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Soil Survey of the Lower Salinas Valley, California.

BY

MACY H. LAPHAM AND W. H. HEILEMAN.

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SOIL SURVEY OF THE LOWER SALINAS VALLEY CALIFORNIA.

By MACY H. LAPHAM and W. H. HEILEMAN.

LOCATION AND BOUNDARIES OF THE AREA.

The Salinas Valley is the largest of the many valleys inclosed within the Coast Range system in California. From the Bay of Monterey it extends in a southeasterly direction, in a line parallel with the coast, to its head a distance of about 100 miles. It's average width is from 7 to 9 miles. The lower portion of the valley, or the area surveyed, is bounded upon the upper or southeastern extremity by the San Lorenzo River and Pine Creek, which break through the inclosing mountains and enter the Salinas River from opposite directions near King City.

Upon the northwest the valley is bounded by the Bay of Monterey and upon its sides by the Sierra Santa Lucia and the Sierra Salinas ranges, with their outlying spurs, upon the west, and by the Gabilan and Mount Diablo ranges upon the east, the latter separating the Salinas Valley from the great San Joaquin Valley of the interior of the State. (See fig. 20, p. 447.)

Of the area mapped something more than one-half consists of uplands devoted almost exclusively to the growing of barley, wheat, and oats, except for an occasional extensive stock ranch. In certain sheltered portions fruit raising is followed with profit. Upon the lowland soils of the valley grain growing is also followed to a considerable extent. Large areas of these lands are, however, devoted to the production of sugar beets, potatoes, and beans, and to dairy farming, and more limited areas to profitable apple orchards.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The county of Monterey, in which the area surveyed lies, is in date of settlement one of the oldest portions of California. Its early history is that of the founding and occupation by the Spanish friars of the historic missions, now crumbling into ruins. To the persistent and faithful work of the Spanish fathers in penetrating these unknown regions much credit is due. Their indomitable courage not only gave them conquest over savage tribes and discouraging natural barriers, but paved the way for the more recent settlers and for the advent of varied and important agricultural industries.

Agricultural development, however, during this period was very meager. The early efforts put forth by these conscientious and venturesome people were for the conversion of the pagan tribes rather than the planting of crops for the support of the convents. At this time game was plentiful and rich natural pastures free. The Indian tribes, who took shelter in the missions, were, however, deprived of this easy mode of existence, and farming in a small way began, in some cases aided by the construction of more or less complete systems for irrigation. This was, however, for many years limited to the growing of a few acres of grain and vegetables, under the supervision of the church, and to the supplying of only the immediate wants of the inhabitants.

Later on nearly all the valuable lands of the county lying in the valley and rich creek bottoms were applied for and obtained under the Spanish Crown as extensive land grants or ranches. These grants were honored later when the land was ceded to the United States. The old Spanish surveys of these ranches, with the original boundary lines, are still recognized throughout the Salinas Valley. Some have since been subdivided and sold to settlers in smaller tracts, while others are still intact and leased to tenants.

Owing to this cause, coupled with the slow development of irrigation, an extensive rather than an intensive system of agriculture prevails in the Salinas Valley.

With the gradual settlement of the lands grazing became the principal industry. The first record of wheat growing for market in the older portions of the Salinas Valley dates back to about 1853, but not until several years later did wheat become an important agricultural product.

In the neighborhood of Gonzales and Chualar wheat growing upon a commercial scale began about 1874. At that time a most excellent yield was obtained, reaching in favorable seasons 30 sacks per acre. From this time on wheat was raised continuously for about fifteen years, with no rotation of crops and no application of fertilizers, with the result that the lands, consisting chiefly of the weaker upland soils, were greatly impoverished. About this time also the grain smut made its appearance and, finding favorable conditions for growth, spread rapidly. In the later eighties the yield of wheat had fallen off to 8 or 10 sacks per acre, and the crop proving unprofitable, barley was taken up and is now the staple crop upon the uplands of the Salinas Valley.

Sugar-beet culture has within the past fifteen years come to be one of the important industries of the valley. The areas devoted to the successful cultivation of beets are under irrigation, and necessary conditions for profitable beet culture are being rapidly extended.

Dairy products, potatoes, beans, and fruit have within recent years become important agricultural products.

The agricultural development of the Salinas Valley, owing to existing natural conditions, presents a somewhat checkered aspect. A fertile soil, good markets and shipping facilities, and favorable seasons have caused rapid progress, but in late years there have been dry seasons and the scourge of bacterial and fungus diseases, and seasons of plenty have alternated with those of total failure.

CLIMATE.

The climate of the Salinas Valley is arid. It is characterized by a wet and a dry season, with a notoriously inconstant and fickle rainfall, but little variation in mean monthly temperatures in the lower valley, a brisk, steady wind movement, especially during the dry season, and, during a large part of the year, the prevalence of fogs at regular intervals.

The rainy season occurs during the late fall and the winter months. It sometimes begins as early as October or November, and is occasionally delayed as late as midwinter. There is not only a wide variation in the rainfall of the valley from year to year, but often considerable variation for the same season in different parts of the valley.

Generally speaking, the supply diminishes as the head of the valley is approached, although this is subject to variation, and the seasonal rainfall at Soledad, in the central part of the area mapped, is often less than at either Salinas or King City. A study of the rainfall record at these places presents strikingly the fluctuation in the supply from year to year. When it is considered that the seasonal supply may vary from 5 inches or less in one season to over 20 in the following, it is readily seen why dry-farming in the Salinas Valley has come to be considered as a business of uncertain returns.

During the dry season, from May to November, the precipitation is very light or almost nothing. As the rainy season approaches the wind movement changes from the northwest to the southeast, and occasionally cloudy days occur, with more or less frequent showers, and rains lasting from one or two hours to as many days. In the valley the rain usually falls in gentle, but sometimes quite heavy, showers. Cloudbursts and thunderstorms are very rare in the valley, but sometimes occur in the mountains.

While there is but little variation in the mean monthly and annual temperature, there is quite a range in the daily variation, especially in the upper portions of the valley, where during the summer months a very high temperature may be reached during the middle of the day. This is accompanied, however, by a low relative humidity and brisk wind movement, greatly reducing the sensible temperature. The nights are always cool, the air being generally quiet and foggy. During the winter the wind movement decreases in force and extent and clear nights are often accompanied by frosts.

Throughout the valley snow is seen only upon the mountain tops. Killing frosts may occur from the middle of November to the middle of April, and, while ice is rarely formed, the frosts are too frequent and severe to allow of the growing of citrus and other tender fruits, except in certain favored and very limited areas. Such areas lie along the base of the foothills and mountains bordering the valley, and several hundred feet above the valley floor.

The following table, compiled from records of the Weather Bureau, gives the normal monthly and annual temperature and precipitation as returned by the stations at King City, Soledad, and Salinas:

Normal monthly and annual temperature and precipitation for the Salinas Valley.

Month.	Temperature.			Precipitation.		
	King City.	Soledad.	Salinas.	King City.	Soledad.	Salinas.
	°F.	°F.	°F.	Inches.	Inches.	Inches.
January	49.3	46.7	47.4	2.11	1.90	2.93
February	49.3	49.8	49.4	1.82	1.50	2.28
March	54.3	53.4	52.3	1.97	1.52	2.18
April	57.2	57.4	59.7	.48	.63	1.32
May	61.7	62.5	59.9	.26	.28	.49
June	64.6	65.4	61.9	.03	.07	.17
July	67.5	65.5	62.6	.00	Tr.	Tr.
August	67.6	65.3	61.6	.01	.01	.02
September	66.8	65.1	61.1	.27	.08	.18
October	61.0	60.0	57.1	.71	.45	.78
November	54.9	52.9	52.6	1.16	.92	1.30
December	49.7	48.9	49.5	2.64	1.57	2.41
Normal annual	58.6	57.8	56.0	11.45	8.96	14.12

The winds play a very important part in the climate of the Salinas Valley. During the dry season the trade winds, entering the valley from the Bay of Monterey, strike the parallel ranges of the Coast mountain system and are deflected up the valley. These winds enter the valley in the early forenoon, and, as the upper and narrower portion of the valley is approached, blow with increased force. They prevail in the lower portion of the valley from a westerly and in the upper portion from a northwesterly direction throughout the entire dry season. Their maximum velocity is usually reached in the early afternoon, and as evening approaches they gradually decrease in force and nearly or quite cease during the night.

With the approach of the rainy season the trade winds gradually decrease in force and finally give way altogether to winds which prevail during the winter season from a southeasterly direction. They frequently bring rain, and blow with much less force and regularity than the trades of the dry season. The influence of the strong daily winds of the Salinas Valley is seen not only in their effect upon crop conditions, but in the drifting sand dunes of the river bottoms, the dwarfed and twisted trees of the upper terraces, and the scored and polished rocks of the hills themselves.

During the dry season the fogs usually appear in the portion of the valley adjacent to the seashore during the night, although there are occasionally cloudy days. These fog banks often rise from the sea and encroach upon the land very suddenly, sometimes lasting but a short time and as suddenly giving way to clear skies and bright sunshine. Above Salinas the white fog banks usually appear only in the late afternoon or evening, swiftly drifting up the valley and enveloping its lower portion, usually remaining until the appearance of the morning sun, when they quickly melt away and disappear over the mountain tops.

During the winter months the fogs occur with much less frequency and regularity.

The prevalence of fogs throughout the dry season is undoubtedly important in conserving the moisture supply in the soil and growing crops by checking evaporation.

PHYSIOGRAPHY AND GEOLOGY.

For much of the information bearing upon the physiography and geology of this region we are indebted to Mr. Homer Hamlin, of the United States Geological Survey.

The lower portion of the valley, extending from the bay of Monterey to several miles above Salinas, is a nearly level plain, from 5 to 8 miles in width. To the east the valley boundaries gradually disappear in the rolling sand hills of the terrace formation, which abut in turn against the mountains of the Gabilan Range. Upon the west side the transition from valley to the sands of the mesa lands is more abrupt, being marked by a line of bluffs immediately west of the Salinas River.

As the head of the valley is approached its width gradually decreases, averaging above Soledad about 6 miles, with slight variations. The main eastern wall of the lower valley is formed by that portion of the Santa Cruz-Gabilan Mountains lying south of the Pajaro River, and known as the Gabilan Range. This range extends as a rather low ridge, culminating in the lofty Fremonts Peak when nearly east of Salinas. From this point it again drops down until a point near Soledad is reached, where it becomes no longer prominent as a valley wall. The east wall of the upper portion of the valley is formed by the Mount Diablo Range and its foothills and mesa lands. This range extends from the vicinity of San Francisco in a southeasterly direction parallel to the coast for nearly 300 miles. Upon the west side of the valley the Santa Lucia Range, extending as a lofty unbroken ridge from Carmelo Bay to Cuesta Pass in San Luis Obispo County, is the most prominent. This range flanks the coast as a line of precipitous cliffs, affording but few landing places. Its east-side slopes descend rapidly to the valley, with but few intervening foothills. Lying between the northern portion of the valley and this range is the Sierra de Salinas, which forms the valley boundary northward from the Arroyo Seco for 25 miles, where it gives place to the Terrace mesa lands.

The valley is drained by the Salinas River with its tributaries, chief of which are the San Lorenzo and the Arroyo Seco.

The slope of the valley trough parallel to its axis is shown by the following table, giving the elevations above sea level of the Southern Pacific Railway stations throughout the portion of the valley surveyed:

Station.	Elevation.	Station.	Elevation.
	Feet.		*Feet.*
King City	363	Chualar	103
Soledad	180	Salinas	44
Gonzales	127	Castroville	17

The geological structure of the valley as a whole is that of a great synclinal fold lying between the Santa Lucia and the Mount Diablo ranges. The main fold is deflected between the Mount Diablo and the Gabilan ranges in the neighborhood of Soledad, the lower valley being largely composed of subordinate folds.

The valley itself is naturally quite sharply divided into two physiographic divisions—uplands and bottom lands.

By the uplands is meant that portion of the valley, covering about one-half the area mapped, bordering the foothills, usually quite sharply distinguished from the bottom lands by soils of loose, open, coarse texture, distinct natural vegetation, and prominent physiographic features.

Upon the Salinas sheet nearly all the soils of this class lie upon the east side of the valley, the Salinas River, with its adjacent bottom lands, for the greater part of its course, quite closely hugging the western valley wall. Upon the Soledad sheet extensive areas of these upland soils fall upon each side of the valley trough.

Throughout the greater part of the valley the uplands consist of a series of symmetrical alluvial fans or mesa lands, extending from the foothills or mountains toward the valley trough with a slope usually of from 3° to 5°. They pass gradually into the level valley bottoms or are cut near their lower borders by river terraces, dropping off sharply to the bottom lands below. Their upper portions are often several hundred feet above the valley floor, and they are often deeply cut by small arroyos or stream channels having precipitous sides and flat bottoms covered with coarse sand and gravel.

The chief physiographic feature of the bottom lands consists of a succession of well-defined terraces, extending throughout the valley in

FIG. 2.—BARLEY STUBBLE IN THE SALINAS VALLEY.

The growing of barley without irrigation has been the great industry of the valley. It supplanted wheat, and is now in turn being supplanted by sugar-beet culture.

a direction generally parallel to the streams. They are especially well marked along the San Lorenzo near King City and in the upper valley, along the Salinas.

In the Salinas Valley there have been a remarkable series of uplifts, followed by increased activity in the erosion of the valley floor by streams These have been followed successively by periods of subsidence, during which a large amount of deposition took place. This, coupled with the fluctuations in the water supply of the streams, has given rise to a terraced valley, its trough followed by a meandering stream, and each terrace being a remnant of an ancient flood plain. The Salinas River channel is from a few rods to a half mile or more in width, filled during the dry season with spits and dunes of wind-blown sand, with here and there only a small stream of water, which disappears at intervals in the porous quicksands to reappear farther down the course. In winter, however, with the first heavy rains, the water rushes into the streams from the mountain gorges, and the Salinas River becomes a sediment-laden torrent. As its waters sweep against its curving banks they are rapidly undercut, and the overlying earth falling into the stream serves to increase the load of sediment already carried. In this manner the river often rapidly encroaches upon the adjoining lands, laying waste hundreds of acres in a single season, in spite of attempts to check the damage by the use of timber and brush jetties. The sediment thus derived from the lands above is hurried to the sea or deposited in quiet waters upon overflowed lands of the lower terraces. As much as 10 inches of fine sand and silt has thus been deposited upon some of the overflowed land of the lower valley in a single season.

As the river approaches the valley mouth it gradually becomes narrower, until the bars and dunes of sand disappear in the neighborhood of the Southern Pacific Railway bridge, 1 mile west of Morocojo. From this point the river continues as a narrow stream with low banks until it finds its way into the sea a short distance below Moss landing. Considerable land lying adjacent to the river along this portion of its course is overflowed during flood seasons. The mouth of the Salinas River was at one time probably at a point nearly west of Morocojo, but for the last 7 miles of its course it is now separated from the sea by a narrow line of sand dunes.

Branching from the river along its lower course are a number of open sloughs which often extend to the south and east for several miles and are sometimes of considerable depth. Tide water sometimes extends up the lower of these sloughs for a considerable distance and they frequently widen into shallow, marshy lakes. The occurrence of these sloughs is a characteristic physiographic feature of the lower Salinas Valley.

In the description of the various rock formations which follows the names used were decided upon by the United States Geological Survey merely provisionally, pending an attempt to correlate them with other previously described formations.

The rocks of the Bed Rock series, of which the Sierra de Salinas and the Gabilan ranges are composed, consist of ancient metamorphic and crystalline rocks—gneiss, schist, slate, marble or limestone, and granites being most common. Overlying these rocks are the unaltered sedimentary rocks which were deposited upon their upturned and eroded surfaces. Considerable evidence of volcanic material ejected from the Gabilan Range is present in this series.

The age of the rocks of this series is unknown. They disintegrate into sands and sandy loams, often very light and porous, and containing a large proportion of fine, angular gravel. With the exception of the extreme lower end of the valley nearly all the upland soils below Soledad are derived from the rocks of this series.

The rocks of the Franciscan series, consisting of conglomerates, sandstones, shales, jasper, and serpentine, extend as a narrow ridge along the Mount Diablo Range. They are of Mesozoic age, belonging either to the Cretaceous or Jurassic period, and generally disintegrate into a heavy gray adobe soil, covering much of the mesa and foothill country to the north and east of King City. The rocks of this series are important from the fact that nearly all the waters of this area carry a relatively large amount of the alkali salts.

The rocks of the Monterey series consist chiefly of siliceous shales, varying in color and density from white or yellowish chalky deposits to heavy dark-brown or black cherts, the modification frequently producing a banded appearance. These rocks were derived largely from minute organic remains and occur in beds of great thickness. Volcanic ash sometimes occurs also in limited quantities in this formation.

These shales weather into angular fragments, and gravels of this material occur in large quantities along the slopes of the Santa Lucia Range. The rocks of this series extend from the Arroyo Seco southeastward to the limits of the soil map.

The Arroyo Seco formation outcrops along the west side of the valley, northeast of the Monterey series, and consists of light-colored friable sandstones several hundred feet in thickness. It underlies in horizontal beds the mesa lands to the east and northeast of King City, and is probably of the Neocene age.

The Terrace formation is encountered at the lower end of the valley, extending to Monterey upon the west and to the Pajaro River and the Gabilan Range upon the north and east. Its rocks consist chiefly of unconsolidated or friable sandstones of a reddish color, the particles of which consist of well-rounded quartzose sand. This is the most recent formation of the Salinas Valley and marks the site of a system of ancient sea beaches now raised several hundred feet above sea level. These Terrace sandhills often break into sharp ridges, weathering into perpendicular, towerlike cliffs, in striking contrast to the smooth, domelike contour lines of the older formations. These rocks are of the Pleistocene period, and weather into loose, coarse, red, yellowish, or brownish sands.

The deposits of the bottom lands of the valley consist chiefly of river detritus, consisting of sands and gravels, fine sands of a micaceous nature, silt, and in smaller proportions clays. These deposits are of the Pleistocene period.

In the above descriptions only those formations have been mentioned which are important from their relation to the soils of the valley.

In the geological and physiographic structure of the Salinas Valley erosion has played a very important part. Among the agencies which have played important rôles in rock disintegration and soil formation in this area are the sun and the wind. The splitting apart of rocks and rock fragments under strains set up by sudden changes in temperature from day to night undoubtedly plays an important part in the rock disintegration of the upper valley. The abrasive effect of the sands, when carried at high velocity by the winds of the valley, is also believed to have been an important factor in rock disintegration.

SOILS.

The soils of the Salinas Valley fall naturally into three classes—upland soils, valley soils, and recent sedimentary soils, each of which classes is quite distinct in its typical form, and often separated from the others by strong physiographic features. The soils of the valley lands and the recent sediments, however, are subject to considerable variation and often grade into each other in a perplexing manner, and consequently the soils of the bottom lands of the lower valley present a complex and spotted appearance.

In the upland soils are included the main grain-producing lands of the valley.

The valley lands consist of the soils of the original valley floor, although the types falling in this class are not always confined strictly to the lower levels of the valley.

By the recent sedimentary soils is meant those soils consisting of gravels, sands, and silts of later origin, still being deposited by the Salinas River in flood time.

The areas of the several soil types and the percentage which each forms of the total area surveyed are shown in the following table:

Areas of different soils.

Soil.	Salinas sheet.	Soledad sheet.	Total area.	
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Placentia sandy loam	59,090	14,910	74,000	33.6
Fresno sand	11,560	13,470	25,030	11.4
Soledad gravelly sand	230	7,370	7,600	3.5
Arroyo seco sandy loam	....	9,570	9,570	4.3
Salinas shale loam	....	13,730	13,730	6.2
Salinas gray adobe	9,950	8,450	18,400	8.4
San Joaquin black adobe	11,580	....	11,580	5.3
River wash	3,170	7,590	10,760	4.9
Hanford fine sand	9,620	7,420	17,040	7.7
Fresno fine sandy loam	11,850	6,480	18,330	8.3
Santiago silt loam	3,910	10,210	14,120	6.4
Total	120 960	99,200	220,160	....

PLACENTIA SANDY LOAM.

This soil covers a larger area in the Salinas Valley than any other soil type. Upon the Salinas sheet it comprises nearly half the area surveyed and extends from a line nearly following the Southern Pacific Railway eastward to the Gabilan Range. Much smaller areas of it are found upon the southwest side of the valley.

Upon the upper portion of the Soledad sheet several large areas are shown upon both sides of the valley floor. Some 2,000 acres of this soil type are also found in the San Lorenzo rancho, near King City. This soil here occurs upon the upper elevations of the lower foothills and mesa lands, and in its virgin condition is treeless and covered with native grasses.

The areas of this soil occurring throughout the valley below King City are generally found upon the alluvial cones which spread out from the many small canyon mouths, often coalescing and forming broad, gently sloping mesa lands, frequently covered with quite a vigorous growth of live oak. Upon the King City mesa this soil seems to be chiefly residual in character. It usually contains a small amount of fine gravel, the subsoil often containing considerable coarse gravel. It is usually underlain at about 18 inches by a light gray adobe, often containing considerable coarse sand and fine gravel.

Farther down the valley and bordering the Sierra de Salinas and the Gabilan Range this soil is derived from rocks of the Bed Rock series, consisting chiefly of gneiss, schists, and granites. The particles vary in size from bowlders to fine sediment, brought down and distributed by torrential streams from canyon mouths. Bordering the Gabilan Range this soil contains usually a relatively large amount of coarse

FIG. 1.—PLACENTIA SANDY LOAM SOIL, SHOWING CHARACTERISTIC NATIVE GROWTH OF OAK.

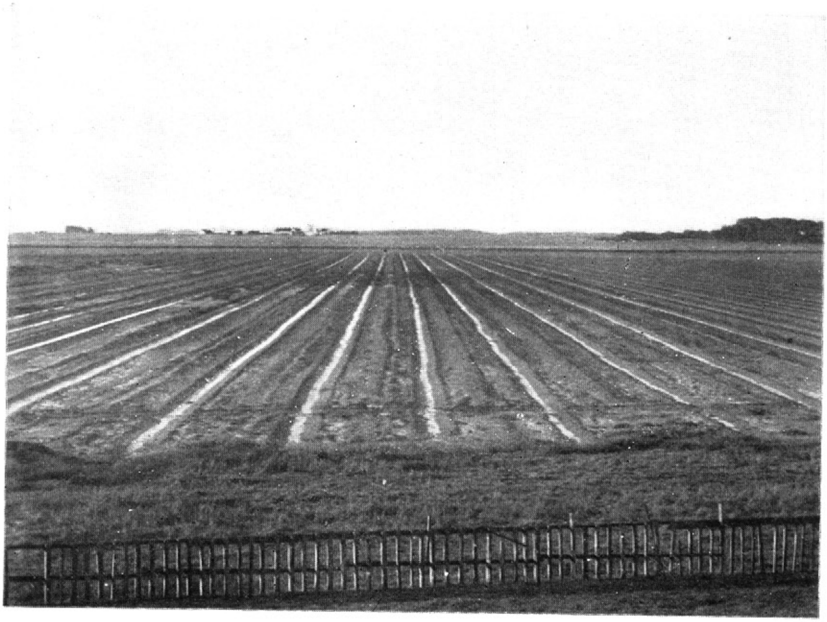

FIG. 2.—RECLAMATION OF TIDAL FLATS BY RIDGE CULTIVATION AND SHALLOW-SURFACE DRAINAGE.

sand and fine gravel of a sharp, angular nature. Near Soledad this characteristic is intensified, and it is there that the Placentia sandy loam grades into the Soledad gravelly sand.

In the lower valley the state of decomposition seems to be less advanced than at King City, and the soil is often rather deficient in organic matter. It is here, as in the King City mesa, underlain with a sandy gray adobe.

The mechanical composition of typical samples of Placentia sandy loam is given below:

Mechanical analyses of Placentia sandy loam.

[Fine earth.]

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6338	2½ miles NE. of King City.	Sandy loam, 0 to 12 inches.	0.03	2.06	0.44	17.22	20.66	26.84	7.74	15.06	10.09
6336	1 mile E. of King City.	Sandy loam, 0 to 14 inches.	.03	2.88	2.40	6.04	8.38	28.36	17.64	23.74	10.09
6337	Subsoil of 6336....	Sandy loam, 14 to 72 inches.	.04	2.94	2.52	5.06	7.46	22.84	15.52	32.72	11.34
6339	Subsoil of 6338....	Sandy loam, 12 to 72 inches.	.04	2.26	.40	11.40	14.00	22.60	7.20	28.44	13.70

Although of a light, sandy nature, this soil frequently becomes very compact upon the surface. Those portions of the area in which the occurrence of gravel is a distinctive feature are indicated on the soil map by the proper symbol.

Near the base of the fans, upon which the soil generally lies, the coarse sand and fine gravel disappear and the soil assumes a fine texture, grading into the soils of the bottom lands.

This type of soil is devoted almost exclusively to the raising of barley and, in more limited areas, wheat. Owing to its elevated position and the lack of water this land is unirrigated. Considering its loose, open texture, it resists drought fairly well, and in a favorable season produces a profitable crop. Barley yields from 12 to 15 sacks per acre. Under existing climatic conditions, however, the production of grain crops on this land is very uncertain.

Fruits, consisting of apples, almonds, prunes, and other stone fruits, do well in limited areas, if supplied with sufficient moisture and protected from the fierce winds. The more sensitive fruits, however, must be grown at a sufficient elevation above the valley to afford protection from frosts.

Owing to its position and porous nature this soil is well drained and free from alkali.

FRESNO SAND.

Fresno sand occurs throughout the Salinas Valley in areas varying in extent from a few acres to several square miles. Although there are some quite broad and extensive areas, in its typical form it lies as rather narrow areas along the delta and flood plains of the Salinas River, the Arroyo Seco, and the various canyon streams. It occurs in both the upland and bottom lands.

Its surface is generally level, some of the areas being overflowed during flood season, but in a few cases, in parts of the valley bordering the Salinas River and exposed to wind action, it exists as rolling dunes of wind-rippled, drifting sand. The level flood-plain areas are often covered with a dense growth of willows. Upon some of the higher lands in proximity to the sands of the river channel small areas of Fresno sand have been deposited by the wind over the original soils.

This soil often occurs as a sheet following a creek channel through the fans of the Placentia sandy loam, and it here generally supports a vigorous growth of live oak and sycamore. The bottoms of the deep ravines cutting the alluvial cones of the uplands are also filled with soil of this type.

The soil is largely of granitic origin, the particles being chiefly quartz, with a considerable proportion of micaceous material. It is formed upon the uplands by stream wash from the foothills and mountains. Upon the lowlands it is deposited by the currents of the Salinas River and the Arroyo Seco. When occurring near the mountains or in stream beds of steep slopes it usually contains a considerable amount of waterworn gravel, varying in size according to the distance from its source. The Fresno sand is generally 6 feet or more in depth, composed of smooth, waterworn particles, rather coarse in texture, and having nearly all the more soluble materials leached out.

The mechanical composition of this soil is given below:

Mechanical analyses of Fresno sand.

[Fine earth.]

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6323	1 mile W. of King City.	Sand, 0 to 12 inches.	0.05	1.40	......	7.00	21.04	56.16	10.94	2.22	1.03
6324	One-half mile N. of Moss Landing.	Sand, 0 to 12 inches.	.04	2.94	0.32	12.76	29.36	31.94	7.78	8.70	6.42
6325	Subsoil of 6324....	Sand, 12 to 72 inches.	.03	2.64	.54	12.92	29.52	30.16	5.96	10.84	7.31

A large proportion of the soil of this type bordering streams is waste land, being subject to overflow. Some of it, however, is devoted to the growing of grain, beans, and truck crops, with fair results in favorable seasons. From their elevated position the better areas of this type can not be irrigated, and were this possible it would prove an expensive process through loss of water by seepage. The soil is well drained and naturally free from alkali.

The terrace sand is a distinct phase of the Fresno sand and is found only in a few areas at the extreme lower portion of the valley lying between Elkhorn Slough and Castroville. This phase of the Fresno sand is essentially an upland soil, covering the rolling hills and ridges of the terrace formation previously described. To the northeast these hills continue as oak and chaparral thickets, with an occasional orchard-covered slope, far beyond the limits of the area mapped, until they reach the ridge of the Gabilan Range.

Like the true Fresno sand, this soil consists largely of quartz grains, the more soluble material having been dissolved out and carried away. It is derived from the friable sandstones of the terrace formation. The results of the mechanical analyses of this soil and subsoil are given in Nos. 6324 and 6325 of the Fresno sand.

The terrace sand is a coarse reddish or brownish sand of well-rounded particles, becoming lighter in color and texture as the summits of the hills are approached. Near the coast it contains considerable marine organic matter. It is chiefly dry-farmed to black oats, producing in a favorable season from 30 to 40 sacks (of about 85 pounds each) per acre. This land can not be irrigated, but the rainfall is here more abundant than farther up the valley, and the deficiency is further made up by the frequent heavy fogs. Other grain is raised with less success, owing to the ill effect of the fogs. Farther back from the sea, and protected somewhat from fogs and winds, this land produces excellent fruit, chiefly apples and prunes. This loose soil should be well cultivated to prevent excessive loss of soil moisture through evaporation. It is well drained and free from alkali.

SOLEDAD GRAVELLY SAND.

This soil occurs in one large area covering several thousand acres on the northeastern side of the valley and in the vicinity of Soledad. In its physiographic features, origin, and process of formation it is similar to the Placentia sandy loam of the same region, into which it grades. The state of decomposition is but very little advanced.

This soil is 6 feet or more in depth and of a brownish color. It contains very little loam or other fine material, but is made up almost entirely of coarse sand and fine gravel, composed of small, angular fragments of granitic rock. Although of a very loose texture, it sometimes becomes very compact and hard upon the surface, especially in roadbeds, where it forms an extremely hard, smooth surface, resembling macadam. It is not easily worked in a dry condition, and when very wet is said to become boggy and miry. Its distinguishing feature consists in the high percentage of sharp, fine gravel when it carries.

The mechanical composition of this soil is shown in the following table:

Mechanical analysis of Soledad gravelly sand.

[Fine earth.]

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6367	Soledad, Cal ...	Gravelly sand, 0 to 24 inches.	0.02	2.18	25.58	17.78	8.84	14.34	8.84	13.16	8.56

This soil is dry-farmed exclusively to grain. It is probably deficient in organic matter and other plant food and holds but little moisture, which it retains with difficulty. The yield of grain is very light, except in the most favorable seasons.

The soil is naturally well drained and free from an excess of alkali salts.

ARROYO SECO SANDY LOAM.

The typical Arroyo Seco sandy loam occurs in one area, covering several square miles, and extending in a northeasterly direction into the valley from the mouth of the Arroyo Seco. The larger part of this soil area occurs upon the southern portion of the Arroyo Seco Rancho, although it covers some 2,000 acres of the northwestern portion of the Posa de los Ositos Rancho.

This soil lies upon a broad, nearly level tract of land, sloping gently toward the valley trough. It is elevated somewhat above the present bed of the Arroyo Seco, but lies below the level of the adjoining lands. The Arroyo Seco seems to have cut through the surrounding Salinas shale loam, and to have deposited the Arroyo Seco sandy loam at a later period.

This soil originated with the granites and schists of the Arroyo Seco Canyon, and was laid down as an alluvial fan from that source. Its state of decomposition is not far advanced, and its surface is exposed to the strong winds of the dry season, which has given rise to the formation of many small streaks of wind-blown sand.

The Arroyo Seco sandy loam is 6 feet or more in depth, of a brownish or yellowish color, and generally of a loose and open texture, but sometimes, in limited areas, becoming compact upon the surface. The most striking feature of this type of soil consists in its high percentage of schistose and granitic gravel and small, usually well-rounded bowlders.

The mechanical composition of this soil is as follows:

Mechanical analysis of Arroyo Seco sandy loam.

[Fine earth.]

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6322	Arroyo Seco ..	Sandy loam, 0 to 6 inches.	0.03	2.64	8.66	9.76	7.42	24.18	21.18	18.96	7.53

This soil is devoted to the growing of wheat and barley, but the yields are generally rather light. It is somewhat deficient in organic matter and dries out quickly during dry seasons. A portion of this area lies under the Arroyo Seco Canal of the Salinas Valley Water Company, but owing to the large amount of coarse gravel and bowlders present in the soil under irrigation there is a heavy loss of water by seepage.

Like the previously described soils, this type is free from alkali.

Occurring upon the table-lands of the western side of the valley and directly east of Soledad is another soil area classed under the Arroyo Seco sandy loam type. This land is, however, considered as a distinct phase. In physiography and origin it is generally similar, but it differs from the typical Arroyo Seco sandy loam in lacking the heavy percentage of gravel. Consequently it is of a less light and loose nature, and, although unirrigated, loses its moisture by evaporation less readily. It is considered to be superior in value to that of the gravelly phase and in favorable seasons yields fair crops of grain.

SALINAS SHALE LOAM.

The Salinas shale loam occurs in large, uniform areas along the southwestern border of the Salinas Valley, extending from Pine Creek northwestward nearly to Paraiso Springs. Originally existing as a single area, it has been divided near its lower end by the Arroyo Seco, with its resulting types of sand and Arroyo Seco sandy loam. Like the previously described soils of the uplands, it occupies a somewhat elevated position along the table-lands and fans, extending toward the valley floor as a broad, even plain of gentle slope.

This soil originates with the siliceous shales of the Monterey series, mingled with more or less quartzose and granitic material. It owes its formation to wash from canyon streams. It is 6 feet or more in depth, of dark brown or gray color, shading to light gray below, cleaving vertically when subjected to stream erosion, sometimes becoming compact upon the surface, and resembling in its physical properties the adobes of the lighter type. Its most conspicuous feature consists in the presence of large quantities of angular or lenticular waterworn pebbles, white or brown in color, and varying in material from a soft, friable chalk to flint. As the valley trough is approached the occurrence of this shale gravel becomes less marked or entirely disappears.

A mechanical analysis of this soil is as follows:

Mechanical analysis of Salinas shale loam.

[Fine earth.]

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6345	Posa de los Ositos Rancho.	Gravelly silt loam, 0 to 24 inches.	0.03	3.08	1.44	2.12	1.80	7.94	9.22	58.26	16.49

Like nearly all the other upland soils, it is devoted almost exclusively to the growing of barley and wheat. It is unirrigated, and while producing fair crops in favorable seasons it is rather light and deficient in moisture-retaining properties. With sufficient irrigation it should make an excellent soil for peaches and other stone fruits.

From its porous condition and elevated position it is well drained and free from alkali.

SALINAS GRAY ADOBE.

The Salinas gray adobe occupies irregular areas, varying in extent and physiography, throughout the Salinas Valley. In the upper portion of the valley it covers extensive areas only upon the San Lorenzo Rancho, lying to the north and east of King City, where it extends from the nearly flat surface of the valley floor upon and over much of the lower foothills and mesa lands. These soil areas are generally treeless, but covered with native grasses, which afford excellent pasture for stock.

This soil on the mesa lands originates with the rocks of the Franciscan series and in its formation is primarily residual. From the upper terraces it has been washed down and now overlies the lighter soils of the valley floor adjacent to the mesa lands.

In the lower valley it occurs in irregular areas, often rather narrow but continuous for some distance, lying between the upland soils and the recent sediments bordering the river channel. Here, as in the upper valley, however, the soil often extends upon the valley uplands for some distance. This is especially noticeable in the northeastern portion of the valley and in the vicinity of the slough country

In the lower valley the origin and formation of the Salinas gray adobe is not so easily explained. It seems as though soils differing much in origin and process of formation may, under climatic influences peculiar to this portion of the West, assume certain peculiar and similar characteristics, and come within the class of soils known as adobes.

The greater proportion of Salinas gray adobe lies upon the nearly flat valley floor and is plainly alluvial in its origin. Many of the peculiar features of this soil, characteristic of all true adobes, have undoubtedly resulted, however, from recent weathering of the alluvium and from certain important physical and chemical changes occurring since the alluvium was laid down in its present position. Changes in level may account for the later occurrence of portions of the adobe areas upon the upper terraces.

Some of the granitic formations, however, are known to produce light-colored sandy adobes as a normal product of weathering. When washed to lower levels or depressed by movements of the earth's crust and subjected to further weathering and decomposition, modified by the influence of lacustrine or swamp action, these soils may become

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darker in color and finer in texture, and be transformed into the heavier adobes of the gray and black valley type. This process seems to have taken place with some of the adobes of the lower Salinas Valley.

The Salinas gray adobe is of a dark grayish or brown color, grading to black, and in its typical section upon the valley lands is about 30 inches in depth, underlain by the material of the Fresno fine sandy loam grading to fine sand. Upon the mesa and hill lands it is from 4 to 6 feet in depth, with the subsoil light gray in color and frequently underlain by coarse sand and gravel. Upon the uplands of the lower valley it frequently contains enough coarse sand, consisting of angular quartz fragments, to make this a distinctive feature. This coarse material disappears as the valley trough is approached, the proportion of fine material is increased, and the soil grades into thê fine-textured, heavy San Joaquin black adobe.

The mechanical analyses of soil and subsoil of this type are given below:

Mechanical analyses of Salinas gray adobe.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6343	1 mile NE. of King City.	Gray adobe, 0 to 12 inches.	0.04	2.78	0.64	3.88	6.48	13.78	13.96	39.12	19.72
6340	3 miles N. of King City.	Silty adobe, 0 to 26 inches.	.07	4.68	......	.70	5.52	12.06	2.84	28.80	45.59
6342	Subsoil of 6340....	Sand, 36 to 72 inches.	.06	2.58	Tr.	2.60	21.58	42.06	9.42	11.12	10.26
6344	Subsoil of 6343....	Fine sandy loam, 12 to 48 inches.	.03	3.22	1.06	4.58	17.62	20.38	7.04	21.80	24.87
6341	Subsoil of 6340....	Silt loam, 26 to 36 inches.	.07	4.18	......	1.36	9.06	12.54	5.74	38.44	28.65

This soil, like all true adobes, is very sticky when wet, becomes very hard when dry, and cracks in a system of rectangular checks, forming small cubes or blocks of soil from 1 to 2 inches in diameter. This property is best observed in an exposure formed by a cut in a terrace side and exposed to the sun. This soil is capable of holding very large quantities of moisture, and, if properly cultivated, loses it slowly by evaporation. This soil is largely devoted to the growing of grain and sugar beets. It is considered one of the most valuable soils of the valley, yielding in a favorable season from 20 to 30 sacks of barley per acre, while, if irrigated, such a crop is assured each season. The irrigated beet lands yield from 14 to 18 tons of beets per acre. The Salinas gray adobe is generally underlain by material of a lighter type, and has a slight slope toward the valley trough. The soil itself, however, is very stiff and heavy, and water passes very slowly through it; hence drainage through the soil does not quickly take place. When the proper moisture and other physical conditions are established, however, this soil becomes in texture a friable fine sandy loam. It does not contain injurious amounts of the alkali salts, except in a few very small, poorly drained areas adjacent to slough channels.

SAN JOAQUIN BLACK ADOBE.

The San Joaquin black adobe occurs only in the middle and lower valley and only within the Salinas sheet. In its mode of occurrence and physiographic position it is similar to the Salinas gray adobe. In its most pronounced heavy phase, however, it usually occupies slough or lake bottoms slightly below the level of the surrounding country. In its lighter phases it is not distinguished from the adjoining soils by marked physiographic features. What has been said in regard to the origin and formation of the Salinas gray adobe applies to this type. The evidences of alluvial origin are here, however, more marked, the transition from the gray to the heavy black type of adobe being largely due to the maceration and incorporation of a larger proportion of vegetable matter. Coarse, angular particles sometimes appear in this soil in areas lying along the terrace slopes, but the texture is generally finer and disintegration and decomposition further advanced than that of the gray adobe.

Like the gray adobe, it is in its typical form about 30 inches deep and underlain by lighter material; but in remnants of slough channels, where it assumes its heaviest features, it may extend to the depth of 10 feet or more with but little variation In the vicinity of the tidal sloughs small areas of stiff, tenacious clays, mixed with a large amount of undecomposed vegetable matter, are encountered. This deposit soon grades into the black adobe of the heavy type upon exposure, maceration, and further decomposition.

The mechanical composition of soil and subsoil of the San Joaquin black adobe is given below:

Mechanical analyses of San Joaquin black adobe.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6349	5 miles NW. of Salinas.	Adobe, light phase, 0 to 12 inches.	0.06	4.24	......	0.22	0.34	12.14	18.56	47.26	17.60
6356	1½ miles NE. of Spreckels.	Heavy black adobe, 0 to 12 inches.	.04	6.72	......	Tr.	.18	2.12	3.26	50.04	36.84
6346	5 miles NW. of Salinas.	Heavy adobe, 0 to 12 inches.	.05	5.76	1.40	7.42	5.98	11.68	2.16	21.58	44.55
6350	Subsoil of 6349	Silt loam, 12 to 36 inches.	.05	3.88	......	Tr.	.54	12.94	20.36	44.50	17.55
6351	Subsoil of 6349	Fine sandy loam, 36 to 72 inches.	.12	3.32	.16	.14	.20	14.90	20.70	45.34	15.22
6357	Subsoil of 6356	Heavy adobe, 12 to 24 inches.	.04	6.26	......	......	.18	1.00	1.98	54.40	36.14
6358	Subsoil of 6356	Silt loam, 24 to 72 inches.	.05	3.80	......	Tr.	.38	14.54	13.46	46.02	21.27
6347	Subsoil of 6346	Heavy adobe, 12 to 36 inches.	.12	7.16	Tr.	.28	.24	.76	.24	26.88	63.90
6348	Subsoil of 6346	Clay subsoil, 36 to 72 inches.	.12	5.40	.12	.06	.08	.60	2.24	47.26	43.64

Upon the higher levels, and in its lighter form, this soil assumes the character of a black, fine-textured sandy loam, containing an appreciable amount of sharp, fine sand, becoming friable and easily tilled when thoroughly moist but not wet. It, however, readily clods and bakes, and cracks badly upon exposure to the sun. The heavier phases of the lower depressions when wet are very stiff and tenacious, and when dry are very hard, the surface often being divided by a system of cracks from 3 to 4 inches wide, and sometimes as many feet deep, into a system of polygonal blocks from 6 inches to 2 feet in diameter. This most pronounced heavy phase usually occurs, however, only as narrow slough channels or necks cutting into the higher lands. Such areas are usually abandoned as unfit for farming purposes.

In regard to its value, yields of crops, condition of drainage, and presence of alkali, it is very similar to the Salinas gray adobe previously described.

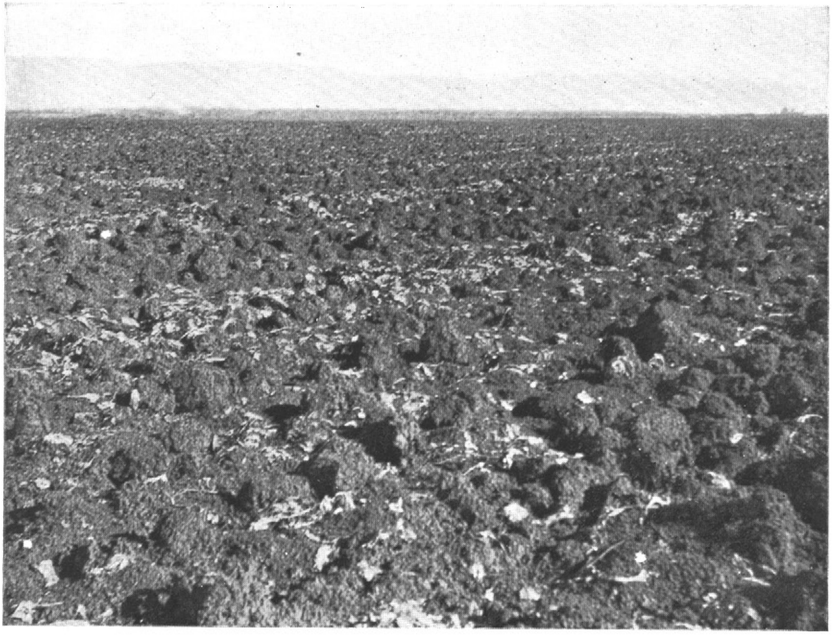

FIG. 1.—SAN JOAQUIN BLACK ADOBE AFTER BEETS HAVE BEEN HARVESTED, SHOWING CHARACTER OF SOIL.

FIG. 2.—SURFACE OF THE SAN JOAQUIN BLACK ADOBE, SHOWING CHARACTERISTIC CRACKING OF THE SOIL WHEN IT DRIES.

In the Salinas Valley this heavy adobe is esteemed the best soil for sugar beets. It is difficult to work and is best ploughed deeply with a gang plow propelled by steam engines, so as to get a deep, loose seed bed for the beets to develop in.

RIVER WASH.

River wash occupies a large portion of the present, and a few old, channels of the Salinas River and its tributaries. Occurring in greatest extent in the upper valley, it gradually disappears as tide water is approached, owing to the narrowing and deepening of the channel. It exists as low, flat sand spits, bars, exposed river bed, or sand dunes. It is generally dry in summer, but overflowed during the winter season. It is often covered with a dense growth of willows. This soil consists of the coarse, insoluble matter brought down by streams, grading from a white, rather coarse granitic or quartzose sand to coarse gravel and bowlders.

It is considered waste land and of no agricultural value.

HANFORD FINE SAND.

The Hanford fine sand usually occupies rather narrow areas upon the lower valley floor or river terraces, lying nearly parallel to the river channel. Its surface is usually level or slightly inclined toward the river channel. The smaller and lower areas are sometimes subject to overflow and thickly covered with willows. This soil is composed of the finer sands brought down from formations in which granitic and schistose rocks predominate. It is carried by currents of moderate velocity and deposited in slack water. The soil is a fine, light, yellowish sand, made up of small, well-abraded quartz grains and small mica plates, the latter often present in sufficient quantities to give to the soil a peculiar smooth and greasy feel when rubbed between the fingers. In its typical condition it contains but a small percentage of loam, and when wet is but slightly sticky.

The soil usually contains but little vegetable matter and the particles are quite resistant to weathering. It generally has a depth of 6 feet or more, but is often streaked with the heavier sedimentary deposits. Near Blanco there is a large area of this soil 3 feet in depth, overlying black adobe, where it must have been deposited at some time when the present river channel was several feet above its present bed, or else during seasons of unusual floods.

The mechanical composition of soil and subsoil is shown below:

Mechanical analyses of Hanford fine sand.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6335	1 mile E. of King City.	Fine sand, 0 to 24 inches.	0.06	2.66	0.18	1.76	8.68	43.10	20.56	20.10	2.64
6333	2½ miles NE. of King City.	Fine sand, 0 to 18 inches.	.05	1.82	......	1.14	5.60	39.64	30.48	16.62	3.41
6334	Subsoil of 6333....	Fine sand, 18 to 36 inches.	.07	2.98	Tr.	.84	3.32	35.34	20.74	31.46	4.71

The above samples were taken from a lower terrace near the bank of the San Lorenzo River, in the vicinity of King City. The soil is here slightly coarser and sharper in texture than the typical soil, containing a larger percentage of angular fragments and less mica than the areas farther down the valley. Considerable areas of this land lying between Soledad and Castroville are devoted to the growing of alfalfa for dairy purposes, irrigation being done by pumping. This land is easily cultivated, but dries out quickly in dry seasons. Well supplied with moisture it becomes a valuable soil. Beets are successfully grown on this soil, but to a less extent and with much less profit than on the heavier soils. Potatoes prove an excellent crop on the Hanford fine sand in the lower valley and are of superior quality. Pumpkins, carrots, and various truck and root crops also do well upon this soil, and fruits not requiring the heavier soils may be profitably raised if properly irrigated and drained. Irrigation of this type is, however, often accompanied by considerable loss through seepage, unless the distributing ditches are constructed of some material not easily permeable.

Owing to its open, porous nature the Hanford fine sand possesses an excellent natural underdrainage, in all except in a few limited areas occurring upon lower levels. In only a very few small, uncultivated areas on poorly drained lower terraces does it contain alkali salts in harmful quantities.

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam, like the Hanford fine sand, occurs in irregular bodies, covering much of the lower terraces and valley floor adjacent to the Salinas River, throughout the area surveyed. Its surface is generally level or sloping slightly in the direction of the river, with portions sometimes subject to overflow during the flood season.

FIG. 1.—POTATO FIELD ON FRESNO FINE SANDY LOAM NEAR SALINAS.

FIG. 2.—SUGAR BEETS ON SAN JOAQUIN BLACK ADOBE.

In origin and process of formation it is similar to the Hanford fine sand, but it contains a much larger proportion of silt, loam, and organic matter. It is also in a more advanced state of decomposition than the Hanford fine sand. In the lower valley it frequently becomes somewhat more coarse and sharp, nearly black in color, and sticky when wet, readily forming clods, and sometimes baking and cracking upon exposure to sun. In appearance and physical properties this phase greatly resembles the lighter phase of the San Joaquin black adobe, into which it often grades.

The Fresno fine sandy loam in typical sections is usually 6 feet or more in depth, but is often streaked with fine sand and the heavier sedimentary soils. It frequently becomes compact upon the surface. It varies in color from light yellowish to dark gray or drab, and sometimes to nearly black, according to the age of the deposit and the amount of organic matter incorporated in it.

The mechanical composition of this soil and subsoil is given below:

Mechanical analyses of Fresno fine sandy loam.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6329	2½ miles NE. of King City.	Fine sandy loam, 0 to 12 inches.	0.06	3.84	0.22	1.44	3.18	25.78	19.32	39.70	6.86
6326	1 mile W. of King City.	Fine sandy loam, 0 to 12 inches.	.08	4.62	.24	Tr.	.42	9.56	24.94	49.00	10.86
6327	Subsoil of 6326....	Fine sandy loam, 12 to 24 inches.	.06	2.60	......	Tr.	.30	7.80	51.04	33.94	4.60
6328	Subsoil of 6326....	Fine sandy loam, 24 to 72 inches.	.13	3.84	......	......	.22	1.52	16.20	60.22	17.99

The areas of this soil type are largely given to the growing of sugar beets, grain, and potatoes, which yield profitably. The heavier phases, usually selected for beet production, approach in value and yield the adobe lands. In portions well supplied with moisture throughout the year, apple orchards bear well and pay handsomely.

The drainage of the Fresno fine sandy loam is good, excepting the heavier phases and areas on the lower terraces not far above the water table. It is free from alkali, except in a few very small, low areas adjacent to river and slough channels and tidal flats.

SANTIAGO SILT LOAM.

In location, extent, and physiography the Santiago silt loam greatly resembles the Hanford fine sand and the Fresno fine sandy loam. It sometimes occurs in small areas upon the lowest river terraces, but in its most extensive areas it is usually found upon the middle or upper terraces, sometimes extending outward to the boundary of the upland soils. In its origin it is a recent alluvium, consisting of a very large amount of silt, with some fine sand and clay, and deposited in flood season from the slack, turbid waters upon the broad flood plain. In this manner as much as 10 inches or more of this sediment is sometimes deposited by the Salinas River upon the lower terraces in a single season, occasionally, in seasons of unusual flood, burying the growing crops.

The Santiago silt loam is a dense, heavy soil, very sticky when wet, and yellowish to gray or light brown in color. In typical sections it is about 30 inches in depth, underlain by Fresno fine sandy loam and fine sand. Its capacity for taking up and holding moisture, if properly cultivated, is very high. It is tilled with difficulty, unless in the proper physical condition, and in general physical properties it closely resembles the Salinas gray adobe, into which it grades and into which it seems that it may be ultimately transformed. Its lighter phases more closely resemble the Fresno fine sandy loam.

The mechanical composition of soil and subsoil is shown below:

Mechanical analyses of Santiago silt loam.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6365	1½ miles NE. of King City.	Silt loam, 0 to 30 inches.	0.05	3.52	0.76	1.86	1.82	12.70	18.48	41.08	18.43
6363	1 mile N. of King City.	Silt loam, 0 to 24 inches.	.06	4.86	Tr.	.44	.62	7.54	9.98	54.08	21.74
6364	Subsoil of 6363....	Fine sandy loam, 24 to 72 inches.	.05	4.20	......	1.28	.62	11.72	25.26	41.56	15.05
6366	Subsoil of 6365....	Fine sandy loam, 30 to 48 inches.	.05	3.12	.46	1.74	1.46	8.74	11.64	56.46	15.89

While a large part of this soil is dry-farmed or irrigated for grain, several thousand acres are yearly devoted to the growing of sugar beets. In value, adaptation to crops, and yields it compares very favorably with the adobe soils, considered the most valuable of the Salinas Valley soils. With irrigation, 18 tons of beets per acre may be raised on the Santiago silt loam. While its natural underdrainage is good, the soil itself is but slowly permeable by water, and hence is not as quickly drained as the lighter soil types.

This soil type is free from alkali in injurious quantities, except in small patches in the vicinity of slough channels and the tidal marshes.

METHODS OF CULTIVATION AND IRRIGATION.

In the Salinas Valley, as in many other sections settled under similar circumstances, a very extensive system of agriculture has been followed, and the very uncertain system of dry-farming for grain, with its seasons of abundant harvest alternating with those of total failure, still continues upon nearly all the upland soils and upon a large proportion of the bottom lands. This practice has developed methods of cultivation which, while in keeping with the system of farming, are not producing maximum crops.

The preparation and subsequent cultivation of the land is too often performed in a very cursory and incomplete manner. Plowing is largely done with gang plows throwing from 4 to 6 furrows, and is rarely deep enough to produce the best results. Often a depth of only 3 inches or less is reached in the plowing of the fields for grain. This not only fails to prepare the seed-bed in a thorough manner and fit the soil to hold and retain a sufficient amount of moisture, but in time tends to produce a compact condition of the soil known as a plow sole immediately beneath the surface.

Rarely is any provision made for returning to the land any portion of the valuable elements removed from it by cropping, and too little heed is given to rotation of crops and to summer fallowing, a practice that would put the soil in the best condition to receive and retain the scanty rainfall. The importance of these matters is, however, now gradually being realized, and some of the larger ranch owners now make provision in their leases for plowing the land to a certain depth, practicing rotation of crops, summer fallowing, and in general for a more thorough and intensive system of cultivation.

The practice of summer fallowing upon the dry-farmed grain lands of the middle valley is said to often double the crop the following year.

While a more thorough and expensive system of cultivation might be considered as a needless expense in a year of failure, it is probable that by more thorough management a portion of a crop, at least, might be saved, where otherwise there is total failure. The production of sugar beets calls for a much more intensive system of agriculture; hence the heavy lands devoted to this product are in general cultivated in a more thorough manner.

For several years of the time during which sugar beets have been grown in the Salinas Valley very serious trouble has been caused by a disease which by common consent is known as the "beet blight." The season of 1901 was a good one in the Salinas Valley, and very little trouble was experienced from the blight. However, at King City a few blighted beets were noticed, and at Santa Margarita very serious damage was done to the small area planted there. Close attention was paid to the matter during the time of the soil survey, and enough was seen to warrant the following statement: Many of the soils of the Salinas Valley are either neutral or slightly acid; few of the soils show the slightest effervescence with hydrochloric acid, indicating a very small amount or no carbonate of lime. Sugar beets require an alkaline soil. Perhaps there is no crop more sensitive to acid soils. At Santa Margarita the soils were slightly acid; at King City some of the soils were slightly acid, some neutral, and some alkaline. On the soils around Salinas irrigated with factory waste water, which contains finely divided carbonate of lime, the blight was not observed this year. It is well known that liming the soils after the blight has become well started will not prevent the disease, but so far as known the disease has not occurred in the Salinas Valley on a soil which is alkaline to litmus paper.

On subjecting the soils to chemical analysis none of them showed a deficiency of lime, yet several were acid and none would effervesce; therefore it is to be assumed that the lime was present in some other form than the carbonate.

Liming will certainly benefit all of the soils devoted to sugar-beet growing, and it is possible that much of the damage by blight can thus be prevented. The lime is preferably to be applied in the form of burnt lime. At King City and Santa Margarita in particular there is no doubt that lime would be beneficial.

In conclusion, it is thought by the writer that the deficiency of lime as carbonate gives rise to a neutral or slightly acid soil condition, which is a very important, if not the most important, factor in the cause of the beet blight.

Where the soils have been irrigated with factory waste water great benefits have been observed. This water carries back to the lands practically everything taken off by the beets except the sugar. The following table gives the results of an analysis of the soluble material and suspended matter in this water. All of the essential plant foods—potassium, phosphoric acid, and nitrogen—are seen to be abundant, and lime is present in great quantity.

Chemical analysis of factory waste water being used for irrigation.

SOLUBLE MATERIAL.

Ions.	Parts per 100,000.	Conventional combinations.	Parts per 100,000.
Calcium (Ca)	4.20	Calcium sulphate ($CaSO_4$)	11.70
Magnesium (Mg)	2.50	Calcium bicarbonate ($Ca(HCO_3)_2$)	3.20
Sodium (Na)	9.30	Magnesium bicarbonate ($Mg(HCO_3)_2$)	15.00
Potassium (K)	5.20	Potassium chloride (KCl)	9.90
Sulphuric acid (SO_4)	8.30	Sodium bicarbonate ($NaHCO_3$)	34.40
Chlorine (Cl)	4.70		74.20
Bicarbonic acid (HCO_3)	40.00		
Phosphoric acid (PO_4)	Tr.		
Total solids in solution	74.20		

PARTIAL ANALYSIS OF RESIDUE.

Constituent.	Per cent.
Calcium oxide (CaO)	2.24
Magnesium oxide (MgO)	1.30
Potassium oxide (K_2O)	1.67
Nitrogen (N)	6.10
Phosphorous pentoxide (P_2O_5)	0.29
Aluminum and iron compounds $\left\{\begin{matrix} Fe_2O_3 \\ Al_2O_3 \end{matrix}\right\}$	14.64

There were approximately 80 parts residue to 100,000 parts of water.

The earliest irrigation in the Salinas Valley of which we have record was practiced by the Mission fathers in the latter part of the eighteenth century. Stock raising, mining, and extensive grain farming, however, occupied the attention of the people, and with the abandoning of the missions about 1830 irrigation fell into disuse and was not practiced for nearly fifty years thereafter. Not until 1877 were the first claims filed in Monterey County for water to be taken from the Salinas River, and irrigation in the Salinas Valley is still largely in an undeveloped condition. It is being realized, however, that dry-farming for grain does not bring the soil to a high state of fertility, and that the natural rainfall of the Salinas Valley is sufficient to produce a profitable crop only in the most favorable seasons.

Irrigation in the Salinas Valley falls into two classes, viz, gravity irrigation from streams and irrigation by pumping.

In all about 70 claims have been filed for water to be taken from the Salinas River and its tributaries. In the greater number of these cases, however, the irrigation systems exist only on paper, and all systems show a great discrepancy between the amount claimed and the actual carrying capacity of the ditches. The claims in the aggregate greatly exceed the amount of available water in the streams, unless it be for a very few days in seasons of unusual flood.

In the irrigating systems now existing the methods generally in use are too crude for the economical transmission and use of water or for a just measurement of the amount actually due each patron. A reform in the present laws governing the filing of claims and the appropriation of water for irrigation purposes would be a blessing to the inhabitants of the Salinas Valley, for already much expensive and useless litigation has resulted from their insufficiency.

The aggregated claims for water for irrigation purposes to be taken from the Salinas River, the Arroyo Seco, and the San Lorenzo River, with the actual carrying capacity of headworks and canals, taken from a report upon Irrigation Problems in the Salinas Valley, published by Prof. Charles D. Marx,[a] are tabulated below:

Total amount of water for which claims have been filed and capacity of canals in the Salinas Valley area.

Stream.	Claimed.	Capacity of canals.
	Second-feet.	*Second-feet.*
Salinas River	4,748	1,293.5
Arroyo Seco	4,091	467.0
San Lorenzo River	230	685.5

The main irrigating canals in use are those of the Salinas Valley Water Company, with offices at King City, taking water from the Salinas and San Lorenzo rivers, one until recently owned by the same company, taking water from Arroyo Seco Canyon, and one in the vicinity of Gonzales, constructed by the Gonzales Water Company. The Arroyo Seco Canal has, however, proved inefficient, and its rights have been acquired by the Spreckels Sugar Company, which is now constructing a canal upon the west side of the Arroyo Seco, covering the land to and including the Soledad Rancho.

The water supply of the Salinas Valley streams is very variable. Nearly all the streams, except in the vicinity of the mountains, become nearly or quite dry during the summer, while with the first heavy rains they are flooded to overflowing.

It will be necessary, in order to preserve a maximum amount of water for irrigation purposes, to check the great waste of water by the construction of storage reservoirs at favorable sites, which may be drawn upon when the rivers become too low to supply the canals. The building of storage reservoirs is, however, an expensive undertaking and often involves engineering difficulties not easily overcome. It would also undoubtedly result in litigation under the present laws covering such cases.

[a] Irrigation Investigations in California. Bul. 100, Office of Experiment Stations, U. S. Department of Agriculture.

The average results of daily gauge readings of the flow of Salinas River, taken by the United States Geological Survey at the Salinas bridge during the flood season in 1901, is shown below:

Average monthly flow and total discharge of Salinas River at Salinas bridge in 1901.

Month.	Average flow per second.	Total discharge per month.
	Cubic feet.	*Acre feet.*
January	4,920	3,025,190
February	4,170	231,570
March	1,060	65,176
April	270	16,070
May	533	32,772
June	55	3,390
July	27	1,660

The quality of the water of the Salinas River is generally good and it can be safely used for irrigation. During the progress of the survey a number of tests were made of the river water throughout the valley. The results show that it carries only about 50 parts of soluble matter per 100,000. These observations were taken during the dry season, when the amount of alkali salts would be expected to be largest.

The waters of the Arroyo Seco spring from a granite formation and are unusually pure. This water is much superior to that of the Salinas River, and need not be considered, even in seasons of greatest scarcity of supply, unsafe for irrigation purposes.

The headwaters of the San Lorenzo River, however, spring from a formation carrying an excess of readily soluble salts. The well waters of this region are notoriously bad, and many are totally unfit for domestic use.

During the dry season the channel of the San Lorenzo River below the canyon is entirely dry. In the vicinity of the dwindling streams above the canyon a thick whitish crust appears in patches upon the surface of the moist sand. This crust consists of the alkali salts carried to the sand in solution by the waters of the stream and brought to the surface by evaporation of the water.

The appearance of these salt crusts may always be considered as an indication of the presence of alkali in dangerous quantities.

A chemical analysis of a sample of the water of San Lorenzo River taken August 11, 1901, gave the following results:

Analysis of water of San Lorenzo River.

Ions.	Parts per 100,000.	Conventional combination.	Parts per 100,000.
Calcium (Ca)	23.50	Calcium sulphate ($CaSO_4$)	80.20
Magnesium (Mg)	11.60	Magnesium sulphate ($MgSO_4$)	57.40
Sodium (Na)	115.20	Sodium sulphate (Na_2SO_4)	175.20
Potassium (K)	5.80	Potassium sulphate (K_2SO_4)	10.70
Sulphuric acid (SO_4)	220.70	Sodium chloride (NaCl)	119.30
Chlorine (Cl)	77.20	Sodium bicarbonate ($NaHCO_3$)	34.10
Bicarbonic acid (HCO_3)	24.80	Sodium carbonate (Na_2CO_3)	4.20
Carbonic acid (CO_3)	2.30		481.10
Total solids	481.10		

Any water containing this amount of soluble mineral matter is unfit for use in irrigation and would certainly result in the ruin of the heavy, tenacious beet lands of the valley. It should, however, be noted that this sample was collected during the dry season and represents probably the most concentrated condition of the water at any time of the year, and with the exception, perhaps, of the first rush of flood water, which would carry a large share of the alkali accumulated during the summer season, the flood waters of this stream might be so dilute in the quantity of alkali salts carried as to be safe for storage and subsequent irrigation purposes. This matter requires further investigation.

In the Salinas Valley the water is generally applied to the land by a system of rectangular or contour checks. The irrigation of the heavy adobe land is a process involving considerable time, as these lands absorb water slowly and in enormous quantities, but if proper methods are taken to retain the moisture when once thoroughly irrigated the soil will hold enough moisture to grow crops for an astonishing length of time. This is a fortunate circumstance indeed for residents of the Salinas Valley, where under the present system of irrigation from streams by gravity ditches sufficient water is generally available to supply the ditches only during the flood or winter season. Irrigation usually takes place during the winter, and upon some of the heavy adobe beet soils one thorough irrigation will, with the scanty rainfall, supply moisture enough to produce crops for one year and sometimes for two years.

During the last few years the subject of irrigation in the Salinas Valley by pumping water from wells or from stream channels has received considerable attention and already many such plants have been put in operation by enterprising farmers and ranch owners.

One of the largest of these plants has recently been constructed upon the Spreckels Sugar Company's ranch at King City. This plant will, it is expected, greatly augment the facilities for irrigating lands in that vicinity.

In the vicinity of Soledad two large pumping plants are in operation, the water being taken from the Salinas River. One of these plants, operated by the Salvation Army colony, supplies water through a 16-inch centrifugal pump, throwing on an average 5,000 gallons per minute. This water is sold to colonists at $2 per hour, the cost of irrigation being from $1.75 to $2 per acre. This plant irrigates about 200 acres, with a capacity of 300 more. The other plant, which is situated near the "army" pumping plant, supplies water at about the same cost.

Upon the San Vicente Rancho, near Gonzales, there are two other plants worthy of note, typical of this system of irrigation, situated upon the Williams and Doud ranches. These plants take water from several wells from 110 to 250 feet in depth, the Doud plant throwing 4,000 gallons per minute with an 80-horsepower gasoline engine. The cost of irrigating upon these ranches is from $2 to $3 per acre.

Extensive plants are also maintained by the Spreckels Sugar Company upon the Willoughby tract near Chualar, and upon Ranch No. 1, in the vicinity of Spreckels. Below Soledad and in the neighborhood of Blanco, where smaller farms worked by their individual owners are the rule, the number of private pumping plants increases. The most of the wells supplying these plants are from 150 to 200 feet deep, and from 6 to 10 inches in diameter, the water-bearing strata being coarse sand and gravel. The water in nearly all of these deeper wells ordinarily stands within from 5 to 20 feet of the surface, but is lowered from 10 to 15 feet by continuous heavy pumping. The cost of irrigation averages between $2 and $3.50 per acre, although by the use of crude oil of the lighter type with gasoline engines, which is now becoming practicable, it is thought this cost can be considerbly reduced.

While the underground water supply of the Salinas Valley is by no means inexhaustible, there is undoubtedly opportunity for a much greater extension of irrigation by this system in the vicinity of the bottom lands without seriously affecting the supply. It is unlikely, however, that much of the upland soil will ever be irrigated by pumping from wells, because of the increased cost of pumping from deeper wells and the decrease in available underground water supply.

The character of the water obtained from the deeper wells of the valley is generally good, and in no case have waters obtained from any of these wells been found unfit for irrigation purposes. In a few cases only have some of the shallower wells of the bottom lands been found to carry enough of the alkali salts to be unfit for irrigation or domestic use. The wells about King City, however, generally carry a large amount of soluble mineral matter, and with a few exceptions, notably waters taken from the Salinas River, or from the river water stratum, would be considered questionable for purposes of irrigation.

The results of chemical analyses given below show the character of water pumped from the well at the bridge crossing the Salinas River near King City, which is considered safe, and from a well in the town, which is evidently unfit for use in irrigation.

Analyses of well water, King City, Cal.

Constituent.	S. P. Co.'s well at bridge, one-half mile W. of King City.	Ford and Sanborn's well, center of town, King City.
	Parts per 100,000.	*Parts per 100,000.*
Ions:		
Calcium (Ca)	6.60	9.08
Magnesium (Mg)	3.00	7.38
Sodium (Na)	4.00	14.89
Potassium (K)	.90	1.69
Sulphuric acid (SO_4)	11.90	52.22
Chlorine (Cl)	3.30	9.08
Bicarbonic acid (HCO_3)	25.40	32.78
Carbonic acid (CO_3)	.60	.88
Conventional combinations:		
Calcium bicarbonate ($Ca(HCO_3)_2$)	26.70	36.82
Magnesium sulphate ($MgSO_4$)	15.00	36.62
Sodium sulphate (Na_2SO_4)	....	34.01
Potassium chlorid (KCl)	1.70	3.19
Sodium chlorid (NaCl)	4.00	12.21
Sodium bicarbonate ($NaHCO_3$)	7.30	6.79
Sodium carbonate ($NaCO_3$)	1.00	1.26
Total solids	55.70	131.60

As in gravity irrigation from streams, the water is usually applied by flooding in rectangular or contour checks.

While involving considerable expense for labor and machinery, this system of irrigation from wells has the advantage of supplying moisture whenever needed throughout the year. It is also often cheaper than the construction and maintenance of an extensive system of headworks and canals, and greatly reduces the loss by seepage where water must be brought by gravity over many miles of open, porous soils.

The increase in the number of new wells must, however, sooner or later affect the water supply of the older wells. This is likely to result in more or less litigation unless laws are enacted covering the appropriation and use of underground waters.

Extensive areas of the Spreckels Sugar Company's beet lands in the vicinity of Spreckels are now irrigated by factory waste water, the water being pumped to the lands as it comes from the factory and allowed to thoroughly permeate the soil by flooding. The turning of this water, containing a large amount of organic matter, upon the soil not only irrigates the land and acts as a fertilizer, but also prevents the pollution of stream waters by the factory waste.

While it is unlikely that the entire Salinas Valley will ever be thoroughly irrigated, the outlook for extension in this direction is promising. Its inhabitants have been slow to profit by the opportunities for irrigation, but they are in much more favorable circumstances to-day than many farmers of neighboring sections of the State, whose lands have been ruined by the excessive and injudicious application of water.

UNDERGROUND AND SEEPAGE WATERS.

The importance of the character and position of the underground and seepage waters in their effect upon the agriculture of a region is apparent. While the maximum production is secured in an arid region in which the water table lies close enough to the surface to supply the upper soil and plant roots with sufficient moisture, great danger exists in subirrigation if alkali salts are present in the soil. Moreover, if the water table approaches the surface too closely, it may, in any climate, result in cold, water-logged, unworkable soils, especially if the soil is of a heavy, tenacious nature. It may retard vegetable growth by limiting the processes of decomposition and nitrification, taking place only in well-aerated soils, to a narrow zone, or it may kill plants outright—for no ordinary field crop or fruit tree can thrive or even live with its roots continually submerged in water.

A potent source of alarm in the arid regions, however, is the effect of the rise of the water table upon the distribution of the alkali salts, which are always liable to occur in the soil of regions of scant rainfall.

The importance of this factor is shown in a study of the conditions of the Hanford and Fresno areas of the San Joaquin Valley. But a few years ago the water table upon much of this land was far below the danger point, and no trouble from the presence of the alkali salts was expected. With the spread of irrigation, however, enormous quantities of water were thrown upon the land. This resulted, naturally, in the rise of the water table to within a few feet of the surface and the concentration of the alkali salts in the surface soil through the process of capillarity and evaporation. This phenomenon is known locally as the "rise of the alkali," and much valuable land has, in the region referred to, been ruined or badly damaged in this manner.

While the alkali question in the lower Salinas Valley has not yet given rise to serious apprehensions, it was deemed advisable to at least touch upon this subject in this report.

Upon the upland soils of the valley the depth to surface water is generally 20 feet or more, and no danger need here be expected from the rise of the water table.

The areas indicated by the first interval (—3 feet on the underground water map, Pl. LXXVII) are those of the sloughs and tidal flats, and indicate swamp and overflowed lands. Much of the area consists either of open bodies of water or of waste land. All such areas, as well as those in which the underground water stands at from 3 to 6 feet, require drainage. This is, however, not easily accomplished, as much of these areas lies but little above sea level. The land in proximity to the sea is often rendered unfit for cultivation by the effects of brackish tide water. In a few cases existing slough channels afford an outlet for drainage of limited areas of this land. Much of the land of the Monterey County farm and vicinity has been drained into such sloughs.

Upon the areas where ground water is indicated as occurring at a depth of from 6 to 10 feet there is no immediate danger. There is, however, with an abundant supply of water, always a tendency toward overirrigation. Should an increase in the available water supply in the future lead to heavy irrigation, the level of the water table in this region would undoubtedly be raised. This might not only result in water-logging some of the more valuable soils of the lower terraces, but also in causing such a concentration of the alkali salts, now distributed through the soils of the Salinas Valley in quantities too dilute to harm vegetation, as to damage or even ruin the lands. Hence irrigation, even in the Salinas Valley, where but little or no trouble from alkali has ever been experienced, should be practiced with intelligence and moderation. With the application of water in heavy quantities the natural underdrainage of the soil should be aided if necessary by artificial means. This, especially, would be necessary in the case of the heavy silt and adobe lands, now so valuable for their production of sugar beets. It is always well to remember that he who uses the greatest amount of water is not always the most successful irrigator.

ALKALI IN SOILS.

Very few areas are found in the Salinas Valley in which alkali is present in harmful quantities, except in the vicinity of the sloughs and tidal flats near the coast. This alkali is of the sodium chloride type and largely of marine origin. In the upper valley the alkali of the streams and wells seems to approach that of the sodium sulphate type. The waters also carry considerable magnesium sulphate or epsom salts. Alkali of this type, however, was at no place discovered in injurious quantities in the soils of the valley. In the middle and lower valley, from Gonzales down, very small spots in old slough channels and upon lower terraces adjacent to the river were occasionally encountered, upon which slight crust accumulations and the native vegetation indicated the presence of a considerable proportion of the alkali salts. These spots were, however, too small to be shown upon the map, and generally occurred only upon uncultivated lands. The salts of this part of the

UNDERGROUND WATER MAP, SALINAS SHEET

-3	3-6	6-10	+10
Water less than 3 feet deep	Water from 3 to 6 ft. deep	Water from 6 to 10 ft. deep	Water more than 10 ft. deep

valley were probably derived partly from the alkali-bearing minerals of the soil and partly from ancient tidal flats. There seems to be, in the aggregate, however, a considerable amount of the alkali salts in the soils of the valley and sediment lands of the middle and lower parts of the area mapped. These salts often are distributed throughout the soil to the depth of from 10 to 15 feet, but for the most part, in their present distribution, in quantities not injurious to crops. It must be borne in mind, however, that the use of a large amount of water for irrigation purposes, unless accompanied by thorough underdrainage and a vigorous system of deep and thorough cultivation to check evaporation, may result in the subsequent rise of the water table and the accumulation and concentration of this soluble mineral matter in the upper few feet of the soil in quantities injurious to vegetable growth. The use of too much water in irrigated sections is frequently the cause of greater loss than the use of too little, and the value of the maintenance of a loose mulch of well-cultivated soil upon the surface in checking evaporation during the dry season is too often not appreciated.

As long as irrigation is practiced carefully and intelligently, however, and the value of drainage and the maintenance of thorough tillage is recognized, the inhabitants of the Salinas Valley need have little fear of alkali.

RECLAMATION OF ALKALI LANDS.

Many valuable mineral salts are commonly associated with the harmful alkali salts. This accounts for the wonderful productiveness of alkali lands where the alkali is not present in sufficient quantities to make vegetable growth impossible; and for the same reason alkali lands when once reclaimed become most productive.

The removal of the salts from the surface by flooding is often practiced, but its results are usually unsatisfactory, unless a large amount of water be used and allowed to thoroughly permeate the soil, carrying the soluble material to natural or artificial underdrainage channels, and that this may result the soil must either possess good natural drainage or be tiled or ditched.

The reclamation of alkali lands by thorough artificial drainage, while expensive, is the most satisfactory and the most profitable in the end.

Upon some of the lower lands of the tidal flats of the lower Salinas Valley a partial reclamation is being effected by shallow cultivation and drainage of the immediate surface. This has produced upon lands formerly barren a growth of native salt grass and other alkali-resistant vegetation, making the lands at least of some value as pasture lands.

AGRICULTURAL CONDITIONS.

The fluctuation in the weather and crop conditions during the past few years has greatly affected the agricultural development of the

Salinas Valley. The dreaded dry seasons seem recently to have grown in frequency and severity, and especially has this been true in the upper portion of the valley. Owing to the scarcity of rainfall for the seven years preceding the season of 1900–1901 the crops of the unirrigated lands of the upper valley have been partial or total failures. In the lower valley, where the protracted droughts have been a trifle less severe, the conditions have been a little less discouraging. As a result of these untoward conditions the value of real estate has decreased, and many small farmers have become badly in debt or lost their homes altogether.

During the season just past, however, the crops were again favored with an abundant rainfall, and again there was a season of plenty. The warehouses were crowded to bursting with the sacks of grain, sugar beets were hurried to the factory in train loads, and business enterprises resumed normal activity. The Salinas Valley is once more an agricultural district of great importance, and its inhabitants are anxiously looking forward to the future and what it may bring.

The assessed valuation of all property of Monterey County according to the census of 1900 was $17,772,018, the rate of taxation being $1.50 per $100. The assessed valuation of real estate alone amounted to $12,013,470. The value of the land of course depends much upon its character and position. The better grade of uplands that are not under irrigation can generally be bought for from $20 to $30 per acre; the heavier beet lands of the bottoms, if under irrigation, bring from $60 to $75 per acre.

As before stated, a large number of the original ranchos of the Salinas Valley remain intact. These ranchos are leased in small tracts to tenants, who generally furnish the seed and farming machinery and pay three-fourths of the crop, harvested and delivered at the warehouses, for the use of the land. A large proportion of the tenants are of foreign birth, the Swiss and Danish races predominating. These people are generally industrious and intelligent, many of them having practiced an intensive system of agriculture in the old country. The transition to the extensive, easy-going methods of cultivation so common in the West has, however, too often led to lax methods of tillage. But rarely is any fertilizing material returned to the land, unless stipulated in the lease contracts, and the operations of plowing and subsequent preparation and cultivation of the land are often very incomplete.

It could hardly be expected, however, that a large section of country owned by a few land holders and farmed largely by tenants should reach as high a state of agricultural development as that in which small farms, worked by the individual owners, are the rule. This fact is pointed out by Professor Hilgard, who says in one of the reports of the California Experiment Station: "It is small farms and intelligent culture that constitute the prosperity of an agricultural community."

The subject of more thorough culture and irrigation is now, however, attracting considerable attention from the farmers of the region, and the force of necessity combined with opportunities for good business investment will not long allow the Salinas Valley to lag behind in these matters.

Of the crops grown, barley is produced in the greatest quantities, the Chevalier variety proving more profitable than the whiter varieties because of the effect of the prevailing fogs. The sowing is generally completed by the middle or latter part of December, unless delayed by the late appearance of the fall or winter rains. Upon the uplands near the coast, influenced by the frequent fogs, black oats are raised to a considerable extent, producing about 30 sacks per acre. Oats are also raised to a less extent in the upper valley, the black varieties, however, generally producing crops of better quality than the white varieties, which are frequently damaged by fogs. Sugar beets are at present one of the most profitable crops of the valley. A large share of the most valuable beet lands are now owned or leased by the Spreckels Sugar Company, which operates at Spreckels, 4 miles from Salinas, the largest beet-sugar factory in the world. This plant requires the yearly product of about 30,000 acres of beet lands to supply its needs. During the season of 1900–1901, 270,000 tons of beets were produced in the Salinas Valley and its smaller tributary districts, the Pajaro Valley, and areas in San Benito and Santa Clara counties. The average yield of the lands of the Salinas Valley is from 14 to 16 tons of beets per acre. During this season $1,250,000, in round numbers, was paid out by the Salinas factory for labor and beets. To produce the beets grown, over 200,000 pounds of beet seed were used during the past season, most of which was imported from Germany. The question of growing beet seed is now receiving considerable attention in California, and it is quite likely that a large part of the seed used will soon be produced in this country.

As the profitable production of sugar beets requires very thorough preparation and cultivation of the land and, in the Salinas Valley, the aid of irrigation, the growth of this industry has greatly helped the general agricultural development of the region. The lands are generally irrigated and plowed deeply during the winter, although some of the heavy adobe lands of the Spreckels Sugar Company's ranches are sometimes broken up during the dry season by the aid of steam plows. In this operation a heavy gang plow, consisting of some seven or eight plows and cutting to a depth of 8 or 10 inches, is hauled through the heavy adobe lands by a cable playing between massive traction engines. This machinery is usually of English man ufacture, and built especially for the purpose. The labor of caring for the soil is generally done under contract by Japanese and, to less extent, Chinese laborers, the cost being about $1 per ton.

Upon the lighter soils of the bottoms potato raising is an important industry. The crop is either irrigated by pumping from wells or streams, or is planted upon the lower terraces, where the water table is close to the surface. In favorable years this crop produces a yield of 100 or more sacks per acre. The potatoes are of fine quality.

While the Salinas Valley can not be considered a fruit-producing area, the outlook in certain lines of this industry is promising. This is true especially of apples, for the production of which the Pajaro Valley, joining the Salinas Valley upon the north, is famous. It now seems evident that this crop can be produced in protected but well-watered portions of the Salinas Valley with equal success. The most promising varieties are the Belleflower, Pearmain, and Newtown Pippin. The fruit is carefully wrapped in paper, packed in boxes holding a given number of apples of a certain grade, and placed upon the fancy Eastern and European markets. Many of our Eastern apple growers might well take a lesson in marketing fruit from the producers of the Salinas Valley.

Of the other industries of the valley, butter and cheese making is perhaps the most promising and important. Many small private creameries and cheese factories are in operation throughout the bottom lands of the middle and lower valley. Many of these are operated by Swiss, and while an especially fancy grade of goods is not produced the industry is a paying one. There is room for the production of the better grades of butter and cheese. The butter and cheese interests of the valley are already estimated to amount to $1,500,000 annually. In conjunction with dairying, alfalfa, grown in small irrigated plots, is an important crop.

Stock raising, especially the fattening of steers for market and the raising of draft horses, is a profitable industry and might well be extended to some of the less profitable grain lands. Poultry raising has in the past been sadly neglected and offers good inducements to investors of limited means.

Good shipping facilities are furnished by the Southern Pacific Railway, which traverses the entire length of the valley, and by the Pajaro Valley Consolidated Railroad, a narrow-gauge line extending from Spreckels to Watsonville, in the Pajaro Valley, a distance of 30 miles. In addition to this, freight may be cheaply shipped by water between Moss Landing, in the lower valley, and various coast points, including San Francisco.

Of the insect pests and diseases causing losses in the valley, the most serious are the blight or California beet disease and the aphis, attacking the sugar beet, and the grain smut, which seriously affects wheat.

The California beet disease appeared first in 1899, resulting in a total loss of the crop upon some of the most productive ranches. During the past season, however, it did but little damage in the area surveyed. This disease is now being carefully studied by the foremost scientists of our own country and Europe, and it is hoped there may be soon found a remedy that will effectuallv check its ravages should the disease reappear.

With the careful extension of an effective and safe system of irrigation in the Salinas Valley, with the increasing knowledge and appreciation of the value of thorough cultivation, and with the acquiring of small farms by individual owners, which is gradually taking place, the future outlook for this important section is promising.

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