U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UTAH AGRICULTURAL EXPERIMENT STATION,
F. S. HARRIS, DIRECTOR; D. S. JENNINGS, IN CHARGE SOIL SURVEY.

# SOIL SURVEY OF THE DELTA AREA, UTAH.

BY

A. T. STRAHORN, OF THE U. S. DEPARTMENT OF AGRICULTURE,
IN CHARGE, H. STUCKI, AND D. S. JENNINGS, OF THE
UTAH AGRICULTURAL EXPERIMENT STATION.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1919.]

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# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
*Washington, D. C., March 11, 1922.*

SIR: Under the cooperative agreement with the Utah Agricultural Experiment Station, F. S. Harris, director, a soil survey of the Delta area was carried to completion during the field season of 1919.

I have the honor to transmit herewith the manuscript and map covering this work and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1919, as authorized by law.

Respectfully,

MILTON WHITNEY,
*Chief of Bureau.*

Hon. H. C. WALLACE,
*Secretary of Agriculture.*

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Soil map, Delta area sheet, Utah.

# SOIL SURVEY OF THE DELTA AREA, UTAH.

By A. T. STRAHORN, of the U. S. Department of Agriculture, In Charge, and H. STUCKI and D. S. JENNINGS, of the Utah Agricultural Experiment Station.—Area Inspected by MACY H. LAPHAM.

## DESCRIPTION OF THE AREA.

The Delta area is located in the west-central part of the State of Utah about 140 miles by rail south and slightly west of Salt Lake City. The area lies in the Sevier Desert in the northeastern part of Millard County. The boundaries of the area, which follow township and section lines, include all the land within the several recently organized drainage districts in the valley, as well as the adjacent lands lying near some of the larger irrigation canals. The area is approximately 20 miles in length from north to south, averages about 8 miles in width, and contains about 180 square miles, or 115,200 acres of land.

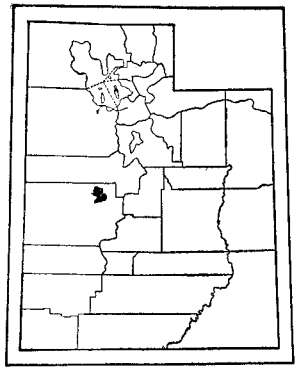


FIG. 1.—Sketch map showing location of Delta area, Utah.

Topographically, the area consists of a part of the Lynn Bench and its southern extension occurring along the eastern boundary of the area, and the lower moderately sloping floor of the Sevier Desert. The Lynn Bench is an extensive terrace rising from 50 to 75 feet above the lower lands. The terrace margin is well defined and steeply sloping to eroded; the terrace surface is smooth to gently rolling, and is marked by occasional small mounds of windblown sand. The southern extension of the Lynn Bench is a smooth to sharply rolling plain lying between the floor of the desert and the base of the mountains along the eastern side of the valley. The western boundary of this plain lies just within the eastern boundary of the area surveyed. In places the western edge of the plain is eroded and well defined, but in most places it passes into the lower lands through smooth, gentle slopes and with imperceptible changes in soil materials. The Sevier Desert, constituting part

of the bottom of former Lake Bonneville, is a rather smooth plain sloping south, west, and north from the western margin of the Lynn Bench. The surface elevation of this plain ranges from about 4,565 feet to 4,640 feet above sea level. The slope ranges from 5 feet per mile to 20 feet per mile. The principal irregularities of surface are the depressed channel and flood plain of the Sevier River and a somewhat rolling topography in the extreme southern and western parts of the area. In these rolling districts there are occasional knolls and ridges from 6 to 12 feet in height, and in many places a very low, irregular, broken terrace may be traced for considerable distances. Below this terrace the land is exceedingly smooth and with hardly any slope. The Sevier River crosses the area in a southwesterly direction and occupies a channel from 6 to 30 feet or more below the level of the plain. Southward for about 7 miles from the point where the river enters the area it meanders through a narrow flood plain inclosed by vertical or steeply sloping bluffs. South of this to the southern boundary of the area the river follows a tortuous course, flowing in a narrow channel and having no flood plains. Other minor irregularities in the surface of the plain include occasional small sand dunes scattered throughout the area and old abandoned stream channels. Most of the latter are isolated, short, narrow depressions only a few feet in depth, but in two cases such channels are continuous for several miles.

The Sevier River and Tenmile Hollow Creek drain the Delta area. The Sevier River and its tributaries have their source in the elevated plateaus in the Sevier Mountains, about 120 miles south of this area. The river takes a general northerly course to a point some 30 miles northeast of Delta, and, turning sharply to the southwest, crosses the desert and discharges into Sevier Lake, some 25 miles southwest of the town of Delta. Tenmile Hollow Creek is a small intermittent stream southeast of Delta, which gathers surface and seepage waters along its course and discharges into Mud Lake, a short distance south of the area.

The Sevier Desert was apparently first visited by white men in 1776, when two Franciscan friars, Escalante and Dominguez, passed southward in search of a route between the mission at Santa Fe and the missions on the California coast. From about 1825 until shortly after the arrival of the Mormons at the present site of Salt Lake City in 1847 numerous trappers and explorers passed through this part of the State, but it was not until about 1851–52 that the first permanent settlement was made. At that time Brigham Young selected a site on Chalk Creek (about 30 miles southeast of the present town of Delta) for the first capital of the Territory of Utah. This settlement was known as Fillmore, and has been the county seat since the organization of Millard County. Other settlements,

such as Oak City, Holden, and Meadow, sprang up later along the western base of the Canyon Mountains, in situations where the mountain streams afforded a supply of water for domestic use and for the irrigation of small tracts of land. Development on the floor of the desert did not take place until about 1860, when some land in the southwestern part of this area was irrigated by the diversion of water from the Sevier River. Oasis was established upon the construction of the Utah Central Railroad, about 1875, between Salt Lake City and Milford. This road, known as the Los Angeles & Salt Lake Railroad, was later extended to Los Angeles, Calif., and is now a part of the Union Pacific System.

The population of the area is largely rural. Delta, Hinckley, Oasis, and Deseret are the larger towns in the area, Delta being the commercial center of the district. Sutherland, Woodrow, and Sugarville are crossroad stores northwest of Delta, and Steele, Erwin, Abbott, Wilson, Gordon, Lucerne, and La Moto are sidings on a branch line of railroad where facilities are available for the loading of sugar beets during the harvest season.

The main line of the Los Angeles & Salt Lake Railroad passes through the area in a northeast-southwest direction and affords outlets to eastern, northern, and Pacific coast markets. A branch line extending northwest from Delta is largely utilized for transporting sugar beets to the factory at that place.

The area is well supplied with earth roads. Similar roads extend east and south to the outlying settlements along the base of the Canyon Range, and two wagon roads extend west into Nevada. The roads are usually in good condition when dry, but are often impassable during the irrigation season, owing to the careless use of irrigation water.

## CLIMATE.

With the exception of an unofficial record of the rainfall at Deseret for a number of years, there are no climatic data available for the Delta area.

The annual precipitation for this region is apparently about 8 inches, the larger part being in the form of rain. June, July, and August are usually the driest months of the year, and about 50 per cent of the annual precipitation comes in the months of February to May, inclusive. During the spring months the storms occasionally bring sufficient rain to help the early growth of crops, and the fall rains may be of some aid to fall-sown grain, but during the rest of the growing season the precipitation is very light, and irrigation is necessary for crop production. The snowfall is light and seldom covers the ground, except for short periods after the heavier storms. Hail and electrical storms are rare.

The seasonal temperatures seem to vary from somewhat over 100° F. during the summer months to probably as low as —15° during the winter season. Killing frosts in the fall usually occur early in September and are a matter of considerable importance, as the yield of alfalfa seed and hay may be seriously affected by early freezing temperatures. The last killing frost in the spring usually occurs late in May, and although unseasonably low temperatures may, in occasional years, do some damage during the growing season the principal crops (alfalfa, grain, and sugar beets) seldom suffer any material injury.

The wind movement is usually high during spring and summer, and low during the rest of the year. Strong southerly winds often blow for days at a time during summer, making haying operations difficult, and affecting the water content of the irrigated soils. The direction of the prevailing winds is north.

## AGRICULTURE.

Agriculture in the Delta area had its beginning about 1860, when a small colony of settlers from Fillmore began the irrigation and cultivation of the lands south of the present town of Deseret. Water was diverted from the Sevier River, but as there were no storage facilities the supply was uncertain during the latter part of the growing season. Owing to this and the isolation of the district, development was very slow. It was not until about 30 years ago that the districts around Abraham, Hinckley, and Oasis were brought under irrigation through the storage in and diversion of water from the Gunnison Bend Reservoir. The region south of Delta and in the northern parts of the area east of the Abraham district were opened to settlement about 10 years ago, following the construction of additional storage works on the Sevier River some distance north of the town of Delta.

Alfalfa hay and seed were practically the only crops grown in the valley 10 or 12 years ago. During that time some of the hay was fed, but the larger part of it was baled and shipped to outside markets. When the northern and eastern parts of the area were developed, a considerable acreage was devoted to grain. The growing of grain has lately been extended to the older districts, but the largest acreage is still in the northern part of the area. Sugar beets have become one of the leading crops of the district within the last 4 years.

The last season (1918) grain occupied about 9,000 acres, 80 per cent of which was fall-sown wheat. The average yield is less than 10 bushels per acre. Grain is irrigated by flooding, usually once in the fall, and once or twice in the spring, depending upon the soil and the

season. Spring-sown grain is often irrigated four or five times. Fall-sown grain is the principal crop on newly broken ground, and upon old ground it commonly follows native grass or sugar beets.

Alfalfa, which was grown on about 13,000 acres during 1918, is sown only upon land that has been under cultivation for some time. Some difficulty is commonly experienced in obtaining good stands of this crop. Apparently this is partly due to the absence of the necessary bacteria, and very often to the crusting and baking of the surface of the heavier soils. Two or three cuttings of hay a season and some fall pasturage are obtained if no seed is ripened. When seed is desired, only one cutting of hay is made, about the 1st of July, and the following growth is allowed to mature. The seed crop is usually cut early in September, and is occasionally affected in both quantity and quality by early frosts. In 1918 the average yield of seed in the district was about 6 bushels per acre. The 1919 crop was all contracted for at prices ranging from 22 to 29 cents per pound. Alfalfa hay is selling (1919) for about $20 a ton in the stack.

Sugar beets are grown only upon land that has been under cultivation for some time, and it is the prevailing opinion that they do best when grown on land previously in alfalfa. This year (1919) about 10,000 acres were in beets, and the average yield was about 6 tons per acre. Under contracts with the sugar factory in effect for this season, the farmers were paid a flat rate of $10 per ton.

The growing of vegetables and fruits is rarely attempted, although there is no reason why this area should not produce a sufficient supply of fruits and vegetables, except the more tender, to meet the local demands. The prevalence of late spring frosts will probably prevent fruit growing becoming a commercial enterprise. Small quantities of fruits and vegetables are brought into this district from settlements on the east, but the larger proportion of such perishables come from California and Idaho, and from the older farming districts of the northern part of the State. Dairying has received little attention up to the present time, although there are no reasons why this should not become one of the important industries of the valley. Few cattle are raised within the area, but cattle from outside points are fed during the winter in increasing numbers.

No commercial fertilizers are used in the area, and but very little of the land receives any manure or other form of organic material. Most of the soils have a very unfavorable structure, so that they bake and crack after the application of water. This structure not only makes the usual tillage operations difficult, but it often makes it difficult to secure satisfactory stands of young plants.

SOILS.

The valley in which the Delta area lies is structural in origin, being due to faulting and block movement, the Pavant Range, bounding it on the east, consisting of a raised block and the valley a depressed one.

The original valley surface over the whole area included in the Delta soil survey has been covered to great depth by rock waste, probably brought into the valley mainly by the Sevier River and deposited partly in a great lake (Lake Bonneville) once occupying[1] it and to some extent by local wash from the adjacent Pavant Range.

It is possible that more or less material from various lands around the now extinct lake reached this valley and was deposited in it during the period when the lake was in existence. The essential fact about the material is that it came from geologic formations not only varying greatly in age—from Devonian to Tertiary—but as widely in their lithologic and mineralogic characters. The Sevier River and its tributaries that have contributed material to this area drain areas of sandstone, limestone, volcanic rocks, probably volcanic ash, and shale. It traverses also beds of gypsum, rock salt, rocks with high percentages of sodium and magnesium salts, alum salts, and alunite. It can be seen, therefore, that the deposits consist of an extremely wide range of geologic and mineralogic material.[2]

The older sediments have been deeply buried and appear only at the higher levels of the former lake, and within the Delta area heavy compact stratified materials that appear to represent such deposits are found in only a very few localities. The lighter textured materials deposited within the basin are usually finely stratified, and the abrupt variations in the texture of the sediments appear to indicate that the fluctuations in the depth of the lake may have been sharply defined, there being long periods of submergence when silts and clays predominated in the sediments, and periods of recession when the coarser textured materials were carried farther into the lake. Aside from the local erosion of the sediments by the Sevier River, as it develops its depressed flood plain, the soils are stable at the present time, and there has been but little change in the topography or the distribution of soil material since the disappearance of Sevier Lake.

Plate I, Figure 1, shows an exposure of the sedimentary deposits of the desert floor. Within the delta of the Sevier River, these consist in part of compact, light-colored, stratified clays, and more extensively of light-textured, porous, gravelly materials, the former being old lacustrine sediments and the latter apparently represent-

[1] U. S. Geological Survey, Monograph No. 1.

[2] This statement is based on information furnished by Dr. William Petersen, director Utah Agricultural Experiment Station.

ing what was a submerged delta of the Sevier River at a time when Lake Bonneville may have been somewhat below its maximum level. The remainder of the deposits in the area represent materials that were carried by the Sevier River into the fluctuating Sevier Lake. The source of much of the older sediments is unknown, but the more recent materials, coming from within the watershed of the Sevier River, have been derived largely from sandstone and shale, and metamorphosed sediments represented mainly by reddish quartzites. Areas of igneous rocks also occur in the higher regions of the watershed, but as they are less easily eroded they have probably contributed little to the formation of the present soils. Notwithstanding this supposed derivation of the soil material from noncarbonate rocks, all the soils have a high lime content, ranging, in those so far analyzed, up to 20 per cent or more of the air-dried sample.

With the exception of minor areas of Dunesand and Rough stony land, all of the soils within the area are classed in the old-valley filling group. They are formed therefore from waterlaid deposits that have undergone physical and probably chemical changes through weathering since they were accumulated. The physical changes are manifested in the surface soils by certain conditions of structure which range from smooth, hard, and compact, to loose and puffy. A mottling of colors is commonly present in the heavier textured subsoils, and a compacted layer is usually found a few inches below the surface. The group is represented locally by seven series of soils. Each series has certain rather pronounced and consistent characteristics of color and structure that distinguish it from the other series. Each of these series of soils is divided into soil types, the differentiation of these being based upon differences in texture determined by the relative content of sand, silt, and clay.

With the exception of the Lynndyl series and the two types of miscellaneous materials, the topography of these types is that of a smooth, moderately sloping plain, broken in the southern and western parts of the area by a low rolling surface. All these series are markedly calcareous in both the surface soil and subsoil, and, although no hardpan is present, the soils of one series show a slight tendency toward cementation a few inches below the surface.

In color the surface soils range from light brown to dark gray. The soil materials are seldom sharply defined by color differences, but merge one into another through faint gradations, and the soil boundaries, as shown upon the map, seldom represent distinct lines of demarcation but rather mark the approximate center of a zone of color transition. Not only is it a difficult matter to establish a satisfactory differentiation of the soils in this survey on a basis of color, but distinction on a basis of texture is often equally illu-

sive. This is due mainly to the large amount of silt in all the heavier types, and also to a pronounced flocculation of the materials in the surface soils, which makes the soil texture appear to be lighter than it really is.

In the virgin soils throughout the area there is developed consistently a thin surface crust beneath which there occurs a layer a few inches thick of a loose, flocculated material. The same feature develops in the areas that have been left out of cultivation for a year or so. This peculiarity is less pronounced in the soils of the Lynndyl series, and usually most strongly developed in the heavier textured types of the other series. Hard, barren, playa-like surfaces are developed in a number of localities, and in two places were of sufficient extent to be mapped as a soil phase.

All the types mapped in this area were developed under arid conditions. They are treeless, rather low in content of organic matter, and unleached, and contain much lime in both surface soil and subsoil.

The arable soils mapped in the Delta area are classed in the Cache, Woodrow, Oasis, Gordon, Abbott, Lynndyl, and Lahontan series. Dunesand and Rough stony land comprise two additional nonagricultural types of miscellaneous materials.

The types of the Cache series are characterized by light brownish gray or light grayish brown surface soils, with a pinkish or reddish tint, and a light pinkish gray subsoil. Both surface soil and subsoil are highly calcareous, and the lime gives a light-gray color to dry field surfaces and samples, and particularly to samples of the subsoil. The substratum consists of calcareous lake-laid silts and clays, stratified, compact, and in places jointed, and of pinkish or light reddish brown color. In this area the surface soils under moist field conditions are somewhat browner than in areas previously mapped, and the subsoil is not so pink and in places includes darker colored strata. The soils are derived from old lake-laid deposits which had their source mainly in limestones, quartzites, and other sedimentary rocks. The topography is flat, and the drainage in most places rather poor, the internal movement of water being retarded by the compact heavy subsoil. The soils were developed under conditions of low rainfall. They are treeless, and in places contain excessive amounts of alkali salts. The Cache loam and the Cache silty clay loam are mapped in this area.

The surface soils of the Woodrow series, when dry, are prevailingly light grayish brown to gray in color, with considerable areas of grayish-brown and dark-gray variations, and small local areas in which the color approaches a light reddish brown when moist. The subsoil is of heavy texture and light-brown color, modified by thin strata of red, reddish brown, and black and by mottlings of

gray and reddish brown. The surface is usually smooth, though in places gently rolling. Surface and internal drainage are sufficient under conditions of normal rainfall, but the heavy subsoil retards the escape of irrigation water, and areas of alkali and water-logged soils occur. Two types of the Woodrow series are mapped in this area, the clay loam and the clay.

In the Oasis series the color of the surface soils is like that of the Woodrow series, except that the reddish-brown color occurring in places in the Woodrow soils does not occur in the Oasis. As with the Woodrow series, the boundaries between types of this and of the associated Gordon and Abbott series are indefinite. The subsoil, though generally light textured, may contain thin strata of heavier materials, prevailingly light brown, with local variations of light yellowish brown. The topography of the Oasis soils ranges from smooth and gently sloping to slightly undulating. The drainage afforded by the light-textured subsoil is ample to care for the normal precipitation, but where large amounts of irrigation water are used areas of water-logged soils occur. Three types and two phases of this series are mapped in this area—the Oasis fine sandy loam with a bench phase, the Oasis silty clay loam with a light-textured bench phase, and the Oasis clay.

Under moist field conditions the surface soils of the types included in the Gordon series are dark brownish gray or dark gray; the dry surfaces and dry sample have a somewhat lighter gray color. Within the areas the color is uniform, but toward their margins, where the soils grade into types of the Woodrow or Oasis series, it shades toward light brown or grayish brown. The subsoil is similar to that of the Oasis subsoil in color, texture, and structure. Considerable areas of the Gordon soils carry rather large amounts of alkali. In some places this series has a gently rolling topography, but generally the surface is smooth and in places so level as to suggest the location of former lakes or ponds. The Gordon clay and a slick phase and friable phase of the type are mapped in the present area.

The Abbott series includes types with dark-gray or brownish-gray soils which appear lighter gray on bleached field surfaces and in dry samples. The color is uniform, except in zones of transition into the lighter colored soils of the Woodrow or the Oasis series. In color, texture, and structure the surface soils of the Abbott series are very similar to those of the Gordon series, but there is a marked difference in the subsoils. The subsoil of the Abbott is prevailingly light brownish gray to gray, mottled here and there, heavy in texture, and compact in structure. Some of the types contain alkali. One type, the Abbott clay, with a silty phase, has been mapped in this area.

The types of the Lynndyl series have light-brown surface soils and a subsoil either similar in color to the soil or showing various shades of brown. Except in very small areas, both the surface soil and subsoil contain appreciable quantities of fine waterworn gravel, and in many places the gravel is so abundant as to form the bulk of the subsoil material. The deeper substratum, where exposed along the Sevier River, exhibits strata of compact fine sands, gravels, and, in a few places, other materials. Both the surface soil and subsoil are highly calcareous, and in places there is a slightly cemented structure a few inches below the surface. The topography is gently rolling, and the drainage is excessive. The soil is free from alkali. Only one type of the Lynndyl series, the gravelly sandy loam, is found in the Delta area.

The types included in the Lahontan series have light grayish brown to light brownish gray surface soils, and compact stratified grayish clay, subsoils. Commonly there is a thin layer of black fine sandy loam just above the clay. The Lahontan series is derived from the old lake sediments. In the present area material of this kind is exposed in only two localities, but the deposits undoubtedly underlie all the soils, and appear at or near the surface in considerable bodies a short distance east of the area. The natural drainage is deficient, the soils are highly charged with alkali, and in one body a badly water-logged condition has developed through seepage from an adjacent canal. Only one type, the Lahontan clay loam, is mapped in the Delta area.

Dunesand and Rough stony land include miscellaneous materials. The Dunesand is largely nonagricultural, and the Rough stony land is entirely so.

The soil types of the Delta area are described in detail in the following pages of this report, and their distribution is shown on the accompanying soil map. The table below shows the actual and relative extent of the types in the area.

*Areas of different soils.*

| Soil. | Acres. | Per cent. | Soil. | Acres. | Per cent. |
|---|---|---|---|---|---|
| Oasis clay | 28,480 | 24.7 | Cache silty clay loam | 11,392 | 9.9 |
| Gordon clay | 12,992 | | Woodrow clay loam | 9,024 | 7.8 |
| Friable phase | 1,856 | 13.2 | Woodrow clay | 5,376 | 4.7 |
| Slick phase | 384 | | Lynndyl gravelly sandy loam | 1,856 | 1.6 |
| Oasis silty clay loam | 14,400 | 12.9 | Cache loam | 1,408 | 1.2 |
| Light-textured bench phase | 448 | | Lahontan clay loam | 1,344 | 1.2 |
| Oasis fine sandy loam | 13,440 | 11.8 | Dunesand | 512 | .4 |
| Bench phase | 128 | | Rough stony land | 64 | .1 |
| Abbott clay | 8,960 | 10.5 | Total | 115,200 | ..... |
| Silty phase | 3,136 | | | | |

CACHE LOAM.

The Cache loam consists of a light brownish gray to light grayish brown loam, 10 to 24 inches deep, resting on a subsoil composed of strata of light grayish brown to dull grayish brown clay loam and clay, usually silty in texture, extending to a depth of 6 feet or more. The color of the surface soil is rendered darker than normal in places by the presence of seepage water and excessive amounts of alkali. Dry surface and subsoil samples have a lighter color, in which gray predominates. Where the type merges into types of the Gordon or Abbott series the color shades to a dark gray. The surface soil is usually porous, the particles being well flocculated, but in many places where there is considerable alkali or excessive moisture it is very compact and can hardly be distinguished from the heavier types of the series. The subsoil is generally heavy and compact, but contains occasional thin strata of light-brown fine sandy loam. Gray and brown mottling is not uncommon in the subsoil.

The type is confined to a few small bodies in the extreme southern and western parts of the area. The topography is smooth, except in one area northwest of Abraham, where it is rolling and hummocky. The drainage is somewhat deficient, owing to the compact structure of the subsoil, and some areas have a high water table and excessive amounts of alkali.

Nearly all the Cache loam is under cultivation. The principal crops are alfalfa, grain, and sugar beets. Alfalfa probably occupies over 50 per cent of the total area of the type. This soil is easily tilled and is retentive of moisture. Where the water-logged and alkali areas are reclaimed, even this land can be utilized for crop production.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the type:

*Mechanical analyses of Cache 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.* |
| 520725 | Soil | 0.0 | 0.0 | 0.3 | 8.3 | 34.6 | 39.2 | 17.7 |
| 520726 | Subsoil | .0 | .0 | .0 | 1.2 | 20.6 | 58.7 | 19.6 |

CACHE SILTY CLAY LOAM.

The Cache silty clay loam is a light grayish brown sticky silty clay loam, 8 to 30 inches deep, underlain by a subsoil of compact, grayish-brown, stratified clay loam and clay. In dry samples the color is lighter and the gray color predominates. The surface soil

grades imperceptibly into grayish-brown and dark-gray variations where the type merges into associated types of the Gordon or the Abbott series. A very light reddish brown or pinkish tint is developed in places, but is less pronounced than in some of the other types. In the virgin areas the surface soil is somewhat compact and has a grayish color, but the surface material in the larger areas has a rather puffy, flocculent structure, which is most strongly developed around the desert shrubs. The subsoil is prevailingly heavy and compact, but locally the texture of the surface soil continues downward to a depth of several feet, and in places the subsoil contains seams and thin layers of fine sand and fine sandy loam. The color of the subsoil is also varied by grayish-brown and reddish-brown mottlings, and by thin strata that are dark brown, black, or red.

The largest development of this type is a nearly continuous body extending in a general southeastern direction from the town of Delta to the southern boundary of the area and southwesterly from that place along the railroad for a distance of about 3 miles. Several areas, each having an extent of several hundred acres, are developed in the vicinity of Sutherland and east of Woodrow, and smaller areas occur throughout the survey.

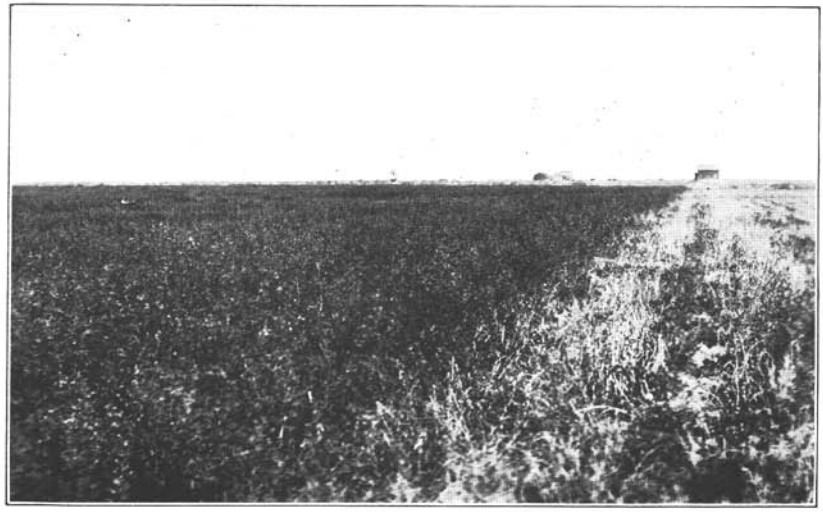
Because of the heavy subsoil drainage is generally deficient, though the conditions vary widely in the different areas. The greater part of those bordering upon the Gunnison Bend Reservoir and the Sevier River has been but little affected by water-logging from irrigation. In a number of other localities, where some of the larger canals pass through or near bodies of the type, as east of Delta and Sutherland, seepage waters have ruined a considerable acreage of land. Along Tenmile Hollow Creek, and farther south near the boundary of the area, unfavorable moisture conditions and excessive accumulations of alkali seem always to have existed. The large area of this type that extends southwest from the town of Delta carries but little alkali, and parts of it may be considered as free from alkali. Throughout most of the other areas, however, alkali is either present in quantities that inhibit crop growth or approximate the limit of tolerance for cultivated crops.

A large part of this type is under cultivation at the present time, but some of this would probably be abandoned soon were it not for the protective drainage measures now being carried out. Some areas of soil are still in a virgin state because of unfavorable alkali conditions, and a large acreage of this type that was once under cultivation has been abandoned; in some cases the true alkali conditions were not realized at the time of development, in other cases the soil has, to use a local expression, "gone bad" through the effects of accumulation of alkali salts caused by seepage and the use of excessive quantities of irrigation water.

S. 10497.

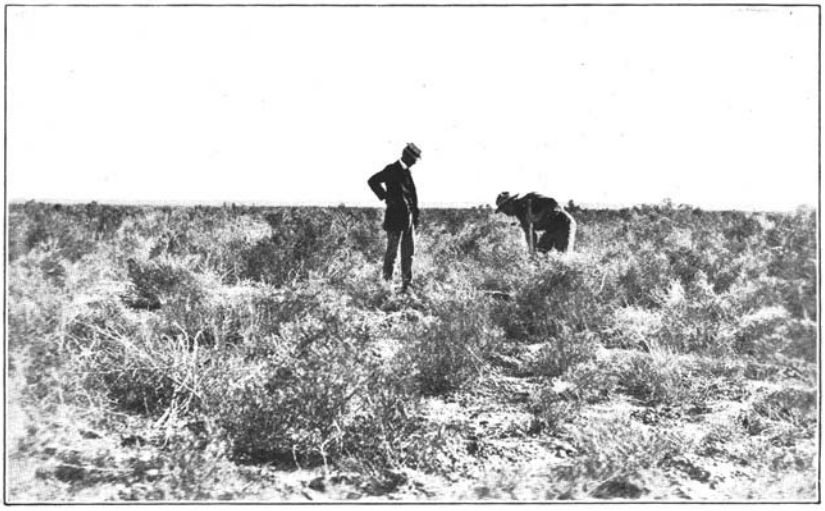
FIG. 1.—EXPOSED SECTION IN BANK OF SEVIER RIVER AT SPILLWAY OF GUNNISON BEND RESERVOIR.

Showing stratified sediments of the desert floor from which most of the soils of the Delta Area are derived.



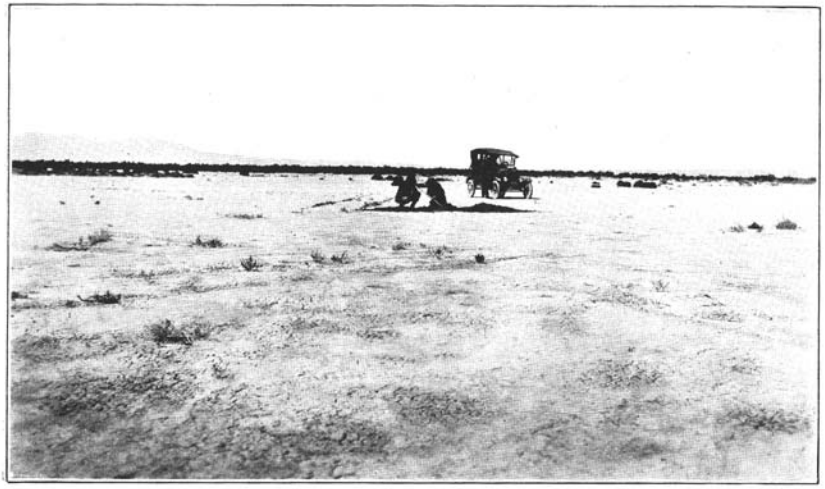
S. 10662.

FIG. 2.—ALFALFA ON OASIS CLAY.



S. 10661.

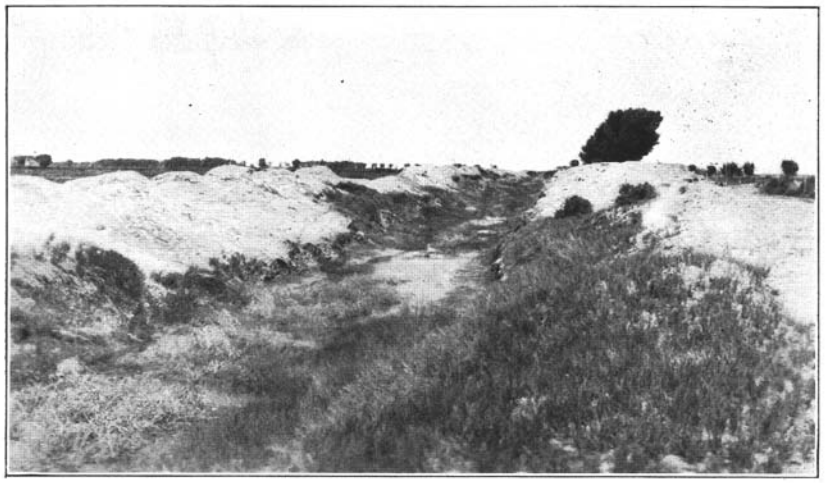
FIG. 1.—GROWTH OF GREASEWOOD ON OASIS CLAY.



S. 10659.

FIG. 2.—AREA OF GORDON CLAY, SLICK PHASE.

Note barren and cracked surface.



S. 10512.

FIG. 1.—OLD DRAINAGE CANAL IN LOW, WATER-LOGGED PART OF THE AREA.

This canal was ineffective, owing to insufficient depth.

S. 10665.

FIG. 2.—RECENTLY EXCAVATED DRAINAGE DITCH MADE WITH DREDGER.

An example of recent drainage construction, in which the canals are wider and of greater depth and effectiveness.

The Cache silty clay loam, particularly in its heavier variations, is rather difficult to handle, as it has a tendency to bake and crack and form crusts on the surface after rains or irrigation. It is frequently necessary to use an early irrigation to help the young plants to break through the crust. A more liberal incorporation of organic matter would greatly reduce the cracking and crusting tendency of this soil, and make plowing and cultivation easier. Sugar beets and alfalfa are the principal crops grown. Several areas, particularly in the southern part of the survey, lie too low to be benefited by the proposed drainage systems; the rest of the type can be reclaimed.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Cache silty clay loam:

*Mechanical analyses of Cache silty 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.* |
| 520715 | Soil | 0.0 | 1.4 | 0.6 | 8.8 | 4.3 | 58.0 | 27.2 |
| 520716 | Subsoil | .1 | .6 | .4 | 2.2 | 2.4 | 48.6 | 45.5 |

WOODROW CLAY LOAM.

The surface soil of the Woodrow clay loam consists of a light grayish brown to grayish-brown heavy sticky clay loam 12 to 24 inches deep. In dry samples the gray color predominates. The subsoil is a light grayish brown to gray and rarely a yellowish-brown clay. Pronounced gray to dark-gray variations in the color of the surface soil occur in the vicinity of types of either the Gordon or Abbott series. Material of reddish-brown color is found in a small area about 2½ miles north of Hinckley, and a pinkish tinge occurs in several of the bodies south of Delta. In a number of places thin layers of dark-brown to black, or nearly red, heavy-textured material are present in the lower part of the surface soil and in the subsoil. In virgin areas the surface soil commonly consists of a very thin crust, which cracks upon drying, underlain by a loose, flocculent layer, 2 to 4 inches deep, and this in turn by the sticky clay loam. This condition is particularly well developed in the southern part of T. 17 S., R. 8 W. This structure is destroyed by cultivation, and the surfaces of recently abandoned fields show a tendency toward an adobe structure. Locally the surface soil extends without distinctive subsoil to a depth of 6 feet or more. The normal clay texture of the subsoil in places, particularly adjacent to members of the Oasis and Gordon series, is interrupted by thin strata of light-brown or light yellowish brown fine sand or fine sandy loam. Mottlings of grayish color and reddish-

brown stains are not uncommon in the subsoil. Hardpan does not occur, but the subsoil is very compact in places and obstructs the free movement of the soil moisture. Some small areas in which the surface soil is heavier than typical, being a light clay in texture, are included with this type.

The Woodrow clay loam is rather extensively developed immediately east of Oasis, and there are some fair-sized bodies in the more southern parts of the area. In the central and nothern parts the areas are smaller and fewer in number.

The surface of the Woodrow clay loam is very smooth in the body east of Oasis and in nearly all parts of the area, except west of Hinckley, where it is nearly everywhere gently rolling and in places so broken that the land is hardly adapted for irrigation.

The drainage of the type is restricted. In the southern bodies the soil is permanently too wet for cultivation, and because of its low position it can not be profitably reclaimed. Many of the more elevated bodies to the north are wet, either because of seepage or the careless use of irrigation water. These bodies can be reclaimed by drainage and again made profitable farming land. The larger part of the type east of Oasis contains too much alkali for the production of crops, and a similar condition exists in the southern bodies and in those west of Hinckley. North of Hinckley the alkali content of the soil varies considerably in the different bodies. Only a small part of the type west of Sugarville can be considered as free from alkali.

All this soil in the vicinity of Oasis was at one time under cultivation, but it has largely been abandoned because of alkali. Similar conditions exist in many of the bodies north and east of Oasis and Deseret. In the southern townships of the area the larger part of the type has never been under cultivation, and the rather uneven surface west of Hinckley has retarded the development of land in that district. The soil puddles readily when irrigated, and bakes into hard clods upon drying. Tillage is difficult at all times, and there is but a short period when the soil is in a favorable working condition. The liberal use of manure or other forms of organic matter would greatly reduce the tendency of the soil to bake and crack, and render crop production more certain.

### WOODROW CLAY.

The Woodrow clay consists of 6 feet or more of a grayish-brown to brownish-gray clay, the gray being more pronounced in the dry sample. Considerable areas of the clay types of both the Gordon and Abbott series have a similar color, and considerable difficulty was experienced in placing the boundaries separating these types. Below the surface the material is normally browner than the surface material, and commonly marked with grayish or reddish-brown mottlings, and cut by occasional thin strata of material ranging in color

from yellowish and grayish brown to reddish brown. The surface soil in places assumes the puffy, flocculent condition that is developed throughout much of the clay loam of the series. In other places, particularly in the southwestern corner of the area, and to a less extent in the body south of Abraham, the surface soil often cracks and bakes into small clods in a manner that is strongly suggestive of the adobe soils. The subsoil is not cemented, but is in places so compact as greatly to retard the movement of water. The normal clay subsoil is occasionally interrupted by thin strata of lighter textured materials, particularly in the vicinity of members of the Oasis and Gordon series.

The Woodrow clay occurs only in the southern half of the area, principally west of Deseret and along the southern boundary. One area of this type in the southern part of T. 17 S., R. 8 W., has a rolling and hummocky topography, but most of the areas have a smooth, flat surface.

Drainage is deficient. Along the southern boundary east of the main line of the railroad some areas occupy low flats, are constantly wet, and can not be reclaimed. Some of the more northerly areas are unfavorably moist and in their natural condition can not be cultivated, but all these will be reclaimable after completion of drainage systems now being installed. Very little of the type is free from dangerous amounts of alkali. Except in the southern bodies of low elevation, the greater part of the alkali salts lies at some distance below the surface, and in the native state the alkali conditions are not always apparent. As a result many tracts have been cultivated for a short period, and finally abandoned. These are now returning to their original condition, and the amount of alkali present can be determined only by a series of tests covering the entire soil profile.

This type is devoted almost exclusively to the production of alfalfa. The soil is difficult to handle at all times, and owing to the marked tendency of the surface soil to form a hard crust after irrigation, considerable difficulty is often experienced in obtaining a satisfactory stand of young plants. The thorough incorporation of organic matter would tend to correct this condition to a considerable degree.

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

*Mechanical analyses of Woodrow clay.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 520711 | Soil | 0.1 | 0.6 | 0.4 | 2.4 | 3.1 | 41.7 | 51.7 |
| 520712 | Subsoil | .0 | .0 | .1 | 1.6 | 7.1 | 38.7 | 52.7 |

OASIS FINE SANDY LOAM.

The surface soil of the Oasis fine sandy loam is a light grayish brown or light brownish gray very friable fine sandy loam, about 12 inches deep. The brown color is accentuated under moist field conditions. Material of this texture may extend to a depth of 6 feet or more, but generally the subsoil, which is very irregular in texture, ranges from fine sand to silty clay. The lighter textured materials predominate; the heavier materials are confined for the most part, to thin strata occurring at varying depths. West of the main line of the railroad the surface soil is more sandy than east of it, and in the eastern part of the area the soil contains considerable silt and clay, the line of separation between this type and adjacent bodies of Oasis silty clay loam being in places rather indefinite. In some of the larger areas of the type, particularly in the vicinity of areas of Dunesand, the surface is marked in places by deposits of wind-blown sand and fine sand.

The Oasis fine sandy loam occurs throughout the area in bodies of varying size, from those too small to be shown upon the map (which are included with other types), to those several thousand acres in extent. The most extensive development of the type is south and west of Deseret.

West of Deseret the surface of the type is smooth, except where broken by occasional shallow drainage courses. South of Deseret the surface is moderately rolling, and consists in part of a rather well developed ridge following the meanders of an abandoned river channel. In the northern and central parts of the area the surface is marked in places by slight elevations, and a few of the areas are gently rolling, but none are so uneven that they may not be brought under cultivation.

The drainage of the type is adequate under natural conditions, but is not in all places sufficient to remove seepage and waste irrigation water. Wet conditions, accompanied by an excess of alkali, are most common in the area at Hinckley and in a smaller area in section 9 west of Woodrow. In the southwestern part of the survey the water table is relatively near the surface, but alkali has not accumulated in excessive quantities in all the areas. Under natural conditions the larger part of the type apparently did not carry alkali in injurious amounts, and the presence of these salts in dangerous amounts in certain areas is due almost wholly to an excess of subsurface moisture. With the exception of the areas in the southwestern corner of the survey, where the land is probably too low to be drained, all of this type can be reclaimed.

Alfalfa occupies the largest acreage on this type, with sugar beets ranking second and grain third in extent of plantings. The soil is

easily handled at all times, but requires somewhat more water for irrigation than the heavier soils.

*Oasis fine sandy loam, bench phase.*—The bench phase of the Oasis fine sandy loam is a rather coarse textured light grayish brown fine sandy loam containing small quantities of fine waterworn gravel, underlain at about 16 inches by sandy loam or sand. These subsoil materials may extend to a depth of 6 feet or more, but around the margins of the areas a compact grayish clay, similar to the subsoil of the Lahontan clay loam, is encountered in the lower part of the soil section. This phase is developed in one small body along the eastern boundary of the area, about 5 miles southeast of Delta. It occupies a gentle slope leading from the floor of the desert to a higher terrace just east of the area. The typical soil material of this phase has been derived from alluvial deposits of the Sevier River, brought apparently from the adjacent mesa. The soil is well drained and free from alkali. Practically the entire area is planted to alfalfa.

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

*Mechanical analyses of Oasis 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.* |
| 520701 | Soil | 0.0 | 0.0 | 1.1 | 37.5 | 37.1 | 16.8 | 7.7 |
| 520702 | Subsoil | .0 | .0 | 5.6 | 57.7 | 25.0 | 8.1 | 3.7 |

OASIS SILTY CLAY LOAM.

The surface soil of the Oasis silty clay loam consists of 10 to 30 inches of light grayish brown silty clay loam which, in the areas of lighter texture, is porous and friable. The subsoil consists mainly of stratified fine sand and fine sandy loam, with included thin strata of light-brown silt loam or clay loam occurring at varying depths. The color of the surface soil in places has a pinkish tint, and below 3 or 4 inches, is modified locally by layers of a decided reddish brown color, and here and there by materials ranging in color from dark brown to black. The depth of these strata varies considerably within short distances, with the result that the surfaces of newly broken fields present a mosiac of shades of brown, red, and black. With continued cultivation these colors eventually blend into a uniform tint that varies from the normal color of the type according to the proportion of more strongly colored materials included. In color this type grades imperceptibly into the soils of the Gordon and the Abbott series.

The lighter textured variations of the type resemble closely the fine sandy loam of the series, and identification is in many places made difficult by the presence of small deposits of wind-blown fine sand that have found lodgment around the desert shrubs.

The most extensive development of the Oasis silty clay loam is in the central part of the survey, where a continuous area extends from a point about 2 miles north of Hinckley eastward to the Gunnison Bend Reservoir and then southward to the southern boundary of the survey. In the western part, in the vicinity of Abraham, there are four or five areas, with a total extent of several hundred acres. Other bodies of considerable size are developed in the eastern part of the area, south of Delta.

West of Abraham, and in T. 17 S., west of Hinckley, the surface of several areas is moderately rolling, and a very gently rolling topography is developed in a number of places south of Oasis. Excepting these, the surface of the type is smooth and level. Both the soil and subsoil are porous and allow free movement of moisture, but several areas are wet from an excess of seepage and irrigation water. With the exception of its extreme southern extension, the large body in the central part of the area is well drained, partly because of its proximity to the reservoir and the depressed channel of the Sevier River, and partly because in several places it is slightly elevated above the adjacent soils. The extreme southern end of this body is considerably lower than the bordering soils, and the surface is but little above the general level of the underground water. Some of the type in the vicinity of Abraham is suffering severely from seepage, and a similar condition has developed in some of the areas in the northern part of T. 16 S. In the vicinity of Abraham the larger part of this type in its present condition is worthless for cultivation, the content of alkali commonly averaging more than 1 per cent, with a considerable proportion of the salts in the surface soil. A part of the body in section 23, north of Abraham, is also practically worthless, and the smaller body in the northern part of the township is in nearly as bad condition. Southeast of Delta the soil is only locally affected by alkali accumulation.

Considerable areas of the type have been abandoned, but where the soil is under cultivation alfalfa occupies by far the largest acreage. In the heavier textured bodies of the type the surface soil has a tendency to form crusts and to crack upon drying, but the normal friable structure can usually be maintained with but little trouble. With the exception of the bodies along the southern boundary of the area, in which the surface is generally too low for efficient drainage, all of the water-logged areas can be reclaimed when the drainage systems now under construction are completed.

*Oasis silty clay loam, light-textured bench phase.*—The light-textured bench phase of the Oasis silty clay loam consists of a very light grayish brown to light brownish gray friable silt loam that extends to depths varying from 18 inches to 6 feet or more. Where this material is less than 6 feet in depth the subsoil is a light grayish brown very fine sandy loam carrying a considerable proportion of silt. The surface material is well flocculated, giving much of this phase the appearance of a rather silty fine sandy loam.

This phase is developed in one body along the boundary of the area due east of Delta, and occurs on a gentle slope intermediate in elevation between the Lynndyl gravelly sandy loam on the Lynn Bench and the lower soils on the floor of the desert. The drainage is excellent and the soil is free from alkali.

None of this phase has been brought under cultivation. It will probably be found best adapted to alfalfa when irrigation water becomes available.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the typical Oasis silty clay loam and of its light-textured bench phase:

*Mechanical analyses of Oasis silty clay loam.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| Typical soil: | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 520705 | Soil | 0.1 | 0.1 | 0.0 | 1.6 | 20.8 | 56.0 | 21.4 |
| 520706 | Subsoil | .0 | .0 | .1 | 32.1 | 38.4 | 19.6 | 9.8 |
| Light-textured bench phase: | | | | | | | | |
| 520707 | Soil | .0 | .1 | .0 | 2.7 | 40.0 | 46.3 | 11.0 |
| 520708 | Subsoil | .0 | .1 | .1 | 3.9 | 33.1 | 48.4 | 14.5 |

OASIS CLAY.

The surface soil of the Oasis clay, as occurring under typical field conditions, is a light grayish brown to grayish-brown compact clay, in places relatively high in silt, and from 8 to 44 inches deep. In the dry sample the color tends to become gray. The soil is underlain by a light-textured subsoil composed of stratified deposits of fine sand and fine sandy loam in which thin strata of compact heavy-textured materials occur to some extent in the deeper parts. In the northeastern section of the area the surface soil in places approximates in color the darker gray of members of the Gordon and Abbott series, and the boundaries of individual areas are in many places more or less arbitrarily drawn.

The color of the surface soil is modified in places by strata of lighter or darker colored materials just below the surface. The

structure of the soil varies considerably, and within very short distances. In places there is a tendency toward the formation of a smooth compact surface layer, immediately underlain by a loose flocculated layer extending to a depth of 3 or 4 inches. This condition appears to be most marked in the eastern tier of sections in T. 16 S., R. 7 W., but none of the areas are of sufficient extent to be shown upon the map as a phase. Between these smooth areas the surface is commonly from one-half to 1 inch higher, and appears as a series of small flattened mounds partly separated by irregular indistinct cracks. Over much of the type the surface soil is rather compact, without being noticeably smooth, and is commonly underlain by a thin somewhat flocculated stratum. In some places under natural conditions, the surface soil has an adobe structure or bears a smooth crust. Over small areas this is checked with wide irregular cracks a foot or more in depth.

The subsoil of the type is usually friable and porous. The heavier variations of the subsoil are commonly brown, while the lighter textured variations are either light brown or grayish brown.

The Oasis clay is the most extensively developed type in the area. It occurs in the eastern part of the area in bodies of several thousand acres in extent, and is widely distributed in small bodies throughout the rest of the area. The surface of the type is uniformly flat and smooth.

In the heavier textured areas of the type the soil is commonly puddled after heavy storms and holds water on the surface for considerable periods, but as a rule the drainage is sufficient for the normal rainfall. Although the subsoil is prevailingly porous, unfavorable moisture conditions, accompanied by the accumulation of alkali, have developed in a number of localities as the result of irrigation. Such areas lie in the vicinity of Abraham and in the northeastern part of T. 16 S., R. 7 W. Drainage conditions in parts of the type in the vicinity of Hinckley are not favorable. A few areas of the type lie in poorly drained districts in the southern part of the area, and are permanently wet. Because of their low elevation, several of those areas can not be reclaimed. The area in the northeastern corner of the survey lies outside the present drainage districts, and could only be reclaimed through the construction of a separate system. A large part of the rest of the type will be provided with open-ditch and tile drains within a short time, the excess moisture permanently removed, and much of the type reclaimed. The soil, however, will always remain a difficult one to handle.

Wherever the moisture content of the soil is above normal, excessive quantities of alkali salts are present. The alkali conditions are most aggravated in the vicinity of Abraham, where several hundred acres, formerly under cultivation, have been abandoned, and much

of the surface is barren of even alkali-resistant vegetation. (Pl. II, Fig. 1.) A similar but somewhat less extreme condition occurs in the vicinity of Hinckley, and south and east of Delta there are considerable areas where alkali is present in rather dangerous proportions. In these latter areas the alkali condition has not in all cases been caused by excess of moisture, and the appearance of the surface soil and the native vegetation does not always indicate the presence of alkali. In other parts of the survey much of the type is practically free from alkali, and the small quantities that are locally present are not sufficient to injure crops, provided there is no marked rise in the present level of the underground water. A rise in the water table would increase the amount of soluble salts in the upper soil and greatly reduce its value for cultivation.

Large areas of the Oasis clay have been abandoned because of the water-logging of the soil and excessive amounts of alkali. Where this type is under cultivation, alfalfa and sugar beets are the principal crops, with acreages about equal. (Pl. I, Fig. 2.) Grain occupies a small acreage.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Oasis clay:

*Mechanical analyses of Oasis clay.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 520709 | Soil | 0.1 | 0.2 | 0.0 | 1.4 | 13.6 | 46.2 | 38.6 |
| 520710 | Subsoil | .0 | .0 | .0 | .5 | 15.7 | 61.6 | 22.2 |

GORDON CLAY.

The Gordon clay is a dark-gray or dark brownish gray to nearly black clay, from 8 to 30 inches deep, normally underlain by light-brown to light brownish gray stratified fine sand and fine sandy loam. Thin strata of light-brown clay loam and clay occur in the subsoil to some extent. The predominating normal structure of the wet surface soil is very compact; the dry soil tends to form a slightly roughened and cracked crust, which is underlain by a more or less flocculent mulch, 2 or 3 inches thick. This structure is destroyed by cultivation, and after irrigation the soil bakes and cracks into large hard clods. The subsoil is prevailingly light textured, but in places it carries a rather high percentage of silt, and this gives rise to noticeable changes in the apparent texture when the material is wet. Where the soil is not irrigated the subsoil is very porous and well flocculated, but under the influence of moisture the flocculent structure is at least partly destroyed, and the silt content tends to

produce a decidedly plastic condition, especially in the deeper materials.

The principal development of the type is in the northern part of the area, from near Wilson, in T. 16 S., R. 7 W., northward and westward to beyond the boundaries of the area. A number of other bodies, several of which are of considerable extent, occur northwest of Deseret. No areas occur east of the Sevier River. The surface of the larger body is smooth, as is that of the one occurring south of Abraham. The areas lying west of Deseret vary from smooth to gently rolling, and small parts are too uneven for irrigation without considerable leveling.

Throughout the type surface and subsurface drainage are slow, and in uncultivated areas much of the water remains on the surface until removed by evaporation. The subsoil is more porous than the soil and allows a fairly free movement of moisture, but this is not sufficient to give thorough drainage, and there are areas of wet land in a number of localities. This condition, which is said to be increasing, is noticeably developed in a narrow area extending northward from near the center of section 18, T. 16 S., R. 7 W. A similar but less serious condition exists in the areas of the type near Deseret. The isolated area in the southwestern corner of the survey apparently lies too low to be benefited by the drains that are now being constructed, but the other areas have sufficient elevation to make their drainage practicable.

In the larger area of the type the alkali content varies from a quantity too small to injure crops to concentrations inhibiting plant growth. South of Abraham all the type carries some alkali, and in two or three places crops are affected. West of Deseret the larger part of the type contains so much alkali that crops can not be grown, and even in less severely affected areas the amount of alkali is dangerously near the limit of tolerance for crop growth.

A considerable proportion of this type was under cultivation at one time and was later abandoned. This was due in some cases to unfavorable moisture and alkali conditions, but in many cases there is no apparent unfavorable soil condition aside from the usual difficulties attendant upon the cultivation of a heavy clay soil, that would cause abandonment. Sugar beets occupy the largest proportion of the area of this type at present under cultivation. Grain and alfalfa are the other more important crops. The soil is very difficult to maintain in good tilth, as it is heavy, compact, and plastic, and must be handled within a narrow range of moisture content. Incorporation of organic matter in liberal quantities would relieve these conditions to some extent, but not completely remove them.

*Gordon clay, slick phase.*—The slick phase of the Gordon clay differs from the typical Gordon clay only in the structure of the first

few inches of the soil. The surface is hard and compact, very smooth, and often barren of vegetation. (Pl. II, Fig. 2.) This material is nearly white, in striking contrast to the surrounding soils, which are prevailingly dark gray to brown. Except for the scanty growth of alkali-resistant plants, this phase resembles the smooth, barren playas common in the western deserts. The surface crust is usually less than an inch thick, and is underlain by a dark-gray layer of loose material, composed of very small granules—flocculated soil particles. This layer is from 2 to 4 inches thick, and is underlain by compact clay material like that in the surface soil.

The tendency of the soils in this survey to assume this barren, crusted structure is not confined to the Gordon clay, but it is only in this type that it occurs in areas of sufficient size to be separated. Only two bodies of this phase are shown on the map. Both are in the western part of T. 16 S., R. 7 W.

*Gordon clay, friable phase.*—The surface soil of the Gordon clay, friable phase, consists of a dark-gray to black clay from 10 to 26 inches deep and somewhat more friable than the typical soil. The subsoil consists of stratified materials, principally light grayish brown fine sand and fine sandy loam. Heavy, compact subsoil strata are rare.

This phase is developed only in T. 16 S., Rs. 7 and 8 W., with the larger number of the bodies in R. 7 W. The surface of the phase is smooth.

The areas are level and surface drainage is somewhat deficient. The subdrainage is complete. In the two bodies of the phase in R. 8 W. the content of alkali is high, and cultivation over the greater part of these has been abandoned. In R. 7 W. the phase everywhere carries small amounts of alkali, but areas in which dangerous amounts occur are of small extent. All this soil lies within the area to be traversed by drains, and conditions should show a marked improvement after these have been completed. Sugar beets are the principal crop on this phase.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the typical Gordon clay:

*Mechanical analyses of Gordon clay.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 520713..... | Soil..... | 0.0 | 0.2 | 0.2 | 5.7 | 17.3 | 42.0 | 34.8 |
| 520714..... | Subsoil..... | .0 | .0 | .0 | 42.3 | 37.2 | 15.8 | 4.7 |

ABBOTT CLAY.

The Abbott clay consists of a dark-gray compact clay surface soil, 8 to 38 inches deep, with minor dark-brown inclusions, underlain by a stratified subsoil of grayish-brown or gray clay of very compact structure. Thin strata of lighter textured materials occur locally in the subsoil, but are not of sufficient extent to materially affect the physical character of the subsoil. In the bodies in the extreme northern part of the area the soil is black when wet and almost black when dry, but in the more southerly bodies near Deseret the type is lighter in color.

In places the surface soil shows a tendency toward the development of slick spots, like those mapped as the slick phase of the Gordon clay, but these spots are too small to be shown on the map. Where the virgin structure of the type has not been disturbed, there is a slightly roughened and finely cracked surface crust and an underlying layer of highly flocculated clay. In areas under cultivation there often forms after irrigation a deep, hard crust that is difficult to handle, and in recently abandoned areas the surface material shows a tendency to assume an adobe structure. The usual dull grayish brown color of the subsoil is interrupted in places by thin strata of reddish-brown or darker colored materials, and by grayish or reddish-brown mottlings.

Several bodies of the type occur in the vicinity of Sugarville and eastward, one lies near Gordon and Wilson, and a somewhat larger development extends westward from Erwin. The type also occurs north and northeast of Abraham and south of that place in the southwestern corner of T. 16 S., R. 7 W., and along the western boundary of the area southwest of Hinckley. South of Abraham the type has a moderately rolling topography, with several places too uneven for irrigation, and near Erwin a slight ridge gives a gently rolling topography to a small area, but throughout the rest of the survey the surface is uniformly level and smooth.

Up to the present time little of the type has been injured by the accumulation of ground water as a result of irrigation, but it is closely associated in places with soils that have become water-logged and will doubtless suffer the same impairment in a short time if drainage work is not done soon. Both surface and subsurface drainage are restricted. There are indications of a rise in the level of the underground water in the area of this type near Sugarville, and unfavorable moisture conditions might develop there within a short time were it not for the drainage systems now being constructed. Most of this type, with the exception of the body in section 34, T. 15 S., R. 7 W., lies within the boundaries of the present drainage districts, and within a short time it will be provided with a system of open and covered drains.

Several of the bodies of the type carry excessive amounts of alkali, and this fact undoubtedly accounts for the abandonment of several hundred acres of land.

Alfalfa, grain, and sugar beets are the leading crops, the last mentioned occupying the largest acreage. Considerable areas have not been placed under cultivation, partly because they have not been included in the normal development of the district, and partly because in some localities the soil was obviously too strongly impregnated with alkali to justify the planting of crops. A considerable proportion of the type, particularly in the northern part of the area, has been abandoned for other reasons than alkali or lack of drainage.

Owing to the compactness and tenacity of the surface soil, this type will always be difficult to handle, although the liberal incorporation of organic matter would improve the physical condition to some extent.

*Abbott clay, silty phase.*—The Abbott clay, silty phase, consists of a dark-gray compact heavy clay loam or clay, relatively high in silt and 10 to 28 inches deep, underlain by stratified materials, mainly compact dull grayish brown clay loams and clays. In a few places the texture of the surface soil is maintained without distinct change to a depth of 6 feet or more, but such occurrences are rare. The color of this phase grades in many places into the colors of similar types in the Woodrow and Oasis series and the boundaries shown on the map are in many places rather arbitrary. Some of the material included with this phase has a rather light brownish tint. In places the clay loam and clay materials of the subsoil are displaced by strata of silt loam or materials of even lighter texture. A grayish-brown or reddish-brown mottling is not uncommon in the subsoil where the clay predominates.

The phase occurs principally in T. 16 S., R. 7 W., a small body west of Hinckley being the extreme southern development. The areas have a smooth level surface.

The texture and structure of the soil material is not favorable to rapid internal drainage, but up to the time of making the survey water logging of the land has occurred in but few places. With the exception of the body west of Hinckley, and in section 11, T. 16 S., R. 7 W., where the alkali content of the soil is dangerously near the limit for crop growth, only small amounts of injurious salts are present, and in a few places the soil is practically alkali free.

Sugar beets occupy almost the entire cultivated acreage of the phase. The soil tends to crust over after irrigation, but it is not quite so difficult to handle as the heavier typical Abbott clay. All this phase will be served by drains upon the completion of the works now in process of construction.

The table following gives the results of mechanical analyses of samples of the soil and subsoil of the typical Abbott clay and of its silty phase:

*Mechanical analyses of Abbott clay.*

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---|---|---|---|---|---|---|---|---|
| Typical soil: | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 520723 | Soil | 0.0 | 0.0 | 0.6 | 3.3 | 4.9 | 33.6 | 57.8 |
| 520724 | Subsoil | .0 | 1.3 | .7 | 6.6 | 8.5 | 36.6 | 46.3 |
| Silty phase: | | | | | | | | |
| 520719 | Soil | .1 | .2 | .3 | 3.9 | 5.3 | 45.7 | 44.5 |
| 520720 | Subsoil | .1 | 1.0 | .3 | 1.9 | 2.7 | 61.0 | 33.0 |

LYNNDYL GRAVELLY SANDY LOAM.

The surface soil of the Lynndyl gravelly sandy loam consists of 6 to 12 inches of a light-brown to light grayish brown sandy loam containing fine waterworn gravel and little organic matter. The subsoil and substratum consist of irregularly stratified gravel, sand, and sandy loam of light grayish brown color.

As occurring in this area, the surface soil varies considerably in texture from place to place, ranging from loamy fine sand to rather heavy textured sandy loam, but these variations are too small in extent to be shown upon the map as separate types or phases. Wind-blown sand occurs in small isolated dunes on the surface and in accumulations about the base of shrubs. The materials in the subsoil and substratum vary so widely in texture and structure that no consistent character is maintained, but they are prevailingly coarse-textured and porous. Slight cementation of the material by lime a few inches below the surface exists in places, but in all cases the material is easily crushed in the hand.

The Lynndyl gravelly sandy loam occurs in the eastern part of the area, forming the southern and western parts of a terrace that extends several miles north of the area. The surface is level to gently rolling and lies from 50 to 75 feet above the floor of the valley. The terrace slopes are steep or precipitous. Drainage is excessive.

None of the type within the Delta area is under cultivation at the present time, but on a few tracts just beyond the boundaries of the area alfalfa apparently succeeds. Considerably more water will be required for irrigation than on the other soils in the area.

The following table gives the results of mechanical analysis of a sample of the soil of this type:

*Mechanical analysis of Lynndyl gravelly 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.* |
| 520717 | Soil | 3.4 | 10.2 | 13.0 | 20.7 | 18.9 | 22.5 | 11.2 |

### LAHONTAN CLAY LOAM.

The Lahontan clay loam consists of 12 to 24 inches of a light grayish brown or light brownish gray clay loam, underlain by stratified deposits ranging from dark-brown or black fine sandy loam to grayish-white compact clay. In a few localities erosion has produced a rather uneven topography and in some areas the surface soil has been removed and the underlying gray clays exposed. Other variations consist of local hummocks of wind-blown materials and of small areas covered with material washed down from the higher slopes. In some local areas the surface soil is of heavier texture than typical.

The subsoil is subject to considerable variation in the thickness and arrangement of the several strata composing it. The darker colored fine sandy loam stratum is almost entirely absent from the northern part and is occasionally wanting in the southern part of the type. The clay, while predominantly grayish white, often includes seams and mottlings of darker gray and greenish colors. Upon exposure to the air this material breaks down, forming a flocculent grayish mass that resembles slaked lime.

Only two areas of this type are developed within the Delta area. One of these lies in sec. 27, T. 15 S., R. 7 W., and the other along the eastern boundary of the area in T. 17 S., R. 6 W. The northern area occupies a smooth flat area depressed a few feet below the adjacent soils, while the southern area occupies a slightly elevated position, with a surface sloping moderately to the west and either smooth or gently rolling and hummocky. The drainage is deficient. Practically all this type carries excessive quantities of alkali and is not suitable for farming.

### DUNESAND.

Dunesand consists of masses of light-brown wind-blown sand and fine sand occurring in the form of small isolated dunes in various parts of the area. Some of the areas have an extent as large as 40 acres, but most of them cover less than 5 acres, and many are too small to be shown on the map. The dunes are stationary and covered with brush, and in their present condition are nonagricultural. Some of the smaller dunes will in time be leveled and the land planted to crops, but the majority of them are too large to be removed.

### ROUGH STONY LAND.

Two small areas of Rough stony land occur in the extreme southwestern corner of the area, where they form the lower slopes of an extensive basalt mesa or table-land that lies just beyond the boundary of this survey. The material varies from steep talus slopes of

angular basaltic fragments to more gentle slopes carrying a thin mantle of fine sandy loam over masses of basalt. The type is entirely nonagricultural.

### ALKALI AND DRAINAGE.

Alkali, as a term applied to soils, refers to soluble inorganic or mineral salts that may be present in amounts sufficiently large to be dangerous to or prohibitive of the growth of cultivated crops.

Alkali accumulates in the soil mainly in two ways; either it was contained in the soil material at the time the soil was formed or deposited, or it was accumulated at some later period through the currents and movement of surface or underground waters containing the soluble materials.

The alkali in the soil of the Delta area was accumulated in both these ways. As the soil materials were carried into the present Sevier basin by the various streams, small amounts of soluble materials were present in the transporting waters, and these became concentrated and remained in the soil upon the removal of the water by evaporation. The rainfall of this region is low and not sufficient materially to leach the soluble salts or affect their distribution in the soil and subsoil after deposition, and the amount of soluble salts in the virgin soils at the present time is probably very much as it was at the time the soils emerged from the waters of Sevier Lake. In some of the cultivated lands the content of alkali has been considerably increased by the addition of soluble materials carried in the irrigation water in the last 40 or 50 years; but in other lands the salts have probably been removed, and most certainly thev have been concentrated in a number of districts.

In this survey the amount of alkali salts occurring in the soil was determined in the field by the use of an electrolytic bridge (Wheatstone bridge), and the conditions shown upon the accompanying alkali map are the result of such field tests and of field studies of the condition of crops and the character of the native vegetation. The alkali map shows by means of colors the location and extent of the several grades of alkali lands, and in addition, by means of ruling, the areas in which the alkali salts are localized either in the surface soil or in the subsoil.

Four grades of alkali lands are mapped. The map (Pl. A.) shows the conditions as they existed at the time of the survey, but it does not necessarily follow that percentages of alkali shown will everywhere be present within each area separated, as the effects of alkali upon vegetation are very often dependent upon the distribution of the salts in the soil. In a soil containing but 0.2 per cent, there will be no indication of its presence either by soil or plant conditions, provid-

ing the salts are uniformly distributed throughout the mass of the soil. On the other hand, the total amount of alkali in the soil may be no greater than the above amount, but the soil may be entirely unproductive because the salts are concentrated at or near the surface. In the study of alkali conditions in this area it was found to be a general rule that the condition of the crops, and the growth and character of the native vegetation, were rather closely associated with the amount of alkali in the soil. Exceptions to this general rule occur in several localities, but in such cases a concentration of soluble salts is present in some part of the soil profile.

In the classification used in this area, the A, or alkali-free, grade includes all areas in which there were no indications of alkali salts in injurious amounts, either from the appearance of the soil, the character of the native vegetation, or the condition of the cultivated crops. While small quantities of salts occur in the soils of this grade, the average, as determined by field tests, is 0.26 per cent, which in this survey is considered insufficient to cause material damage.

The largest single body of this grade of land is in the area occupied by the Lynndyl gravelly sandy loam northwest of Delta. A smaller body of that type east of Delta is also of the same grade. In the lower lands the most extensive area of alkali-free soils is in T. 17 S., R. 7 W., in the districts adjacent to the Gunnison Bend Reservoir, and the depressed channel of the Sevier River. There is a considerable acreage of alkali-free soils throughout the central part of T. 16 S., R. 7 W., but the individual areas are smaller than those to the south. Smaller isolated areas of this grade occur throughout the rest of the northern and central parts of the area, but in all of T. 18 S. there is practically no alkali-free soil.

The B grade, or that of moderate alkali concentration, includes all areas where the crops are beginning to show the effects of the presence of alkali, and where, judging from the appearance of the soil and the character of the native vegetation, alkali is present in small but moderately injurious quantities. The average in the soils in this grade of land, as determined by field tests, is 0.42 per cent. Over most of the land of this grade the soluble salts are uniformly distributed throughout the soil material to a depth of 6 feet, and the areas where they are concentrated in either the surface soil or subsoil are few and of small extent. This grade, which is more extensive than any other, is developed in areas of considerable size in every township except one, T. 18 S., R. 6 W.

The C grade, or that of high alkali concentration, includes all areas where crops are still being grown, but where they are evidently badly affected by alkali. In this grade the average amount of alkali in the soil, as determined by field tests, was 0.62 per cent. In the

virgin soils the distribution of salts in this grade, as indicated by soil and vegetative conditions, is not markedly different from that of the D grade, and the separation of these grades is probably not very accurate. The largest areas of the C grade lie in T. 17 S., R. 6 W., and areas of varying size in all the other townships.

The D grade, or that of greatest alkali accumulation, includes all areas where the amount of alkali is sufficient to prevent the successful growing of crops and where under virgin conditions the surface soil is either incrusted and barren of vegetation, or carries only scattering growths of the most alkali-resistant plants. In this grade the average amount of alkali is more than 3 per cent. Such lands are extensive in the northern and southern parts of the area near the eastern boundary, in the vicinity of Abraham, around Hinckley and about 3 miles southward, and in a number of places along the southern boundary of the area. Throughout the rest of the survey high concentrations of alkali are found in every township, but the individual areas are for the most part small.

In the cultivated areas it is not always possible to determine the condition of the soils, with respect to accumulation of alkali salts, prior to the beginning of irrigation, as the effect of irrigation may have been to reduce the amount of alkali in some localities, and it certainly has increased the amount present in the soil in several districts. In the virgin soils at the present time very excessive amounts of alkali are present in an irregular body extending from section 13, T. 16 S., R. 7 W., northward to the boundary of the area, and a similar body lies along the eastern boundary of the area in T. 17 S., R. 6 W. In both of these localities the concentration of alkali is apparently largely due to a slow continuous seepage from the higher lands immediately east of the area. In the extreme southern part of the area considerable bodies of virgin soil occupy a very low elevation, nearly as low as Mud Lake, a short distance south of the area, and these soils undoubtedly have contained excessive amounts of alkali ever since they emerged from the waters of the lake. In the southwestern part of the area, in T. 17 S., R. 8 W., the greater part of the virgin soils has apparently not been affected by the use of irrigation water, and the present alkali conditions are undoubtedly essentially as they were prior to settlement of the area. Throughout practically all of the rest of the area the alkali conditions have been modified by irrigation, and the original conditions are unknown. As the larger part of this land was at one time successfully cultivated, it may be inferred that the content of soluble mineral salts was generally low, at least in the surface soil. With the extension of irrigation canals excessive amounts of alkali have developed in a number of localities, directly as a result

of seepage from canals and less directly through a general rise in the level of the water table.

A notable instance of the effect of seepage is found in T. 16 S., R. 7 W., where a large canal skirts the outer boundary of the Lynn Bench and extends north between sections 22 and 23. Another area seriously affected from the same cause is found along the northern line of T. 17 S., R. 8 W., and extending in a southerly direction along a canal that is largely above the surface of the ground. The most widespread damage from alkali, however, has resulted through the rise in the level of the underground water. Generally this condition first developed in the southern part of the area and extended northward as the irrigation canals reached out to cover new lands. The most striking example of damage due to a rise in the ground water level is in the vicinity of Abraham, where several thousand acres have been made entirely worthless for agriculture. A similar condition has arisen in the vicinity of Hinckley, and in another area of less extent in the northwestern part of T. 16 S., R. 7 W. Throughout the larger part of the rest of the area, excluding the districts where alkali has always been present, large amounts of alkali are found in bodies of varying size. Were it not for the extensive drainage systems that are now being constructed to remove the excess ground water, it seems probable that the acreage of alkali lands would increase rapidly within the next few years, and the crop-producing acreage would fall to an alarmingly low figure.

The need for drainage systems, particularly in the southern part of the area, had been realized for several years, before the Delta South Tract Drainage District was organized to include about 10,000 acres southeast of the town of Delta, and Drainage District No. 1 was organized to include about 5,240 acres in the vicinity of Hinckley. (Pl. III, Fig. 1.) As adverse underground water and alkali conditions continued to develop in the land outside the two districts, it was evident that steps must be taken to relieve those conditions, or large areas of tillable soil would have to be abandoned. As a result Drainage Districts Nos. 2, 3, and 4 were organized to cover practically all the irrigated lands in the valley not covered by the older districts. The work of construction is now (1919) going on at a rapid rate. (Pl. III, Fig. 2.)

## IRRIGATION.

The climate of this region is distinctly arid, and irrigation is absolutely necessary for the production of crops.

Water for irrigation was first taken from the Sevier River, about 1860, when a colony of settlers from Fillmore established a settle-

ment near the present site of Deseret. The dams placed in the channel of the Sevier River for the diversion of water were repeatedly washed out by the spring floods, and the result was often a shortage of water during the growing season. Later, as the population of the valley increased, reservoirs were constructed to impound the flood waters and insure a continuous supply of water. The reservoirs now constructed along the river are said to have a capacity considerably beyond any known discharge of the river.

The only gravity supply of irrigation water for this area is in the flow of the Sevier River. Stream gaugings taken during a period of 12 years at a point near Leamington show an average annual run-off of about 300,000 acre-feet. At a point about 6 miles above Delta the discharge is about 350,000 acre-feet, the gain being due partly to one or two small tributaries, but largely to water from underground seepage and springs. A possible supply of water for irrigation, that has not yet been developed, consists of the underground water now tapped for domestic use at various depths below 100 feet. In some of the wells there is a slight flow; in the greater number the water rises to within a few feet of the surface. The water is of very good quality, and there is no apparent reason why this supply could not be drawn on, at least to some extent, for irrigation by sinking 10 or 12 inch casings and installing gasoline engines and pumps.

Water for the lands in this area is first diverted from the Sevier River at a point about 6 miles above Delta. One branch of this canal carries water to the lands in T. 17 S., R. 6 W., and supplies a part of T. 18 S., R. 6 W. The larger branch extends west around the point of the Lynn Bench and supplies practically all of the land in T. 16 S., R. 7 W., all of the lands in T. 15 S., Rs. 7 and 8 W., and a small area in the northern part of T. 16 S., R. 8 W. Gunnison Bend Reservoir, west of Delta, serves to impound some of the flow of the Sevier River, and by the dams at the southern end of the reservoir the water is raised to a level that permits of its diversion for the irrigation of lands in the Abraham, Hinckley, Deseret, and Oasis districts.

In the irrigation of alfalfa and small grains the fields are divided into checks of varying size, which are flooded whenever necessary. Sugar beets are irrigated by the furrow method. The irrigation season is from about April 15 to late in September or early in October. Much more water is used in this district than is needed, probably over 3½ acre feet being used, and this is in large part due to waste of water by the users, as well as to the use of unnecessarily large quantities of water in the fields. In several localities some water is lost by seepage from the larger canals, but that loss is small compared with the unnecessary waste that takes place after the water leaves the larger canals. It is probable that, with proper management, as little as 18

inches of water could be used, with no damage to crops, and with benefit to the soils. The annual cost of water to the farmers varies from 50 cents to $1.50 an acre, the charges made by the various companies ranging within these extremes.

## SUMMARY.

The Delta area, Utah, comprises 180 square miles, or 115,200 acres. It lies about 140 miles southwest of Salt Lake City, in the northeastern part of Millard County and the eastern part of the Sevier Desert. Topographically it is a smooth plain, the surface of which is broken only by the low terrace forming the Lynn Bench, and by the depressed channel of the Sevier River.

The Sevier River traverses the area in a southwesterly direction, but has no tributary streams within the area. Tenmile Hollow Creek is a small intermittent stream that carries seepage and waste irrigation waters and discharges into Mud Lake, just south of the area.

Delta is the largest town in the area, and the commercial center of this district. Oasis, Deseret, and Hinckley are small rural settlements, south and west of Delta.

A line of the Union Pacific system passes through the area, and affords an outlet to northern, eastern, and Pacific-coast markets. The area is well supplied with graded earth roads.

The climate is arid, the rainfall averaging about 8 inches. The precipitation occurs largely during the late winter and spring months. The maximum summer temperature is about 100° F., and during the winter the thermometer may go as low as —10 or —15° F. Killing frosts often occur as late as the latter part of May, and the first frosts in the fall are expected early in September. High winds are common throughout all but the winter months. The usual climatic conditions favor the growing of all the hardier field crops and vegetables, but the short growing season, the cool nights, and the danger of late spring frosts prevent the growth of the more tender plants and fruits.

Alfalfa, sugar beets, and grain are practically the only crops grown in the area.

With minor exceptions, the soils are derived from somewhat weathered sediments deposited by the Sevier River. They are prevailingly heavy in texture and range from light grayish brown or light brownish gray to dark gray in color. Both surface soils and subsoils are highly calcareous.

Seven series of soils are mapped, and these are represented by 11 types and 5 type phases. In addition, two miscellaneous classifications, Dunesand and Rough stony land, are mapped. Only about one-third of the area is under cultivation at the present time. The

types of the Cache, Woodrow, Oasis, Gordon, and Abbott series are the most important agricultural soils.

The drainage is not always sufficient to remove the excess irrigation water and as a result there are considerable areas in which unfavorable alkali and moisture conditions have rendered the land worthless for cultivation. Most of these areas can be reclaimed, and extensive drainage operations are now being carried out to effect such reclamation.

Irrigation is necessary for crop production, and the flow of the Sevier River is stored in reservoirs to insure a supply of water during the growing season. Underground water constitutes a possible source of future supply.

○

[PUBLIC RESOLUTION—No. 9.]

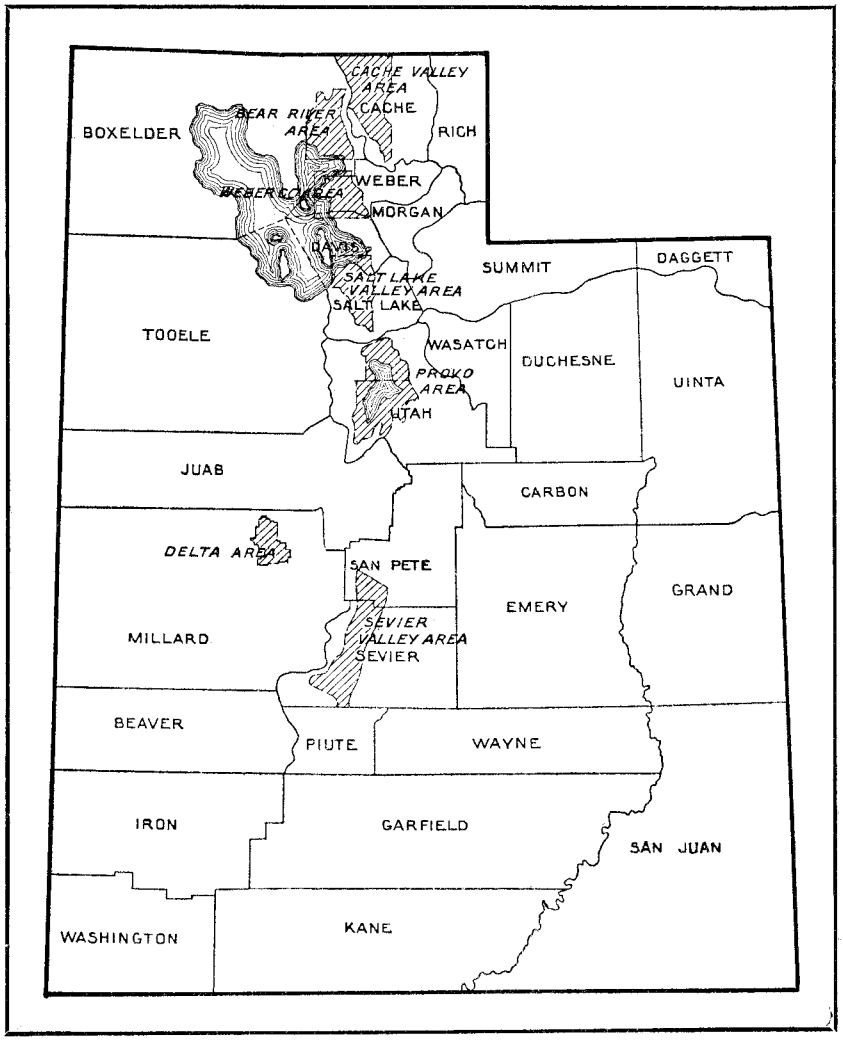
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

*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.]




Areas surveyed in Utah shown by shading.

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