most ordinary farm crops should do well upon this soil wherever the hardpan does not approach the surface too closely. At present grain hay and grain are grown, without the aid of irrigation, giving fair yields in favorable seasons. The growing of these crops and of alfalfa under irrigation is becoming more important from year to year, and is much more profitable than under the old system of dry farming.

The following table gives the results of mechanical analyses of a typical sample of the soil and subsoil of this type:

Mechanical analyses of Fresno sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13074	Soil	2.0	13.2	6.5	17.1	16.7	31.1	13.4
13075, 13076	Subsoil	3.7	14.4	6.9	17.7	14.9	29.8	12.5

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 13076, 2.18 per cent.

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam consists of 6 feet or more of light-gray sandy loam of fine ashy texture and compact structure. The soil is very smooth and quite sticky when wet, and has a tendency to puddle. The ashy texture and compact structure are most evident at the depth of about 3 feet or 3½ feet, at which point a white hardpan stratum is frequently encountered. The extreme lower part of the soil section is sometimes considerably lighter in texture than the overlying soil.

The Fresno fine sandy loam is not an extensive soil type. It occurs in the southern part of the survey in the vicinity of French Camp, Lathrop, and Atlanta, usually as irregular elongated bodies extending in a northwesterly and southeasterly direction. The surface is usually low, flat, sometimes slightly depressed, generally treeless, and without distinctive topographic features. Owing to position and the presence of hardpan, natural drainage is deficient and percolation is arrested, pools of water frequently remaining in the roads and fields for a long time after heavy rains.

The origin and mode of formation of this soil is essentially the same as that of the Fresno sandy loam, the material being of a finer grade. As in that type, alkali salts in small quantities are of general occurrence. They are usually found in the underlying hardpan or compact subsoil, and in depressed, poorly drained areas have accumulated at the surface in such quantities as to be injurious to ordinary farm crops.

A considerable area of the Fresno fine sandy loam is, in its present condition, adapted only to grazing. In those sections of better natural drainage and where the hardpan is less impervious or continuous or lies at some distance below the surface, alfalfa, grains, and probably vines and small fruits should do well under irrigation, if care be taken not to apply excessive quantities of water. At present the type is devoted mainly to grazing and to dry-farming to grains and grain hay.

The following table gives the results of mechanical analyses of a typical sample of the soil and the subsoil of this type.

Mechanical analyses of Fresno fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13053	Soil	0.0	2.8	6.6	37.1	24.1	21.1	8.8
13054	Subsoil	.2	2.2	4.4	24.3	31.0	35.3	12.4

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 13054, 1.36 per cent.

FRESNO SAND.

The Fresno sand consists of a light-gray or light-brown sand of medium texture and loose incoherent structure, and extends to a depth of 6 or more feet. The soil throughout the section carries considerable coarse angular material.

This type occurs in a very irregular body, with relatively long and narrow projections extending in a general northwesterly and southeasterly direction to the south and east from French Camp and Lathrop. It covers a considerable area, and in the southern part of Twp. 1 S., R. 7 E. it is the prevailing type of soil. The surface is generally slightly rolling, treeless, and unmarked by vegetation except wild grasses and a great variety of brilliantly colored wild flowers appearing during the early spring. The soil passes gradually into the adjacent fine sands and sandy loams, and includes bodies of these soils too small to be shown upon the map.

Owing to its position, character of surface, and open, porous texture, this soil is naturally very well drained. Lower lying areas and depressions may, however, become saturated and rendered unproductive from a too copious use of irrigation waters upon the higher slopes, and there are already instances of impairment of the lower lying lands from this cause.

As in the case of the adjacent soils the materials forming the Fresno sand originally came from the weathering of the rocks of the Sierras. The wash from these has been transported by streams and distributed over the valley plain in gently sloping fanlike forms. The materials forming the Fresno sand, however, are believed to be mainly derived from granitic rocks.

Owing to the good natural drainage and to the loose open structure of the soil, it is free from injurious alkali salts. The soil, however retains little moisture and therefore is hardly a satisfactory soil for grain or shallow-rooted crops without irrigation. Where irrigated, it is well adapted to alfalfa and general forage crops. Cherries, peaches, small fruits, and early truck crops would also prove profitable. Alfalfa and grain are the principal crops grown at present. Alfalfa, which is grown with the aid of irrigation, yields well. The yield of grain, dry-farmed, is generally very light.

The following table gives the results of mechanical analyses of a typical sample of the soil and the subsoil of this type:

Mechanical analyses of Fresno sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13049	Soil	5.0	28.7	19.8	30.4	12.8	4.8	3.0
13050	Subsoil	1.9	18.9	18.6	34.7	15.9	5.7	5.7

FRESNO FINE SAND

The Fresno fine sand consists typically of a light-yellow or light-brown micaceous sand of fine, smooth texture and open, porous structure, extending to the depth of 6 or more feet. In the Fresno fine sand of the Stockton area the lower part of the soil section is frequently slightly heavier and somewhat more tenacious when wet than nearer the surface. It is usually free from gravel or other coarse material, except where there is an admixture of the adjacent Fresno sand.

The Fresno fine sand is found in several long, narrow areas associated with the Fresno sand and Fresno fine sandy loam south and southeast of French Camp. The surface is generally nearly level or only slightly uneven. The native vegetation is similar to that of the Fresno sand, consisting of grasses and flowering weeds.

While the areas of Fresno fine sand are only slightly above adjacent soils of somewhat deficient drainage, percolation, evaporation, and lateral movement of the soil water is rapid. The soil is somewhat deficient in moisture-retaining properties, and frequent cultivation becomes of great importance in conserving moisture for the use of the crops.

In origin and mode of formation the Fresno fine sand is similar to the Fresno sand, micaceous granitic material predominating. It is free from alkali salts in injurious quantities, although the deeper subsoil contains small quantities, which under excessive irrigation, coupled with insufficient cultivation and drainage, might in time become concentrated at the surface in sufficient amounts to prove injurious to ordinary crops. There is generally no hardpan formation in this soil within the depth of 6 feet.

The Fresno fine sand is best adapted to the growing, under irrigation, of alfalfa, forage crops, or hardy fruits, requiring a loose, well-drained soil. It is generally devoted at present to grazing and to the growing of alfalfa and grain with and without irrigation, the yields being generally slightly better than those obtained from the Fresno sand. This is especially true in the case of the dry-farmed areas.

The following table gives the results of mechanical analyses of a typical sample of the soil and the subsoil of this type:

Mechanical analyses of Fresno fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
18351	Soil	0.9	0.2	8.5	34.6	28.3	19.8	5.6
18352	Subsoil	.7	5.9	9.1	34.7	28.7	15.8	5.0

SAN JOAQUIN SANDY LOAM.

The San Joaquin sandy loam consists of about 30 inches of sandy loam of medium texture and of light-red color, underlain by an impenetrable hardpan of fine texture and dense structure. The coarser particles in the soil are angular and sharp and tend to give it a friable structure when in a favorable condition, but when wet the materials become sticky, with a tendency toward puddling and baking. The lower part of the soil becomes slightly heavier in texture and more compact in structure, the 4 inches immediately above the hardpan containing considerable clay and exhibiting the structure of adobe. While the average thickness of the soil covering is 30 inches, the depth to hardpan is subject to some variation.

This soil occurs only in a single extensive and uniform body east of Ellisworth in the southeastern part of the area. The surface is treeless, except in the vicinity of minor stream channels, is sometimes marked by slight depressions, and slopes, in general, slightly to the northwest. While occupying a more favorable position for drainage than many of the soils of the area, as in the case of the San Joaquin loam, the percolation is checked by the underlying hardpan, and drainage in the lower depressions and in areas of slight inclination is deficient.

The San Joaquin sandy loam owes its origin probably to deposition of the material originating in the rocks of the Sierra Nevada Mountains, in the waters of an ancient Pleistocene lake or bay, the material being modified by later alluvial wash and by the secondary hardpan formation. Alkali is not found in injurious quantities in the soil.

Owing to the presence of hardpan the San Joaquin sandy loam is not adapted to fruit trees, alfalfa, or other deep-rooted or heavily irrigated crops. Grain hay and grains, grown without the aid of irrigation, are the principal crops, the yields being fair in favorable seasons.

The following table gives the results of mechanical analyses of a typical sample of the soil and the subsoil of this type:

Mechanical analyses of San Joaquin sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13089	Soil	4.8	16.9	8.9	16.6	14.8	23.4	13.6
13090	Subsoil	2.8	16.7	8.5	16.7	13.5	22.6	18.8

STOCKTON LOAM.

The Stockton loam is subject to considerable variation in color, texture, and character of soil and subsoil. Typically it consists of 6 or more feet of light chocolate-brown to nearly black loam of medium

texture and of somewhat compact structure. The lower portion of the section is somewhat lighter in color and frequently in texture, although the subsoil frequently becomes a fine silty loam. The soil is easily cultivated and friable when in proper moisture condition, but becomes sticky when wet and has a tendency to puddle. Limited areas occur in which the texture and structure of the soil approaches that of the adjacent soil, the Stockton loam blending with the other types.

The Stockton loam is a type of considerable extent and importance, occurring in irregular bodies in the central and eastern parts of the survey. The larger and most typical areas occur northeast of Stockton and in the vicinity of Waterloo and Linden. Small elongated bodies frequently occur along streams in other parts of the area. The surface is usually level or only slightly uneven, and elevated but little above the adjacent heavier soils. Drainage is sometimes deficient during seasons of heavy rains, but in general the conditions are satisfactory during the growing and harvesting seasons. A few slight depressions occur which would be benefited by artificial drainage.

A light sandy phase of this soil occurs, in which the upper 3 feet consists of a light loam of dark or black color, containing a large amount of rather coarse, loose sand. This is underlain at about 3 feet by the loam of fine silty texture and light color which is found in the typical soil. This phase occurs as occasional streaks or as slight mounds or ridges, usually in the vicinity of former or present stream channels. The largest area is found near the northern margin of the area about 7 miles northwest of the center of the city of Stockton. It is generally well drained, free from alkali, somewhat less retentive of moisture than the typical soil, but similar in other important features.

Like the adjacent soils of the valley floor, the Stockton loam is of alluvial origin, resulting from the deposition of heterogeneous sediments, in ancient lakes or bays, and streams, modified by an admixture of more recent sediments laid down by existing streams. It possesses in a high degree the power to retain moisture, and under proper cultivation may be rendered capable of supplying the needs of crops during long periods of drought. It is also generally free from alkali salts, although small patches occasionally occur in a few districts of deficient drainage, where the salts have become concentrated in injurious quantities at or near the surface. Such alkali areas are, however, in the aggregate of but relatively small extent.

The Stockton loam is well adapted to the growing of small and stone fruits suited to the climate, and also to alfalfa, onions, cabbage, and other vegetables, grain, and grain hay. At present the two crops last named, grown without irrigation, are the principal products. The yields are generally good, unless reduced by unfavorable seasons. To some extent vegetables and fruits are also grown with profit in the vicinity of Stockton.

The following table gives the results of mechanical analyses of a typical sample of the soil and the subsoil of this type:

Mechanical analyses of Stockton loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13056	Soil	0.5	5.8	8.4	25.4	18.7	22.2	19.0
13058	Subsoil	.1	7.9	12.8	31.2	17.0	13.8	18.2

STOCKTON LOAM ADOBE.

The soil of the Stockton loam adobe consists of a heavy, black clay loam adobe, extending to the depth of about 30 inches, and containing a considerable admixture of sand, consisting mainly of coarse angular white particles. This is underlain to a depth of 6 or more feet by a fine silty or silty clay loam of light-yellow color. The soil is of a very dense compact structure and frequently checked upon the surface. It becomes very sticky when wet, and unless properly cultivated puddles readily and bakes upon exposure.

The Stockton loam adobe occurs only in a single body, and that of limited extent, lying north of Stockton and along the northern margin of the area. The surface is generally nearly level or only slightly uneven, and marked by an occasional clump of valley oak or by willows in the vicinity of stream channels. By gradual diminution in the proportion of sand the grades into the other adobe lands lying to the south.

Owing to relatively low position and to the compact structure and heavy texture of the soil, natural drainage is frequently deficient, especially during and following seasons of heavy rains. Artificial drainage is sometimes resorted to and might be further extended with beneficial results.

Deposits from ancient lakes or bays with the later addition of sediments from streams, modified by the various agencies of weathering, have given rise to this soil. The original materials have been derived from a great variety of rocks, as in the case of nearly all the soils of the area. No hardpan formation seems to occur and alkali salts only in very small quantities, though the latter are sufficient to increase somewhat the tendency of the soil to puddle. The fields are marked by small light-colored spots, which appear upon cultivation and are believed to be due to peculiarities of physical structure, probably induced by the action of small quantities of soluble salts. These light-colored spots are frequently less productive than the rest of the field.

This soil is probably best adapted to grazing and the growing of alfalfa, grain, hay, and forage crops, the purposes for which it is at present used.

The following table gives the results of mechanical analyses of typical samples of the Stockton loam adobe:

Mechanical analyses of Stockton loam 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.*	*Per cent.*
13061	Soil	0.5	3.0	3.3	15.2	21.6	30.8	25.9
13062	Subsoil	.6	3.0	2.9	15.1	20.6	43.3	14.8

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 13061, 1.45 per cent; No. 13062, 2.18 per cent.

STOCKTON CLAY ADOBE.

The Stockton clay adobe consists of a chocolate-brown to nearly black heavy clay adobe, with a depth of about 36 inches, and underlain to a depth of 6 or more feet by a light-yellow subsoil of fine, silty clay texture. The soil is of close compact structure, polishing highly upon the soil auger, is exceedingly tenacious and of a stiff puttylike consistency when wet, checking at the surface into large blocks by deep surface cracks upon exposure. In advanced stages of checking, the larger blocks are divided and subdivided by smaller checks and cracks, causing the surface to break up on cultivation into a loose mass of small blocks and pellets of the size of small peas and larger.

The subsoil is of much less dense and compact structure than the soil, but is very sticky when wet, and frequently carries small rounded concretions or incipient hardpan formation. Both soil and subsoil frequently contain small subangular rock particles of the size of fine gravel.

The more extensive and typical bodies of the Stockton clay adobe occur near the eastern part of the area, in the vicinity of Ellisworth and Collegeville. Many smaller irregular bodies are, however, scattered throughout the eastern half of the survey. The surface is low, nearly level, and without distinctive natural features, except for an occasional growth of valley oak. The soil grades into the adjacent loams and the heavy and dense Stockton clay loam adobe. Owing to unfavorable position and to the dense, heavy nature of the soil, natural drainage is generally deficient during the rainy seasons, farm operations and even travel over the roads being greatly hampered or temporarily suspended.

The Stockton clay adobe in the main owes its origin to the distribution over the valley floor of very finely divided rock material, derived from a great variety of rocks and modified by an admixture of ancient Pleistocene sediments.

Owing to the texture and structure of the soil, percolation is arrested and the soil when dry absorbs water very slowly. It is,

however, capable of holding a great amount of water when saturated, which is slowly given up under evaporation. Under proper methods of cultivation it is thus able to retain much moisture throughout the dry summer seasons, and to supply the crop needs during prolonged droughts. The soil is also generally free from impervious hardpan or alkali salts in such quantities as to become detrimental to crops. The small light-colored spots noted in the description of the Stockton loam adobe are also of frequent occurrence in the type under discussion.

This soil is not generally well adapted to early vegetables or fruits, or to crops requiring a light, well-drained soil. It is best suited to the production of alfalfa, forage crops, grain, and grain hay. Dairying and stock raising should be profitable industries where the trampling of the soil in wet seasons by stock can be avoided. Alfalfa, grain hay, and grain are the principal crops now grown, the yields being generally good or relatively heavy in favorable seasons. Vines, tree fruits, and vegetables are grown to a limited extent upon lighter phases of the type in the district lying northeast of Stockton, with fair yields under careful cultivation and attention.

The following table gives the results of mechanical analyses of typical samples of the soil and the subsoil of this type:

Mechanical analyses of Stockton 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.*	*Per cent.*
18068	Soil	0.4	1.5	1.6	7.5	12.8	32.4	40.2
18064	Subsoil	.8	1.0	1.9	8.1	12.0	33.1	42.8

STOCKTON CLAY LOAM ADOBE.

The Stockton clay loam adobe consists of a black clay loam adobe, similar in structure features to the Stockton clay adobe, but of smoother texture, being generally free from coarse or gritty material. It polishes highly upon the soil auger and assumes an exceedingly tenacious, waxy or stiff, puttylike consistency when wet. During the dry season the checking of the surface is often developed to a remarkable degree. It is underlain at about 3 feet by a yellow heavy silty or silty clay subsoil, becoming lighter in the lower part of the section and similar to that of the Stockton clay adobe. The surface of the subsoil in the more southerly lying bodies is frequently somewhat compacted and partially cemented immediately below the overlying soil into a soft, imperfect hardpan or separated from the overlying soil by a thin white crust of relatively soft, calcareous hardpan.

The Stockton clay loam adobe is one of the most important soils of the area, occurring in the most extensive and typical bodies to the

north, south, and east of Stockton. The surface is low, level, and without topographic variety. An occasional grove of valley oak appears, but much less frequently than upon the adjacent soils of lighter texture and more open structure.

As in the Stockton clay adobe, the natural drainage is poor, the soil becoming uncultivable during wet seasons. The mode of formation of this soil is somewhat obscure. The materials constituting it are probably derived from a great variety of rocks, and have been distributed by the waters of streams and tides and modified by the incorporation and decomposition of vegetable matter. It is generally free from alkali salts in injurious quantities, and in its pronounced moisture-retaining properties is very similar to the Stockton clay adobe.

Like the Stockton clay adobe also, it is best adapted to alfalfa, grass and forage crops, and grains, which crops are at present the principal ones grown. The yields are generally good, unless proper preparation of the land is prevented by unfavorable weather and drainage conditions, or the growth of the crop is retarded by the ravages of fungous diseases or insect pests, the development of rust or other fungus sometimes being induced by the wet conditions in the low-lying areas.

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

Mechanical analyses of Stockton clay loam 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.*	*Per cent.*
18006.....	Soil.....	0.5	1.8	2.0	12.8	17.9	35.0	30.9
18007, 18008	Subsoil	.5	1.0	2.1	17.1	20.3	34.4	23.7

SACRAMENTO CLAY LOAM.

The Sacramento clay loam occurs typically as a dark-colored, nearly black heavy silty clay loam, containing a large proportion of organic matter, the remains of decaying vegetation. The soil generally extends to the depth of about 30 inches. The proportion of organic matter is usually, but not always, less in the first few inches than in the lower part of the soil section. Vegetable fiber is of frequent occurrence, but the greater part of the organic matter is thoroughly decomposed. The dark-colored soil is underlain by a light-yellow fine silty loam, frequently grading into a very fine sandy loam, and extending to the depth of 6 or more feet. Both soil and subsoil are free from gravel or other coarse material, of somewhat compact structure, sticky when wet, but friable under cultivation.

The type is subject to considerable variation in depth, texture, character of subsoil, and in the relative amounts of silt and organic matter. In the vicinity of the adjacent peat lands it is underlain by the partially decomposed peat instead of by the yellow silty loam subsoil, as described. A silty clay phase also occurs in a few small areas in the vicinity of the San Joaquin River and some of its larger tributaries. This phase consists of a deposit of from a few inches to 2 feet or more of a light yellow, very fine, heavy silty or silty clay loam, very sticky when wet, and of rather compact, dense structure, underlain by the peaty and silty loam materials of the typical soil. It is similar to the typical soil in most other particulars, but is of a more refractory, denser texture and structure and requires more careful preparation and cultivation.

The Sacramento clay loam is an extensive and important soil type, occurring in the central and southwestern parts of the area. The surface is generally level or only slightly inclined, and treeless, except in the vicinity of the streams. The depressions, which are of deficient drainage, are usually marked by a growth of tules or rushes. The soil passes gradually into the adjacent peat lands, adobes, and loams.

Percolation is sometimes retarded by the compact structure of the subsoil, which, with the low-lying position and gentle slope, often results in insufficient natural drainage, and open drainage ditches are frequently encountered in the cultivated areas of this type.

The Sacramento clay loam owes its origin to the admixture of the fine river silts, derived from a variety of rocks and distributed by the San Joaquin River and its tributaries and branches, with the fine alluvial and decomposed organic matter of the tidal fresh-water marshes or peat lands. The material from these two sources is either intimately mixed or deposited in alternating strata. The soil is generally free from alkali salts in injurious quantities, and under proper cultivation possesses valuable moisture-retaining properties.

While containing a large amount of organic plant food, and generally productive, the crop yields decline where a single crop is grown continuously. When the water table is not too close to the surface, the type is best adapted to alfalfa, to grass and forage crops such as redtop, rye grass, timothy, some of the clovers—and to root crops, beans, vegetables, and grain. Much of this land is admirably adapted to dairying and stock raising. Small and tree fruits, consisting of peaches, apricots, pears, and cherries, also do well in the higher and better drained areas of lighter texture.

Grain hay and grain, consisting of wheat, barley, and oats, are the principal crops, the yields being usually good. Alfalfa, in connection with dairying and stock raising, is also grown in limited quantities. In small, favorably situated bodies, especially in the vicinity of the

San Joaquin River, fruit and vegetable production is of considerable importance and profit.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Sacramento 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.*	*Per cent.*
13057	Soil	0.3	0.8	0.5	2.5	6.3	40.3	49.7
13058	Subsoil	.5	.8	.4	9.0	26.2	46.5	16.6

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 13058, 1.36 per cent.

PEAT.

In point of extent of area covered, naturally unproductive condition, progress of reclamation operations, and agricultural possibilities, the Peat lands of the Stockton area are of great interest and importance.

In typical section the soil consists of 6 feet or more of fine alluvial river and tidal silts, intimately commingled with partially decayed vegetable matter, undecomposed plant roots, stems, and fibers occurring in great profusion. This material is dark brown to black, of an exceedingly smooth and pasty consistency when wet, of spongy texture, and generally saturated with water at a depth of 2 or 3 feet or less. In certain districts subjected to recent overflow by streams in flood, the surface foot frequently consists largely of river silts, in which the usual proportion of organic matter is greatly decreased. The subsoil is, however, the same.

The depth of the Peat is also subject to considerable variation, usually increasing in the direction of the lower San Joaquin River, which leaves the area near the northwestern extremity. Near the margins of the soil bodies it is frequently underlain at a depth of from 4 to 6 feet by a stratum of sandy clay of bluish cast, or by compact river silts and fine sands, though over the greater proportion of the soil area the underlying light-colored fine river sands are encountered only at a depth of from 10 to 15 feet or more, while in the northwestern portion of the area the depth of the peaty deposits is much greater. In parts of this latter mentioned section only the immediate crust is of sufficient solidity and toughness to bear the weight of farm animals or machinery, the underlying material being in an exceedingly soft semifluid condition, and extending to great depths.

Although quite sticky when wet, there is but little or no tendency toward puddling, the surface being friable and easily cultivated after the first breaking or cutting away of the surface accumulation of the

tough roots of aquatic plants. No gravel or other coarse material appears in either soil or subsoil.

This important soil type occurs only in the San Joaquin River delta region, where it covers the greater proportion of the entire western half of the area surveyed. The topographic and drainage features, mineralogical origin, and mode of formation are much the same as in the other soils of the lower delta. The drainage conditions will be discussed more particularly under the succeeding heading.

Extreme lightness in weight constitutes a very striking feature of the Peat, large fragments frequently becoming detached and floating about with the stream and tidal currents.

The soil carries a great supply of plant food and under favorable conditions yields enormously. This has given rise to the belief that the soil is capable of continuously producing all manner of crops, without regard to the principles of ordinary farm management or crop rotation. This belief is not borne out by agricultural practice. While ranking among the most productive soils known and while maintaining this productiveness, when farmed under ordinary, careful, modern methods, the long-continued growing of successive crops of grain, as in the case of other soils, is resulting in decreased production. The profitable growing of successive crops of potatoes is said to be limited to three or four years.

The accidental ignition of the Peat from "tule fires," or in other ways, often proves troublesome, the organic material of the soil slowly smoldering until practically removed, unless the fire be checked by flooding. This leaves the soil a mere bed of red or light-colored ash, and greatly reduces its value, and, moreover, increases capillary movement and rapid evaporation from the surface, resulting frequently in the surface accumulation of alkali salts in injurious quantities. When not modified by ignition, the capillary or upward movement of soil waters takes place so slowly that the application of irrigation waters to the soil surface frequently becomes necessary during the dry season, although the soil may be saturated with water at the depth of 3 or 4 feet, or even less.

While alkali salts exist in these soils and in the surface waters in considerable amounts, under ordinary conditions they are not of sufficent concentration to become injurious to ordinary crops, and their accumulation in harmful quantities takes place only through the destruction of the natural, coarse, mulchlike structure of the soil.

The Peat is generally ill adapted to the growing of alfalfa or other deep-rooted crops, owing to the close approach to the surface of the water table. On the other hand, it is admirably adapted to certain special crops, such as asparagus, beans, onions, or other vegetables, forage crops, timothy, redtop, ryegrass, some of the clovers, and to potatoes or grain. The risk of damage to crops and lands from fires

caused by steam harvesters is, however, of some importance in grain production. Harvesting is also sometimes interfered with by the wet condition of the lands, resulting from high water and imperfect levee or drainage systems.

In the older reclaimed districts and in those not devoted to special crops this soil is especially adapted to the growing of hay and forage crops in connection with dairying and stock raising.

Of the foregoing crops grain, potatoes, beans, asparagus, onions, and other vegetables are the principal products. Dairying is also an important interest. Alfalfa is successfully grown upon some of the earlier reclaimed and better drained tracts. In newly reclaimed districts crops are sometimes uncertain for the first one or two seasons, owing to imperfections and delay in establishing proper drainage conditions. Considerable risk and expense always attend the practice of agriculture upon this soil type, but, with the exceptions noted, the yields and profits during favorable seasons are usually so great as to offset occasional losses.

SPECIAL SOIL PROBLEMS.

The occurrence of a hardpan formation within the limit of the root zone of crops is of great importance in its bearing upon percolation, drainage, the conservation of soil moisture, and direct effect upon plant growth. Not only is the root zone of crops greatly limited by the occurrence of impenetrable hardpan strata lying near the soil surface, but cultivation is frequently interrupted, the movement of soil water arrested, drainage retarded, and the power to retain and to deliver moisture decreased. Lands in which this hardpan occurs usually become dry during periods of drought or dry seasons, and if irrigated, frequently become waterlogged, crops thus suffering from the extremes of moisture condition.

In the Stockton area hardpan is of frequent or of general occurrence in a few of the soil types. It is, however, subject to great variation in structure and in its effects upon agriculture. The most pronounced hardpan is found in the San Joaquin loam and the San Joaquin sandy loam, lying along the eastern margin of the sheet. It is generally of light-red color, fine texture, save for an occasional inclusion of gravel, and dense structure, impenetrable to the soil auger or to the roots of plants. It usually occurs at a depth of from but a few inches to 3 feet and is frequently exposed at the surface by slight erosion. It does not soften upon application of water, and when exposed to the air weathers very slowly. It is of secondary formation, resulting from physical and chemical changes that take place in the soil and cause the cementing of the material into a dense, impenetrable mass. The red color is produced by the iron salts present in the soil, and this mineral is doubtless instrumental in the formation of the hardpan.

Throughout the eastern-central part of the area a much less intractable and therefore less injurious hardpan occurs. It is found within the zone of ordinary root development only in the case of some of the lower lying, heavy adobe soils, and amounts merely to partial cementation of the underlying heavy loam subsoil by lime carbonate. A thin white crust of true lime carbonate hardpan of quite dense structure frequently separates the soil and subsoil. Both this crust and the underlying compact and partially cemented subsoil are penetrated by the soil auger and probably frequently by the roots of trees and field plants. It lies uniformly at a lower depth than the hardpan first described, which is another reason why it is much less injurious in its effects upon crops.

The white hardpan of the Fresno fine sandy loam occurring in the southern and eastern parts of the area is, however, of a more dense and firm character and of greater importance in its influence upon growing crops. This material consists of a firm white stratum, usually only a few inches in thickness, of fine texture, and ashy consistency when pulverized. It softens slowly upon application of water. Several of these strata may occur separated by the unconsolidated soil. Much of the fine ashy material is probably of volcanic origin, rich in alkali salts, and consolidated by lime and alkali carbonates. It does not approach the surface so closely as to interfere with plowing or other cultivation, and is much less extensive, uniform, and continuous than the red hardpan found in the eastern part of the area. It is of importance mainly as being the seat of much of the injurious alkali salts of this district and in its effect of retarding the removal of such salts by the drainage water.

While no areas occur in the Stockton area that may be properly designated as "worn-out" lands, the productiveness of certain soils of the valley and delta has been decreased by continued cropping to grain or other crops. In such cases, a more careful system of culture, the rotation of crops, the production of fat stock and farm animals, and the practice of a more diversified system of farming are to be recommended where consistent with location and with climatic and soil conditions.

The improvement of the areas of "burned-out" Peat is also a matter of importance. Careful management is necessary to bring these patches to their former state of productivity. The addition of coarse animal and vegetable manures and the culture of clovers, forage crops, and the practice of green manuring is recommended.

RECLAMATION OF SWAMP LANDS.

It is to modern engineering skill in the erection of levees and the drainage of the delta or swamp lands covering the most of the western portion of the Stockton area that this extensive district owes its agricultural importance. Lying but a few feet above low-tide

level, these island tracts, as previously noted, are thickly covered with a dense growth of the round tule (*Scirpus lacustris*). This aquatic reed, dying down each year and again annually springing up from the roots, together with rank aquatic grasses, soon forms a more or less completely submerged mat of partially decomposed vegetable remains which readily collects alluvial deposits from the flooded streams and gives rise to a rich soil, mapped as Peat. The development of this section has made rapid strides during the past few years, and the reclamation of other extensive tracts is still in progress, while in the northwestern margin of the map accompanying this report is indicated by swamp symbol a large area still unreclaimed.

Although early efforts were successful in bringing under cultivation large and valuable tracts bordering the upper courses of the streams, upon some of the tracts adjoining the lower San Joaquin River reclamation works of early construction have been completely destroyed and the land has returned to its native condition.

Reclamation of these lands consists essentially in throwing up levees or dikes along the streams, thus protecting the lands from inundation at every recurring flood or period of high tide. This is followed by construction of drainage ditches, the removal of the waters from the soil by pumping over the levees, and the bringing of the land under cultivation by appropriate means. The last-mentioned step will be touched upon under "Agricultural methods." In the construction of the earlier levees the spade, wheelbarrow, and scraper were largely employed. The levees were built close to the edge of the streams, with narrow crown and abruptly sloping walls. Settling frequently caused the levee to topple over or the loose Peat soil was quickly eroded away by the currents during heavy floods.

With the introduction of the steam dredger and the benefit of experience, and the employment of engineering skill, levee construction has become more successful. These dredgers, of the "clam-shell" type, work day and night and are capable of removing tons of sediment from the stream bottoms in a few minutes, placing the material in proper position upon the levee. Owing to the soft, spongy nature of the deeper peat and finer alluvial deposits, the newly made levee soon settles and the process must be repeated until a condition of stability is reached. When the mass has settled sufficiently to have reached the firm underlying sands, no further addition is usually required save for an occasional leveling up. The better and most successful levees are now built at some distance back from the rivers, the distance varying from 40 to 200 feet, and have wide bases and crowns and moderately sloping faces. In the American Review of Reviews for September, 1904, in an article written by Mr. A. J. Wells, the average cost of leveeing is given at from $15 to $20 an acre. The cost is commonly assessed pro rata upon the owners of the lands benefited, organized into reclamation districts.

In draining areas inclosed, the water is pumped over the levees from artificial drainage channels or from minor natural sloughs serving that purpose. For this work pumping plants are employed, either permanently located near the levee or installed upon barges and towed from place to place. The small plants and those of medium size are usually permanent and are operated by gasoline or by steam generated with crude-oil fuel. The larger plants used in the first freeing of the tracts of the flood waters frequently consist of batteries of powerful centrifugal pumps. These are operated by steam and are sometimes installed upon floating barges, which are particularly serviceable from the ease with which they may be moved from place to place.

While extensive tracts are still partially or wholly unreclaimed, practically all the lands lying within the Stockton area are reclaimable and will doubtless soon be rendered capable of cultivation.

WATER SUPPLY FOR IRRIGATION.

For many years irrigation in the vicinity of Stockton was generally considered unnecessary. With the introduction of fruits and other specialized crops, however, the artificial application of water often proved very beneficial. The building up of the dairying industries, fostered by the growing of alfalfa, rendered irrigation a necessity, for although in the growing of fruits and vegetables much may be done with an intermittent or limited water supply supplemented by frequent cultivation, the growing of alfalfa calls for a more extensive system, cheap and abundant supply, and thorough and regular application.

The great part of the area surveyed still remains unirrigated, but the practice is becoming more common with the development of intensive agriculture. The water used for irrigation is derived partly from the streams and partly from a subterranean source. In the southeastern part of the area a considerable acreage is covered by the lower branches of an extensive system of canals and laterals, the water being taken from Stanislaus River. Another system of considerable proportions, taking water from the Calaveras River near Stockton, passes through the north-central part of the area. Most of the water afforded by this latter system is, however, applied in the vicinity of Lodi and Woodbridge, which are some distance north of the limits of the district mapped.

Alfalfa is the principal crop irrigated under these systems in the Stockton area. While the water supplied by them is sometimes limited in amount, there is in general, particularly under the system taking water from the Stanislaus, more than enough for the area cultivated, so that if a tendency toward the reckless and too lavish use of irrigating waters could be checked the area irrigated could be here greatly extended.

Irrigation upon the delta lands lying below ordinary or high-tide level of the adjacent streams is cheaply and easily effected by tapping the streams through head gates placed in the levees. Alfalfa, vegetables, and the special crops of the island district are supplied with water in this manner, for although the water table lies close to the surface in this district, capillary movement is slow and the surface soil becomes very dry during the protracted dry summer season. The character of the stream water of the Stockton area, as regards fitness for irrigation purposes, is highly satisfactory. The water derived from an underground source is raised by windmills or small pumping plants operated by electricity, gasoline, or steam generated with crude-oil fuel. While tracts so irrigated are small, there is in the aggregate a considerable area devoted to the cultivation of alfalfa, vegetables, and fruit irrigated in this manner. The water derived from the first water-bearing stratum is frequently greatly inferior in purity to that taken from the streams. That from the second or third stratum, tapped by the most of these plants, is, however, relatively free from soluble salts, and may be considered safe for use in irrigation.

UNDERGROUND AND SEEPAGE WATERS.

The character of the underground water is of interest in giving some indication of the quantity and character of the soluble mineral salts in the subsoils, such salts readily making their appearance in the water of wells or springs.

In the western section of the delta part of the area, particularly in the vicinity of Holt and westward, the underground water frequently carries in solution relatively large quantities of alkali salts, indicating their presence in the soils to some depth. Of these salts sodium chloride, or common table salt, usually occurs in large quantities. In certain districts, however, the more nauseating magnesium salts predominate, and many of the wells carry such quantities of these salts as to be unfit for domestic use. The salts probably originate in marine deposits of a much earlier period, and although occurring in some quantity in the aggregate, owing to peculiar soil conditions need occasion no alarm as long as the normal structure of the soil is not disturbed.

The occurrence of seepage water in an irrigated district is usually due to the immoderate use of water in irrigation, or to the loss of water by leakage or seepage through the soils from canals and reservoirs, coupled with natural conditions of deficient drainage. This usually leads to a condition of water-logged soils occurring along the lower slopes, the formation of rank-smelling, disease and insect breeding pools, and unproductive marshes.

Although profuse irrigation may be carried on for several years before the appearance of these water-logged areas or seepage sinks,

under conditions favoring their appearance the tendency is always toward their rapid increase in number and extent. While such extreme conditions as occur in many heavily irrigated districts are not apparent in the Stockton area, there are a number of small spots and local depressions lying in the southeastern portion of the area that have been subject to considerable injury in this way.

Unless greater economy be practiced in the use of water it is feared that areas of seepage lands, at present not extensive, may rapidly increase. An outlet should also be provided for these local areas of naturally deficient drainage by construction of open ditches, or preferably by tile drains, of sufficient capacity to remove the excess soil or seepage waters from water-logged slopes and flooded sinks and convey them into natural or artificial channels leading to the larger streams.

ALKALI IN SOILS.

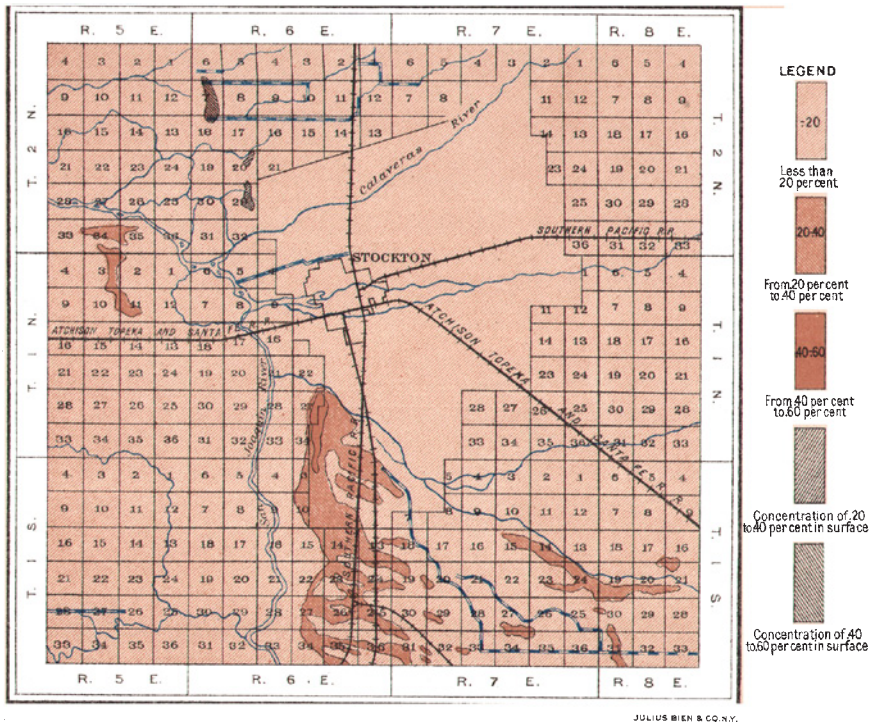
Alkali salts exist in injurious quantities in only a relatively small part of the soils of the Stockton area (see colored Plates I and II). In the vicinity of Stockton an occasional small patch sometimes appears. This condition is especially noticeable in one or two localities along the Linden road. Areas of slight concentration also occur immediately northwest of Stockton and along the edge of the swamp lands. The main alkali areas are found in the southern and southeastern parts of the area, usually in areas of the Fresno fine sandy loam and also in limited areas of reclaimed Peat lying a short distance west of Rough-and-Ready Island.

Excluding the deposits in the peat, where the alkali salts have been derived from marine sediments, the alkali of the Stockton area is derived from the eruptive or altered rocks of the Sierra Nevada Mountains, from the volcanic ash material occurring to a great extent in the soils of the central part of the San Joaquin Valley, and from the hardpan subsoil of the Fresno fine sandy loam. Although termed "alkali" salts, very few of the salts common in the Stockton area are true alkalis; that is, of alkaline reaction. Sodium chloride and sodium sulphate are of common occurrence. The truly corrosive and much more highly injurious sodium carbonate also usually appears wherever the total salt content is high enough to threaten crop production. In considering the injurious effects of alkali, 0.20 per cent is considered as the minimum limit of danger for ordinary irrigated crops, this amount, while not greatly in excess, usually decreasing yields of crops to a certain extent, and causing the appearance of frequent barren spots. In the case of the sodium carbonate or "black alkali," however, 0.05 per cent is considered the minimum concentration beyond which crops begin to suffer.

The relative concentration and distribution of these salts in the soils and subsoils depend upon a variety of circumstances, but

Plate I.

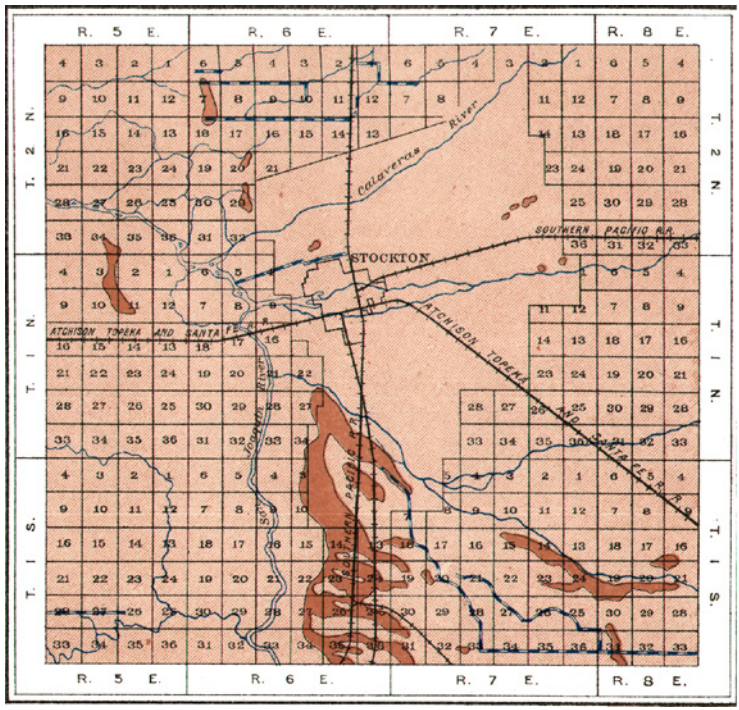
REPORT OF BUREAU OF SOILS U.S. DEPT. AGR. 1905.



JULIUS BIEN & CO. N.Y.

ALKALI MAP, STOCKTON SHEET.

Plate II.



BLACK ALKALI MAP, STOCKTON SHEET.

REPORT OF BUREAU OF SOILS U.S. DEPT. AGR. 1905.

largely upon the soil texture and structure, the position of the underground water table, and the rapidity and direction of the movements of the soil water. In soils of loose, open texture and structure, under influence of gravity movements caused by the application of water in excess of saturation by rainfall or irrigation, the salts are dissolved and carried downward and outward. In soils of fine texture and compact structure the movement is less rapid. Under the influence of evaporation upward capillary movement takes place, supplying moisture from the subsoils at the surface as removed by evaporation. Conditions favoring rapid evaporation and long-continued capillary movement—as, for instance, long periods of hot, dry weather, compact, uncultivated, and unshaded soil surfaces, and a water-logged condition of the subsoils, i. e., the occurrence of the water table near the surface, a condition frequently caused by the use of immoderate quantities of irrigating waters upon higher levels—tend toward concentration of the alkali salts at or near the soil surface. On the other hand, cultivation and consequent formation of a soil mulch, the checking of evaporation and capillary movement, the heavy application of water to the surface by rainfall or irrigation, together with conditions favoring the drainage of the subsoils, tend toward the removal of these salts from the surface. In the Stockton area the alkali salts are usually concentrated upon or near the surface. Occasionally the greatest concentration is found in the underlying hardpan, but rarely does the accumulation of the alkali salts in injurious amounts extend to the depth of 6 feet.

Several methods have been proposed for the partial or complete reclamation of alkali lands. The only permanent method, however, consists in thorough underdrainage, together with an occasional flooding of the surface. As soon as the soil is freed from excess of salts thorough cultivation should be entered upon, using some of the more alkali-resistant crops, which can be cultivated frequently, or which shade the surface—such, for instance, as sorghum, sugar beets, or alfalfa.

In the case of the alkali areas occurring upon the Peat lands, flooding, followed, as soon as the soil will permit, by cultivation of the surface, should prove beneficial. As much coarse vegetable matter as possible should be incorporated in these ashy areas, and the growing of forage crops to prevent evaporation through shading the surface should be undertaken as soon as practicable after flooding. In the case of the local alkali spots occurring in the heavy soils lying east of Stockton, the practice of the Italian vegetable gardeners in making heavy applications of coarse stable manures is frequently beneficial, improving the soil structure and checking surface evaporation and consequent concentration of the alkali salts.

AGRICULTURAL METHODS.

The Stockton area presents wide variation in agricultural practices, which range from those applicable to the most extensive to the most intensive systems of farming. In general, the methods employed are well adapted to the soils and conditions of the area, though improvement is possible in the methods of irrigation, cultivation, and the care of crops in some sections of the area.

Upon the larger ranches and tracts labor-saving machinery has attained a wide degree of usefulness. In the case of many of the smaller tracts devoted to market gardening and truck growing, the most of the labor is performed by hand by Italians, Chinese, and Japanese, although a wider use of light machinery and garden tools would frequently prove more economical and efficient.

Plowing upon the extensive grain-producing tracts is done with the gang plow in common use throughout this section of the State. While the seed bed is sometimes carelessly prepared, this field operation is in general carried on with greater thoroughness and diligence than in many other extensive grain-growing sections. Plowing, harrowing, and seeding operations take place during the winter months, the grain being sown by drilling or sometimes by broadcasting machines. Combined harvesters are in general use all over the larger tracts, some of which it is reported can harvest, thrash, and sack the grain from a hundred acres in a day at a cost of 14 or 15 cents per 100 pounds. In the low-lying island districts devoted to grain culture farming operations must be carried on with due regard to the moisture and drainage conditions of the spongy Peat soils. Untimely rains or floods occasionally render the soil too wet and soft to allow preparation of the land or harvesting of the crop, although under recent improved conditions of the levees this unfortunate condition does not often occur.

Upon newly reclaimed or soft tracts work horses are commonly provided with peat or "tule" shoes, offering increased surface resistance and preventing the sinking of the animal into the spongy land. Powerful traction engines, built in the form of an immense tricycle and provided with auxiliary rollers or traction wheels 4 or 5 feet wide, are also extensively used to compact the soil. One of these modern machines performs the work of many horses in hauling a series of gang plows, harrows, and grain drills, plowing, harrowing, and seeding the land at one operation. They are also again brought into requisition in hauling the combined harvester during the harvest season, in repairing and improving the public roads, and in hauling heavy loads. Modern labor-saving machinery likewise plays an important part in the production of some of the special crops grown in large tracts in the island district, although its use is here subject to greater natural restrictions.

Preliminary clearing of the Peat lands consists in cutting or rolling the tules flat, after which they are burned. Care must, however, be exercised not to ignite the deeper soil, which from its highly organic character may be largely consumed, leaving the land ashy, unproductive, and filled with deep and dangerous pits.

Rotation of crops and the use of barnyard manure or other fertilizers are not practiced to any great extent upon these extensively-farmed tracts.

Irrigation as applied to the chief irrigated farm crop, alfalfa, is usually carried on by the small rectangular or contour check system, which is well adapted to the soils and topography of the country. Upon the lighter soils of the southeastern portion of the area, however, the lavish use of irrigating waters is a dangerous practice, and if unchecked must result in flooding the lower lands and local depressions with seepage water, thus rendering them unproductive.

The delta lands devoted to the production of asparagus, vegetables, and other special crops are irrigated by subirrigation, the water being simply allowed to flow through laterals fed by a main line tapping the levee. While such a system may prove ruinous in soils heavily impregnated with alkali salts and subject to rapid capillary movement, it here proves a safe, cheap, and convenient method of applying water to the land.

Upon the small tracts of the islands and in the vicinity of Stockton, devoted to the growing of vegetables and fruit, the ordinary operations of plowing, harrowing, and cultivation and care of the crop are usually quite thorough. Some of this labor might, however, be efficiently and more quickly performed by the use of labor-saving machinery. Cultivation of the orchards and vineyards is sometimes neglected, the growth of noxious weeds, particularly the common wild mustard, allowed to go on unchecked, and pruning and spraying operations overlooked. In harvesting and marketing the truck, fruit, and other special crops the methods in vogue are frequently worthy of study and imitation. Barnyard manure in large quantities is applied to the smaller vegetable gardens, which, while not always essential to increase the plant food in the soil, improves the structure of the heavy soils and promotes increased yield. This practice is too frequently neglected in the West and might profitably be extended to most field crops.

The benefits of frequent and thorough cultivation in developing a proper condition of tilth in the heavy adobe soils, in preventing evaporation and conserving soil moisture for the production of plants, and in checking the accumulation of alkali salts through evaporation at the surface of some of the lighter soils of the southeastern portion of the area, are of especial importance.

AGRICULTURAL CONDITIONS.

The value of the farming lands of the Stockton area is increasing rapidly. The farms of the older settled districts, particularly those of the northeastern part of the area, present a neat and orderly appearance, and excellently tilled fields, well-built fences, and substantial and commodious farm buildings bespeak the prosperous and contented condition of their owners. In other less favored parts of the area an occasional vacant or abandoned farm dwelling is seen, indicating that the land, usually devoted entirely to dry-farmed grain, is rented and farmed by some neighbor or nonresident, the buildings sometimes being used merely temporarily by the hired hands during the harvest season. In the recently reclaimed districts of the islands and in many of the smaller tracts of recent conversion to truck farming, dairying, and intensive agriculture the buildings are frequently very modest, of cheap construction, or merely temporary affairs of rough boards, characteristic of newly settled districts.

There is, in general, upon the part of the farming classes, a desire to improve their condition, and to take advantage of modern conveniences and labor-saving devices. Much of the area is covered by rural free mail delivery routes and many of the more isolated farm dwellings are connected by telephone.

While quite extensive districts within the alkali belts bordering the swamp or tule lands and also in the southeastern part of the area are valuable in their present condition only for grazing purposes, the area of worthless lands or those incapable of being brought under profitable cultivation is very small.

Upon the older reclaimed portions of the islands farmed by the actual owners, good farm buildings are of frequent occurrence, but much of this district is as yet held in large tracts and rented for a cash consideration of from $6 to $15 an acre per annum, the tenants, mainly Italians, Chinese, and Japanese, often occupying poor or squalid quarters. This section could, if divided into small tracts, and devoted to dairying and intensive agriculture and farmed by actual owners, be rendered capable of supporting a large population. Many of the large grain-producing tracts of the valley are also rented upon a cash or crop-percentage basis. Statistics show less than half the number of farms of San Joaquin County to be operated by the actual owners. This condition is not in keeping with the opportunities offered in this section for the practice of diversified farming, dairying, and stock raising, or the growing of special crops in small tracts.

In certain districts, particularly in the southeastern part of the area, grain farming is being supplanted by dairying in connection with the growing of alfalfa and other farm crops. Notwithstanding

the great number of small tracts devoted to dairying and to vegetable and fruit production, owing to the existence of the many large valley farms and extensive island tracts the average size farm in San Joaquin County, according to the census of 1900, is 382 acres. This is more than ten times as great as the average size farm in some other of the irrigated districts of the West, the natural advantages of which are far less favorable to crop production in many respects of soil and climate. While not all the lands of the Stockton area, if intensively farmed in 20 or 30 acre tracts, would be capable of supporting a family, many of them would do so, and the average size farm may well be reduced coincidently with the further development of agricultural industries. Many of the Italian vegetable gardeners, by great thrift and unremitting labor, succeed in supporting large families and in accumulating a small competence upon only a few acres, and, in general, small or medium sized farms devoted to diversified farming with dairying, stock, or poultry raising, and the growing of fruits and vegetables upon a small scale, are more to be recommended to intending settlers, especially to those unacquainted with all the peculiar features of climatic and industrial conditions of the country, than the more extensive farming of larger tracts.

Upon the valley farms the general farming operations are usually intelligently performed by white labor at prices current upon the Pacific coast. Upon the extensive rented island tracts much of the labor is performed by Chinese and Japanese. In the raising of fruit and truck crops Chinese and Italian labor predominates. During the grain and fruit harvest season much extra labor is required and is frequently performed by nomadic laborers of mixed races and of a less reliable class. In ordinary teaming and in the use of farm machinery white labor, while usually somewhat more costly, is preferred. The more tedious hard labor necessary in the growing of truck crops and fruits is generally performed by the Latin races and Asiatics.

The production of grain is still the most generally practiced agricultural industry of the Stockton area. Wheat is the most important grain crop, followed in magnitude by barley and rye in the order named. The great part of the valley lands and extensive areas of the older reclaimed island tracts are devoted to this industry. A relatively constant rainfall, together with productive soils, renders this section probably the most important grain-producing district and shipping center of the San Joaquin Valley. While the wheat produced is of fair weight and quality, it is, in common with all California wheats, somewhat deficient in gluten content and consequently of inferior milling qualities. Experiments conducted by State and Federal authorities are now in progress by which it is hoped to produce strains of wheat of satisfactory milling qualities.

The other principal crops of the valley lands consist of alfalfa, table and wine grapes, and deciduous fruits, mainly almonds, peaches, apricots, and cherries. Almonds are especially productive and profitable when properly cared for and when not subject to injury from the frequent spring frosts, the planting of the hardier stock being advised in all cases. Choice early table grapes are usually in good demand and salable at prices giving large profits. The acreage of the vineyards is, however, being rapidly extended, and with the greatly increased product the returns from ordinary or late table grapes or wine grapes leave a narrow margin of profit, and this industry should be carefully studied before embarking in it extensively. The main fruit and grape-producing sections lie in the eastern and northern parts of the area.

Among other important crops of the delta lands, potatoes, beans, onions, asparagus, and other truck crops are produced in great quantities. Potatoes, beans, and asparagus are probably the chief crops of the newly reclaimed lands, potatoes being generally planted as the first crop. The yield and value per acre in San Joaquin County, according to the United States census of 1900, is as follows: Beans, 35.5 bushels, valued at $55.03; potatoes, 124.1 bushels, valued at $62.05 and onions, 402.2 bushels, valued at $232.28. The growing of chicory upon a commercial scale is an industry of some importance.

Dairying and the raising of dairy cattle, beef cattle, horses, sheep, poultry, and mules are well recognized industries and capable of being greatly extended. A limited number of pedigreed horses and dairy cattle of national reputation are produced, but the growing of forage crops and the production of stock upon favorably situated valley and island lands has been greatly neglected.

While more or less unsuccessful attempts are sometimes made to produce upon certain soils crops to which they are not adapted, the principle of the special adaptation of soils, through peculiar chemical, textural, or structural features, to special crops is commonly recognized. Alfalfa is produced chiefly upon the sandy soils of the southeastern part of the area, which is covered by extensive irrigation works. The Peat lands are generally poorly adapted to alfalfa, owing to the close proximity to the surface of the ground water. Some of the clovers and grasses, such as timothy, rye grass, etc., however, here do well. The Peat and Sacramento clay loam, if properly managed, are better adapted to the growing of vegetables, potatoes, and the other special crops produced in this section.

The main public roads are generally improved, and during the dry season good wagon roads cover nearly the whole area. During the rainy season, however, poor natural drainage conditions, with the extremely adhesive nature of the heavy adobe soils, often render the country roads traversing bodies of these soils practically impassable.

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