U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS

SOIL SURVEY OF LAS VEGAS AREA NEVADA

BY

E. J. CARPENTER, IN CHARGE, AND F. O. YOUNGS

[Advance Sheets—Field Operations of the Bureau of Soils, 1923]

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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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SOIL SURVEY OF THE LAS VEGAS AREA, NEVADA

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DESCRIPTION OF THE AREA

The Las Vegas area is situated in Clark County, in the southern part of Nevada, approximately 70 miles north of the extreme southern tip of the State. It lies in a region characterized by well-defined mountain ranges, running north and south, with broad débris-filled valleys, many of which are inclosed basins and are commonly known as "bolson valleys."

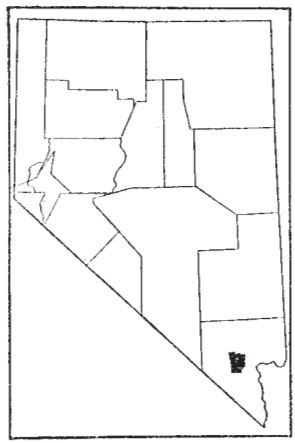


FIG. 8.—Sketch map showing location of the Las Vegas area, Nevada

The area surveyed embraces the greater part of the Las Vegas Valley, which is composed mainly of débris and sediments washed from the Spring Mountains lying to the west and to a less extent from the bordering mountain ranges on the north, south, and east. Included in the survey are also small isolated buttes, as well as the rocky foothills of some of the bordering mountains.

The Desert, Sheep, and Las Vegas Mountain Ranges form an almost continuous mountain wall on the northeast side of the valley, and to the east and southeast low spurs of the Muddy and McCullough Ranges lie north and south of the Las Vegas Wash. On the west the Spring Montain Range, culminating in Charleston Peak at an elevation of 11,910 feet above sea level, forms one of the dominant topographic features of this region. Black Canyon on the Colorado River, a proposed water-storage site for extensive irrigation and power development, lies east of the area at a distance of about 38 miles by road, or 25 miles in an air line.

The boundaries of the area have been drawn to include, so far as present information goes, all land which may be irrigated from flowing wells, or on which water may be pumped at reasonable cost. It should not be inferred, however, that all land within the survey could be profitably watered by pump irrigation. It is also recognized that with future development areas may be found outside of the survey on which water can be developed for irrigation.

In shape the area is roughly rectangular, the western boundaries extending with slight irregularities from a point 3 miles northwest of Tule Springs, south to the township line between townships 22 and 23 south, thence east along the township line to a point about 8 miles east of Bard. From here the boundary of the area extends

northward, but by a series of offsets to conform with land lines the boundary is extended still farther east, so that the northeast corner of the area is 4½ miles east of Valley on the Union Pacific Railroad. The northern boundary also includes Valley, and the northwest part of the area is extended northward to include Tule Springs. The area surveyed contains 308 square miles, or 197,120 acres.

The area mapped consists topographically of broad gently sloping alluvial fans that rise gradually from the trough of the valley to the rugged mountains surrounding the valley. (Pl. 5.) In the northern and southern parts of the area, the fans from opposite sides of the valley meet at their lower ends, thus making the trough of the valley very narrow. In the central part of the area, however, the fans do not reach the axis of the valley, leaving a broad gently sloping plain about 4 miles wide between them lying in the middle of the valley.

At Las Vegas the elevation is 2,033 feet above sea level, and to the west of Tule Springs, at the highest point in the area, the elevation is over 2,600 feet. At Arden the elevation is about 2,450 feet, and at Valley about 2,035 feet. In the interior of the valley east of Las Vegas the general elevation is around 1,700 feet, although it is more than 100 feet lower than this at the point where Las Vegas Wash leaves the area.

The only exit for surplus water in the Las Vegas Valley is through the Las Vegas Wash, which in recent geologic time has cut a deep narrow gorge through the mountains to the east of the valley. The wash is normally dry during the greater part of the year, though in places a small perennial flow is maintained by waste water from flowing wells. No large perennial streams enter the valley from the mountains, though some of the larger canyons carry a small volume of water throughout the year. After leaving the mouths of the canyons, however, the water soon disappears in the coarse débris of the fans. Following heavy thunderstorms the run-off is rapid, and water soon collects in local drainage ways, and finds its way to the trough of the valley. Here it is dispersed over the gently sloping plain in the central part of the valley, before again being collected in a definite channel to continue down the rocky gorge of the Las Vegas Wash and into the Colorado River to the east.

Retarded subdrainage has given rise to accumulations of alkali in several sections of the area, though surface drainage is generally well developed. Erosion is active in many places in the valley, generally in areas lying above the bluff lines.

The area surveyed lies entirely in Clark County, which was organized from part of Lincoln County in 1909. The population of the county, according to the census, was 4,859 in 1920; all of it is classed as rural, there being no towns of 2,500 population. Although the area surveyed covers only 308 square miles in Clark County, whose total extent is over 8,043 square miles, it includes the most thickly populated section of the county. The agricultural district of the area surveyed is very sparsely populated, very little development having taken place. The population is almost entirely American born, though a few Mexicans are employed as laborers on the railroad.

Las Vegas is the county seat and largest town of Clark County, with a population of 2,304. Aside from being a division point, it contains the principal shops of the Los Angeles-Salt Lake Division of the Union Pacific Railroad, which give employment to the greater part of the population. The city has electric lights, good waterworks, stores, hotels, and banks. The Pacific Fruit Express maintains a large icing plant here, at which refrigerator cars are re-iced for transhipment to eastern markets. Arden, in the southern part of the area, is the location of a gypsum mill which has a capacity of 300 tons or more a day. Running water, electric lights, and general stores are available here. Other railroad points consisting only of sidings are Bard, Pierce, Bracken, Wann, and Valley.

The Union Pacific Railroad traverses the area from north to south, and affords good transportation facilities. A narrow-gauge railroad, operated by the United States Gypsum Co., runs from Arden to the quarry about 5 miles west. A railway line was formerly operated from Las Vegas to Goldfield, Tonopah, and northern points but this was discontinued in 1918 and the old road bed is now used as a highway.

The Arrowhead Trail highway between Salt Lake City and southern California, passes through the central part of the area and is in good condition throughout the year. A good graded road also connects Las Vegas with Arden, Goodsprings, and intermediate points. Other roads have been given some attention and are generally in good condition except during heavy storms. Telephones are available throughout the greater part of the area, and electric power for domestic purposes is available in Las Vegas and Arden.

At present but few agricultural products are produced in excess of home needs, but with future agricultural development, good markets are available locally as well as in Salt Lake City, Utah, and Los Angeles, Calif.

CLIMATE

The climate of this region is characterized by long, warm growing seasons, during which extremes of heat are often experienced, but the summer temperature varies rather widely. The winter season is generally of short duration, during which freezing weather often occurs, though extremes of cold are seldom experienced. Snow falls on the points of higher elevation early in the winter and generally lasts till late spring, and occasionally till midsummer in sheltered spots or on the higher peaks. Light snowfalls occur almost every year in the valley, but they seldom last more than a few days.

The mean annual temperature at Las Vegas, in the central part of the area at an elevation of 2,033 feet, is 60.5° F., and the mean for the summer months is 79.1° F. An absolute maximum of 115° is recorded at this station, and temperatures of 110° or 112° are of almost annual occurrence. Temperatures of 100° F. are also occasionally recorded during September, April and May. The absolute minimum recorded in the area is 8° F.

Sufficient rainfall for the profitable production of crops without irrigation is never assured. A mean annual precipitation of 4.82 inches is recorded at Las Vegas. The heaviest rainfall comes during the winter months when over 36 per cent of the total annual pre-

cipitation occurs. During the secondary wet season in the late summer and early fall the rains arise quickly as local thunderstorms on or near the mountain slopes, but decrease in intensity toward the interior of the valley. Though large quantities of water fall locally, the run-off is very rapid and the soils are seldom wet to any appreciable depth. The winter rains are more gentle and are accompanied by but little run-off.

The points of higher elevation are more favorably situated as regards rainfall, as is plainly indicated in all arid regions in the change in native vegetation with elevation. A marked variation in rainfall is also noted from year to year, as is shown by records kept at Las Vegas, where during the driest year on record (1898) a total of 1.64 inches fell, whereas during the wettest year (1915) 8.41 inches fell.

The following table gives the rainfall and temperature records for Las Vegas, in the central part of the area:

Normal monthly, seasonal, and annual temperature and precipitation at Las Vegas

(Elevation 2,033 feet)

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1898)	Total amount for the wettest year (1915)	Snow, average depth
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	41.0	91	12	0.36	0.20	0.75	1.8
January	41.8	80	8	.85	.51	1.73	.1
February	47.2	79	10	.57	.08	1.19	.2
Winter	43.3	91	8	1.78	.79	3.67	2.1
March	52.4	96	16	.37	T.	.40	T.
April	59.8	102	26	.30	.00	.20	.0
May	66.9	114	28	.19	.20	1.40	.0
Spring	59.7	114	16	.86	.20	2.00	T.
June	75.7	112	35	.14	.20	T.	.0
July	81.7	115	40	.64	.05	1.88	.0
August	80.0	112	47	.50	.40	.01	.0
Summer	79.1	115	35	1.28	.65	1.89	.0
September	74.4	108	38	.38	.00	.10	.0
October	61.6	100	29	.24	.00	.00	.0
November	49.5	87	14	.28	T.	.75	.0
Fall	61.8	108	14	.90	T.	.85	.0
Year	60.5	115	8	4.82	1.64	8.41	2.1

The heat of summer is not oppressive owing to the low humidity, and heat prostration is seldom if ever experienced. The high elevation and consequent rare atmosphere contribute to the quick dissipation of the midday heat, and nights are seldom too warm for pleasant rest. The winter days are generally warm and pleasant, though the nights are rather cold. The coldest weather generally is experienced with a north or northwest wind blowing from the snow-capped mountains bordering the area. During the spring,

winds of high velocity, from the south and frequently from the north, sweep over the valley carrying much sand and dust.

The earliest recorded frost in the fall at Las Vegas occurred on October 16, and the latest in the spring, May 12. The average date of the last in the spring is March 30, and of the first in the fall November 7, giving an average growing season of 222 days. Cattle are pastured on the open range throughout the year, and in the central part of the valley many of the hardier vegetables are grown during the winter months without damage from cold.

AGRICULTURE

Since the beginning of recorded history[1] in the region now known as southern Nevada, agriculture has been carried on in a primitive way by the Indian tribes inhabiting the region. About 1770 Spanish padres under the direction of Father Junipero Serra were sent out to explore this region, and traveled up the Colorado River to a point known as the Big Bend, several miles above the proposed site of the Black Canyon Dam. From here exploring parties were sent out in search of mines and agricultural lands. Hearing from the Indians of a country to the west, where Indian corn, sugar cane and wild grasses were grown, they journeyed up the present Las Vegas Wash and into the valley near its head, which they called Las Vegas, meaning "The Meadows," because of the wild grasses found in localities of more plentiful water supply.

Later came other explorers, traders and trappers, the explorers including General Fremont, Kit Carson, and Goedy, who passed through this region in 1842. In 1849 Captain Hunt took the first wagon train through the Las Vegas Valley, traveling from Salt Lake City to southern California. A part of this expedition, dividing at Las Vegas, attempted to reach California by way of Death Valley; but many died from exposure to the intense desert heat of the region, and few escaped.

The first definite attempt at settlement was made in the valley about 1850, when a band of Mormons constructed an adobe fort and dwellings, the ruins of which still remain near the site of the present town of Las Vegas. This settlement prospered, growing grain and such fruits as peaches and apples. About 1856 the first smelter erected west of the Missouri River was operated here to extract lead from ores from the Potosi mine. In 1857, however, Brigham Young recalled the settlers into Utah to repulse United States troops. For several years following this the valley was abandoned. A prosperous settlement that had sprung up in the Moapa Valley to the north and was producing grain, sugar cane, cotton, and tobacco, was also abandoned about 1870 owing to a dispute over taxes between the Mormon settlers and the local county officials.

Following the exodus of the Mormons from this region, cattle raising came to be the dominant industry, many large herds being pastured on the open ranges of the valley and in the mountains. In March, 1885, the State land act became law, giving to the public the opportunity of buying 640 acres of land at $1.25 an acre, by paying

[1] The writer is indebted to Mrs. Helen J. Stewart, a resident of this valley since 1882, for information pertaining to early history.

25 cents an acre down and the balance in 25 years with interest at 6 per cent. Unoccupied State land can still be procured in the valley at this price, while school land is slightly higher, ranging around $10 or more an acre, depending on location and character of the soil. Under the inducement of cheap lands, agriculture again took on a permanent aspect, several plantings of grapes, apricots, peaches, and plums being set out, some of which are still producing. About 1882 alfalfa came to be grown more extensively on the better developed lands, and with the discovery of artesian water in 1906 its production became the dominant industry. Further stimulus was also given to agricultural development by the building of the San Pedro, Los Angeles & Salt Lake Railroad (now the Union Pacific) in 1904.

At the present time some fruit is produced in excess of local needs and finds a ready market in near-by towns and mining camps. Alfalfa is produced on the majority of the irrigated ranches and all surplus hay is sold to supply local demands. It is estimated that about 500 acres in the valley are devoted to alfalfa, which produces on an average about 6 tons per acre. Fruits produced in excess of home needs amount to about 3,000 boxes of peaches annually, 800 boxes of apricots, and 20 tons of grapes. With more mature development of bearing orchards, and with the bringing into bearing of young plantings, it is expected production will be materially increased. Some cherries, apples, figs, and plums are grown for home use and for market. Vegetables are produced in a small way for market, but not in sufficient quantity to supply local needs. Sweet potatoes do well. Blackberries and raspberries succeed. A large planting of figs made recently in the valley should add materially to the output in the near future. Dairy cattle are kept on several ranches in the vicinity of Las Vegas and supply the local demands for milk and cream.

Alfalfa fields are scarified to improve the stand, and in localities of poor stand some reseeding is necessary. No attempt is made, however, to rotate crops, alfalfa occupying the ground as long as a good stand is maintained, when the field is plowed and reseeded. Orchards are given clean cultivation; a few attempts have been made to grow alfalfa and sweet clover as cover crops, though with but slight success.

More livestock and poultry could no doubt be kept with profit. Although excellent markets are available for all surplus hay produced in the valley, the feeding of alfalfa to dairy or beef stock should prove more profitable than marketing it from the ranch. In addition, the manure thus made available would aid greatly in maintaining the yields of alfalfa and other crops.

Some labor is employed on the larger ranches during the summer season and on a few of the dairy ranches throughout the year. Most of the laborers are American born. Milkers are paid $80 to $90 a month and board, and men employed on alfalfa ranches receive $40 to $50 a month and board. The farms are operated largely by the owners, though a few are operated by tenants.

Improved land values vary widely, depending on the extent of improvements and location. The better ranches are held at $200 to $400 an acre, and land in bearing orchards is held at $600 an acre or more. The improved ranches are small, varying from several acres to 60 or 80 acres.

SOILS

Under arid conditions, such as prevail in the Las Vegas Valley, there is but little leaching away of the soluble constituents of the soils, and this is confined mainly to translocation of the soluble materials from the surface soil to the subsoil. In the more recently deposited soils of the valley the time has been too short to show any consistent effect of leaching, but in the soils of greater age the effect of a downward leaching becomes evident in several ways. The least noticeable is that in which the surface soils have had their content of lime carbonate slightly reduced by leaching to lower levels and where the subsoils show slight or hardly evident changes in lime accumulation, structure, or color. In the progressively older soils, the effects of longer leaching and internal weathering are evidenced by the development of subsoils that are more or less firmly cemented with lime or contain nodular and concretionary deposits of lime, by heavy calcareous coatings upon the stone and gravel, and by the development of consistent structural horizons.

In the Las Vegas Valley the geological material from which the soils are now developing, the various soils in the area having reached various stages in their development, consists of (1) alluvial-fan deposits of various ages, but all relatively recent, and (2) recent alluvial sediments. From each of these kinds of material several soils have been developed. A soil series includes all soils that are similar in essential profile characteristics, including color, the number, character, and relative thickness and relative arrangement of the several horizons and the same petrographic character of underlying geological material. Each series consists of a number of soil types. The soil type is the unit of classification and mapping and is differentiated from other types within the same soil series by differences in texture or the relative proportions of the mineral particles of various sizes. The soil type is designated by name and indicates both the series and the texture of any particular area of soil.

Two miscellaneous types of nonagricultural character are mapped.

The parent materials of the soils of this survey have been derived mainly from sedimentary rocks in which limestones and other calcareous rocks predominate. Basaltic rocks and soil materials therefrom occur locally in the southern part of the area.

Owing to the arid climate under which these soils have developed they are characterized by a high content of calcium carbonate in either surface soil or subsoil, or both.

In this region, with normal soil development, particularly in soils having a high content of certain kinds of soluble salts, the virgin areas are characterized by a "desert crust and mulch" structure in which the soil profile is represented by a number of more or less distinct structural horizons. Following rains the surface structure is largely destroyed, but with rapid drying out under the desert sun, a slightly cemented crust is formed over the surface, varying in thickness with climatic conditions, soil texture, and quantity and character of the soluble salts present. Immediately beneath this is a loose pulverulent mulch, usually made up of small spherical or granular soil floccules. This is most pronounced in areas of excessive alkali accumulation, in which the salts have been crystallized out and appear as minute glistening crystals throughout the mulch

layer. Under the mulch there is generally a comparatively friable horizon, more or less leached of salts and lime. In the more mature soils this grades into a more compact horizon in which occur seams and soft nodules of lime carbonate. This is underlain in the older soils by a layer with high concentration of lime carbonate, which in some soil series has developed a firmly cemented hardpan.

In the older soils occupying the upper slopes of the valley an advanced stage in weathering is indicated by a firmly cemented and massively developed gravel hardpan, in which lime carbonate forms the cementing agent. This hardpan may lie at a shallow depth, and in some exposures it has a depth of 10 feet or more. On the lower lying slopes nearer the basin of the valley these older soils are commonly without embedded gravel and are locally underlain by gray, fine-textured hardpan formations in which lenses or plates of calcareous hardpan alternate with gray, highly calcareous, gypsiferous deposits of clayey material high in soluble salts. Throughout the deposits of the older materials in the central and lowest part of the valley are found soils very high in gypsum and lime, without firmly cemented lime-carbonate hardpan, but including gypsiferous hardpan layers which are more or less permeable to plant roots and which become soft and mushy after continued wetting. The soils of this older valley-filling group are classified in the Las Vegas, Bracken, and Reeves series.

The types of the Las Vegas series are characterized by light brownish gray to light grayish brown soils, in many places showing a pronounced pinkish cast. The upper subsoil consists of light brownish gray or gray highly calcareous material which is very compact in the upper part and becomes increasingly compact and partly cemented with depth. Gray caliche or hardpan fragments are numerous throughout the surface soil and upper subsoil. At depths of 10 to 30 inches there normally appears a gray lime-cemented hardpan, generally of somewhat soft structure in the upper part but firm and densely cemented below. In the lower part of the valley and on the lower fan slopes the deeper substratum consists of gray, highly calcareous material, containing in places gypsum and fragmentary plates or lenses of lime hardpan. On the upper fans the hardpan generally consists of firmly cemented gravel and cobble which may continue to 6 feet or more without change or may be underlain by compact material partly cemented and containing occasional zones of true cemented hardpan. In this locality the soil profile consists of 40 per cent or more of gravel and stones. The Las Vegas series is derived chiefly from material of limestone origin, though it contains some sandstone and also acidic rocks of igneous origin. The series occurs both on the upper and lower fan slopes and is locally badly dissected and eroded along the bluff lines bordering the valley. Except in the vicinity of drainage ways the surface is smooth and sufficiently sloping to insure good to fair surface drainage; subdrainage is in places retarded and alkali salts have accumulated. The Las Vegas loamy fine sand, gravelly fine sandy loam, and loam types, with several subordinate phases, are mapped.

The surface soils of the Bracken series are light brown to brown, usually with a shade of pink or red, and when wet are generally dis-

tinctly reddish brown. The subsoil, which is generally encountered at depths of 10 to 20 inches, consists of brownish-gray or light pinkish gray, compact, heavy-textured material containing large quantities of gypsum—in places 40 per cent or more of the soil mass. Lime is abundant throughout, and gypsum crystals appear on the surface. A soft gypsiferous hardpan occurs locally in the subsoil at depths ranging from 24 to 40 inches or more. In places a firm lime-cemented hardpan underlies the soils, generally at depths greater than 50 inches. The soils of the Bracken series are of mixed origin and have been accumulated or modified under conditions of poor drainage. They are among the older soils of the area and in many places have been badly eroded. The topography is generally rolling, though in some places it is smooth and gently sloping. Drainage of the surface soils is now generally good, but subdrainage in many places is restricted. Alkali is of widespread occurrence throughout the soils of the series. Two types of this series are mapped, the Bracken gravelly fine sandy loam and clay loam, the latter including a rolling phase.

The types of the Reeves series are characterized by brownish-gray to light-brown soils, commonly with pale-reddish or pinkish tinge. The subsoil consists of gray, light-buff, pale-salmon, or whitish, chalky material, high in lime carbonate and gypsum, the latter in crystal form. This layer is locally underlain by gypsum hardpan, which is hard when dry but softens under irrigation. Crust and mulch horizons are usually developed in the surface soil, and well-rounded gravel and cobblestones may occur as a surface veneer or "desert pavement" or embedded in the soil material. Fragments of the caliche or hardpan are scattered over the surface in many areas, apparently having been brought up by burrowing animals. The material from the surface down is rich in carbonates, always effervescing freely with dilute hydrochloric acid. The Reeves loamy fine sand, with a rolling phase, is mapped in this area.

A second group of old valley-filling soils includes the soils of the Tonopah and Arden series. In these series the concentration of lime carbonate and gypsum cementation and compaction are not so marked as in the soils of the preceding group. The soils have commonly a well-developed profile consisting of a slightly cemented surface crust, a subsurface mulch, and an underlying zone of moderately friable material that grades into a more compact horizon in which soft seams and nodules of lime carbonate have accumulated. Beneath this is a very compact and frequently slightly cemented layer of heavier texture in which gravels and cobbles are completely lime coated, whereas in the material above the lime coating is generally less well developed and frequently covers only the under part of the gravels. In this lower material the structure is also more platy, the seams of lime frequently forming horizontal lines or planes in contrast to the more vertical ones in the upper sections. The depth to this horizon depends largely on the amount of rainfall occurring at any given elevation, a higher precipitation resulting in a more complete leaching of the surface and consequent deeper development of the lower zones of clay and mineral accumulation. The lower horizon to a depth of 6 feet is generally moderately compact but of fairly open structure.

The types of the Tonopah series are characterized by light grayish brown to pale reddish brown, calcareous surface soils, which are comparatively friable to a depth of 14 inches or more. In many areas the surface soil contains 50 per cent or more of gravel; on the upper fan slopes waterworn cobblestones are abundant, and the proportion of coarse material to fine is even higher than near the lower edges of the fans. Below 14 inches the soil material becomes more compact with depth and generally has a paler reddish brown color, the result of higher lime content. At a depth of 24 inches, or more in the case of the points of higher elevation and greater rainfall, the material is extremely compact and in many places partly cemented, the gravel and cobbles are completely lime coated, and the proportion of coarse material to the finer interstitial material is slightly greater than in the surface soils. Below the horizon which contains the accumulated products of soil weathering there is a zone extending to 6 feet or more which is slightly less compact and shows less cementation. The gravel fragments and stones, which constitute 60 per cent or more of the mass, are not so completely coated with lime as in the upper horizon. As mapped the series includes small areas in which a gravelly lime-cemented hardpan is found underlying the soil material at depths of 50 inches or more. Much younger material, in which slight modification of the soil profile has developed since deposition, has also been included as variations. The soils of the Tonopah series are derived largely from limestone, sandstone, and basaltic rocks, and to a minor extent from rhyolite, and granite. The series occupies the upper alluvial-fan slopes, but extends well down the slopes and into the central part of the valley in the vicinity of the larger drainage ways. The surface is steeply sloping and somewhat dissected on the upper fan slopes, though in general it is smooth and gently sloping, especially near the base of the fans. Owing to the porous character of the soil material, it is everywhere excessively drained and supports only the hardy desert shrubs. The Tonopah gravelly loamy sand, stony sandy loam, and gravelly sandy loam types are mapped, as well as eroded phases of the last two.

The surface soils of the Arden series consist of a surface crust one-fourth inch or more in thickness of light grayish brown to light reddish brown, calcareous material, which is generally of a vesicular structure. Under the surface crust there is generally a layer of 2 inches or more of reddish-brown mulchlike material of granular structure, which passes abruptly into material of slightly compact structure but practically the same color. At an average depth of about 14 inches the subsoil becomes more compact and has a lighter grayish brown color due to the presence of much lime. Below this the material is less compact and generally has a browner color owing to a slightly lower lime content. The topography is for the most part gently undulating or slightly rolling, though dissected and eroded here and there along the larger drainage ways. Both the surface soil and subsoil are well drained and free from alkali. The Arden loamy fine sand and a rolling phase of this type are mapped.

A third group of soils on the alluvial fans includes those in which the normal development of soil horizons has not taken place, probably because of restricted subdrainage and a resultant high water table. Such soils have a less well-defined zone of accumulated

products of soil weathering. They are characterized by heavy, plastic, deeper subsoils, generally gray and highly calcareous, or with a greenish tint, the result of poor aeration and oxidation. Soils of this character have been classed in the Pond and Spring series.

The soils of the Pond series, as occurring in previous surveys, are characterized by light-gray or light brownish gray calcareous surface soils, which have a darker or more pronounced brown color under moist field conditions. The subsoil is gray to brown in color, generally compacted, and contains mottlings and nodular accumulations of lime, but is without well-defined cemented layers. In the present survey, the material classified in this series has accumulated in areas of restricted drainage, and has a much higher content of organic matter and a darker color than the typical Pond material. In this survey the series is therefore represented only by a dark-colored phase of the Pond soils. One type, the Pond silty clay loam, dark-colored phase, is mapped. It is confined largely to areas around the base of small mounds occupied by springs, or to drainage ways which have a perennial flow of water at or near the surface sufficient to support a comparatively good growth of native shrubs or grasses. The soil is somewhat affected with alkali. Subdrainage is restricted, but surface drainage is good.

The Spring series includes soils with light-pinkish or purplish-gray to brown, calcareous soils. When wet the soils have a reddish-brown color. The subsoil to an average depth of about 36 inches consists of more or less stratified calcareous material ranging in color from light grayish brown to light reddish brown. At depths of 36 to 40 inches the subsoil generally becomes much heavier in texture and is light brownish gray or light grayish brown in color; it is generally rather compact and contains occasional seams or mottlings of gray lime concentrations. A bed of gray clay or clay loam, which is the distinguishing feature of the series, is encountered at depths generally not greater than 50 inches. In most places the water table is high and the gray subsoil material is waxy, plastic, and rather impervious, though without cemented hardpan. The series is of mixed origin, and has developed in areas in which subdrainage is now or has been restricted. The surface is smooth and gently sloping. Owing to subsoil conditions, alkali salts are generally present in rather high concentration. The Spring clay loam and the Spring fine sandy loam, with an alluvial phase, are mapped.

Associated with the soils of the more mature profile, especially in the vicinity of drainage ways and in local depressions in which soil material has accumulated in recent times, is found a fourth group of soil materials. These are characterized by permeable surface soils and subsoils in which only a slight modification in profile has taken place since deposition. As distinguished from the recent-alluvial soils, they generally show a slight change in color of soil and subsoil material, owing to oxidation, and a slight compaction and grayer color in the horizon which receives the products leached from the surface. Soils of this character have been classed in the Land series.

The Land series consists of types with light grayish brown to light-brown calcareous surface soils that have a distinct purplish or pink-

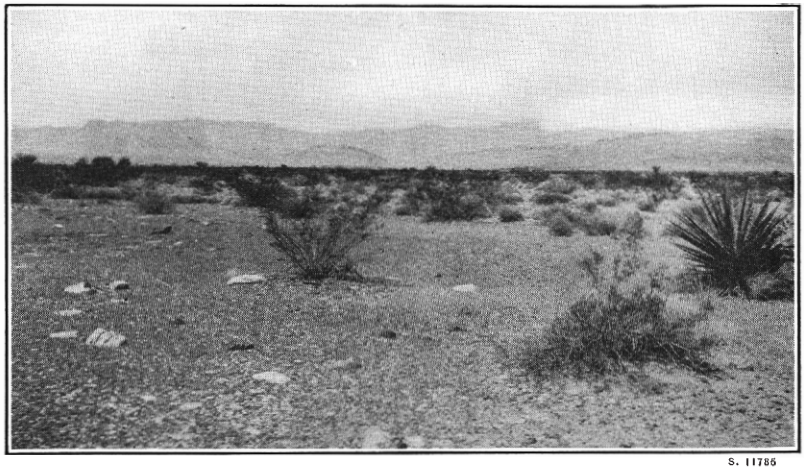
ish tint, resting upon a stratified, calcareous subsoil of the same general character of material but of somewhat grayer color and higher lime content. Under virgin desert conditions a surface crust, 3 inches or more in thickness, overlies a zone of loose, fluffy material high in salts, which grades into speckled or mottled material of granular structure. At depths of 15 inches or less the material is still granular but somewhat more compact and without mottling. Generally at depths of 45 inches or less the material becomes more compact and usually heavier in texture and in places is marked with gray mottlings caused by accumulations of lime. Locally this is underlain by a deeper horizon of more friable character. The series consists of valley-filling soils that have undergone little internal modification from weathering since deposition, though in general sufficient weathering has occurred to differentiate them from the recent-alluvial soils, which are still in the process of accumulation. The Land series is of mixed origin, consisting of soil material that has been reworked to a considerable extent, much of it having been carried from the old higher lying lake or playa deposits, and also mixed to a considerable extent with more recent wash from the higher fans issuing from canyons in the bordering mountains. The topography is smooth except for occasional local washes or sand dunes. The slope is generally sufficient for a free movement of water over the surface, though alkali salts are present in greater or less quantities. The Land fine sandy loam, with heavy and dark phases, and the Land clay loam are mapped.

In areas of comparatively flat topography, which receive run-off from the higher slopes, soil material carried in suspension is in process of accumulation. The soils of such areas are generally stratified owing to alternate deposition of coarse and fine materials, but modification of the soil profile through leaching and weathering of the upper sections has not taken place. No difference in color between soil and subsoil as a result of oxidation of the upper zone is noticeable, the colors being those of materials of different origin. These soils consist of recently deposited alluvial materials. They have been identified as members of the Gila series.

The surface soils of types of the Gila series consist of light grayish-brown to light-brown, calcareous material, with a pinkish tint in places, which grades imperceptibly into the stratified subsoil consisting of the same general character of soil material. The series is confined to localities of gently sloping topography in which sediment-burdened waters are at infrequent intervals depositing their load of suspended material. The surface is smooth except for the shallow drainage ways that carry away surplus water in times of storm. The soils of the series are variously affected with alkali, which has accumulated as the result of imperfect underdrainage. The Gila loam, gravelly fine sand, and very fine sandy loam, with a red phase, are mapped in the area.

Two types of miscellaneous materials, which are essentially non-agricultural, have been mapped in this survey. The Rough stony land includes areas that have a very rough and broken topography or are very stony. Dunesand includes areas of wind-drifted sand.

The soil types are described in detail in subsequent pages of this report. Their distribution is shown on the accompanying soil map.



S. 11785

FIG. 1.—CHARACTERISTIC TOPOGRAPHY, NATIVE VEGETATION, AND DESERT PAVEMENT ON THE LAS VEGAS GRAVELLY FINE SANDY LOAM

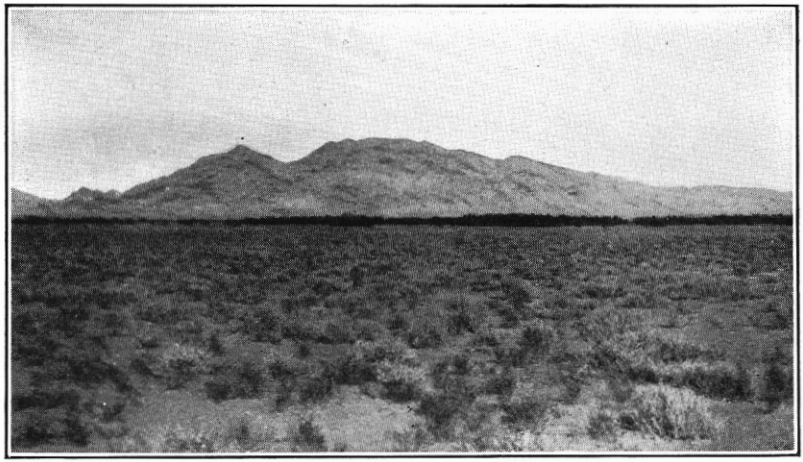


FIG. 2.—CHARACTERISTIC TOPOGRAPHY AND VEGETATION ON SOILS OF THE LAND SERIES. MUDDY MOUNTAINS IN DISTANCE

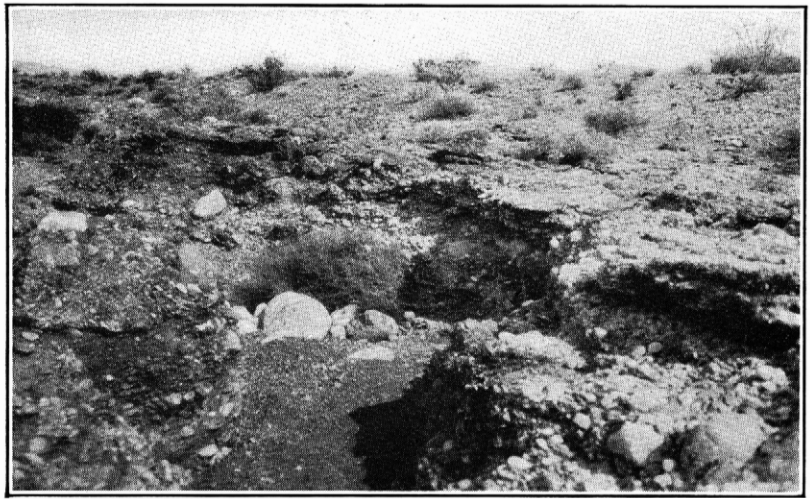
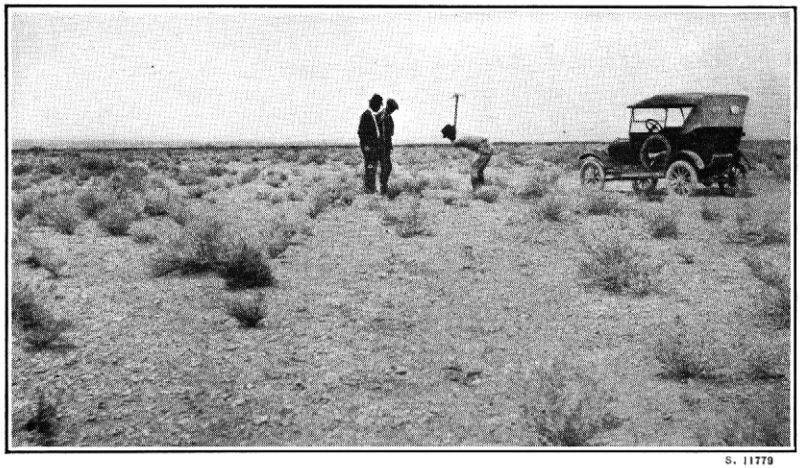


FIG. 1.—EXPOSED HARDPAN IN THE LAS VEGAS GRAVELLY FINE SANDY LOAM



S. 11779

FIG. 2.—TOPOGRAPHY AND VEGETATION ON THE LAS VEGAS LOAM

The table following shows the actual and relative area of each soil mapped:

Areas of different soils

Soil	Acres	Per cent	Soil	Acres	Per cent
Las Vegas loam	10,944		Spring fine sandy loam	3,840	
Eroded phase	18,688	18.8	Alluvial phase	1,536	2.7
Fragmental-hardpan phase	5,312		Las Vegas gravelly sandy loam, reddish phase	4,672	2.4
Alluvial phase	1,920		Land clay loam	4,544	2.3
Las Vegas gravelly fine sandy loam	19,712	13.5	Bracken gravelly fine sandy loam	4,032	2.0
Shallow phase	6,976		Gila very fine sandy loam	3,328	
Las Vegas loamy fine sand	15,872		Red phase	512	2.0
Heavy phase	7,680	12.9	Bracken clay loam	1,600	
Gravelly phase	1,856		Rolling phase	2,112	1.9
Gila gravelly fine sand	21,632	11.0	Tonopah stony sandy loam	1,664	
Reeves loamy fine sand	5,312	5.1	Eroded phase	448	1.0
Rolling phase	4,736		Arden loamy fine sand	1,024	
Land fine sandy loam	4,096		Rolling phase	832	.9
Heavy phase	4,608	5.1	Dunesand	1,728	.9
Dark phase	1,344		Pond silty clay loam, dark-colored phase	1,728	.9
Spring clay loam	9,472	4.8	Rough stony land	384	.2
Tonopah gravelly sandy loam	7,936	4.7			
Eroded phase	1,472				
Gila loam	7,808	4.0			
Tonopah gravelly loamy sand	5,760	2.9	Total	197,120	

LAS VEGAS LOAMY FINE SAND

The surface soil of the Las Vegas loamy fine sand consists of 8 to 12 inches of light grayish brown calcareous loamy fine sand which has a distinctly reddish or pinkish cast, giving to the soil a light reddish brown color when wet. This reddish cast is developed more prominently in this type than in most of the other types of the series. A veneer or "desert pavement" of gravel and caliche fragments occurs over the surface, giving the type the appearance of a gravelly soil, though but little gravel is found in the upper 12 inches of soil. The subsoil consists of a light-gray clay loam which is very compact, becoming more compact and partially cemented with depth. Seams of lime extend downward through the upper subsoil, giving it a slightly columnar structure. At depths generally not greater than 30 inches is found a gray, fine-grained, firmly cemented lime-carbonate hardpan, which is impervious to all root or water penetration except in joints or cracks. In places the hardpan formation consists of a zone, a foot or two in thickness, composed of numerous plates or lenses of cemented material, but in the more prominently developed areas the hardpan consists of 12 to 14 inches of densely cemented fine-textured material. The deeper subsoil, as exposed in cuts, consists of gray, highly calcareous clay or clay loam, in which are embedded numerous more or less continuous plates of hardpan. The underlying material is almost without exception very high in soluble salts.

The type is extensively developed along the lower slopes of the alluvial fans west and south of Las Vegas and in the vicinity of Bracken. Several large areas occur along the south side of the Las Vegas Wash to the south and southwest of Grapevine Springs. Several small areas lie in the vicinity of Valley and elsewhere in the northeast corner of the survey. Three small areas located about 6 miles northwest of Las Vegas have a surface soil of somewhat

coarser sandy texture, but were not differentiated on the map owing to their small extent.

The topography is generally smooth and gently sloping, but in places it is slightly undulating to rolling, especially where the type merges into areas of eroded soils. Surface and subsoil drainage are generally well established, although alkali salts have accumulated in a few places. The type would be poorly adapted to irrigation owing to its shallow depth and droughty character.

The Las Vegas loamy fine sand is largely of limestone origin, but contains some material derived from crystalline igneous rocks. The hardpan formation owes its existence to long periods of weathering in which lime leached from the surface soil has been carried into the subsoil to the point of average penetration of the rainfall of the region. There it has been deposited first as a coating on the rock fragments and finer soil particles, and with each successive wetting additional deposits from solution have finally united the soil particles at this point into a firmly cemented hardpan.

The native vegetation is generally of a stunted character. The type has little or no agricultural value; none of it is under cultivation, and it is not well adapted to crop production because of its shallow character. The type is sold at $5 to $10 or more an acre, depending on location and the character of the adjoining soils.

Las Vegas loamy fine sand, gravelly phase.—The gravelly phase of the Las Vegas loamy fine sand has a surface soil of 8 to 14 inches of light brownish gray to light grayish brown, calcareous, gravelly, loamy fine sand. The subsoil is a light grayish-brown or brownish-gray clay loam, containing a great quantity of caliche fragments, which increase in number with depth. Directly over the true hardpan there is generally a soft, platy hardpan which may be 6 to 8 inches or more in thickness. The hardpan is usually encountered at depths of more than 40 inches, in contrast to the much shallower depth of 30 inches or less at which it is found under the typical Las Vegas loamy fine sand.

The phase is of small extent, being developed only in the northwestern part of the area surveyed. It generally borders the higher areas of gravelly soils where slight accumulations of gravelly material are distributed over the surface at infrequent intervals. The largest area of the phase is 8 miles northwest of Las Vegas, between a higher area in which the material is of recent deposition, and lower bodies of typical Las Vegas soils. One small area lies just east of the larger one, and three areas occur several miles to the northeast.

The gravelly phase is well drained and should prove somewhat better adapted to irrigation than the typical soils of the Las Vegas series.

At present the phase has no agricultural value aside from the grazing it affords, and none of it is under cultivation.

Las Vegas loamy fine sand, heavy phase.—The surface soil of the Las Vegas loamy fine sand, heavy phase, generally consists of 8 to 12 inches of light brownish gray or light grayish brown, calcareous fine sandy loam, which contains occasional fragments of caliche. The subsoil to an average depth of 45 inches consists of grayish-brown or brownish-gray, heavy loam, or clay loam, in which are embedded numerous fragments of caliche. With depth the frag-

ments increase in number, and for several inches above the hardpan they are platy, but soft and easily broken with a pick or shovel. The lower subsoil or substratum consists of gray, fine-textured, firmly cemented hardpan. The phase differs from the typical Las Vegas loamy fine sand in the somewhat heavier texture of the surface soil and the greater depth of soil overlying the hardpan formation.

In an area of the phase about 6 miles northwest of Las Vegas in section 11, T. 20 S., R. 60 E., and in two other areas, one in section 31, T. 19 S., R. 61 E., and the other mainly in section 6, T. 20 S., R. 61 E., the surface soil is a loam. Otherwise these areas have the same characteristics as other bodies of the heavy phase of the Las Vegas loamy fine sand.

Aside from the areas mentioned, the phase is extensively developed in the northern and northwestern parts of the survey. Several fairly large areas are in the vicinity of Tule Springs and east and southeast of that point. Several areas of smaller size are northwest of Las Vegas, associated with other old valley-filling soils near the base of the fans or below the bluff lines. Small areas of irregular outline are found north and northwest of Wann and southeast of Valley. The phase is of mixed origin, but is composed largely of material weathered from sedimentary rocks, particularly limestones.

The topography varies from smooth and gently sloping to slightly undulating. Surface drainage is well developed, and if water were available the phase would be somewhat better adapted to cultivation than the shallower soils of the Las Vegas series.

In the vicinity of drainage ways stunted growths of cat's-claw are found, but desert brush constitutes the greater part of the native vegetation. The phase has a slightly higher value for agriculture than the typical Las Vegas loamy fine sand, and is held at $5 to $15 an acre, depending on location.

LAS VEGAS GRAVELLY SANDY LOAM, REDDISH PHASE

The Las Vegas gravelly sandy loam is represented in this area only by the reddish phase of the type. This phase differs from the typical soils of the Las Vegas series in the more pronounced reddish color of the surface soil, in which it approaches the soils of the related Pinal series as recognized in previous surveys.

The surface soil to a depth of 8 to 12 inches is pronounced reddish brown to pale red in color, but in some areas the color approaches a brownish red. On the surface the soil color often appears to be light reddish brown, or light brown in which a red tint is noticeable; upon wetting, however, the soil color is distinctly brownish red or red. The upper subsoil to a depth of 18 to 40 inches, with an average depth of 30 inches, is a gray, gravelly sandy loam in which a distinct pinkish shade is perceptible. The material is highly calcareous, compact, and slightly cemented. The compaction and cementation increase with depth until the gray, gravelly, lime-cemented hardpan is encountered. The hardpan formation may continue uniform to depths of 6 feet, as is generally the case on the upper fans or may in places rest upon compact, gray, gravelly loam or sandy loam containing numerous zones or plates of material cemented to varying degrees of hardness. Both surface soil and subsoil are extremely gravelly often having 60 per

cent or more of gravel in the mass. On the upper slopes, cobbles and bowlders are of frequent occurrence. In the vicinity of drainage ways there is in places a coating of recent material over the surface and the texture is a loamy sand or sand.

The Las Vegas gravelly sandy loam, reddish phase, is rather extensively developed in the vicinity of Arden and north and northeast of that point. Small areas lie northwest of Pierce, southwest of Bracken, 4 miles west of Las Vegas, and at Bard. In general the phase occupies the lower alluvial-fan slopes on which considerable material from the higher lying areas has accumulated over the hardpan since its formation. The surface is smooth and gently sloping, promoting good drainage and a consequent freedom from alkali salts.

The phase is of mixed origin, though it is probable that limestone and sandstone have contributed most largely to the soil material. Red sandstone, which is exposed in various places at the foot of the Spring Mountain Range, has contributed largely to the brighter shades of color.

This soil has low grazing value. The native vegetation consists of low-growing desert shrubs, as well as creosote bush and cat's-claw, the latter being found only in the vicinity of drainage ways. The soil is not under cultivation, and it is not adapted to agriculture owing to its shallow, droughty character.

LAS VEGAS GRAVELLY FINE SANDY LOAM

The surface soil of the Las Vegas gravelly fine sandy loam consists of 8 to 15 inches of light grayish brown to light brownish gray, calcareous, gravelly fine sandy loam, which has a pinkish cast under dry field conditions but assumes a light-reddish tint when wet. Cobbles and bowlders are numerous on the surface of the type, especially in the vicinity of stream courses on the upper fan slopes, where a desert pavement of gravel is frequently developed. Here the texture may also vary somewhat toward a sandy loam or occasionally a loamy sand. In the upper subsoil the gravels are completely lime coated and the soil material consists of light grayish brown or brownish-gray fine sandy loam, which is very compact and partially cemented. The lower subsoil consists of a dense, firmly cemented gravel hardpan which generally continues to 6 feet or more without change. (Pl. 6, fig. 1.) Where less prominently developed, the hardpan is underlain by very compact and partially cemented material containing gravel and bowlders which are completely lime coated. The surface soil contains a relatively high percentage of gravel generally an inch or more in diameter. The lower part of the soil profile, however, generally contains more than 60 per cent of gravel, cobbles, and bowlders. In the southeastern part of the area, the soil of this type is darker in color, being dark grayish brown or dull brown.

The Las Vegas gravelly fine sandy loam is an extensive type, being prominently developed in all parts of the area along the upper alluvial-fan slopes. Some of the largest areas are west and southwest of Las Vegas and west and northwest of Arden. Other large areas are in the vicinity of Valley and Tule Springs, and south, southeast,

and southwest of Grapevine Springs, in the southeastern part of the survey.

The type occurs on alluvial-fan slopes of gently to steeply sloping topography. The surface is generally smooth, except for the deeply entrenched beds of larger stream courses and the shallow courses of smaller streams. The surface drainage is excessive.

Owing to its shallow character, this type has no present value for agriculture. It supports all varieties of native vegetation found in this region, but their growth is always of a stunted nature. The value of the land rests largely on its pasture qualities, which are very low.

Las Vegas gravelly fine sandy loam, shallow phase.—The shallow phase of the Las Vegas gravelly fine sandy loam consists of 4 to 6 inches of light grayish brown gravelly fine sandy loam overlying a densely cemented gravel hardpan. In many places hardpan is exposed over large areas with only occasional depressions containing a soil mantle. The hardpan is of massive development, being exposed in stream cuts to depths of 15 feet or more, and consists of very firmly cemented sand, gravel, and bowlders.

The phase has developed under normal conditions of soil weathering, but since the formation of the hardpan the surface covering of soil has been largely removed by erosion, only a few areas being found with sufficient soil covering for hardy desert plants to establish a foothold.

Several areas embracing about 11 square miles are mapped along the western boundary of the survey. The largest area lies 3 miles northwest of Pierce; smaller areas are found 7 miles west of Las Vegas and 2 miles west of Tule Springs. Drainage is excessive. The phase is valueless.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of the typical Las Vegas gravelly fine sandy loam:

Mechanical analyses of Las Vegas gravelly 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*
530245	Soil, 0 to 12 inches	2.4	4.3	2.3	28.4	36.7	17.3	8.5
530246	Subsoil, 12 to 18 inches	4.5	4.6	2.2	22.8	33.7	22.4	9.7

LAS VEGAS LOAM

The surface soil of the Las Vegas loam as typically developed consists of 6 to 12 inches of calcareous light grayish brown or pale-brown loam, which has a pinkish or reddish cast. As mapped, however, some material of both lighter and heavier texture is included. In general this type has a grayer color than the lighter textured types of the series. The upper subsoil to an average depth of about 20 inches consists of brownish-gray or grayish-brown, highly calcareous loam, which is very compact and contains occasional plates of gray softly cemented clay caliche. This is underlain by a gray, firmly cemented lime hardpan, which resembles the native limestone of the

region. The hardpan formation varies from 4 to 24 inches or more in thickness and is generally underlain by gray, highly calcareous material of heavy texture, which contains numerous plates or lenses of cemented material, and in nearly all cases contains a large quantity of soluble salts. Nodules or fragments of caliche are common on the surface, and in places there is a thin veneer of gravel.

In a few small areas in the southeastern part of the survey the color is somewhat darker than typical. In this vicinity the soil has been derived to some extent from basalt and has a slightly dark grayish brown color. On the line between sections 8 and 9, T. 22 S., R. 62 E., an area of the Las Vegas loam is mapped which has a texture heavier than typical and a chocolate-brown color. This area is claylike in character, and because of poor drainage is very high in alkali.

The Las Vegas loam is extensively developed throughout the northwestern part of the area. It also occupies some areas in the vicinity of Valley and Las Vegas and some small areas associated with other old valley-filling soils near the base of the alluvial fans and in other places of moderately sloping topography. The surface is generally smooth, with sufficient slope to promote fair surface drainage, though over the majority of the type alkali salts occur in varying degrees of concentration. Near the bluff lines that border the valley, and in the vicinity of drainage ways, the type has been badly dissected, and such areas have been mapped separately as an eroded phase.

The native vegatation consists of desert shrubs and other more or less stunted desert plants. (Pl. 6, fig. 2.) The type has a low value for grazing, and where cultivated is very droughty. Only one small area of the type is cultivated and that is utilized in connection with other better soils. Unimproved land of this type can be had for $5 to $10 an acre.

Las Vegas loam, eroded phase.—The eroded phase of the Las Vegas loam consists of eroded or dissected areas of the typical Las Vegas loam type. In such areas the surface soil is generally very shallow, as is also the upper subsoil horizon. In many cases hardpan is exposed over large areas, and in general the phase is so badly dissected as to preclude any possibility of cultivation. Small areas, generally comprising less than 10 acres, might possibly be cultivated, but because of the shallow soil such areas have little agricultural value. The surface soil varies in texture from sandy loam to clay loam, but the variations are of minor extent and are not mapped separately. The subsoil is exposed in many places and generally consists of heavy-textured gray material which contains a large amount of soluble salts.

The eroded phase of the Las Vegas loam is extensively developed in practically all parts of the survey. Some of the larger areas are southeast of Las Vegas, south of Grapevine Springs, in the vicinity of Bracken, and west and northwest of Wann.

Las Vegas loam, fragmental-hardpan phase.—The Las Vegas loam, fragmental-hardpan phase, has a surface layer of 8 to 12 inches of light grayish brown calcareous loam. This rests upon brownish-gray or light grayish-brown fine sandy loam or loam in which are embedded numerous fragments or plates of hardpan ma-

terial that are comparatively soft and are discontinuous. This material is permeable to plant roots and water, and generally extends to depths of 36 inches or more before encountering a firmly cemented gray hardpan. The depth to hardpan varies but is generally less than 54 inches. The phase is differentiated from the typical Las Vegas loam because of the large content of hardpan fragments and the greater depth of soil over the true hardpan. The hardpan under this phase is generally platy in character, some of the plates or lenses being 4 inches or more in thickness. The surface of the phase is nearly everywhere covered with fragments or nodules of caliche or hardpan fragments. In section 29, T. 20 S., R. 61 E., along the east side of the section line are areas of this phase which consist of a loam overlying hardpan at 40 to 48 inches, with but few fragments in the upper 36 inches of soil.

The largest areas of the fragmental-hardpan phase are north and northwest of Las Vegas. Areas of smaller size are found in the vicinity of Wann and west of Las Vegas. One small area lies near Tule Springs. The surface is smooth and only slightly sloping. Surface drainage is well developed, though comparatively poor subdrainage has resulted in slight accumulations of alkali in some areas.

In some cases the phase has received material from the higher lying areas in which a great number of hardpan fragments were present, and consequently the true hardpan occurs at greater depths than typical. In other places the upper hardpan plates appear to have been formed in place, but are of a soft and fragmental character, so that in most cases plant roots penetrate them with no great difficulty.

The native vegetation consists of creosote bush, rabbit brush, and various other forms of low-growing desert brush. A small part of the phase is under cultivation, being devoted to the production of grain and alfalfa. Unimproved land is held at less than $10 to $15 an acre, depending on location with respect to water supply.

Las Vegas loam, alluvial phase.—The alluvial phase of the Las Vegas loam consists of 10 to 18 inches or more of light-brown or light grayish brown, calcareous, friable loam of rather silty texture, which has a perceptible cast of pink. This surface material is of recent deposition and shows no effect of weathering or modification subsequent to deposition. Underlying this is a brownish-gray, heavier material, generally of loam or clay loam texture, which gives evidence of slight weathering and internal modification by the presence of blotches or seams of gray lime accumulation. At depths usually not greater than 24 inches the subsoil is a gray loam or clay loam, loosely cemented and containing many fragments of caliche. This rests upon true lime-cemented hardpan at depths of 40 to 60 inches. The phase differs from the typical Las Vegas loam in the younger and more friable character of the surface soil and the greater depth to hardpan.

The alluvial phase is of small extent, being confined to several bodies occurring in the northwestern part of the area. The largest body is 6 miles northwest of Las Vegas. A smaller one occurs in section 36, T. 19 S., R. 60 E., and extends southeastward about 2 miles. Other areas lie north and south of Tule Springs and north and northwest of Wann.

The phase occupies areas of comparatively flat topography in which the surface soils are being added to from year to year by deposition of material carried from other areas. The drainage of the phase is moderately well established. Alkali salts are found only in small quantities.

The native vegetation consists largely of creosote bush, which grows quite luxuriantly. Mesquite also grows quite well, especially near drainage ways. Scattering clumps of grass grow on the phase and give it somewhat better grazing value than the shallower soils with which it is associated. None of the phase is under cultivation, but with future development it should be found valuable in the production of vines, alfalfa, and grain, as well as some of the shallower rooted tree fruits. When sold the phase is held at about the same price or slightly higher than adjoining soils.

BRACKEN GRAVELLY FINE SANDY LOAM

The surface soil of the Bracken gravelly fine sandy loam consists of 8 to 12 inches of light grayish brown, calcareous, gravelly fine sandy loam, which, in common with other soils of this area, has a characteristic pink or reddish tint. The gravels range in size from those no larger than a pea to some 2 inches or more in diameter, and are angular in shape, having undergone but little modification during transportation from the adjacent mountain slopes. They are generally accumulated on the surface or confined to the surface material. On the upper alluvial-fan slopes cobbles and bowlders are not infrequently found in both soil and subsoil. The subsoil consists of a light-gray loam or clay loam, very compact and full of gypsum and lime. Gravels occupy in general about 40 per cent of the subsoil mass and are largely embedded in gypsum. A pinkish shade is developed in the subsoil when very much of the finer soil material is present. A cemented hardpan is developed locally in the type, generally at depths greater than 40 inches, but such areas have not been differentiated on the map owing to the difficulty in boring or digging in the compact gravelly material.

The type is confined almost entirely to the eastern part of the survey, where it occupies the lowest slopes of the fans at the base of the Muddy Mountains. In section 14, T. 21 S., R. 62 E., an area is mapped which is so badly eroded and dissected by stream ways as to make it totally unfit for agricultural development. In section 16, T. 20 S., R. 62 E., another area of rolling topography is mapped which has slight agricultural value owing to the difficulty that would be experienced in leveling it for irrigation. More typical areas lie 3 miles southeast of Valley, and others occur in isolated positions south of Valley. The largest area extends in an almost continuous body along the base of the fan slopes of the Muddy Mountains east of Las Vegas.

The topography varies from smooth and sloping to gently undulating. In all places drainage of soil and subsoil is well developed. The streams issuing from the mountains have in most cases cut deep steep-sided trenches, and in small local areas erosion has occurred to some extent.

The type has little agricultural value because of the gravelly character of the surface soil and the highly gypsiferous and gravelly

character of the subsoil. It also occupies a relatively unfavorable location with respect to known water supply. When sold in connection with other soils it has a depressing influence on their value.

The results of mechanical analysis of a sample of the soil of the Bracken gravelly fine sandy loam are given in the following table:

Mechanical analysis of Bracken gravelly fine sandy loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
530211	Soil, 0 to 10 inches	*Per cent* 1.4	*Per cent* 1.8	*Per cent* 1.9	*Per cent* 48.4	*Per cent* 20.5	*Per cent* 15.8	*Per cent* 9.4

BRACKEN CLAY LOAM

The Bracken clay loam, in the virgin condition, is characterized by a surface crust one-half inch or less in thickness, which is generally of a porous or vesicular structure. Under the surface crust the material has a granular mulch structure and contains crystals of salts. This passes abruptly at depths of 1 to 2 inches into a moderately compact, light-brown, calcareous clay loam, which has a distinct tint of pink. The crust and mulch formation is generally of slightly lighter texture and when dry has a pronounced shade of purple. The layers constituting the surface horizon have been leached to some extent of lime and other more or less readily soluble or decomposable minerals, which have accumulated in a lower horizon, generally at a depth of 7 to 15 inches from the surface. This horizon is of clay or clay loam texture and columnar structure, and has gray streaks or mottlings of lime and other minerals throughout. The third horizon, which contains a great deal of gypsum, differentiates this type from the soils of the Spring series, with which it is associated. The zone of gypsum concentration consists of gray clay loam or clay, generally very compact and partially cemented and in many places containing plates of rather firm cementation. Locally at depths of more than 40 inches the gypsiferous material rests on firmly cemented lime-carbonate hardpan. Areas of the type containing enough gravel in the surface soil to interfere somewhat with cultivation have been indicated on the soil map by means of gravel symbols; the gravel does not extend into the subsoil.

The Bracken clay loam is inextensively developed in the vicinity of Wann and Valley. Other areas are found 1½ miles south and southwest of Las Vegas. The topography varies from smooth and gently sloping to slightly undulating. Surface drainage is generally good, though a restricted subdrainage has resulted in the accumulation of alkali salts.

The native vegetation consists largely of low-growing desert brush, together with some creosote bush of rather stunted growth. None of the type is under cultivation. With future development the alkali-free areas should be very well adapted to the production of grains and alfalfa. Unimproved land is held at $10 to $20 an acre, depending on location.

Bracken clay loam, rolling phase.—The rolling phase of the Bracken clay loam differs from the normal type largely in topog-

raphy, though as a general rule the ridges have a thinner coating of soil, and the intervening depressions have a deeper soil covering over the gray, gypsiferous subsoil. In many places the soil is not over 15 inches deep over the subsoil, which locally consists almost entirely of a soft gypsum concentration.

The phase is typically developed in an area lying 2 miles southeast of Las Vegas. Smaller areas are associated with the eroded phase of the Las Vegas loam throughout the southeastern part of the survey, as well as in the vicinity and north of Wann. Some of these areas contain gravel in the surface soil and are indicated on the map by gravel symbols.

The surface of the phase consists of low rolling ridges and hills with narrow intervening depressions. In all cases the value of the phase for agricultural purposes other than grazing is very limited, owing to the difficulty of irrigation. None of the phase is under cultivation nor is it likely to be used extensively for agriculture. Small areas of this phase, when adjacent to other deeper soils, may be brought under cultivation.

REEVES LOAMY FINE SAND

The surface soil of the Reeves loamy fine sand consists of 10 to 14 inches of light-brown, somewhat compact, calcareous, loamy fine sand, which has a distinctly pinkish or pale-reddish cast. When wet the color of the soil is a light reddish brown. A veneer of gravel is found on the surface in places, but gravel does not occur in the soil or subsoil to any extent. The surface soil changes abruptly to a gray highly calcareous loam or clay loam, which has a pinkish cast and contains 50 per cent or more of gypsum. A soft gypsiferous hardpan occurs locally at depths of 30 inches or more; this can be penetrated by plant roots and upon wetting becomes mushy. A true lime-cemented hardpan is found in a few places, generally at depths of 45 to 60 inches, but is not typical of this series. In areas of poor subdrainage the lower part of the subsoil may have a greenish cast. In some of the flatter areas of the type the texture of the surface soil varies to a fine sandy loam. Two areas lying south of the Las Vegas Wash, near the eastern edge of the survey, are darker colored than typical, having a dark grayish brown or dull-brown surface soil over a dull-gray subsoil.

The Reeves loamy fine sand is extensively developed 6 miles south of Las Vegas, in the vicinity of Bracken, and elsewhere throughout the areas of old valley-filling soils lying south and west of the depression in the central part of the valley. The surface is smooth, with only occasional depressions which carry surplus water in time of storm. Surface drainage is fairly well developed, though subdrainage is rather poor. Alkali-affected areas are common throughout the extent of the type.

The Reeves loamy fine sand is not used extensively for agriculture, only two small areas of about 10 acres being under cultivation. Alfalfa, tree fruits, and vines are grown successfully, though the rooting systems appear to suffer somewhat in the gypsiferous subsoil. The soil has a fair water-holding capacity, but does not retain moisture very long.

Unimproved land of this type has a wide range in selling price; some of the areas which are favorably situated with respect to flowing water are held at $40 to $50 an acre or more, whereas land removed from the developed flowing-well areas may be had for $15 to $20 an acre.

The soil could be greatly improved by the addition of organic matter, both in respect to the retention of water and ease of cultivation. It is probable that truck gardening and the production of the more shallow rooted crops could be most successfully practiced on the type.

Reeves loamy fine sand, rolling phase.—The rolling phase of the Reeves loamy fine sand consists of 6 to 10 inches of light-brown, calcareous, loamy fine sand. In the lower depressions between the ridges the soil covering over the gray gypsiferous material is generally 10 to 14 inches or more thick. In places the subsoil has been reworked to some extent so that a mottled light-brown and gray material containing much gypsum is encountered above the undisturbed subsoil, characteristic of the type.

The chief distinguishing character of the phase, in contrast to the typical soil, is a rolling surface consisting of low rolling hills or ridges, with shallow intervening depressions. The phase has low agricultural value because of the rolling topography, which would make irrigation very difficult if not impossible in places. An area of the phase in the northern part of sections 8 and 9, T. 22 S., R. 61 E. is very badly dissected and almost entirely unsuited to cultivation.

The rolling phase is extensively developed south and southeast of Las Vegas, where it is associated with the eroded phase of the Las Vegas loam. Areas of smaller size are found in the vicinity of Bracken, Grapevine Springs, and Pierce.

The phase is used only for grazing, for which it has low value, since the native vegetation consists almost entirely of desert brush of little value as stock food. When sold alone, the land is held at $5 to $10 an acre or more, depending on location.

TONOPAH GRAVELLY LOAMY SAND

The surface soil of the Tonopah gravelly loamy sand consists of 8 to 14 inches of grayish-brown or dull-brown, calcareous, friable gravelly loamy sand. The surface soil often presents a reddish-brown tint, especially when wet. The subsoil consists of darker brown gravelly sand, which shows but slight compaction in the upper section, and grades imperceptibly into more friable material in the lower depths. Gravel and cobbles comprise more than 50 per cent of the soil mass, and generally increase in abundance with depth.

The type is a valley-filling soil in which little appreciable internal modification has taken place since deposition. In many places near drainage ways deposits of material are made over the surface at frequent intervals, and here the type shows even less evidence of age than in areas farther from the drainage ways. It is derived in part from basaltic rock, which, together with dark-colored limestone material, gives to it a dark or dull-brown color.

The Tonopah gravelly loamy sand is typically developed in the southern and southeastern parts of the area, where it occupies the

lower slopes of the alluvial fans from the McCullough Mountain Range. The surface of the type is gently sloping. Drainage is good to excessive on the surface and in the subsoil. In areas adjacent to stream courses the topography is slightly rolling or gullied.

The native vegetation, which consists almost entirely of creosote bush, with very little grass has practically no grazing value. At present the type is not under cultivation, nor is it likely to be used extensively for agriculture in the future because of its gravelly, droughty character. When sold alone it is held at $5 to $10 an acre.

TONOPAH STONY SANDY LOAM

The surface soil of the Tonopah stony sandy loam to a depth of 2 inches consists of calcareous light-brown to dark grayish brown sandy loam of compact vesicular structure and containing much stone and gravel. This changes abruptly to a light-brown to dark-brown or dull-brown, calcareous, gravelly sandy loam of moderately compact and somewhat platy structure, which when dry has a dark-reddish cast. A gradual transition occurs between this and the underlying material, which below an average depth of about 12 inches consists of compact and partially cemented brown to dark grayish brown, highly calcareous sandy loam or loam containing many mottlings or seams of lime accumulation. Gravel occupies about 50 per cent or more of the soil mass and is very much lime coated. The deeper subsoil consists of moderately compact, calcareous, light reddish brown sandy loam which contains a higher percentage of gravel and cobbles than does the surface soil. Where the surface has been undisturbed for a long period of years the gravel covering has formed the "desert pavement" characteristic of undisturbed soils in wind-swept desert regions. On the upper fan slopes and in the vicinity of drainage ways the surface is often strewn with bowlders a foot or more in diameter, in some cases almost completely covering the surface and comprising the greater part of the soil mass. The type corresponds to the Tonopah gravelly sandy loam in age and soil profile, but is derived to a greater extent from basaltic rocks, and consequently the surface soil is darker in color and more stony.

The type is not extensive in the area and is not very important agriculturally. It is confined entirely to the southeastern part of the survey, where it occupies the lower slopes of the fans from the McCullough Mountains. The largest areas are southeast and southwest of Grapevine Springs. The surface of the type is smooth and gently sloping, except near drainage ways where it has been gullied to some extent. Alkali salts have not accumulated in the soil of the type to any extent.

The type supports only a scattering growth of creosote bush and is not used for agriculture. It would have very small value for agriculture even if water were available for irrigation. Land of this type can be had for $5 to $10 an acre.

Tonopah stony sandy loam, eroded phase.—The eroded phase of the Tonopah stony sandy loam differs from the typical soil principally in the character of the topography. The surface is marked by long rolling ridges, with narrow intervening depressions, in which the more friable upper soil is somewhat deeper than typical,

whereas on the slopes of the ridges the soil covering is shallower. The drainage is excessive, and consequently the native vegetation is more meager than that on the typical soil. Because of the difficulty that would be experienced in irrigating the phase, the land suited for agriculture is confined chiefly to strips occurring between the ridges, which are generally narrow and discontinuous. Four small areas of the phase, constituting less than a square mile, are mapped south of Grapevine Springs.

The results of mechanical analyses of samples of the soil and subsoil of the typical Tonopah stony sandy loam are shown in the table below:

Mechanical analyses of Tonopah stony sandy loam

[Fine earth]

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*
530237	Soil, 0 to 2 inches	0.7	2.9	3.2	32.4	26.9	24.6	9.4
530238	Subsoil, 2 to 12 inches	1.1	4.4	4.0	40.2	31.0	11.1	8.3

TONOPAH GRAVELLY SANDY LOAM

The surface crust of the Tonopah gravelly sandy loam, in the virgin condition, consists of about 2 inches of light grayish brown or pale reddish brown loam of vesicular structure, which contains considerable gravel and has a gravel veneer over the surface. This has been leached of its lime and other more or less soluble minerals to some extent, but is still quite highly calcareous. The surface horizon consists of light reddish brown gravelly sandy loam, which is quite firm in structure, breaks up rather cloddy, and extends to a depth of about 10 to 14 inches. Below this to a depth of 20 to 24 inches is a pale reddish brown gravelly material of heavier texture, which is very compact and partially cemented from the continued deposition of lime carbonate around the gravel and smaller soil particles at the depth of average penetration of the rainfall in this region. Gray plates or seams of lime are numerous. Below this horizon the subsoil, though still very compact, contains less interstitial material, and the gravel has a less uniform coating of lime. The fine material consists of light reddish brown sandy loam or loam. The type contains 60 per cent or more of gravel and cobbles in the soil mass, the proportion increasing as the mountains are approached.

The surface gravel has the polished surface and dark-brown stain common to long-exposed rocks in desert regions. The pebbles are closely packed together and much of the finer soil material has been swept away by wind, leaving a smooth, even, glossy surface marked by occasional protruding bowlders or cobbles, thus forming what is commonly known as a "desert pavement."

Several bodies of this type in the southwestern part of the area have reddish-brown soil, in contrast to the paler colors developed elsewhere in the area. A hardpan is encountered under the type here and there in areas of advanced weathering or where a more recent deposition has been made over the old hardpan; but such

areas are not typical. Two areas in the northwestern part of the survey have large cobbles and stones in the surface soil and have been indicated on the map by stone symbols.

The Tonopah gravelly sandy loam is typically developed in the northwestern part of the survey in several areas of varying size west and southwest of Tule Springs. Other large and small areas are mapped in the region around Arden and along the eastern margin of the survey east of Las Vegas. The type occupies the alluvial-fan slopes, generally in a position intermediate between the soils of hardpan formation and those of comparatively recent deposition.

The topography varies from smooth, gently sloping areas to others of steep slope in which the local drainage ways have cut deep channels. The drainage of the type is well developed and in the steeper areas is excessive. Because of the gravelly character of the soil and subsoil, the type is poorly adapted to agriculture.

Creosote bush and other desert brush occupy the type under virgin conditions. About 20 acres are under cultivation, devoted largely to alfalfa production, and to a lesser extent to grapes and larger tree fruits. With future development the type should be found best adapted to the production of the deep-rooted crops of low water requirement. Alfalfa requires frequent heavy applications of water, and when so treated it yields slightly less on this type than on the Spring fine sandy loam. Improved land of this type is held at $100 to $150 an acre. Unimproved land is held at $5 to $20 an acre, depending on location.

Tonopah gravelly sandy loam, eroded phase.—The eroded phase of the Tonopah gravelly sandy loam consists of 8 to 10 inches of light grayish brown or light reddish brown, calcareous, gravelly sandy loam, overlying an upper subsoil of pale reddish brown or light grayish brown, very compact loam or clay loam. The lower subsoil commonly consists of compact gravelly sandy loam, but along the lower margin of the phase it may be composed of pale reddish brown or grayish-brown fine-textured material similar to that in the lower part of the Arden soil profile. Such areas resemble the typical Tonopah gravelly sandy loam in character of surface soil and upper subsoil and are therefore included.

The phase has been differentiated from the typical Tonopah gravelly sandy loam on account of its eroded character. Throughout its extent the topography is such as to preclude agricultural development, except in small local areas, generally of 10 acres or less, along the course of drainage ways. The phase is confined to the northwestern part of the survey, south and southeast of Tule Springs. Drainage is excessive throughout. The phase is sold only in connection with other soils and has a depressing influence on their value.

ARDEN LOAMY FINE SAND

The surface soil of the Arden loamy fine sand under undisturbed conditions, consists of three horizons. The surface crust, one-half inch or less thick, is a calcareous light grayish brown fine sandy loam, of vesicular structure, which has a shade of pink or purple when dry, but when wet is a reddish brown. Below this is a red-

dish-brown, calcareous, heavy fine sandy loam, of granular, mulch-like structure, to a depth of 2½ inches or less. This is underlain to an average depth of about 12 inches by a light reddish brown, calcareous, slightly compact or firm, loamy fine sand. The subsoil has two distinct horizons as the result of weathering and leaching of the surface soil and accumulation of lime in the subsoil. The upper part is a compact grayish-brown fine sandy loam or loam, containing an appreciable concentration of lime and other products of soil weathering. The deeper subsoil consists of light-brown, less compacted, fine sandy loam, which has a pinkish cast.

Strata or lenses of gravel and sand are found in the subsoil in places, especially in the higher positions. In areas adjacent to soils of the Bracken series the subsoil consists locally of highly gypsiferous material similar to that under the Bracken soils. Another variation is found in the case of two small areas, one in section 32 and the other in section 34, T. 21 S., R. 62 E. Here the color is somewhat darker than typical, being dull brown or dark grayish brown with a reddish tint.

The type is inextensive. The principal areas lie in the region east of Pierce and Arden and west of Bracken.

The Arden loamy fine sand occurs on the lower alluvial-fan slopes, generally occupying a position intermediate between the gravelly soils of the upper slopes and the more calcareous or gypsiferous soils of the interior of the valley. The surface is smooth and sufficiently sloping to promote good drainage of soil and subsoil. The type should prove very well adapted to irrigation where water is available. (Pl. 7, fig. 1.)

The native vegetation consists largely of creosote bush and other forms of vegetation which have no value for grazing. About 10 acres of the type are in cultivation and support a variety of fruit trees, consisting largely of pears, peaches, and cherries, which maintain a vigorous growth and yield abundantly. (Pl. 7, fig. 2.) Improved land of this type in producing orchards is held at $800 an acre. Unimproved land can be purchased for $5 to $20 an acre, according to location.

Arden loamy fine sand, rolling phase.—The rolling phase of the Arden loamy fine sand differs from the typical soil in topography and in the depth of soil material between the ridges. In these depressions, especially in areas bordering soils of the Bracken series, the underlying highly gypsiferous material occurs at shallow depths, whereas on the ridges it is not generally found in the 6-foot section. In areas distant from soils of the Bracken series there is only a slight soil covering over the subsoil, especially on the slopes of the ridges.

The phase occurs in several areas of various sizes about 2 miles northeast of Pierce.

Owing to its rolling topography very little of the phase is suitable for irrigation without considerable outlay for labor and other expense in leveling. The small area in section 9, T. 22 S., R. 61 E., is badly eroded and has no value for agriculture.

POND SILTY CLAY LOAM, DARK-COLORED PHASE

The typical Pond silty clay loam does not occur in this survey, this type being represented only by a dark-colored phase. This is

not typical of the Pond series, and if of greater extent and importance would be recognized as representing a distinct series of soils.

The surface soil of the Pond silty clay loam, dark-colored phase, in the virgin condition, consists of three horizons. The surface layer of one-half inch or less consists of compacted dark grayish brown, calcareous silty loam, which is usually grayer in color than the underlying material. The second horizon consists of dark-brown or dark grayish brown, calcareous silty clay loam, containing crystallized salts, which give it a granular or mealy structure. This passes abruptly into a calcareous slightly compact silty clay loam of dark-brown color with a shade of gray. The upper subsoil encountered at an average depth of about 12 inches consists of dark brownish gray clay or clay loam which is quite compact. At an average depth of about 40 inches the subsoil is a gray to dark-gray clay or clay loam which is very calcareous and is somewhat granular in structure due to the presence of crystallized gypsum.

In a small area 1 mile west of Las Vegas and in a larger one in sections 25 and 26, T. 20 S., R. 61 E., the surface soil is lighter in color than typical, consisting of grayish-brown material. In the vicinity of springs the soil contains slightly more organic matter than elsewhere, and the color is darker than typical; here also the subsoil is likely to be more gypsiferous than typical, especially near the bluff lines from which the springs issue. In places a dark color is developed to a depth of 6 feet or more, with but slight gray development in the subsoil.

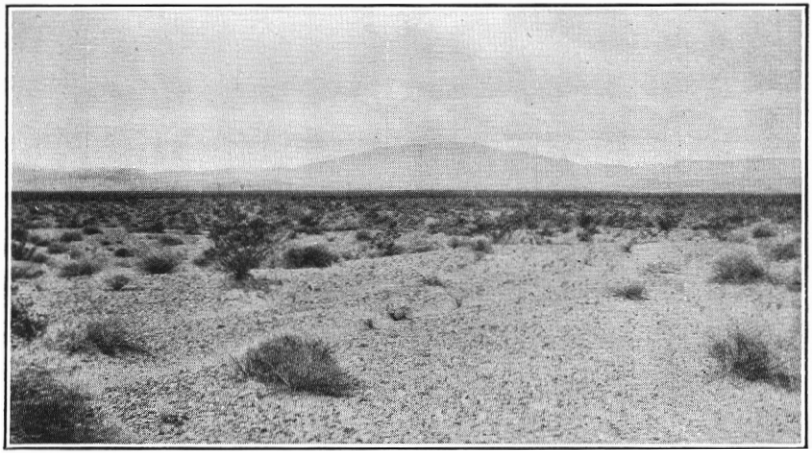
The phase is of minor extent. The largest area is northeast of Las Vegas, where it extends along the course of a drainage way formed by waste water from several springs. Another narrow area extends from the springs 2 miles west of Las Vegas to the edge of the bluff line north of the town. Smaller areas are found at Tule Springs, east of Grapevine Springs, and at various other springs in the valley.

The phase is developed in localities where a perennial flow of water at or near the surface of the ground supports a vigorous growth of native plants and grasses, which upon decay give to the soil a high organic-matter content and its characteristic dark color. The surface is generally slightly gullied, but of gentle slope favorable to irrigation. Alkali salts are present in various concentrations, due to a somewhat impeded subsoil drainage.

Though of small extent, the soil is relatively important agriculturally, since 25 per cent or more is under cultivation. Garden truck, grapes and other fruits of excellent quality are produced. Yields are high, although other poorer soils are frequently cultivated in connection with it. Alfalfa yields 5 to 6 tons per acre, and maintains a good stand.

Improved areas of this soil when sold alone are valued at $300 to $500 an acre, depending on location and improvements. Other soils with which it is associated generally have a depressing effect on its value. Unimproved land of this phase is held at $50 to $100 an acre.

This soil could be used more extensively in the production of small fruits, vegetables, and shallow-rooted vines. Tree fruits

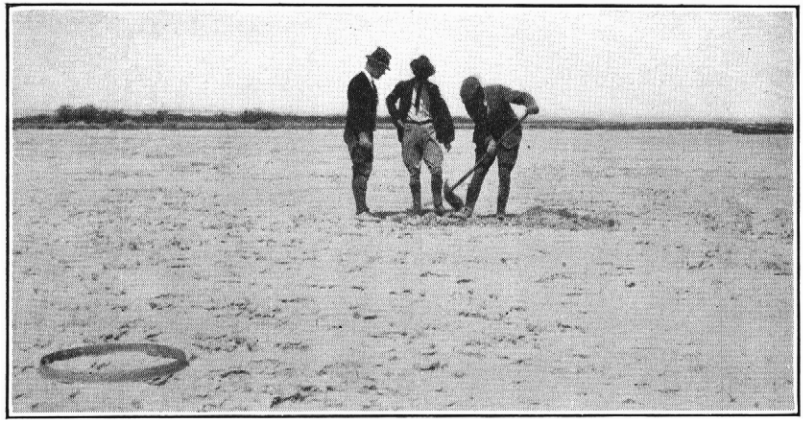


S. 11780

FIG. 1.—NATIVE VEGETATION, TOPOGRAPHY, AND DESERT PAVEMENT ON THE ARDEN LOAMY FINE SAND. CHARLESTON PEAK IN DISTANCE

S. 11800

FIG. 2.—PEACH ORCHARD ON ARDEN LOAMY FINE SAND



S. 11796

FIG. 1.—BARREN OR SLICK SPOT IN AREA OF HIGH ALKALI ACCUMULATION IN THE LAND CLAY LOAM

The soil in such places has a pronounced crust and mulch structure and is known locally as "self-rising land"

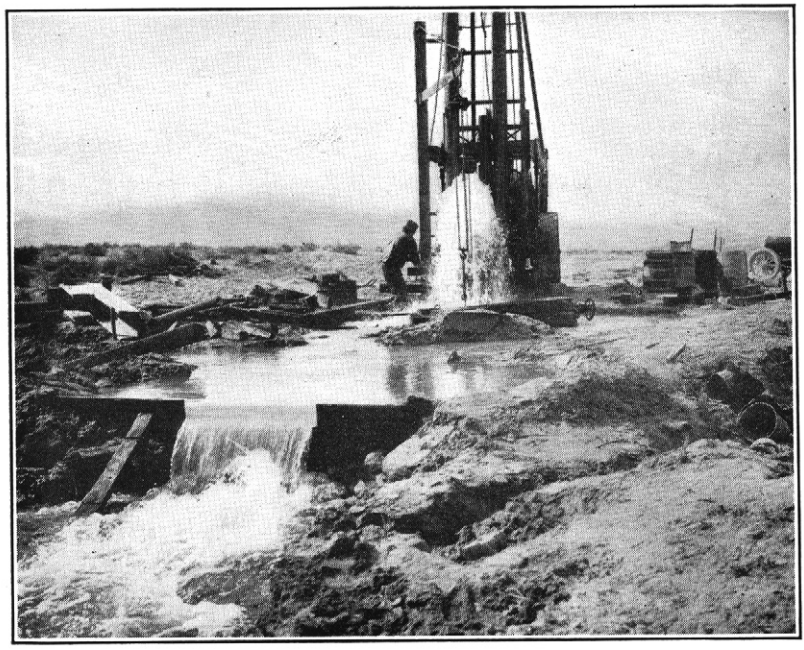


PHOTO BY GEORGE HARDMAN

FIG. 2.—NEWLY DEVELOPED ARTESIAN WELL NEAR LAS VEGAS

should also be well adapted to the phase when drained, especially in areas somewhat protected from frost.

SPRING FINE SANDY LOAM

The surface soil of the Spring fine sandy loam consists, under virgin conditions, of a calcareous light grayish brown fine sand or fine sandy loam surface crust of one-half inch or less in thickness, underlain by 3 inches or less of calcareous, light reddish brown fine sandy loam of granular or mealy structure. A third horizon extending to an average depth of 17 inches consists of light brown or light grayish brown friable fine sandy loam. Below this is a light-brown or light grayish brown fine sandy loam of slight compaction, which overlies a grayish-brown fine sandy loam or compact loam. At 40 inches or more is found a gray, compact plastic clay or clay loam which is waxy or plastic when wet, but assumes a crumbly structure upon drying.

The Spring fine sandy loam is typically developed south and southwest of Las Vegas. It is somewhat variable in the areas lying north and northeast of that point. The upper soil materials are largely a product of rather recent deposition. The subsoil, however, is largely a product of soil development under conditions of imperfect subdrainage. In the vicinity of Las Vegas imperfect subdrainage has resulted in a high water table, but this is not the case throughout the extent of the type. It is probable, however, that if irrigation should be practiced extensively a high water table would result. In local areas north of Las Vegas hardpan is found at depths of 60 inches or more, though such areas are too small to be shown separately on the soil map. A fairly large area lying 4½ miles northeast of Las Vegas has a silt loam texture. In another area 1½ miles north of Las Vegas and in one 2 miles northeast of that point the texture more nearly approaches a sandy loam. A small area in section 14, T. 20 S., R. 61 E., has a gravelly surface soil of more recent deposition.

The surface of the type is smooth and gently sloping, except in the vicinity of drainage ways, where it is gullied to some extent. One small area in section 20, T. 20 S., R. 61 E., is rolling and in places somewhat eroded. Surface drainage is very well developed. Subdrainage is restricted, owing to the compact subsoil, which retards the movement of underground water. Areas affected by alkali concentrations are found throughout the type.

The Spring fine sandy loam supports a luxuriant growth of wild grasses in localities which receive the discharge from springs or in which a high water table has developed. Low-growing desert shrubs afford some grazing, so that the type has appreciable value for pasture under virgin conditions. About 140 acres are under cultivation, being utilized largely in the production of alfalfa. Fruit and vegetables are also grown on the type for home use and produce well under favorable conditions.

Alfalfa is cut six to seven times a season and yields on an average about 5 tons per acre. Higher yields are reported from good stands in favorable seasons. Reseeding is generally necessary at frequent

intervals because the stand is short lived where the water table is high. Bermuda grass causes considerable difficulty in old fields, but can be largely eradicated by frequent cultivation during the summer season.

The principal need of the type is drainage. After drainage is established, the addition of organic matter would materially improve the structure and increase the water-holding capacity and fertility of the soil. Results obtained elsewhere in this region indicate that the inoculation of all seed of leguminous crops to be sown on new ground would prove highly profitable. The feeding of alfalfa to livestock should prove more profitable than marketing it from the ranch, and the manure would be valuable in maintaining the yields of hay. With drainage the type should prove well adapted to the production of small fruit and truck. Owing to its unfavorable location with respect to frost its value for tree fruit production is somewhat questionable.

Improved land of this type sells for $150 to $300 an acre, depending on location and improvements. Unimproved land can be had for $15 to $25 an acre, according to location.

Spring fine sandy loam, alluvial phase.—The alluvial phase of the Spring fine sandy loam consists of 10 to 15 inches of light grayish brown silt loam of mellow structure, over stratified material of the same color. The various strata consist of silt loam, loam, or fine sandy loam. This material generally extends to 30 inches or more and is underlain by the typical subsoil of the Spring fine sandy loam of moderately compact grayish-brown or brownish-gray loam or clay loam, over the gray, heavy-textured subsoil, characteristic of the series. The surface soil of the phase is of recent deposition and is generally still in the process of accumulation, and the subsoil is composed of old valley-filling material which has suffered considerable modification since deposition. Gypsum is present locally in appreciable amounts in the deeper subsoil and where drainage is poor this zone may have a greenish-gray tint.

The phase is developed in the trough of the valley. It occupies a large area southeast of Tule Springs, and two small bodies, one in section 36, T. 19 S., R. 60 E., and another in section 4, T. 20 S., R. 61 E. The surface of the latter area is somewhat rolling in character and would entail considerable labor and expense to level for irrigation.

The phase occurs largely in the vicinity of drainage ways or in localities in which the drainage courses from the mountains are checked in their flow and are depositing their load of suspended material over the older deposits of the valley floor. The surface is slightly dissected in the vicinity of drainage ways, though in general it is smooth and gently sloping, rendering the soil well adapted to irrigation.

The native vegetation consists almost exclusively of creosote bush, with scattering clumps of native grasses which offer a fair amount of grazing in the spring months. The phase is well adapted to irrigation, but because of the difficulty of procuring water, very little of it has been placed under cultivation, and that only in the past year. It should prove well adapted to the production of fruits suited to the climate of this region, on account of the lower water

requirements of fruit. Were plenty of water available, alfalfa would also prove a highly productive crop. Unimproved land is held at $5 to $25 an acre according to location.

The results of mechanical analyses of samples taken at various depths in the profile of the typical Spring fine sandy loam are given in the following table:

Mechanical analyses of Spring 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*
530259	Surface crust, 0 to ¼ inch	0.2	0.4	0.6	53.6	32.0	6.8	6.6
530260	Mulch, ¼ to 3 inches	.0	.4	.6	44.0	27.0	8.3	19.8
530261	Subsurface, 3 to 17 inches	.0	.2	.6	42.0	33.4	11.6	12.2
530262	Subsoil, 17 to 32 inches	.0	.2	.6	31.4	36.4	14.0	17.4
530263	Subsoil, 32 to 48 inches	.0	.0	.6	19.4	36.9	22.0	21.1
530264	Subsoil, 48 to 72 inches	.0	.2	.2	11.0	28.4	23.3	36.9

SPRING CLAY LOAM

The surface horizon of the Spring clay loam consists of a surface crust of 1 inch or less of light grayish brown fine sandy loam to clay loam of firm, compact structure, underlain by a granular mulch of light-brown heavy clay loam which has a shade of gray. This passes abruptly into light-brown, moderately compact material, which is frequently stratified, the different strata varying from silt loam to clay loam. A brownish-gray, compact clay loam or clay occupies a transitional zone above the typical subsoil of gray clay or heavy clay loam, which is stiff and waxy when wet but becomes quite crumbly upon drying. The gray subsoil material is encountered at various depths below 45 inches, generally at shallower depths in the northwestern part of the area than in the vicinity of Las Vegas. In the latter location the water table is within the 6-foot depth, usually at about the same depth as the gray material.

The type is an old valley-filling soil which appears to have developed under conditions of imperfect subdrainage. A high water table does not occur throughout the area of its occurrence, though a large area south and east of Las Vegas has a poorly drained subsoil. Other large areas of the type lie one-half mile and 5 miles northwest of Las Vegas. Smaller isolated bodies occur throughout the lower lying soils north of Las Vegas in the vicinity of Wann, and south and southeast of Valley.

In an area 2 miles south of Valley the gray subsoil material is tough and heavy in character, but is less waxy than typical. In sections 6 and 8, T. 21 S., R. 62 E., and in sections 1 and 17, T. 20 S., R. 61 E., are found nontypical areas in which the surface is very badly dissected, so as to make irrigation impossible without much labor and expense for leveling.

In general the topography is smooth, with slight variation in surface elevation, though the fall toward the central part of the valley is generally sufficient to promote good surface drainage. Subdrainage is imperfect owing to the existence of subsoil barriers that

impede the movement of underground water. Alkali salts are common throughout the extent of the type.

The native vegetation consists of creosote bush and low desert brush, some of which affords a small quantity of forage for range stock. In localities where the ground water approaches the surface and in the vicinity of springs, sacaton and galleta grasses grow luxuriantly.

About 80 acres of the type are under cultivation, on which are grown alfalfa, peaches, plums, apricots, pears, cherries, small fruits, and truck crops. Alfalfa is cut six or seven times a season and yields on an average about 5 tons per acre, some higher yields being reported. Though a good stand is generally obtained, some difficulty is experienced in keeping out Bermuda grass, and because of a high water table the stand is short lived. Fruit trees produce well on the type in favorable seasons, where drainage conditions are favorable, but owing to the danger of frost in the interior of the valley the crop is uncertain. The fruit is of excellent quality.

Improved land of this type in fruit is held at $300 to $400 an acre, and that in alfalfa is held at slightly less. Unimproved land can be had for $10 to $30 an acre, depending on location with respect to markets and water.

The chief need of the type is the addition of organic matter. In the lower part of the valley drainage would materially improve the soil for all crop production.

The following table gives the results of mechanical analyses of samples representing different layers of the Spring clay loam:

Mechanical analyses of Spring clay loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
530270	Surface crust, 0 to ⅛ inch	0.1	0.1	0.0	7.2	46.4	18.8	27.2
530271	Mulch, ⅛ to 2½ inches	.2	.1	.0	9.2	40.2	20.3	30.0
530272	Subsurface, 2½ to 8 inches	.3	.2	.1	7.4	42.5	20.9	28.5
530273	Subsoil, 8 to 26 inches	.0	.1	.2	8.8	37.2	23.4	30.4
530274	Subsoil, 26 to 54 inches	.0	.1	.3	4.8	32.6	27.8	34.6
530275	Subsoil, 54 to 72 inches	.2	.7	.6	7.3	25.9	23.6	41.5

LAND FINE SANDY LOAM

The surface soil of the Land fine sandy loam consists of 6 to 12 inches of brown or light grayish brown calcareous fine sandy loam in which a reddish or pinkish color sometimes occurs. The underlying material is stratified, consisting of calcareous fine sandy loam, silt loam, or clay loam, or clay of light grayish brown or light reddish brown color, in which the lime is quite uniformly distributed. At depths of 40 inches or less a slight zone of compaction is generally encountered which contains a slightly higher lime concentration than the material above or below. Small areas are included in which the surface texture approaches a loamy fine sand. Two small areas are also included in which the surface is very hummocky and would require much labor and expense to level. The hummocks generally consist of fine wind-blown sand, whereas the intervening flats are of fine sandy loam or loam texture.

The type is confined to areas bordering stream ways in the interior of the valley, and generally adjoining lighter textured soils of recent deposition. Most of the areas are small; some of the larger ones lie southeast of Las Vegas. Other areas are found north of Las Vegas, in the vicinity of Grapevine Springs, southeast of Valley, and east of Pierce. A small area 2¼ miles west of Bracken is the only one outside the valley trough.

The surface of the type is generally smooth and of sufficient slope to insure good surface drainage. The subsoil is better drained than in the other types of the series, with the result that alkali salts are not generally present in very high concentration. The type lends itself well to irrigation, being absorptive and retentive of moisture where well cultivated and supplied with moderate quantities of organic matter.

The type is one of the more important soils of the area, from the standpoint of utilization. Under virgin conditions it supports a scattering growth of mesquite, cat's-claw, and alkali-resistant brush or grasses. Where cultivated it is utilized largely in the production of alfalfa, though small plantings of fruits, melons, and vegetables yield well and are of excellent quality. The acreage devoted to alfalfa constitutes 90 per cent or more of the cultivated land. With good stands in favorable seasons six or seven cuttings are secured, which yield an average of about 4 to 5 tons per acre, though yields of 6 tons or more per acre are reported.

Improved land of this type sells for $200 to $400 an acre, depending on location and improvements. Unimproved land is held at $15 to $100 an acre, the higher priced lands being favorably situated with respect to flowing well areas.

The type could be materially improved in water-holding capacity, ease of cultivation, and fertility by the addition of organic matter. It is believed that it would prove desirable to inoculate all seed of leguminous plants before seeding, especially in virgin soil. The type should be well adapted to a more extensive production of vegetables and melons. Windbreaks are desirable around cultivated fields, adding much to the attractiveness of the ranch as well as preventing to a large degree the blowing of the surface soil after cultivation. For this purpose the Athel tree (*Tamarix articulata*), an evergreen tree adapted to desert conditions, is recommended. The tree makes a rapid growth and can be used for fuel and for fence posts.

Land fine sandy loam, heavy phase.—The surface soil of the Land fine sandy loam, heavy phase, consists of 6 to 12 inches of calcareous, dull reddish brown, friable fine sandy loam. In places a cloddy surface crust 4 inches or less in thickness overlies a zone of high alkali-salt concentration of a fluffy or granular structure. To an average depth of about 15 inches the subsoil consists of light reddish brown fine sandy loam or loam of moderate compaction in which occur gray flakes of lime and salt. Below this it is a light reddish brown friable fine sandy loam or silt loam which may continue to 6 feet or more without change or may be underlain with stratified material of similar color and structure.

This phase is typically developed in the lower lying flat east of Las Vegas, where two large areas extend in a north and south di-

rection, more or less parallel to each other. Other areas of smaller size occur in the northeastern part of the survey bordering the higher lying older soils of the alluvial-fan slopes. Several small areas border the Las Vegas Wash, near and southwest of Grapevine Springs.

The topography varies from smooth, gently sloping areas to others that are almost flat. In the latter the drainage of surface and subsoil is generally restricted, with the result that alkali salts are present in high concentration. As a rule, however, the slope is sufficient to promote surface drainage, though alkali concentrations occur everywhere because of retarded subdrainage.

The soil absorbs water readily and retains it, and is well adapted to irrigation. The smooth, gently sloping surface makes necessary only slight preparation of the ground for irrigation.

None of the phase is under cultivation at the present time. At one time about 80 acres were used for growing alfalfa and cotton, and good yields were obtained where alkali conditions were favorable. A sharp decline in the price of cotton in 1920–21 caused the abandonment of the project.

Improved land of this phase is held at $400 an acre. Unimproved land can be had for $10 to $35 an acre, depending on location and known source of water supply.

With future development the soil should be productive of alfalfa, cofn, sorghums, and grains, as well as small fruits, where alkali conditions are favorable. Its value for the production of tree fruits is somewhat doubtful owing to its unfavorable location with respect to frosts.

Land fine sandy loam, dark phase.—The surface soil of the dark phase of the Land fine sandy loam consists of 10 to 14 inches of dark-brown or dark grayish brown fine sandy loam, which merges generally at depths of 20 inches or less into the typical stratified subsoil of light reddish brown material characteristic of the Land fine sandy loam. When wet the surface color is a deep dark-brown to black. In some localities, especially those distant from the channel of the Las Vegas Wash, the texture is somewhat heavier, consisting of a silt loam or occasionally a light clay loam.

The phase is confined to one body of about 2 square miles, on the north side of the Las Vegas Wash, extending from Grapevine Springs southwestward about 3 miles. The surface is gently sloping throughout the extent of the area. Internal drainage is poorly developed, resulting in a high water table and consequent high alkali accumulation. A heavy growth of salt grass and in places other native desert grasses, as well as occasional clumps of mesquite, have contributed to a relatively high organic-matter content, and consequent dark color of the surface soil.

A small better drained part of the phase is utilized in the production of alfalfa, which maintains a good stand and yields well.

Improved land of this phase is held at about the same figure as other improved land in this locality. Unimproved land is valued at slightly less than the better drained areas with which it is associated.

The principal need of the phase is drainage, after which thorough leaching of the soil to remove alkali salts should render it well

adapted to the production of all crops suited to the climate of the region.

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

Mechanical analyses of Land 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*
530213	Soil, 0 to 8 inches	0.0	0.4	0.6	33.9	35.5	16.1	13.5
530215	Subsoil, 42 to 48 inches	.6	2.7	2.0	10.0	13.9	26.8	44.1
530216	Subsoil, 48 to 72 inches	.0	.3	.4	24.5	27.0	19.6	28.3

LAND CLAY LOAM

The surface horizon of the Land clay loam consists of a mulch about 2 inches in thickness of brown or light grayish brown clay loam which has a distinct pinkish tint. This changes abruptly to a light reddish brown friable clay loam, which contains a considerable accumulation of alkali salts. In some localities the salt concentration forms a gray zone composed largely of alkali salt crystals. At an average depth of about 12 inches the upper subsoil consists of light-brown moderately compact clay loam, which has a distinct pinkish cast. Numerous mottlings or specks of gray salt or lime accumulations are found in this horizon, decreasing in number with depth. This is underlain by a light grayish brown friable loam, which generally continues uniform to a depth of 6 feet or more, though in some places it is stratified. Lime is abundant in both soil and subsoil, and is rather evenly distributed, a slight concentration being generally discernible in the upper subsoil. The surface soil of this type is somewhat redder than in the other soils of the Land series.

The Land clay loam is confined to areas of comparatively recent deposition in the interior of the valley. An area of about 3 square miles lies northeast of Las Vegas, and another large area occurs north of Grapevine Springs. Other areas of smaller size are found east and northeast of Las Vegas at distances of 2, 3, and 5 miles.

Some areas of the type have almost flat topography, whereas others are moderately sloping, insuring good surface drainage, though subsoil drainage is frequently imperfect. In the vicinity of drainage ways the surface is somewhat irregular and would require some leveling for irrigation, but as a whole the type could be irrigated with but small expense for leveling.

The Land clay loam is well adapted to irrigation, as the soil has a high water-holding capacity and absorbs water readily. With the addition of organic matter and cultivation it should also be very retentive of moisture. Alkali concentrations are numerous, and certain areas of high concentration, as indicated on the accompanying alkali map, are of doubtful agricultural value. (Pl. 8, fig. 1.) None of the type is under cultivation, but with development of water for irrigation it should prove highly productive of grain, alfalfa, corn, sorghums, and small fruits where alkali and drainage conditions are favorable.

Unimproved land of this type is held at $15 to $35 an acre depending on location with respect to markets and known water supply.

GILA GRAVELLY FINE SAND

The surface soil of the Gila gravelly fine sand consists of 8 to 14 inches of pale reddish brown, calcareous gravelly sand, predominantly of fine texture, and containing 50 per cent or more of gravel and cobbles. The material is friable and extremely porous. The subsoil to a depth of 72 inches or more consists of very slightly compacted pale reddish brown or light-brown gravelly fine sand, which as a rule contains slightly more gravel and cobbles than the surface soil. Throughout the type slight weathering or modification is indicated in the soil profile. The gravels are generally free of lime coating or have only a little coating on the under side. The type represents a recently accumulated soil which has not yet developed the zone of compact heavier textured material or of pronounced lime accumulation characteristic of weathered soils of the area, though modification in place is more evident in this type than in other soil types of this series. In a few places the gravelly surface material characteristic of the type has been deposited over heavier subsoil material of the Bracken series, but such areas are of minor extent and have not been mapped separately.

The Gila gravelly fine sand is typically developed along the lower alluvial-fan slopes throughout the survey. One of the largest areas occurs northwest of Las Vegas and borders the edge of the survey for a distance of 5 miles. Other large areas lie south of Arden, around Pierce, and west of Bracken. Smaller areas occur west of Las Vegas, along the lower fan slopes in the eastern part of the valley, and in the vicinity of Wann and Valley.

The surface is generally somewhat gullied by local drainage ways, though few areas would entail much labor or expense in leveling for irrigation. The drainage of the type is good to excessive, resulting in a complete freedom from alkali accumulations. In the vicinity of drainage ways the type is overflowed occasionally following heavy thunderstorms.

Less than 10 acres of the type are under cultivation, on which are grown peaches, apricots, pears and other fruits for home use. Without abundant water for irrigation the type has little or no value for agriculture on account of its porous droughty character. This type has added protection from frosts because of its location on the fan slopes above the lower soils of the valley floor.

Land of this type in improved orchards is held at $400 to $600 an acre, depending on the age of the trees and their condition. Unimproved land is valued principally for its grazing qualities, which are low; it can be had for $5 to $20 an acre, according to location.

GILA VERY FINE SANDY LOAM

The surface of the Gila very fine sandy loam consists of 10 to 14 inches of light grayish brown or light-brown, calcareous very fine sandy loam, which has a distinctly pinkish cast. In places the type

contains gravel in sufficient quantity to interfere with cultivation; such areas have been shown on the soil map by means of gravel symbols. The subsoil, which consists of material similar in color to the surface soil, is stratified. The strata range from a few inches to 2 feet or more in thickness and are generally of fine sandy loam, silt loam, or very fine sandy loam texture. In a few places the soil material has a uniform texture to a depth of 6 feet or more. In areas of the type derived from the redder colored rocks and reworked red valley-filling soils, a pronounced reddish tint is noticeable in the soil and subsoil. In one area in section 9, T. 22 S., R. 62 E., the soil is dark grayish brown or dull grayish brown in color, due to its derivation in part from dark-colored basaltic rock. An area in section 36, T. 19 S., R. 62 E., has a porous gravelly subsoil, making it much more droughty than the typical soil.

The type is confined largely to the low flat in the central part of the valley, though other areas are found on the alluvial fans, where the slightly sloping topography has resulted in the deposition of sediments carried by run-off from the higher lands. A relatively large area of the type at Wann extends northward along the channels of several drainage ways. Another area of considerable size is found in the eastern part of the survey, where the Las Vegas Wash leaves the area. A small area lies 5 miles east of Las Vegas, at the base of the fans issuing from the Muddy Mountains. Other areas are found east of Pierce, southeast of Las Vegas, and south of Tule Springs.

The Gila very fine sandy loam is well adapted to irrigation, though the type would in many cases require some leveling, owing to its irregular surface. The soil absorbs water readily, but is not as retentive of moisture as the heavier textured types of the series. Drainage is well developed over the type rendering it comparatively free of alkali.

Unimproved land is held at $5 to $25 an acre, depending on location with respect to known water supply.

The chief need of the type when under cultivation would be the addition of organic matter to improve its water-holding capacity, and to prevent its baking or running together after irrigation. Recommendations for the improvement and utilization of the Land fine sandy loam are also applicable to this type.

Gila very fine sandy loam, red phase.—The red phase of the Gila very fine sandy loam consists of 10 to 14 inches of reddish-brown or brownish-red, calcareous very fine sandy loam, over material of the same color, which is somewhat stratified, the different strata varying in texture from silt loam to sandy loam. The phase shows no modification due to weathering, the lime being uniformly distributed, with no tendency toward compaction apparent in the subsoil.

The only area of the phase mapped is 4 miles southeast of Valley. It has a comparatively flat topography, though surface and subsoil drainage are moderately well developed, resulting in but slight alkali accumulation. The phase has the same value for agricultural purposes as the typical Gila very fine sandy loam, and will respond to the same cultural treatment.

In the table below are given the results of mechanical analyses of samples of the soil and subsoil of the typical Gila very fine sandy loam:

Mechanical analyses of Gila very 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*
530217	Soil, 0 to 12 inches	0.2	0.2	0.2	30.1	47.1	17.5	4.7
530218	Subsoil, 12 to 72 inches	.1	.3	.5	61.2	19.4	12.8	5.6

GILA LOAM

The surface soil of the Gila loam consists of 8 to 15 inches of calcareous, light grayish brown, friable, rather silty loam, which in places has a distinctly pinkish tint. The subsoil consists of stratified material of friable structure, which is calcareous and of light grayish brown color with a shade of pink. The texture of the strata may vary from clay loam to sandy loam, and the thickness may vary from a few inches to several feet and in places may continue to 6 feet or more without change. In the vicinity of stream ways the surface texture is generally quite variable, often consisting of silt loam or fine sandy loam. Such variations are of small extent and have not been shown separately on the soil map.

The type is confined to stream ways and areas of flat topography which receive a deposition of sediment from year to year. The largest area of the type occupies a narrow belt from 3 miles northwest of Wann, southeastward to the point where the Las Vegas Wash leaves the area. It occurs in the course of the drainage ways that carry surplus water from the region of Tule Springs and the country outside the survey to the northwest of Tule Springs. Small areas are found 4 miles southeast of Valley, 4 miles east of Pierce, 3½ miles southeast of Las Vegas, and 4½ miles south of Tule Springs.

The surface of the type is gullied somewhat by local drainage channels, though in only a few cases would much labor or expense be necessary for leveling. In section 15, T. 20 S., R. 62 E., are two small areas which are badly eroded and could be irrigated only after great expense for leveling. In general, however, the type is well adapted to irrigation, except in areas of high alkali concentration or others in which flood waters could not be controlled.

In its virgin condition the type supports a vigorous growth of low-growing desert brush and occasional areas of mesquite. Inkweed and other alkali-resistant weeds or shrubs are found in highly alkaline areas. About 40 acres of the type have been planted to figs last season (1922–23); otherwise the type has not been developed for agriculture.

Unimproved land of Gila loam can be had for $10 to $30 an acre. Areas of this type included with other undeveloped lands which are held by the State can be had at $1.25 an acre.

With the development of water for irrigation and adequate protection from washing during floods, the type should prove highly productive of all crops suited to the climate of this region. On

account of the poor air drainage in the floor of the valley, frost would be detrimental to the production of tree fruits and other plants sensitive to frosts in the late spring, but little trouble should be experienced with frost in higher lying areas of moderately sloping topography.

The results of mechanical analyses of samples of the soil and subsoil of the Gila loam are given in the following table:

Mechanical analyses of Gila 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*
530205	Soil, 0 to 14 inches	0.0	0.0	0.0	5.8	32.4	41.6	20.2
530206	Subsoil, 14 to 72 inches	.0	.0	.1	1.5	13.2	55.8	29.1

ROUGH STONY LAND

At various places on the alluvial fans near the base of the higher mountains are found isolated buttes or ridges composed largely of outcropping or fragmental rock of sedimentary origin, limestone and impure gypsum deposits generally constituting the greater part of their mass. Because of torrential summer rains and the effect of severe winds, very little soil has been formed, except in protected pockets, and only an occasional drought-resistant desert bush or cactus is found over the surface. Owing to the steep and rocky character of the slopes these areas have no value for agriculture and are mapped as Rough stony land. Several small areas of this type are found east of Bard, 1 mile west of Arden, and 5 miles southeast of Valley.

DUNESAND

In the vicinity of drainage ways, especially in places where the streams spread out fan shaped over flat surfaces, sand and finer sediments are deposited after each overflow. Before vegetation can secure a foothold and thus protect it to some extent from being shifted about, much of the material is picked up and carried by winds, until it lodges around some desert brush or other obstruction. With each successive windstorm additional deposits of material are accumulated until a mound composed largely of fine and very fine sand is built up, often to 20 feet or more in height and covering several acres. Such mounds are commonly known as sand dunes and have no value for agriculture in their present condition. The cost of leveling the dunes is in most cases prohibitive, though when leveled they may be utilized for agriculture where plenty of water is available. The material composing the dunes is light brown in color and calcareous. Small areas of Dunesand are mapped south, southeast, northeast, and northwest of Las Vegas and southwest of Grapevine Springs.

ALKALI AND LAND CLASSIFICATION

In the Las Vegas area there are three factors that have limiting effects on profitable agricultural development, and disregard of any

of them could result in complete failure. Without water for irrigation the profitable production of crops is impossible. The subject of water supply has been completely covered from the standpoint of occurrence and quality of water in Water Supply Paper No. 365, published by the United States Geological Survey. Of equal importance with water supply are the factors of alkali concentration and character and depth of soil. Other factors involved in the selection of a farm include location with respect to market, air drainage, and character of crop to be grown.

On the accompanying combined land classification and alkali map a simplified grouping of the soils of the area has been made, placing soils of similar agricultural value and possibilities in certain groups which are discussed later. General alkali conditions have also been approximately shown on the same map, by means of which the relation of the soils to areas of injurious alkali concentration may be ascertained.

ALKALI

On the accompanying map the location of field samples tested for concentration of alkali salts has been shown by a dot, and the average percentage of total alkali salts to a depth of 6 feet or to impervious hardpan is expressed in figures. Samples were taken by sections: The upper 36 inches constituted the first three sections, each representing 12 inches of the soil profile; and the lower 3 feet were taken in two sections of 18 inches each. The percentage of soluble salts in the air-dry soil was determined by means of the electrolytic bridge for each section and the average for the 6 feet or to hardpan was determined from the percentages of the sections.

The soils have been separated into two grades; those having concentrations of over 0.2 per cent of soluble salts in the air-dry soil are inclosed within boundary lines on the map and marked by the symbol "A"; those having less than 0.2 per cent, which are considered free of alkali from the standpoint of crop production, are shown by the symbol "F." No attempt has been made to further differentiate the affected areas into grades of various concentration, owing to the difficulty that would be experienced in drawing accurate boundaries in areas in which there are no cultivated crops from the condition of which the probable salt concentration might be judged. The percentages as expressed on the alkali map will, however, represent the approximate alkali concentration for that immediate location and for soils of similar profile, texture, drainage, and topography in the near vicinity. Marked variations in salt concentration between different samples in the same locality, generally are accounted for by differences in soil character, drainage, or topography.

In the Las Vegas area the areas of highest alkali concentration are generally associated with poor drainage of surface or subsoil. However, in areas consisting of old lake deposits, which at the present time are well drained and locally eroded, the material underlying the hardpan is full of alkali and contributes largely to the alkali conditions in the areas of more recent soils. Where the hardpan formation overlying the lake deposits is soft or fragmental the surface soils are generally more or less affected with alkali.

There are several areas of high concentration in the valley, one near the point where the Las Vegas Wash leaves the area, another to the south and southwest of Grapevine Springs, and another at Bracken. The lower portion of the valley has a high salt concentration as does also an area lying about 3 miles southeast of Las Vegas. Areas of lower concentration embrace the greater part of the lower valley from Tule Springs south to a point about 10 miles south of Las Vegas. On the east the alkali affected area extends to the edge of the flat in the lower part of the valley. It also extends northward including the soils in the flatter part of the area as far as Valley. In some of the badly affected localities small areas have been cultivated, and by means of adequate drainage of surplus water the soils have been largely freed of salts.

A number of factors have to be considered in judging the suitability of an alkali soil to agriculture, or its feasibility of reclamation. Without good drainage, either natural or artificial, no system of alkali reclamation can be permanently successful. In most cases continued successful crop production will not be possible on soils which have a high water table and even moderate amounts of alkali. This is due to the fact that the continued evaporation of water from the surface keeps the alkali concentrated in the surface soil generally in sufficient quantity to affect or prevent vegetative growth, especially of plants more sensitive to alkali. Sodium carbonate or "black alkali" is generally considered the most injurious, followed in order by the chloride and sulphate salts. Weather conditions, texture of the soil, tillage methods, and localization in the soil section of horizons of salt concentration, all influence the amount of injury that may be expected from a given concentration of alkali. Therefore, it may readily be seen that a positive statement can not be made in regard to the amount of alkali that any given plant can withstand, without a complete knowledge of farm practice, local soil, climatic, and drainage conditions, and local concentration and character of the salts.

Crops differ also in their tolerance to alkali accumulations. With conditions favorable, it is generally recognized that alfalfa can be grown successfully on soils containing 0.3 to 0.4 per cent of alkali, and under certain conditions on even higher concentrations, if once a good stand can be established. In the case of raw soils with rather high alkali concentration and fair drainage, the salt content can oftentimes be reduced by surface flooding to such an extent that most crops will grow successfully. Sweet clover is one of the better legumes for alkali soils, growing well on soils with 0.6 to 0.8 per cent of alkali. Like alfalfa, however, it is sensitive to alkali in the seedling stage, and care should be exercised to keep alkali salts below the feeding zone of the young roots until the plant becomes established. Vetch, field peas, and beans are sensitive to alkali and are injured by low concentrations.

The grasses as a whole are resistant, though bluegrass will not grow on soils with any appreciable amount of alkali. Giant rye grass, orchard grass, redtop, and broom grass are good grasses for alkali soils of low to moderate accumulation.

Rye, sugar beets, and the sorghums, such as milo, are generally recognized as being resistant to alkali, and should be of value

in future agricultural development of the region. Barley is usually slightly more resistant than oats or wheat.

Asparagus, onions, celery, and radishes do well on soils with moderate amounts of alkali, and should prove valuable crops on the lighter textured soils of the area, which under cultivation contain less than 0.5 per cent of soluble salts.

In the Las Vegas area the slope is sufficient in all cases to promote artificial drainage of the soils by means of underground tile and open ditches, though in some cases natural drainage is poorly developed because of natural barriers to the movement of free underground water. With drainage of alkali lands, in the process of their reclamation, certain cultural practices should be observed, such as deep plowing and frequent cultivation to loosen up the soil and prevent evaporation, turning under green-manure crops, planting alkali-resistant crops, flushing the soils, and, in the case of black alkali, neutralizing the carbonates by the addition of gypsum or sulphur.

LAND CLASSIFICATION

In the general land classification, as indicated on the land classification and alkali map, the soils of the Las Vegas area have been placed in four groups, according to their approximate relative value for agricultural purposes. Each group represents soils which in a general way are similar in suitability for crop production, considered from the standpoint of depth and character of the soil material. Within each group, however, alkali conditions render certain areas much better adapted to agriculture than others. In addition, differences in texture, which are discussed in the descriptions of the soil types, make the soils better adapted to one type of farming than another.

The first group includes soils with permeable subsoils to a depth of 6 feet or more, which are well adapted to agriculture where drainage and alkali conditions are favorable. The group embraces the soils of recent deposition (the Gila series), also those of slightly greater age, which have not yet developed appreciable internal modification (the Land series). The soils of the group are absorptive of moisture and retain it well, especially some of the heavier textured types of the group. The surface drainage of this group is generally good, though subdrainage is restricted and alkali salts are present throughout the greater part of this class of land.

With the development of water for irrigation, the soils of this group should be well adapted to general farm crops and to truck crops. Areas favorably situated with respect to frost should be well adapted to fruit, but in general the soils of this group are subject to late spring frosts.

In the second group are soils which have undergone considerable modification since deposition, resulting in compact subsoils, which are without cementation, but interfere more or less with plant-root development. The group is well adapted to agriculture, being retentive of moisture and also having a high water-holding capacity. In some areas within the group the soils would absorb water very slowly. The group also includes areas with poor subdrainage, in some of which a high water table has developed. Alkali salts

are present almost everywhere, though generally in comparatively low concentrations. The group includes soils of the Spring, Pond, and Arden series.

With future development the soils of this group should prove well adapted to alfalfa, grain, milo, and other sorghums; also to fruit and vegetables in areas favorably situated with respect to frost.

The third group includes soils of comparatively shallow character, or of rolling topography, such that their value for agriculture is restricted. The group includes the soils of the Bracken, Reeves, and Tonopah series. It also includes all the phases of the Las Vegas series except the shallow phase of the gravelly fine sandy loam type, and all the rolling phases of the different types except that of the Arden loamy fine sand.

The drainage of the soils of this group is well established, though alkali salts are present, generally in low concentrations, in the flatter areas. Owing to their comparatively shallow character, the soils of this group would be rather droughty under irrigation, and best adapted to shallow-rooted grains and to vines of low water requirements, which could withstand occasional periods of drought successfully.

The fourth group consists of shallow soils which have little or no agricultural value. The group includes the soils of the Las Vegas series, all eroded soils, and Rough stony land and Dunesand. For the greater part the soils of the group are entirely valueless, though occasional areas may be found on which crops of low water requirement and those fitted to endure periods of drought would grow successfully. The drainage of the group is good, though some areas of old lake deposits contain alkali in places.

WATER RESOURCES AND IRRIGATION [3]

Although the early settlers found no permanent Indian settlements in the Las Vegas Valley, the remains of canals around some of the larger springs and mounds occupied by these indicate that irrigation was practiced at some time in the past. However, the Indians or their forerunners did not discover that the artesian water which gave rise to these springs existed at comparatively shallow depths, hence their development was meager and their influence on subsequent development of no consequence.

Lying as an oasis on the dry, hot stretches of the old Mormon Trail to California, the Las Vegas Springs early became an important stopping place. Since the first days of the gold rush in 1849, the land watered by these springs has been steadily developing and increasing in importance. To-day the city of Las Vegas and the Las Vegas Ranch depend on these magnificent springs for their water supply.

Until the discovery of artesian water in 1906 agricultural development was limited. However, two fine ranches, the Las Vegas and the Kyle ranches, were started in the early days. The former is watered by the Las Vegas Springs and the latter by several small springs issuing from a prominent terrace. The value of these places as indi-

[3] This chapter is contributed by George Hardman, assistant research professor of irrigation, agricultural experiment station, Nevada.

cators of the possibilities of the desert lands in this valley, and as guides in the later and more extensive development, is hard to estimate.

About 225 wells have been sunk in the Las Vegas Valley. Many of these are nonflowing, many more have a flow so small as to be worthless for irrigation, whereas a few, perhaps 30, have a discharge high enough to be valuable. (Pl. 8, fig. 2.) In one case the flow from a number of small wells has been united and made of value. Discharges vary from a few gallons per minute to more than 1,200 gallons from the largest well, and 2,700 gallons from the Las Vegas Springs. The total flow from the artesian wells in the valley is not far from 25 second-feet, to which should be added about 10 second-feet from springs and surface flow, making a total of 35 second-feet or 1,400 inches of water. With a duty of water of 1 second-foot to 80 acres there is now sufficient water to care for about 2,800 acres of land. There are no indications that the limit of artesian development has been reached and the pumping possibilities have scarcely been touched. Cheap electrical power should undoubtedly stimulate activity in this direction and add much agricultural land not within the artesian area.

Little accurate information has been gathered on the duty of water for various crops and soils, but judging from the few cases where wells of known flow are utilized on known areas, the actual duty for such crops as alfalfa is 1 second-foot for 60 to 80 acres. For fruits the acreage per second-foot is much larger. Furthermore, as the raw, desert lands become subdued and more amenable, less water is required. The winters are mild and open and winter irrigation of many crops is entirely feasible. Considering all these factors, it seems unwise to attempt to establish a definite acreage that can be served by a second-foot of continuous flow.

An unfailing source of supply to replenish the underground reservoir is essential for a permanent artesian or pumping area. The exact extent of this supply for the Las Vegas Valley, which from all indications comes from the Spring Mountain Range on the west side of the valley, is not yet known. These mountains are lofty, the highest peak, Mount Charleston, reaching the imposing height of nearly 12,000 feet. The precipitation on the peaks is quite heavy, though no exact measurements have been taken. Owing to the looseness and depth of the soil on the mountain slopes, there is practically no run-off, most of the streams disappearing almost as soon as they appear, hence the percentage of loss is low. It must be remembered that the Spring Mountains, or, as they are commonly called, the Charleston Mountains, must furnish water for the Pahrump Valley artesian area and the Indian Spring Valley area, as well as the Las Vegas area. Provided the loss through percolation into the deep-lying strata and thence into the Colorado River is not too large, it would apparently require only a very moderate precipitation to care for the present underflow in all these areas.

Data are lacking upon which to base any estimate of the extent to which further development of artesian water in these valleys may go before a failing supply becomes apparent, but the limit has apparently not yet been reached.

SUMMARY

The Las Vegas area is situated in Clark County in southern Nevada. It has an area of 308 square miles, or 197,120 acres. The greater part of the area consists of broad gently sloping alluvial fans, with a smaller flatter area in the central part of the valley. The general elevation of the area is about 2,033 feet.

No large perennial streams enter the area, though some of the mountain canyons carry water throughout the year. Surplus surface water during periods of flood is carried from the valley through the Las Vegas Wash, which empties into the Colorado River to the east.

The agricultural section of the area is thinly populated, the greater part of the population being located in the town of Las Vegas. The Union Pacific Railroad offers good transportation facilities for the valley.

The summers are characterized by hot days and comparatively cool nights. The winters are mild. Freezing weather is of annual occurrence but does not last more than a few days at a time. The mean annual temperature is 60.5° F. The average length of the growing season is 222 days. The mean annual precipitation is 4.82 inches, making irrigation essential for the production of crops.

Alfalfa is the principal crop grown on the ranches of the valley, with small quantities of fruits, such as peaches, apricots, grapes, figs, and apples. Enough dairy cattle are kept on the ranches of the valley to supply the local demand for milk and cream.

The soils of the valley are derived mainly from limestone, with slight admixtures of materials derived from basalt and other crystalline igneous rocks. The older soils of the alluvial fans have been modified to a great degree by weathering and accumulation of lime in the subsoils, with the result that lime-carbonate hardpan underlies a large part, giving rise to soils of the Las Vegas series; while highly gypsiferous subsoils have given rise to soils of the Bracken and Reeves series. Other alluvial-fan soils of a porous, gravelly character are classed in the Tonopah series.

Well-weathered old valley-filling soils having compact subsoils, which are adapted to agriculture, are classed in the Spring, Arden, and Pond series. Soils with slightly compact subsoils and only slightly weathered are classed in the Land series. The soils of recent deposition are placed in the Gila series. The Land and Gila soils are considered the best soils in the area.

Alkali is of widespread distribution in the valley, but generally of low concentration, except in places in the lower, more poorly drained central part of the valley and in the vicinity of Grapevine Springs and Bracken. Any permanent system of reclamation of alkali-affected land is dependent on drainage.

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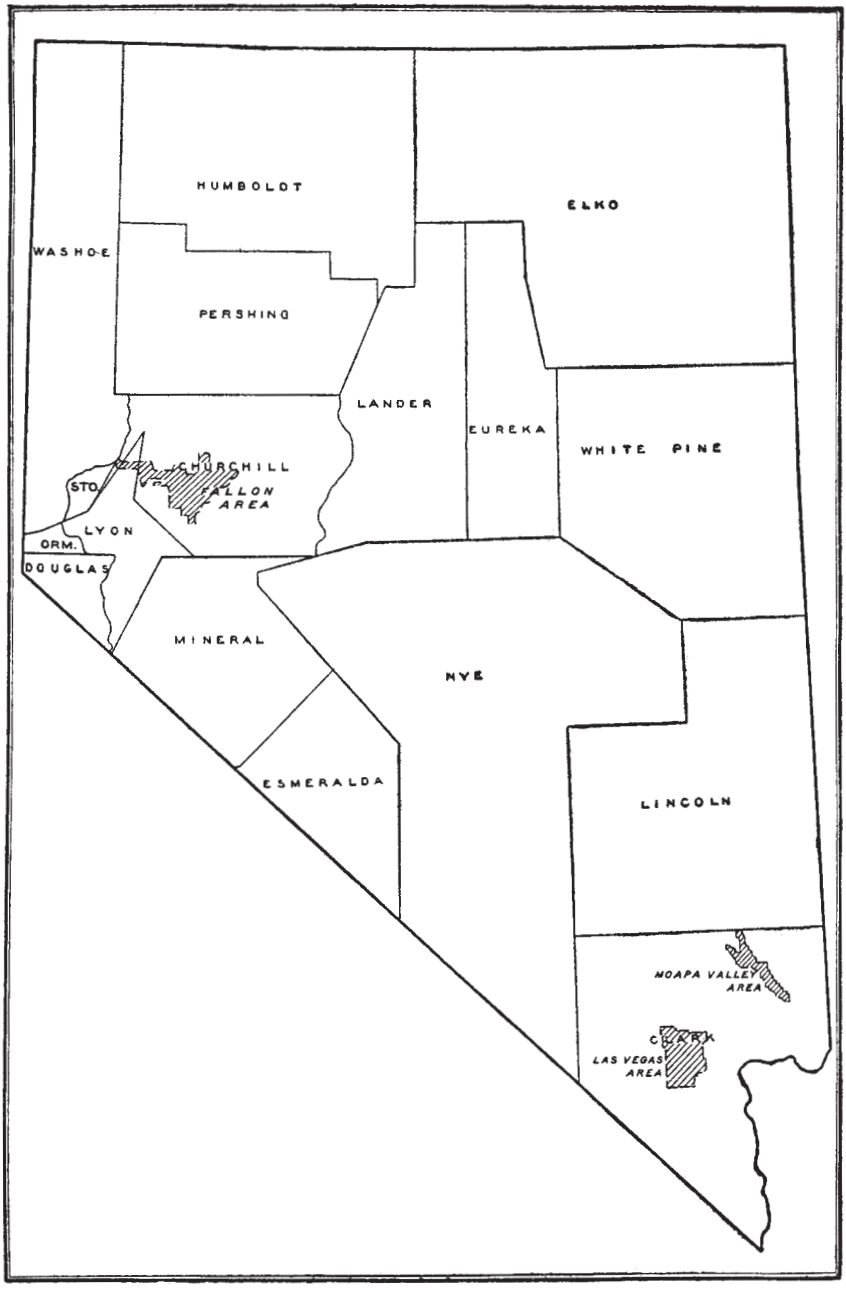

Areas surveyed in Nevada, shown by shading

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