U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS.
IN COOPERATION WITH THE UNIVERSITY OF ARIZONA
DEPARTMENT OF IRRIGATION.

SOIL SURVEY OF THE BENSON AREA, ARIZONA.

BY

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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 as the Bureau of Soils.]

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By E. J. CARPENTER, of the United States Department of Agriculture, in Charge, and W. S. BRANSFORD, of the University of Arizona Department of Irrigation.

DESCRIPTION OF THE AREA.

The Benson area is situated in the southeastern part of Arizona, and comprises a part of the San Pedro Valley in the west-central part of Cochise County. It lies about 42 miles southeast of Tucson. On the east and west the boundaries of the area are determined by physiographic features, while on the north and south they are determined by the estimated potential water supply of the San Pedro River for irrigation. The southern boundary of the area is about 35 miles north of the international boundary between the United States and Mexico. The northern boundary of the area lies about 25 miles south of the Cochise-Graham County line. The area is oblong, with the longer dimension approximately north and south. It includes about 85 square miles, or 54,400 acres. The extreme western and eastern limits of the area are, respectively, 7 and 16 miles east of the Cochise-Pima County line.

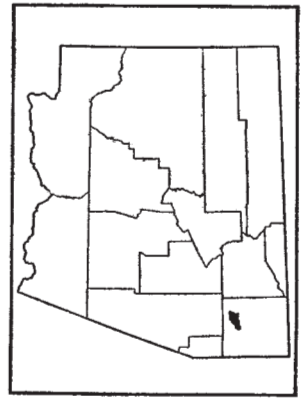


FIG. 11.—Sketch map showing location of the Benson area, Arizona.

The area surveyed occupies a part of the trough or plain of the San Pedro River which has been eroded through old, unconsolidated deposits. The remnants of these deposits form the margins of the present valley. They consist mainly of compact beds of stratified materials, in which are included lenses or layers of "caliche" or other cemented strata and which probably were deposited during the earlier geologic development of the region in the waters of an extensive lake or under conditions of ponded drainage. (Pl. IX, fig. 1.)

On the east side of the area are the Dragoon Mountains, trending in a northwest-southeast direction, and on the west the Whetstone Mountains, with about the same trend. From the base of these ranges extensive alluvial fans reach far out into the valley. These deposits, consisting of waterworn gravel and finer soil material, were superimposed over the earlier lake-laid deposits. They have a thickness of only a few feet near the axis of the valley and increase in depth as the mountain ranges are approached. During a long period of erosion the channel of the river has been materially lowered, and these

marginal slopes have been eroded away to nearly the same depth for distances varying from less than 1 mile to 3 miles or more on each side of the river.

The margin of this eroded valley is marked by a steep escarpment or a line of bluffs 50 to 100 feet or more high. This escarpment is irregular in outline and deeply dissected by narrow steep-sided ravines, canyons, and drainage channels heading several miles back toward the mountains. (Pl. X, fig. 1.) The surface of the old sedimentary deposits is deeply dissected for a mile or more back from the present bluff line. Numerous embayments of the eroded valley are separated by narrow flat-topped mesas and wedge-shaped ridges. Scattered through the valley are isolated knolls or ridges of the alluvial-fan and lake-laid materials which have escaped complete erosion and which, owing to a protective covering of gravel and the small run-off are being eroded very slowly at the present time. (Pl. X, fig 2.)

Within very recent years another erosion cycle has commenced in which the river channel and also the channels of the lateral drainage ways are rapidly being lowered in the later alluvium. (Pl. IX, fig. 2.) Over the present valley floor are many deep, narrow "barrancas" or vertical-walled flat-bottomed stream ways which extend a mile or more back from the river and end abruptly in a high vertical bank over which the water plunges in time of storm, undermining the stream course and tearing away the soft recent valley fill.

The stream valley, while extremely irregular in outline, as marked by the bluff line, is roughly ovate-oblong in shape. Its width at the southern extremity of the area is about 3 miles, and gradually increases northward to Benson, where a maximum width of 6 miles is attained. From here the valley narrows rapidly until at the northern boundary of the survey it is less than 1 mile wide. The axial slope of the valley, from south to north in the direction of stream flow is quite gradual, but the lateral slopes from the bordering bluff lines toward the stream channel are much greater. Except for the occasional arroyos or eroded areas, the surface of the valley is rather smooth and gently undulating.

The alluvial flood plains of the area are of small extent and are confined entirely to the larger drainage ways or to washes entering the San Pedro River. They are overflowed whenever there is sufficient rain to start run-off from the higher slopes.

The valley has an elevation of 3,576 feet at Union Station, Benson, and 3,710 feet at Land[1] in the southern part of the area. Curvo station on the Southern Pacific Railroad on the eastern boundary of the survey, is situated on the desert plain above the bluff line and has an elevation of 3,836 feet above sea level.

With the exception of small washes that enter the San Pedro from the east and west, the drainage of the area is northward to the Gila River, into which the San Pedro empties about 70 miles north of the area surveyed. Dragoon Wash, which drains an extensive area at the base of the Dragoon Mountains and which enters the area surveyed just north of St. David, is the only tributary of the San Pedro River of any importance in the Benson area. The drainage of the area is excellent, except in sections east and southeast of Land, where the

[1] U. S. Geological Survey. A dictionary of altitudes.

ground water is reached at a depth of 10 to 20 feet, and numerous springs contribute to a poorly drained condition of a small flat area bordering the river. The channel of the San Pedro River is gradually being cut lower into the valley floor, and this will probably tend to improve drainage in this locality.

In 1853 the region now known as San Pedro Valley, together with the rest of Arizona that lies south of the Gila River, was ceded to the United States by Mexico through the Gadsden purchase. Following this, several exploring parties passed through this region while surveying boundary lines or railway routes. In 1877 a small settlement consisting of eight families was established near the site of the old town of St. David, about 2 miles south of the present town of that name. At this time the country was largely overrun by the Apache Indians, though they were held somewhat under control by United States troops. Down the river, a few miles below the present town of Benson, a small Mexican settlement called Tres Alamos was located on the mail route between El Paso and Tucson. The nearest settlement of any size was Tucson, from which all supplies for this region were freighted. The growth of the settlement was consequently slow until in 1880, in which year the Southern Pacific Railroad was built, giving more ready access to the region. The county of Cochise was formed from part of Pima County in 1879, and Tombstone, which was then a rapidly growing mining town and the largest in this region, was made the county seat.

No estimate can be given as to the total population of the area surveyed, since census figures directly applicable are not available. The white settlers are mainly of English descent and largely American born. A large percentage of the people, who are of Mormon faith, came to this country from Utah. The Central and Eastern States also contributed to the present population. The foreign-born population consists principally of Mexicans and a few Chinese, and most of these reside in the town of Benson. The most thickly populated sections of the area are those bordering the San Pedro River north and south of Benson. Here water is available for irrigation, and the soil is largely under cultivation in small tracts of 40 acres or less.

There are no incorporated towns in the area. Benson, situated in the north-central part of the area on the Southern Pacific Railroad, is the largest town. St. David, a small Mormon settlement in the south-central part of the area, is next in importance, and Pomerene is another Mormon settlement in the northern part of the area. Land, Fenner, and Curvo are railway points within the survey.

The area is well supplied with transportation facilities; the main San Francisco-New Orleans line of the Southern Pacific Railroad crosses the north-central part of the area, and a branch line of the same road, operating between Benson and Nogales, traverses the area from Benson south. The El Paso & Southwestern Railroad also operates a branch line from Fairbanks to Benson, paralleling the Southern Pacific branch at a distance of a quarter of a mile or less. A well-graded highway traverses the area from Benson south. Another road upon which some work has been done crosses the area east and west, passing through Benson. In the more thickly settled communities the roads are in fair shape, but elsewhere they are few and poor.

Rural social life is developed to a high degree, especially in the Mormon settlements of St. David and Pomerene. Good schools and churches are numerous throughout the area. Telephones are in general use. Electricity for lighting and power is obtainable from private plants.

Good markets are available for all surplus agricultural products of the area, though at the present time few commodities are produced in excess of home needs. The products shipped are mostly of a nonperishable nature, and, with the exception of cattle, none are shipped to any distance. Tucson, Bisbee, and Douglas receive practically all the fresh fruit, grain, hay, dairy, and poultry products shipped from the area. Range cattle are generally marketed in Omaha or Kansas City; local markets absorb most of the fat stock

CLIMATE.

The climate of this section of Arizona is distinctly arid. Owing to the scanty rainfall and hot summer weather, crops can not be matured successfully without irrigation. The rainfall in the mountains and on the desert slopes adjacent to the survey is variable, though in the valley it is fairly uniform. The mean annual rainfall of 8.6 inches at Benson is fairly representative of the area as a whole. However, owing to the occurrence of local thunderstorms, small local areas may receive considerable rainfall, while other sections receive none at all. The rains occur as local thunderstorms of considerable intensity, largely during July, August, and September, when over 50 per cent of the total annual rainfall occurs. April, May, and June, on the other hand, are normally extremely dry, only slightly more than one-half inch of rain falling during this period. During the remainder of the year the rainfall is rather uniform, with an average of about 0.6 inch per month. The rainfall for the wettest year on record at the Weather Bureau station at Benson was 22.58 inches in 1905, and for the driest year, 4.24 inches in 1885.

The summers are hot, though not oppressive. High maximum temperatures are recorded during May, June, July, August, and September, though the hot spells generally are not of long duration. The nights are usually cool, and during the hottest days the air is cool and pleasant in the shade. The mean annual temperature at Benson is 62.8° F., and for June, July, and August, 78.7° F. The highest recorded temperature is 110° F. and the lowest, 5° F. Though hail is not unknown in this region, it usually comes during the fall and seldom does any damage to crops. Snow falls every year in the mountains, where it remains for several weeks at a time. In the valley a light snowfall is often experienced during November, December, January, and February, though it rarely exceeds one-half inch in depth and lasts only a few hours. Lack of protection of winter grains sometimes causes slight losses from freezing.

The average date of the last killing frost in the spring at Benson is March 15, and the average date of the first in the fall is November 14, giving an average growing season of 243 days. The latest recorded killing frost in the spring occurred on April 19, and the earliest in fall on October 20. The growing season is long enough to mature most varieties of deciduous fruits, but owing to variable

spring temperatures, fruit trees are often forced into bloom early in the year, only to be severely frosted. This condition can be guarded against to some extent, however, by selecting an orchard site that has good air drainage.

On account of the torrential character of the summer rainfall, much of it is lost as run-off, and frequently the damage caused by erosion outweighs the benefits derived from the moisture supplied to crops. The wind movement over this region is largely from the west or southwest, and during the spring there are occasional windstorms of high velocity.

The climate of this region is generally considered healthful and is much sought by people suffering from pulmonary troubles.

The following table, compiled from the records of the Weather Bureau station, gives temperature and rainfall data for Benson, located in the north-central part of the area surveyed:

Normal monthly, seasonal, and annual temperature and precipitation at Benson.

[Elevation, 3,523 feet.][1]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1885).	Total amount for the wettest year (1905).	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	46.2	83	10	0.57	0.17	0.79	0.3
January	47.2	83	5	.64	.05	1.08	.5
February	50.2	85	10	.72	.95	3.34	.2
Winter	47.9	85	5	1.93	1.17	5.21	1.0
March	55.3	94	13	.52	.07	4.20	T.
April	60.7	96	24	.15	.00	2.01	.0
May	67.1	106	32	.13	.00	.00	.0
Spring	61.0	106	13	.80	.07	6.21	T.
June	76.9	110	40	.31	.75	1.77	.0
July	80.3	108	50	2.20	.58	1.30	.0
August	78.8	108	43	1.23	1.44	1.68	.0
Summer	78.7	110	40	3.84	2.77	4.75	.0
September	73.2	103	35	1.03	.14	2.83	.0
October	63.6	97	25	.68	.00	.50	.0
November	54.1	93	16	.42	.09	3.08	.1
Fall	63.6	103	16	2.13	.23	6.41	.1
Year	62.8	110	5	8.60	4.24	22.58	1.1

[1] United States Geological Survey. A dictionary of altitudes.

AGRICULTURE.

Before the coming of the white settlers to the region now known as the San Pedro Valley the Apache Indians bitterly contested with other tribes their right to the hunting grounds and grass-covered slopes of the valley, which afforded excellent pasture for wild game and the few horses they possessed. In 1872 the Indians were partly subdued by United States troops and placed within reservation bound-

aries. In the fall of 1877 a small settlement of white people, consisting of eight families, was established at the site of the old town of St. David. During the fall and spring of 1878 and 1879 a ditch was constructed from the San Pedro River which provided irrigation water for maturing a crop of wheat and barley.

Though they found the entire region covered with a luxuriant growth of grama and galleta grass, affording excellent grazing, they had brought no stock with them and were therefore dependent for their meat supply upon the herds of deer and antelope that inhabited the valley. The agricultural products they could grow were supplemented by supplies from Tucson, the nearest trading post. Following the building of the Southern Pacific Railroad in 1880, the valley became slightly better settled, but the people still depended for a livelihood largely on the growing of cultivated crops.

About the year 1884, however, stockmen began to utilize the grass-covered valley slopes for grazing. Owing to various causes, probably to some extent at least to mismanagement and overgrazing, the grass rapidly began to disappear and severe erosion set in, with the consequent lowering of the San Pedro River from a small poorly defined channel to its present course 40 to 80 feet below the valley floor. In place of the luxuriant growth of grasses yielding three-quarters to 1 ton of hay per acre is now found a dense growth of mesquite bordering the river and lesser growths of mesquite, cacti, and creosote bush on the valley slopes, from which but little grazing is derived.

Following a severe earthquake in this region in 1881, a small flow of water was found issuing from the ground near the present town of St. David. This was the first indication of the presence of artesian water. About 1886 the first artesian well was sunk. This was followed by extensive prospecting throughout the valley, with the result that now nearly every ranch within the survey has one to several flowing wells. After the discovery of artesian water, the ditches drawing water for irrigation from the river were badly neglected for a time, but they have been entirely rebuilt, and irrigation on the east side of the valley is obtained mainly from this source. The few farms located west of the river are entirely dependent on water supplied from flowing wells.

The agriculture of the area has changed but little from that first practiced. The introduction of alfalfa has added a valuable source of income to farmers in this area, but the growing of wheat and barley and the marketing of livestock continue to be the dominant agricultural industries. A few fruit trees, such as apple, peach, and cherry, were planted soon after the region was first settled, and an excellent quality of fruit is produced. However, owing to damage by frosts, yields are not always certain, and fruit growing has not been developed on a commercial scale. Some apples are marketed, but other fruits are not produced in excess of local needs.

Alfalfa is the principal cash crop of the area, five to six annual cuttings of a ton or more a cutting being obtained. The hay is marketed chiefly in Bisbee and Douglas, at top market prices. Barley also finds a ready sale in the same markets. Wheat is shipped principally to Tucson, where it is ground into flour.

Range cattle are marketed largely in the Central States, being shipped as feeder cattle to locations near markets. The range is entirely fenced and is controlled largely by the Boquillas Cattle Co. Many of the ranchers pasture a few head on their own land or privately owned homestead land under fence. A few dairy cattle are kept on nearly every ranch to supply home needs. However, the dairy industry is not developed, owing to insufficient local demand and the cost of transporting dairy products to outside markets. Hogs are raised in small numbers.

Some field corn is grown and utilized locally as stock feed. Kafir and milo have been grown to some extent, but have not been found profitable because of the destructiveness of birds. Poultry is kept on many farms and in some cases is the principal source of income, cultivated crops being grown mainly to supply feed for the flocks. Local markets consume most of the poultry and eggs, though any surplus is sure of ready sale either in Tucson or the mining towns of Bisbee and Douglas. Beekeeping is developed to a considerable extent and has proved highly profitable in the last few years. An abundance of mesquite furnishes an excellent supply of honey for several weeks, which is supplemented by alfalfa and numerous wild flowers and shrubs. During the last three years 182 tons of honey were marketed from Benson.

Vegetables of excellent quality are produced on every farm for home use. In a few instances onions have been grown for market and have produced good yields of excellent quality. Potatoes have been grown, largely for home use, with excellent yields. Strawberries also produce well in home gardens.

Agricultural statistics directly applicable to the area surveyed are not available, so that no estimate of total production can be given. However, the following table, compiled from information furnished by the Southern Pacific Railroad and the El Paso & Southwestern Railroad, shows the quantities of the products shipped from Benson in carload lots in 1918, 1919, and 1920:

Agricultural products shipped from Benson in carload lots.

Commodity.	1918	1919	1920
	Cars.	*Cars.*	*Cars.*
Cattle	105	175	152
Hay	31	23	22
Watermelons	2	6	2
Wheat	.....	.....	1
Potatoes	.....	.....	1
Cabbage	.....	1	.....

Because of the low annual rainfall and the high summer temperatures, dry farming can not be practiced successfully in this region. The agricultural development of the valley has therefore of necessity been confined to the area in which artesian water or water diverted from the San Pedro River is available for irrigation. Under irrigation the farmers utilize the light-textured soils largely in the production of such crops as potatoes, alfalfa, and vegetables, and the heavier soils principally for grain production.

Land which is to be put in crops in the spring is flooded as often as practicable during the winter with the idea of storing as much water as possible for summer, when it is likely to be scarce. Just before planting a crop the ground is plowed or disked, and worked down by harrowing or rolling until a good seed bed is prepared. After the crop is up it is irrigated as often as possible until the water supply fails. The crop is then left to mature on water stored in the ground. Wheat is generally threshed and sold from the farm, while barley is either cut green for hay or threshed and fed to fattening stock. Alfalfa is cut and stored in barns or sheds for home use, the surplus being baled in the field for shipment to outside markets.

In general the farm machinery is of old type and not very plentiful. Crops are sown largely by broadcasting. Harvesting is done by machinery, which may be owned jointly by several ranchers. The work stock is of medium weight, and the cattle are usually of mixed breeds.

The irrigation of alfalfa is done largely by running the water over the soil between checks placed 30 to 40 feet apart, and grain is generally irrigated by running water down small ditches between the grain rows, a method known as the corrugation system. Alfalfa is generally left on the same land for several seasons, some fields having been in this crop for 15 years or more. No attempt has been made to follow a definite crop rotation, though the same crop is not grown on a piece of ground two years in succession if possible to avoid it.

The soils are generally productive, where sufficient water for irrigation is available. No fertilizer except barnyard manure is used in the area. The irrigation water obtained from the river generally carries much silt, which aids materially in maintaining productiveness.

The farm laborers are principally Mexicans, who receive $1.50 to $1.75 a day and board. The farms, however, are small, and most of the work is done by the farm owner. When additional labor is necessary in the harvesting of crops, the ranch owners exchange labor whenever possible. Men employed on cattle ranches are paid $35 to $45 a month and board.

The average size of the irrigated farm is about 30 acres, though some farms contain as much as 60 acres. The land is usually held in tracts of 160 acres or more, and, except in the better developed sections, only a small proportion of the land is cultivated. Improved land is held at $90 to $120 an acre, with an average for the valley as a whole of about $100 an acre. Some of the better improved lands are held at $250 an acre. Unimproved land under fence varies in price from $8 to $20 an acre.

SOILS.

The Benson area is situated in the mountain region of southeastern Arizona. It occupies part of a structural valley which has received extensive sedimentary deposits from adjacent mountain ranges. These ranges are composed of many varieties of rock, including granite, schist, quartzite, limestone, and various volcanic rocks. The unconsolidated deposits of the valley are moderately young, geologically, but in places a hardpan has developed, and in all cases the

materials are weathered and compacted. These older deposits form the desert slopes, marginal to the area surveyed. They are eroded and dissected, and where included within the survey constitute areas of rough and broken nonagricultural land.

Materials eroded from the slopes of these deposits have, however, entered into the formation of the arable soils within the area surveyed. Because of their comparatively recent deposition, the soils are only moderately weathered and do not contain any hardpan formation. Most of these deposits, considered from a soil standpoint, however, are sufficiently old to be classed with the old valley-filling soils, as, through the agencies of weathering, the lime and finer soil materials have been carried into the subsoils, developing the conditions of compaction and structure typical of this group of soils.

The minor streams or washes flowing over the surface of these soils continue to carry in suspension material eroded from the higher slopes. This material is now being deposited along their courses and gives rise to recent-alluvial soils. It is generally similar in color and origin to the adjacent older deposits, but the derived soils lack the significant physical characteristics of the old valley-filling soils.

On the basis of differences in the mode of formation, state of weathering, and topographic position, the soils of the area have been classified in three groups, namely, old valley-filling soils, recent-alluvial soils, and miscellaneous materials. The soils comprising the old valley-filling group are the most important from the standpoint of use and of area covered; the miscellaneous materials rank second in extent but are of no economic importance; and the recent-alluvial soils are smallest in extent, comprising a total area of less than 4 square miles.

Each of the two groups of arable soils is represented by one or more soil series. The series consists of soils that are similar in color, origin, mode of formation, subsoil, and drainage. Each soil series consists of soil types that differ from each other in texture or the relative proportions of mineral particles of the various sizes, such as the sands, silt, and clay. The soil type is the unit in soil mapping. Minor variations within soil types are designated phases.

The old valley-filling soils extend from the channel of the San Pedro River to the bordering rough broken slopes. They are derived from the weathering in place of unconsolidated material of mixed origin, but apparently derived largely from the quartz-bearing rocks. These soils consist almost entirely of materials eroded from the bordering desert slopes. Although relatively recent in most cases, they have the compacted horizons and profile characteristics of old valley-filling soils. They are high in lime, but generally low in organic matter. Erosion is active in areas lying near the river or along the larger lateral drainage ways. With the exception of a very small area, the drainage of the soils of this group is good to excessive.

Six soil series are recognized in this group, the Anthony, McClellan, Imperial, Curtis, San Pedro, and Riggs.

The surface soils of the Anthony series are light pinkish brown to light grayish brown in color. The subsoil is generally of about the same color as the surface soil, but is slightly more compact, especially in the upper part. The types are decidedly calcareous, the lime being

quite uniformly distributed through the soil profile. The surface is smooth or gently undulating, with a moderate slope toward the axis of the valley (Pl. XI, fig. 1.) Drainage is well developed. Four types of this series are mapped in this survey, the Anthony gravelly loamy sand, very fine sand, fine sandy loam, and silt loam, the last two types including phases.

The McClellan series consists of light pinkish brown to reddish-brown surface soils overlying a subsoil that in most places has a more pronounced red or darker, grayish-brown color. An overwash of pinkish-gray material, 2 to 6 inches deep, is generally found upon the surface, being more prominent on the heavy than on the lighter textured types. Lime is abundant in both surface and subsoil, and is concentrated in the subsoil, which is feebly cemented and in places is slightly mottled with gray. The subsoil is normally heavier in texture than the surface soils and is compact in the upper part. The soils of this series are confined largely to the outer edges of the valley floor adjoining the eroded slopes. The topography varies from smooth to gently undulating, with a pronounced slope toward the center of the valley. Surface drainage is good to excessive, but internal drainage is more or less restricted by the compact subsoil. This series is distinguished from the Anthony series by the prevailing or more pronounced reddish-brown color, heavy texture, and compact character of the subsoil. It appears to represent a somewhat more advanced stage in weathering of the valley-filling materials, with more pronounced accumulation of lime and of clay in the subsoil. It is represented in this survey by two types, the McClellan fine sandy loam and the silty clay loam, with several phases.

The Imperial series is characterized by reddish-brown or dark purplish brown to deep chocolate brown surface soils, which in this area are overlain by a thin veneer of pinkish material. The subsoil is generally of the same color as the surface soil or is slightly darker, and is heavy and compact. This series is derived from stratified valley-filling deposits of mixed origin which, however, are not greatly weathered, the soil approaching in profile the more recent alluvial soils. The lime content of both surface soil and subsoil is high, with a tendency toward accumulation in the upper subsoil. The surface is generally smooth, except for a few drainage ways. Drainage is usually good. One type, the Imperial clay, with a dark-colored phase, is mapped.

The surface soils of the Curtis series are light pinkish brown or light grayish brown in color. The subsoil is similar in color to the soil or is of a darker chocolate brown or purplish-brown color. It is compact but permeable to a depth of 40 to 60 inches. Beneath this is a stratum of porous sandy or gravelly material of light grayish brown or gray color. This light-textured stratum distinguishes this series from the others in the area. The soils are derived from the weathering of old valley-filling deposits of mixed origin. The surface is slightly undulating and both surface and internal drainage are good. Lime is plentiful in both surface and subsoil, with a tendency toward accumulation in the upper subsoil. The series is represented in this survey by a single type, the Curtis silt loam.

The San Pedro series includes types with light-brown or light reddish brown to brown surface soils. The upper subsoil is of similar or slightly lighter color, but passes into a dark-brown to dark purplish brown, compact, and consistently heavy material. The subsoil is generally stratified and contains mottlings of soft, gray lime concretions. Both surface soil and subsoil are calcareous. The soils are derived from stratified water-laid deposits somewhat altered by weathering and reworking by surface waters since deposition. They occupy positions adjacent to the San Pedro River, where drainage was rather poorly developed prior to the recent lowering of the channel of the river, and as a consequence the soils contain more or less alkali. The San Pedro fine sandy loam, including a coarse-textured phase, and the San Pedro silt loam were mapped in the area.

The Riggs series consists of very dark chocolate brown or very dark purplish brown to dark-gray or black surface soils and upper subsoils. These are normally of heavy texture and compact structure. The deeper subsoil typically has a reddish or pinkish tint and a variable texture. In a few places it is lighter both in texture and in color than the overlying material. Lime is abundant and in places is accumulated in the subsoil. The series is derived from unconsolidated stratified deposits of mixed origin which appear to have been laid down under conditions of obstructed drainage, and have since been eroded and physically altered through weathering. The drainage is poor, resulting in high accumulations of alkali. In origin, mode of formation, and occurrence this series is similar to the associated San Pedro series, the principal difference being that the darker colored materials forming the deeper subsoil of the San Pedro series appear in the surface soils and upper subsoil of the Riggs series. The series is represented in the area by the Riggs clay, and a light-textured phase of the clay.

The recent-alluvial soils in the Benson area are of small extent. They consist of materials eroded mainly by undercutting of the steep-sided banks of local intermittent drainage channels through the old unconsolidated deposits marginal to the valleys. After reaching the valley floor the water flows between low banks, which it often overflows, depositing its sediments. The resulting soils are subject to periodic overflow and are still in the process of accumulation. The surface is generally smooth. The recent-alluvial soils differ from the soils derived from old valley-filling deposits in the absence of the compact and poorly aerated subsoil of that group. They are represented in this area by the Gila series.

The Gila series consists of light grayish brown to pale reddish brown calcareous surface soils and subsoils, uniform in texture and structure to a depth of 6 feet or more. They are distinguished from the soils of the Anthony series only by the absence of the somewhat compact subsoil of the latter series. The Gila series is best developed along the larger drainage ways. The topography is smooth and moderately sloping. The drainage is good to excessive, insuring freedom from alkali. One type, the Gila gravelly sand, is mapped.

The group of miscellaneous materials includes Rough broken land and Riverwash, both of which are essentially nonagricultural. Rough broken land consists of badly eroded areas, in general too steep or

broken for cultivation; and Riverwash consists of loose gravels and sands which are subject to frequent overflow and are too porous and leachy to produce crops.

The various soil types of the Benson area are described in detail in the following pages of this report. Their distribution is shown on the accompanying soil map. The table below gives the actual and relative extent of each type mapped:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Rough broken land	17,280	31.8	Gila gravelly sand	2,240	4.1
Anthony gravelly loamy sand	8,896	16.4	Anthony fine sandy loam	1,152	4.0
McClellan silty clay loam	1,984		Gravelly phase	1,024	
Gray phase	3,328	11.2	San Pedro fine sandy loam	832	3.4
Porous-subsoil phase	832		Coarse-textured phase	1,024	
McClellan fine sandy loam	2,624		Curtis silt loam	1,472	2.7
Gravelly phase	1,856	8.8	Riggs clay	1,024	2.4
Light-textured phase	320		Light-textured phase	256	
Imperial clay	1,664	5.3	San Pedro silt loam	1,152	2.1
Dark-colored phase	1,216		Riverwash	1,024	1.9
Anthony silt loam	1,728		Anthony very fine sand	576	1.1
Heavy phase	512	4.8			
Light-textured phase	384		Total	54,400	

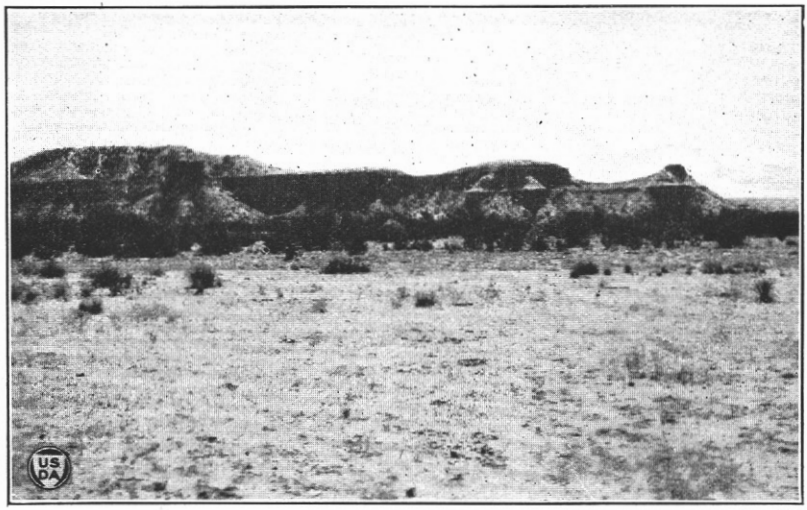
ANTHONY GRAVELLY LOAMY SAND.

The surface soil of the Anthony gravelly loamy sand consists of 8 to 14 inches of light pinkish or light grayish brown loamy gravelly sand. The subsoil generally consists of the same character of material, but in places is slightly heavier in texture. The upper subsoil is slightly more compact than the lower part.

The soil is low in organic matter but contains considerable lime, which is distributed rather evenly through the profile, though there is a slight accumulation in the upper subsoil. The soil absorbs water readily, but much of it is lost through evaporation and percolation in the loose subsoil. The gravel is generally small and well rounded. Small areas are nearly gravel free, while others are extremely gravelly, the latter being found mainly near stream courses.

Along the upper slopes of the valley and bordering the larger drainage ways small areas of recent-alluvial material are included with this type as mapped. It also includes areas in which the surface and subsoil materials are somewhat darker than typical. In some of these areas the texture is also slightly heavier, and there is a more pronounced accumulation of lime in the subsoil. These heavier areas represent a coarse sandy loam which in places is underlain by a heavier and compact deeper subsoil.

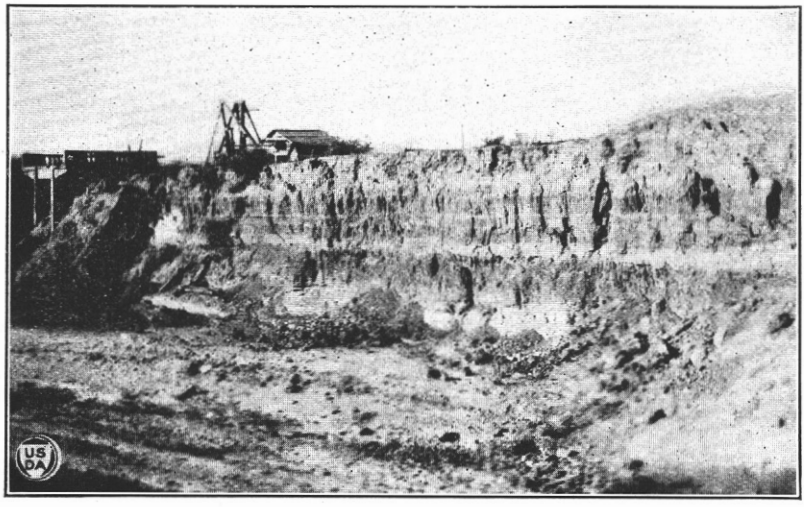
The Anthony gravelly loamy sand is one of the more extensive types found in the area. It usually occurs along the upper slopes of the valley bordering the eroded bluffs or along the channels of intermittent streams issuing from them. In the central part of the valley it frequently occupies slight mounds or ridges. The type is well developed near and north of Pomerene and south from Benson for a distance of about 4 miles. Other small areas lie north and south of Fenner and in the vicinities of St. David, Land, and Curtis School.



S. 11184

FIG. 1.—VALLEY FLOOR AND MARGINAL ESCARPMENT OF THE SAN PEDRO RIVER VALLEY

Soils of the Anthony series in the foreground



S. 11181

FIG. 2.—VERTICAL BANK OF CHANNEL OF THE SAN PEDRO RIVER

Showing profile of stratified sediments that give rise to the soils of the San Pedro series

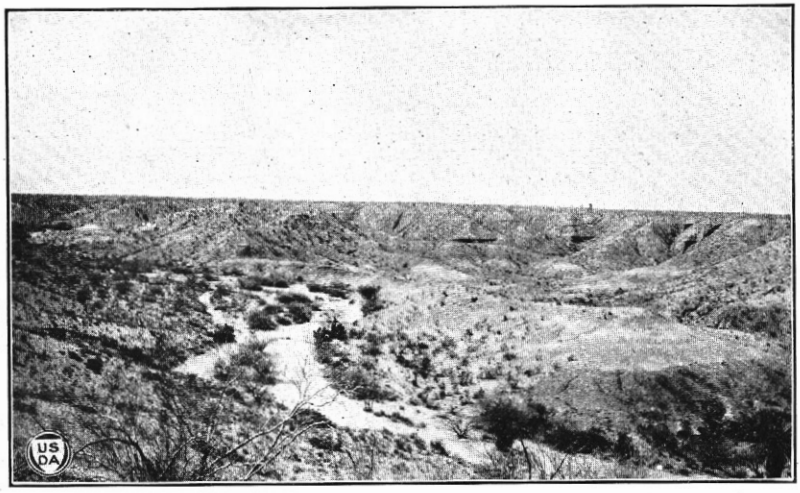


FIG. 1.—TOPOGRAPHY OF ROUGH BROKEN LAND

Dry bed of intermittent desert stream in foreground

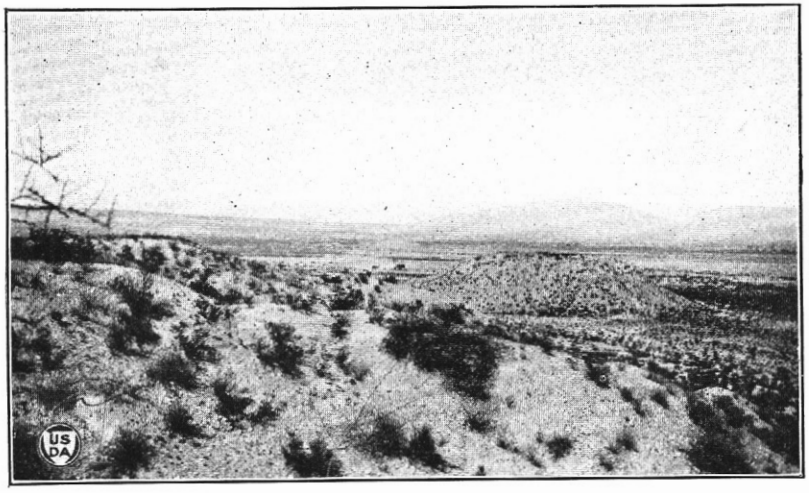


FIG. 2.—ERODED MARGINAL SLOPE AND OUTLYING REMNANT OF OLD UNCONSOLIDATED DEPOSITS

The surface varies from smooth to moderately undulating. The slope is generally pronounced and near the upper edges of the valley the type is faintly dissected by drainage ways. Drainage is good to excessive. Though the type could be irrigated without great labor or expense in leveling, yet on account of its leachy character it is not as well adapted to irrigation as the heavier textured types of the series.

A somewhat stunted growth of mesquite, creosote bush, yucca, and sotol is found over the type, together with a few clumps of grass, which afford poor grazing. Probably less than 1 per cent of the type is under cultivation. Fair yields of wheat, barley, and alfalfa are obtained, and vegetables for home use are grown successfully on the type at Benson.

Improved land of this type sells for $65 to $85 an acre, depending largely on improvements. Unimproved land is held at $8 to $15 an acre.

With an adequate water supply developed, this type should prove adapted to early vegetables, small fruits, potatoes, and deep-rooted crops such as alfalfa. Liberal quantities of organic matter should be incorporated as soon as the land is put under cultivation. This can be done by applying barnyard manure, or by plowing under rye or oats in the green state. Fall-sown grain would probably be more productive than that sown in the spring.

ANTHONY VERY FINE SAND.

The surface soil of the Anthony very fine sand consists of 14 to 20 inches of pinkish or pale reddish brown calcareous very fine sand, containing considerable mica. The subsoil is of similar color or slightly grayer and of about the same texture as the surface soil, rarely becoming heavier than a loamy very fine sand. The compaction of the subsoil is slight as compared with other calcareous old valley-filling soils and in profile the type approaches that of the recent-alluvial soils. Grayish-brown or black, rather heavy material underlies the entire type at depths generally below 6 feet, though in places the subsoil grades into it at depths of 60 inches or more. In places this underlying material contains alkali in varying concentrations, though the lighter textured material is generally free of alkali salts.

This type is confined largely to the banks of the San Pedro River, in the northern part of the valley, but one area lies northeast of Curtis School. The areas lie well above overflow. The surface is characterized by small mounds or narrow ridges and is more or less dissected by drainage ways entering the river. Drainage as a rule is excessive, and the type is poorly adapted to irrigation on account of its porous structure.

Along the San Pedro River the type is covered with a luxuriant growth of mesquite, producing numerous seed pods which are a highly nutritious cattle food. Areas away from the river support only a stunted growth of desert vegetation. None of this type is under cultivation, being used entirely for grazing. It is sold only in connection with other soils.

Under irrigation the type would assume the properties of a very fine sandy loam and should produce a good quality of vegetables and small fruits earlier in the year than other soils of the area. The soil is best adapted to early maturing crops and deep-rooted plants and trees.

ANTHONY FINE SANDY LOAM.

The surface soil of the Anthony fine sandy loam is a light grayish brown or pinkish-brown, calcareous fine sandy loam, containing a relatively large proportion of fine and very fine sand. The subsoil consists of a calcareous fine sandy loam of light-brown or light grayish brown color, tinged with pink. When wet the subsoil is readily permeable, but upon drying it is quite compact and feebly cemented by lime. Gravel is scattered over the surface of the type, especially near drainage ways. In places the surface soil of the type has been reworked by winds and surface waters to some extent and thin deposits of recent-alluvial material have been superimposed over small areas. The soil absorbs moisture readily, but owing to the low content of organic matter and the porous structure it does not retain it very long. In some cultivated fields that have received applications of organic matter the surface soil is decidedly brown, especially when wet.

The Anthony fine sandy loam, though inextensive, is agriculturally important. One of the largest areas lies about 3½ miles north of Benson; smaller areas are found near Pomerene, Fenner, Land, St. David, and Curtis School. The surface is smooth and gently undulating. Uncultivated land can be leveled at small expense, and with its natural good drainage the type should prove well adapted to irrigation. On some of the steeper areas the soils will probably have a tendency to erode, and care, therefore, must be exercised in laying out an irrigation system.

About 4 per cent of the type is under cultivation, the rest supporting a sparse growth of mesquite and creosote bush. Small clumps of grass over most of the type afford some pasturage, but in general the grazing value is low. Under cultivation wheat and barley are the principal crops, a small area being devoted to alfalfa. Wheat yields 12 to 15 bushels and barley 30 to 45 bushels per acre. Alfalfa yields from 4 to 6 tons of hay per acre, depending on the season and the number of cuttings. Potatoes, other vegetables, and small fruits produced for home use return good yields of excellent quality.

The Anthony fine sandy loam is held at $80 to $100 an acre for improved land; unimproved land can be bought for $8 to $15 an acre.

More thorough cultivation and the addition of organic matter would improve the water-holding capacity of this soil, as well as increase production in other ways. Owing to a lack of water for irrigation during the summer season, excessive quantities are used when available, with the result that the soil is water-logged for two or three months of the year. This practice is harmful in that it stops bacterial and chemical action in the soil and produces a poorly aerated water-logged condition that interferes seriously with plant-root development. Most plants, therefore, root principally in the surface soil, and during periods of drought are not able to reach into the subsoil for moisture. A moderate quantity of water stored in the soil by

maintaining a mulch over the surface by frequent cultivation should prove a more profitable method of handling this soil. The type is well adapted to potatoes, vegetables, and small fruit.

Anthony fine sandy loam, gravelly phase.—The surface soil of the Anthony fine sandy loam, gravelly phase, is a light-brown or brown gravelly fine sandy loam extending to a depth of 8 to 12 inches. The subsoil is heavier in texture than the surface soil, has a light-brown or grayish-brown color, and carries considerable gravel and gritty material. The upper subsoil is compact, feebly cemented by lime, and well weathered. Both surface and subsoil are strongly calcareous. There is, however, a tendency toward accumulation of the lime in the more compact upper subsoil. Included areas of this phase too small to be shown on the soil map have received a slight veneer of recent-alluvial material similar in color and character to the typical surface soil material of this phase. Near drainage ways the soil is somewhat lighter in texture than typical. The gravel in this type varies in size, but is generally small and well rounded, and is intermixed with considerable quantities of grit and coarse sand.

This phase of the Anthony fine sandy loam occurs mainly in small areas—60 acres or less. Several such areas lie south and west of Pomerene and small scattered areas lie north of that point. A comparatively large area occurs east of St. David, and a small one about 1 mile southwest of Curtis School. The surface is smooth and gently sloping or slightly undulating. Drainage is good to excessive, though with good cultural methods and a plentiful supply of water the soil in all cases could be made productive. Under irrigation the steeper areas would have a tendency to erode, especially if the water were run down the length of the slopes and a large head of water used.

The native vegetation consists principally of mesquite, catclaw, and cresote bush. Native grasses are not very plentiful and the phase has little value for grazing. About 15 per cent of it is under cultivation, the principal crops grown being wheat, barley, and alfalfa. Crops often suffer from drought and yields are somewhat lower than on the typical Anthony fine sandy loam.

Owing to the small size of the areas, the gravelly phase is not generally sold alone. Its value at the present time depends largely on the water supply available for irrigation.

The phase could be more extensively utilized in producing vegetables, small fruits, and other early crops, also such deep-rooted crops as alfalfa. Recommendations given for the improvement of the typical Anthony fine sandy loam are applicable to this phase.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the typical Anthony fine sandy loam and of the gravelly phase of the type:

Mechanical analyses of Anthony fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical soil:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510703	Soil	0.4	1.3	2.2	26.1	26.6	27.0	16.2
510704	Subsoil	.4	2.2	3.0	25.0	21.9	34.0	13.5
Gravelly phase:								
510705	Soil	3.9	9.0	7.5	30.4	14.1	19.7	15.8
510706	Subsoil	5.0	13.6	7.4	29.6	16.0	16.6	12.1

ANTHONY SILT LOAM.

The surface soil of the Anthony silt loam consists of 10 to 14 inches of light-purplish or pinkish-brown to light-brown smooth silt loam, the subsoil is a light pinkish brown compact silt loam or silty clay loam which either continues to a depth of 6 feet or more, or else rests upon a less compact, lighter textured deeper subsoil or substratum of the same color. Surface and subsoil contain much lime, but are generally deficient in organic matter. When wet this soil is brown and with the addition of organic matter under cultivation it tends to retain the brownish color when dry. Dry samples, and dry surfaces in virgin areas, however, are decidedly pinkish or purplish. The soil takes water readily and is easily maintained in good tilth. Near drainage ways the texture of the type in places approaches a very fine sandy loam.

The Anthony silt loam is most prominently developed in several areas north of St. David. Other areas are found south and west of Pomerene. The surface is smooth and gently undulating, and drainage is well developed. The type normally occupies positions adjacent to the eroded bluffs, or bordering shallow drainage ways. It is largely free from alkali salts.

Less than 1 per cent of the type is under cultivation. The principal crops grown are wheat and barley, with yields similar to those on the Curtis silt loam. The native vegetation consists largely of mesquite, which maintains a luxuriant growth on areas bordering the San Pedro River. The higher lying areas have a more stunted growth of mesquite, yucca, and sotol, and often have a fair stand of grasses valued for pasture.

Improved land of this type sells for $70 to $95 an acre, and unimproved land at $8 to $15 an acre.

The soil is retentive of moisture when well handled, and is all capable of irrigation. As with other desert soils, oxidation is well advanced, resulting in a low humus content. More thorough cultivation would generally result in increased yields under irrigation.

Anthony silt loam, light-textured phase.—The surface soil of the Anthony silt loam, light-textured phase, consists of 8 to 12 inches of a light reddish brown or brown calcareous very fine sandy loam. When wet the soil usually is dark reddish brown in color, but in the dry samples and in dry field surfaces a lighter reddish brown color is developed. The subsoil consists of a compacted dark chocolate brown to light reddish brown calcareous clay loam or silt loam. While of somewhat compact structure, the soil absorbs water readily and is rarely eroded. It also retains moisture well especially when properly cultivated.

This phase of the Anthony silt loam occurs in small areas associated with other old valley-filling soils in the southern part of the survey. One area lies just south of Land, two others lie 1 mile and 1½ miles north of Land, and smaller areas are found bordering the Rough broken land west and southwest of Land. The topography varies from smooth to gently undulating. Both surface drainage and underdrainage are thorough. Were water available this phase could be placed under cultivation at small expense. It should be well adapted to irrigation.

Less than 1 per cent of this soil is under irrigation. The principal crops grown are alfalfa and grain. The native vegetation consists largely of mesquite and creosote bush. A sparse growth of grasses affords a little grazing.

With development and irrigation, the phase should be productive of such crops as potatoes, berries, and fruit. Corn and alfalfa should also do well.

Anthony silt loam, heavy phase.—The surface soil of the Anthony silt loam, heavy phase, consists of 4 to 10 inches of light pinkish brown or light grayish brown calcareous clay loam, low in organic matter and carrying a relatively large proportion of silt and fine sand. The subsoil generally consists of two layers, the upper one being composed of pale reddish brown, compact, calcareous silty clay loam or clay loam, and the lower a pinkish-brown, calcareous silt loam or silty clay loam of less compact structure. In places the subsoil contains lenses or seams of fine sand or fine sandy loam. The compact upper subsoil absorbs water slowly, especially after a protracted dry period, but when once wet it is permeable and retentive of moisture. The surface soil of this phase is slightly grayer than is typical of soils of the Anthony series, but it approaches the Anthony more closely in color than it does the other series of the survey.

The largest area of this phase lies about one-half mile north of Curtis School. Four small areas lie northwest of Pomerene and another about one-half mile southwest of that place.

The topography is smooth and slopes gently, making the soil well adapted to irrigation. In general the phase occupies positions adjacent to drainage ways and in places is cut by deep narrow drainage channels, and the drainage is good. In some of the lower areas along the San Pedro River alkali salts have accumulated to some extent.

Most of the phase is not in cultivation, but where cultivated, good yields of wheat and barley are obtained. The native vegetation is sparse and consists principally of mesquite and scattering clumps of grass. With water available for irrigation, the soil should prove well adapted to alfalfa, wheat, barley, and corn. Vegetables and small fruits should also produce well. On account of the heavy texture of the soil it would be somewhat difficult to handle. The addition of organic matter would improve the tilth and increase the water-holding capacity of this soil.

Improved land of this phase of the Anthony silt loam is held at $75 to $100 an acre. Unimproved land sells for $10 to $15 an acre.

The results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the typical Anthony silt loam are given in the following table:

Mechanical analyses of Anthony silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510767	Soil	0.3	1.4	1.1	8.2	9.2	59.1	20.9
510768	Upper subsoil	.1	.5	.5	6.5	16.4	59.2	17.0
510769	Subsoil	.0	.1	.4	15.4	29.4	47.8	7.0

M'CLELLAN FINE SANDY LOAM.

The surface soil of the McClellan fine sandy loam to a depth of 8 to 12 inches is a pinkish-brown or pale reddish brown calcareous fine sandy loam containing a relatively large quantity of very fine sand. The subsoil is generally represented by two layers, the upper one consisting of material similar in color to the surface soil, but of silt loam or loam texture and somewhat more compact structure, and the lower composed of a compact light reddish brown silty clay loam or silt loam, slightly darker than the surface soil. The lower layer is not generally encountered above 60 inches, and may be entirely absent within a depth of 6 feet. In the vicinity of drainage ways the surface soil locally contains small gravel and in places a thin deposit of recent-alluvial material of sandy loam texture has been deposited over it. Rain falling on the type is largely absorbed, and the soil is fairly retentive of moisture, though not to the same degree as the heavier textured types of the series.

This type occurs mainly at the foot of the bluffs outlining the valley or along small stream courses. One of the largest areas lies 2 miles west of St. David; other areas of considerable size are near and south of Fenner. Numerous small areas are scattered throughout the valley.

The topography varies from smooth and moderately sloping to ridged or gently undulating. Where the latter type of surface occurs the land would require some leveling before it could be irrigated. The type is well drained and largely free from alkali, only the lower lying areas adjoining soils of heavier texture showing slight concentrations of salts. The type is well adapted to irrigation, though care would have to be exercised on some of the steeper slopes to prevent erosion or washing.

Several small areas of this type are in cultivation, though in all they do not constitute 1 per cent of its area. The native vegetation, consisting of mesquite, creosote bush, and in many places a fair stand of grasses, is vigorous. The soil is all used for grazing, excepting the small area under cultivation. Wheat, barley, alfalfa, and watermelons are grown with fair yields. Where sufficient irrigation water is available to mature a crop, wheat yields 12 to 15 bushels per acre, barley 30 to 40 bushels per acre, and alfalfa, which is cut four or five times, 4 to 5 tons of hay per acre per season. Better yields may be expected with a more plentiful supply of water. Watermelons of good quality are produced on this type. Potatoes and strawberries, produced at present only for home use, yield well and are of excellent quality.

Improved farms located on land composed largely of this type are held at $90 to $100 an acre. Unimproved land under fence is held at $10 to $15 an acre.

The soil is easily handled and retentive of moisture under good farm practices. Organic matter is essential for best results and can be supplied either as barnyard manure or as green-manure crops. The soil is warm and well adapted to the production of garden vegetables, small fruits, potatoes, and alfalfa. Wheat, barley, and corn do well, but not so well as on the heavier soils. The production of alfalfa should lead to an expansion of dairying and hog raising. Areas of the type favorably situated with regard to freedom from frost should prove well adapted to fruit culture. Among the small

fruits, strawberries appear to offer possibilities for successful production on a commercial scale. Chickens and turkeys are kept on nearly every ranch and are an important source of income.

McClellan fine sandy loam, light-textured phase.—The surface soil of the light-textured phase of the McClellan fine sandy loam consists of 8 to 14 inches of loose sandy loam of a pinkish-brown or light-red color. The subsoil is similar in color to the surface soil, but differs in texture, being a compact silt loam or clay loam. The surface soil contains considerable medium sand and some coarse sand, and a few areas contain gravel. The soil absorbs water very readily, but loses it quickly through evaporation.

The phase occurs in two small areas northeast of St. David, in one area about 2 miles southeast of Pomerene and in one at the northern boundary of the survey. The topography varies from smooth to gently undulating or ridged. Little work would be required to fit most of the phase for irrigation. The phase has good to excessive drainage and is entirely free of alkali. Under irrigation the soil would probably require a great deal of water to mature a crop, owing to its open structure and low power of retaining moisture.

The phase is not cultivated and its value for grazing is low, as the desert vegetation is generally small and scattering. Suggestions given for the development of the typical McClellan fine sandy loam are also applicable to this soil.

McClellan fine sandy loam, gravelly phase.—The McClellan fine sandy loam, gravelly phase, consists of 8 to 14 inches of light reddish brown or pinkish-brown gravelly fine sandy loam overlying a subsoil of the same color but of variable texture. The subsoil generally consists of silt loam or clay loam with lenses or seams of coarse material at variable depths. The soil is low in organic matter. It absorbs water rapidly but does not retain it long. The content of lime is high in surface soil and subsoil.

The McClellan fine sandy loam, gravelly phase, generally occurs along the bluffs at the margin of the valley floor or occupies slight mounds or ridges in the central part of the valley 6 to 18 inches or more above the surface of the other soils. The topography is gently undulating or ridged, making necessary some leveling before irrigation. Drainage is good to excessive, and accumulations of alkali salts are confined to areas with the heavier subsoil. The phase is not as well adapted to irrigation as the heavier textured soils of the valley.

The phase is devoted to grazing, for which it has low value, as the growth of grass is sparse and creosote bush and mesquite are scattered and generally of stunted growth. The land has the same price as other desert soils with which it is associated, though for future development it is probably somewhat less valuable than the heavier soils.

McClellan fine sandy loam, gravelly phase, could best be improved by liberal applications of organic matter. It should prove adapted to about the same range of crops as the light-textured phase of this soil type.

The following table gives the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the typical McClellan fine sandy loam:

Mechanical analyses of McClellan fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510726	Soil	0.2	0.5	0.5	19.1	31.7	36.4	11.7
510727	Upper subsoil	.0	.3	.4	3.9	12.1	64.9	18.8
510728	Lower subsoil	.0	.8	1.0	6.5	3.3	55.8	32.6

M'CLELLAN SILTY CLAY LOAM.

The surface soil of the McClellan silty clay loam consists of 8 to 12 inches of deep pinkish brown or light reddish brown, calcareous silty clay loam. The surface is generally covered with a thin veneer of 1 to 4 inches of pinkish-gray alluvial material of later deposition. The subsoil consists of a deep pinkish brown or dark purplish brown to light reddish brown silty clay loam to clay. The subsoil is rather compact, highly calcareous, being softly cemented with lime, and uniform in color and texture to a depth of 6 feet or more. The surface soil is low in organic matter and bakes slightly upon drying; consequently it is slow to absorb moisture until wet to some depth, after which water penetrates readily and is retained quite well.

The type generally contains alkali salts, especially on the slopes near the axis of the valley, where drainage is not as well developed as in the higher lying areas. The concentration of the salts is variable, and the presence of black alkali increases the possibility of injury to cultivated crops.

The largest areas of this type are at and near Benson. Several small areas lie east and northeast of Benson and in the vicinity of St. David, Land, and the Curtis School. The run-off from the higher slopes has cut deep narrow gullies through most of the areas of the type; otherwise the surface is smooth and well adapted to irrigation. Surface drainage is good, but the subsoil is frequently poorly drained, resulting in the accumulation of alkali salts.

The native vegetation of mesquite and catclaw is usully of stunted growth and generally sparse. A few small included areas of somewhat heavier texture support a more vigorous growth of desert vegetation. The small part of the type under cultivation is devoted principally to wheat and barley, with yields somewhat less than on the Curtis silt loam. With more water for irrigation, the difference in favor of the latter soil would probably be greater. Vegetables grown in home gardens produce well and are of good quality, though the soil is somewhat difficult to handle.

Improved land of this type is held at $60 to $90 an acre, and unimproved land can be had for $8 to $15 an acre.

With the addition of organic matter and good cultural methods this soil should prove well adapted to grain and hay crops, as well as to berries and vegetables.

McClellan silty clay loam, porous-subsoil phase.—The porous-subsoil phase differs from the typical McClellan silty clay loam in the occurrence of a porous, gravelly, deeper subsoil or substratum, which varies in thickness from 10 to 20 inches or more. The surface soil is deep pinkish brown or light reddish brown and overlies an upper subsoil of somewhat deeper purplish brown color. The porous lower

subsoil consists of a mixture of gravel and sand or coarse sand of about the same color as the overlying material. This is encountered at depths of 40 to 50 inches and generally continues to depths of 6 feet or more.

The largest area of the phase is at Curtis School. Smaller areas occur in the northern extension of the valley and near Benson and Fenner, and one small area lies about 1¼ miles southwest of Land. The surface is smooth and gently undulating, except for occasional gullies or drainage ways passing through it. Drainage is well developed. In places alkali is present, but only in low concentrations. The phase is well adapted to irrigation, though it would be somewhat more droughty than the typical McClellan silty clay loam.

The phase is of little importance except for the grazing it affords. With future development it should prove quite productive and easy to handle. It gives yields of wheat and barley comparable to those on the Curtis silt loam. A few apple trees on the phase are in good condition and productive.

Improved land is held at $75 to $100 an acre, depending largely on improvements. Unimproved tracts are held at the same price as other unimproved land in the area.

McClellan silty clay loam, gray phase.—The surface soil of the McClellan silty clay loam, gray phase, consists of brown or light grayish brown smooth textured silty clay loam with a shade of pink, but the grayish color is more pronounced in the surface material than is the case in other soils of this series, being conspicuous in places to a depth of over 8 inches. The subsoil is a pinkish-brown or light reddish brown clay loam, silty clay loam, or clay, which is usually moderately compact and continues uniform in color and texture to a depth of 6 feet or more. The surface soil is friable and retentive of moisture. It is well supplied with lime, but deficient in organic matter. The subsoil is highly calcareous and in many places contains definite accumulations of lime.

This phase of the McClellan silty clay loam is best developed in the middle part of the valley or near stream courses. Some of the largest areas lie along the San Pedro River between Benson and St. David; south of St. David the areas are small and scattered.

The surface is smooth and gently sloping or slightly undulating. Drainage ways are numerous and have deep, steep-sided channels. Surface drainage is well developed, but in the areas bordering the river underdrainage is somewhat retarded, and here the soil almost invariably contains accumulations of alkali. In times of heavy rainfall the run-off on the higher lying areas causes considerable erosion. The soil is well adapted to irrigation, being easy to till and retentive of moisture.

Less than 1 per cent of the phase is under cultivation, the remainder being utilized for grazing. Mesquite and creosote bush are the principal types of native vegetation, though some areas have fair stands of grasses. Wheat, barley, and alfalfa are the principal cultivated crops, and the yields are good when plenty of water is available for irrigation.

McClellan silty clay loam, gray phase, is held at $75 to $100 an acre when well improved. Unimproved land is held at the prevailing price of $8 to $15 an acre for desert land under fence.

With the addition of organic matter and a plentiful supply of irrigation water, this soil should prove productive of all crops suited to the local climatic conditions, especially small fruits, potatoes, vegetables, alfalfa, and grains. Poultry husbandry, dairying, and hog raising could also be successfully extended.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the typical McClellan silty clay loam, and of the soil, subsurface, and subsoil of the gray phase of the type:

Mechanical analyses of McClellan silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical soil:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510746	Soil	0.0	0.8	0.5	3.5	6.8	63.6	25.1
510747	Subsoil	.0	.1	.2	9.4	9.9	32.3	48.1
Gray phase:								
510712	Soil	.0	1.6	.7	4.9	7.0	57.2	28.9
510713	Subsurface	.0	.6	1.0	9.8	6.8	37.0	45.1
510714	Subsoil	.0	.1	.4	7.2	6.1	38.8	47.7

IMPERIAL CLAY.

The surface soil of the Imperial clay consists of 10 to 14 inches of dark chocolate brown or purplish-brown calcareous clay, which in places is relatively high in silt. Locally the surface of the type is covered with a layer, 2 to 4 inches thick, of pinkish-brown material of slightly lighter texture. The subsoil is a reddish-brown calcareous clay. It is generally uniform in color and texture to a depth of 6 feet or more, though there is a slight variation toward a lighter color in places in the lower subsoil. The upper part of the subsoil is somewhat more compact and of slightly higher lime content. The soil is low in organic matter, is sticky when wet, and has a tendency to bake when dry, with the result that water is not readily absorbed and much rainfall is lost as run-off. When once wet, however, this soil takes water readily and retains it well.

The type generally occurs along drainage ways in positions slightly lower than the adjoining soils. The largest area lies about 1½ miles south of Fenner; it is comparatively level and the subdrainage is somewhat restricted. Other areas occur at and near Benson, north of Pomerene, and near Land.

The topography is smooth and gently sloping, except near stream courses, where there are deep narrow cuts, which, with further run-off, will result in a seriously eroded condition of the entire type. Because of the impeded underdrainage, the heavy subsoil in places is impregnated with alkali salts. The slope is favorable for irrigation, as is also the soil structure, though the soil probably will take water more slowly than other less plastic soils.

The Imperial clay supports a good stand of grasses in some localities, especially in the area south of Fenner. Other areas are devoid of vegetation or support a small growth of mesquite, so that run-off is rapid and erosion active. Only a few acres of this type are under cultivation. These are used for growing wheat, barley, and milo. The cultivated land is affected with alkali, and yields are consequently lower than might be expected on areas free from alkali. Vege-

tables of good quality are grown for home use on this soil at Benson, though the soil is somewhat difficult to handle.

Unless measures are taken to check the rapid run-off characteristic of the region, the type will probably suffer severely from erosion. Under cultivation it should prove best adapted to grain and hay crops. The addition of organic matter would make the soil easier to handle and more absorptive of moisture.

Imperial clay, dark-colored phase.—The dark-colored phase of the Imperial clay differs from the typical Imperial clay only in the darker color of the surface soil and subsoil, both of which have a deep purplish or dark chocolate brown color, which when wet appears dark red. The subsoil is generally compact and columnar in structure, indicating modification by weathering. It ranges in texture from clay to silty clay, and owing to impeded underdrainage it contains more or less alkali. An overwash of pinkish-brown or pinkish-gray material 2 to 4 inches thick covers the soil in places. Lime is abundant in surface soil and subsoil.

The phase occurs along stream courses in the southern part of the area. Several small areas lie near Land and St. David. The surface is somewhat dissected by small drainage channels, 3 to 6 feet deep; otherwise it is smooth and gently sloping, affording good surface drainage. Underdrainage is not so well developed. The soil takes water slowly and is somewhat difficult to handle, making it slightly less desirable for irrigation than the lighter textured soils.

The native vegetation consists largely of mesquite and wild grasses. Some areas afford very good grazing. A few acres at present (1921) support a good stand of alfalfa that promises yields similar to those on the gray phase of the McClellan silty clay loam, with which this phase is associated.

Suggestions for the utilization and improvement of the typical Imperial clay are also applicable to this phase.

Below are given the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the typical Imperial clay:

Mechanical analyses of Imperial clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510709	Soil	0.0	0.2	0.3	6.2	12.9	37.8	43.0
510710	Upper subsoil	.0	.0	.1	5.2	9.8	39.5	45.6
510711	Lower subsoil	.0	.0	.3	4.7	5.9	35.7	53.4

CURTIS SILT LOAM.

The surface soil of the Curtis silt loam consists of 8 to 12 inches of pinkish-brown or light grayish brown smooth-textured silt loam. The subsoil consists of a compact pinkish-brown silt loam or silty clay loam overlying grayish-brown or light-brown sand, sandy loam, or gravelly sandy loam. This light-textured layer is encountered at depths of 36 to 50 inches and is from 12 to 30 inches thick. The material below this, when reached within the 6-foot section, consists of a pinkish-brown clay loam or silty clay loam. Lime is abundant in the surface soil and subsoil, with a tendency toward accumulation

in the compact upper subsoil. On a few areas too small to be shown upon the soil map the surface soil contains considerable small gravel and is lighter in texture than typical. The eastern part of the area at St. David, embracing the part in the immediate vicinity and east of this town, is somewhat lower in silt and higher in clay content than typical. If this variation were more extensive it would have been mapped as Curtis clay loam.

The largest area of the type is in the vicinity of St. David. An important area lies south of Curtis School, and others occur at various distances east and northwest of Benson.

The surface is gently undulating and slopes moderately toward the center of the valley. The run-off is very slight and eroded areas are uncommon. The surface drainage is excellent, and underdrainage is in places excessive. Alkali salts are of rare occurrence in this soil.

The type is well adapted to irrigation, and where water is available it is largely in cultivation. It is one of the most important soils in the area from the standpoint of use, though its total area is not great as compared with several other types. The soil is naturally droughty and the desert vegetation is somewhat stunted in growth and rather sparse. Under irrigation crops sometimes suffer for want of water during the late summer, but where plenty of water is available the Curtis silt loam is one of the more productive soils of the area. The chief crops are wheat, barley, alfalfa, and fruit. Dairying is developed to a small extent on part of the type. Chickens and turkeys are produced on many of the farms. Vegetables, including potatoes and sweet potatoes, yield well and are produced on most farms for home use. Wheat yields 15 to 20 bushels per acre, barley 40 to 50 bushels per acre, and alfalfa, which is cut 4 to 5 times, yields 4 to 6 tons per acre. (Pl. XI, fig. 2.) Apples and peaches yield well in favorable seasons, and the quality of the fruit is excellent. Corn is grown occasionally and yields 50 to 70 bushels per acre.

Well-improved land of this type is sold at $100 to $150 an acre, and unimproved land outside of the artesian-well district or above the present canals is held at $10 to $20 an acre.

The principal need of this soil is the addition of organic matter, after which more thorough cultivation and judicious use of water in irrigation should be practiced. Less frequent irrigation but more thorough cultivation in the spring would probably result in better crops and keep the soil in better condition. This type is well adapted to diversified farming, and it would seem that the dairy industry could be extended with profit.

The following table gives the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the Curtis silt loam:

Mechanical analyses of Curtis silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510715	Soil	0.4	0.7	0.5	6.2	18.0	52.8	21.7
510716	Upper subsoil	.0	.1	.2	6.6	17.7	55.0	20.6
510717	Lower subsoil	8.7	17.9	9.5	2.49	19.5	13.6	6.1

SAN PEDRO FINE SANDY LOAM.

The surface soil of the San Pedro fine sandy loam consists of 6 to 12 inches of a light grayish brown or light-brown fine sandy loam, tinged with pink. The soil is low in organic matter and very loose and porous. The subsoil consists of stratified material, the profile showing two or more strata. The upper layer is of about the same texture as the surface soil, but has a more reddish or pinkish-brown color and varies in thickness from 6 to 14 inches. This is underlain by very dark gray compact clay or silty clay. In places this lower layer is not encountered above 45 inches. Locally the surface soil is rather light textured and approaches a fine sand. The lime content of the surface soil is slight, but lime is abundant in the subsoil, particularly in the deeper, heavy-textured material in which gray mottlings occur in places. The type occurs along the San Pedro River in narrow strips which lie slightly higher than the adjoining soils. The most important areas are between St. David and the northern boundary of the area. Two very small areas lie west and southwest of Curtis School.

The topography is smooth and gently sloping, except for the occasional drainage ways entering the river. Surface drainage is well developed, and the soil is largely free from alkali, but the subsoil in places contains large quantities, which were accumulated under conditions of poor drainage prior to the cutting of the present river channel. The type lies well above overflow.

A few acres of the San Pedro fine sandy loam are used for growing wheat and barley. The crops often suffer for moisture during the seasons when water for irrigation is scarce. Originally the type supported a luxuriant growth of grasses, but because of overgrazing and the lowering of the ground water by the deepening of the river channel, the deep-rooted mesquite and catclaw have largely taken possession of the land.

The type is valued chiefly for the grazing which it affords, though with development it should be valuable for the production of berries, potatoes, and alfalfa. Organic matter should be added in liberal quantities to attain best results.

San Pedro fine sandy loam, coarse-textured phase.—The San Pedro fine sandy loam, coarse-textured phase, consists of 8 to 12 inches of calcareous, reddish-brown or dull-red sandy loam or fine sandy loam, carrying considerable coarse sand and some small gravel. The soil readily absorbs moisture but loses it rapidly by evaporation. The subsoil is composed of several strata, varying in thickness from 10 to 30 inches and ranging in color from pinkish gray to very dark purplish brown, dull black, or drab. The texture varies, the lighter colored strata consisting of clay loam or silt loam, and the darker colored layers generally being of silty clay loam or clay texture. The subsoil materials are highly calcareous, and some of the strata of heavier texture are mottled with gray lime accumulations, and in places contain soft lime carbonate nodules.

This phase occurs in five narrow areas along the San Pedro River between St. David and Curtis School. It lies several feet above overflow. The surface is cut by a few drainage ways entering the river, otherwise it is smooth and gently sloping. Surface drainage is good,

as is also the underdrainage, which was rather poor before the river channel was eroded to its present depth. With development the phase should be adapted to cultivation, unless seepage from higher lying areas should cause alkali to become troublesome.

The phase supports a vigorous growth of mesquite and catclaw, which has largely supplanted the grama and galleta grasses that formerly flourished. This land is valued only for the grazing it affords. It is sold with adjoining soils and is valued at $10 to $20 an acre.

Under cultivation the soil should be productive of alfalfa, small fruits, and potatoes. The soil is naturally deficent in organic matter.

SAN PEDRO SILT LOAM.

The surface soil of the San Pedro silt loam consists of 8 to 12 inches of light pinkish brown, calcareous, mellow silt loam. The upper subsoil consists of stratified material ranging in color from light grayish brown to light reddish brown and in texture from a sandy loam to a silty clay loam. At an average depth of about 36 inches this is underlain by a deeper subsoil consisting of very dark purplish brown or chocolate-brown to very dark gray clay or silty clay of compact structure, slightly mottled with rusty-brown iron stains. The subsoil throughout is high in lime and pronounced accumulations of lime usually occur in the deeper and more compact material. The texture of the surface soil varies somewhat, ranging from very fine sandy loam to light clay loam in areas too small to be shown on the map, though in general the texture of the type is a silt loam.

San Pedro silt loam occupies positions adjacent to the larger stream courses, where drainage apparently was somewhat restricted at the time the heavier materials of the deeper subsoil were laid down. At present drainage is well developed owing to the recent lowering of the channel of the river. The type carries more or less alkali. The largest area of the type lies along the east bank of the San Pedro River north and south of Pomerene. Other scattered areas are found bordering the river from near Benson to the boundary of the area on the south. Two areas are mapped in the vicinity of Fenner. The surface is smooth, almost flat, and continuous except for a few deep cuts. The type receives much run-off from the higher lying slopes, but water does not stand on the surface very long. Accumulations of alkali salts lessen the value of this type for irrigation, though it is probable that they could be largely removed in the course of several years.

As mapped, the type includes a variation that resembles the typical soil in every characteristic of color and structure of soil and subsoil, but has a heavy surface soil of clay loam texture. However, owing to the relatively high content of organic matter and of medium sand, the soil is friable and easily handled. This variation occurs in two small areas occupying positions lower than the adjoining soils along the San Pedro River. These areas lie northwest of Pomerene, at distances of 1 mile and $3\frac{3}{4}$ miles, respectively. The surface is level, and the poor drainage has resulted in rather high concentrations of alkali.

Another variation of this type includes three small areas in which the surface soil is a pinkish-brown or reddish-brown silty clay loam, plastic when wet, but assumes a crumbly structure when dry. The soil absorbs water readily and is retentive of moisture. The subsoil is composed of dark-colored, heavy-textured, stratified sediments. Both surface soil and subsoil are high in lime and moderately well supplied with organic matter.

One of these areas lies 1 mile northwest of Curtis School and another is near Benson. They occupy slightly depressed positions in the former flood plain of the river, but owing to the lowering of the river channel, they are now several feet above overflow. The surface is smooth and nearly flat, and the drainage is poor. Alkali is present in rather high concentrations, consequently the soil has a low value for irrigation.

A few acres of the San Pedro silt loam are in cultivation, being used for growing wheat and barley, to which the soil seems well adapted. A luxuriant growth of grasses is found on part of the type, elsewhere the only growth consists of mesquite and catclaw.

Several ranches adjoining the San Pedro River have small apiaries, which are a source of considerable income. The bees obtain a great deal of honey from the mesquite, which makes a heavy growth along the river, as well as from other sources, such as alfalfa.

The San Pedro silt loam is confined to small areas and is sold only in connection with other soils. It has a comparatively high grazing value, and for cultivated crops it ranks with adjoining soils. Although the soil is low in organic matter, it has a better supply than other desert types of the area. Under cultivation it should prove best adapted to grain and alfalfa.

The table below gives the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the San Pedro silt loam:

Mechanical analyses of San Pedro silt loam.

Number.	Description.	Fine gravel.	Course sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510770	Soil	0.1	0.5	0.2	1.7	16.7	64.3	16.6
510771	Upper subsoil	.0	.1	.1	3.4	12.6	57.1	26.8
510772	Lower subsoil	.0	.5	1.2	9.1	8.2	40.0	41.0

RIGGS CLAY.

The surface soil of the Riggs clay consists of 8 to 12 inches of dull brownish gray to black calcareous clay, which is sticky when wet and bakes and becomes compact when dry. In areas where the content of organic matter is high the soil is darker than typical and less plastic and has a tendancy to crumble when dry. The subsoil is formed of two layers. The upper one consists of dark-brown or dark brownish gray clay, slightly mottled with rusty-brown iron stains. At depths of 32 to 50 inches this passes into reddish-brown or pinkish-brown clay loam or clay. In places the lower stratum is absent and the deeper subsoil is darker in color than typical, but becomes some-

what lighter with increasing depth. Both surface and subsoil are well supplied with lime and slight accumulations occur in the subsoil. This type is represented by only a few flat poorly drained areas in the vicinity of the San Pedro River. One area lies just east of Land, where it receives much run-off from the higher slopes as well as waste water from several flowing wells and springs. Other areas lie south of St. David and east of Benson. The surface is smooth and comparatively flat, and surface and subdrainage are poorly developed. Alkali in varying degrees of concentration is found throughout the type.

The native vegetation consists in part of mesquite and catclaw, and in part of native grasses which have high value for grazing. Small areas are utilized in the production of wheat and barley. Areas in which the alkali content is low are well adapted to grain and produce good yields.

The Riggs clay is sold only in connection with other soils. Improved land composed largely of this type is held at $70 to $95 an acre. Unimproved land is held at $10 to $18 an acre.

The type would be benefited by drainage, which could be supplied either by deep ditches or underdrains, after which the leaching of the soil would aid greatly in removing alkali. Under irrigation the type, where the content of alkali is low, should be adapted to diversified farming, including the production of small grains, corn, and alfalfa as feed for hogs and dairy cattle, and the selling of surplus wheat or barley.

Riggs clay, light-textured phase.—The surface soil of the Riggs clay, light-textured phase, consists of dull brownish gray to black calcareous clay loam of rather high silt content. The subsoil consists of two sections. The upper layer is a compact dull-gray or dull grayish brown to black, calcareous clay or silty clay loam. The lower one is a pinkish-brown calcareous silt loam or loam, or in places a sandy loam, which upon drying assumes a dull-grayish color. The soil is easily cultivated and maintained in good tilth.

The phase is confined to a few small areas of stream-laid deposits bordering the San Pedro River which now lie several feet above overflow. The principal areas are situated 1½ miles south of St. David and near the southern boundary of the survey. The surface is generally smooth and nearly flat, except for occasional deep narrow cuts formed by run-off from the higher areas. It requires very little leveling for irrigation. Drainage, both surface and internal, is somewhat slow, and consequently alkali has accumulated to some extent.

A few acres of the phase are under cultivation, being devoted to the production of wheat, corn, and barley. The yields are similar to those on the McClellan fine sandy loam. Mesquite, catclaw, and grasses occupy the soil in its virgin state, and it is used almost entirely for pasture. A fair stand of native grasses over part of the phase makes it of higher value for grazing than soils lying above the former river flood plain.

Areas of this phase, reasonably free from alkali, or from which the salts can be leached successfully, should be well adapted to all crops suited to the climatic conditions of this region. The production of

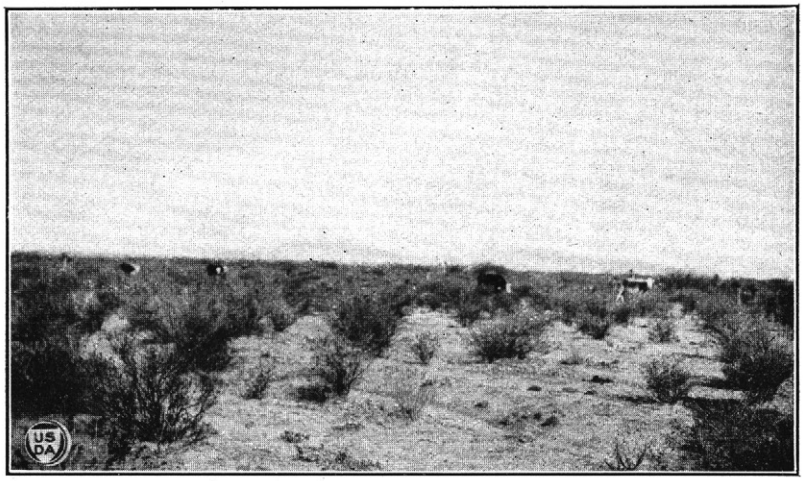


FIG. 1.—TOPOGRAPHY AND NATIVE VEGETATION ON THE SOILS OF THE ANTHONY SERIES

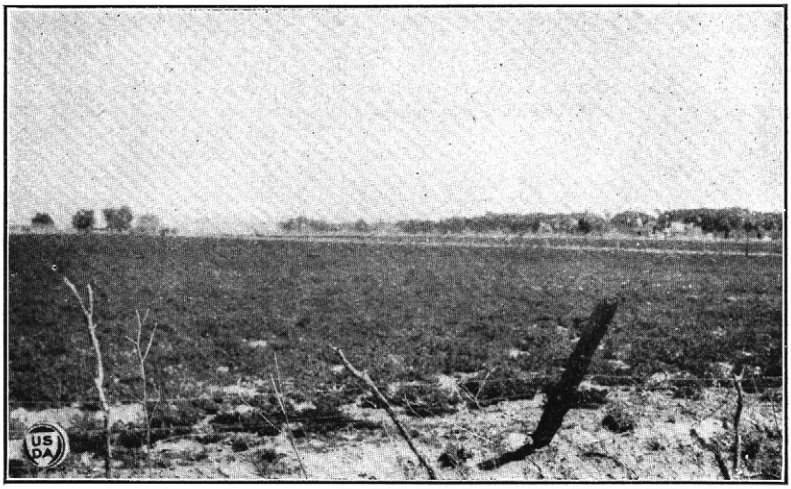


FIG. 2.—A GOOD STAND OF ALFALFA ON IRRIGATED LAND OF THE CURTIS SILT LOAM

corn, small grain, and alfalfa, combined with stock raising or dairying, can generally be relied upon as the most successful form of agriculture.

The table below gives the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the typical Riggs clay:

Mechanical analyses of Riggs clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510743	Soil	0.0	0.0	0.3	5.8	14.8	35.5	43.7
510744	Upper subsoil	.0	3	.4	6.7	9.5	36.9	46.2
510745	Lower subsoil	.0	0	.1	7.3	12.6	39.7	40.2

GILA GRAVELLY SAND.

The surface soil of the Gila gravelly sand consists of 10 to 14 inchse of light-brown or light grayish brown calcareous, gravelly sand with a pale-red or pink tint. It is very loose and friable, being composed principally of the coarse and medium grades of sand, mixed with gravel of various sizes and generally well rounded. The subsoil has the same color as the surface soil, and consists of calcareous loamy gravelly sand, generally stratified with seams or lenses of different textured material. Cobblestones and bowlders are often found scattered over the surface and embedded in the surface soil and subsoil. In places the color of the surface soil and subsoil is distinctly pink or pale red, but such areas are small and have not been mapped separately.

The type occurs along the base of the bluff lines bordering the valley and especially on the flood plains of the drainage ways issuing from the eroded old deposits. It occupies several large areas near and north of Pomerene. Numerous small areas occur throughout the survey, extending back into the Rough broken land along small drainage courses, or projecting out into the valley a short distance from the bluff line to where the waters carried by the streams spread out over the surface and drop their sediments. Owing to periodic overflows and the droughty character of the type, it is not adapted to irrigation. Drainage is excessive, resulting in complete freedom from alkali salts.

Bordering the larger drainage ways the native vegetation is largely a vigorous growth of mesquite and catclaw, which, because of their deep-rooting character, are able to obtain moisture where the more shallow-rooted grasses fail. Along the smaller drainage ways, where underground moisture is lacking during long periods, stunted growths of various forms of desert vegetation are found. The type is not cultivated and has little value for grazing. Under cultivation it would be less productive than the other desert soils because of its poor water-holding capacity.

ROUGH BROKEN LAND.

On the east and west the valley of the San Pedro River is bordered by steep desert slopes, consisting of old unconsolidated water-laid materials, which are separated from the lower lying soils of the valley

by steep escarpments or bluffs. These steep, dissected, and eroded areas have been classified as Rough broken land. Most of this land is too steep and broken to be of any agricultural value. Small buttes and isolated areas of similar material occurring within the valley are also included.

The Rough broken land is composed of materials of mixed origin which since deposition have been considerably altered through a long period of weathering. The eroded bluffs in places show cemented hardpan formations 1 foot to 3 feet or more in thickness. The arable soils of the valley are derived largely from material eroded from these deposits.

Occasional areas, usually not over 10 to 20 acres in extent, might be utilized for dry farming in seasons of unusually heavy rainfall, but are unsuited to irrigation owing to lack of water and the excessive cost of leveling.

The drainage is excessive, and only the more hardy desert plants survive the long seasons of drought. The land is utilized to some extent for grazing, for which it has little value.

RIVERWASH.

Riverwash consists of bars and beaches and the dry beds of the streams of the area. It is confined principally to the channel of the San Pedro River and the larger drainage ways which enter it. The soil in the San Pedro River channel, to a depth of 6 feet or more, consists chiefly of poorly assorted coarse, medium, and fine sand. Along the small drainage ways the deposits are coarser, consisting of coarse sand, gravel, and cobblestones.

Riverwash supports no native vegetation except occasional willows or mesquite along the banks of the streams. Owing to its low position and frequent overflow, it has no agriculture value.

ALKALI.

The Benson area is situated in a region of low rainfall, where leaching of the soil is slight, and where, therefore, relatively large accumulations of soluble mineral compounds appear in the soils. Some of these compounds are essential to plant growth, or at least are stimulating when occurring in small quantities, but under the conditions of high concentration found here most of them are injurious. These salts are commonly known as "alkali," though but few of them are chemically of alkaline reaction.

In the Benson area the occurrence of alkali salts was determined by means of the electrolytic bridge, by the use of which the approximate average salt content to a depth of 6 feet was ascertained. The results of these field determinations, with the approximate boundaries of the areas of alkali accumulation, are shown on an accompanying map. The location of each sample taken for alkali determination is indicated on this map by a large dot, with a number showing the average percentage of salts in the air-dry soil to a depth of 6 feet. All areas containing more than 0.2 per cent of alkali are considered to be of questionable value for maximum crop production of the more sensitive crops until reclaimed. Such areas have been inclosed by

boundaries and indicated by the symbol "A." Areas having less than 0.2 per cent of salts are generally considered free from injurious alkali accumulations.

The alkali-affected areas occur largely in the flat, more poorly drained soils bordering the San Pedro River and in some of the heavier textured types adjoining the larger tributary drainage ways. Only one small area of alkali accumulation, 3½ miles south of Benson, is separated from the unbroken body of alkali soils adjacent to the river. In this area the surface drainage is rather poor and much of the run-off from the higher slopes penetrates the soil. It is, however, removed to a large extent by underground water movement, and consequently the salt concentration is low.

Within the areas shown on the alkali map as containing more than 0.2 per cent of salts the soils of highest elevation generally have a low alkali concentration. The adjacent, lower lying, and more poorly drained soils, especially those of heavy texture, in many places contain highly concentrated accumulations. It is seen, therefore, that the percentage of salts indicated by results of field tests, as shown on the map, may indicate only in a general way the salt concentration occurring between individual borings. Surface indications of alkali accumulation, either of salt crust or of native alkali-resistant vegetation, are too slight in this area to serve as a guide in drawing alkali boundaries in sufficient detail to establish different grades of concentration or as a reliable index of alkali concentration in any locality. Topographic features, principally those influencing drainage, have, however, formed an effective guide in establishing the boundaries of alkali areas.

Concentrations of alkali salts are injurious to plant growth if they interfere with absorption of soil moisture by the roots of the plant or if they are toxic or corrosive to its tissues. Such concentrations vary for different alkali salts and also for different plants, some plants withstanding much higher concentrations than others. The position of the point of maximum concentration of salts in the soil column, and other factors, some of them more or less under control of the farm operator, also cause a variation in the degree of concentration that can be endured by any given plant. It is therefore difficult to state, except in a general way, at what point of concentration injury will result to plant growth.

Sodium carbonate, or "black alkali," is probably the most injurious of all the common alkali salts. In addition to its corrosive action on vegetable matter, it also destroys the tilth of the soil, causing it to harden and making it difficult to handle under irrigation. In determinations made in this area this salt was detected in the majority of borings. In general, where more than 0.08 per cent of black alkali is present in the 6-foot section, in connection with low concentration of other salts, injury will result to plant growth. The point at which growth will be prohibited will depend on the proportion and kind of other salts present, the texture of the soil, and the point of localization of the salts in the soil profile, as well as other factors. However, it is generally recognized that with 0.1 per cent of black alkali in the surface 2 feet of soil the growth of most ordinary crops will be inhibited or at least greatly reduced.

The most common white alkali salts occurring in the area consist of sodium chloride, sodium sulphate, and magnesium sulphate. Several other salts are included with the white alkali salts, but they are seldom found in the soil in soluble form in appreciable quantities. The white alkali salts are generally recognized to be less injurious to crops than the black alkali, the minimum of injurious accumulation ranging from 0.2 to 0.4 per cent or more, according to the crop grown and the degree and point of localization of the salts in the surface soil or subsoil. With greater than 0.6 per cent of white alkali salts in the soil, successful crop production under ordinary conditions is doubtful until the soil has been reclaimed. As in the case of black alkali, there are several modifying factors, such as the distribution of the salts in the soil profile, the texture of the soil, the kind of salts, and other local influences.

Among the grain crops adapted to this region, rye is the most tolerant of alkali. Though the yield of grain is low on alkali land, the crop has a rather high value when turned under as a green manure, improving the tilth and rendering conditions more favorable for other cultivated crops. Other grain crops, in the generally accepted order of their tolerance, are barley, oats, wheat, and corn. While barley is fairly resistant to alkali, corn is sensitive to even small quantities of salts. Kafir is also well adapted to the soils and climate of this region and has about the same or slightly higher tolerance than barley.

Millet and the sorghums are among the most alkali-resistant of the cultivated forage crops, and should prove adapted to the soils and climate of this region. Sorghum especially is resistant and is suited for use as a temporary crop during process of reclamation.

The legumes as a family are sensitive to alkali, especially in the seedling stage, but after becoming established they have about the same resistance as wheat or oats. On soils in which the alkali concentration is largely in the surface soil, the legumes are more resistant after becoming established than the grains, as their feeding zone is much deeper. Sweet clover, a valuable green-manure and forage crop, is slightly more resistant than alfalfa. Beans can be grown to some extent on soils containing white alkali, but are sensitive to concentrations of over 0.3 per cent. Vetch, which has about the same resistance as oats or wheat, produces succulent winter forage and should prove valuable in this region in connection with the dairy industry.

The more important means commonly used in reclaiming alkali land are flooding with drainage, the growing of alkali-resistant crops, the addition of organic matter, thorough cultivation and maintenance of a mulch of loose earth to prevent evaporation, and flushing the soils when evaporation has concentrated the salts on the surface. Where black alkali occurs, improvement has in some cases been brought about by the addition of gypsum, thus converting, through chemical reaction, the carbonate to the less harmful sulphate. The addition of nitric or sulphuric acid in small quantities has also resulted in benefit to soils, though the treatment has not been extensively practiced. Barnyard manure is to be especially recommended on account of its value in improving the physical character of the soil, increasing its permeability and in reducing evaporation, as well as for its fertilizing value.

Of these various means of improvement, however, thorough drainage of the lands, preferably by means of underground tile, followed by flooding and leaching of the soil, is the only thorough and practicable means of permanent reclamation of areas in which salts have accumulated to any extent or in which conditions are favorable to recurrence of salt accumulation.

SUMMARY.

The Benson area is situated in southeastern Arizona, and occupies a part of the valley of the San Pedro River in the northwestern part of Cochise County. The valley is bounded on the east and west by desert slopes separated from the valley floor by steep, eroded bluffs. The area surveyed includes about 85 square miles, or 54,400 acres. With the exception of areas in the vicinity of the valley trough, the drainage of the area is well established.

Where water is available for irrigation, the valley is quite thickly settled, but few people reside outside the irrigated sections. Benson, St. David, and Pomerene are the largest towns. Transportation facilities are good, and developed areas are well supplied with roads.

The climate is hot and arid, with a mean annual temperature of 62.8° F., and a mean annual precipitation of 8.6 inches. Over 50 per cent of the rainfall occurs during July, August, and September, while during the months of April, May, and June only slightly more than one-half inch of rainfall normally occurs. The absolute maximum temperature is 110° F., and the absolute minimum 5° F. The average date of the last killing frost in the spring is March 15, and that of the earliest in the fall, November 14, giving an average length of growing season of 243 days.

Agriculture in the Benson area is limited to areas in which water can be obtained for irrigation from artesian wells or by diversion from the San Pedro River. The first crops of wheat and barley were matured in 1879. About 1884, cattle raising became the dominant industry, and this continues to be one of the important sources of income in the valley. The principal crops grown are wheat, barley, and alfalfa. Wheat and alfalfa are produced in excess of home needs.

The farm buildings are built largely of adobe. A few farms are well improved. Farm machinery is scarce and of an old type.

The possibility of irrigation has influenced distribution of crops more than has the character of the soil.

The farm laborers are mostly Mexicans. The farms are small, however, and little outside labor is employed except in harvesting time.

Well-improved land is held at $90 to $120 an acre, while unimproved land can be had for $8 to $20 an acre.

The soils of the area have been classified in three groups: Old valley-filling soils, recent-alluvial soils, and miscellaneous materials. The old valley-filling soils are are of greatest extent.

The old valley-filling soils are grouped in six soil series, the Anthony, McClellan, Imperial, Curtis, San Pedro, and Riggs.

The heavier types of these series are used largely in the production of grains, and the lighter textured types are used in the production of both grain and alfalfa. The McClellan, Imperial, San Pedro, and Riggs soils are affected with alkali in some places.

The Gila gravelly sand, the only recent-alluvial soil mapped in the area, is little suited to irrigation on account of its droughty character.

The miscellaneous materials include Rough broken land and River-wash, both of which are nonagricultural, either because of adverse topographic features or unfavorable character of soil material, or both.

Alkali occurs in the soils lying in the vicinity of the valley trough. The concentrations are high in some of the flatter areas, but decrease with increase in elevation and slope. More or less black alkali occurs in all areas affected with alkali. The alkali-free areas are characterized by sufficient slope to insure good surface and internal drainage. The area of alkali-free soils is much greater than that affected with alkali salts.

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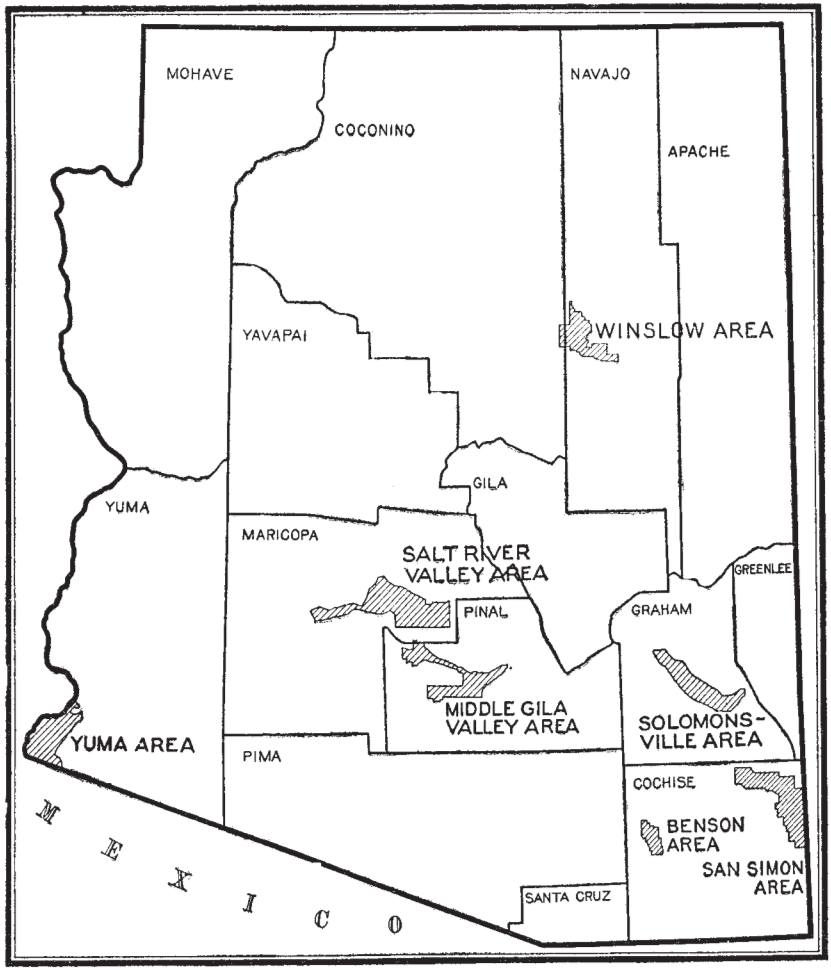

Areas surveyed in Arizona shown by shading.

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