SOIL SURVEY OF THE INDIO AREA, CALIFORNIA.

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LOCATION AND BOUNDARIES OF THE AREA.

The area included in this survey is a part of the Colorado desert. The branch of the sea which once covered all of this country formed a narrow neck extending from the present Gulf of California in a northwesterly direction. Indio is situated at the upper end of this dry sea

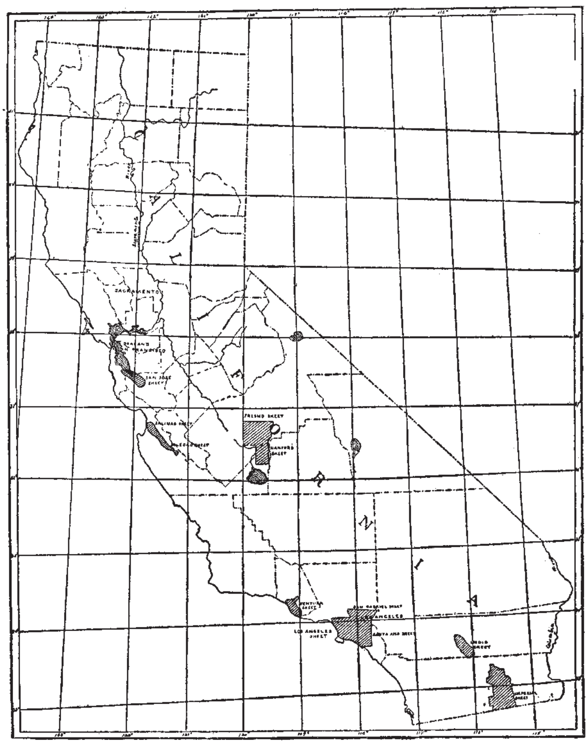

FIG. 60.—Sketch map showing location of the Indio area, California.

basin, and is about 15 feet below sea level. The area surveyed extends from a point about 100 feet above sea level, a few miles northwest of the town of Indio, southwestward into the Salton Basin. The San Bernardino range of mountains bounds the area on the north and east, while the Santa Rosa and San Jacinto mountains bound it on the southwest and south. The northwest boundary of the area was established arbitrarily, and is believed to mark the limit of possible irrigation from the present source of water supply. The badly alkaline lands of the Salton Basin form the southeastern boundary of the area, since all of the land inclosed in the basin is so alkaline as to be unfit for cultivation. The total area surveyed covers about 234 square miles.

CLIMATE.

The climate of the valley is semitropical and arid. It is characterized by cloudless skies, low relative humidity, high temperature in summer, and but slight frosts in winter. The summers are long and excessively hot, but owing to the dryness of the atmosphere the high temperature is not nearly so oppressive as temperatures of 20 or 25 degrees lower in the humid parts of the country. Very rarely is the weather such as to interfere with field work, except in cases of violent wind storms. These are common during the spring, and are often of such velocity as to lift quite large particles of sand and fine gravel. The work of the winds may be clearly seen in the soils and vegetation of the valley. "Blow outs" are very common in the sandy soils, and shrubs and plants often have the soil about their roots almost entirely removed by the winds. Great quantities of sand are annually blown from one part of the valley to the other, and many small hills and hummocks are to be found on the lee side of shrubs, trees, or other obstructions. Much of this destructive effect of the winds will be eliminated by the planting of crops and trees as the country becomes settled.

Hardly any snow and but little rain falls during the year. The rains usually occur at long intervals as heavy downpours. One heavy rain and three very light rains occurred during about four and one-half months of the fall and winter of 1902–3, while the party was in the country or in its immediate vicinity. On the mountains immediately adjoining the area, however, considerable snow falls during the winter, and this is the source of much of the artesian water of the valley.

The following table, compiled from records of the Weather Bureau stations at Indio and Volcano Springs, shows the mean monthly and annual temperature and precipitation of the area:

Normal monthly and annual temperature and precipitation.

Month.	Indio.		Volcano Springs.		Month.	Indio.		Volcano Springs.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	52.8	0.92	55.9	0.25	August	93.0	0.14	100.7	0.09
February	58.4	.40	60.5	.39	September	86.5	.11	90.0	.01
March	65.5	.20	68.4	.07	October	75.4	.08	77.9	.17
April	72.5	.04	78.9	.00	November	62.6	.19	64.9	.08
May	80.1	.03	86.8	.00	December	56.6	.40	56.1	.43
June	88.3	.00	96.5	.00	Year	73.9	2.51	78.1	1.60
July	94.5	.00	101.4	.11					

PHYSIOGRAPHY AND GEOLOGY.

The greater part of the Indio area is a uniformly sloping plain with a surface suited to irrigation. The average slope is about 12 feet to the mile, ranging from 6 feet at the eastern boundary to about 20 feet to the mile in the vicinity of Indio. In the trough of the valley, and about Salton Sink, there are very few knolls, dunes, or other local variations from grade, and very little leveling is necessary to prepare the land for irrigation; but in the western part of the area, in the vicinity of Indio, there are dunes which in some instances are so numerous and of such size as to make the cost of leveling exceed the present value of the land. The sandy and gravelly soils along the base of the mountains on each side of the valley are cut by small arroyos which extend out from the mountains and carry water during flood time. At the mouths of these arroyos the deposit from their flood waters has formed more or less extensive cone deltas, which give an undulating surface to this part of the valley, and this will make the detailed engineering features of irrigation more difficult. On these gravelly soils the slope is often 200 feet per mile. The lower part of the valley was deposited in the waters of the Gulf of California when it extended to this point, but all around the edges of the valley the wash from the mountains has covered the sedimentary deposits. The lower ranges of mountains are in places shaly sandstone, but the main part of the ranges are granite, and it is from this material that most of the wash is derived.

Whitewater River flows through the valley, its present bed being near the southern range of mountains. Evidences of former beds are seen farther north. The shifting of the sands during seasons of drought, when the river was dry, has gradually forced the river southward. At present the river has water in its lower reaches only in time of excessive floods. For the rest of the year it is merely a dry bed of sand, the water finding its way to the Salton Sink through the subsoil. In nearly the whole area mapped artesian water is found at a depth varying from 300 to 600 feet. Wells in this artesian basin are discussed elsewhere in the report.

SOILS.

Unlike the soils of the Imperial area of this same basin, the surface soils of the Indio area are nearly all of a very sandy, loose, friable texture. There is only about 9 per cent of the soil as heavy as a clay—and this does not appear so in the field—all the rest being sandy loam or a soil of coarser texture than sandy loam. This great difference in the soils of the two districts is due to the difference in origin. Practically all of the soils of the Imperial area came from the Colorado River sediment, while the surface soils here are wholly wash from the surrounding mountains. These Indio soils extend below Mortmere and range from sea level to about 250 feet below in a distance of only 20 miles. The surface of the entire valley is covered with small shells, showing that the soils were probably deposited under water.

Five types of soil were mapped. The following table gives the names and areas of these soils:

Areas of different soils.

Soil.	Acres.	Per cent.
Fresno sandy loam	42,432	28.3
Fresno fine sandy loam	36,032	24.0
Fresno sand	50,112	33.4
Imperial clay	13,120	8.8
Dunesand	8,256	5.5
Total	149,952	

FRESNO SAND.

The Fresno sand is composed of rather incoherent, medium to coarse sand of a whitish-gray color. The particles consist principally of slightly rounded quartz fragments with a liberal admixture of mica and granitic sand. The soil is 6 feet or more in depth, and is underlain by a slightly coarser phase of the same material. It is found along both sides of the valley, skirting the mountains. Above Indio the type is somewhat rough and steep, with a general slope toward the valley, but could be prepared for cultivation with little expense.

The gravelly phase of the Fresno sand consists of a coarse, harsh sand of grayish-white color, intermixed with a high percentage of fine gravel and bowlders, the latter varying in size from one-fourth inch to 12 inches or more in diameter. The soil is 6 feet or more in depth, and is underlain by a coarser material of the same general character. This phase is found above the old sea beach, skirting the mountains on each side of the valley, and is rather rough and broken, consisting of a great number of alluvial fans or cone deltas, which have been formed at the mouths of many small canyons and washes which debouch from the mountains upon the valley. Every rain storm now adds to these soils, the surface often being greatly modified by a single rain.

The Fresno sand, in its typical phase, is made up of the old beach sand of Salton Sink with additions of material washed down from the mountains. Because of its position and the coarseness of its particles this soil will always be well drained and free from alkali. As it is nearly all above the present water supply no attempt has been made to cultivate it, but if water were available it would make a very good soil for the many truck crops of the valley, as well as for fruits, grain, and alfalfa.

DUNESAND.

The Dunesand areas consist of low, broad, crescent-shaped dunes, 2 to 12 feet high. The material of the dunes is the same as that of the Fresno sand, the dunes being simply the sand blown up into ridges and otherwise modified by wind action. It is found to the west and south of Indio, along and above the old beach line of the sink, nearly all of the type being above sea level. The surface of the Dunesand is very rough and irregular, necessitating the expenditure of considerable labor and money to prepare it for irrigation. Owing to the coarse texture of the soil and its elevation, it is well drained and free from alkali. None of this soil has yet been cultivated, and because of the expense of preparing it for irrigation it is of no present agricultural value.

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam is the principal soil of the Indio area. It is a very micaceous, slate-colored fine sand, with the properties of a sandy loam. It consists of finely pulverized particles of mineral matter somewhat resembling ash, ranges in depth from 2½ to 5 feet, and is usually underlain with sandy loam or sand. Occasionally the surface soil is underlain by a foot or so of loam, which in turn is underlain by the sandy loam or sand. The particles going to make up this type of soil are of remarkably uniform size, being nearly all fine and very fine sand. These particles fit very closely together, making nearly all the soil spaces of suitable size for free capillary movement of water, giving the soil not only a very high capillary power, but offering little resistance to such movement. For this reason a greater uniformity of moisture content exists in this soil than in any other soil of the area. This peculiarity of texture also makes it possible for a great quantity of water to be lifted and evaporated at the surface; hence the soil in in the lower levels is generally alkaline.

The surface of the Fresno sandy loam is usually of uniform slope, with very few minor scoriations or modifications from wind action. It extends from the lowest levels to nearly 100 feet above sea level, and in all cases is admirably suited for irrigation. The greater part of this soil is well drained, although under a small part in the lower levels the water table is within capillary reach of the surface, and, consequently, the soil in such locations is quite badly alkaline. Like the other soils of the valley, this type is the product of erosion from the surrounding mountains.

Melons, sweet potatoes, wheat, barley, and a small quantity of alfalfa, as well as nearly all kinds of garden crops, have been grown on this soil with marked success. It is well adapted to any crop that is suited to the climate of the area. A better soil for general purposes would be difficult to find, since it is easily cultivated, very productive, and retains moisture well.

The following table shows the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Fresno sandy loam.

No.	Locality.	Description.	Organic matter.	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.*
8187	NE. cor. sec. 27, T. 6 S., R. 8 E.	Fine sandy loam, 0 to 72 inches.	0.58	0.00	0.40	1.06	20.16	52.92	18.16	7.08
8189	NE. cor. sec. 11, T. 6 S., R. 7 E.	Fine sandy loam, 0 to 72 inches.	.12	.20	.62	1.62	19.40	48.50	19.70	9.64
8183	SW. cor. sec. 31, T. 5 S., R. 7 E.	Fine sandy loam, 0 to 36 inches.	.24	Tr.	.50	1.50	22.66	21.44	33.18	20.40
8188	SE. cor. sec. 10, T. 8 S., R. 9 E.	Fine sandy loam, 0 to 72 inches.	.18	Tr.	.70	2.50	23.10	29.20	19.30	24.20
8185	SE. cor. sec. 8, T. 6 S., R. 7 E.	Fine sandy loam, 0 to 12 inches.	.88	.14	1.40	2.00	11.84	21.70	35.06	27.22
8184	Subsoil of 8183......	Sandy loam, 36 to 72 inches.	.19	.00	.50	1.30	23.20	44.60	16.64	13.56
8186	Subsoil of 8185......	Fine sandy loam, 12 to 60 inches.	.32	.34	.62	.70	7.60	24.52	47.52	17.96

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 8187, 2.80 per cent; No. 8189, 3 per cent; No. 8183, 2 per cent; No. 8188, 3 per cent; No. 8185, 36.80 per cent; No. 8184, 1.60 per cent; No. 8186, 6.20 per cent.

FRESNO SANDY LOAM.

The Fresno sandy loam is a loose, friable, grayish, micaceous soil from 3 to 6 feet deep, underlain with coarse sand to an undetermined depth. It is usually found on the slopes just below areas of the Fresno sand or Dunesand. Most of this soil is found in T. 7 S., R. 8 E., and T. 8 S., R. 9 E., but small areas occur throughout the district mapped.

The Fresno fine sandy loam was originally a smooth, apparently level soil of uniform grade with a slope of approximately 20 feet to the mile. After the subsidence of the water in which it was deposited, the strong winds prevailing in this valley greatly modified the surface in places. "Blow-outs," or wide, shallow depressions, have been formed, the soil from which has been piled up as small dunes or low ridges along the lee side of trees, bushes, and other obstructions. These, however, are not a serious obstacle to cultivation, being easily leveled in preparing the land for irrigation.

In the lower levels the Fresno fine sandy loam is poorly drained and has a very high water table, which in most cases is less than 10 feet from the surface. The capillary power of the soil is great enough to lift this water to the surface, there to be evaporated and leave its content of soluble salts. In this way the lower part of the type has become very alkaline. In the higher levels it is usually well drained and free from alkali salts.

Like the other soils of this district, the Fresno fine sandy loam is derived by wash from the mountains surrounding the valley and was deposited under the waters of the basin when it formed an arm of the sea. Very little has as yet been cultivated, but where not too strongly alkaline it will produce in abundance any of the crops suited to the climate.

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

Mechanical analyses of Fresno fine sandy loam.

No.	Locality.	Description.	Organic matter.	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.*
8175	NW. cor. sec. 10, T. 6 S., R. 7 E.	Sandy loam, 0 to 72 inches.	0.20	0.20	0.72	4.10	26.18	53.88	11.80	2.96
8176	SE. cor. sec. 11, T. 6 S., R. 7 E.	Sandy loam, 0 to 36 inches.	.19	.04	.38	1.60	29.22	48.80	15.62	4.30
8177	NE. cor. sec. 19, T. 8 S., R. 9 E.	Sandy loam, 0 to 12 inches.	.21	.16	.72	2.80	19.70	29.76	31.18	15.16
8180	SW. cor. sec. 27, T. 8 S., R. 9 E.	Sandy loam, 0 to 12 inches.	.84	.00	1.24	3.60	20.16	25.46	18.14	30.66
8181	Subsoil of 8180......	Sandy loam, 12 to 48 inches.	.32	.10	2.30	7.10	37.70	32.80	12.52	7.18
8178	Subsoil of 8177......	Sandy loam, 12 to 36 inches.	.16	.30	.46	2.48	20.70	27.92	38.64	9.50
8179	Subsoil of 8177......	Sandy loam, 36 to 72 inches.	.16	.30	1.80	4.40	18.60	27.48	25.20	21.80
8182	Subsoil of 8180......	Sandy loam, 48 to 60 inches.	.26	.14	1.14	3.30	19.20	23.32	26.20	26.30

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 8175, 2.60 per cent; No. 8176, 1.40 per cent; No. 8177, 4.80 per cent; No. 8180, 6.60 per cent; No. 8181, 5.80 per cent; No. 8178, 7 per cent; No. 8179, 9.20 per cent; No. 8182, 11.40 per cent.

IMPERIAL CLAY.

The Imperial clay is a compact, plastic, micaceous slate-colored clay loam or clay 1 to 2 feet in depth, underlain with clay loam or clay. The material of the surface soil consists chiefly of a mixture of clay, silt, and fine sand. It is found mostly in low and apparently level places. In the southwestern part of T. 7 S., R. 9 E., and in the northern part of T. 8 S., R. 9 E., the largest area of this type occurs. Only small patches are found elsewhere.

This soil has been formed principally from the sediment carried down from the mountains immediately surrounding this part of the sink, with a slight admixture of sediment from the Colorado River. The presence of fresh and of brackish water shells in the soil goes to show that it was deposited under water.

Nearly all of the Imperial clay mapped is too strongly alkaline to grow any but the most alkali-resistant crops, and the heavy character of the subsoil would make it expensive and difficult to drain. It is naturally a strong soil, however, and if free from alkali it would be very productive.

The following table shows the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Imperial clay.

No.	Locality.	Description.	Organic matter.	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.*
8190	NW. cor. sec. 29, T. 6 S., R. 8 E.	Clay loam, 0 to 12 inches.	0.52	0.30	0.60	0.60	4.90	31.60	35.00	27.02
8193	SE. cor. sec. 10, T. 8 S., R. 9 E.	Clay, 0 to 12 inches..	.99	.00	.00	.10	.48	5.24	28.08	63.48
8191	SE. cor. sec. 9, T. 8 S., R. 9 E.	Clay, 0 to 12 inches..	.53	.00	.12	.10	1.40	5.60	25.32	66.52
8192	Subsoil of 8191......	Clay, 24 to 72 inches.	.95	.30	.58	.40	1.40	4.50	26.20	64.12
8194	Subsoil of 8193......	Heavy loam, 12 to 48 inches.	.61	.10	.30	.16	.80	3.00	22.48	70.52

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 8190, 7.59 per cent; No. 8193, 20 per cent; No. 8191, 15.89 per cent; No. 8192, 11.75 per cent; No. 8194, 14.90 per cent.

WATER SUPPLY.

All the irrigation water in the Indio area comes from wells. At some future time the Colorado River may be made to irrigate a part of the lower lying land, but at present the only supply worthy of mention is that coming from underground. Wells here are of two kinds—surface or pumping wells and artesian or flowing wells. For several years after the Southern Pacific Railroad was built through this valley all the water for its use was pumped from shallow wells at Indio and Walters. A great deal of experimenting at Indio finally resulted in a well with small flow. Soon afterwards a large 10-inch well was dug at Walters, and now furnishes all the water for the railroad from Walters east to Yuma. These wells cost a great deal of money and as yet no thought of wells for irrigation was entertained. Finally Mr. Tingman of Indio succeeded in getting a well that furnished water for irrigating a small garden. Hydraulic boring machines were then introduced and so lessened the cost that wells could be drilled for general irrigation purposes. The artesian wells are between 400 and 500 feet deep, the water being found in a stratum of fine gravel.

There are now in all about 200 artesian wells in the valley, the most of which are 2 inches in diameter. Of the remainder, only one is 10 inches in diameter—the one at Walters—while four or five are 6 inches and about thirty 3 or 4 inches in diameter. For the more common smaller wells $500 is about the average cost.

The amount of water a well will flow varies greatly with its location. Near Walters, Mortmere, and as far up as Coachilla the flow from a 3-inch well is generally enough to irrigate 40 acres of land. Some wells flow much more water than others, and some crops require more water than others.

There is a sensible diminution of the flow from artesian wells in the valley. This is especially noticeable in the vicinity of Indio. Where three years ago wells flowed several inches over the casing they now have to be pumped. This supply will surely be further diminished as more wells are put in on the lower levels, and for much of the country now irrigated from flowing wells pumping will be necessary. This has been the history of all artesian districts; the wells at higher levels always cease to flow and have to be pumped as their supply is lessened by wells being bored at lower levels.

ALKALI IN SOILS.

All of the soils in the lower levels of this area contain alkali, but in some cases not in sufficient quantities to injure crops. In the land immediately adjoining the Salton Sink, where the soils are generally heaviest, the percentage of alkali is very high, but the proportion diminishes rapidly in the higher levels. On the alkali map accompanying this report the areas affected are shown, and are classified according to the average amount of alkali contained in the surface 6 feet of soil. Borings were made at intervals throughout the area to a depth of 6 feet, and the percentage of alkali for each foot of soil was determined. From the mean percentage of alkali for 6 feet of soil of each boring the alkali map was prepared. The soils were classified into those containing less than 0.20 per cent, from 0.20 to 0.40 per cent, from 0.40 to 0.60 per cent, from 0.60 to 1 per cent, from 1 to 3 per cent, and more than 3 per cent of alkali.

The extent of these several grades of alkali soils in the Indio area is shown in the following table:

Areas of different grades of alkali soil.

Grade of soil.	Acres.	Per cent of area.
Less than 0.20 per cent	82,996	55.3
From 0.20 to 0.40 per cent	17,984	12.0
From 0.40 to 0.60 per cent	4,032	2.7
From 0.60 to 1 per cent	1,216	.9
From 1 to 3 per cent	27,968	18.6
Over 3 per cent	15,756	10.5
Total	149,952	....

The first class of soil, containing less than 0.20 per cent, represents land that is practically free from alkali. Only the most sensitive crops are affected by the small amount of salts in this class, and all the crops suited to the climate and soils do well. By referring to the maps accompanying this report it will be seen that most of the areas of this grade outlined on the alkali map correspond to areas of Dunesand, or Fresno sand, on the soil map, while the other types of soil usually contain alkali above 0.20 per cent.

Where the land contains from 0.20 to 0.40 per cent of alkali most crops can be grown, though when the maximum limit is reached certain crops, such as alfalfa, grapes, and the grains, suffer. This degree of alkalinity is usually found in a sandy loam or fine sandy loam, though in some few cases it is also found in sand. In and about the town of Coachilla two rather large areas of this grade of alkali soil are found, but no injury to the crops here grown is apparent.

On land containing from 0.40 to 0.60 per cent of alkali alfalfa will barely grow and wheat and barley are measureably affected. Only four small areas of this grade, altogether amounting to only about 2 square miles, were found.

Land containing from 0.60 to 1 per cent of alkali will not grow any but the most alkali-resistant crops, such as sugar beets, sorghum, date palms, and the native salt grasses. Several areas were found in the lower levels close to the Salton Sink and a few smaller ones in the upper part of the valley. No cultivation has as yet been attempted on lands containing this amount of alkali.

On land containing from 1 to 3 per cent of alkali none of the agricultural crops will grow except date palms, sugar beets, sorghum, and the native salt grasses, and of these sugar beets and sorghum make a very poor growth. Salt bushes and alkali weeds form the principal vegetation at the present time. More than 1 per cent of alkali is found in nearly all of the land in the lower levels close to the Salton

Sink, and a large area of it extends from the sink up the trough of the valley to the town of Indio.

It is easy to understand that on evaporation of the sea water which once covered the Salton Basin large quantities of alkali were left in the soil. But this is not the only source of the alkali for this part of the basin, and, in fact, this accounts but for a small percentage of the local alkali accumulations. In the lower levels the alkali is distinctly of marine origin. The soils were deposited and saturated with salty water, which on evaporation left them strongly alkaline. Because of their heavy character and low-lying position the alkali has not been washed from these soils, but, on the contrary, alkali salts have been accumulating as the result of drainage from the upper levels.

In the upper levels of the area, however, the alkali comes from alkali-bearing sandstones and shales found in the mountains adjoining this area. At times of heavy rainfall considerable quantities of salts are dissolved from these rocks and carried into the valley, where the water sinks into the light sandy soils. Over a great part of the valley the ground water is within a few feet of the surface. In many cases it is so close that the soils of high capillary power can raise it to the surface. Constant evaporation of the water, leaving behind its small load of salts, soon results in a surface accumulation of alkali, which is only partly carried back into the soil by percolation of rain water. This is the manner in which the greater part of the soils of the Indio area became alkaline.

Nearly all of the alkaline soils in the Indio area are accompanied by a high water table. Whenever this is true the greater proportion of the salts is in the surface foot. On the strongly alkaline soils immediately surrounding the sink, the alkali extends in harmful quantities below the surface 6 feet, while farther up the valley the alkali is in many cases contained almost wholly in the first to the third foot. Only in a very few cases where the surface soil is light, is underlain by a heavier soil, and the water table is below 10 feet. is there more alkali in the lower levels than at the surface.

RECLAMATION OF ALKALI LANDS.

The gravity of the alkali problem in any arid country is dependent upon the amount and kind of salts in the soil, the amount of salt in the irrigation water, and the drainage of the country. Drainage may be taken to include not only the drainage of the country as a whole, in the sense of being free from excessive amounts of ground water, but drainage within the soil itself—the rate at which the water leaches through the soil.

The alkali map which accompanies this report shows much of the valley to contain excessive amounts of alkali. To the uninformed observer this would seem to be a very grave state of affairs, for some of the percentages shown on the map are too great to permit the growing of many of the common crops. This alkali, however, is all at or near the surface of the soil. Here there are no deep-seated alkali deposits, the ground water all over the valley is of good quality, and no alkali is found below the ground water. Since the ground water is nearly always near the surface the soil lying above the water table (except in the lower levels) contains practically all the alkali in the vertical section of soil. About the Salton Sink the ground water has taken up enough salt from lateral percolation through alkali lands lands above to be quite salty.

The ground water comes from heavy rainfall and melting snows in the mountains surrounding this part of the basin. The waters of old Whitewater River, which flowed into the bay when this was an arm of the sea, disappear in the sands near Indio and find their way to the sink through subterranean channels. Thus there is a continual stream of underground water passing through the soils of the valley. For this reason the valley may be said to have poor regional drainage, while the drainage in the soil itself, its permeability, is very good.

The slope of the country mapped is on an average 12 feet to the mile, and for that part between Walters and Indio it is nearly 20 feet to the mile. With the coarse soils and heavy grades there would be no trouble about drainage if it were not for the steady stream of underground water flowing through the soil. This has been the source of all the alkali trouble. It has come so near the surface that in the trough of the valley evaporation from the surface has alkalized a considerable part of the lands. Since the drainage in the soil itself is good the obvious thing to do is to devise some means of carrying off this ground water more quickly than is the case where it leaches through the soil. If the water table could be permanently lowered the soil generally would not need to be drained artificially, and one or two heavy floodings would so reclaim the worst soils that alkali-resistant crops could be grown. All that is necessary is to lower the ground water and flood the surface, being careful to cultivate the soil as soon as possible after each wetting, so as to prevent the evaporation of water from the surface and the deposition there of the alkali carried in solution.

The best method of draining the valley can be determined only after careful surveys, but in all likelihood a long, deep, open ditch running down the center of the valley, with lateral ditches on both sides, would be sufficient to keep the general level of the ground water below 6 feet.

Whatever the method adopted for the general drainage and reclamation of the lands of the valley, the individual farmer will be dependent upon his own knowledge and resources for the reclamation of his own particular field. In this reclamation work he should keep in mind the well established principle that alkali follows the water until evaporation takes place. His energies should be devoted to the prevention of evaporation from the surface of his land, for it is at the surface that alkali does most damage to young and tender plants. The best method of getting alkali out of the land is by heavy surface flooding. Except where the water table comes to within 6 feet of the surface the land of the valley can be entirely reclaimed in this way. The alkali being washed into the subsoil and kept there by preventing surface evaporation will eventually be carried away by the stream of subterranean water.

Flooding without drainage, while it betters the lands lying at higher levels, can not fail to be detrimental to lands lying at a lower level. Since a comprehensive system of reclamation, to include the whole of the valley, is so simple and can be placed in operation so cheaply, it seems a very unbusinesslike procedure to injure one part of the valley in order to better another part when all might be permanently reclaimed.

The greatest obstacle to reclamation is the comparatively small head of water at the command of individual landowners. All the water is from artesian wells, and irrigating is done only on a small part of the farm at one time, and usually by the furrow method. The capacity of the wells is not great enough to flood very much of the open, sandy soil. The porous nature of the soils makes it almost impossible to combine the flow of wells situated at some distance from one another. This state of affairs can no doubt be remedied by making larger wells, which will be capped and allowed to flow only when the water is needed for irrigation.

When the land is flooded the greatest care should be taken to have all the surface leveled off. Any hummocks or ridges extending above the water will furnish points from which the water will evaporate, and the current, instead of being wholly downward, will be partly toward the surface, and much of the alkali washed from the soil in the immediate vicinity will be deposited on these high spots.

After the land has been partially reclaimed furrow irrigation may be practiced, as this method is much more economical of water, and the crops adapted to this valley, such as melons, grapes, truck, etc., are more easily irrigated in this way. Where furrow irrigation is practiced care should be taken to have the furrows as deep as practicable without injuring the plants, and to cultivate the soil as soon as possible after irrigation. When ridged crops, such as sweet potatoes and melons are grown, borders should be thrown up, dividing the field off into lands, and these lands should be flooded after the crop has been harvested, the surface being cultivated immediately afterwards. This flooding may not be necessary every year, but in any other method of irrigation than flooding a periodical flooding is necessary in order to wash into the subsoil the small amount of surface accumulation of salts that are found in even the most carefully cultivated fields.

If ordinary care is exercised in the cultivation of the lands of this valley there is no reason why they should not become steadily better, until even the most sensitive crops can be grown and trouble from alkali ceases entirely.

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