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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF SOILS—MILTON WHITNEY, Chief.



# SOIL SURVEY OF THE SOLOMONSVILLE AREA, ARIZONA.

BY

MACY H. LAPHAM AND N. P. NEILL.

[Advance Sheets—Field Operations of the Bureau of Soils, 1903.]  
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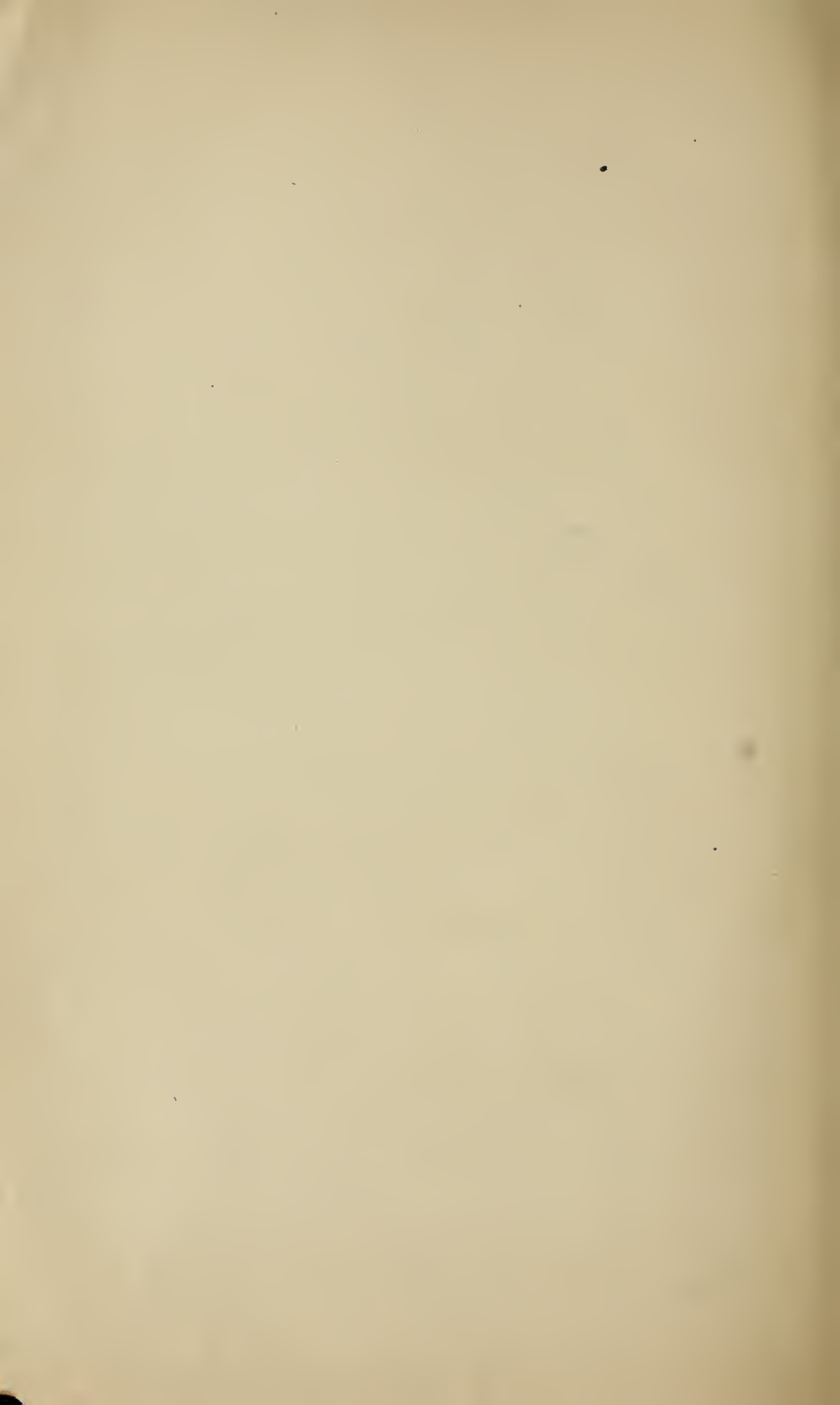


WASHINGTON:  
GOVERNMENT PRINTING OFFICE.

1904.







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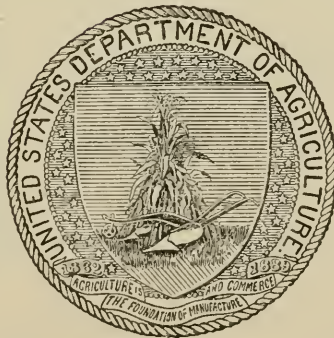
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[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

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# SOIL SURVEY OF THE SOLOMONSVILLE AREA, ARIZONA.

By MACY H. LAPHAM and N. P. NEILL.

## LOCATION AND BOUNDARIES OF THE AREA.

The area with which this report deals lies in the southeastern part of the Territory of Arizona. It embraces about 108 square miles, for the most part well irrigated and under a moderately intensive system

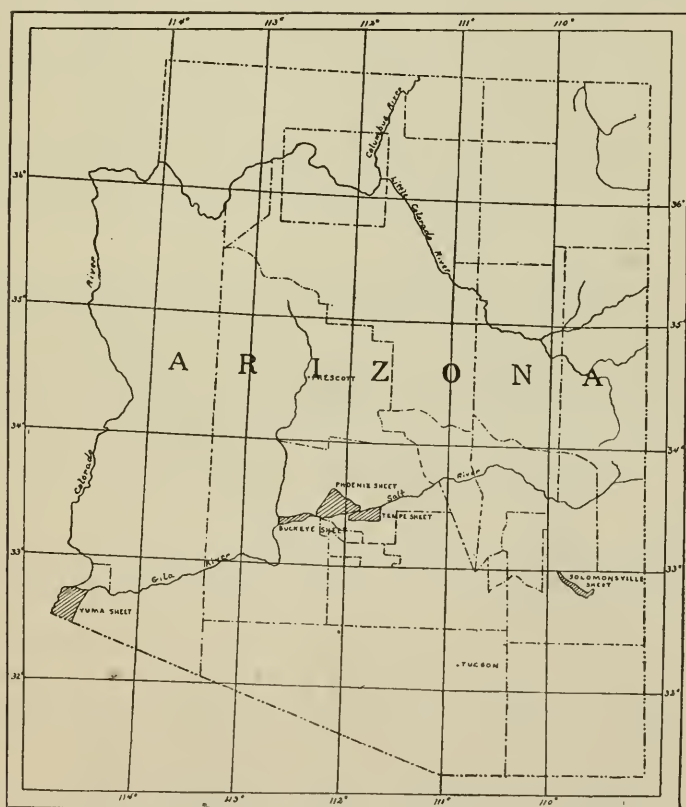


FIG. 1.—Sketch map showing position of the Solomonsville area, Arizona.

of agriculture, lying along the valley of the upper Gila River. The area covers a tract of land from 2 to 6 miles in width, extending north-westward from Solomonsville, the uppermost town of importance in

the valley, to the township line near Fort Thomas. Above Solomonsville the area covered by the irrigated lands becomes somewhat narrower and extends in a general northeasterly direction for a distance of about 8 miles. Here the valley suddenly contracts to a series of narrow canyons and the head of irrigation is reached. Upon each side the area is bounded by arbitrary lines running parallel to the lands under irrigation and cutting the lines of the bordering bluffs and high mesas near their margins.

The soil map of this area is published on a scale of 1 inch to the mile. As no base map was available it was necessary to make a plane-table survey of the area in connection with the soil work.

#### HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

This section of Arizona was undoubtedly at one time inhabited by prehistoric races who reached a higher state of civilization than the Indians known to the early settlers. They lived in villages and cultivated the soil with the aid of irrigation. Remains of their dwellings, irrigation canals, implements, and pottery are abundant. The origin and fate of these people can only be conjectured. Their history, customs, and arts have no place in the legends of the oldest Indian tribes, and their former occupancy of the land is shown only by these scattered relics.

The Indian tribes inhabiting the country at the time of its exploration and settlement were a nomadic and much less progressive race. If they practiced agriculture at all it was only in a limited and crude way. The Indians of this section were mostly of the Apache tribe, and when, as frequently occurred, they took the warpath in opposition to the white settlers they were extremely cruel and formidable enemies.

The mineral wealth of the surrounding mountains was the early incentive to exploration and settlement. The opening of the mines, now famous for the production of copper, in the vicinity of Clifton and Morenci, called for a supply of hay, grain, and charcoal. It was to supply these wants that the first settlers entered the Gila Valley in the later seventies and took up land about Solomonsville and San Jose.

The northwestern part of the area owes its settlement and reclamation to the Mormons. These people entered the valley in large numbers, beginning about 1880. They came in families and colonies with the intention of founding permanent homes, and built up an intensive system of agriculture. They have, for the most part, been very successful. Small, well cultivated farms have taken the place of the desert, and neat farm buildings, often of brick, have replaced the temporary houses of mud or canvas. In recent years the immigration of Mormons has been somewhat retarded and their numbers have decreased on account of their removal to the Mormon settlements of Mexico.

A large proportion of the lands of the area have been brought under

cultivation within recent years, and the limits of irrigation are at the present time being quite rapidly extended. Progress in the adoption of modern methods of cultivation and of labor-saving devices has also been rapid.

#### CLIMATE.

The climate of this section is essentially arid, the average annual rainfall being less than 10 inches. This condition is accompanied by low relative humidity, marked absence of clouds or fog, high maximum and average annual temperature, and vigorous wind movement at certain seasons of the year—all factors most favorable to evaporation and intensifying the aridity resulting from insufficient rainfall.

The practice of agriculture without the aid of irrigation is not attempted in this section, and the success of agriculture depends to a greater extent upon the rainfall in the region of the headwaters of the Gila River and its tributaries than in the immediate vicinity of the irrigated lands. These streams head in the mountains at a much higher altitude than the valley, and hence receive the rainfall of a much more humid climate, the amount of precipitation increasing rapidly with the elevation.

The seasonal floods, caused by the mountain rains and the more or less uncertain showers and rains of the valley, occur during the middle and late summer months, sometimes continuing through the fall. During the winter and spring the precipitation is slight. Thunder storms during the summer and rainy seasons are frequently accompanied by severe dust storms and sometimes by hail.

The following table is from records of the Weather Bureau stations at Dudleyville and Fort Grant. The former station lies a few miles west of the area in Pinal County, and the latter in Graham County, just outside of the southern boundary of the survey.

*Normal monthly and annual temperature and precipitation.*

Month.	Fort Grant.		Dudleyville.		Month.	Fort Grant.		Dudleyville.	
	Temper- ature.	Precipi- tation.	Temper- ature.	Precipi- tation.		Temper- ature.	Precipi- tation.	Temper- ature.	Precipi- tation.
	° F.	Inches.	° F.	Inches.		° F.	Inches.	° F.	Inches.
January .....	44.0	0.92	46.6	1.28	August .....	77.0	3.22	82.5	2.26
February ....	47.0	1.24	50.2	1.07	September ..	72.3	1.84	77.7	1.20
March .....	52.4	1.13	55.5	.83	October .....	63.5	.91	66.2	.99
April .....	58.8	.38	63.3	.45	November ..	51.5	.86	55.7	.82
May .....	67.9	.29	71.2	.36	December...	46.1	1.52	48.1	1.09
June.....	76.9	.65	79.1	.30	Year ..	61.4	16.85	65.1	12.34
July .....	79.1	3.86	84.9	1.69					

The winters are clear and mild. Frosts are of frequent but snow of very rare occurrence in the valley. During the summer months the days are extremely hot, but the sensible temperature is greatly reduced by the low relative humidity. The nights are generally cool

and pleasant. Owing to the frequent severe frosts occurring in the valley during the winter season the growing of citrus fruits is impossible. The average date of the last killing frost in spring at Fort Grant is April 7; at Dudleyville, March 30; and of the first in fall, Fort Grant, November 29; Dudleyville, November 11.

During the fall and winter the wind movement is moderate. With the advance of spring, however, the winds blow with increasing force and severe wind and dust storms often occur during the spring and summer.

#### PHYSIOGRAPHY AND GEOLOGY.

The mountains of this area consist of rugged chains and spurs, often rising in perpendicular cliffs and capped with jagged peaks. Only the tops of the higher ranges are forested or covered with other than desert vegetation. Between the ranges lie level valleys, usually traversed by a stream, often of intermittent flow. Spreading outward from the base of the mountains to the valleys below is a succession of evenly sloping or gently undulating plains. These plains, formed of mountain waste brought down by swiftly moving flood streams, head in the narrow canyons of the mountain slopes, from which they extend in broad, symmetrical, cone or fanlike deltas. As they recede from the canyons the areas coalesce, forming a single, broad *débris* apron at the foot of the mountains. The valleys have in many cases been filled to great depths by this material.

The Gila Valley is almost wholly inclosed by rugged mountain ranges. Upon the north and east it is bounded by the generally barren outlying peaks and hills of the Gila Range, through which the Gila River cuts at the Narrows, some 10 miles above Solomonsville. Along the southwestern boundary it is inclosed by the Pinaleno Range, culminating in the rugged and lofty peak of Mount Graham. This peak rises to a height of over 10,000 feet above sea level, and until late in spring retains the winter snows in its lofty canyons and on its forest-covered slopes. To the northwest the valley is much contracted by scattered peaks and ranges, the highest of which is Mount Trumbull.

The mountains consist primarily of granite, with frequent intrusions of volcanic rocks, usually lavas of recent date. Upon the upper slopes of the higher peaks springs and streams are abundant.

Approaching the San Simon Valley, the southwestern side of the Gila Valley is bounded by the undulating plains lying at the foot of the Pinaleno and Peloncillo ranges.

The *débris* apron extends nearly or quite to the valley trough, being interrupted only by recent erosion of the valley streams. The agency of the canyon streams in building up this great sheet, composed mostly of material derived from granitic and volcanic rocks, is apparent. The soils are usually of a reddish or chocolate-brown color and

of moderately fine texture. Near the mouths of extensive canyons and washes occur deposits of sand, usually of coarse texture. Throughout the deposits of the foot slope gravel occurs in large and quite uniform quantities. The surface is frequently entirely covered with fine angular gravel of volcanic origin, which, when embedded in the soil, forms a hard, smooth surface. In other positions the gravel consists largely of granitic fragments, with considerable quartz, feldspar, and other common rocks. Wherever the foot slopes are cut by streams prominent bluff and terrace lines are formed. These are sometimes quite extensive and often very abrupt. In the vicinity and covering the edges of these terraces gravel deposits also occur, the fragments varying in size from that of a pea to small, well-rounded boulders.

The terraces are often deeply cut by small washes and canyon streams heading upon the terrace levels and forming a secondary system of canyon mouths and fans upon the valley bottom below. Horizontal beds of drab or gray-colored sandstone, underlying the surface material of the foot slopes, are frequently exposed in the deeper cuts along the foot-slope margins. Strata of clays and shales in advanced stages of decomposition often occur interbedded with the sandstone.

The strata of gravel are often cemented into a calcareous hardpan exposed along cuts and margins of the terraces. This material frequently caps the mesa lands and covers the softer earths and rocks below.

The character of the material of the secondary foot slope is similar to that of the main foot slope above, from which it is derived. The surface of the fans is usually of gentle slope and covered only with scattered cacti of various species, yucca, greasewood, and various other desert plants.

The river bottom or valley trough occupies a tract from 1 to 5 miles in width, through which flows the Gila River. The river course has been partially refilled by alluvial sediments. The Gila River and its tributaries carry in suspension a vast amount of sediment which is deposited in considerable quantities along the river flood plain during high water. The cutting away of the stream banks as the stream shifted from side to side has produced the level bottom, flanked by the steep slopes of the terrace-bordered mesa lands. From the valley trough the bottom extends outward with gentle slope to the bluff lines marking the margins of the mesa lands. Small terraces of recent origin frequently occur in the valley bottom. The material consists of alluvial deposits ranging from silts and sands to coarse gravel. Near the base of the terraces marking the valley borders these alluvial deposits are frequently overlain by wash from the mesa lands and canyon streams. Portions adjacent to the river channel are frequently occupied by extensive deposits of fine river sands of uneven, wind-blown surface and covered with a heavy growth of willow and cottonwood.

A considerable part of the water supply comes from melting snow, springs, and mountain streams near the source of the Gila River, and an important part from the tributary Gila Bonita, Prieto, and Blue creeks, and the San Francisco River, all emptying into the river above Solomonsville.

San Simon River, which enters the Gila near Solomonsville, is ordinarily an insignificant and poorly defined water course. It drains a large extent of country known as the San Simon Valley, lying in the southeastern part of the Territory, and is subject to sudden and heavy floods. At such times vast quantities of a very fine, heavy silt are brought down and deposited in the lower valley, and in that part of the Gila Valley lying between Solomonsville and Safford.

## SOILS.

The extent and position of the different soil types of this area are shown in colors upon the map, each color representing a distinct type described in the following pages. Soil profiles indicating the character of the soil to a depth of 6 feet are given on the margin of the map. The presence of gravel in the soil in such quantities as to influence its texture and agricultural value is shown by symbol.

The soils of this area fall naturally into two more or less widely separated divisions, viz, colluvial soils and alluvial soils. In the extreme and pronounced types the distinction is evident; with the less pronounced types the soils of the two divisions grade together by imperceptible degrees, and the classification is of a somewhat arbitrary character.

The colluvial soils make up the original foot slopes of the mountains, and consist of mountain waste deposited in gently sloping plains by intermittent floods from cloud-bursts falling upon the mountain sides. The soils of the system of secondary fans previously described are also included in this class. Under the soils classed as alluvial fall those formed by river sediment brought for considerable distances in suspension and deposited by floods along the river flood plain.

The colluvial soils are the Maricopa gravelly loam, Maricopa sand, and Maricopa sandy loam. The alluvial types are Riverwash, Pecos sand, Gila fine sandy loam, and Maricopa silt loam. The following table gives the extent of each of these types:

*Areas of different soils.*

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Maricopa sand.....	17,728	25.6	Pecos sand.....	6,720	9.7
Maricopa gravelly loam.....	12,864	18.6	Riverwash.....	256	.4
Maricopa silt loam.....	11,648	16.8	Total.....	69,184	.....
Maricopa sandy loam.....	10,368	15.0			
Gila fine sandy loam.....	9,600	13.9			

## MARICOPA GRAVELLY LOAM.

The areas of the Maricopa gravelly loam consist of remnants of the original foot slope of the mountains. The depth of this soil, except in the vicinity of eroded areas where it may be underlain by a calcareous hardpan, is always at least 6 feet, and often much greater.

The Maricopa gravelly loam consists of a chocolate-brown loam of a rather compact, fine, silty texture, containing a considerable proportion of fine, angular gravel. The soil usually becomes somewhat heavier in the lower part of the profile. In exposures in the cuts and washes so common in areas of this soil the subsoil is frequently seen to be of a very heavy, compact nature, cracking upon exposure to the weather and resembling adobe. The fine earth material of this soil is somewhat heavier in this than in other areas where it occurs.

Before cultivation the surface of the soil is compact, smooth, and often thickly strewn with small gravel, usually quite well rounded. In local spots this gravel is almost entirely of volcanic origin, often partly embedded in the soil and imparting a peculiarly hard, smooth, glistening surface, but the particles are of small size and would not interfere with cultivation. The soil becomes quite sticky when wet and bakes somewhat when puddled and dried. Along the margins of the cuts, washes, and terraces, and over portions modified by erosion, the gravel is larger and the quantity greater, and the soil becomes lighter and more sandy by loss of the finer particles through erosion. A great part of this area along the terraces, or in places of severe erosion, is rendered very difficult or impossible of cultivation by excess of gravel. Strata of very hard and refractory hardpan, similar to that occurring in the "Mortar Beds" of the Tertiary gravels of the Great Plains in eastern Colorado (see Soil Survey in the Arkansas Valley, Field Operations of the Bureau of Soils, 1902), also occur in the subsoil of these terrace and eroded areas. Each strata probably represents the upper limit of the water table at some time during the early history of the valley.

Areas of the Maricopa gravelly loam occur on the upper terraces throughout the area surveyed, generally forming the borders of the cultivated valley lands. Areas also occur upon the mesa lands. The surface, except where eroded, is level or gently sloping. These lands are, however, often cut by narrow canyons from 25 to 100 or more feet in depth, with steep or nearly vertical walls. Small domelike elevations or hills, with surface thickly strewn with cobbles and gravel, frequently occur in the vicinity of the canyon mouths.

Small seepage springs, alkaline in character, sometimes occur along the margins of the terrace borders upon the northern and eastern sides of the valley. Fairly good natural drainage is, however, usually afforded by underlying gravel beds.

This soil is derived from the weathered débris of the rocks of the surrounding mountains. During the processes of valley filling this

material has been distributed and modified by mountain torrents and floods. Subsequent wind action has in places also modified the deposits.

Small quantities of gypsum sometimes occur in this soil. Some of the heavier subsoils and the adjacent rocks are strongly impregnated with sodium chloride, which, through percolating waters, gives rise to the salt springs already mentioned. Sulphates are also of common occurrence.

The Maricopa gravelly loam lies entirely above the valley bottom and beyond the reach of the irrigating systems. It is therefore at present of no agricultural value except for grazing. The vegetation consists of a growth of cacti, small flowering annuals, yucca, and other plants of the desert.

Should water be brought upon these lands they could, with the exception of the broken and excessively gravelly areas, be made to produce all the general farm crops of this region. Fruit should do well upon this soil, and the slight elevation should make damage from frost less likely than in the valley lands. The irrigation of any portion of these lands (barring the possibility of artesian irrigation) is out of the question without the construction of extensive storage reservoirs.

The results of a mechanical analysis of the fine earth of this soil are given in the following table:

*Mechanical analysis of Maricopa gravelly 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 0.001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
S131	SE, ¼ sec. 26, T. 7 S., R. 26 E.	Brown gravelly loam, 0 to 12 inches.	0.25	6.42	10.34	5.72	8.90	9.98	29.18	29.46

GILA FINE SANDY LOAM.

The Gila fine sandy loam is a mellow sandy loam 6 feet or more in depth, of dark color and fine sandy or silty texture. The coarser sands of adjoining types are sometimes mingled with this finer sediment, but this occurs only to a slight extent. In lower areas lying close to the course of the Gila River it is sometimes less than 6 feet in depth, and is underlain by river sand and gravel. Gravel is of rare occurrence upon the surface.

This soil occurs in long, narrow bands lying near the course of the Gila River and extending throughout the entire valley. It occupies the intermediate position between the Pecos sand and the soil of the higher valley slopes. Small bodies less uniform in texture sometimes occur at the base of the terraces forming the valley borders, or extend



outward from the normal position near the valley trough. The soil grades, often very quickly, into the Pecos sand and the Maricopa silt loam.

Occupying the lower parts of the valley, this soil type is generally level and has little surface variation, although sometimes slightly pitted and cut by river flood channels. It usually lies several feet above the stream level. When not separated from stream courses by areas of other soil types it is set off from the stream by vertically eroded terraces. In the native vegetation cottonwood and willow predominate. This soil does not readily bake or puddle, except where it lies next to areas of the Maricopa silt loam and other soils containing a considerable admixture of silt and clay. While it retains moisture well and does not leach as readily as the Pecos sand, it allows the ready percolation of water. The usual underlying deposits of sand and gravel furnish good natural drainage. Artificial drainage is necessary only in a few localities where seepage water has collected from the drainage of adjacent soils or from the use of excessive quantities of water in irrigation.

The origin of this soil and the agencies prominent in its formation are similar to those of the Pecos sand, the proportion of the finer alluvial material here being considerably greater.

The Gila fine sandy loam carries considerable mica, which greatly increases its porosity and counteracts the binding effects of the heavier sediments. The mineral plant foods are usually present in sufficient quantities and the soil is usually rich in organic matter. Owing to low position and marked capillary power the soil carries small quantities of alkali salts. Except where there is considerable seepage from higher levels these are not present in alarming quantities.

This is one of the most fertile and valuable soils of the valley, producing large crops of wheat, barley, and alfalfa. It is well adapted to the culture of fruit, especially apples, as well as to sugar beets, alfalfa, and grains, including wheat, barley, corn, and sorghum.

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

*Mechanical analyses of Gila 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.
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
8129	Sec. 2, T. 7 S., R. 27 E.	Fine sandy loam, 0 to 12 inches.	0.89	0.16	0.34	0.50	8.50	19.34	46.98	24.10
8130	Subsoil of 8129.....	Fine sandy loam, 12 to 48 inches.	.76	.48	2.32	2.40	18.98	31.16	33.22	11.42

## MARICOPA SAND.

The Maricopa sand consists of the coarser materials of the secondary deltas. Typically it is a medium coarse-textured, sharp sand, mainly of quartz or feldspar, light gray or whitish in color and 6 feet or more in depth. Near the margin of the soil areas, where it has been washed and blown over the adjacent types, the depth of the soil sometimes becomes less than 6 feet and the texture somewhat finer, approaching that of a sandy loam in character. In the vicinity of the canyon mouths it is often striated with layers of micaceous fine sand or fine sandy loam, which gives to the soil the properties of a fine sandy loam. Such areas are, however, local in character. It is here also often cut by streaks and beds of coarse, wellworn gravel deposited in flood time by the canyon streams. These beds are sometimes cemented by calcium carbonate into a hardpan similar to that underlying parts of the Maricopa gravelly loam.

Gravel is a prominent feature throughout the greater portion of the areas of this type. The particles are usually more or less worn and well rounded and consist chiefly of fragments of quartz, feldspar, and granite, although fragments of volcanic rocks are common. As the outer margins of the fans are approached the gravel gradually disappears, the soil in its nongravelly phase sometimes covering large areas.

The Maricopa sand in its typical form occurs as long, narrow areas skirting the valley margins and extending along the base of the slopes of the Maricopa gravelly loam, or as broad, extensive tracts extending into the valley from the secondary fans and canyon washes. This type is one of the most extensive of the soils in the area, covering over 25 per cent of the total area. The surface is usually level or gently sloping. In the vicinity of the canyon mouths it is sometimes cut by channels of small, intermittent streams. Along the upper and middle slopes of the fans, where exposed to the action of strong winds, small dunes and drifts are sometimes formed. These are, however, not extensive and are easily leveled. This soil in its typically loose, porous condition is well drained and at no place is artificial drainage necessary.

The Maricopa sand is derived from the coarser materials washed from the terrace margins of the Maricopa gravelly loam and the sand of the streams borne from longer distances. These materials have been further modified by wind action and the boundaries of the type are still being shifted and extended by the strong winds.

The alkali salts are present in this soil only in small quantities and need cause no apprehension unless they should accumulate through seepage from higher irrigated land or are brought to the surface by irrigation in the few places where the soil is shallow and underlain by a heavy, alkaline subsoil.

Bodies of the Maricopa sand lying adjacent to the gravel-covered slopes of the Maricopa gravelly loam and in close proximity to canyon mouths often contain such a large percentage of gravel as to render them unfit for cultivation. Such areas are usually above the canal lines and are of no agricultural value except for grazing. The lower slopes, where gravel occurs only as small pebbles and in moderate or small amounts, or disappears altogether, yield, under proper cultivation and irrigation, fair crops of alfalfa, wheat, and barley. This soil is somewhat deficient in organic matter, and the practice of green and stable manuring, with careful rotation of crops, is recommended. The type is easily tilled, and with proper treatment should form valuable land for the production of fruit and truck crops.

There is an upland phase of this soil which, with the exception of a small area south of Pima, lies above the present level of irrigation and is of value only for grazing.

The following table shows the results of mechanical analyses of the fine earth of this type:

*Mechanical analyses of Maricopa sand.*

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.
8145	Sec. 20, T. 7 S., R. 26 E.	Gravelly sand, 0 to 12 inches.	0.56	5.02	7.68	7.06	21.74	23.58	26.38	8.54
8143	Sec. 22, T. 7 S., R. 26 E.	Coarse sand, 0 to 12 inches.	.47	1.40	7.82	10.14	29.76	18.76	22.64	9.46
8144	Subsoil of 8143.....	Coarse sand, 12 to 72 inches.	.45	1.06	6.34	10.44	35.24	18.96	21.04	6.86

MARICOPA SANDY LOAM.

The Maricopa sandy loam consists of a coarse grayish or brownish sandy loam, usually 6 feet or more in depth. In the vicinity of the canyon mouths are frequent interlacing beds of coarse gravel, river-wash, and lime-gravel hardpan. Small deposits of fine micaceous sand, sandy loam, and silt sometimes occur. Gravel also occurs upon the surface, sometimes in excessive quantities.

The bodies of this soil nearer the middle of the valley floor and covered by the irrigating systems are free from gravel, or nearly so. Where gravel does occur it varies from small pebbles to small bowlders and is similar in character to that of the Maricopa sand.

The subsoil of this type is sometimes streaked and pitted with small patches of the Maricopa sand. Near its outer boundaries the soil is

sometimes less than 6 feet in depth and is underlain by the adjacent valley soil, over which it has been spread by freshets or winds.

In point of extent and agricultural value this is an important soil type. Long, narrow bodies of the soil occur throughout the area along the margin of the Maricopa gravelly loam and the Maricopa sand. More uniform and extensive bodies are found over the base of the larger secondary fans forming the outer slopes and levels of the valley floor. Often the fans consist almost wholly of this material, and a number of such fans and washes frequently coalesce into broad sheets covering large areas along the outlying portions of the valley. Such bodies occur in the vicinity of Safford, Thatcher, and Pima. On one side it grades into the coarse Maricopa sand and on the other into the Gila fine sandy loam and the Maricopa silt loam.

The surface of this soil type is usually level, although sometimes pitted by erosion and occasionally cut by small washes. It possesses good natural drainage, artificial drainage of the land being rendered necessary only where seepage water from adjoining land has collected. Such areas are at present of very small extent.

In origin and processes of formation this type is very similar to the Maricopa sand, the only difference consisting in the small percentage of fine sand and silt deposits of the Gila River that have been added to the Maricopa sand.

Alkali salts occur in the Maricopa sandy loam only to a very limited extent. Except in small areas near the soil boundaries, where the salts from heavier subsoils may accumulate at the surface under the influence of irrigation, this alkali need cause no alarm.

This soil type is easily tilled, does not puddle or bake, and when properly cultivated and fertilized with green or stable manure produces excellent crops of grain, alfalfa, fruit, and vegetables. It carries less mineral and organic plant food than the heavier soils of the valley and is more easily exhausted, but the constant addition of sediment from the irrigating water tends to remedy this.

This type is especially adapted to the growing of garden and truck crops, tomatoes, small and stone fruits, and apples. It is very retentive of moisture and is considered one of the most valuable soils of the valley. With proper cultivation sugar beets would probably do well on this soil.

The table following shows the results of mechanical analyses of typical samples of fine earth of this soil.

*Mechanical analyses of Maricopa 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.
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
8139	SE. $\frac{1}{4}$ sec. 26, T. 7 S., R. 26 E.	Sandy loam, 0 to 12 inches.	0.47	3.26	8.98	10.48	25.06	15.58	23.80	12.84
8141	Sec. 21, T. 7 S., R. 26 E.	Coarse sandy loam, 0 to 12 inches.	1.07	1.18	4.44	4.44	14.80	12.44	27.98	34.68
8142	Subsoil of 8141.....	Sandy loam, 12 to 72 inches.	.76	1.00	5.58	6.10	25.80	18.40	30.58	12.50
8140	Subsoil of 8139.....	Gravelly sandy loam, 12 to 72 inches.	.51	9.62	13.96	8.26	11.94	12.90	24.82	18.40

## MARICOPA SILT LOAM.

The Maricopa silt loam is a heavy brownish silt loam, usually 6 feet or more in depth. It has an exceedingly fine texture, crumbling to an impalpable powder when dry, but becoming very sticky when wet. It is easily puddled, bakes upon exposure to the sun, and resembles in physical characteristics an adobe soil. It covers extensive areas, is of uniform texture, and erodes into vertically walled washes and bluffs. It often extends to great depths, but is sometimes interstratified at less than 6 feet with layers of coarse and fine sands and gravels. Near the valley trough it is often less than 6 feet in depth and is underlain by materials of the Gila fine sandy loam and the Pecos sand. Except as very fine particles the presence of gravel on the surface is rare. North and west from Solomonsville the soil assumes a very dense, heavy nature, resembling the eastern clay soils.

The most extensive and typical areas of this type occur along San Simon Creek, extending from Solomonsville to Safford, and in the vicinity of Matthews. Other bodies occur in long, narrow strips throughout the valley. The soil is easily distinguished from the soils of coarser texture. It grades gradually into the Gila fine sandy loam.

The surface of this type is usually smooth and level, except where cut by washes. The banks of these washes are from 5 to 20 feet high, nearly vertical, stand for long periods of time, and are distinctive of this soil type. Native vegetation is sparse and upon wind-swept areas is almost wanting. On the lower lying parts of the areas there is a rank growth of willow.

The Maricopa silt loam is very compact and impervious, percolation takes place slowly, and except where underlain at 6 feet or less by

strata of sand or gravel the underdrainage is poor. The surface drainage is also often deficient. A considerable proportion of the cultivated area of this soil type has been damaged by this lack of drainage and by seepage from adjoining soils, and should be artificially drained.

This soil is formed by the deposition of the heavier silt and alluvial material carried by the Gila River and its tributaries, vast quantities of which are brought down and deposited by these streams in times of flood.

The Maricopa silt loam contains an abundance of organic matter and mineral plant food. It also carries normally in the subsoil, often at great depths, large quantities of alkali. When localized within the first 6 feet of the surface this may be, and usually is, present in dangerous quantities, and in nearly all the areas of this type which have been irrigated for some length of time there has been in many places an injurious accumulation in the surface soil.

This soil, owing to its close texture, tendency to puddle and bake, and sticky condition when wet, is somewhat refractory and is cultivated with considerable difficulty. Deep plowing, the application of straw or coarse stable manure, and frequent and thorough cultivation are necessary to improve the physical condition of the land. In areas damaged by seepage water or alkali this treatment should be supplemented by thorough artificial drainage. When not damaged by alkali or seepage water, and properly cultivated, this soil yields heavy crops of alfalfa and grain.

The Maricopa silt loam is best adapted to alfalfa, wheat, barley, sorgum, Egyptian and Indian corn, and sugar beets. In those places where the alkali salts exist in excess sorghum, beets, and alfalfa will be found to give the best results.

The following table shows the texture of this soil type:

*Mechanical analyses of Maricopa silt 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.
8134	Sec. 18, T. 7 S., R. 27 E.	Heavy silty loam, 0 to 12 inches.	1.11	0.00	0.08	0.10	0.86	2.12	72.98	23.84
8137	Sec. 30, T. 7 S., R. 27 E.	Heavy silty loam, 0 to 12 inches.	.54	.10	.20	.20	1.58	9.10	62.14	25.86
8136	Subsoil of 8134.....	Fine sandy loam, 48 to 72 inches.	.26	.00	.10	.20	10.02	20.78	52.98	15.92
8135	Subsoil of 8134.....	Heavy silty loam, 12 to 48 inches.	1.08	.00	.12	.16	2.90	14.42	61.22	21.16
8138	Subsoil of 8137.....	Heavy silty loam, 12 to 72 inches.	.25	.04	.06	.18	2.10	5.74	53.20	38.12

## PECOS SAND.

The Pecos sand is a type of wide distribution, having been recognized by the Bureau of Soils in its surveys of the Pecos Valley, New Mexico, and the Salt River Valley, Arizona. It consists of a uniform fine river sand of a light-gray or whitish color, 6 feet or more in depth, except where blown or washed over adjacent soil types. Small areas of Riverwash, as well as gravel and streaks and patches of river silt frequently occur within the limits of this soil type. It is underlain by sand and gravel.

The Pecos sand occurs in one long, narrow area lying adjacent to the Gila River, following the valley trough throughout the entire area. It is one of the most easily recognized and uniform soil types of the area surveyed.

This soil occurs only in the river bottoms and is unmarked by rock outcrops, bluffs, or prominent terrace lines. In its natural condition the surface is more or less uneven, due to the action of water and wind, and small dunes are still being formed. The characteristic vegetation near the river channel consists of willow and cottonwood, while upon the drier lands the prevailing growth is mesquite. The soil is of a loose, porous texture, and very leachy, and much irrigation water is lost from canals crossing it.

The Pecos sand is derived from the granitic and volcanic rocks of the mountains. These have weathered into finely abraded and water-worn material, which remains in suspension in the swiftly running water of the river for a considerable time, and is deposited as broad sheets along the river flood plain during times of flood. The brisk winds of the valley are constantly drifting this finer material about, covering adjacent soil formations and extending the boundaries of this type. This movement is greatly checked by the dense growth of willow common upon the moister parts of this soil.

Mica occurs in this soil in noticeable but not excessive amounts. Alkali occurs in small quantities, but there is not enough of it to impair the value of these lands for agriculture. But a small proportion of the Pecos sand is at present cultivated, mainly because of the difficulty and expense of clearing off the willow, cottonwood, and mesquite, and leveling the land for irrigation. Small tracts are, however, being cleared, and with thorough cultivation and frequent manuring produce fair crops of grain, alfalfa, and fruit.

The Pecos sand is somewhat deficient in organic matter and in some of the important mineral plant foods. Owing to its leachy character, the supply of plant food will become rapidly depleted if the soil is not intelligently cultivated and fertilized. Frequent stirring greatly assists this soil to retain moisture during dry seasons. It is easily cultivated, and if properly farmed should make an excellent soil for truck crops and small fruits.

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

*Mechanical analyses of Pecos sand.*

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 0.001 mm.
				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
8132	Sec. 18, T. 7 S., R. 27 E.	Fine sand, 0 to 12 inches.	0.67	0.04	0.22	0.70	26.90	28.02	37.22	6.86
8133	Subsoil of 8132....	Fine sand, 12 to 36 inches.	.48	.30	.66	.86	22.82	39.16	32.96	3.18

RIVERWASH.

Riverwash consists of coarse sand, well-rounded gravel, and small bowlders, and varies in depth from a few inches to several feet. It is of small extent and no agricultural value in this area, occurring only as a few narrow streaks in the mesa lands and in areas of Maricopa sand and Maricopa sandy loam. Poorly defined areas, too small to be shown upon the soil map, frequently occur within the limits of these two soils.

WATER SUPPLY FOR IRRIGATION.

The entire water supply for irrigation in this area is taken from the Gila River. Over twenty canals, the most of them small and of a more or less private nature, or else operated in cooperation by those to whom water is supplied, furnish water to the valley lands. These canals are well distributed throughout the entire area.

The largest and oldest of the canals is the Montezuma, constructed in 1871, covering lands along the southern part of the area surveyed. Some of the other more important systems are the San Jose, Union, Central, Graham, Smithville, Bryce, Oregon, and Fort Thomas canals.

A considerable part of the water of the Gila River comes from the melting snows in the higher mountains near the headwaters of the main stream and its tributaries. Frequent rains and showers in the higher altitudes supplement this supply. During the late summer the rainy season occurs and the supply is greatly augmented by floods. In general the water supply of the area has been satisfactory. Excessively dry seasons have occurred at times, during which crops under nearly all the canal systems have suffered, but usually no continued or widespread crop failures have occurred. The extension of the canal systems and the increasing activity in agriculture are, however, beginning



to affect the supply, and greater economy in the use of water will be necessary in the future. Several very important questions regarding priority of rights claimed by rival cooperative companies are now in litigation.

The water of the Gila River carries large quantities of sediment and small, but not necessarily dangerous, quantities of the alkali salts. In the upper part of the valley there are usually less than 75 parts of solid matter to 100,000 parts water. Such water is very good for irrigation purposes. The results of a chemical analysis of a sample of the water taken from the Montezuma Canal at Solomonsville late in January, 1903, are as follows:

*Analysis of water taken from the Montezuma Canal at Solomonsville, Ariz.*

Ions.	Parts per 100,000.	Conventional combinations.	Parts per 100,000.
Calcium (Ca).....	6.80	Calcium sulphate (CaSO <sub>4</sub> ).....	7.80
Magnesium (Mg).....	2.20	Calcium chloride (CaCl <sub>2</sub> ).....	12.40
Sodium (Na).....	5.50	Magnesium chloride (MgCl <sub>2</sub> ).....	8.60
Potassium (K).....	5.50	Potassium bicarbonate (KHCO <sub>3</sub> ).....	14.00
Sulphuric acid (SO <sub>4</sub> ).....	5.50	Sodium bicarbonate (NaHCO <sub>3</sub> ).....	19.10
Chlorine (Cl).....	14.70	Sodium chloride (NaCl).....	.70
Bicarbonic acid (HCO <sub>3</sub> ).....	22.40	Total solids.....	62.60
Total solids.....	62.60		

Below Solomonsville, except during periods of more than average flow, the river is several times exhausted for irrigation purposes, being resupplied by underflow and by seepage from surrounding irrigated lands. As might be expected, the alkali content of the water increases with the progress of the river through the valley. Even in the lower part of the valley, however, the percentage of alkali is not sufficient to cause alarm if proper precautions in irrigation and drainage are taken.

The diverting dams, headworks, and canals are usually constructed by the farmers themselves, and are built as cheaply as possible. They are often of an unstable or temporary character and are readily destroyed by floods. This is especially true in the case of the diverting dams. These are generally built of loose boulders and brush, and while not possessing the permanency of more expensive headworks, are quickly and cheaply replaced.

The alluvial sediments of the Gila River are of considerable importance as fertilizer. Chemical analysis shows this material to be very rich in organic and mineral plant nutrients. In places several inches of this sediment have been deposited upon the land in the course of a few years, saving many dollars that would otherwise be spent for fertilizers. The large percentage of sediment carried by the water also

causes trouble by rapidly silting up the canals, making frequent cleaning necessary. This may be partly prevented by giving the canals considerable fall.

During recent years, owing to the development of extensive mining interests in the Clifton copper district, tailings from the leachers have been carried into the waters of the Gila through the San Francisco River. This is causing great alarm among the residents of the Gila Valley. It is claimed that pumpkins, chili, tomatoes, and nearly all vines and many vegetables once yielding heavily can no longer be grown. That there is some truth in this seems evident from the fact that such plants thrive until brought in contact with the sediments of the irrigating water, especially if such irrigation be excessive. The quantity of this material, consisting mostly of finely pulverized rock, is sufficient to impart a light grayish or milky color to the water. These conditions are most evident in the upper part of the valley, in the vicinity of Solomonsville and Safford. In order to determine the cause of the trouble samples of the water were collected from the Montezuma and the San Jose canals, above Solomonsville, on March 23, 1903.

At the laboratories in Washington, where these samples were sent for analysis, the most delicate chemical tests failed to reveal the presence of any injurious substances in the waters. Upon the examination of the sediment collected from these waters, small but unmistakable traces of copper were detected. Analyses of samples of sediment thrown out from the bottom of an irrigation lateral had also proved the presence of small amounts of copper in the river sediments. The amount of the substance occurring in the sediment was in all cases very small, and not sufficient for a quantitative determination. Copper in a soluble form is, however, very poisonous to plant life, even in very small quantities. That relatively large amounts of the sediment, when deposited about the roots of growing plants, should contain enough copper to prove injurious to crops would not be impossible.

The question of storage reservoirs is important and interesting. It is possible that sites available for this purpose may exist in the valley narrows above the head of irrigation. Could such a system be installed, large areas of the mesa land would be brought under cultivation.

#### UNDERGROUND AND SEEPAGE WATER.

In a few wells of the area, lying along the lower valley levels and adjacent to the main stream channels, water is encountered at a depth of less than 10 feet. Such cases are, however, comparatively rare. Along the higher levels and outer valley margins the water table is found at a depth of from 50 to 75 feet or more. The average depth of wells extending only to the first water-bearing stratum is probably from 20 to 30 feet.

As indicating the alkali content of the subsoil, the character of the underground water is important. In general the well waters of the Gila Valley carry large, often very large, quantities of soluble salts, thus indicating the presence of an excess of alkali in the subsoil. In a few cases the deeper wells, reaching to the second or third water-bearing stratum, and cased to prevent the entrance of surface water, supply water superior to that from the shallower wells. In many other cases, however, especially in the central and lower parts of the valley, the water of the deeper wells carries much more alkali than those of less depth. This seems to be the case wherever the heavier subsoils extend to great depths. Many of the well waters of the valley are unfit for domestic use. At Pima a boring was extended to the depth of over 800 feet through heavy sedimentary material in an attempt to secure artesian water, resulting only in a large supply of underground water (not confined under pressure) inferior to the water of an adjacent surface well, which was itself unfit for domestic purposes.

The results of chemical analyses of several well waters of the area follow:

*Analyses of well waters.*

[Parts per 100,000.]

Constituent.	No. 18, surface well, sec. 2, T. 7 S., R. 27 E.	No. 28, open well, 35 feet deep.	Well near Safford, 43 feet deep.
<b>Ions:</b>			
Calcium (Ca).....	6.8	6.6	18.1
Magnesium (Mg).....	2.1	2.3	4.4
Sodium (Na).....	48.6	47.7	19.3
Potassium (K).....	9.1	3.7	1.3
Sulphuric acid (SO <sub>4</sub> ).....	40.0	27.8	13.4
Chlorine (Cl).....	43.4	39.4	37.9
Bicarbonic acid (HCO <sub>3</sub> ).....	48.4	60.5	48.4
<b>Conventional combinations:</b>			
Calcium sulphate (CaSO <sub>4</sub> ).....	23.1	22.4	18.9
Calcium bicarbonate (CaHCO <sub>3</sub> ).....			50.9
Magnesium sulphate (MgSO <sub>4</sub> ).....	10.4	11.4	
Magnesium chloride (MgCl).....			17.2
Potassium chloride (KCl).....	17.3	7.0	2.5
Sodium sulphate (Na <sub>2</sub> SO <sub>4</sub> ).....	22.8	4.3	
Sodium bicarbonate (NaHCO <sub>3</sub> ).....	66.7	83.3	13.9
Sodium chloride (NaCl).....	58.1	59.6	39.4
Total solids.....	198.4	188.0	142.8

Seepage water is abundant, but has collected to a dangerous extent in only a few localities. The accumulation of such water, either in pools or sloughs or filling the soil spaces of low-lying and poorly-drained lands, is caused either by leakage through the sides and bottoms of canals and laterals, or by excessive irrigation of higher lying lands. Water in excess of the amount required by growing crops percolates downward, fills the subsoil, and finds its way through the

more porous substrata to lower levels and local drainage basins. In this way large areas of valuable land at lower levels are damaged, being converted into alkali flats, bogs, or marshes. The effect of this upon the composition and distribution of the alkali salts of the soil and upon the valuable organic and mineral plant foods is important. Not only does a water-logged soil lead to the formation of alkali salts of the most dangerous character and their concentration within the zone of root activity, but the water leaches from the soil the valuable mineral elements, retards proper aeration, produces harmful changes in the physical structure of the soil, and arrests the development of the nitrifying and other bacteria so important to the growth of plants and the fertility of the soil.

Small bodies of land, somewhat damaged by seepage water, occur along the lower valley level throughout the area. The most extensive area, and the one subjected to the greatest injury, occurs in the Gila fine sandy loam and the Maricopa silt loam, about 1 mile north of Thatcher. Here is an area of once valuable land, covering hundreds of acres, extending westward along the river for several miles, where the water stands upon the surface or is found but a few feet below. The accumulation of this seepage water results from excessive irrigation of surrounding lands, coupled with insufficient natural drainage.

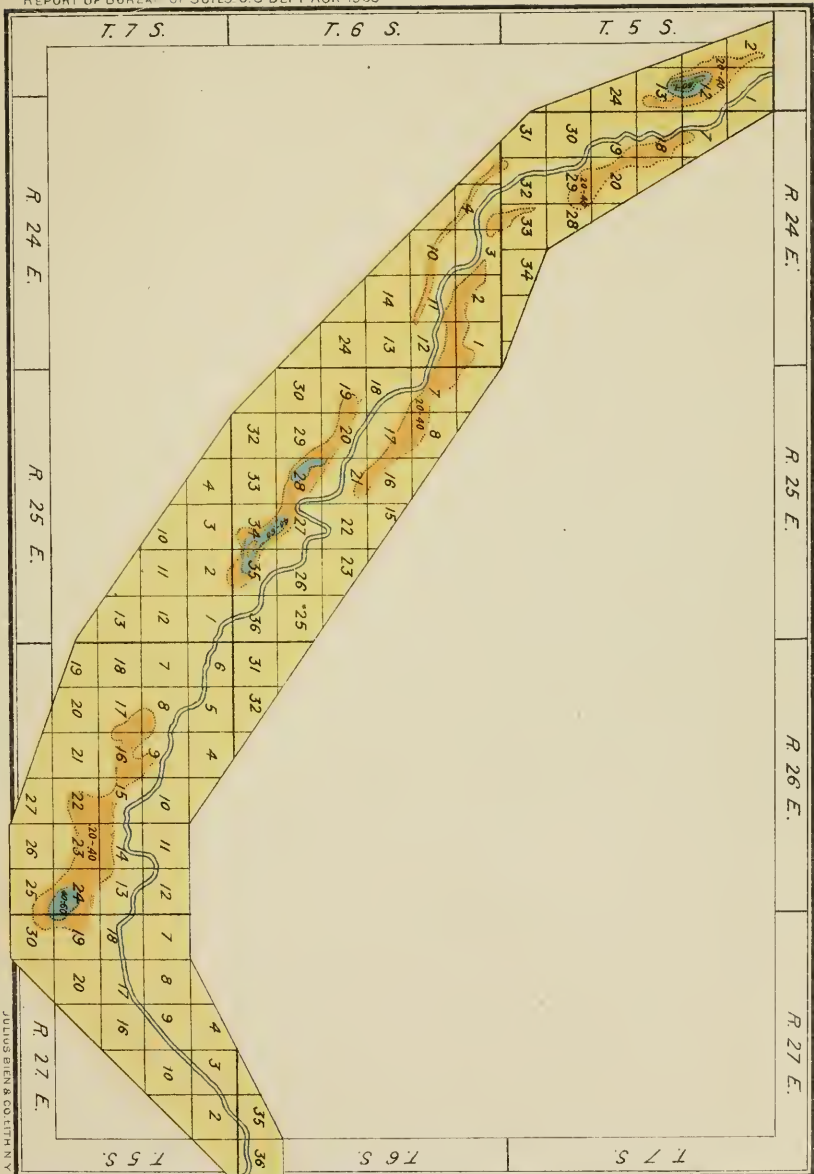
Underground drainage in irrigated regions has been too long a neglected subject. It is now, however, becoming of equal and in some respects greater importance than the drainage of lands in humid regions. Even the digging of a few open ditches through the water-logged tracts would reduce the water content of the land to a great degree. Upon the more badly damaged areas a system of tile drainage would prove of great value.

#### ALKALI IN SOILS.

The alkali of the Gila Valley is confined for the most part to the Maricopa silt loam. The areas in which the salts prevail to a dangerous extent occur only in a half dozen or so places, usually following the boundaries of the Maricopa silt loam and covering from one-half square mile to 3 square miles each.

The position of these areas, and the average salt content to the depth of 6 feet, may be ascertained by reference to Plate I. The proportion of alkaline soil as compared with the total area surveyed is considerable. The damage thus far done is, however, in many cases slight, the alkali and seepage conditions upon the whole being very much better than in many of the irrigated districts of the West. The conditions, however, demand careful attention to prevent an extension of the areas affected by seepage water and the further deterioration of lands already more or less alkaline. Over a considerable proportion

ALKALI MAP, SOLOMONSVILLE SHEET, ARIZONA.



JULIUS BIEN & CO. LITH. N.Y.

- LEGEND
- 20  
LESS THAN  
20 PER CENT
  - 20-40  
FROM 20 PER CENT  
TO 40 PER CENT
  - 40-60  
FROM 40 PER CENT  
TO 60 PER CENT
  - 60-100  
FROM 60 PER CENT  
TO 100 PER CENT.



of the area containing from 0.20 to 0.40 per cent most of the alkali exists in the lower part of the 6-foot section. Alfalfa, when once started, makes nearly a normal growth on these areas, and in some cases does well. In soils in which the salt content does not exceed 0.40 per cent, sugar beets, sorghum, and alfalfa may be grown with profit; provided precautions are taken in starting the crop. Often a moderately heavy irrigation before seeding will result in the movement of the surface salts toward the subsoil. By the time they return to the surface the crop may have sufficient stand and vitality to endure the injurious effects of the salts. Even slight alkali accumulations, however, are always a source of danger, and soils in which they exist should be carefully handled.

Sodium chloride, or common table salt, is of common occurrence in the Gila Valley area and forms a large proportion of the alkali salts of the region, both in the soils and in the underground waters. While less harmful in its effect upon plant growth than some of the other salts, it is in abnormal quantities a dangerous substance.

Sodium sulphate also occurs here in large amounts, and with sodium chloride forms by far the greater proportion of the total alkali salts of the area. Upon the surface it sometimes appears as a white, powdery crust, readily blown into the air, and has an irritating effect upon the mucous membrane of the throat and nasal passages.

These two salts form practically all the "white alkali" of this area, the sulphates, chlorides, and phosphates of calcium, potassium, and sodium, respectively, occurring in small amounts.

Bicarbonate and carbonate of sodium are also common alkali salts, appearing to some extent in the Gila Valley area. The former is classed with the less harmful of the alkali salts. It may, however, by giving rise to the sodium carbonate, be indirectly capable of doing great injury.

Sodium carbonate, or "black alkali," as it is commonly called, is one of the most dangerous salts. It is, strictly speaking, an "alkali," corroding and destroying both the humus or vegetable matter of the soil and the tissues of growing plants. In its effects it is several times more deadly than either the chloride, sulphate, or bicarbonate of sodium. Its action in corroding and dissolving the organic matter of the soil imparts to the moist soil surface, and to pools of seepage water where it is concentrated, an inky black color. Although sodium carbonate is frequently detected both in the soil and water of the area, it occurs in large or dangerous quantities only in a few spots, too small to be shown on the map, where the total salt content is greatest. Sodium carbonate may, in poorly drained areas, be formed by the evaporation of bicarbonate solutions from the surface, carbon dioxide being slowly given off and the salt remaining in the less carbonated form, or as

the "normal salt." Hence the matter of drainage becomes doubly important in areas in which the comparatively harmless bicarbonate of sodium prevails.

In the Gila Valley area the subsoils of the heavier types carry in the aggregate great quantities of the alkali salts. Fortunately, however, natural drainage is good and the practice of excessive irrigation is less frequent than in many western areas. The water table lies at such depths under the greater portion of the area that the movement of salts upward takes place only to a limited extent. The accumulation of the alkali salts upon the surface results for the most part from evaporation of irrigating water carrying in solution the salts derived from percolation of the upper portion of the soil section. The water table plays but little or no part in the accumulation.

#### RECLAMATION OF ALKALI LAND.

There is always a tendency in irrigated districts to use a greater quantity of water than is actually necessary. This excess, unless carried away through efficient natural or artificial drainage channels, sooner or later results in raising the water table. At the present time but little of the irrigated lands of the valley are in need of drainage. Should future irrigation result in raising the water table, however, as is likely, trouble will ensue, especially in the heavier soils. When the water approaches within 6 feet or less of the surface the limit of safety is reached and provision should at once be made for carrying away the excess of water. Tile or open drains at intervals of one-eighth or one-fourth mile will assist greatly in keeping the water table below the danger line.

Among the most prominent methods proposed for reclaiming alkali lands may be mentioned the removal of the crust by scraping, the application of chemical correctives, the growing of alkali-resistant crops, and drainage. Of these only the last mentioned is thoroughly effective, since it is the only method which removes the cause of the trouble. Some of the other methods may, however, be used with good results in connection with drainage.

The removal of the alkali salts by scraping the surface calls for much labor and must be constantly repeated, any good that may result being merely temporary. This method need receive little serious consideration.

The application of gypsum is practiced with beneficial results in soils where there occurs an excess of sodium carbonate or "black alkali." In this case chemical reaction takes place, and the injurious carbonate salt is changed into the less injurious "white alkali." This method alone does not remove the cause or permanently improve the land, and it is but a question of time until the white alkali itself will accumulate in sufficient quantities to be destructive of plant life.



The utilization of alkali lands and the gradual removal of the excess of alkali salts have been attempted with partial success by the growing of certain alkali-resistant plants of more or less economic value. The harvesting of the crop in the case of such plants removes a considerable amount of the alkali salts, which have been taken into the plant tissues and cells. This method is successful only to a limited extent, and, like the others mentioned, it fails to remove the cause. It is worthy of notice, however, that some field crops will thrive in the presence of a greater quantity of the alkali salts than others. This is true particularly of sorghum, sugar beets, and alfalfa. Land upon which the injury from alkali is slight, but sufficient to damage the less resistant crops, should be used for growing these hardier crops.

But it is thorough drainage of the land that must be considered the only practical and efficient remedy for the reclamation of alkali lands. This alone removes the cause by doing away with the excess of seepage water and lowering the water table. It both checks further accumulation and makes possible the removal of the salt already in the surface soil. A system of open drains will do, but lines of tile at frequent intervals are not only more efficient, but are no hindrance to cultivation, and are permanent. The intervals between the drains will vary with the rate of flow of water through the soil, and can best be determined in an area by experiment on a small scale. The depth should be such as to keep the water table below the danger line, which, in this area, is not less than 6 feet.

The drainage of large areas into the Gila River might, in time of low water, increase the salt content of its water to such an extent as to impair its fitness for irrigation. But with the gradual extension of drainage through the limited area requiring it in this district the effect would be negligible.

After the installation of the drainage system the salts should be removed by washing them out through the drains by frequent flooding of the land. The water should be added to a depth of 3 or 4 inches, and maintained at that depth as long as possible or until the land is sufficiently sweetened to allow the growing of crops. Occasional flooding with larger quantities of water is less effective. The cultivation of the soil between floodings should be very thorough, deep plowing and frequent stirring being very important. As soon as enough salt is removed to allow seed to germinate the growing of the more alkali-resistant crops should be begun, and, as the reclamation proceeds, those less resistant should be gradually introduced.

#### AGRICULTURAL METHODS.

The general agricultural practice of the area is careful and intelligent, but there are many instances of wasteful and slovenly methods. The cultivation has changed gradually from an extensive to a more

intensive system, with a decrease in the size of farms and the wider introduction of irrigation. In some cases an incongruous mixture of the two systems is seen, the most frequent deficiency being in the matter of the preparation of the land. Where grain is grown the plowing often consists of merely scratching the surface of the soil with a harrow. Upon the lighter soils, following corn or some other closely cultivated crop, this might be sufficient, but in the heavier soils the seeding of grain upon alfalfa stubble or pasture land in this manner is a mere makeshift such as deserves no place under any system of agriculture. Deficient preparation and cultivation renders the soil compact and increases evaporation and the accumulation of alkali, makes it difficult of aeration and root penetration, and hinders the formation of plant food.

More care is often taken in harvesting and marketing the crop than in raising it. Alfalfa is the principal crop of the valley. Three and sometimes four cuttings are obtained, yielding from 4 to 6 tons per acre. This is usually baled and shipped out of the area, bringing about \$10 a ton loaded on the cars. The cost of cutting, stacking, and baling should not greatly exceed \$2 a ton, and the hay will usually bring \$5 a ton in the stack.

Corn, wheat, and barley are also important crops in this area. Corn is usually planted in midsummer and harvested in October, and frequently follows a crop of wheat or barley. In favorable seasons wheat yields from 30 to 40 bushels per acre and there is a good demand for the grain at fairly high prices for local milling purposes. The old-established Sonora variety is generally grown and is sown late in the season. The White Russian variety is grown to some extent and is sown in the early fall. The former variety is, however, most commonly raised, being more resistant to drought. The grain is of good weight and makes excellent flour.

The use of commercial fertilizers is very limited; the use of stable and green manures is common, but might be greatly extended with beneficial results. The rotation of crops receives much less attention than it should.

Irrigation of the grains and alfalfa is mainly by flooding in rectangular or contour checks. Irrigation immediately after seeding is usually avoided when the water carries much sediment, as this sometimes forms a close, compact layer over the seed bed, through which the young plants make their way with difficulty. The fruits, vegetables, and similar crops are irrigated by the furrow method. With this method the alkali salts have a tendency to accumulate in the elevations over which the water does not flow. Irrigation by flooding, coupled with artificial drainage when necessary, and deep and frequent plowing and cultivation, should be the general practice.

## AGRICULTURAL CONDITIONS.

The farming class of the Gila Valley is made up of Americans and Mexicans, possessing various degrees of intelligence, education, ambition, and knowledge of agriculture. It is thus but natural that there should be varying degrees of success and prosperity. In farming, as well as in business enterprises throughout the valley, there have been many failures. This has in both cases resulted from overstocking, lack of intelligent direction, indiscreet speculation, endeavor to promote prosperity by indulging in "boom" methods, and the inflation of values, or the want of persistent effort. Many of the oldest settlers have left the area to make their homes in other parts of the country, but this has not always been from failure or dissatisfaction.

At present the agricultural industry is making a natural if slow growth, and the agricultural classes may be said, upon the whole, to be in a prosperous state.

The farms usually contain 160 acres or less. In the more thickly settled parts of the area, especially in the Mormon settlements, small farms and intensive cultivation are the rule. Here a farm of 40 acres is considered large. But few farms are rented. A remarkable freedom from mortgage and other indebtedness among the farming class exists here. Tax rates would in the East be considered excessive, but this is partly compensated for by the low valuation of property and the relatively high prices for farm produce. There is a growing tendency to improve the farm stock, to erect more substantial farm buildings, and to render farm life more attractive. The farm dwellings are of all grades, from the rude thatched huts of the Mexican laborers to the pretentious brick houses of the richer farmers.

The farm labor is usually satisfactory and efficient in character and the wages not excessive, considering the rate of wages paid in the trades and arts in this section, the average being \$30 a month with board.

Wheat, barley, alfalfa, and corn are the principal field crops of the area. Oats do not mature well and are but little grown. Sorghum is raised to some extent and is used in fattening cattle. Fruit growing has in the past attracted little attention, but is now increasing in importance and is likely to become an important industry in this area. The growing of early fruits—peaches, apricots, almonds, etc.—is attended with considerable risk, owing to the late spring frosts. Apples, plums, and cherries are more hardy, yield abundantly, and find ready market. The outlook for the apple industry is especially favorable. The fattening of lambs, hogs, and cattle upon the rich alfalfa hay and pasture is an important industry, and when intelligently followed is a source of handsome profit. Raising poultry offers tempting inducements to the intelligent and experienced breeder. The

general neglect of this industry, the absence of cold winters, and the eagerness with which eggs and poultry are sought in the market make this an inviting opening. Truck farming is another neglected industry which is capable of profitable development. Large areas of light, warm, early soils occur, which with proper manuring, irrigation, and cultivation could be made to yield large returns in early vegetables. It is believed that by the use of a cheese-cloth or canvas covering, such as is used in parts of Florida, lettuce, onions, cabbages, tomatoes, radishes, and other vegetables could be placed upon the market nearly the year around.

A series of important experiments in the culture of the sugar beet has been carried on in this area by the Arizona Agricultural Experiment Station. Some of the soils of the area are admirably adapted to this crop, and good average yields with a fairly high sugar content and percentage of purity are obtained. While the results are less gratifying than in some of the great sugar-beet sections of California and Colorado, they are sufficiently promising to interest capital. This bulky product can not, however, be profitably shipped except for short distances, and the establishment of this industry will depend upon the erection of a factory near the source of supply. It is worthy of note, however, that growing sugar beets as a food for fattening sheep and cattle is now of considerable importance in other localities, where feeders are offering as good prices as the sugar factories.

In the attempt to discover special crops for this section, a trial of some of the more drought-resistant macaroni wheats should be made.

In the more remote parts of the valley marketing the crops is laborious and expensive, as farm produce has often to be hauled long distances over rough or sandy roads. The entire area is traversed by the Globe, Gila Valley and Northern Railway, but shipments by rail are very costly, owing to high freight rates. In this respect this portion of the Southwest is unfortunate, and improvement in shipping facilities is badly needed.

The valley is as a whole thickly settled. The most important towns within the area surveyed are Solomonsville, Safford, Thatcher, and Pima. Local markets are found in all these places for farm and garden produce. A part of this goes to supply the adjacent mining camps and military posts. With the growth of an intensive system of agriculture, improvement in methods of irrigation, cultivation, and drainage, and the recognition of the adaptability of soil and climate to special crops, the Gila Valley is destined to assume great importance in the Territory. The lands of the Salt and Gila river valleys produce practically all the crops grown in Arizona.

Mg

SOIL PROFILE  
3 feet deep

Moisture  
20% to 30% from  
0 to 100



0 to 100



0 to 100

Moisture  
10% to 20% from  
0 to 100



0 to 100

Moisture  
5% to 10% from  
0 to 100



0 to 100

Moisture  
5% to 10% from  
0 to 100



0 to 100

Moisture  
5% to 10% from  
0 to 100



0 to 100

Moisture  
5% to 10% from  
0 to 100



0 to 100

LEGEND

Gravelly area

Sand

SsC Sandy loam

SsP Fine sandy loam

SsC Silty loam

SsC Sand and gravel

LEGEND



Moisture 20% to 30% from 0 to 100



Moisture 10% to 20% from 0 to 100



Moisture 5% to 10% from 0 to 100



Moisture 5% to 10% from 0 to 100



Moisture 5% to 10% from 0 to 100



Moisture 5% to 10% from 0 to 100



Moisture 5% to 10% from 0 to 100



Moisture 5% to 10% from 0 to 100







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